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NRRI TECHNICAL REPORT

Minnesota Department of Natural Resources 2021 Minnesota Colonial Waterbird Surveys

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PROJECT OVERVIEW

The Minnesota colonial waterbird surveys began in 2004 in an effort to document the distribution and abundance of colonial nesting waterbirds in the state. The Minnesota Department of Natural Resources (MN DNR) partnered with researchers at the University of Minnesota to initiate monitoring efforts at colony sites of target waterbird species across the state (Table 1; Cuthbert and Hamilton 2016). The monitoring initially focused on documenting the number and distribution of two focal species, American White Pelican (*Pelecanus erythrorhynchos*) and Double-crested Cormorant (*Phalacrocorax auritus*), due to public concerns about the potential impacts of perceived population increases on recreation activities (e.g., fishing; Wires and Cuthbert 2006). The goal of monitoring was to evaluate efficacy of Double-crested Cormorant control efforts and document the status of American White Pelicans, which are a state-listed Species of Special Concern and Species in Greatest Conservation Need (SGCN; MN DNR 2016).

Since the initial MN DNR waterbird surveys, conducted in 2004 and 2005, the intent was to conduct statewide surveys every five years. Surveys were conducted as planned in 2010 and 2015, but due to Covid-19 related work and travel restrictions, it was only possible to conduct a partial survey in 2020. Therefore, the primary objective of the 2021 survey was to complete the fourth census and provide a summary of the combined 2020–2021 survey results to MN DNR. The 2020 surveys were conducted by researchers at the University of Minnesota - Twin Cities campus and the 2021 surveys were conducted by researchers in the Avian Ecology Lab at the Natural Resources Research Institute (NRRI), Duluth, MN. The broad aim of this report is to provide a description of how sites were selected in 2020/21, which species were included as targets, and to provide recommendations for future monitoring efforts in the state. We include site-specific estimates of abundance for primary and secondary (when possible) target species for the combined 2020–2021 surveys. We also provide abundance and distribution estimates for primary target species for the current (2020–2021) and past census efforts at priority monitoring locations and focus on how future monitoring objectives and survey methodologies can best be tailored to maximize efficiency while providing necessary detail to effectively document population status of waterbirds breeding in Minnesota.

Several additional waterbird species listed as SGCN in Minnesota include: Common Tern (*Sterna hirundo*), Black Tern (*Chlidonias niger*), Forster's Tern (*Sterna forsteri*), Piping Plover (*Charadrius melodus*), Franklin's Gull (*Leucophaeus pipixcan*), and Black-crowned Night-Heron (*Nycticorax nycticorax*). These species also require long-term monitoring to assess population status and associated habitat conditions, which are poorly monitored by other non-targeted surveys (MN DNR 2016; Cuthbert and Hamilton 2016). There are ongoing concerns for two additional colonial nesting species: Great Blue Heron (*Ardea herodias*) and Great Egret (*Ardea alba*). Although they are not state-listed species, the number of Great Blue Heron nesting colonies appears to have declined by ~30% since 1985, and the number of Great Egret nesting colonies remains low throughout the state. Overall, little is known about colony persistence or changes in the distribution and abundance of these species throughout the state (Pfannmuller et al. 2017). For these reasons, in 2021 we implemented additional surveys at secondary sites in an attempt to obtain information about the status of these species in the state.

Table 1. List of waterbird species included as targets for MN DNR monitoring efforts in Minnesota. Species' common names and associated four-letter codes are provided along with their state (SPC = species of special concern; END = endangered; THR = threatened; SGCN = species of greatest conservation need) or regional (GLS = priority species in Great Lakes Surveys) listing status. Survey category describes the relative importance of surveying each species during the census period. Species listed as Primary are the highest priority species and receive the greatest weight in the site selection process, followed by secondary species, which receive less weight in the site selection process, and incidental species, which are not considered in the site selection process but included in counts when encountered.

Species	alpha code	Status	Survey Category
American White Pelican	AWPE	SPC	Primary
Double-crested Cormorant	DCCO		Primary
Piping Plover*	PIPL	END	Primary
Common Tern*	COTE	THR	Primary
Black-crowned Night-Heron	BCNH	SGCN	Primary
Great Blue Heron	GBHE	None	Secondary
Great Egret	GREG	None	Secondary
Herring Gull	HERG	None	Secondary
Ring-billed Gull	RBGU	None	Secondary
Franklin's Gull	FRGU	SPC	Incidental
Forster's Tern	FOTE	SPC	Incidental
Black Tern	BLTE	SGCN	Incidental
Caspian Tern	CATE		

*these species may be surveyed by other efforts; coordinate accordingly

METHODS

Target Species

The primary target species for the 2020–2021 census period, identified by MN DNR non-game, fisheries, and EWR biologists, were American White Pelican, Double-crested Cormorant, and Common Tern. Due to Covid-19 restrictions, the survey effort in 2020 was focused solely on obtaining up-to-date information on the number of nesting Double-crested Cormorants at selected sites. For target species, the goal was to estimate the abundance of nesting pairs at each surveyed location and to provide any relevant detail on breeding activity (e.g., chicks present). Additionally, presence/absence information was recorded for observations of secondary target species or incidentals (Table 1), and estimates of abundance were included for these species where feasible. Surveys conducted specifically to document Common Tern nesting in Minnesota were not included in this report, as they were contracted to be surveyed by individuals outside of UMN and NRRI. Although information on secondary and incidental observations is provided when possible, it was beyond the scope and feasibility of the 2020/21 surveys to provide in-depth estimates of nesting pairs for most waterbird species. Furthermore, the survey methodology was not focused on wetland habitats; therefore, wetland-dependent species such as Franklin's Gull, Forster's Tern, and Black Tern were not adequately surveyed. We provide suggestions for monitoring these species in future survey efforts in the discussion section. In 2021, we selected additional sites to be surveyed for Great Blue Heron and Great Egret, which were identified as active

during the MN BBA (2009–2012). One goal was to estimate the effort that would be needed to survey these species on the ground for future monitoring efforts and to document any changes in colony attendance at these sites where breeding was confirmed during the MN BBA effort.

Site Selection

In 2020, the MN DNR identified 54 locations throughout the state to be included in the fourth Minnesota colonial waterbird census (Appendix A). These sites included previously identified high-use nesting locations for American White Pelicans and Double-crested Cormorants from 2015 surveys and a subset of sites where these species were observed in surveys conducted prior to 2015, as well as potentially new colony locations (e.g., locations where Double-crested Cormorants had been observed during the breeding season, but no nesting activity had been documented) (Cuthbert and Hamilton 2016). All surveys conducted in 2020 were done via ground- or boat-based surveys (Appendix B).

Due to logistical constraints associated with Covid-19, only a portion of the sites intended to be surveyed in 2020 were able to be visited (*n* = 14), and only known or potential Double-crested Cormorant nesting locations were targeted. Therefore, the primary objective of the 2021 survey was to sample the remaining 2020 sites (*n* = 39) as well as revisit five islands surveyed at two sites in 2020: Egret Island [*n* =1] and Marsh Lake [*n* = 4]), which were only partially surveyed or required a different survey method to get reliable estimates (e.g., aerial surveys vs. boat/ground surveys).

In 2021, a total of 41 surveys were conducted at locations throughout the state that had been identified as high-priority survey locations by MN DNR in 2020 (Appendix A). These sites included 31 locations previously identified as high-use nesting locations for American White Pelicans and Double-crested Cormorants by MN DNR (Cuthbert and Hamilton 2016). The remaining 10 sites were identified as locations that should be monitored for potential nesting activity but where neither species was detected in 2015. All of these 41 surveys were conducted via airplane.

In 2021, NRRI researchers also compiled spatial data from the MN Breeding Bird Atlas (MN BBA; Pfannmuller et al. 2017) to identify additional locations in the state where secondary target species were confirmed to breed during the atlas (2009–2012). We used this information to identify previously confirmed nesting locations for Great Blue Heron and Great Egret in the state (*n* = 90 Great Blue Heron and *n* = 24 Great Egret; Pfannmuller et al. 2017). We chose a subset of 28 sites where these species were confirmed to have bred (*n* = 24 Great Blue Heron, *n* = 3 Great Egret, *n* = 1 both species) and surveyed them using ground-based methods. These locations were chosen to be surveyed based on accessibility (i.e., can be visited by ground) and other logistical constraints (i.e., field crew safety and availability).

Survey Methodology

2020 Surveys

Overview

A total of 14 sites were visited by University of Minnesota field biologists between May 4–June 9, 2020. Visits were timed to match the best phenology of nesting (based on previous survey data) as well as weather. Counts were conducted on the ground or through observations from a boat or land opposite the colony. Numbers of cormorant nests were estimated by direct nest count while at the colony or by

counting the number of birds on nests in aerial photographs. Aerial photographs were obtained at two locations (three colony sites) by the United States Department of Agriculture Animal and Plant Health Inspection Service (APHIS) through use of a drone on June 4–5, 2020. All counts/estimates were conducted by trained field biologists. Surveys were conducted via canoe or a 14 ft Zodiac with a 25 hp engine. Drones were piloted by USDA APHIS biologists.

Nest Estimates

Estimates were obtained on numbers of breeding Double-crested Cormorants at study sites where this species was found nesting (Appendix B). The count datum was the active nest and it was considered to represent one pair of birds. Active nests were defined as nests containing eggs and/or chicks, or apparently occupied nests (obvious nests that may lack eggs or chicks but have signs of active use (e.g., fresh nesting material, well formed, incubating adult present). In aerial photographs, active nests were defined by birds apparently sitting on or tending nests. For tree-nesting Double-crested 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 the presence of co-nesting colonial waterbird species at all sites where they occurred. No nesting pair estimates were obtained for these species during 2020.

Multiple census techniques were used to obtain estimates of nesting birds. The 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) and by project personnel.

