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Project Title: The American White Pelican and Double-crested Cormorant in Minnesota in 2010: Distribution, abundance and population change

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INTRODUCTION

In many portions of North America, significant increases in numbers of American White Pelican (*Pelecanus erythrorhynchos*) (AWPE) and Double-crested Cormorant (*Phalacrocorax auritus*) (DCCO) occurred between 1970 - 2000 (Wires and Cuthbert 2006; Evans and Knopf 1993). Minnesota was no exception; data from survey efforts in the 1960s to 2000 indicate both species increased in the state during this period (Minnesota Department of Natural Resources (MN DNR), Natural Heritage Information System). As these species became more abundant in MN, both were perceived to affect recreation opportunities and local business economies because they consume fish (Wires and Cuthbert, 2003; K.V. Haws, pers. comm., S. Mortensen, pers. comm.).

Concern over increases in numbers of Double-crested Cormorants at the national level led to establishment of the Public Resource Depredation Order (PRDO) for cormorants in 2003. This order authorizes federal, state and tribal agencies in 24 states to "take" (kill) Double-crested Cormorants believed to be impacting public resources on public and private (with owner permission) lands without acquiring a permit (USDI/USFWS 2003). As of fall 2010, cormorant management under the PRDO in Minnesota has been undertaken on Knife Island, Lake Superior, Little Pelican Island, Leech Lake, and Lake of the Woods; additionally, control has occurred on Waconia and Wells lakes under animal damage/depredation permits. Currently, no policy exists to allow reduction of large numbers of the American White Pelican, but public concerns about impacts related to its consumption of fish have been expressed (Wires and Cuthbert 2003; King 2005).

In addition to these increases and potential for fishery impacts, several other diverse issues related to these species provide justification for tracking their population trends in MN,

including: 1) Cormorants are managed at a number of sites, and monitoring their statewide numbers is integral in evaluating how control is affecting Minnesota's population; 2) American White Pelican is a State-listed Special Concern Species and is also classified as a species of greatest conservation need (SGCN) in Minnesota's State Wildlife Action Plan (MN DNR 2006), along with Common Tern (State Threatened) and Black-crowned Night-Heron. Potential for disturbance to all three of these SGCN species, along with other co-nesting colonial waterbirds (e.g., herons, egrets, gulls) at cormorant colonies, is a significant concern because cormorant management occurs at several diverse locations, and because cormorant nesting activity can change habitat for tree-nesting birds. 3) On 20 April 2010, the Deepwater Horizon Explosion occurred on the Gulf Coast, resulting in the largest oil spill in history in U.S. waters, with the potential to impact pelicans; these birds overwinter in the area affected by the oil spill. 4) Cormorants and pelicans are sensitive to environmental contaminants (Evans and Knopf 1993, Hatch and Weseloh 1999). 5) Both cormorants and pelicans have often been targets of illegal control. 6) Monitoring long-term changes in SGCN populations and habitats is a goal of Minnesota's State Wildlife Action plan, and identifying and addressing the effects that emerging issues (e.g. impact of cormorant populations and control efforts) may have on populations of SGCN species, is one of the plan's strategies (MN DNR 2006).

In 2004-05, the first statewide breeding census for cormorants and pelicans in MN was undertaken (Wires et al. 2006). This census established important baseline data for these species, describing their distribution and estimating the sizes of their breeding populations. This census also documented presence of other nesting colonial waterbird species at cormorant colonies and provided estimates of their nest numbers. In 2010, a second complete census was conducted, with the following objectives:

1) Document the current distribution and abundance of Double-crested Cormorants and American White Pelicans, and evaluate changes in distribution and numbers that have occurred between 2004/05 and 2010.

2) Survey colonial waterbird use at 25% of the colonies found to be inactive in 2004.

3) Obtain presence / absence information for all other species of colonial waterbirds (e.g. gulls, terns, waders) that co-occur at cormorant and pelican colonies active in 2010; if possible, obtain estimates of number of nests or provide size range category (e.g., 1-50, 51-100).

4) Obtain nesting numbers for Black-crowned Night-heron, Piping Plover or Common Tern where they occur in mixed species colonies.

5) Evaluate changes in numbers of other colonial waterbird species present in cormorant and pelican colonies that occurred between 2004/05 and 2010.

This report summarizes results of the second census,

METHODS

Potential nesting locations and site visits. Nesting locations chosen for site visits were determined through four strategies: 1) review of all sites visited in the 2004 census (n=142); 2) an e-mail solicitation to MN DNR field staff by the DNR liaison requesting information on new colonies not identified in the 2004 census, and on colonies inactive in 2004 but known to have become active since that time; 3) incidental observation of potentially active sites during a preliminary reconnaissance flight and other flights to determine status and activity of particular sites; and 4) revisits to a subset of colonies (~25%) that were inactive during the 2004 census,

and for which no subsequent information was available, to determine if inactive sites remain inactive. All potential sites were visited on the ground or by airplane to determine activity status.

