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Historic Populations of the Double-crested Cormorant (*Phalacrocorax auritus*): Implications for Conservation and Management in the 21st Century

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Abstract.—In North America, the Double-crested Cormorant (*Phalacrocorax auritus*) is currently abundant, widely distributed across five broad geographic regions, and often perceived as overabundant. In many U.S. states and Canadian provinces, policy makers are pressured to significantly reduce cormorant numbers, primarily to minimize conflicts between cormorants and fish resources. Concurrently, large-scale conservation plans recently developed for birds in the Americas depart from the traditional narrow focus on threatened and endangered species to encompass broader and more representative goals (e.g., Partners in Flight's objective to "keep common birds common"). In recent waterbird conservation initiatives, historic distribution and abundance provide the basis for conservation focus; these initiatives advocate conservation of birds in natural numbers and natural habitats. To provide a context in which current populations of Double-crested Cormorants can be understood, we reviewed historic and current breeding and wintering records to determine historic distribution (pre-1900), current distribution (1970-1999), and extent of range expansion across North America. Early records suggest Double-crested Cormorants were present in large numbers throughout much of their current range; colonies and flocks much larger than any known in the 1990s are well documented. However, numbers sharply declined through the late 1800s as cormorants were greatly reduced and/or extirpated in many areas. The population partially recovered through at least the mid-1900s, but experienced a second major decline during the 1950s-1970s. In the late 1970s, a second rebound began across much of the continent; the largest breeding populations (Canadian/U.S. interior, Atlantic Coast >80% of total) increased from approximately 32,000 pairs in the early 1970s to >226,000 pairs in the late 1990s. Comparison of historic and current records challenges the opinion that cormorants are currently overabundant, and suggests that perception of overabundance rests on socio-political rather than biological or ecological factors. For this species, and others that are seen as competitors with humans, limits of human tolerance (i.e. "social carrying capacity") are far narrower than those of biological carrying capacity. Because large numbers have been typical for cormorants historically, population targets based on fishery or other objectives derived from human values will likely be readily surpassed, require intensive management, and significantly depart from the concept of conserving birds in natural numbers and natural habitats. Although managing fish-eating birds to benefit fishery yields may increase some fish populations, this approach does not resolve or address the underlying problems causing current fish population declines across the continent, and is in direct conflict with current broad scale conservation initiatives. To ensure inclusion of cormorants and other fish-eating birds in these conservation plans, the avian conservation community must continue to press for programs based on ecosystem health and process that recognize humans, fish and cormorants as three components of a complex system driven by many species and dynamic interactions. Received 11 July 2005, accepted 10 October 2005.

Key words.—Double-crested Cormorant, historic populations, distribution, current abundance, conservation vs. management plans.

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INTRODUCTION

In May of 1604, Samuel de Champlain sailed along the southwest coast of Nova Scotia and visited several islands. One, "The Isle of Cormorants", west of Cape Sable, was "so named because of the infinite number of these birds of whose eggs we took a barrel full" (Champlain 1922). On his visit to the nearby Seal Island group, Champlain wrote "the abun-

dance of birds of different kinds is so great that no one would believe it possible unless he had seen it—such as cormorants . . ." Though Champlain does not identify the species of cormorant he observed, Lewis (1929) concluded some of the birds were likely Double-crested Cormorants (*Phalacrocorax auritus*) (DCCO); more than 200 years after Champlain's visit, Audubon (1840-1844) reported Double-crested Cormorants breeding on the Seal Islands.

By the late 19th and early 20th centuries, however, the abundance of cormorants Champlain and others observed across much of North America had greatly diminished. As early as 1634, cormorants were reported “to destroy abundance of small fish” (Wood 1634); since this time, the perception of cormorant diet and foraging behavior has changed little and has been a significant factor affecting the distribution and abundance of the DCCO in North America. Human efforts to reduce numbers and eliminate populations have been documented throughout European settlement, and species history during the latter part of the 19th and the first quarter of the 20th centuries has been described as “a history of persecution and gradual abandonment of one breeding place after another” (Lewis 1929).

Between the 1920s-1940s, DCCOs began a period of population recovery and expansion in several areas. This period was relatively short-lived, however, as widespread use of DDT beginning in the 1940s, combined with legal and illegal control activities and habitat change, led to a second major period of DCCO population declines (e.g., Carter *et al.* 1995; Hatch 1995; Krohn *et al.* 1995; Ludwig *et al.* 1995; Weseloh *et al.* 1995). Between the late 1940s-1970s, numbers plummeted sharply across much of the species range.

Conversely, history of the species during the last third of the 20th century can be described as one of protection and conservation efforts. In 1972 the DCCO was Blue Listed by National Audubon Society (Tate and Tate 1982) and added to the U.S. Migratory Bird Treaty Act protected bird list (23 U.S.T. 260 (1972)). In the same year, DDT was also banned (U.S. EPA 1972). These actions, along with changes in the prey base (e.g., increases in forage fish in natural waters and development of large-scale aquaculture facilities) contributed to the recent period of spectacular growth in numbers and return of DCCOs to many portions of the historic range from which they had long been absent. Presently, the species is widespread and abundantly distributed with five major breeding regions described: Alaska, the Pacific Coast, Canadian and U.S. Interior, Gulf

Coast, and Atlantic Coast (Hatch and Weseloh 1999; Wires *et al.* 2001).

In this paper, we identify conflicts between federal policy and continental/regional conservation plans that are closely linked to interpretations of recent population growth. Current DCCO numbers are reported to be at “all time” or “historic” highs (USDA/WS Activity/Fact sheet; USFWS News Release for DCCO Proposed Rule, Mar. 2003; Wywiałowski 1999), and to have “irrupted” during the last 20 years (Glahn *et al.* 2000). Though historical information is limited (Hatch 1995; Wires *et al.* 2001) the U.S. Fish and Wildlife Service (USFWS) Proposed Rule for DCCO (USDI/FWS 2003a) stated, “population levels are greater now than in the past.” Additionally, the species is frequently characterized as “overabundant” (e.g., Farquhar 2001; USDA/APHIS/WS 2003; USFWS Waterbird Fact Sheet, Jan 2002). Growing concern over population changes and possible impacts to natural resources led USFWS, in conjunction with U.S. Dept. of Agriculture/Wildlife Services (USDA/WS), to prepare an Environmental Impact Statement (USDI/FWS 2003b), and publish a Final Rule which establishes a Public Resource Depredation Order for DCCOs effective in 24 states (geared towards Interior, Southeastern and Atlantic coast populations), and revises the 1998 DCCO Aquaculture Depredation Order to include lethal control at winter roost sites (USDI/FWS 2003c). At the same time, large-scale conservation plans for waterbirds in North America and Canada are based on sustaining and/or restoring waterbird populations throughout their historical range (Kushlan *et al.* 2002; Milko *et al.* 2003).

To provide a context for the abundance of current (1970-2000) populations we review historic (*circa* 1900 and earlier) populations of Double-crested Cormorants. Though human modification of the environment was well under way in the 19th century, human induced environmental change greatly accelerated in the 20th century and severely impacted many wildlife species (Askins 1999), including DCCOs (Hatch and Weseloh 1999). Therefore, we examine occurrence during

the historic period because populations at this time were more representative of the numbers that existed under relatively “natural” conditions. We explore the concept of “overabundance” as it relates to distribution and abundance of cormorants, perceptions about cormorant population growth and recovery, and biological carrying capacity vs. “wildlife acceptance capacity”. Because establishing population objectives is a goal for major bird conservation plans (e.g., Partners in Flight (Bonney *et al.* 1999), North American Waterbird Plan (Kushlan *et al.* 2002), North American Waterfowl Management Plan (NAWMP 1998), U.S. Shorebird Conservation Plan (Brown *et al.* 2001)), we also discuss factors that have influenced population objectives for cormorants.

METHODS

To describe historic (pre-1900) breeding distribution of DCCOs in North America, we reviewed early ornithological and archaeological records reported in journals, state breeding bird atlases, books and maps. All records that reported observations of nests, chicks and/or eggs were considered breeding records. Records that contained circumstantial or anecdotal evidence indicating cormorants may have been breeding were explored and considered probable breeding records based on factors such as long-term occurrence in area, season record was obtained, age of specimen seen, and author's comments and apparent level of knowledge. Records of breeding obtained post-1900 were included if they indicated the colony site was historic or had likely been occupied prior to 1900. Because most early records did not provide numerical estimates we were unable to estimate historic number of breeding birds on a regional level. However, early records often included qualitative descriptions of abundance and sometimes estimates of numbers of pairs or nests. We carefully examined these descriptions to obtain information on and assess historic abundance.

To describe current (1970-2000) breeding distribution and abundance, we obtained census and survey data from university, state and provincial biologists monitoring DCCOs across the continent. Most of these individuals and agencies regularly census DCCO colonies and they provided us with estimates of breeding pairs.

In an effort to present biologically relevant information for current and historic populations, we report population data in the context of distinct breeding zones. Hatch and Weseloh (1999) described five main breeding zones for DCCOs in North America: Alaska, Pacific Coast, Canadian and U.S. Interior, Florida and the western Caribbean, and the Atlantic Coast, which largely correspond to distribution of the five subspecies (Palmer 1962; Johnsgard 1993). Though thought to reflect fairly distinct breeding populations, recent expansion and re-colonization has blurred boundaries between and among these zones (Hatch and Weseloh

1999; Wires *et al.* 2001). Border states between Interior and Florida/Caribbean populations, Interior and Pacific Coast populations, and Florida/Caribbean and Atlantic Coast populations (e.g., Texas, New Mexico, Idaho, inland southern states, the Carolinas), qualify as “gray areas” or regions where it is not possible to identify precisely what zone breeding cormorants belong to without banding and molecular studies. To determine the most likely population zone for each colony documented prior to 1900 and between 1970-2000, we relied on subspecies distribution information and consideration of logical geographic units. Latitude/longitude coordinates were obtained for historic and current breeding sites and mapped within each breeding zone. For some historic sites, only general locations (e.g., county, central portion of state) were documented; for these sites, best approximate locations were mapped. Changes in abundance and distribution were examined by comparing current and historic records within each of the breeding zones.

RESULTS

Distribution

Archaeological records.—We did not conduct an exhaustive search for archeological records. Those we report were obtained while searching for early records and are based on skeletal remains retrieved from Native American middens. Though only four records were found, they indicate DCCOs were present in three of five breeding zones (Fig. 1) between 500-5000 years ago. Bones of young birds collected from middens on the Pacific and North Atlantic coasts indicate DCCOs were breeding on both coasts. Skeletal material retrieved from middens on Amchitka, Aleutian Islands, documents presence but does not verify breeding because no bones of young birds were found.