During ground counts, technicians walked through colonies and tallied the number of active nests on hand-held tally counters. Ground nests were marked with biodegradable spray paint using a construction wand. To count nests in trees, trees were marked with paint 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 drone photographs, photos of nesting birds were obtained while piloting the drone over the colony site. Aerial images were downloaded from memory cards to a computer. Apparently incubating birds or birds tending young were marked with software image editing pens and hand counted. Birds sitting on nests typically have distinct postures and were easily recognizable as nesting birds by technicians trained to identify and count birds in photographs. Birds standing or loafing that were obviously not on a nest were not counted.

2021 Surveys

Overview

A total of 41 sites were surveyed via aerial flights on four dates between May 5–12, 2021 (Fig. 1; Appendix B). The aircraft used was a Cessna 185. The pilot and technician were the only two people present in the plane during each survey. Global positioning system (GPS) coordinates of each of the sites were provided to the pilot beforehand; on the day prior to flying, each site was “digitally scouted” on Google Earth so that the technician had an idea of what to expect at each site prior to arrival in the air.

Screenshots of this satellite imagery were also downloaded to the technician's cell phone to be used as a reference when flying over a survey location.

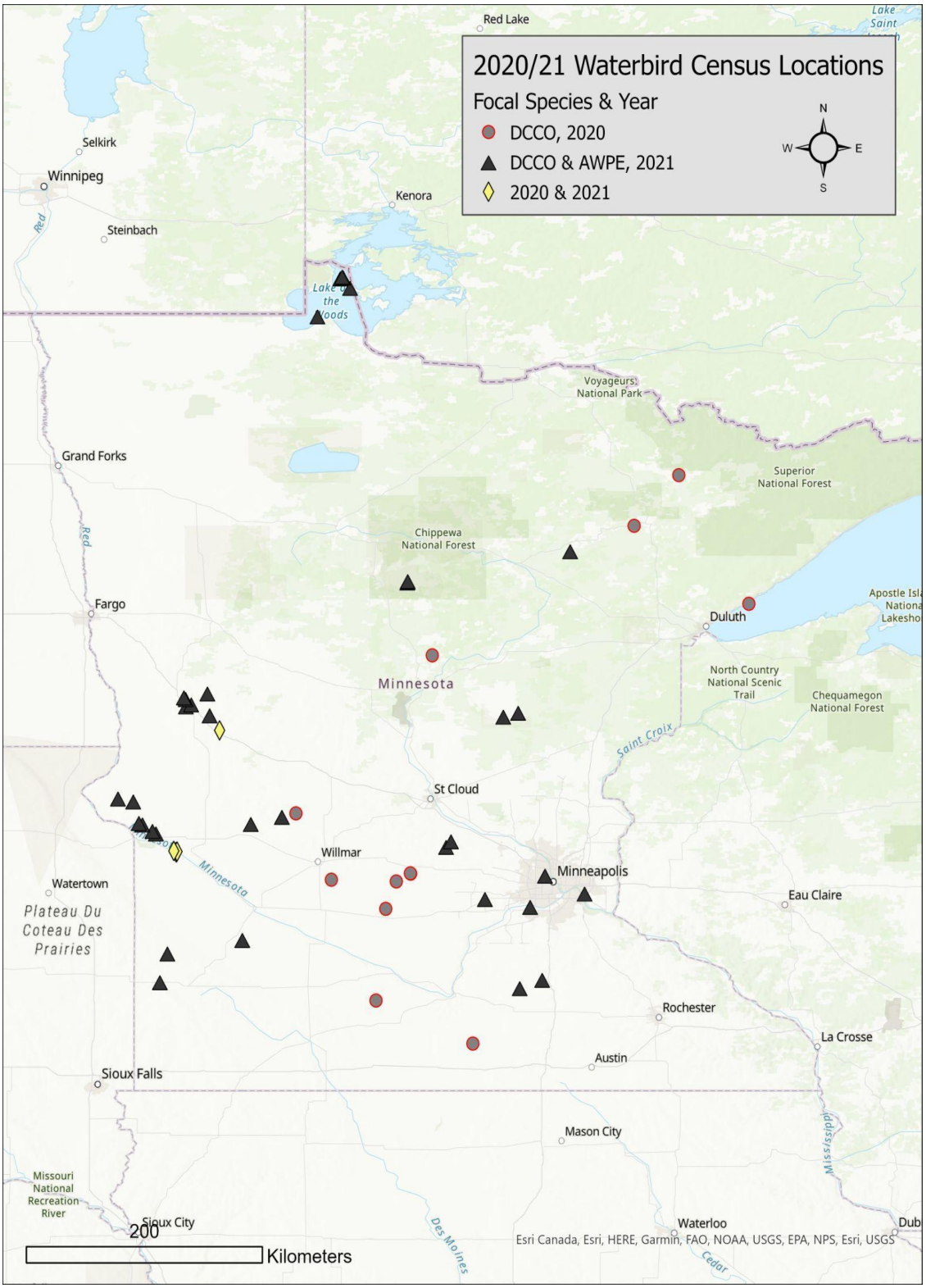

Figure 1. Survey locations for the 2020–2021 MN DNR Waterbird Census.

Camera, photograph settings, and photograph storage

All colony photographs were taken with a Nikon D500, a DSLR with a 20.9 megapixel APS-C sensor, and an AF-S DX NKKOR 18-200mm f/3.5-5.6G ED VR II lens; this combination provided a 35mm equivalent focal length of 27-300mm. Prior to each survey flight, camera batteries were fully charged, memory (SD) cards were formatted, and the camera's internal calendar and clock were verified. An extra battery and memory card were also brought on the plane.

All photographs were taken with the aperture wide open (i.e., f/3.5 at 18mm and f/5.6 at 200mm) with a shutter speed between 1/1000 s and 1/1250 s and auto ISO. Exposure compensation was metered at -0.7 to -1.0 stop off the ground substrate in order to reduce overexposure of bright white birds such as American White Pelican and Great Egret. Lens vibration reduction was enabled at all times. All camera files were shot in the highest quality RAW format available in-camera (producing ~45 MB files).

Immediately following each aerial survey flight, photographs were downloaded from the SD card to a 1 TB Western Digital external hard drive. These files were then copied to a separate but identical hard drive that was kept in a different physical location from the first in case of hard drive loss or failure.

In flight, the sequential file numbers automatically assigned to photographs by the camera were recorded in a notebook at the beginning and end of each colony visit to ensure pictures were later matched to the proper colony. Time stamps were also useful to ensure all photographs from a colony were processed together.

Photograph processing

Photographs were offloaded from the SD card into colony-specific folders on the external hard drive in accordance with the unique file names recorded during flight at each site. These folders were then opened using Photo Mechanic (Camera Bits, Inc., Portland, Oregon, USA) and culled into the smallest number of pictures that covered the entire colony. Often an overview photograph of the entire island was useful in matching more "zoomed-in" photographs. Photographs were then opened in Photoshop (Adobe, Inc., San Jose, California, USA). Photos were then viewed at 100–200% of the original size, and colored dots corresponding to each species were added on top of the image on each nest and then counted (Fig. 2).

Figure 2. An example aerial photograph from a portion of the Swartout Lake waterbird colony before (left) and after (right) nest counts were completed. Red dots represent Double-crested Cormorant nests and Blue dots represent American White Pelican nests.

2021 Great Blue Heron & Great Egret Surveys

A total of 27 sites were visited by NRRI biologists between May 7–12, 2021 (Fig. 1). Counts were conducted on the ground or at land opposite the colony (Fig. 3). Numbers of nests were estimated by direct nest count when possible or by counting the number of birds on nests from the best vantage point. All counts/estimates were conducted by trained field biologists.

Nest Estimates

The protocol used to survey Great Blue Heron and Great Egret generally followed the protocol developed by Cuthbert and Wires (2011) to census waterbird colonies on the Great Lakes. Surveyors counted the number of apparently occupied nests, defined as a nest with eggs or chicks, or nests that are composed of sticks, herbaceous vegetation, or debris, and appear to have been formed during the current breeding season. Information regarding nesting state and count coverage/quality was provided as well. Surveyors also collected basic habitat information at each site visited (e.g., dominant landscape setting, nesting substrate and habitat; Appendix D).