Field survey crews accessed colonies from land, by watercraft or from the air, depending on accessibility of the site. Watercraft used included a 17 ft Lund boat with 40 hp motor, an 18 ft Zodiac with 90 hp motor, and a canoe. Aircraft used included a Cessna 185, a Cessna 185 with floats, and a Scout plane. At a few locations, it was not logistically feasible to census birds by direct ground counts but good views of the colony were available from the shore, and estimates were obtained through careful counts made from the shore with a spotting scope.

Nest estimates. Nest estimates were obtained for cormorants and pelicans at all sites where these species nested. The count datum was the active nest, and was considered to represent one pair of birds. Active nests were defined as nests containing eggs and/or chicks, apparently occupied nests (obvious nests that may lack eggs or chicks but have signs of active use (e.g. fresh nesting material, well formed)). In aerial photos, active nests were defined by birds apparently sitting on or tending nests. For tree-nesting cormorants counted during ground counts, apparently occupied nests with signs of active use (e.g. recently formed and upright aggregations of sticks, herbaceous vegetation) were counted when nest contents were not visible. We also documented presence of co-nesting colonial waterbird species at all sites where they occurred. When possible, we obtained estimates of their nest numbers. Count datum for these species was also the active or apparently active nest, which was identified by the same criteria used for cormorants.

Multiple census techniques were used to obtain estimates of nesting birds. Method used depended on accessibility and sensitivity of a particular site and species. Techniques included direct ground counts of marked nests at colony sites, nest counts made from boats, and counts of

nests based on aerial photographs. All counts were conducted following Great Lakes Colonial Waterbird Survey protocol (Cuthbert and Wires 2011), mostly by field assistants and project personnel. A small number of sites were counted by other individuals who have familiarity and expertise with colonial nesting waterbirds and regularly monitor these sites (e.g., Little Pelican Island at Leech Lake, Little Pine Island at Voyageurs National Park, and Hennepin and Spirit islands at Mille Lacs Lake).

During ground counts, technicians walked through colonies and tallied the number of active nests on hand-held counters. At sites with > 25 breeding pairs, ground nests were marked with spray paint. To count nests in trees, trees were marked with flagging tape and the number of nests in each tree for each species was counted. In counts made from a boat, birds visible sitting on nests were counted to represent a pair.

In counts based on aerial photographs, photos of nesting birds were obtained while flying over the colony site in a small fixed-wing aircraft at approximately 70-90 mph (T. Pfingsten, pers. comm.) using a hand-held digital camera equipped with an image stabilized lens. Photos were taken from approximately 500 feet above the colony site producing either oblique or vertical images. Photos were downloaded from memory cards to a computer and three categories of birds were marked and hand counted using the software program Arc Map. Birds sitting on nests typically have distinct postures and were easily recognizable as nesting birds by technicians trained to identify and count birds on photographs. Birds standing or loafing that were obviously not on a nest were marked and distinguished from nesting birds to avoid including them in the nest estimate. Birds with uncertain status (i.e., could not distinguish if they were nesting or standing) were also marked and distinguished from the other two categories. We then used the proportion of nesting to non-nesting birds to estimate the number of birds with

uncertain status that were likely nesting; these likely nesting birds were then added to the total nest estimate for a particular location.

Detectability of nests. Though no studies were conducted to assess detectability rates for the species censused in MN, field work utilizing a double-observer approach to estimate detection probability and abundance (Nichols et al. 2000) for five ground-nesting species during ground counts was conducted in the Great Lakes (Cuthbert and Wires 2007). This work demonstrated that marking nests greatly increases estimate accuracy at sites with > 25 nests; when nests were marked, detection probability was on average high (95% for single observers). Of the five species considered in the study, observers had the highest detection of ground-nesting Double-crested Cormorants; on average, 98% of their nests were detected in a sample by one observer. This work also compared counts between observers and concluded that trained observers were equal in their ability to detect nests; the observer sample size was small (n = 2), however. Although no information was available on detectability rates for tree nesting birds, marking trees and counting the number of nests in a tree is known to increase estimate accuracy (D.V. Weseloh, pers. comm.).

