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Double-crested Cormorants (DCCO, *Phalacrocorax auritus*) and American White Pelicans (AWPE, *Pelecanus erythrorhynchos*) are migratory piscivorous birds that breed in North America. Both species are abundant spring and fall migrants in Nebraska. DCCOs are also common, albeit local, breeders in northwestern Nebraska (Sharpe et al. 2001). DCCO and AWPE numbers have increased throughout their range in recent decades (U.S. Fish and Wildlife Service [USFWS] 2003, Sauer et al. 2013). Both species, but primarily DCCOs, have become increasingly controversial because of increased numbers and also because their principal food source is fish, a resource humans value. Concentrations of DCCOs, and to a lesser extent those of AWPEs, can impact small impoundments such as aquaculture facilities and are suspected of reducing sportfish populations on recreational water bodies (Erwin 1995, King 2005, Trapp et al. 1997, USFWS 2003, Seefelt and Gillingham 2006, Groen and Steinwand 2010).

Localized conflicts between humans and DCCOs and AWPEs have occurred regularly at fish hatcheries and have occasionally been reported at small water bodies in Nebraska (Richard Holland, Nebraska Game and Parks Commission, personal communication). We define a conflict as a situation where DCCOs and/or AWPEs

have adverse effects on humans and/or human resources. These localized conflicts between humans and DCCOs and/or AWPEs are readily identified because such instances occur at commercial fish hatcheries and result in property loss. However, DCCOs and AWPEs are suspected to negatively impact sportfish resources at large water bodies in North America, including those that serve as commercial and recreational public fisheries (Trapp et al. 1997, Dorr et al. 2010). Similar concerns have been expressed about recreational public fisheries at Sandhills lakes in Nebraska (Richard Holland, Nebraska Game and Parks Commission, personal communication).

Even though DCCOs and AWPEs are known as abundant migrants in Nebraska, existing information is not sufficient to assess whether numbers during migration are at a level that could impact sportfish resources at Sandhills lakes. We studied DCCO and AWPE occurrence and abundance at Sandhills lakes during the 2012 fall migration.

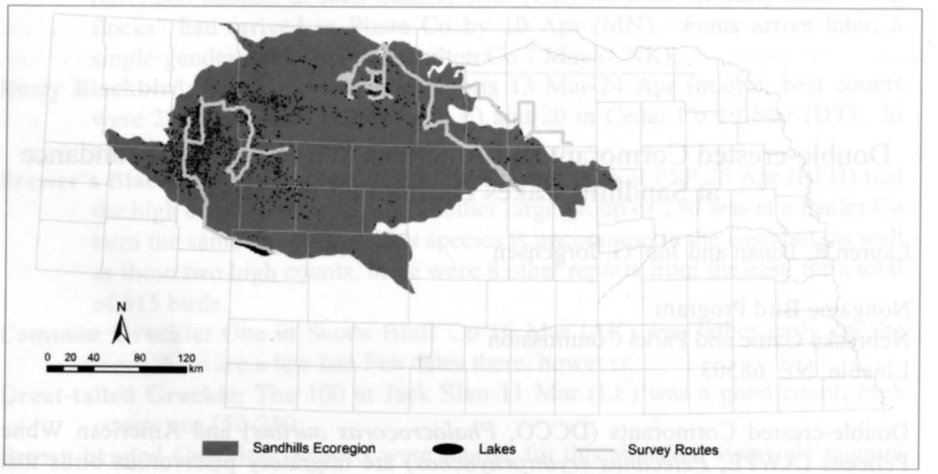

Figure 1. Study area and survey routes – the dark gray area shows the Sandhills ecoregion, the black dots show all lakes within the ecoregion, and the bold light gray lines show the two survey routes.

METHODS

We identified the Sandhills ecoregion, more precisely Sandhills lakes, as our study area (Figure 1). The Sandhills ecoregion covers approximately 12,100,000 acres (4,900,000 hectares) and includes nearly 2,000 shallow lakes (Schneider et al. 2011). We divided the study area into an east and a west region and used ArcGIS (version 9.3) to develop a survey route in each region (Figure 1). We designed routes along public roads in each region; all lakes within a one kilometer distance from the road were selected to be surveyed. Five priority areas included in the study were Lake McConaughy, Crescent Lake National Wildlife Refuge, Calamus Reservoir,

Valentine National Wildlife Refuge, and Merritt Reservoir. We selected survey routes that included priority areas and minimized distance traveled, while maximizing the number of lakes less than one kilometer from the road, the number of public fishing lakes, and the proportion of lakes greater than 160 acres (65 hectares). The west region route consisted of 81 lakes including Lake McConaughy and Crescent Lake National Wildlife Refuge. The east region route consisted of 63 lakes including Calamus Reservoir, Merritt Reservoir, and Valentine National Wildlife Refuge.