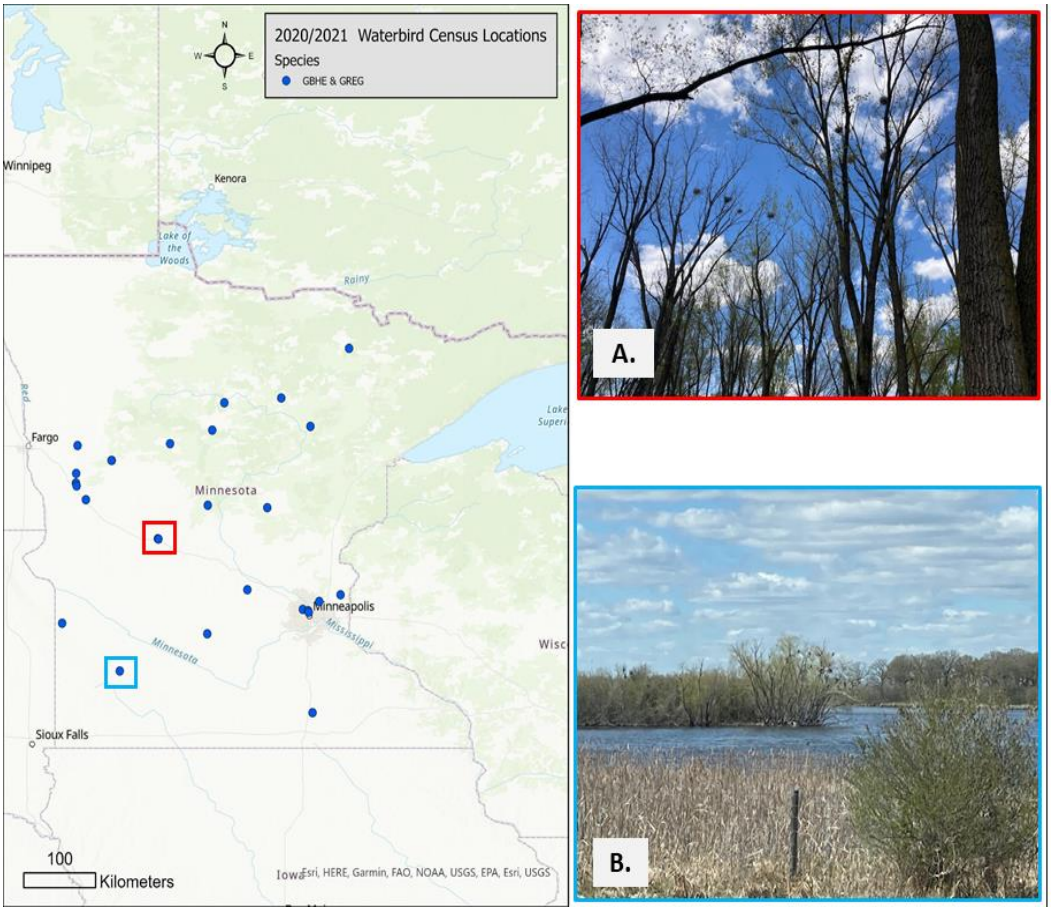

Figure 3. Example of Great Blue Heron & Great Egret survey locations. **A.** Colony with ~15 active Great Blue Heron nests located near Amiret, MN. **B.** Colony near Osakis, MN with ~11 active Double-crested Cormorant nests, no Great Blue Heron or Great Egret nests present.

Data Compilation and Submission

Data collected during the 2020–2021 surveys are provided as summaries in the appendices associated with this report. Data specifically regarding use of drones in 2020 was submitted to MN DNR in a 2020 report. For the 2021 surveys, all of the aerial photographs and flight notes associated with the American White Pelican and Double-crested Cormorant surveys have been digitally archived at NRRI and can be made available upon request. Datasheets associated with the Great Blue Heron and Great Egret surveys have been scanned and digitally archived at NRRI and can be made available upon request.

RESULTS

Efforts to detect active Double-crested Cormorant and American White Pelican nests in 2020/21 were successful. Surveys were conducted during favorable conditions (e.g., pre-leaf out) when visibility was high and both species could be adequately detected using ground, boat, and aerial surveys. The typical timeframe to conduct these surveys in Minnesota is May 15–June 15, although the survey window is flexible and dependent on phenology, with start dates occurring as early as April 29. Six priority monitoring sites, where these species have been documented to consistently nest in high numbers,

were surveyed in 2020/21 (Fig. 4; Appendix C). Multiple survey locations occurred, primarily on islands, located within each priority monitoring site: Lake of the Woods (*n* = 6), Leech Lake (*n* = 3), Marsh Lake (*n* = 6), Mille Lacs (*n* = 2), Minnesota Lake (*n* = 2) and Pigeon Lake (*n* = 2). Note that not all survey locations were surveyed in each census period and that sometimes species were present but not observed to be actively nesting (Appendix A). Double-crested Cormorants were nesting at 30 of 53 sites surveyed in 2020/21 (Fig. 5). American White Pelicans were present at 16 of 53 sites surveyed in 2020/21, and nesting was confirmed at 12 locations (Fig. 6).

2020 Double-crested Cormorant Surveys

A total of 13 sites were visited in 2020. One site, West 2 Rivers Reservoir in St. Louis County was not visited, three sites (Hanska, Big Kandi, and Cedar) had no evidence of nesting Double-crested Cormorants, although there were reports that birds were observed there at various times during breeding and migration periods. The remaining sites had nesting Double-crested Cormorants (Appendix B). Researchers from the University of Minnesota determined that use of drones in censusing colonial waterbirds in the state had significant potential. These results were summarized in a report provided to MN DNR by Cuthbert et al. in 2020.

2021 Double-crested Cormorant/American White Pelican Surveys

A total of 41 sites were visited in 2021. There was no evidence of nesting Double-crested Cormorants at 23 sites (Fig. 5). Of those, 14 had been previously unoccupied in the 2015 census period and 5 sites where breeding activity had been documented were not active (Lake Benton, Banding Island [Marsh Lake], Swenson Lake, Barry Lake WPA, and O'Brien Lake). At sites where nesting was documented in 2020/21, the number of nesting pairs ranged from 4 (Mink Lake) to 2000 (Egret Island; Fig. 5). For American White Pelicans, there was no evidence of nesting at 26 sites (Fig. 6). American White Pelicans were present at four sites but not documented to be nesting, and active nesting was documented at 11 sites; the number of nesting pairs ranging from 10 (Egret Island) to 8521 (Marsh Lake - Big Island; Fig. 6).

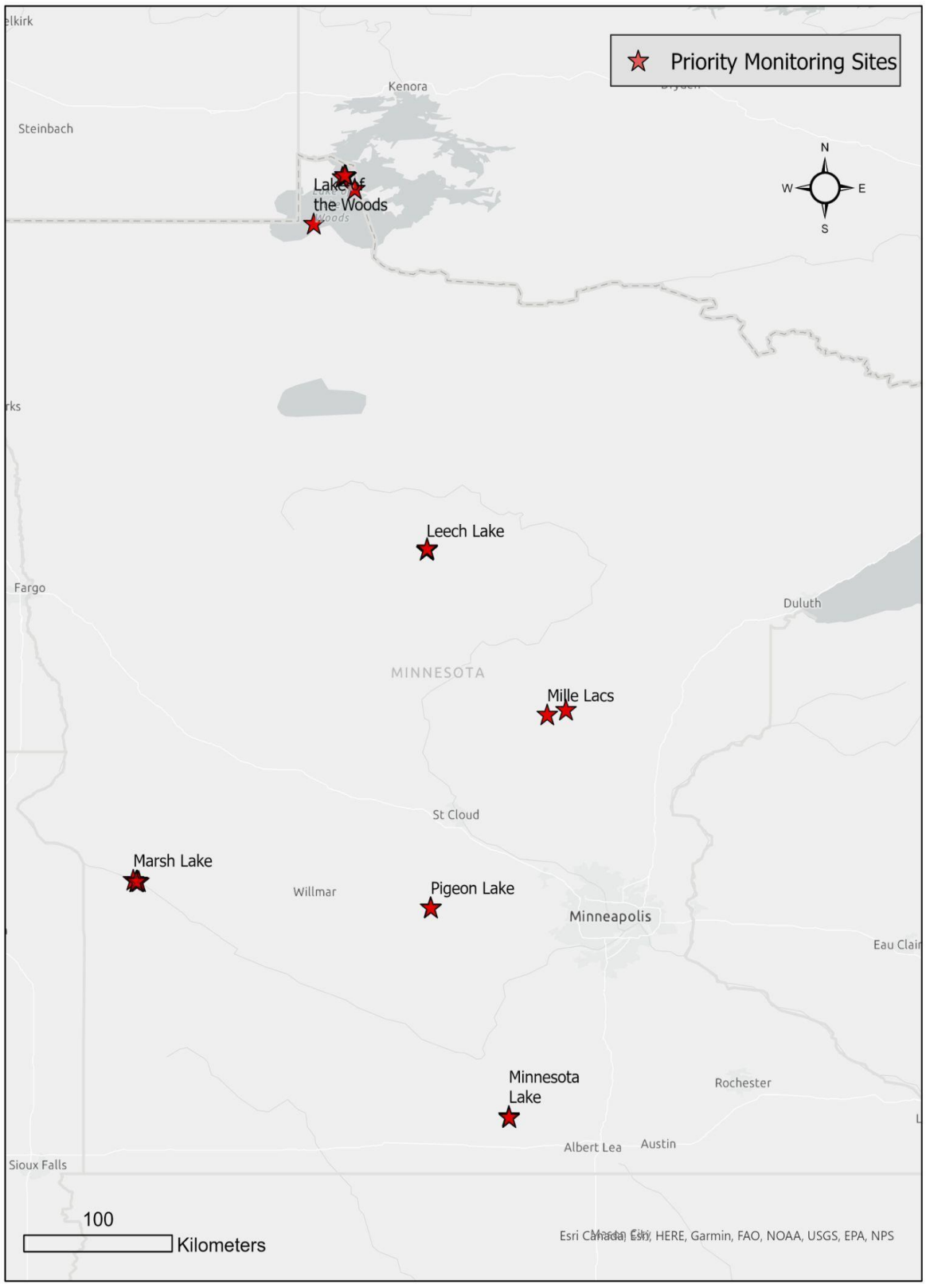

Figure 4. Priority monitoring sites surveyed in 2020/2021.