Detectability rates have not been obtained for nests estimated based on aerial photographs, nor have differences in observer skill in estimating birds through this method been measured. However, measurement error (the amount of error obtained in measuring the same object more than once) for estimates of Double-crested Cormorants at 15 sites in the Great Lakes and MN obtained through paired ground counts and aerial photographs was very low, 0.5% of total variation between colonies considered (L.R.Wires and F.J. Cuthbert, unpubl. data). Additionally, for the 15 sites considered, aerial estimates were on average within 9% of estimates based on ground counts, indicating that estimates based on high quality aerial photographs are

good predictors of numbers on the ground. Although similar comparisons were not made for pelicans, this species is large and easy to see, and therefore aerial estimates for these birds are also assumed to closely predict numbers on the ground. More work needs to be done to assess the accuracy of the method for tree-nesting cormorants, egrets, and herons, but preliminary data from the Great Lakes indicates that high quality photos can produce similar results as ground counts, and in some cases may provide more accurate counts (Cuthbert and Wires 2011). For example, birds on nests are sometimes more visible when viewing from the top of the canopy than from below, and because birds typically stay on nests during aerial photography, it is often much easier to positively identify owners of nests in mixed species colonies.

Census Timing. The goal for all species was to estimate the peak number of nests at each site. The optimal time for conducting counts was based on several considerations: 1) review of previous census dates at all active colonies and nest stages observed; 2) an initial reconnaissance flight in late April to assess colony activity and status from the metro area south to Faribault and Martin counties (n = 18 sites); 3) communication with individuals that regularly visit individual sites and are familiar with phenology. The typical survey period to meet this goal in MN is May 15-June 15, although the survey window stretched from late-April to late-June.

RESULTS

Potential nest sites and site visits. A total of 162 sites were identified as potential breeding locations for cormorants and pelicans. All spatially unique land masses with potential for breeding birds were considered individual sites, even when islands were near one another. Of the 162 sites, 142 were identified in the 2004 census; 20 additional sites were identified through e-mail solicitation to MN DNR field staff and through communications with other individuals who

had discovered potential sites since 2004. A total of 86 sites were visited between 20 April and 24 June to determine status, and an additional 14 sites were reported to us as inactive based on visits by individuals familiar with these sites. Fifty-eight sites were assumed inactive based on factors that made breeding at these sites unlikely (e.g., habitat change, time since last active, reports from professionals familiar with current conditions at these sites). A few sites were determined to be outside the study area (n=3) or to no longer exist (n=1). All potential sites and their survey status are shown in Table 1.

Active sites, species composition and nest estimates. Of the 162 potential sites, a total of 46 had nesting cormorants (n=42), pelicans (n=17) or both (n=13) (Figure 1). The total number of nests estimated for American White Pelican was 15,999; for Double-crested Cormorants, the total number estimated was 15,425 (Table 2). In addition to cormorants and pelicans, nesting by the following colonial waterbird species was documented at 34 of the 46 sites: Black-crowned Night-Heron, Caspian Tern, Common Tern, Great Blue Heron, Great Egret, Ring-billed Gull and Herring Gull (Figure 1). Numbers of nests estimated for each species at each site are shown in Table 2.

Re-visits to subset of sites inactive in 2004. In the 2004 census, 99 potential sites were not used for nesting by cormorants or pelicans. In 2010, we revisited 37 (37%) of these to determine if inactive sites remain inactive. Of these 37, only three (8%) were active in 2010 (Tables 3 and 4). These included O'Brian Lake, Potato Island-Lake Vermillion, and Red Lake Rock-Lake of the Woods.

Changes in distribution and numbers of the American White Pelican. The number of American White Pelican nests estimated in this survey was very similar to the number estimated in 2004/05 (n=15,610; Table 3). Overall, the 2010 estimate was higher by 2.5%, a difference that

could represent a true increase in numbers or be simply due to sampling error. Breeding distribution across the state also remained essentially the same, with colonies in the northern, west-central and southern portions of the state (Figure 2). During both survey periods, nearly the entire population (97-99%) occurred on six lakes; however, numbers changed significantly at several of these locations (Table 3; Figure 3). At the Marsh Lake Complex, a very large number nested on Currie Island, which was not active during the last survey, and numbers nearly doubled on the Peninsula. At these two locations, initial counts obtained were 4,332 and 4,185 nests, respectively. But because vegetation on these islands partially obscured our view of some birds, these counts were believed to have underestimated numbers by at least 10%, based on careful examination of the photos, and so were increased accordingly (Table 2). Substantial declines were detected on Big, Banding and Small islands. Overall, our results suggest that numbers at the Marsh Lake complex declined by as much as 15% since 2005.

On Minnesota Lake, numbers increased overall by 41%. A smaller number of pelicans nested on the lake proper than in 2004, but a large number was discovered in a nearby agricultural field. On 15 June 2010, we obtained an estimate of an additional 748 nests at this location.

At Lake of the Woods, numbers nearly doubled since 2004. Significant increases occurred on two of the islands active in the last survey, and an additional site that was not occupied in 2004, Red Lake Rock, was used for nesting by a large number of pelicans in 2010 (Table 3).