Early ornithological records (1500-1900).—Prior to 1900, cormorants were widely distributed across North America, and occurred in all five of the hypothesized breeding zones (Fig. 1). Approximately 80% of the locations shown are documented breeding sites (i.e., have records of nests, eggs, or young); we designated the remaining 20% as probable or possible breeding locations based on circumstantial or anecdotal information (e.g., time of year observed, author's comment). Systematic surveys for birds were not formalized at most locations prior to the twentieth century; thus, the number of records within each breeding zone does not

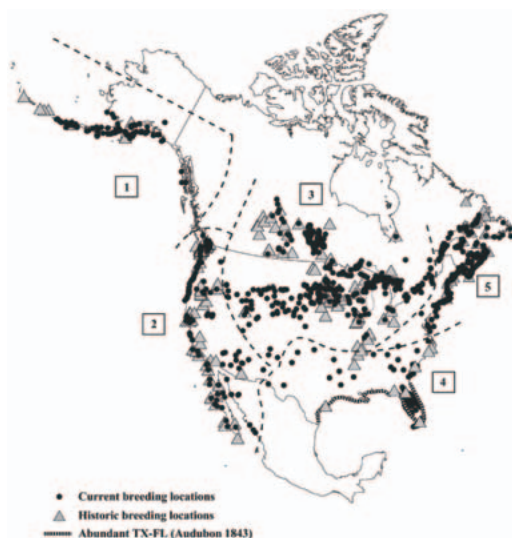


Figure 1. Historic (1900 and earlier) and current (1970-2000) breeding locations of the Double-crested Cormorant in North America. 1) Alaska; 2) Pacific Coast; 3) Canadian and U.S. Interior; 4) Southeast U.S./Caribbean; 5) Northeast Atlantic Coast.

reflect abundance of breeding birds or extent of distribution. In some areas (e.g., Pacific and Atlantic coasts), multiple records prior to 1900 are available; in others (e.g. some parts of the Interior and Gulf Coast), little effort was made to survey avifauna prior to the twentieth century (Ridgway 1874).

Current records (1970-2000).—In general, distribution of the current population is similar to that of the historic population (Fig. 1). All records shown are documented nest sites, and, with the exception of states and provinces for which data were not available, represent the continental breeding distribution. Important areas that appear different from historic distribution (Fig. 1) include the Great Lakes and western portion of the Interior range; interior portion of southeastern U.S.; and southeastern Alaska. Comparison of historic and current distribution maps suggests the species currently has a wider distribution in these zones.

Abundance

Historic abundance.—While precise counts are not available for most colonies prior to the twentieth century, records located for

each population zone suggest historic populations of DCCO were very large. To indicate relative abundance within each population zone we summarized colony observations and qualitative descriptions for each breeding region (see Zone Summaries below).

Current abundance.—Census efforts among states and provinces are rarely coordinated across breeding zones due to several factors (e.g., limited funding, political boundaries). Therefore, colony size typically is not estimated during the same year or using the same census technique across a population. Additionally, some important areas that provide breeding habitat for large numbers of cormorants (e.g., Mexico, Manitoba) are not regularly censused and little is known about cormorants in major portions of these areas. Thus, accurate estimates for regional (zone-wide) populations are not available. However, most areas within the five breeding zones are regularly censused and estimates of breeding pairs are available for many colony sites. To indicate relative abundance of DCCOs in each population zone we report (Table 2) population estimates for each breeding region based on the most recent and complete census efforts.

Alaska Summary

Birds in this zone comprise the subspecies *P.a. cinnatus*, the most restricted (Palmer 1962) and smallest of the five populations. Between 1970 and 2000, DCCOs were confirmed nesting at 126 colonies, mostly along the southern coast and on the Aleutian Islands (Fig. 1). Alaska has not conducted statewide censuses of all colonies in the same year and the number of breeding birds is not known. However, 106 sites were censused at least once between 1970 and 2000; most colonies (93%) were small (<100 pairs), and a total of 3,029 pairs was reported (Table 2). Because so few data are available over such a broad time period it is not possible to comment on how closely this estimate approximates actual numbers, but the abundance of small colonies suggests the population is small.

Determining historic distribution and abundance in this zone is complicated by the

large-scale introduction of foxes (*Alopex lagopus*; *Vulpes vulpes*) to Alaska that occurred between 1750 and the early 1900s (Bailey 1993). Because introduced foxes had major impacts on nesting seabirds (Bailey 1993; Carter 1995), records collected during the historic period may reflect a recently modified distribution and abundance. Turner (1885) described DCCOs as abundant residents and breeders in the Near Islands in the western Aleutians in the late 1800s, and Clark (1911) reported they were still present on these islands as breeders in the early 1900s. However, the peak in fur farming did not occur until the early 1900s, with the most rapid growth occurring in the 1920s (Bailey 1993); by the mid-1930s, DCCOs were no longer breeding in the Near Islands (Murie 1959). Today the western-most breeding point is Chuginidak, Aleutian Islands (52°51'04", 169°49'69").

Gabrielson and Lincoln (1959) note that reports of DCCOs breeding throughout southeastern Alaska could not be confirmed with available information. They reviewed early records up to 1945, and defined the breeding distribution "from Kodiak westward at suitable places along the Alaska Peninsula far out into the Aleutian Islands." All observed colonies were small (<100 pairs).

Based on available information, current DCCO distribution appears more restricted than in the past. In this portion of the range, DCCOs utilize level ground for nesting, which makes colonies vulnerable to terrestrial predators (Siegel-Causey *et al.* 1991). Introduction of foxes may have limited cormorant distribution, and if large colonies existed, they may have been substantially reduced before they were documented, particularly in the Aleutian Islands and Gulf of Alaska (Siegel-Causey *et al.* 1991; Carter *et al.* 1995). Murie (1959) noted a "drastic change" in the Alaska distribution since about 1906. Disappearance from portions of the range combined with increased predation pressure suggests DCCOs may have been more abundant historically, at least in parts of this region, than they are today. Additional causes that may have contributed to declines include other introduced predators and rabbits, and

human disturbance (Siegel-Causey *et al.* 1991; Bailey 1993; Carter *et al.* 1995).

Pacific Coast Summary

Birds in this zone comprise the subspecies *P.a. albociliatus*. Between 1970 and 2000, nesting was documented at 248 sites (Table 2). The current breeding population occurs mostly along the coast from southern British Columbia to at least Bird Island, Sinaloa, Mexico (Fig. 2), and possibly further south (Carter *et al.* 1995). Significant colonies also occur inland. Summing available estimates for the late 1980s and 1990s, approximately 33,000 nesting pairs were documented in the region primarily during the mid-to-late 1990s. However, estimates from important portions of this region are dated, and large-scale movement among breeding birds occurs. In the Salton Sea, dramatic increases in breeding birds occurred during the mid-to-late 1990s, and cannot be attributed to productivity rates alone (D. Shuford, Point Reyes Bird Observatory (PRBO), pers. comm.); most birds were believed to be immigrants from other locations, possibly Mexico (D. Shuford, PRBO, pers. comm.). Because of large shifts and intercolony movement, frequent monitoring efforts over wide areas are required to estimate regional population size (Carter *et al.* 1995). Although data collection and census efforts have not been coordinated across the region, available information indicates this population is the third largest, but relatively small in comparison to the North Atlantic Coast and Interior populations.

With the exception of British Columbia, the DCCO was recorded as a breeding species throughout most of the Pacific Coast prior to 1900. The earliest breeding records we located were bones of young cormorants retrieved from a shell mound in Emeryville, CA. Samples from the mound indicate that aboriginal people utilized the area as long as 2,550 years ago and hunted a great diversity of waterbirds, including DCCOs (Howard 1929; Sher 1994; Broughton 2004). Although bones of DCCOs are abundant at archaeological sites throughout the Straits of Georgia,

British Columbia, indicating the species occupied this area for the past 5,000 years, no skeletal remains of young birds were identified in excavations (Hobson and Driver 1989). Nesting was not documented in the province until 1927 (Munro 1928). However, based on archaeological evidence, Hobson and Driver (1989) suggest that the first documented nesting for this species may actually represent a re-colonization of the area.

Multiple records indicate breeding DCCOs were historically abundant across much of their Pacific Coast range (Squires 1917; Ray 1915; Chamberlin 1895; Willett 1910, 1933; Howell 1917; Grinnell 1908; Finley 1907, 1915; Linton 1907; Lamb and Howell 1913; Goldman 1908; Salvadori 1865; Lamb 1927; Bryant 1889; Bancroft 1927b; Bendire 1877; Dawson 1908, 1911). The largest cormorant colony ever recorded on the continent existed at San Martin Island, Baja California, MX; Wright (1913) estimated 348,840 nests at this site. The estimated size of this colony alone is larger than each of the five current regional populations and may be comparable to current continental population size. Although Wright's estimate was later considered an overestimate and revised by J. R. Jehl to 213,500 pairs (Hatch 1995) based on the area of the island, the revised estimate still dwarfs the present size of the entire Pacific Coast and much of the North American population. Even if Jehl's estimate is off by an order of magnitude, no colony approaches this size anywhere in North America.

By the late 1800s and early 1900s, the DCCO had experienced substantial decline and loss of breeding colonies along several portions of its Pacific Coast range. The species was heavily persecuted by humans, and breeding birds were shot at colonies and nests destroyed. In addition, habitat was lost due to agricultural and water developments (Carter *et al.* 1995). Review of early records suggests that the DCCO was far more abundant in this zone historically than it is today.

Interior Summary

Birds in this zone represent a substantial portion of *P.a. auritus*' distribution. Between

1970 and 2000, nesting was reported at 704-754 sites (Table 2). This is the largest, most widespread breeding population; it spans the prairie provinces of Canada, the Canadian and U.S. Great Lakes, and southwestern Quebec. The distribution extends west of Minnesota to southwestern Idaho, and as far south as central Utah and central Colorado. Local breeding also occurs in central Kansas and possibly northern New Mexico. Breeding birds in Idaho were included in this zone based on Burleigh (1972), who reported that 11 specimens collected from different locations in Idaho were intermediate in their characters between *P.a. auritus* and *P.a. albociliatus*, but closer to *auritus*. Birds breeding in the Upper Rio Grande drainage and Middle Pecos River, New Mexico, were also included in this zone, based on plumage characters of *P.a. auritus* (S. Williams, NM Dept. Game and Fish, pers. comm.). Genetic analyses need to be undertaken to confirm these subspecies designations.