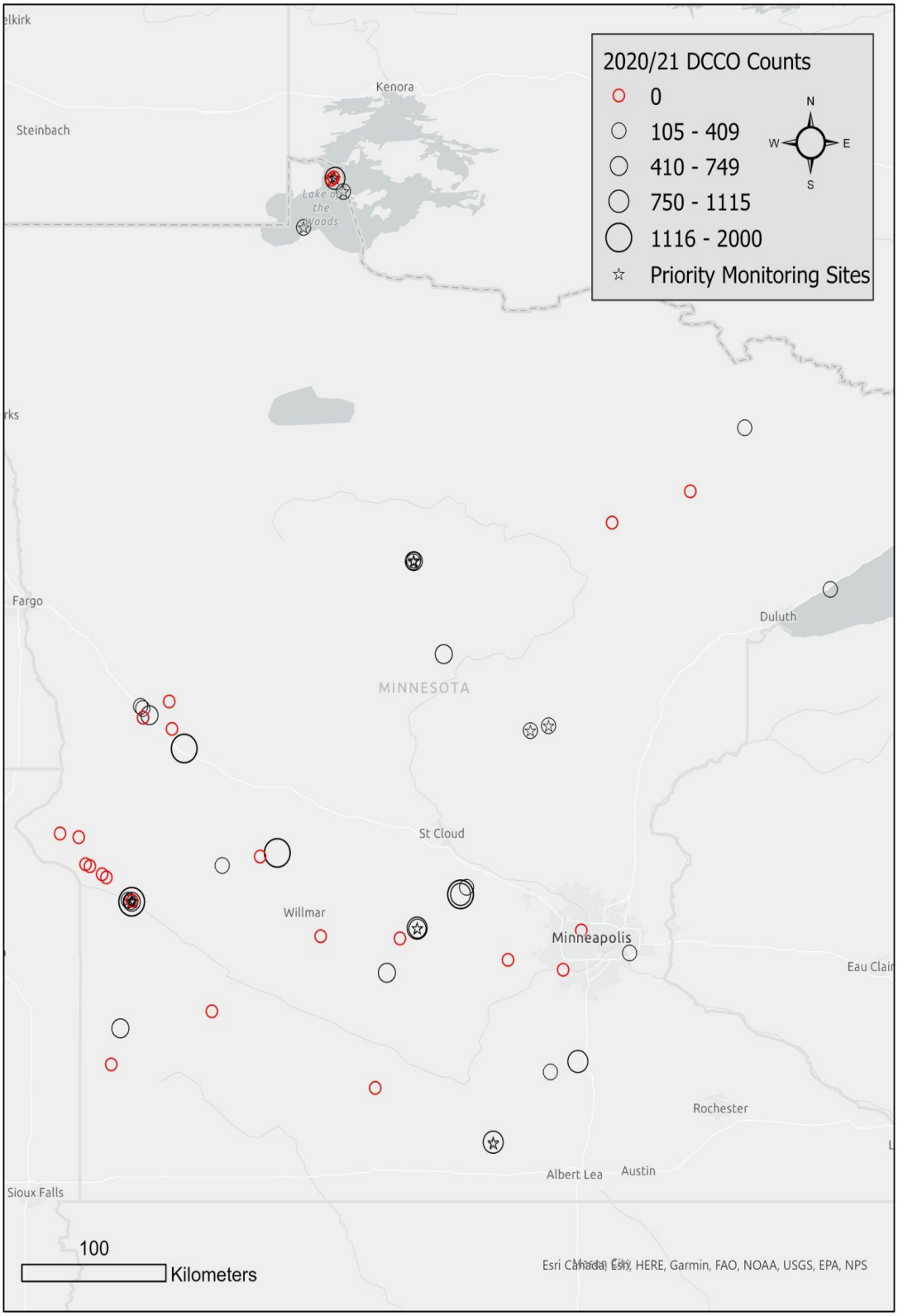

Figure 5. Distribution and estimated number of nesting pairs of Double-crested Cormorant (DCCO) across 53 sites surveyed in Minnesota in 2020/21.

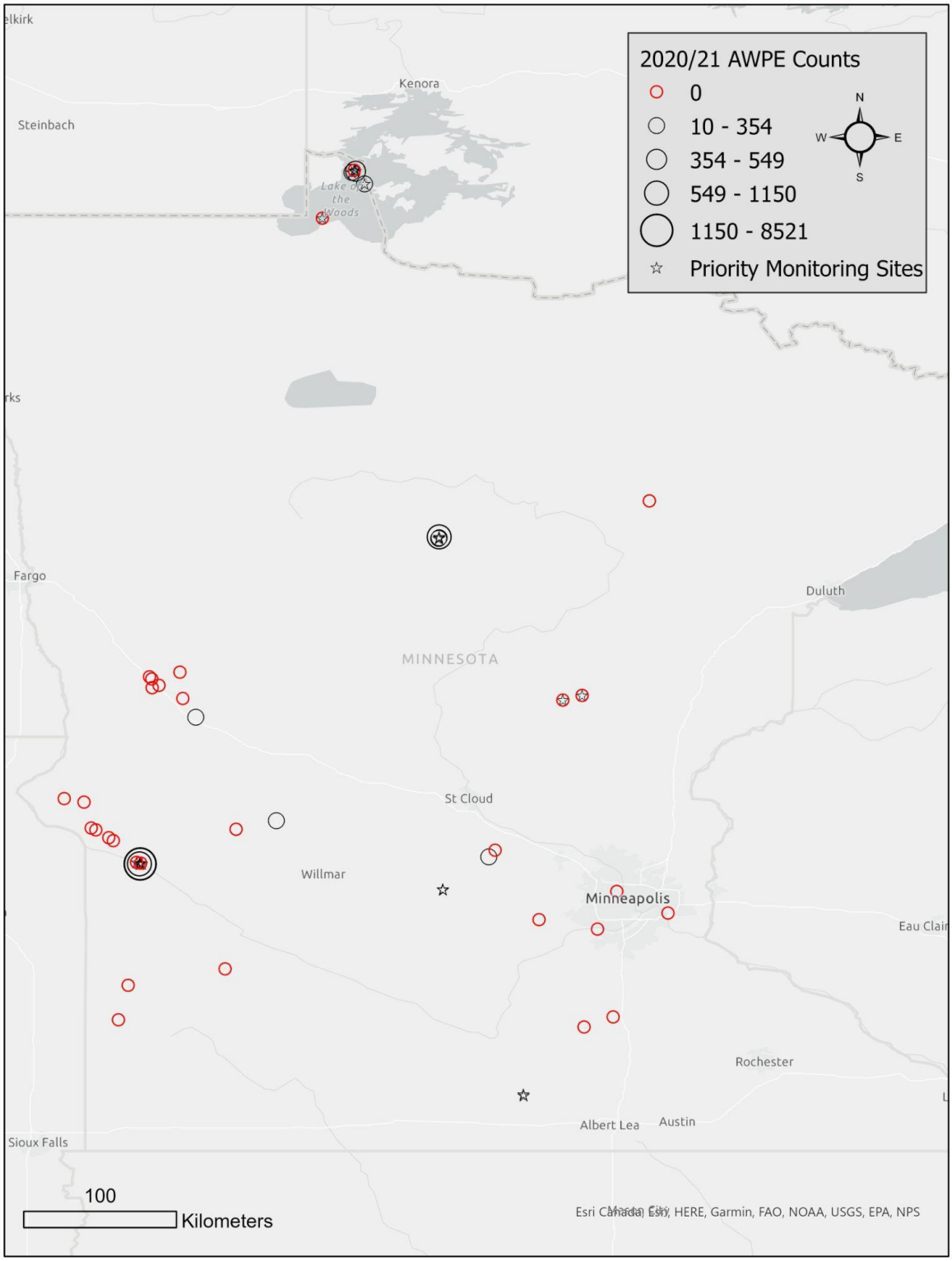

Figure 6. Distribution and estimated number of nesting pairs of American White Pelican (AWPE) nesting pairs across 53 sites surveyed in Minnesota in 2020/21.

Priority Monitoring Site Summaries

Lake of the Woods

The estimated number of American White Pelicans nesting at Lake of the Woods has remained relatively constant throughout the four census periods. Estimated numbers of nesting American White Pelicans increased slightly from 877 in 2015 to 991 in 2020/21 (Fig. 7). There were no nesting birds observed at Techout Island in 2020/21, but numbers were higher at the other three islands where American White Pelicans have previously been documented to be nesting (Crowduck, Little Massacre, and O'Dell islands). The estimated number of Double-crested Cormorants has also remained relatively consistent throughout the three census periods since a decline observed after the initial 2004/05 census, when Double-crested Cormorant control efforts occurred. Estimated numbers of nesting Double-crested Cormorant increased slightly from 1240 in 2015 to 1378 in 2020/21 (Fig. 7), with 71% of the birds detected on O'Dell Island. This site (O'Dell Island) was abandoned in 2010 due to the presence of a family of red foxes (Vulpes vulpes) but was recolonized by Double-crested Cormorants and other waterbirds in 2015.

Leech Lake

The estimated number of American White Pelicans nesting on Leech Lake was ~ four times higher in 2020/21 (1476 nesting pairs) than in 2015 (357 nesting pairs; Fig. 7). Numbers were higher at all three of the islands surveyed (Gull, Little Pelican, and Pelican islands); however, the largest increase was observed at Pelican Island, which increased from an estimated 226 nesting pairs in 2015 to 1150 in 2020/21. The estimated number of Double-crested Cormorants nesting at Leech Lake was higher than 2015 estimates as well, with 496 pairs in 2015 and 827 in 2020/21. However, these numbers were still well below those of 2004/05 estimates (2524 nests), which occurred prior to Double-crested Cormorant control efforts in 2015. Numbers were slightly higher at Gull and Little Pelican islands, but nests were also observed on Pelican Island (83 nests) where there were no nests observed in 2015. However, the island was not counted in earlier census efforts (2004/05, 2010).

Marsh Lake

The estimated number of American White Pelicans nesting on Marsh Lake in 2020/21 was slightly lower (9380 nests) than in 2015 (10289 nests; Fig. 7). The majority of nests (91%) were observed on Big Island (8521 nests), whereas in previous years ~ 50% of the nests occurred on Peninsula and Currie islands, which were not inhabited in 2015 or 2020/21. Satellite images suggest these locations are highly vegetated and not presently suitable for nesting waterbirds. The total number of nesting Double-crested Cormorants was also slightly lower in 2020/21 (1082 nests) compared to 2015 (1139 nests). However, because the majority of nests in 2015 were observed on Big Island (914 nests) and Small Island was colonized in 2020/21 (317 nests), the average number of nests/site was higher in 2020/21 (Fig. 7). The number of American White Pelican nests counted in 2020/21 at Marsh Lake are similar to 2015 surveys and represent a marked decrease in nesting pairs for this site from previous census periods.