Other lakes with single colony sites also experienced substantial increases, including Swartout Lake, Lake Johanna and Leech Lake (Table 3).

Changes in distribution and numbers of the Double-crested Cormorant. As was the case with pelicans, the number of Double-crested Cormorant nests estimated in this survey was very similar to the number estimated in 2004. Overall, the 2010 estimate was lower by ~4%, a difference that could represent a true decline in numbers or be simply due to sampling error. Breeding distribution across the state also remained essentially the same, with colonies located across much of the state, except for the northwest, southwest and southeast corners. Most colonies were documented in a region running diagonally through the central portion of the state between Ottertail County in the North, and Faribault County in the South (Figure 4).

During both survey periods ten lakes and islands comprised 75% or more of the state's population; however, numbers changed significantly at several of these locations (Table 4; Figure 5). The most significant change occurred at Lake of the Woods, where cormorant numbers declined by 62%, representing a loss of 2,677 nests. Most of this decline was attributable to the abandonment of O'Dell Island, where nearly 2,000 pairs were recorded in 2004, but substantial declines occurred at other Lake of the Woods colonies as well. Substantial declines were also documented on Leech and Long lakes. At Leech Lake, numbers on Little Pelican Island decreased by 73%, a reduction of 1,836 pairs. At Long Lake, numbers declined by 45%, representing a loss of 616 pairs.

These substantial declines appeared to be offset by significant increases in several other areas. On Pigeon and Minnesota lakes, numbers increased by 43% and 73%, while on Wells and Swartout lakes, numbers increased by 153% and 717%, respectively. Gains on these lakes represented a total of 2,511 breeding pairs. Several smaller but notable increases also occurred on Marsh Lake, Lake Johanna, Egret Island (Pelican Lake), and Lake Hassel. In addition, new

sites with between 300-400 birds each were documented on Lake Vermillion and Hawks Nest Lake.

Presence and estimates of other colonial waterbird species at cormorant colonies. In addition to pelicans, seven other nesting colonial waterbird species were documented at cormorant colonies, including Black-crowned Night Heron, Great Blue Heron, Great Egret, Ring-billed Gull, Herring Gull, Common Tern and Caspian Tern (Table 2). Figure 6 shows the location of cormorant sites (31% of total) that had relatively high colonial waterbird diversity ($\geq$ 4 species). Great Blue Herons were the most common nesting associate, followed by Great Egret, present at 18 (43%) and 16 (38%) of active cormorant colonies, respectively. Nesting by Black-crowned Night Herons was confirmed at four sites; however, this species may have been present at additional sites but missed due to census technique used or limitations at certain sites. For instance, at Lake Johanna and Swartout Lake, aerial photography was used to estimate numbers of and avoid disturbing nesting pelicans, but this method does not accurately detect and census the more inconspicuous Black-crowned Night-Heron, which was present at these sites in 2004. Additionally, at Pigeon Lake (Vegetated island) a ground count was conducted for pelicans but Black-crowned Night-Herons, which were documented on this island in 2004, were not counted due to potential for disturbance to pelicans. Thus Black-crowned Night-Herons were reported as "not censused" at these sites, and their presence or absence was not documented. Figure 7 shows location of cormorant sites (48% of total) shared with $\geq$ 1 wading bird species. Figures 6 and 7 also indicate that the ten sites comprising most of the state's cormorant population were also characterized by high colonial waterbird diversity (90%), and were typically shared with waders (80%) and pelicans (70%), suggesting that these sites are important for colonial waterbirds in general.

Number of sites cormorants shared with American White Pelicans, Great Egrets, Ring-billed Gulls, and Common Terns increased in 2010 while the number shared with Great Blue Herons decreased (Table 4). The number shared with Herring Gulls remained the same. The overall numbers of Great Blue Heron nests at cormorant colonies declined by 17% since 2004, while numbers of American White Pelican, Great Egret, Ring-billed Gull, Herring Gull and Common Tern nests at cormorant colonies increased by 7%, 32%, 740%, 290% and 9%, respectively. It was not possible to accurately summarize numbers of cormorant sites shared with Black-crowned Night-Herons for reasons noted above. Additionally, all estimates provided for Black-crowned Night-Herons should be regarded as minimum numbers because it was not possible to make exhaustive searches for this species while counting the other colonial waterbirds. Therefore, it was not possible to accurately assess changes in numbers of this species at cormorant colonies across the state. Nevertheless, a large decline (97%) in night-heron numbers appeared to have occurred at Long Lake, indicating a loss of 200 pairs. While an exhaustive search was not undertaken for night-herons at this location, we estimate < 50 pairs of night-herons nested on the island in 2010. Since the majority of night-herons that co-occurred with cormorants in 2004 were at this location (68%), the 2010 estimate for Long Lake indicates a substantial decline in the number of night-herons co-nesting with cormorants overall. Caspian Terns were not documented at any cormorant sites in 2004; they colonized the Leech Lake, Little Pelican Island site in 2007, where their numbers have increased every year since (S. Mortensen, pers. comm.).