Recent estimates based on complete counts are available for about half the states and provinces where cormorants breed. With the exception of Manitoba, complete counts are available for most of the areas where cormorants nest in large numbers. The largest numbers occur in the Great Lakes and Prairie Provinces. Summing the most recent estimates available for each state and province gives a very rough estimate of 170,000 pairs for the region in the 1990s (Table 2). However, the breeding population is significantly larger than this. Recent estimates are not available for some areas, and several estimates for other areas were based on partial counts. With the exception of Manitoba, DCCOs are not known to breed in very large numbers (several thousands) in most portions of the Interior range where estimates were missing or incomplete (Hatch 1995, Wires *et al.* 2001). In Manitoba, however, DCCOs do breed in large numbers, particularly on Lake Winnipegosis. The last province-wide survey was conducted in 1979, at which time 22,642 active nests were documented; 9,053 nests were on Lake Winnipegosis, an extremely important area for waterbird nesting (Koonz and Rakowski

1985). The last census of Lake Winnipegosis in 1999 indicated pairs of nesting cormorants had quadrupled since the previous survey 20 years earlier (Table 2). Assuming cormorant numbers across Manitoba increased at the same rate, there may be as many as 90,000 pairs in Manitoba province-wide (W. Koonz, Manitoba Dept. Nat. Res., pers. comm.). Given these gaps, the Interior population in the late 1990s may have been closer to 270,000 pairs but the accuracy of this estimate is unknown.

In many parts of the Interior region, the early breeding history of the DCCO is well known. Pre-1900 records document nesting by the species across most of the region and suggest it had been a long-time and abundant breeder in several areas, particularly in the Prairie Provinces and the mid-western states, where many large colonies were documented. In Minnesota, Hatch (1892) reported DCCOs bred in nearly all parts of the state, and was "occasional to innumerable" depending on how close one was to breeding colonies. At the Minnesota-Iowa border, observers reported "the air is jist black with em' an they're nestin' on the island so yer can't see it for eggs" (Whitehead 1887). In Missouri, Widmann (1907) reported cormorants breeding in "considerable numbers." In Ohio, "boatloads" were killed at St. Mary's Reservoir (Langdon 1878). At Lake of the Woods, Ontario, "great numbers" of young were killed in the late 1700s (Tanner 1994). Lakes Winnipeg and Winnipegosis, Manitoba, have long been recognized for their very large colonies (Seton 1886; Bent 1922). Lake Isle a la Crosse, Saskatchewan, also had a "large" regular breeding colony (Seton 1908). For additional records see Barnes 1890; Cooke 1888; Roberts 1932; Agersborg 1885; Stansbury 1853.

The Great Lakes is the one area within the region where status (e.g., breeder or migrant) and early history of the cormorant are not clear. For example, investigators reported that DCCOs colonized and invaded the Great Lakes in the early 20th century, moving in an easterly direction after the first nesting was reported on western Lake Superior in 1913 (Postupalsky 1978; Weseloh and Collier 1995). However, records and other evidence

indicate DCCOs were present in the area prior to the 20th century, suggesting this portion of the cormorant's North American range was occupied earlier than 1913, and possibly breeding. These records and evidence, described below, fall into the following categories: anecdotal, geographic place names, and general breeding distribution.

In the first category, three anecdotal records are important in presumed colonization history. The earliest reported observation of cormorants breeding at a specific location on the Great Lakes proper is an anecdotal record; Postupalsky (1978) cites a personal communication from Frank Novy that cormorants were breeding in the Great Lakes on western Lake Superior in 1913. No additional information is available about this record. However, because no other records were known at the time of Postupalsky's publication, this 1913 personal communication is regarded as the first nesting of cormorants in the Great Lakes. Additionally, the order in which the Great Lakes were hypothetically colonized is traced to it (Postupalsky 1978; Weseloh and Collier 1995). The first documented account of cormorants nesting on the Great Lakes proper is reported in Fargo and Van Tyne (1927). This record reports discovery of a small colony (10 nests) in 1926 at Agawa Rocks, Agawa Bay, on the eastern shore of Lake Superior. However, Fargo and Van Tyne noted that local residents told them "the cormorants had nested there for years." No additional information is available about this colony, but this anecdotal information suggests cormorants had a history of breeding in the area prior to discovery of the colony. A third record (Baillie 1947) from Georgian Bay, Lake Huron, reports that cormorants were nesting in the general vicinity of the Mink Islands in 1919; though this record was never verified, based on other nesting records, Baillie (1947) believed the record was probably accurate. This record places breeding cormorants much farther east into the Great Lakes more than a decade earlier than was hypothesized by Postupalsky (1978) and Weseloh and Collier (1995).

In the second category, geographic place names suggest cormorants were present in

the area and recognized by both Native Americans and settlers, but their status as breeders or migrants is not reported. The earliest of these place names is found on a General Surveyors Office Plat Map of Forsyth Township, Michigan. On 4 Aug, 1854, this map was signed and filed in the General Land Office in Detroit, and documents the existence of two lakes, Shag Lake and Little Shag Lake. Shag, a common vernacular name for cormorant, suggests cormorants were present in the area when the map was prepared. These lakes still exist and are located in the upper peninsula in Marquette Co, about 8-16 km from Lake Superior and within 64 km of Lake Michigan, Bay de Noc area, where cormorants are currently abundant. The map survey work was done during the third quarter (July-Sept) of 1844, and further subdivisions of the township were completed during the third and fourth (Oct-Dec) quarters of 1852. Thus cormorants occurred in the area during the summer and or fall months but their status (breeder, migrant) is unknown. The second geographic place name is from Lake Onaping, Ontario, about 64 km north of the North Channel, Georgian Bay area (Bell 1891). At this location a rock forming part of the cliffs on the west side of the lake was named by the Ojibwa "Kakakeshiwishtagwaning", which means "the cormorant's head", and suggests that the Ojibwa were familiar with cormorants in this landscape.

In the third category, the first four editions of the Checklist of North American Birds (1886, 1895, 1910 and 1931) all report the Great Lakes as part of the breeding range of the DCCO but give no specific locations within the lakes. These records indicate cormorants were breeding in the Great Lakes region earlier than 1913, but because specific locales are not provided it is not possible to determine if cormorants nested on the Great Lakes proper, or on nearby inland lakes. An additional record reports capture of a cormorant in June, 1877, at Sandusky Bay, OH (Wheaton 1882). No other information is available about this record, but the presence of a cormorant at this time of year suggests the bird may have been breeding.

As occurred over much of the continental range, DCCOs in the interior underwent substantial declines in the late 1800s and early 1900s. Persistent human persecution and habitat degradation resulted in colony declines, abandonment and local extirpation from several states (e.g., South Dakota, Indiana, Ohio, Missouri, Iowa, Illinois, Arkansas) (Lewis 1929). Because so few estimates are available pre-1900 and data vary greatly among states and provinces, it is not possible to determine if cormorants were more abundant historically in this zone than they are today. For some areas (e.g., Indiana, Ohio, Iowa, Arkansas, Illinois, Minnesota, Missouri) available data suggest breeding cormorants were more abundant historically. Additionally, very large migrant flocks were observed that were much larger than those currently known to pass through the region. In Minnesota, a flock of migrating cormorants was described that was "four miles long and one-and-a-half miles wide" (Sennett 1891). Though numbers declined throughout much of the Interior by the turn of the century, large numbers were still occasionally observed; in 1926, a flock estimated at 100,000 to one million individuals was described migrating up the Mississippi River past LaCrosse, and was so large "that at times it was impossible to see the sunset sky through the mass" (Grassett 1926). During recent years (1970-2000), no flocks anywhere near this size have been reported.

In other areas of this zone (e.g., the Great Lakes), current numbers are much greater than they were in the late 1800s-early 1900s, and are the highest recorded in the history of the region. In the Prairie Provinces, cormorants were historically and are currently abundant, but it is not possible to determine if abundance has greatly changed.

Southeast U.S. and Caribbean

Birds breeding along the Gulf Coast, the south Atlantic Coast, and in the Caribbean comprise the subspecies *P.a. floridanus*, while birds breeding in the Bahamas and Cuba are classified as *P.a. heuretus* (Hatch and Weseloh 1999). This breeding zone extends from

southern and central Texas to Florida, and along the Atlantic Coast through Florida, Georgia, and the Carolinas. Birds breeding in southern Texas and southwestern Arkansas were included in this zone based on subspecies distribution maps (Palmer 1962; Johnsgard 1993). Because North Carolina has been reported as the northern breeding limit for *P.a. floridanus* (Audubon 1840-1844; Bent 1922; Johnsgard 1993), and other authors have suggested that Carolina birds may comprise this subspecies (Palmer 1962; Clapp and Buckley 1984; Post and Post 1988), we included birds breeding in the Carolinas as part of the Southeastern U.S./Caribbean zone. Recent estimates based on complete counts are available for most of the known colonies, with the exception of southern Texas, the Yucatan and the Caribbean. The largest known numbers occur in Florida. Summing estimates available for the region in the 1990s gives an approximate estimate of 9,400 pairs at >108 sites (Table 2).

Prior to the 20th century, the DCCO was "constantly resident in the Floridas and their Keys, and along the coast to Texas" (Audubon 1840-1844). Breeding was recorded in North Carolina as early as the 18th century; at that time cormorants were reported to "lay their eggs in . . . the Islands, in the Sound and near the Sea Shoar in the Banks, and sometimes on high trees, as the Shags do" (Brickell 1737). Several records document breeding along both the Gulf and Atlantic coasts (Table 1).

Although no quantitative data were located to provide a comparison between current and historic abundance, descriptions suggest breeding cormorants were more abundant in this zone prior to the 20th century than they are today. Presently, breeding cormorants are only abundant in Florida (Wires *et al.* 2001), while historically they were very numerous in multiple areas of the region. Audubon (1843) reported "many thousands" breeding in the Florida Keys in 1832; Bricknell (1737) stated that in North Carolina, they were "as numerous all over these Parts of America as in any part of the World"; Audubon (1843) and Beyer *et al.* (1907) described cormorants as "abundant" in the

Louisiana interior and on the coast; and Howell (1911) reported this species as "formerly abundant in the rivers and swamps of eastern Arkansas". Additionally, based on Audubon's (1840-1844) description, DCCOs may have been present as breeders along the Alabama, Mississippi and Texas coasts.