Mille Lacs

There were no American White Pelicans detected to be nesting on Mille Lacs Lake in 2020/21, which is consistent with previous censuses (Fig. 7). The estimated number of Double-crested Cormorant nests in 2020/21 (513 nests) was nearly identical to the 2015 census (519 nests). In 2015, all but five nests were located on Spirit Island but in 2020/21, 104 of 513 nests were on Hennepin Island.

Minnesota Lake

American White Pelicans were present but not observed to be nesting at one of the two nesting colonies on Minnesota Lake in 2020. The second location at Minnesota Lake (NA-008) was not counted in 2020, but there were no nests observed there in the 2015 census. There were 936 Double-crested Cormorant nests counted at the island on Minnesota Lake, where American White Pelicans were also observed in 2020. This is slightly lower than in 2015 (1097 nests; Fig. 7). Researchers suggest this site could potentially be surveyed via drone due to openness and inaccessibility due to private land ownership nearby.

Pigeon Lake

American White Pelicans were present at both islands (Bare and Vegetated) on Pigeon Lake during the 2020 census, but estimates of nesting pairs were not documented. A slightly lower number of Double-crested Cormorant nests were counted in 2020 (1598 nests) relative to 2015 (1786 nests; Fig. 7). Bare island is almost devoid of vegetation and has the largest number of nesting cormorants. The second island has some bare areas but significant patches of trees. Bare Island has nesting American White Pelicans and Great Blue Herons. Vegetated Island has fewer Double-crested Cormorants but large numbers of American White Pelicans and a significant Great Blue Heron colony. Drone use would be excellent for Bare Island but more limited for Vegetated Island for Double-crested Cormorants, which have moved from Vegetated Island to Bare Island since the 2015 census.

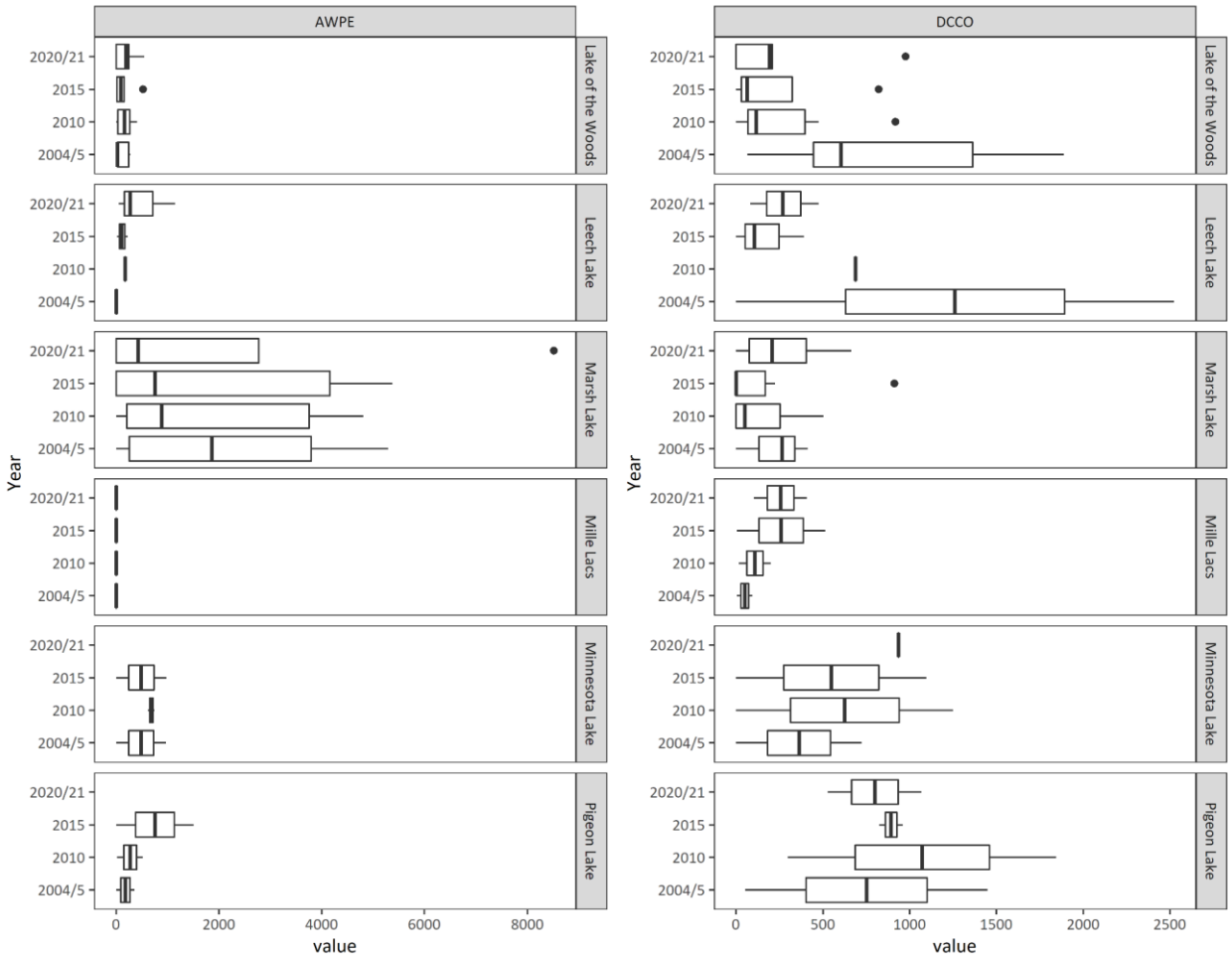

Figure 7. Estimates of the number of nesting American White Pelican (AWPE) and Double-crested Cormorant (DCCO) at each of the six priority monitoring sites. Note: these are raw counts and do not account for differences in detectability between sites and among years, or survey methods.

Presence and estimates of other colonial waterbird species at primary monitoring sites

In addition to Double-crested Cormorant and American White Pelican, seven other colonial waterbird species were documented during the 2020/21 census (Appendix B). The number of species occurring at each site ranged from zero to five. For sites with waterbirds present, the average was two species per site. The two sites with the highest species richness were Little Pelican Island in Leech Lake, where nesting was confirmed for American White Pelican, Double-crested Cormorant, Ring-billed Gull, Common Tern, and Caspian Tern. The other site was Lake Johanna, which was surveyed in 2020 (only presence/absence of species other than Double-crested Cormorant were documented), where—in addition to nesting Double-crested Cormorants and American White Pelicans—Black-crowned Night-Herons, Great Blue Herons, and Great Egrets were observed.

It is not possible to provide statistical summaries for secondary focal species because nest estimates are not consistently available (i.e., only presence/absence available for many locations). Therefore, we summarized the counts of secondary species detected at each site. Black-crowned Night-Herons were present but not observed to be nesting at three locations: Egret Island, Preston Lake, and Lake Johanna.

Great Blue Herons were documented to be nesting at nine primary monitoring sites (*n* = 648 nesting pairs) and present at eight additional locations that were documented via ground-based surveys (Fig. 8). Great Egrets were nesting at six primary monitoring sites (*n* = 1977 nesting pairs) and were documented at six additional sites (Fig. 9). Ring-billed Gulls were nesting at seven sites (*n* = 11,010 nesting pairs) and present at one additional site. For Ring-billed Gulls, the majority of nests were observed at three locations: Big Island (*n* = 4000) and Rock Island (*n* = 3670) on Marsh Lake and Little Pelican Island (*n* = 3040) on Leech Lake. The remaining three waterbird species observed were all nesting on Leech Lake: Herring Gull were nesting on Gull Island (*n* = 14 nesting pairs) and Common Tern and Caspian Tern were nesting on Little Pelican Island (*n* = 183 Common Tern and *n* = 10 Caspian Tern). Herring Gulls were also present at three additional sites: Potato Island - Lake Vermillion, Knife Island - Lake Superior, and Gooseberry Island - Pelican Lake (Appendix B).

2021 Great Blue Heron/Great Egret ground-based surveys

Of the 25 locations surveyed for Great Blue Heron in 2021, there were no active nests observed at 56% of the sites (Fig. 8). These sites had been identified as confirmed nesting locations for this species during the MN BBA (2009–2012). During the ground-based counts, the estimated number of apparently occupied nests ranged from 3 to > 53 (Fig. 8). Only one of four locations where nesting was confirmed for Great Egret during the MN BBA (2009–2012) was still active (City Park in Fergus Falls, MN). However, this species was observed breeding at two other sites where Great Blue Heron were previously nesting (an island in Preston Lake NW of Stewart, MN and a Heron Rookery on an island in the Mississippi River, Minneapolis, MN; Fig. 8) and the estimated number of apparently occupied nests ranged from 7 to 78 (Fig. 9).

Four other waterbird species were observed during the ground-based surveys. Double-crested Cormorants were observed nesting at 5 of the 28 sites, ranging in size from 4 to 107 active nests and documented as present but not actively nesting at one additional site. Ring-billed Gulls were present at one site (*n* = 35 birds) on Grotto Lake in Fergus Falls, MN, but not actively nesting. American White Pelicans were present, but not actively nesting, at two sites; on a small lake west of Mink Lake, NW of Maple Lake, MN (*n* = 10 birds) and on Sweetwater WMA, SW of Marietta, MN (*n* = 15 birds). Black-crowned Night-Herons were observed actively building a nest at one site on Grotto Lake in Fergus Falls, MN (*n* = 2 birds).