Monitoring changes in numbers of species at sites with and without control. We obtained estimates of nesting cormorants at two different time periods in the nesting cycle at seven sites, three where cormorant control occurred and four where no cormorant control occurred (Table 5).

At sites without control comparison of numbers estimated between late April and mid-to-late May indicated that numbers essentially remained stable or continued to increase significantly (21-28%) during this period. Conversely, at two sites where control occurred, numbers declined significantly (Wells Lake, 21%) during the same period, or after control occurred (Leech Lake, 65-70%, where control was drawn out through much of the nesting period). Numbers at Lake Waconia suggest that little change occurred between late-April (prior to control) and mid-May (post-control). However, confidence in the early estimate was low and may have underestimated numbers present.

We also obtained pre- and post-control estimates of some co-nesters at Waconia and Wells lakes (Table 5). On Wells Lake, estimates indicate numbers of Great Blue Herons and Great Egrets increased between the first and second census. On Lake Waconia, estimates for Great Egrets suggest numbers essentially remained the same between censuses. Pre-control numbers at this lake were not available for Great Blue Herons or Black-crowned Night-Herons. Pre-control numbers of co-nesters were not provided for Leech Lake.

DISCUSSION

Detecting active sites. Efforts to detect active sites in 2010 appear adequate to determine current distribution and abundance for both species. Colonies of cormorants and pelicans in interior areas are fairly conspicuous and are typically discovered shortly after initiation. Therefore, "advertising" the census effort to wildlife personnel leads to more complete information on current distribution.

Reviewing information on previous activity of individual sites helps to minimize the cost and effort of the census by eliminating visits to sites that have a high probability of inactivity.

We now have a database with pertinent information to identify sites with high potential for nesting activity. Of the three sites that were inactive during the last survey, and found to be active during this survey, two were associated with lakes that had other active colonies. Because these lakes were visited to check on these active sites, previously inactive sites that had recently become active had a high probability of being detected. The other inactive site that became active was identified through discussion with a DNR biologist who recommended it be checked and assisted field technicians with the site visit (J. Hines, pers. comm.). Therefore, we recommend site history documented in this and the previous census be reviewed before the next survey to help identify sites that will require visits and sites that can be assumed inactive.

Changes in numbers of pelicans. At Marsh Lake, pelicans have nested at six sites, five islands and a pensinsula, and numbers have increased greatly since nesting was resumed in the state by this species at this site in 1968. The complex of islands at this site constitutes not only the most significant area in the state for breeding pelicans, but also one of the most significant breeding sites on the continent for this species (King and Anderson 2005). Because of the complexity and significance of this site, a separate census effort was undertaken by Jeff DiMatteo, PhD student at North Dakota State University, also under contract with the DNR Nongame Program. This census also utilized aerial photography, and obtained digital images through a flight conducted between 0930 to 1000 hours on 20 May. While our census effort indicated a decline of 15% from 2005/05, results of the DiMatteo census effort indicated numbers increased by 7% (J. DiMatteo, unpublished report to MN DNR). Factors that could have resulted in differences between the two estimates include:

1) Census dates. Communications with the biologist at the Lac Qui Parle WMA (J. Wollenberg, pers. comm.) indicated that optimal census dates for pelicans in 2010 were

May 20-May 28. Both census efforts took place during this time period. However, our census effort was conducted five days after the DiMatteo census, and it is possible numbers changed between survey periods.

2) Estimate methodology and interpretation. For our estimate, all birds on nests were identified and counted manually, while the DiMatteo census analyzed images using UTHSCSA Image Tool Software (University of Texas Health Science Center, San Antonio Texas) along with supplemental manual counting. Counting birds manually is a more conservative method than automated counting done with a computer program, and may have produced a lower estimate. Additionally, there may have been differences in the interpretation of nesting vs. non-nesting birds. In our photos, we identified 2,304 birds in the colony as non nesting (based on stance or posture), and these individuals were not included in our estimate.

3) Photograph angle. Differences in photographic technique can affect visibility of nesting birds, which can in turn affect numbers estimated. Vertical views more clearly show birds nesting in vegetation but can be difficult to obtain. Our photos were obtained from both oblique and vertical views, and nesting birds were clearly visible in most portions of the islands, with the exception of the more heavily vegetated portions, particularly on Currie Island and the Peninsula. Photographs used by Dimatteo were obtained from mostly vertical shots and may have provided better views of birds nesting in vegetation (J. Wollenberg, pers. comm.). Although we corrected for our limited visibility on some islands, we may still have underestimated in some areas. Nevertheless, most of the nesting area utilized within the complex was visually open, and differences

between the two estimates represented approximately 2,800 nests, a much greater number than we believe we missed due to vegetation.