We initiated our study in mid-August, which corresponds with the arrival of migrant DCCOs in Nebraska during fall migration (Sharpe et al. 2001). We conducted a two-day survey of each route once a month from August through October 2012. The majority of lakes along each route were surveyed three times, once each month. A small number of lakes (26) were only surveyed twice. We surveyed small to medium-sized lakes (< 900 acres or < 365 hectares) from the nearest one to three access locations depending on the lake size and accessibility. Large lakes and reservoirs were surveyed from all available access points. We visually scanned each lake using binoculars and conducted counts using a spotting scope. We recorded DCCO and AWPE presence/absence and the number of each species present.

DATA SUMMARIZATION

We categorized all lakes in the study area by type and size. We identified three lake types: reservoirs, public fishing lakes, and other lakes. We defined public fishing lakes as lakes with public fishing access excluding reservoirs. We defined other lakes as all lakes in the Sandhills ecoregion that did not fit the other two categories; this included privately owned lakes that may or may not have fishing and publicly owned lakes that do not allow fishing. We categorized lakes by size using the following five size categories: ≥ 1000 acres, 700 – 999 acres, 400 – 699 acres, 100 – 399 acres, and < 100 acres. We determined the proportion of lakes in each size and type category included in the study.

We produced three metrics: presence/absence, abundance, and density to summarize DCCO and AWPE occurrence at Sandhills lakes. We considered each lake as a data point in these analyses. We calculated the percentage of lakes with DCCOs present and the percentage of lakes with AWPEs present by lake type and size. We constructed histograms showing DCCO and AWPE abundance and density at Sandhills lakes. We summarized DCCO and AWPE abundance temporally by adding all individuals recorded, for each species, by month to show the period within fall migration when the largest concentrations were present in the Sandhills ecoregion.

RESULTS

We conducted surveys from 7 August to 16 October 2012. We made a total of 406 lake surveys; 118 lakes were surveyed three times and 26 lakes were surveyed twice. We surveyed 100% of reservoirs (Lake McConaughy, Calamus and Merritt Reservoirs), 77% of public fishing lakes, and 6% of "other lakes" in our study area. We surveyed 93% of the lakes larger than 400 acres. We found 24% of lakes surveyed were dry; these lakes were all small, shallow, "other lakes" and smaller than 100 acres.

Table 1. Number and percent of lakes surveyed with DCCOs and AWPEs present, by lake type and size.

Categories	Number Surveyed	Number with DCCOs	Percent with DCCOs	Number with AWPEs	Percent with AWPEs
Lake Type					
Reservoirs	9	5	56%	5	56%
Public Fishing Lakes	77	34	44%	17	22%
Other Lakes	320	39	12%	31	10%
Lake Size					
≥ 1000 acres	9	5	56%	5	56%
700 – 999 acres	9	4	44%	3	33%
400 – 699 acres	24	15	63%	13	54%
100 – 399 acres	94	27	29%	17	18%
< 100 acres	270	27	10%	15	6%
TOTAL	**406**	**78**	**19%**	**53**	**13%**

Out of 406 lake surveys, 19% had DCCOs present and 13% had AWPEs present (Table 1). DCCOs and AWPEs were absent on the majority of the lake surveys; most lakes with DCCOs and/or AWPEs had relatively small groups present (< 50, Figure 2). The only lake with greater than 300 DCCOs during any survey was Calamus Reservoir, where 7500 DCCOs were estimated to be present on 15 October; 88% of all DCCOs recorded during the study were at Calamus Reservoir. Calamus Reservoir also had the largest concentration of AWPEs, with an estimated 1490

AWPEs observed on 15 October. However, AWPEs were more evenly distributed across lake types with the largest proportion of AWPEs observed at "other lakes".