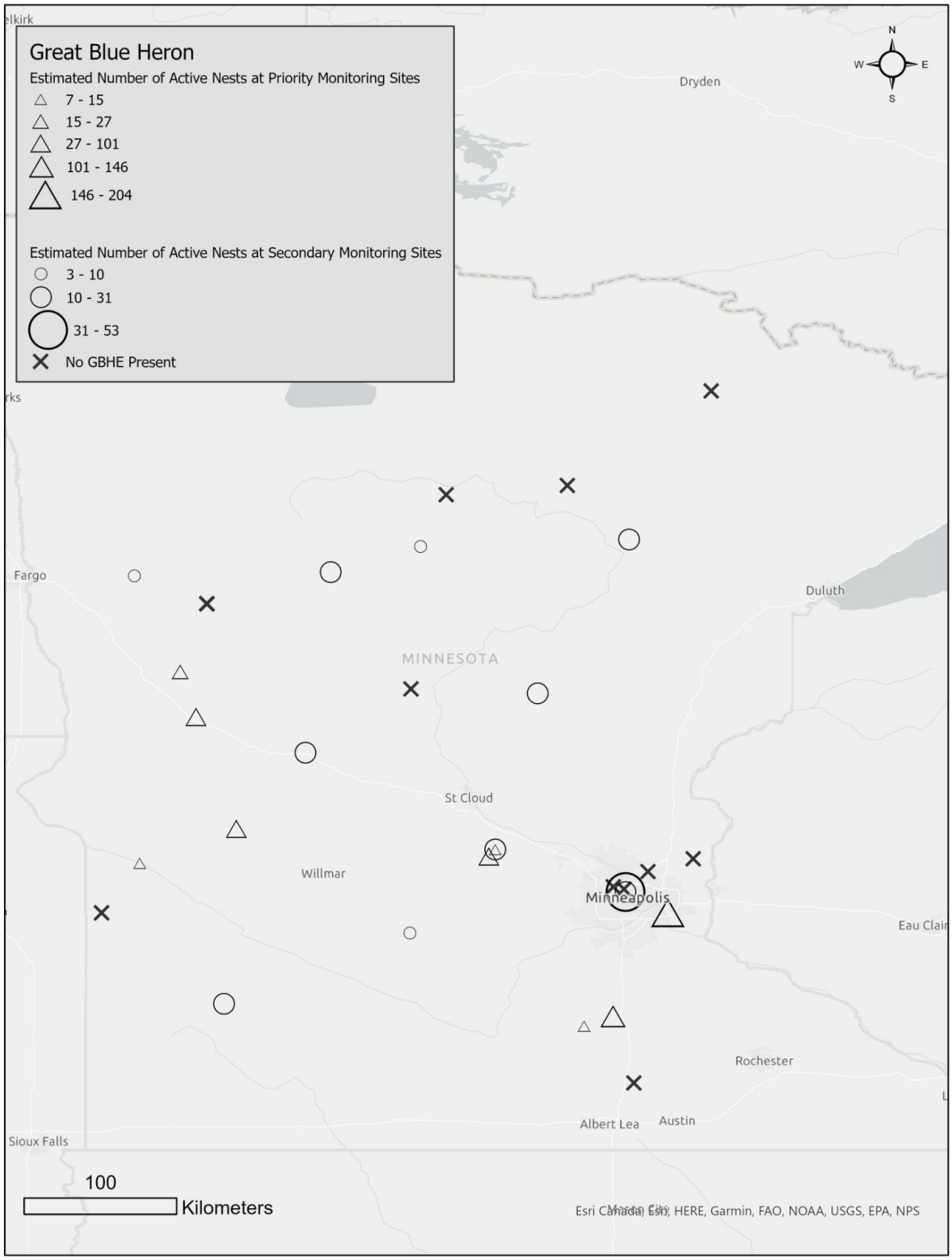

Figure 8. Distribution and estimated number of nesting pairs of Great Blue Heron (GBHE) across 25 sites surveyed in Minnesota in 2021.

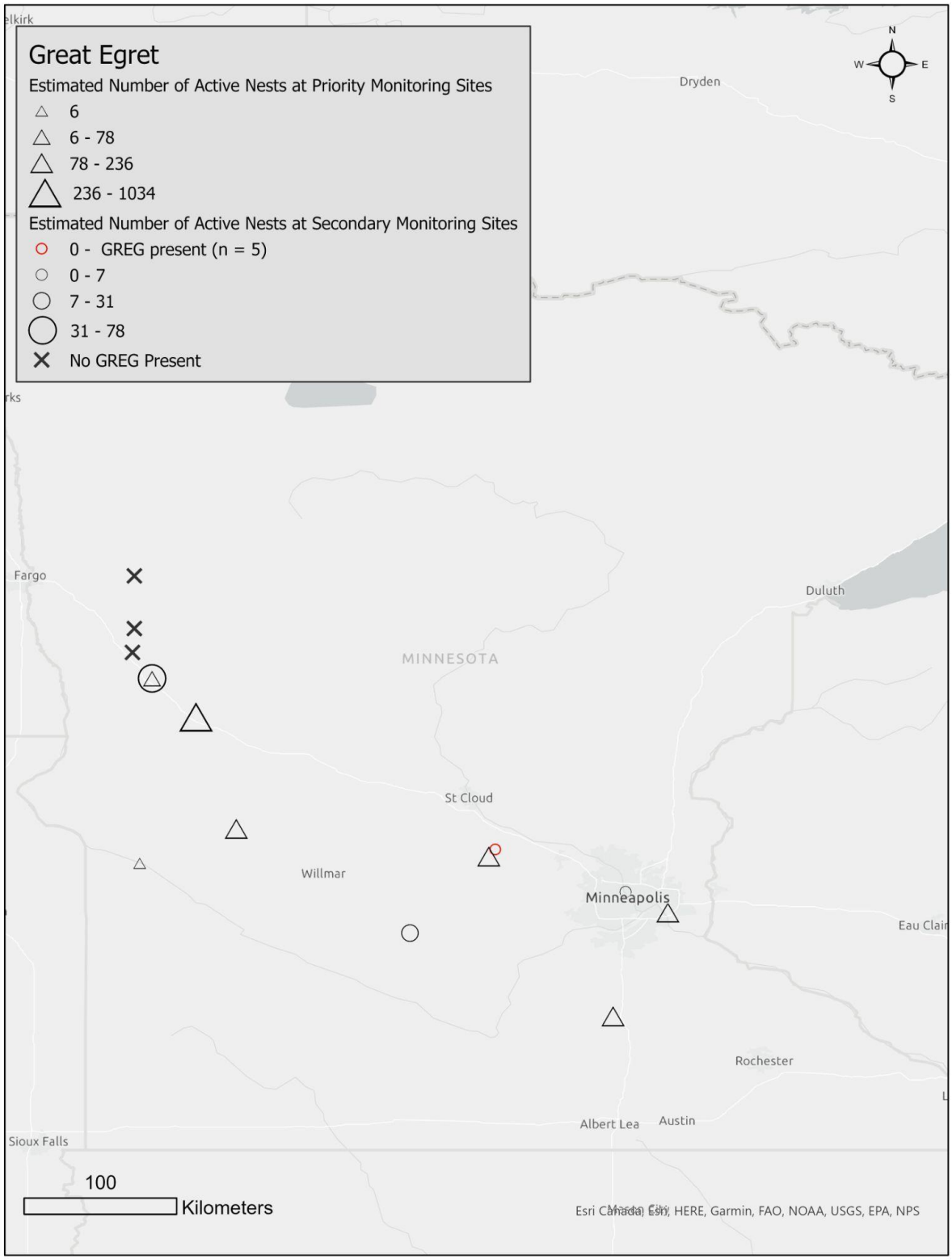

Figure 9. Distribution and estimated number of nesting pairs of Great Egret (GREG) across 25 sites surveyed in Minnesota in 2021.

DISCUSSION

The MN DNR has identified numerous priorities that, if achieved, will help inform conservation needs for wildlife in the state. One of the most important is species information (e.g., population trends) that are necessary to determine population status and stability (MN DNR 2016) and can most reliably be achieved through long-term monitoring efforts. The initial objectives of the colonial waterbird monitoring program were to evaluate efficacy of Double-crested Cormorant control efforts, document the status of American White Pelican, and monitor long-term changes in SGCN populations and habitats (Cuthbert and Hamilton 2016). In 2021, we added a new objective: to document colonial nesting species of conservation concern at secondary survey sites.

Double-crested Cormorant Monitoring

Since 2004, a total of 171 sites have been surveyed across the state. Of these, six sites have been actively managed for Double-crested Cormorants: Potato Island, Lake Vermilion, Knife Island, Lake Superior, Little Pelican Island, Leech Lake, Lake of the Woods, Wells Lake, and Lake Waconia (Cuthbert and Hamilton 2016). Four of these sites were surveyed in 2020/21. At Leech Lake, the number of nesting pairs on Little Pelican Island decreased by 81% from 2524 in 2004/05 to 476 in 2021. However, the number of nests in 2020/21 (*n* = 476) increased by 19% from 2015 surveys (*n* = 391). At Lake of the Woods, total nesting numbers decreased by 68% from 4370 in 2004/05 to 1378 in 2021. The number of nests in 2020/21 (*n* = 1378) increased by 10% from 2015 surveys (*n* = 1240). There was no nesting activity observed at Lake Waconia in 2021, as in 2015. At Wells Lake, the number of nesting pairs increased by 49% from 472 in 2004/05 to 920 in 2021. This number increased substantially from 2015 surveys when 285 nests were documented. Aside from Wells Lake, a reduced number of nesting pairs has been maintained at these sites post-control efforts. Therefore, the management efforts appear to have been successful at the site-level for reducing nesting activity of Double-crested Cormorants. However, the current methods described in this report to monitor Double-crested Cormorants in the state do not provide detailed information that allows for estimating population size, trends, and changes in distribution throughout the state. This type of information is necessary to support the development of effective management recommendations and for assessing impacts of management actions at a state-wide level.