Northeast Atlantic Coast

Birds in this zone are also placed in the subspecies *P.a. auritus*, and breed along the Atlantic Coast from southern Newfoundland, the northern shore of the Gulf and estuary of the St. Lawrence River, Anticosti Island, Magdalen Island, south along the coast to New York City and Long Island (Hatch and Weseloh 1999). The range is expanding south with recent breeding and re-colonization in New Jersey, Delaware, Maryland and Virginia, as far south as Hopewell. Recent estimates based on complete counts are available for nearly all colonies known to be active in this region, with the exception of New Brunswick (Table 2). The largest numbers occur in Quebec in the St. Lawrence River, Estuary and Gulf, along the coast of Maine, and in the Maritime Provinces. Summing estimates available for the region in the 1990s gives an approximate estimate of 87,000 breeding pairs at 381-382 sites. This number should be interpreted cautiously because intercolony movement is common and the size of individual colonies may change dramatically from year to year in substantial portions of the region (J. F. Rail, Canadian Wildlife Service (CWS), pers. comm.). Additionally, a culling program in the St. Lawrence River in 1989 significantly reduced numbers in Quebec in the 1990s.

Archaeological records document cormorants as a breeding species in this zone from the late prehistoric period (about 1500 AD) (Luedtke 1980). Several historic records report breeding from the Straits of Belle Isle, northwest coast of the Island of Newfoundland, south to as far as Boston Harbor, Massachusetts (Table 1). The historic breeding distribution may have extended further south; Mendall (1936) notes that Williams' (1643) observations of Native American use

Table 1. Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

| Region | Site | Early Date (bp = before present) | Status | Latitude | Longitude | Source |
|----------------------|--|----------------------------------|--------|-----------|------------|----------------------------------|
| Zone 1 Alaska | | | | | | |
| AK | Amchitka | 2,650 bp | B | 51°32' | 179°00' | Siegel-Causey <i>et al.</i> 1999 |
| AK | W. Aleutians, Nearer I., Attu | prior to 1885 | B | 52°54'09" | 172°54'34" | Turner 1885; Clark 1911 |
| AK | W. Aleutians, Nearer I., Agattu | prior to 1885 | B | 52°26'07" | 173°34'32" | Turner 1885; Clark 1911 |
| AK | Atka | 1906 | PB | 52°08'17" | 174°26'43" | Clark 1911 |
| AK | Unalga Pass | 1906 | PB | 53°57'04" | 166°12'18" | Clark 1911 |
| AK | Iliamna Lake | 1902 | B | 59°39'12" | 154°41'28" | Gabrielson and Lincoln 1959 |
| AK | Kodiak | 1843 | PB | 57°23'46" | 153°29'00" | Gabrielson and Lincoln 1959 |
| Zone 2 Pacific Coast | | | | | | |
| AZ | Tucson | 1897 | PB | 32°13'18" | 110°55'33" | Phillips <i>et al.</i> 1964 |
| B.C. | Vancouver I, Central E. coast | 1500 BC-400 AD | PB | 49°19'30" | 124°17'30" | Hobson & Driver 1989 |
| B.C. | Gulf I, Active Pass | 3500 BC-1800 AD | PB | 48°51'25" | 123°20'00" | Hobson & Driver 1989 |
| B.C. | S. Vancouver I. | 500-1000 AD | PB | 48°26'05" | 123°26'53" | Hobson & Driver 1989 |
| B.C. | Boundary Bay/Fraser River | 1500 BC-400AD | PB | 49°01'48" | 123°03'55" | Hobson & Driver 1989 |
| B.C. | Fraser River | 2300BC-1000AD | PB | 49°09'30" | 122°56'25" | Hobson & Driver 1989 |
| B.C. | Bare Island (Mandart I.) | 1927 | B | 48°38'00" | 123°17'00" | Munro 1928 |
| CA | Emeryville Shell Mound | 550 BC-1770 AD | B | 37°49'53" | 122°17'03" | Howard 1929; Sher 1994 |
| CA | S. Farallon I. | mid-1800s | B | 37°42'00" | 123°00'00" | Bryant 1888; Dawson 1911 |
| CA | Seal Rocks San Francisco | prior to 1917 | B | 37°46'42" | 122°30'53" | Squires 1917 |
| CA | Eagle Lake | 1914 | B | 40°38'42" | 120°44'34" | Ray 1915 |
| CA | Clear Lake, Lake Co. | 1895 | B | 39°03'42" | 122°49'34" | Chamberlin 1895 |
| CA | Clear Lake, Modoc Co. | 1918 | B | 41°16'32" | 120°16'33" | Willett 1919 |
| CA | Santa Barbara I. | 1897 | B | 33°28'32" | 119°02'07" | Howell 1917; Willett 1933 |
| CA | Anacapa (Santa Barbara group) | 1910 | B | 34°00'16" | 119°23'55" | Willett 1910; Howell 1917 |
| CA | Prince I. (0.5 mile from San Miguel I) | 1910 | B | 34°03'29" | 120°19'57" | Willett 1910; Howell 1917 |
| CA | Santa Cruz I. | 1895 | B | 34°01'00" | 119°43'00" | Howell 1917 |
| CA | Lake Henshaw, San Diego Co. | prior to 1933 | B | 33°14'30" | 116°45'44" | Willett 1933 |
| CA | Pelican Island, Salton Sea | 1908 | B | 33°20'00" | 115°50'00" | Grinnell 1908 |
| CA | Tule Lake (CA/OR border) | 1895 | B | 41°54'34" | 121°31'55" | Finley 1907 |
| CA | Island in (Lower) Klamath Lake Resv. | 1912 | B | 41°58'22" | 121°47'45" | Finley 1912 |
| CA | Klamath Lake, Lower | 1915 | B | 41°58'22" | 121°47'45" | Finley 1915 |
| CA | Rattlesnake I (Tule Lake) | 1895 | B | 39°00'36" | 122°40'44" | Finley 1907 |

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

| Region | Site | Early Date (bp = before present) | Status | Latitude | Longitude | Source |
|--------|---|----------------------------------|--------|-----------|------------|----------------------------|
| CA | Butte Creek, Sutter Co. | prior to 1926 | B | 39°11'41" | 121°56'07" | Moffitt 1939 |
| CA | Cut-off Slough, S of Suisan | 1920 | B | 38°05'25" | 122°00'33" | Moffitt 1939 |
| CA | Buena Vista Lake, Kern Co. | 1907 | B | 35°11'31" | 119°17'37" | Linton 1907 |
| CA | Buena Vista Lake, Kern Co. (Pelican I.) | 1912 | B | 35°12'39" | 119°16'03" | Lamb and Howell 1913 |
| CA | Tulare Lake | 1907 | B | 36°08'20" | 119°43'28" | Goldman 1908 |
| MX | Navidad I. | 1865; 1924 | B | 27°54'30" | 115°13'00" | Salvadori 1865; Lamb 1927 |
| MX | Cerros I. (Isla Cedros) | prior to 1889 | B | 28°03' | 115°20' | Bryant 1889 |
| MX | Magdalena Bay | 1889 | B | 25°00' | 112°20' | Bryant 1889 |
| MX | Santa Margarita Island | 1889 | B | 24°30' | 112°10' | Bryant 1889 |
| MX | Cape St. Lucas, Lower CA | 1859 | PB | 23°00' | 82°20' | Baird 1859 |
| MX | San Roque I., w. coast BC | 1927 | B | 27°09'30" | 114°22'30" | Huey 1927 |
| MX | Gulf, near San Jose Island | 1902 | B | 25°00' | 110°40' | Brewster 1902 |
| MX | Scammons Lagoon | 1926 | B | 28°20' | 114°22' | Bancroft 1927(a,b) |
| MX | Los Coronados | mid-1920s | B | 32°25'30" | 117°15'30" | Bancroft 1927(b) |
| MX | Todos Santos | mid-1920s | B | 31°47'00" | 116°46'00" | Bancroft 1927(b) |
| MX | San Luis I., central Gulf. BC | mid-1920s | B | 29°58'00" | 114°26'00" | Bancroft 1927(b) |
| MX | San Martin I., LC | 1913 | B | 30°29'30" | 116°06'30" | Wright 1913 |
| OR | Columbia river mouth* | 1805 | PB | 46°13'20" | 123°49'22" | Lewis and Clark 1814 |
| OR | Fort Klamath | 1886-1887 | PB | 42°41'37" | 121°58'10" | Merrill 1888 |
| OR | Williamson's River | 1886-1887 | PB | 42°27'54" | 121°57'21" | Merrill 1888 |
| OR | Diamond Lake | 1886-1887 | PB | 43°09'32" | 122°08'59" | Merrill 1888 |
| OR | Camp Harney | 1875 | B | 43°38'36" | 118°49'18" | Bendire 1877 |
| OR | Malheur Lake | 1875, 1918 | B | 43°21'20" | 118°41'56" | Bendire 1878; Willett 1919 |
| OR | Three Arch Rocks | 1901 | B | 45°27'51" | 123°59'12" | Finley 1902, 1905 |
| OR | Sylvies River | 1877 | B | 44°00'01" | 118°55'37" | Bendire 1878 |
| WA | Olympic Peninsula Outer coast, "Olympiades" | | | | | |
| | Erin's Bride | 1905-1907 | B | 47°18' | 124°16' | Dawson 1908 |
| | The Grenville Arch | 1905-1907 | B | 47°18'20" | 124°17' | Dawson 1908 |
| | The Grenville Pillar | 1905-1907 | B | 47°18'20" | 124°17' | Dawson 1908 |
| | Split Rock | 1905-1907 | B | 47°24'20" | 124°21'45" | Dawson 1908 |
| | Willoughby Rock | 1905-1907 | B | 47°24'40" | 124°21'22" | Dawson 1908 |
| | Destruction Island | 1905-1907 | B | 47°40'20" | 124°30' | Dawson 1908 |
| | North Rock | 1905-1907 | B | 47°44'45" | 124°29'50" | Dawson 1908 |