Out of 406 lake surveys, 389 (96%) had less than 0.1 DCCO per acre (Figure 3). The highest density of DCCOs was observed at Calamus Reservoir (1.3 DCCOs per acre) on 15 October. All other lakes had less than 0.6 DCCOs per acre with the exception of a small lake with 0.9 DCCOs per acre on 18 September; this lake was approximately eight acres and had seven DCCOs present.

Out of 406 lake surveys, 382 (94%) had less than 0.1 AWPEs per acre (Figure 3). The highest density of AWPEs (3.7 AWPEs per acre) was observed at Little Hay Lake, a 27 acre lake at Valentine National Wildlife Refuge, on 27 August. Seven lakes had greater than one AWPE per acre; most of which were "other lakes" with the exception of one public fishing lake at Avocet Wildlife Management Area.

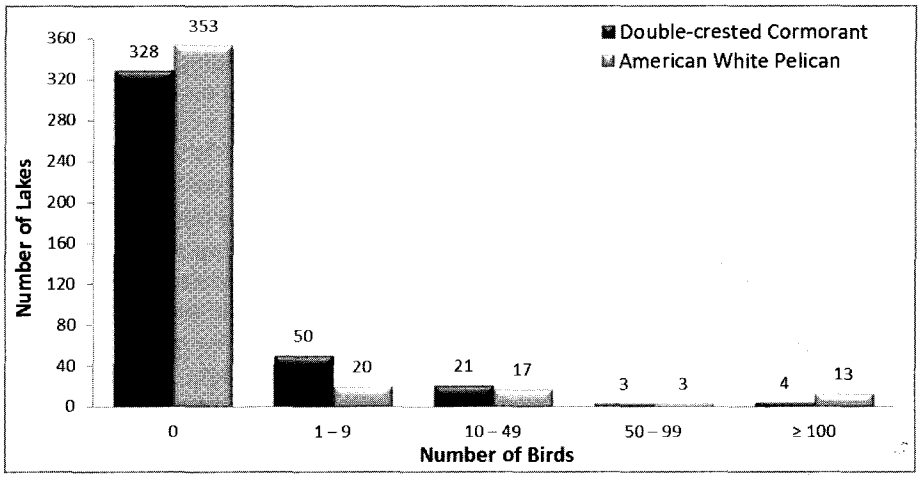

Figure 2. Frequency of DCCO and AWPE abundance (counts) at Sandhill Lakes.

DCCO numbers increased 20 fold from August to October with the largest number of DCCOs being observed in October (Table 2). In August, 66% of DCCOs were observed on "other lakes". In September and October, most DCCOs were observed on reservoirs (82% in September and 97% in October). We observed the largest number of AWPEs in September (Table 2).

DISCUSSION

Fish are a private economic interest when produced commercially for food and stocking. Fish are also a public resource when they occur in public waters and are harvested through recreational fishing. Piscivorous birds feed on fish and,

conceivably, large concentrations of piscivorous birds may cause negative impacts on these resources (Erwin 1995, King 2005, Trapp et al. 1997, USFWS 2003, Seefelt and Gillingham 2006, Groen and Steinwand 2010). All native piscivorous birds that occur in the United States are protected by the federal Migratory Bird Treaty Act (USFWS 2003). Thus, conflicts naturally arise when piscivorous species occur in large concentrations or increase substantially in overall numbers. The DCCO is the piscivorous bird species most frequently identified as causing negative impacts to both public and private resources (USFWS 2003). The AWPE is another piscivorous bird identified, albeit much less frequently and with much less vigor, as causing negative impacts to both public and private resources. DCCOs and AWPEs occur commonly and occasionally in concentrations in Nebraska. Fishing interests have raised concerns about DCCO and AWPE impacts on private and public fish resources in Nebraska, particularly relatively shallow Sandhills lakes (Richard Holland, Nebraska Game and Parks Commission, personal communication).