In 2020/21, a total of 21 survey locations in six sites were identified as priority monitoring sites for Double-crested Cormorants based on 2015 survey data (i.e., sites with the greatest number of nests in 2015; Fig. 4). As suggested in the 2015 report, Lake Johanna and Swartout Lake should be considered priority monitoring sites for this species based on the high number of nesting pairs. At Lake Johanna, the number of nesting Double-crested Cormorants has increased by 95% since the 2004/05 census, with *n* = 97 pairs in 2004/05 and *n* = 1966 pairs in 2020/21. The number of nesting pairs was similar to numbers estimated in the 2015 census (*n* = 1904 pairs). At Swartout Lake, nesting increased by 87% from *n* = 49 pairs in 2004/05 to *n* = 378 in 2020/21. The number of nesting pairs increased by 53% from the 2015 census (*n* = 176 pairs).

Ultimately, the Double-crested Cormorant adaptive management strategy should focus on maintaining the species as a natural part of Minnesota's biodiversity while minimizing potential negative ecological impacts of control efforts. Currently, a “dual-frame” approach is used for site selection; this approach focuses sampling effort on the largest, active colonies and also includes 10% of sampling site that are outside known active colonies. Continuing to use the “dual-frame” approach is recommended, as it provides more robust population estimates and information on distribution and colony dynamics

(Haines and Pollock 1998). Identification of active nesting colonies throughout the state, stratifying site selection by colony size, randomly selecting potential sites, and documenting cormorant control efforts over time will facilitate future analyses of these data. Establishing a systematic protocol for monitoring populations and outcomes of cormorant management will also help to assess trade-offs between sample size and effort (i.e., cost). For example, the monitoring objective for the Double-crested Cormorant Monitoring Program in the Pacific Flyway is to be able to detect a 5% change/year in the state's cormorant population with 80% power ($\beta = 0.20$) and a 10% Type I error rate ($\alpha = 0.10$). Results of a power analysis conducted by the Pacific Flyway Council determined that monitoring 44 sites (33 active colonies and 11 potential colony sites) every third year for at least 10 years was the most cost-effective approach in their geographic area of interest (Pacific Flyway Council 2013). We suggest using a similar approach to increase statistical rigor of monitoring data in Minnesota.

Air-, water-, and ground-based techniques can be used to monitor cormorants (Steinkamp et al. 2003). Because cormorants nest in a variety of habitats, the most appropriate monitoring technique for individual colonies should be dictated by habitat characteristics, location, and logistical constraints. We found aerial surveys to be an effective approach for 20 of the 22 colonies at which Double-crested Cormorants nested in 2021. The only two colonies where aerial surveys may have been less effective were locations where nests were located in dense, green vegetation of live trees. The advantages of aerial surveys include reducing disturbance to colonies and efficiency when conducting surveys for multiple species (e.g., American White Pelicans) in an area.

The conflict surrounding Double-crested Cormorants, with respect to commercial and natural resources, is an ongoing and widespread issue. Anecdotal evidence is often used to suggest cormorants are to blame for reductions in fish harvests, but this claim has not been upheld by research and remains a subject of debate. Multiple factors such as habitat loss, pollution, and invasive species can lead to fisheries declines. There is no research that supports the claim that cormorants are responsible for widespread declines to fish populations. Spatially explicit, long-term data on Double-crested Cormorant diet, prey fish populations, and colony dynamics are needed to better understand ongoing issues and inform management plans.

American White Pelican Monitoring

Overall, the monitoring data from the six priority sites indicate that an estimated 11,847 pairs of American White Pelicans nested at the priority sites in 2020/21 and that this number is similar to estimates from the 2015 census ($n = 16501$), noting that in 2020 numbers of nesting pairs were not estimated at all priority sites. Similar to the points made above, the current monitoring approach is not adequate for estimating the state's breeding population size, changes in productivity, trends, or changes in distribution over time. As with Double-crested Cormorant monitoring, we recommend setting a monitoring objective that includes use of a dual-frame approach for bolstering the sample size, and therefore statistical power of the current monitoring program. For example, the Pacific Flyway Council set the monitoring objective to detect a 6% change/year of American White Pelican, with 80% power ($\beta = 0.20$) and a 10% Type I error rate ($\alpha = 0.10$) over a 10- year period (Pacific Flyway Council 2013).

Similar to Double-crested Cormorants, American White Pelicans can be surveyed using multiple techniques (Steinkamp et al. 2003), but we recommend aerial flights during which photographs are taken for subsequent analysis as described in the methods section above. Pelicans nest on the ground in relatively bare, open areas that are easily viewed from the air. Their large body size and white coloration make them highly detectable in photographs. Additionally, this species is known to be skittish and will

abandon nests relatively easily if approached on foot (Knopf and Evans 2020). Importantly, recent research on American White Pelicans found that populations in the western United States have significant density-dependence where the breeding population size one year is negatively influenced by the breeding population size in the prior year (Moulton et al. 2018). To determine the potential influence of density dependence on Minnesota's pelican populations, back-to-back survey years are recommended. Nest counts of breeding pelican colonies have been shown to be an effective approach for documenting population trends; however, because of high variability in nest success, productivity estimates (e.g., counts of hatchlings) are also recommended (Moulton et al. 2018). Lastly, to better understand population dynamics over time, additional efforts to color-mark or capture/recapture banded individuals from focal sites are needed.

2021 Ground-based Monitoring Efforts

Great Blue Heron Monitoring

We utilized data from the MN BBA to assess differences in colony activity and estimate colony persistence. Overall, there was a reduction in 56 % of sites where nesting was confirmed for Great Blue Heron based on documentation during BBA efforts. Great Blue Heron is not a species of conservation concern in Minnesota; however, they have not been consistently monitored for several decades. The changes we documented in Great Blue Heron occupancy at locations where active nests were confirmed during the MN BBA suggests more information is needed to determine whether site fidelity/colony persistence is lower at smaller breeding sites or if these declines are suggestive of a more significant large-scale decline of the species in the state. Moreover, Great Blue Heron are top predators in wetland habitats and therefore can be used as a biological indicator species for the health of wetland ecosystems. For example, herons have been used as bioindicators of contaminants (e.g., Custer et al. 1991), condition of prey stocks (e.g., Frederick and Spalding 1994), and ecosystem behavior (Ogden 1994). Great Blue Herons are sensitive to habitat loss and associated human disturbance, therefore monitoring can provide for early detection of declining and vulnerable populations and to assess the efficacy of ongoing management plans. Additional monitoring of Great Blue Heron colonies is warranted to better understand distribution and dynamics of the species, which can inform wetland management efforts. Recommendations for effective monitoring approaches for the species can be found in Green (1985) and McKearnan (1997).

We recommend a combination approach of air and water/ground surveys for monitoring Great Blue Heron colonies. This species nests in a variety of habitats but tends to nest in tall trees (both dead or alive) that are very near or over water. Great Blue Herons also nest in much smaller numbers than the two species described above, and as a result there are many more small colonies scattered throughout the state. Aerial surveys will be appropriate at large colonies, during early season surveys before leaf-out, and at sites in close proximity to other priority Double-crested Cormorant and American White Pelican colonies. However, for smaller colonies, we recommend land- or water-based surveys like those implemented by field technicians in 2021.

Great Egret Monitoring

Along with Great Blue Herons, monitoring populations of Great Egrets in a systematic way in Minnesota is long overdue. This species is increasing its population and expanding its range northward throughout North America, a trend that will likely continue in the future. While it is not a species of conservation

concern in Minnesota, it is a wetland-dependent species, and more detailed studies are needed to understand how it uses this habitat throughout the state, how the species interacts with other colonial waterbirds such as Great Blue Herons, and how populations fluctuate and move across the landscape. Great Egrets are also top predators in wetland ecosystems, and the implications of this, as described above in relation to Great Blue Herons, apply equally to this species. Similarly, we recommend the same approach for monitoring Great Egrets as we do for Great Blue Herons.

Black-crowned Night-Heron Monitoring

Black-crowned Night-Herons are secretive, and most active during the evening and night and are therefore difficult to monitor. They inhabit swamps, marshes, and the edges of rivers, streams, and lakes during the breeding season, with nest sites often found in small trees over water. The species has been identified as a SGCN by the MN DNR and as "climate endangered" due to predicted loss of breeding habitat (Langham et al. 2015). In Minnesota, they rely on wetland habitats in the southern and western parts of the state for breeding. Therefore, protection of existing nesting islands and large wetland complexes is critical for the conservation of this species. An accurate population assessment at the known nesting sites is critical; however, a dedicated effort will be necessary for effectively monitoring this species (Cuthbert and Wires 2011).

Future Recommendations

Monitoring of colonial waterbirds in Minnesota beyond the two focal species is necessary and would provide novel and valuable information for state wildlife managers. Great Blue Herons, Great Egrets, and Black-crowned Night-Herons are not surveyed well by other non-targeted bird surveys such as the North American Breeding Bird Survey. The Minnesota BBA provides valuable information, but a decadal time scale is far too long for monitoring population changes. To-date, the colonial waterbird surveys completed every five years have provided the most useful information about the populations of these species in the state, but this information is incomplete and tangential to the primary aims of the survey. We advocate for an increased focus on all colonial waterbird species in the state.

Utilizing additional data sources (e.g., MN BBA, eBird) could aid in identifying future high priority survey locations to effectively monitor all waterbird species breeding in the state while providing a baseline and framework for statistical analyses going forward. This approach may also help identify where these species are likely co-nesting or nesting in high numbers. Prioritizing high-use multi-species sites can help maximize efficiency when targeting a broad array of waterbird species in future survey efforts. This approach has been utilized for waterbird surveys conducted in the Great Lakes region (Cuthbert and Wires 2011), whereby sites expected to have higher numbers of focal species would be prioritized.

To determine whether changes in the number of nesting waterbirds at priority monitoring sites reflect changes occurring at a state population level requires a statewide census to document the distribution and abundance of these species over time. Because of differences in species detectability, behavior, and breeding habitat requirements, we recommend developing standardized operating procedures for each suite of species (primary vs. secondary target species) and survey methodology (e.g., ground, boat, and aerial) based on monitoring objectives and anticipated outcomes. This will provide the framework necessary to collect data in a consistent manner and ensure methodology will provide robust information for decision making (Fig. 10).