Most likely, differences in interpretation combined with differences in photos were the primary factors influencing the estimates.

Although different estimates resulted from these efforts, both suggest a decline in birds over the last several years. Annual monitoring efforts at Marsh Lake indicate pelican numbers peaked in 2006, but have been declining ever since (J. Wollenberg, pers. comm.). Causes for decline are not known, but birds may have reached carrying capacity at this site and numbers are stabilizing. It is also possible that some birds from this site have dispersed to other sites in the southern and central portions of the state, as substantial increases during the same time frame have occurred at Lake Johanna, and Minnesota, Swartout and Pigeon lakes. Despite the decline, the large numbers observed at Marsh Lake by both efforts indicate that the colony continues to thrive, and that Marsh Lake remains extremely important to the state's population.

At the Minnesota Lake site, water levels were very high in 2010, and on the lake proper only a small island was available for nesting. Conversely, in 2004, water levels were lower and the island was connected to the land through a peninsula, leaving a larger area available for nesting. Limited space in 2010 likely explains the lower numbers observed on the lake proper. Discovery of a large number of pelicans nesting in a nearby agricultural field in 2010 may indicate that numbers at this site have increased substantially since 2004, but overflowed to a less optimal site because no adequate nesting space remained on the lake by May 17. The agricultural field site was visited by a DNR biologist on June 15, and the nests had been abandoned (L. Gelvin-Invaer, pers. comm.).

The substantial increases observed at other sites around the state (Lake of the Woods, Lake Johanna, Leech Lake, Pigeon Lake, and Swartout Lake) suggest that nesting habitat and food resources for pelicans in Minnesota are broadly distributed and may be of high quality. Although the statewide population estimate remained similar between census efforts, the increases at these sites also suggest that Minnesota's pelican population is likely more resilient presently than it was during the last census. In 2004-05, about 85% of the state's population was aggregated at a single location, Marsh Lake. In 2010, the proportion of the state's population at this location was smaller (70%), while the number of birds occurring at multiple other locations approximately doubled. The distribution of more birds at multiple locations is significant because it makes the state's population less vulnerable to stochastic events such as storms, disease, and human caused disturbance. Surveys for the entire state will likely be repeated in 2011 and 2012, and trends at Marsh Lake and these other sites will be carefully examined.

Although the majority of pelican sites are shared with nesting cormorants, cormorant control was undertaken at only one site used by nesting pelicans in 2010, Little Pelican Island, Leech Lake. Pelicans attempted to nest at this site for a number of years and had only marginal success; human disturbance during survey and cormorant control efforts was assumed to be an important factor. However, recent increases in pelican numbers at this site have occurred with annual surveys and ongoing cormorant control, so human disturbance may not have been limiting numbers initially (S. Mortensen, pers. comm.). Nevertheless, pelicans are typically quite sensitive to human disturbance, and in most locations are censused through aerial photography. Therefore we recommend that potential impacts be carefully evaluated if any cormorant control measures are considered at other pelican sites shared with cormorants.

Changes in numbers of cormorants. While cormorant numbers and distribution across the state remained similar overall to those observed in 2004, changes in specific locations appeared to be due to a variety of factors. At Lake of the Woods, the large colony observed on O'Dell Island in 2004 was gone in 2010, apparently due to a family of red foxes (*Vulpes vulpes*) that was observed on the island. On Little Massacre island, a Bald Eagle (*Haliaeetus leucocephalus*) nest was discovered and the entire colony abandoned in 2009 (K. Haws, pers. comm.). The reduced numbers counted in 2010 may have been related to this occurrence. Factors related to the significant declines on Crowduck and Techout islands are unknown. With the exception of the small number of birds at Red Lake Rock, most cormorants nesting at these islands previously did not disperse to other islands on the U.S. side of the lake. It is possible that they moved to islands on the Canadian side of Lake of the Woods but no data on numbers at Canadian sites in 2010 were available. The fact that cormorant numbers declined so dramatically, while pelican numbers increased substantially, suggests that factors related to the decline in cormorants in this area may be cormorant specific. For example, significant increases in pelicans at Crowduck and Techout islands, where cormorants significantly declined, implies that limited food resources or environmental effects were probably not a factor. It is also possible that undetected predation may have caused declines.

The significant decline reported for Leech Lake was due to cormorant control activities on Little Pelican Island, where 2,222 cormorants were killed as part of the management plan. Major declines also occurred on Long Lake but factors responsible are unknown. However, significant increases in phosphorus levels, which can negatively affect aquatic communities, have been reported for the lake since 1997 (MPCA 2010, Draft Report).