This study found that large concentrations (i.e.,>100 birds) of DCCOs and AWPEs occur infrequently and locally in the Sandhills Ecoregion during fall migration. DCCOs were found in concentrations of over 300 individuals at only one of the 144 lakes visited in this study. Calamus Reservoir had the largest overall number and highest density of DCCOs; almost eight times (7.6) more DCCOs were at Calamus Reservoir than the total number present at all other reservoirs, public fishing lakes, and "other lakes" combined. Our results suggest Calamus Reservoir is an important

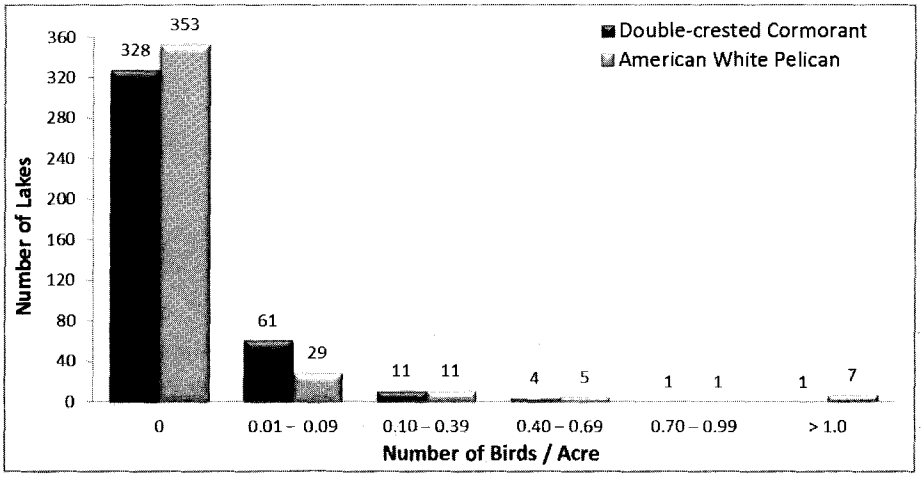

Figure 3. Frequency of DCCO and AWPE density (number/acre) at Sandhill Lake.

staging area for DCCOs during fall migration. Large concentrations were not observed on public fishing lakes or "other lakes". The largest number of DCCOs recorded on a public fishing lake was 80 at Crescent Lake on 10 October. The largest number of DCCOs recorded on "other lakes" was 113 on Goose Lake, Crescent Lake National Wildlife Refuge, on 7 August. However, it should be noted

that a renovated island in Goose Lake supported a breeding colony and adults and near-fledged or fledged juveniles were observed here during the August survey.

In August, the majority of DCCOs were widely distributed in small concentrations at "other lakes". Concentrations were not observed at any lake, with the exception of Goose Lake. During the September surveys DCCO numbers increased on public fishing lakes and reservoirs, but decreased on "other lakes". DCCO numbers peaked in October with a dramatic increase in the numbers observed at Calamus Reservoir. Calamus Reservoir was visited by Jorgensen on 12 November and fewer than 500 DCCOs were present. This additional observation suggests that the October survey recorded peak or near-peak numbers at Calamus Reservoir.

Table 2. Number of DCCOs and AWPEs observed in the Sandhills Ecoregion during fall migration 2012.

Month	DCCO	AWPE
August	387	1746
September	1832	2494
October	8035	2048
TOTAL	**10254**	**6288**

AWPEs were much more evenly distributed across all three lake types. The lake with the largest number of AWPEs was Calamus Reservoir, but some medium-sized public fishing and other lakes had a higher density of AWPEs than Calamus Reservoir. We observed a small number of public fishing lakes (2) and "other lakes" (2) that had between 200 and 500 AWPEs present. AWPE numbers were much more consistent throughout fall migration when compared to DCCOs. AWPE numbers peaked slightly in September.

This study of DCCOs and AWPEs in the Nebraska Sandhills during fall migration provides important preliminary information that can be used to evaluate these species' status. Our results do not provide evidence that Sandhills lakes commonly or routinely host large concentrations (>100 individuals) of DCCOs or AWPEs. Indeed, our results show that most lakes did not have any DCCOs or AWPEs present during fall migration. With an absence of any large concentrations or even individuals, it is highly improbable that either of these piscivorous bird species are negatively impacting public fishing resources in the Sandhills Ecoregion. Our study, however, did not extend into spring migration and bird numbers may be different during that season. Calamus Reservoir was the exception and it appears to be a major staging area for DCCOs during fall migration. NGPC Fisheries Division personnel did not express concerns about large concentrations of DCCOs impacting sportfish resources at Calamus Reservoir because it is believed those birds are feeding mostly on gizzard shad *(Dorosoma cepedianum)* and because lake depth allows fish to avoid capture from diving birds.

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