The objectives of the monitoring program will determine best survey methodology and necessary effort. We recommend the consideration of a rotating survey design, wherein different species are targeted annually throughout a 10-year timeframe. For example, instead of surveying all colonial nesting species at each five year census, which requires a massive effort to adequately survey each of these species in a short time frame (e.g., before leaf out and during peak nesting activity), survey efforts could instead be allocated on an annual or biannual basis with a focus on different target species each census period to more effectively, accurately, and thoroughly document nesting activity for waterbirds in Minnesota (Fig. 10).

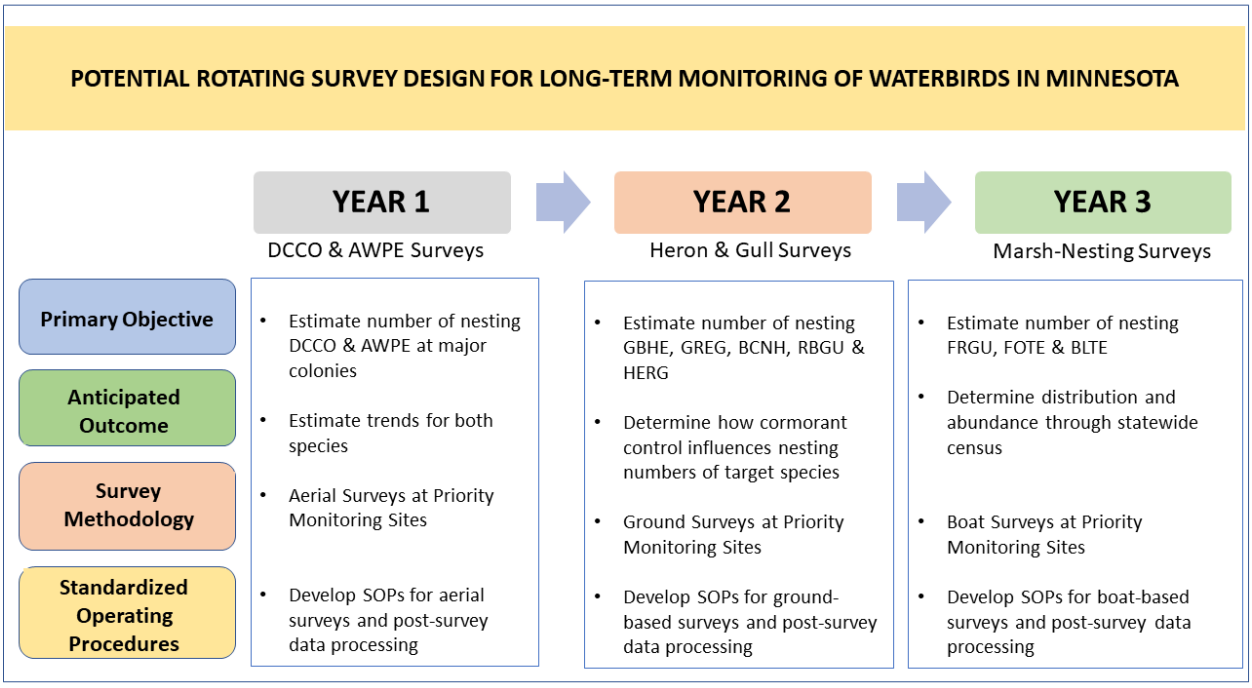

Figure 10. Schematic representing an example of a modified rotating survey schedule designed to address multiple program objectives for different target species and survey methods.

Data Management Recommendations

Utilizing an online database management system to house the long-term census data in a manner that would maintain the baseline data structure necessary for cross-colony comparison and for ease of access would greatly enhance this project. This system could be adapted to meet changing program objectives and would provide the standardization of data collection desired to meet anticipated outcomes. This, in turn, would ensure data quality and increase efficiency for compiling data summaries during each census period. The data management system could be specified independently for each suite of species and survey methodology. If new survey techniques are developed, they can easily be incorporated into the system in a manner that is compatible with previously used methods (e.g., use of drone imagery) and for additional species such as Common Tern and Piping Plover. An online data management system would also eliminate inconsistencies in use of terminology (e.g., selecting consistent and appropriate terms for 'count quality'), which could significantly influence how counts are weighted (e.g., estimates/measures of detectability). We recommend that prior to the sixth census in 2025, project objectives be reassessed, SOPs be developed for each survey methodology and species,

and that a data management plan be developed and data from previous surveys be incorporated into this standardized system.

REFERENCES

Custer, T.W., Rattner, B.A., Ohlendorf, H.M., and Melancohn, M. 1991. Herons and egrets as proposed indicators of estuarine contamination in the United States. Acta International Ornithological Congress 20:2474-2479.

Cuthbert, F.J. 2020. Abbreviated Colonial Waterbird Survey: Double-crested Cormorants in MN. Final Report to Minnesota Department of Natural Resources. December 18 2020.

Cuthbert, F.J., and Hamilton, D. 2016. Assessing Distribution, Abundance and Population Change in the American White Pelican and Double-crested Cormorant in Minnesota: Comparison among Three Census Periods, 2004/05, 2010 and 2015. Final Report to MN Department of Natural Resources. July 15 2016.

Cuthbert, F.J., and Wires, L.R. 2011. The fourth decadal US Great lakes colonial waterbird survey (2007-2010): Results and recommendations to improve the scientific basis for conservation and management. Final Report (Feb 2011) to U.S. Fish and Wildlife Service, Ft. Snelling, MN.

Frederick, P.C., and Spalding, M.G. 1994. Factors affecting reproductive success of wading birds (Ciconiiformes) in the Everglades ecosystem. Pages 659-691. In S. Davis and J.C. Ogden [eds.], Everglades: the ecosystem and its restoration. St. Lucie Press, Del Ray Beach, FL.

Green, J.C. 1985. A Strategy for Monitoring Colonial Waterbird Species in Minnesota. Final report to the Minnesota Department of Natural Resources. http://files.dnr.state.mn.us/eco/nongame/projects/consgrant_reports/1985/1985_green.pdf

Haines, D.E. and Pollock, K.H., 1998. Estimating the number of active and successful bald eagle nests: an application of the dual frame method. Environmental and Ecological Statistics, 5(3), pp.245-256.

Knopf, F.L., and Evans, R.M. 2020. American White Pelican (Pelecanus erythrorhynchos), version 1.0. In Birds of the World (A. F. Poole, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.amwpel.01.

Langham, G.M., Schuetz, J.G., Distler, T., Soykan, C.U., and Wilsey, C. 2015. Conservation Status of North American Birds in the Face of Future Climate Change. PLoS One 10: e0135350. doi: 10.1371/journal.pone.0135350

McKearnan, J.E. 1997. Colonial Waterbird Population Analysis Project, Phase I. Final report to the Minnesota Department of Natural Resources, Natural Heritage and Nongame Research Program. http://files.dnr.state.mn.us/eco/nongame/projects/consgrant_reports/1997/1997_mckearnan.pdf

MN DNR: Minnesota Department of Natural Resources. 2016. Minnesota's Wildlife Action Plan 2015-2025. Division of Ecological and Water Resources, Minnesota Department of Natural Resources. https://files.dnr.state.mn.us/assistance/nrplanning/bigpicture/mnwap/wildlife-action-plan-2015-2025.pdf

Moulton, C.E., Roberts, S.B., Horne, J.S., and Wackenhut, M. 2018. Changes in abundance, productivity, and distribution of western American White Pelicans (Pelecanus erythrorhynchos), 1981-2014, in Trends

and traditions: Avifaunal change in western North America (W. D. Shuford, R. E. Gill, Jr., and C. M. Handel, eds.), Studies of Western Birds 3. Western Field Ornithologists, Camarillo, CA.

Ogden, J.C. 1994. A comparison of wading bird nesting dynamics, 1931- 1946 and 1974-1989 as an indication of changes in ecosystem conditions in the southern Everglades. Pages 533-570. In S. Davis and J.C. Ogden [eds.], Everglades: the ecosystem and its restoration. St. Lucie Press, Del Ray Beach, FL.

Pacific Flyway Council. 2013. A Monitoring Strategy for the Western Population of Double-crested Cormorants within the Pacific Flyway. Pacific Flyway Council, U.S. Fish and Wildlife Service, Portland, Oregon. 37pg.

Pfannmuller, L., Niemi, G., Green, J., Sample, B., Walton, N., Zlonis, E., Brown, T., Bracey, A., Host, G., Reed, J., Rewinkel, K., and Will, N. 2017. The First Minnesota Breeding Bird Atlas (2009-2013). https://mnbirdatlas.org/using-the-atlas/citing-the-website/

Steinkamp, M., Peterjohn, B., Byrd, V., Carter, H., and Lowe, R. 2003. Breeding season survey techniques for seabirds and colonial waterbirds throughout North America. Waterbird Monitoring Partnership of the Waterbirds for Americas Initiative.

Wires, L.R., and Cuthbert, F.J. 2006. Historic populations of the Double-crested Cormorant (Phalacrocorax auritus): implications for conservation and management in the 21st Century. Waterbirds 29: 9-37.

APPENDICES

The following appendices are individually attached to this document:

Appendix A - List of locations that were surveyed for waterbirds in 2020–2021

Appendix B - Estimated number of AWPE and DCCO nests occurring at each colony location surveyed in 2020 and 2021

Appendix C - Estimates for each colonial waterbird species in 2004/5, 2010, 2015, 2020/21 at American White Pelican and Double-crested Cormorant Colonies

Appendix D - Datasheet used to conduct surveys at the Great Blue Heron and Great Egret Secondary Monitoring Sites in 2021