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

| Region | Site | Early Date (bp = before present) | Status | Latitude | Longitude | Source |
|--------|------------------------------|----------------------------------|--------|-----------|------------|--|
| | The Giants' Graveyard | 1905-1907 | B | 47°50'30" | 124°34' | Dawson 1908 |
| | Dohodaaluh | 1905-1907 | B | 47°57' | 124°41' | Dawson 1908 |
| | Carroll Islet | 1905-1907 | B | 48°10' | 124°43'30" | Dawson 1908 |
| | Father and Son | 1905-1907 | B | 48°13'50" | 125°43' | Dawson 1908 |
| WA | Jagged I. | 1915 | B | 47°59'51" | 124°41'39" | Cantwell, in Jewett <i>et al.</i> 1953 |
| WA | Arched Rock | 1915 | B | na | na | Cantwell, in Jewett <i>et al.</i> 1953 |
| WA | Alexander I. | 1914 | B | 47°47'55" | 124°30'19" | Cantwell, in Jewett <i>et al.</i> 1953 |
| | Zone 3 Interior | | | | | |
| AB | Buffalo Lake | prior to 1909 | B | 52°09' | 112°09' | Macoun and Macoun 1909 |
| AB | Ministik Lake | Early 20th | B | 53°21'00" | 113°01'00" | Salt and Wilk 1958 |
| AB | Miquelon Lake | Early 20th | B | 53°15'00" | 112°53'00" | Lewis 1929; Salt and Wilk 1958 |
| AB | Lac la Biche | Early 20th | B | 54°46'00" | 111°58'00" | Lewis 1929; Salt and Wilk 1958 |
| AB | Theroin Lakes | Early 20th | B | 54°05' | 111°30' | Lewis 1929 |
| AB | Primrose Lake | Early 20th | B | 54°48'00" | 110°00'00" | Lewis 1929 |
| IL | Mt. Carmel | Late 1800s | B | 38°24'39" | 87°45'41" | Ridgway 1874 |
| IL | Lacon | prior to 1890 | B | 41°01'30" | 89°22'16" | Barnes 1890 |
| IL | 5 miles N of Marshall Co.* | 1890 | B | 41°11'06" | 89°23'47" | Barnes 1890 |
| IL | Marshall Co.* | 1890 | B | na | na | Barnes 1890 |
| IL | Peoria | Late 1800s | B | 40°43'59" | 89°34'04" | Loucks 1893 |
| IL | Havana (Ill river area)* | 1910 | B | 40°17'45" | 90°03'15" | Smith 1911 |
| IL | Clear Lake (Ill river area)* | 1910 | B | 40°25'35" | 89°55'35" | Smith 1911 |
| IN | Gibson Co.* | prior to 1900 | PB | 38°21'19" | 87°34'03" | Mumford and Keller 1984 |
| IN | Knox Co.* | prior to 1900 | PB | 38°37'57" | 87°31'56" | Mumford and Keller 1984 |
| IN/IL | Wabash River Valley* | 1870s | B | na | na | Ridgway 1874 |
| IN | Posey Co.* | prior to 1900 | PB | 37°49'13" | 87°57'15" | Mumford and Keller 1984 |
| IA | Northern IA* | 1880s or earlier | B | 43°09' | 93°23' | Cooke 1888 |
| MB | Shoal Lake | 1886-1901 | B | 50°30' | 100°00' | Seton 1886; Chapman 1902; Macoun and Macoun 1909 |
| MB | Lake Winnipegosis | Prior to 1900 | B | 52°30' | 100°00' | Seton 1886; Koonz and Rakowski 1985; Bent 1922 |
| MB | Lake Winnipeg | 1886 | PB | 52°07'55" | 97°15'40" | Seton 1886; Macoun and Macoun 1909 |
| MB | Lakes N. of Touchwood Hills | Early 1900s? | B | 54°28'45" | 94°59'46" | Lewis 1929 |
| MB | Ossowa | Early 1900s? | B | unknown | unknown | Lewis 1929 |
| MB | Selkirk Settlement | Early 1900s? | B | 50°09' | 96°52' | Lewis 1929 |

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

| Region | Site | Early Date (bp = before present) | Status | Latitude | Longitude | Source |
|--------|---|----------------------------------|--------|-----------|------------|---|
| MI | Shag Lake, Marquette Co. | 1854 | PB | 46°16'06" | 87°30'27" | General Surveyors' Office Plat Map. Forsyth Township, MI (Township 45 N, Range 26 W.) |
| MI | Little Shag Lake, Marquette Co. | 1854 | PB | 46°15'30" | 87°29'41" | General Surveyors' Office Plat Map. Forsyth Township, MI (Township 45 N, Range 26 W) |
| MN | Lake Minnetonka | 1860s-1875 | B | 42°52' | 93°34' | Hatch 1892; Roberts 1932 |
| MN | Loon Lake | 1886 | B | 43°31' | 95°11' | Whitehead 1887; Roberts 1932 |
| MN | Kawishiwi Lake | Early 1900s | B | 47°50'45" | 91°06'50" | Roberts 1932 |
| MN | Gull Rock, Lake of the Woods | 1915 | B | 49°15'14" | 94°53'08" | Roberts 1932 |
| MN | Elbow Lake | prior to 1925 | B | 46°00' | 95°59' | Lewis 1929 |
| MN | Lake Shetek (Shetek) | 1877 | B | 44°06'56" | 95°41'34" | Hatch 1892; Lewis 1929 |
| MN | Dead Lake | 1885 | B | 46°28' | 96°00' | Hatch 1892; Lewis 1929 |
| MN | Heron Lake | prior to 1925 | B | 43°44' | 95°20' | Lewis 1929 |
| MN | Lake Andrew | prior to 1925 | B | 45°49'20" | 95°25'15" | Lewis 1929 |
| MN | Lanesboro | 1883 | B | 43°43' | 91°59' | Hatch 1892; Lewis 1929 |
| MN | Faribault | prior to 1925 | B | 44°19' | 93°16' | Lewis 1929 |
| MO | S.E. peninsula, MS Lowlands* | prior to 1907 | B | 37°00'01" | 90°01'05" | Widmann 1907 |
| NE | Engineer Cantonment Area* | 1820 | PB | 41°27'18" | 96°00'50" | Thwaites 1905 (in Ducey 2000) |
| ND | Sweetwater Lake, Ramsey Co. | 1897 | B | 48°13'00" | 98°49'20" | Jacobs 1898 (in Stewart 1975) |
| ND | Devils Lake, Bird I. | 1898 | B | 48°01'41" | 98°55'52" | Job 1898; Rolfe 1898 |
| ND | Stump Lake, Nelson Co. | 1898 | B | 47°54'40" | 98°23'02" | Job 1898; Rolfe 1898 |
| OH | Licking Reservoir, Buckeye Lake, Liebs & adjacent islands | prior to 1880 | B | 39°54'26" | 82°31'23" | Wheaton 1882; Trautman 1940; Peterjohn 1989 |
| OH | Lake St. Mary's | 1867 | B | 40°31'17" | 84°25'17" | Langdon 1878 (Dury pers. Comm.) |
| OH | Sandusky Bay | prior to 1877 | PB | 41°28'38" | 82°43'11" | Wheaton 1882 |
| ONT | Lake of the Woods | 1798 | B | 49°30'20" | 94°50'30" | Tanner 1994 |
| ONT | The Cormorant's Head, Onaping Lake | 1890 | PB | 47°04'00" | 81°30'00" | Bell 1891 |
| ONT | Mink Islands, Georgian Bay, Lk. Huron* | 1919 | PB | 45°22'00" | 80°25'00" | Baillie 1947 |
| ONT | Carney Rocks, Black Bay, Lk. Superior* | 1920 | B | 48°40'00" | 88°25'00" | Baillie 1947 |
| ONT | Agawa Rocks (Bay), Lk. Superior* | 1920s or earlier | B | 47°20'00" | 84°40'00" | Fargo and Van Tyne 1927 |
| QUE | Way Rock, James Bay | 1912 | B | 51°50' | 78°59' | Todd 1963 |
| SK | Qu'Appelle | 1886 | B | 50°10' | 103°50' | Seton 1886 |
| SK | Saskatchewan River | 1834 | B | 53°12' | 105°46' | Audubon 1843 |
| SK | Crane Lake | 1894 | B | 50°05'00" | 109°05'00" | Macoun and Macoun 1909 |
| SK | Prince Albert | 1890s or earlier | B | 53°57'00" | 106°22'00" | Macoun and Macoun 1909 |

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

| Region | Site | Early Date (bp = before present) | Status | Latitude | Longitude | Source |
|------------------------------------|-------------------------------------|----------------------------------|--------|-----------|------------|--|
| SK | Big Stick Lake | 1890s or earlier | B | 50°16'00" | 109°20'00" | Macoun and Macoun 1909 |
| SK | Old Wives Lake | 1890s or earlier | B | 50°06'00" | 106°00'00" | Macoun and Macoun 1909 |
| SK | Stony Lake/Rocky Lake | 1924 | B | 53°29' | 108°32' | Mitchell 1925 |
| SK | Suggi Lake | 1910 | B | 54°20' | 102°50' | McInnes 1913 |
| SK | Basin Lake | 1902 | B | 52°38'00" | 105°17'00" | R. Congdon (Roney, pers. comm.); Lewis 1929 |
| SK | Lake Isle a la Crosse | 1907 | B | 56° | 108° | Seton 1908 |
| SD | Clay Co. area* | prior to 1885 | B | 42°43'52" | 96°53'26" | Agersborg 1885 |
| UT | Egg Island, Great Salt Lake | 1849 | B | 41°03'35" | 112°15'47" | Stansbury 1853 |
| UT | White Rock, Great Salt Lake | 1901 | B | 41°00'30" | 112°14'52" | Hayward <i>et al.</i> 1976 |
| WI | Northern and central lakes* | 1890 | B | 45°27' | 89°44' | Carr 1890 |
| Zone 4 Southeastern U.S./Caribbean | | | | | | |
| AR | Walker Lake, MS Co. | 1910 and prior | B | 35°45'24" | 90°03'21" | Howell 1911 |
| AR | Old Town Lake, Phillips Co. | 1913 | PB | 34°24'30" | 90°48'50" | James and Neal 1986 |
| FL | Resident, both coasts* | prior to 1900 | B | na | na | Audubon 1843; Bent 1922 |
| FL | Florida Keys* | 1832 | B | na | na | Audubon 1843 |
| FL | Gainesville | 1894 | B | 29°39'05" | 82°19'30" | Stevenson and Anderson 1994 |
| FL | Wakulla River (at St. Marks) | 1887, 1889 | B | 30°08'57" | 84°12'38" | Pennock 1889 |
| FL | Cuthbert Lake | 1903 | B | 25°12'21" | 80°46'41" | Bent 1922 |
| KY | Hickman, Fulton Co. | 1890-1893 | PB | 36°34'16" | 89°11'10" | Pindar 1925 |
| LA | Coast* | 1830s | B | na | na | Audubon 1843; Beyer <i>et al.</i> 1907 |
| LA | Interior* | 1906 | B | na | na | Beyer <i>et al.</i> 1907; LA Dept. of Cons. 1931 |
| NC | "The islands, banks, sound"* | 1737 | B | 35°15' | 76°25' | Brickell 1737 |
| NC | Great Lake ("Big Lake") | 1898 | B | 34°52'06" | 77°02'18" | Pearson 1899 |
| SC | "Nests somewhere in state" | 1910 | PB | na | na | Wayne 1910 |
| TN | Reelfoot Lake | late 1800s | PB | 36°21'54" | 89°24'13" | Rhoads 1895; Pindar 1925 |
| TX | "Along the coast to TX"* | 1840s | PB | na | na | Audubon 1843 |
| TX | Matagorda peninsula & nearby island | 1926 | B | 28°35'05" | 96°01'05" | Oberholser 1974 |
| Zone 5 Northeast Atlantic Coast | | | | | | |
| CAN/ GNLD | Baffin Bay | 1800s | B | na | na | Audubon 1843 |
| LB | Northwest River, Lake Melville | prior to 1900 | PB | 53°40' | 60°10' | Lewis 1929 |
| ME | SW Coast (Monhegan I. area) | 1614 | PB | 43°45'59" | 69°18'43" | Smith 1616 (in Mendall 1936) |