Changes related to cormorant control. Cormorant control occurred on Leech and Wells lakes and on Lake Waconia. Data obtained during this study suggest that cormorant control did reduce the state's population.

Leech Lake. At Leech Lake, cormorant management was undertaken with a goal of reducing the breeding population to 500 pairs. The initial number of birds prior to control activity was estimated at approximately 4,000-4,600 individuals. To achieve the population goal and to collect birds for fisheries studies, management was conducted throughout the season. The final estimate of breeding pairs was reported as 688 and was based on continual monitoring over the season and obtained by the tribal biologist (S. Mortensen, pers. comm.). Because control was conducted over the breeding season, the effort supressed the breeding population and prevented new birds from assuming the space left by birds that were killed. This effort reduced the Leech Lake colony by 65-70% and likely diminished the state's breeding population by ~ 1,500 pairs (S. Mortensen, pers. comm.). Numbers of pelicans and ring-billed gulls increased between the 2004 and 2010 surveys, while the number of Common Terns declined (Table 4). We did not obtain numbers of other nesting colonial waterbird species before and after management, but control is not thought to have negatively impacted the other colonial waterbirds nesting at this site (S. Mortensen, pers. comm.).

Lake Waconia. At Lake Waconia, the goal was to take 1,000 birds, and no breeding population goal was established. We attempted to obtain estimates of breeding cormorants and co-nesting colonial waterbirds at this site before and after cormorant control occurred. However, we were initially denied permission to access the island and were unable to conduct a ground count of nesting birds prior to management. Therefore, we relied on aerial photos of this island from 20 April to estimate numbers before control. These photos were taken to determine census

timing and specific needs at individual sites, and not with the express purpose of counting birds. Vegetation on the island was fairly advanced by this date, and clear views of nesting cormorants were not obtained. Nevertheless, the photos provided some information on breeding birds and based on them we estimated 467 cormorants on nests (Table 5). We were later granted permission to access the island and on May 16 we conducted a thorough ground count. This count occurred 13 days after control work was completed (G. Nohrenberg, pers. comm.) and we estimated 425 cormorant nests. Although comparison of the 20 April estimate to that obtained in mid-May suggests control had little impact on number of cormorant nests (Table 5), this result is probably misleading, because cormorant numbers may have been underestimated on 20 April, and also were likely not at their peak. While we only obtained multiple nest estimates at four sites without control, these data suggest phenology varies by location, and at some sites cormorants may not reach peak numbers until sometime in May or even later. Also, during the 2004 survey, flights were made over Coney Island approximately every two weeks and numbers of nesting cormorants were estimated, with peak numbers (350-400 pairs) observed between 27 May and 08 June (S. Kittelson, pers. comm.). Therefore, cormorant management may have had a greater impact on numbers at this site than we were able to detect.

In addition, numbers of Great Blue Herons could not confidently be estimated based on the 20 April photos, nor could Black-crowned Night-Herons be detected (but this species was found nesting during the ground count). Great Egrets were easier to see in the photos and for this species we were reasonably confident in our April estimate of 180 nests. While comparison of the later count of Great Egrets to the earlier one suggested numbers essentially remained the same pre- and post-control (Table 5), Great Egrets typically initiate nesting later than the other species and numbers on 20 April probably did not represent peak numbers. While we did not

have good estimates for Great Blue Herons prior to control, numbers obtained for this species and Great Egrets post control indicated a substantial decline since 2004. Reasons for this decline are unknown. Additional census efforts will be undertaken at this site in 2011 to obtain better information on numbers of each of these species before and after control.

Wells Lake. At Wells Lake, the goal was to remove 600 birds and no numeric objective was established for the breeding population. Much of the vegetation on the nesting island is dead, and photos taken on 20 April provided relatively clear views of most nesting cormorants, egrets and herons. Therefore, these photos were used to estimate nesting numbers of each species prior to control. Approximately 1,518 cormorant nests were estimated on 20 April. A ground count was conducted on 18 May,12 days after management efforts removed 600 cormorants (G. Nohrenberg, pers. comm.), and 1,197 cormorant nests were estimated. Comparison of these counts suggests that cormorant control substantially (by 21%) reduced the number of cormorants nesting. Additionally, it is possible that numbers could have declined by more than 21% because numbers on Apr 20 may not have been peak numbers, as explained above. Thus management appeared to reduce the state's breeding population by a minimum of ~ 300 pairs.

Comparison of estimates of Great Blue Heron and Great Egret from 20 April to 18 May indicates nesting numbers of each increased during this time period. However, the 20 April estimates were almost two weeks earlier than control activity, so it is not possible to determine if numbers changed post-control. Estimates based on the post-managment counts indicate numbers of each species increased since the 2004 census. Additional census efforts will be undertaken at this site in 2011 to obtain better information on numbers of each of these species before and after control.

Other colonial waterbird species at cormorant sites. With the exception of the Black-crowned Night-Heron and Great Blue Heron, numbers of other colonial waterbird species nesting at cormorant colonies increased between 2004 and 2010.

The overall decline observed in numbers of Black-crowned Night-Herons is likely the result of several factors: 1) the species was not censused at three sites; 2) minimum numbers were obtained where the species was censused; and 3) the large decrease in nests observed at a single location, Long Lake. At Long Lake, numbers of cormorants and Great Egrets also declined. Though reasons for the decline are not known, the high phosphorous levels documented on the lake noted earlier may be impacting the aquatic community.

The overall decline observed in numbers of Great Blue Herons was due mostly to changes at a few specific colonies, particularly at Lake Waconia and Pig's Eye Lake. In 2004 numbers at both of these sites were estimated as an average over the nesting season based on bi-weekly aerial photography, while numbers in 2010 were estimated during one-time ground counts. In 2010, leaf out was early, with fairly dense vegetation observed at both of these sites by 20 April. As noted above, our ground count at Lake Waconia was conducted after cormorant control occurred, and it is not possible to determine if this affected numbers of herons nesting. At Pig's Eye we conducted a complete ground count on 26 May, which would likely give an accurate estimate of nests since nest building continues in May and previous counts done in June produced higher estimates at this site than counts done in April (Warner 1985). Heron numbers also declined substantially on Pigeon Lake. On the Bare island there appears to be less tree habitat than there was in 2004, which is likely a result of cormorant nesting activity. Additionally, on Minnesota Lake, there was less island space available due to high water levels, and there may also be less vegetation for tree nesting, though this was not measured.

CONCLUSIONS AND RECOMMENDATIONS

Double-crested Cormorants. Results of this census indicate that the breeding population of Double-crested Cormorants is stable and the species is relatively abundant in Minnesota. However, this study indicates that cormorant management did diminish the state's cormorant population in 2010, and without control, the state's cormorant population would have probably increased by ≥ 8%. Additionally, significant declines due to unknown causes have occurred in specific areas, such as Lake of the Woods. Important questions regarding effectiveness and effect of cormorant control on numbers of nesting cormorants remain unanswered and require further study. The effect of cormorant control on the productivity of non-target cormorants is also unknown. Therefore, we have the following recommendations:

1) Continue state-wide monitoring for cormorants every five years as long as cormorant management is undertaken to determine population trends, identify locations where important changes may be occurring, and to evaluate how cormorant management is affecting the state's population.
2) As a starting point conduct complete counts of cormorants at all sites where cormorant control is undertaken before and after control occurs to determine how control affects nesting numbers.
3) Obtain observations on cormorant productivity at sites where cormorant control has occurred to determine effect on non-target cormorants.
4) Monitor the colonies at Lake of the Woods to determine if numbers continue to decline.

5) Conservation priority status should be considered for the ten most important lakes and islands identified for cormorants because they have high colonial waterbird diversity and are typically shared with waders and pelicans, suggesting that these sites are important for colonial waterbirds in general.

American White Pelican. Results of this census indicate that the breeding population of American White Pelicans is stable and relatively abundant in Minnesota. Statewide census efforts will likely be undertaken in 2011 and 2012 to help detect changes in numbers that may have occurred since the Deepwater Horizon oil spill. In addition to this monitoring, we have the following recommendations:

1) Continue state-wide monitoring for pelicans every five years as long as cormorant management is undertaken to determine population trends and identify locations where important changes may be occurring.
2) Maintain current status as Special Concern. The limited number of breeding sites used by this species and the resulting aggregation of pairs at particular locations makes this species vulnerable to stochastic events.

Other colonial waterbird species. Great Blue Herons, Great Egrets and Black-crowned Night-Herons are frequent nesting associates at cormorant colonies, and besides the pelican, the species most likely to be impacted by cormorant nesting and/or control activities. Though changes have occurred in their numbers at cormorant colonies, it is not possible to determine if these changes are meaningful at a state population level because no statewide census has been undertaken and complete information on the distribution and abundance of these species is lacking. Such information is particularly important for the Black-crowned Night-Heron, which is identified as a SGCN. We also have no information on how cormorant management at tree-

nesting colonies affects productivity of these species. Therefore, we have the following recommendations:

1) Determine distribution and abundance of the Great Blue Heron, Great Egret and Black-crowned Night-Heron in Minnesota through a statewide census for these species before the next cormorant census. This will provide important information on percent of overlap with cormorants, and status of each species.
2) Determine nesting numbers of each species present at cormorant colonies where control occurs before and after control.
3) Obtain observations on productivity for these species at sites where cormorant management has occurred.

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