Table 1. (Continued) Early North American breeding records for Double-crested Cormorants (B = breeding; PB = possible/probable breeding; * = Best approximate location; NA = not available).

| Region | Site | Early Date (bp = before present) | Status | Latitude | Longitude | Source |
|--------|--|----------------------------------|--------|-----------|-----------|-----------------------------------|
| ME | Black Point (now Scarborough) | late 17th | B | 43°34'41" | 70°19'20" | Mendall 1936 |
| ME | Black Horse Ledge | 1895 | B | 44°03' | 68°37' | Knight 1908 |
| MA | Calf I., Boston Harbor | 1500 | B | 42°20'30" | 70°53'46" | Luedtke 1980 |
| MA/RI: | no specific location | 1643 | B | na | na | Williams 1643 (in Mendall 1936) |
| NB | Grand Menan | 1871-1872 | PB | 44°40' | 66°50' | Herrick 1873 |
| NF | Cormorant I. | 1833 | B | 51°30' | 57°00' | Audubon 1843 |
| NF | St. George Bay, W.coast | 1594 | PB | 48°20' | 59°00' | Hakluyt 1904; Lewis 1929 |
| NF | Hawk's Bay | 1800s | B | 50°35' | 57°10' | Reeks 1869 |
| NS | Isle of Cormorants, present Green I. | 1604 | B | 43°26'00" | 65°38'00" | Champlain 1922; Lewis 1929 |
| NS | Seal Islands | 1833 | B | 44°37' | 65°46' | Audubon 1843 |
| NS | Mud I. Group | 1604 | PB | 43°25' | 66°01' | Champlain 1922; Lewis 1929 |
| NS | Cape Breton | 1610 | PB | 45°48' | 59°50' | Jesuit Relations 1896; Lewis 1929 |
| QUE | Whapitiguan Harbour | 1833 | B | 50°20' | 60°20' | Audubon 1843 |
| QUE | Magdalen I., I of Cormorants (Shag I.) | 1591 | PB | 47°27' | 61°30' | Hakluyt 1904; Lewis 1929 |
| QUE | Sloop Harbor (now Whale Head) | 1860 | PB | 50°30'00" | 59°29'00" | Coues 1861 |
| QUE | Harrington Harbor | prior to 1929 | B | 50°25' | 59°30' | Lewis 1929 |
| QUE | Bird Bay (E. end of Anticosti I) | 1902, 1904 | B | 49°15' | 61°45' | Schmitt 1902 |
| QUE | Seal Rocks, off St. Genevieve I. | 1909 | B | 50°20' | 63°00' | Townsend and Bent 1910 |
| QUE | Cormorant Isle, off Watachoo | 1909 | B | 50°30' | 62°30' | Townsend and Bent 1910 |
| QUE | Bonaventure I., Gaspe Co., Perce Rocks | 1880 | B | 48°30' | 64°10' | Goss 1889 |
| QUE | Harbour of Great Mecatina | 1833 | B | 50°50' | 58°55' | Audubon 1843 |
| QUE | Rocky island off Agwanus | 1909 | B | 50°15' | 62°10' | Townsend and Bent 1910 |
| QUE | Outer Islands, Coacocho Bay | 1915 | B | 50°20' | 60°20' | Townsend 1917 |
| QUE | Gull I., off Cape Whittle | 1915 | B | 50°20' | 60°10' | Townsend 1917 |

Table 2. Numbers of breeding pairs of Double-crested Cormorants in each breeding zone (A = complete count, estimate at all known colonies; B = partial estimate, does not include all known colonies; C = extrapolated older count or other informed estimate; D = estimate often based on knowledge of most colonies or combining counts of different years; E = only old, indirect or scattered recent knowledge available; NA = Not available).

| Regions of documented breeding | No. known colonies since @1970 | No. pairs last census | No. colonies last census | Year of last census | Source (data are unpublished, obtained through personal communications unless otherwise noted) | Estimate quality | % known active colonies visited |
|---------------------------------|--------------------------------|-----------------------|--------------------------|---------------------|--|------------------|---------------------------------|
| Zone 1 Alaska | | | | | | | |
| Alaska | 126 | 3029 | 106 | 1970-2000 | Carter <i>et al.</i> 1995; D. Drago and S. Stephenson, USFWS | B | NA |
| Subtotals | 126 | 3,029 | 106 | | | | |
| Zone 2 Pacific Coast | | | | | | | |
| Arizona | 12 | 35 | 2 | 2000 | T. Corman, Arizona Game and Fish Department | B | 17 |
| British Columbia | 19 | 610 | 19 | 2000 | I. Moul, Ecological Research Ltd. | A | 100 |
| California | | | | | | | |
| N. Coast, N. Section | 17 | 1,408 | 14 | 1989 | Carter <i>et al.</i> 1995 | A | 100 |
| N. Coast, S. Section | 4 | 75 | 3 | 1995 | Carter <i>et al.</i> 1996, 2000 | A | 100 |
| Central Coast-Outer Coast N | 3 | 413 | 1 | 1995 | Carter <i>et al.</i> 1996, 2000 | A | 100 |
| Central Coast-San Francisco Bay | 9 | 1,429 | 9 | 1990 | Carter <i>et al.</i> 1995 | A | 100 |
| Central Coast-Outer Coast S | 6 | 198 | 6 | 1989 | Carter <i>et al.</i> 1995 | A | 100 |
| Southern Coast | 6 | 1,264 | 6 | 1991 | Carter <i>et al.</i> 1995 | A | 100 |
| Interior | 52 | 6,958 | 33 | 1999 | Dave Shuford, Point Reyes Bird Obs. | A | 100 |
| Mexico | | | | | | | |
| Baja California | 20 | 3,394 | 20 | 1968-1992 | Carter <i>et al.</i> 1995 | B | 100 |
| Sonora & Sinaloa | 7 | 3,575 | 7 | 1973-1991 | Carter <i>et al.</i> 1995 | B | 100 |
| Interior | 2 | 301 | 2 | 1990-1992 | Carter <i>et al.</i> 1995 | B | 100 |
| Nevada | 5 | 838 | 2 | 1998 | L. Neel, Nevada Division of Wildlife; D. Withers, Stillwater NWR | B | 40 |
| New Mexico-Lower Rio Grande | 3 | 600 | 3 | 1996 | S. Williams, New Mexico Game and Fish | A | 100 |
| Oregon | | | | | | | |
| Columbia River Estuary | 5 | 6,300 | 1 | 2000 | D. Roby, Oregon State University | A or B | 100 |
| Coast | 27 | 2,939 | 22 | 1988-1992 | Carter <i>et al.</i> 1995 | A | 100 |
| Interior | 8 | 913 | 5 | 1999 | M. Naughton, USFWS | B | 63 |
| Washington | 43 | | | | | | |
| Coast | 39 | 278 | 10 | 1999 | M. Naughton, USFWS | A | 100 |
| Grays Harbor | 2 | 440 | 2 | 1992 | Carter <i>et al.</i> 1995 | A | 100 |
| Columbia River mouth | 1 | 125 | 1 | 1995 | M. Naughton, USFWS | A | 100 |

Table 2. (Continued) Numbers of breeding pairs of Double-crested Cormorants in each breeding zone (A = complete count, estimate at all known colonies; B = partial estimate, does not include all known colonies; C = extrapolated older count or other informed estimate; D = estimate often based on knowledge of most colonies or combining counts of different years; E = only old, indirect or scattered recent knowledge available; NA = Not available).

| Regions of documented breeding | No. known colonies since @1970 | No. pairs last census | No. colonies last census | Year of last census | Source (data are unpublished, obtained through personal communications unless otherwise noted) | Estimate quality | % known active colonies visited |
|--------------------------------|--------------------------------|----------------------------------|--------------------------|---------------------|--|------------------|---------------------------------|
| Interior | 1 | 652 | 1 | 1997 | J. Stofel and J. Tabor, Washington Dept of Fish and Wildlife | B | 100 |
| Subtotals | 248 | 33,000 | 169 | | | | |
| Zone 3 Interior | | | | | | | |
| Alberta | NA | 7,000 | NA | 1992 | S. Brechtel, AB Provincial Non-game Dept. (in Hatch 1995) | D | NA |
| Colorado | 28 | 1,000 | NA | 1990s | Kingery 1998; R. Levad, CO Bird Observatory | B | NA |
| Iowa | 10 | >844 | 5 | 1998 | K. Bogenschütz, Iowa Dept Natural Resources; Ehresman 1996 | B | NA |
| Idaho | 11 | >1,175-1,401 | 11 | 1993 | Trost 1994 | A | 100 |
| Illinois | 14 | >754 | 6 | 1997 | J. Herkert, II Endangered Species Protection Board | A or B | 100? |
| Indiana | 0 | 0 | | | | | |
| Kansas | 6 | small (all colonies < 300 pairs) | NA | 1992-1997 | W. Busby, Kansas Biological Survey | E | NA |
| Kentucky | 0 | 0 | | | B. Palmer-Ball, Kentucky State Nature Preserve's Commission | | |
| Manitoba (province-wide) | 156 | NA | | | | | NA |
| Lake Winnipegosis | 33 | 36,180 | 33 | 1999 | B. Koonz, Manitoba Dept. Natural Resources | A | 100 |
| Michigan | 48 | 31,079 | 45 | 1997 | Cuthbert <i>et al.</i> 2003 | A | 100 |
| Minnesota | 75 | 8-10,000 | NA | late 1990s | McKearnan 1997; Henderson 2001 | D | NA |
| Missouri | 0 | 0 | | late 1990s | J. Wilson, Missouri Dept. Conservation | | |
| Montana | 50-100 | ~ 40/colony | NA | late 1990s | D. Flath, Montana Fish, Wildlife and Parks | E | NA |
| North Dakota | >12 | ? | NA | late 1990s | C. Grondahl, North Dakota Game and Fish Dept. | | NA |
| Nebraska | 14 | >840 | 1 | 2000 | J. Dinan, Nebraska Game and Parks Commission | B | NA |
| New Mexico (Upper Rio Grande) | 3 | 130 | 3 | 1996 | S. Williams, New Mexico Game and Fish | A | 100 |
| New York (inland) | 12 | 9,072 | 12 | 1997 | R. Miller, New York State Dept. of Environmental Conservation | A | 100 |
| Ohio | 2 | 1,510 | 2 | 1998 | M. Shieldcastle, Ohio Division of Wildlife | A | 100 |
| Ontario | 116 | 35,159 | 74 | 1997 | D. V. Weseloh, Canadian Wildlife Service | A | 100 |
| Quebec (southwestern) | 5 | 212 | 5 | 1990-1997 | J. F. Rail, Canadian Wildlife Service | D | 100 |

Table 2. (Continued) Numbers of breeding pairs of Double-crested Cormorants in each breeding zone (A = complete count, estimate at all known colonies; B = partial estimate, does not include all known colonies; C = extrapolated older count or other informed estimate; D = estimate often based on knowledge of most colonies or combining counts of different years; E = only old, indirect or scattered recent knowledge available; NA = Not available).

| Regions of documented breeding | No. known colonies since @1970 | No. pairs last census | No. colonies last census | Year of last census | Source (data are unpublished, obtained through personal communications unless otherwise noted) | Estimate quality | % known active colonies visited |
|------------------------------------|--------------------------------|-----------------------|--------------------------|---------------------|--|------------------|---------------------------------|
| South Dakota | 36 | >2,962 | 11 | 1991 | R. Peterson, South Dakota Ornithologists' Union; Peterson 1995 | B | 31 |
| Saskatchewan | 19 | 19,547 | 10 | 1991 | K. Roney, Royal Saskatchewan Museum | A | 100 |
| Tennessee | 3 | 29 | 1 | 1999 | R. M. Hatcher, Tennessee Wildlife Resources Agency | A | 100 |
| Texas (northern) | NA | NA | | | J. Herron, Texas Parks and Wildlife | | |
| Utah | 8 | >362 | 4 | 1996 | F. Howe, Utah Division of Wildlife Resources | B | NA |
| Vermont | 5 | 2,805 | 5 | 1999 | L. Garland, Vermont Fish and Wildlife | A | 100 |
| Wisconsin | 46 | 10,546 | 23 | 1997 | S. Matteson, Wisconsin Dept. of Natural Resources | A | 100 |
| Wyoming | 25 | 364 | 8 | 1994 | A. Cerowski, Wyoming Game and Fish Dept. | B | NA |
| Subtotals | 704-754 | >169,570 | >259 | | | | |
| Zone 4 Southeastern U.S./Caribbean | | | | | | | |
| Arkansas (southwestern) | 1 | 100 | 1 | 1999 | M. Hoy, USDA/WS; K. Howe, Arkansas Game and Fish Commission | A | 100 |
| Bahamas | ? | 500 | ? | 1975 | A. Sprunt, National Audubon Society (in Hatch 1995) | E | |
| Cuba | ? | 500 | ? | ? | Palmer 1962 (in Hatch, 1995) | E | |
| Florida | 110 | 6,745 | 84 | 1999 | J. Rodgers, Jr., Florida Game and Fresh Water Fish Commission | A | 100 |
| Georgia | 7 | 40 | 7 | 1993-1996 | B. Winn, Georgia Dept. of Natural Resources | D | 100 |
| Louisiana | 2 | 447 | 2 | 1994-1995 | B. Vermillion, Louisiana Dept. of Wildlife and Fisheries | D | 100 |
| Mississippi | 2 | 33 | 2 | 1998 | Reinhold <i>et al.</i> 1998 | A | 100 |
| North Carolina | 3 | 135 | 1 | 1996 | D. H. Allen, North Carolina Wildlife Resources Commission | A | 100 |
| Oklahoma | 2 | 30 | 1 | 1996 | M. Howerly, Oklahoma Dept. of Wildlife Conservation | A | 100 |
| Puerto Rico/Virgin Is | 0 | 0 | | NA | | | |
| South Carolina | 17 | 895 | 10 | 1996 | T. M. Murphy, South Carolina Dept. of Natural Resources | A | 100 |
| Texas (south) | NA | NA | NA | NA | | None | |

Table 2. (Continued) Numbers of breeding pairs of Double-crested Cormorants in each breeding zone (A = complete count, estimate at all known colonies; B = partial estimate, does not include all known colonies; C = extrapolated older count or other informed estimate; D = estimate often based on knowledge of most colonies or combining counts of different years; E = only old, indirect or scattered recent knowledge available; NA = Not available).

| Regions of documented breeding | No. known colonies since @1970 | No. pairs last census | No. colonies last census | Year of last census | Source (data are unpublished, obtained through personal communications unless otherwise noted) | Estimate quality | % known active colonies visited |
|---------------------------------|--------------------------------|---------------------------|--------------------------|---------------------|--|------------------|---------------------------------|
| Yucatan | ? | 45 | ? | 1985 | A. Sprunt, National Audubon Society (in Hatch 1995) | E | |
| Subtotal | 144 | 9,470 | >108 | | | | |
| Zone 5 Northeast Atlantic Coast | | | | | | | |
| Connecticut | 26 | 961 | 17 | 1998 | J. Victoria, Dept. of Environmental Protection | A | 100 |
| Delaware | 1 | 3 | 1 | 1991 | C. M. Hecksher, Division of Fish and Wildlife | A | 100 |
| Maine | 135 | 17,100 | 117 | 1994-1995 | R. B. Allen, Dept. of Inland Fisheries and Wildlife | A | 100 |
| Maryland | 4 | 1,046 | 4 | 1999 | D. F. Brinker, Maryland Dept. of Natural Resources | A | 100 |
| Massachusetts | 28 | 7,833 | 27 | 1995 | B. G. Blodget, Massachusetts Division of Fisheries and Wildlife | A | 100 |
| New Brunswick | 25? | 9,278 | 15 | 1986-1991 | Lock <i>et al.</i> 1994, Erskine 1992 | B, D | NA |
| Newfoundland | 8-9 | 343-363 | 6-7 | 1996 | Korfanty <i>et al.</i> 1997 | A | 100 |
| New Hampshire | 3 | 20 | 1 | 1998 | J. Kanter, New Hampshire Fish and Game | A | 100 |
| New Jersey | 5 | small (<100 pairs/colony) | 5 | 1993-1997 | J. Walsh, Cape May Bird Obs.; R. Kane, NJ Audubon Society | D | 100 |
| New York-Atlantic Coast | 12 | 3,274 | 9 | 1998 | R. Miller, New York Dept. Environmental Conservation | A | 100 |
| Nova Scotia | 102 | 12,000 | 90 | 1992 | Milton <i>et al.</i> 1995 | A | 100 |
| Pennsylvania | 1 | 3 | 1 | 1998 | D. Brauning, PA Game Commission; R. Ross, USGS/BRD | A | 100 |
| Prince Edward Island | 12 | 7,695 | 8 | 1999 | R. Dibblee, Dept. of Technology and Environment | A | 100 |
| Quebec | 122 | 25-27,000 | 70 | 1990 | Chapelaine and Bedard 1995; J.F. Rail, Canadian Wildlife Service | D | 100 |
| Rhode Island | 10 | 2,058 | 9 | 1997 | C. Raithel, Division of Fish, Wildlife and Estuarine Resources | A | 100 |
| Virginia | 2 | 60-70 | 1 | 1997 | D. Schwab, Virginia Dept. of Game and Inland Fisheries | A | 100 |
| Subtotal | 496-497 | >86,674 | 381-382 | | | | |

of cormorants for food referred either to Massachusetts or Rhode Island or both. Mackay (1894) noted that in the late 1800s, hundreds were observed every spring around Newport County, Rhode Island, at a rock outcrop near Sachuest Point called Cormorant Rocks, which was named on a map as early as 1776. Cormorants were also present historically in Virginia but seasonal presence and distribution is not clear (Lewis 1929).

As in the other breeding zones, sometime during European settlement DCCOs began declining in most parts of the Atlantic range due to heavy human persecution (Lewis 1929; Mendall 1936; Gross 1944; Krohn *et al.* 1995). By the early 19th century, they were extirpated in New England. By the late 19th and early 20th centuries, breeding cormorants had disappeared from Nova Scotia and were greatly reduced in the other Maritime Provinces and Quebec (Lewis 1929; Erskine 1992). Although we found no early estimates or archaeological evidence to which historic and current abundance can quantitatively be compared, early comments and records suggest cormorants were very abundant in this breeding zone prior to European settlement (Williams 1643; Audubon 1843; Reeks 1869; Champlain 1922; Goss 1889; Townsend 1917). Mendall (1936) cites Morton (1637), who wrote of cormorants in New England, "There are greates store of Pilchers: at Michelmas, in many places, I have seene the Cormorants in length 3.0 Miles feedinge upon the Sent." Lewis (1929) reported that several 17th century references mention the abundance of cormorants in Virginia, and that in 1610, one anonymous author reported cormorants among the birds in Virginia rivers "in such abundance as are not in all the world to be equaled."

DISCUSSION

The current breeding range of the DCCO is similar to pre-1900, although some changes have occurred. The range has retracted in Alaska and in southeastern U.S., but expanded along the Atlantic Coast and in the Interior. In the latter regions, some important changes may represent re-colonization events.

DCCO historic abundance and widespread distribution has several implications for current conservation and management efforts, discussed below.

The Great Lakes Population

The Great Lakes region is one of the most important areas in the human-cormorant conflict, and concerns from this region have strongly influenced federal policy decisions for cormorants. Most of the conflict centers on perceived impacts to fisheries from cormorant predation. Currently many factors affect the health of the Great Lakes ecosystem; one of the most significant is establishment of >160 exotic invasive species (Mills *et al.* 1993; Ricciardi 2001). Of these, several (e.g., zebra mussel (*Dreissena polymorpha*) alewife (*Alosa pseudoharengus*), sea lamprey (*Petromyzon marinus*) directly and indirectly impact valuable fisheries (e.g., Mills *et al.* 1993; Belyea *et al.* 1999). Additionally, many other variables (e.g., water temperature variation, declines in benthos abundance) also impact fisheries (Hoyle *et al.* 1998; Pothoven *et al.* 2001). Nevertheless, in areas where declines in sport fish species and catch have occurred, many anglers and fisheries biologists attribute declines to recent increases in DCCO numbers (e.g., Fielder 2004). Additionally, some anglers believe cormorants are non-native to the region, and report that the species was intentionally introduced by the Japanese (F. Cuthbert, pers. obs.). The media has also published articles stating the species is an exotic (Sharp 2004). Finally, large cormorant colonies in this region have once again become the focus of vandalism and destruction as well as legal control activities. For example, in the late 1990s-2000, about 1,350 DCCO adults and chicks were illegally shot at Little Galloo Island, Lake Ontario, New York, and at Little Charity Island, Saginaw Bay, Michigan, by anglers who believed cormorants were responsible for poor catches (Kloor 1999; Lounsbury 2000). In summer 2004, all colonies in the Les Cheneaux Islands area, Michigan, were targeted by USDA/WS for control (e.g., harassment, oiling eggs, shooting

adults) to aid the ailing yellow perch fishery (USDA/APHIS/WS 2004), despite an earlier rigorous study of cormorant predation in this area that concluded cormorants were not a substantial factor in yellow perch mortality (Belyea 1999).

One critical component that shapes perception of a species' role within an ecosystem is knowledge of species history. Previously, occurrence and movement of cormorants through the Great Lakes in the early 1900s was described as an "invasion" (Postupalsky 1978; Weseloh and Collier 1995). Perception of this species as an invader will strongly influence its management because invasive species, variously described as "exotics", "nonindigenous" or "aliens," typically spread and cause net harm to a system (Lodge and Shrader-Frechette 2003). Review of all available records to assess the history of the Double-crested Cormorant in the Great Lakes suggests characterization as an "exotic" or "invasive" is inappropriate, and history in the Great Lakes needs further exploration. Considering records documenting nesting prior to 1900 are available from the western and southern border states of the Great Lakes, and abundant nesting habitat would have been available, apparent species absence is puzzling.

Historic Populations and Current "Overabundance"

Most historic records cited in this work were obtained during the period of European settlement, particularly in the 19th century (Table 1). We assume abundances that existed during this period represent populations under relatively natural conditions (i.e., abundance attained when relatively free from artificial/human modified elements that could lead to inflated or diminished numbers). However, it is possible that in some locations settlers were encountering spectacularly abundant concentrations of cormorants and other wildlife that were responding to release from Native American harvest. Broughton (2004) suggests that the abundant wildlife populations observed in pre-1900 California resulted after Native

Americans experienced dramatic disease-based population declines through coastal contact with European explorers in the 16th century. Thus, for some species, assuming that the pre-1900 time period represents the baseline or benchmark of past populations, may be a questionable assumption (Broughton 2004). Nevertheless, although the impact of Native American harvest on cormorants at a large scale (e.g., state, regional, continental) is not known, the breadth of cormorant records spanning hundreds of years and locations across the continent (Table 1) suggests the Double-crested Cormorant had been an abundant species for a substantial time. Additionally, the clearly documented record of human persecution throughout the European settlement period marks a significant era in the known history of the cormorant, to which massive population declines and local extirpations can be traced.

On a continental level, comparisons of historic and current records indicate cormorants were likely more abundant during initial European settlement than they are today. Therefore, describing the current continental population at an "all time" or "historic" high is misleading. Additionally, in several areas across the continent, portions of the public and some natural resource biologists view the DCCO as a recent addition to the regional avifauna despite historic records that demonstrate new nest records actually represent re-colonization of former breeding areas (Wires *et al.* 2001). Lack of knowledge about historical distribution and abundance has led to significant misconceptions about numbers of cormorants the environment may support. For example, some portions of the public in conflict with this species (e.g., anglers, aquaculturalists) consider mid-century (pre-1980) numbers to be the "norm" for DCCOs; however, numbers and distribution during this period were greatly diminished due to contaminants and persecution (e.g., Gress *et al.* 1973; Vermeer and Rankin 1984; Weseloh *et al.* 1995). Similarly, in the Great Lakes, where cormorants are currently at recorded highs, growth during much of the 20th century was suppressed through legal and illegal control activities and contam-

inants (Ludwig and Summer 1995; Weseloh *et al.* 1995). Thus population size prior to the 1970s (when national legislation protecting cormorants and reducing contaminants was introduced) was smaller due to human intervention and environmental degradation, rather than to natural regulation and biological carrying capacity. Misconceptions about historic numbers and what is “normal” in current ecosystems, rather than science, has fueled much of the debate about need to control DCCOs in North America.

The term “overabundant” is a judgment that needs qualification. Kushlan *et al.* (2002) imply one way to judge overabundance is to determine if a species has exceeded historical norms. This criterion is useful because comparison of current to historic numbers may help determine biologically if there are “too many” individuals of a species. Based on available records, the continental DCCO population has not exceeded historical norms. Additionally, no study has demonstrated DCCOs exceed biological carrying capacity by surpassing food supplies or habitat. Although concern about potential impacts to various resources has been reported in several areas (USDI/FWS 2003b), negative changes in natural resources directly linked to DCCO population growth via rigorous scientific study have been documented at only a few locations (Wires *et al.* 2001; Cuthbert *et al.* 2002).

In biological terms, we suggest characterization of the continental DCCO population as overabundant is inappropriate. This characterization is applicable, at best, only on a local and site-specific level where numbers can be demonstrated to outstrip resources. Applied to the eastern U.S. population, use of the term “overabundant” is meaningful only in terms of “wildlife acceptance capacity” (Decker and Purdy 1988). This term was created to highlight that many wildlife or social acceptance capacity levels may exist for a particular wildlife population at any point in time; this is unlike the concept of biological carrying capacity. Usually, wildlife acceptance capacity is far smaller and more variable than that determined by biological carrying capacity.

Conservation vs. Management Goals

Over the last decade and a half, large-scale conservation plans for birds in the Americas have developed that depart from the traditional narrow focus on threatened and endangered species, and now encompass broader and more representative goals, such as that defined by the vision of Partner’s in Flight’s (PIF) “keep common birds common” (Fitzpatrick 2002). Waterbird conservation plans at national and continental scales directly link species and population goals to historic distribution and abundance (Milko *et al.* 2003; Kushlan *et al.* 2002). Fitzpatrick (2002) takes current bird conservation initiatives one step further and offers the following as a robust mission statement: “Ensure persistence of all American bird populations in their natural numbers, natural habitats, and natural geographic ranges . . .” In these more recent initiatives and perspectives, historic distribution and abundance provide the basis for conservation focus. Thus, when designing management and conservation plans, and developing biologically meaningful population objectives, it is important to recognize where and in what numbers and habitats DCCOs formerly and naturally occurred. Because very large numbers have been typical for this species historically, population targets based on fishery objectives or other human imposed values may be readily surpassed and likely will require intensive management.

In some areas, return of DCCOs after a long period of absence or local/regional rarity has created conflicts over resources because humans are not accustomed to dense concentrations of DCCOs and now more intensively use areas that were formerly occupied by cormorants (Wires *et al.* 2001; Wires and Cuthbert 2003). These conflicts have led to policy decisions and management plans (Glahn *et al.* 2000; USDI/FWS 2003c; USDA/APHIS-WS 2004) that are incompatible with current conservation goals (Wires and Cuthbert 2001; Fitzpatrick 2002; Kushlan *et al.* 2002; Milko *et al.* 2003). For example, the management plan prepared for DCCOs to minimize damage to southern aqua-

culture (Glahn *et al.* 2000) proposes that southern breeding colonies be managed at levels compatible with aquaculture to forestall future depredation problems. Cormorants have recolonized portions of Arkansas and Mississippi after several decades of absence from these states; current colonies are small and few in number (Table 2). Despite no record of cormorant breeding in Arkansas since 1951, most (85%) of the birds at the only known nesting site were collected for research by USDA/APHIS-WS when they resumed breeding in 1999 (Hutchinson 1999). The Arkansas Wildlife Services state director commented that he hoped "we can keep this population down and maybe eliminate it . . . if we let it get out of control we could have cormorants throughout the year" (The Catfish Journal 1999; Hutchinson 1999). Though year-round residence in Arkansas by DCCOs may result in more conflicts with the aquaculture industry, year-round residence was documented historically (Howell 1911; James and Neal 1986).

In spring 2004, several islands in the Great Lakes were selected for large-scale cormorant control but these islands have also been identified as providing significant habitat for birds. For example, the islands in northern Lake Huron, MI, which include the Les Cheneaux Islands, have been proposed as an Important Bird Area (J. P. Cecil, Audubon, pers. comm.), and several of these islands with nesting cormorants were previously prioritized for conservation because of their regional importance to breeding colonial waterbirds (Wires and Cuthbert 2001). At Presqu'île Provincial Park in Ontario, a formally designated Important Bird Area, over 6,000 breeding cormorants were killed in 2004, allegedly to protect an old-growth forest (Ontario Parks 2005).

Conservation of DCCOs and other abundant waterbird species cannot be effective without a unified conservation philosophy based on knowledge of historical populations and policy decisions founded on sound science. Public dissatisfaction with waterbirds is one of the greatest threats affecting long-term survival of waterbird populations (Kushlan *et al.* 2002). Much of this negative

attitude is held because waterbirds eat fish and are perceived as competitors. In the case of the DCCO, its image is especially negative; the human-cormorant conflict is exacerbated because the species was not present or existed in very low numbers for all or most of current human memory in North America.

The fact that very large numbers of DCCOs existed prior to European settlement has fundamental implications for multiple natural resource management issues. Historically, vigorous fish populations sustained large numbers of fish-eating birds; in relatively natural systems, this is still possible (e.g., Davoren and Montevecchi 2003). In highly modified systems (e.g., Great Lakes), controlling native predators does not address the diverse problems that affect this ecosystem and its ailing fisheries. However, in many areas of the Great Lakes, DCCOs have been identified as the major factor limiting fish populations. This, in turn, has led to the development of population objectives for cormorants based largely on fishery objectives. For example, agencies managing cormorants in the U.S. eastern basin of Lake Ontario and on Long Island (Oneida Lake) (New York Department EC), and Canadian colonies on lakes Huron and Ontario (Ontario Ministry of Natural Resources) have established cormorant population sizes hypothesized to increase local fisheries or to achieve local fishery yields (Farquhar *et al.* 2001, 2004; Council of Lake Committees 2003; NYSDEC Newsletter 2004).

Although managing cormorants may benefit some fisheries and resolve human-cormorant conflicts, setting population objectives for cormorants based entirely on fishery or other objectives derived from human values significantly departs from the concept of conserving birds in natural numbers and natural habitats (Fitzpatrick 2002). Given the global state of ailing fisheries and increasing government sensitivity to wildlife acceptance capacity, self-regulating populations of cormorants may only be possible in cormorant "safe zones" where human interests are not allowed to influence cormorant numbers. Because few such "safe zones" are likely to exist, those committed to the con-

servation of fish-eating birds should vigorously oppose strategies that set population objectives based entirely on human interests rather than species biology and regional ecology. Finally, we urge the avian conservation community to support broad conservation strategies based on ecosystem health and process that recognize humans, fish and cormorants as three components of a complex system driven by many species and dynamic interactions.

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