Locations and Numbers of Double-crested Cormorants using Winter Roosts in the Delta Region of Mississippi

ANDREW R. ADERMAN[1] AND EDWARD P. HILL[2]

Mississippi Cooperative Fish and Wildlife Research Unit
Mississippi State, Mississippi 39762, USA

Present addresses:
[1]U.S. Fish and Wildlife Service
P.O. Box 270, Dillingham, Alaska 99576, USA

[2]Denver Wildlife Research Center
Animal Damage Control, Animal and Plant Health Inspection Service
U.S. Department of Agriculture, Building 16, Denver Federal Center
Denver, Colorado 25266, USA

Abstract.—Monthly counts of Double-crested Cormorants (*Phalacrocorax auritus*) were made at 18 night roosts in the Delta region of Mississippi from October through May during winters 1989-90 and 1990-91 as a basis for estimating wintering populations. Populations peaked at 24,660 birds in April 1990 and 26,893 in March 1991. Numbers of Double-crested Cormorants differed among counts (N=9, P=0.037) and roosts (N=13, P=0.016) in 1989-90, but only among roosts (N=17, P=0.0004) during 1990-91. There was no difference (0.1323>P>0.1223) between adjacent evening and morning counts (N=18) at the same roost. Numbers of Double-crested Cormorants counted entering and leaving roosts were highly correlated (τ=0.947, N=28, P <0.005) with cormorants counted in photographic slides taken after Double-crested Cormorants arrived in the evening and before they departed in the morning. However, direct counts made at the roosts and from slides were different (0.0002>P>0.0001). Roost descriptions are given and influences on population fluctuations are discussed.

Key words.—Counts, Double-crested Cormorant, Mississippi, *Phalacrocorax auritus*, roosts, winter population.

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Catfish (*Ictalurus punctatus*) farming in Mississippi began with the construction of the first pond in Sharkey County in 1965 (Wellborn 1983), and continued growth has produced a large and profitable enterprise. The Mississippi Delta presently has over 38,700 ha of commercial catfish ponds producing an annual crop estimated at $323 million (MCES 1991).

Fish-eating birds have long been a concern at aquacultural facilities, because their feeding activities can result in serious economic losses (Mott 1978). Early reports (Lewis 1929) suggested that the majority of Double-crested Cormorants (*Phalacrocorax auritus*) wintered in marine habitats along the Atlantic and Gulf of Mexico coasts, and that they were found on the fresh waters of the Mississippi River system only in small numbers. Weekly aerial surveys of catfish ponds in the Delta region of Mississippi during 1983-84 and 1984-85 (Christopher 1985) revealed no evidence of wintering cormorant populations.

During the 1970s and 1980s, numbers of Double-crested Cormorants in the Great Lakes region began increasing almost exponentially, as use of organochlorine pesticides was curtailed (Craven and Lev 1987). Other recent increases in Double-crested Cormorant breeding populations have been widely documented (Scharf and Shugart 1981, Milton and Austin-Smith 1983, Buckley and Buckley 1984, Hatch 1984, Hobson *et al.* 1989, Ludwig 1984, Hirsch 1985, Blokpoel and Harfenist 1986, Post 1988, Price and Weseloh 1986, Roney 1986, Craven and Lev 1987).

An increase in numbers of wintering Double-crested Cormorants in the lower Mississippi Valley was documented from Christmas Bird Counts in the 1970s and 1980s (Alexander 1977-90). Dolbeer (1990) summarized data from several studies and found annual population increases of 15 to 63%, most notably in the Great Lakes and northern prairie regions of North America. A recent winter sample from the lower Mis-

sissippi Valley (Dolbeer 1991) found that 38 to 70% of bands recovered were from birds banded in north-central North America from Saskatchewan east through the Great Lakes region. Also, about 10% of the cormorants from both coastal New England and Alberta populations, separated by over 3000 km, undertake annual migrations to the lower Mississippi Valley based on band recoveries (Dolbeer 1991).

With the increase in cormorant wintering populations came reports of extensive catfish depredation in the Mississippi Delta. Cormorants have become the major cause of fish losses among catfish farmers. For example, in a survey of Mississippi catfish farmers, Stickley and Andrews (1989) estimated the annual depredation loss, mostly from Double-crested Cormorants, at $3.3 million US, with another $2.1 million US spent on control efforts. Similar estimates of the depredation losses were made by Glahn and Brugger (1995).

This study was initiated in the Delta regions of Mississippi to: (1) locate and map fall, winter, and spring night roosting assemblages of Double-crested Cormorants; (2) make monthly estimates of Double-crested Cormorants at known night roosting sites; (3) compare differences between roost counts made during evening and during the following morning; and (4) compare differences in estimates of Double-crested Cormorants in roosts made from either morning or evening censuses and from those derived from photographic imagery.

Study Area and Methods

Study Location

The study area consisted of the alluvial valley (Delta) region of Mississippi, bounded on the east by the Mississippi Valley Silty Uplands and on the west by the Mississippi River (Pettry and Koos 1980). The area contains approximately 38,733 ha of commercial catfish ponds (MCES 1991) (Fig. 1). Two counties of the region (Humphreys and Sunflower) each have more catfish acreage than any single state in the United States. The flat fertile Delta soils (Alligator, Sharkey, Commerce, Forestdale, Dubbs, Robinsonville, Dundee, Tunica and Tutwiler) developed from rich alluvium of the Mississippi River and its tributaries (Pettry 1977). Their impervious nature and the presence of the water table within 30 m of the surface were favorable to the rapid development of the catfish industry over the last 15 years (Wellborn 1983).

Roost Locations

Information from biologists, fish farmers, hunters, and fishermen on known and suspected roost locations and on the directions of morning and afternoon cormorant flights aided in locating roosts (G. Littuaer, pers. comm.). Incoming morning flights were backtracked to roosts and evening flights were followed to roosts. A helpful clue in determining if Double-crested Cormorants were actively using a site, was the accumulation of feathers along the shorelines of wetland roost sites. Information gained in a companion study on movements of radio-tagged birds also aided in locating roosts.

Monthly Counts

Double-crested Cormorant counts at each roost were made near the beginning of each month (in cooperation with other research involving roost sites) from October to May, 1989-90 and 1990-91. The Double-crested Cormorants in all of the nighttime roosting sites known to be active were censused in the briefest period possible to avoid missing or recounting birds that may have changed roosts during the census period. At the rate of two roosts each day, morning and evening without interruption, the census required 2 to 7 days (Tables 1 and 2).

Observers involved in morning counts were in position before sunrise, while for evening counts, observers were in position three hours before sunset. Ideally, the census positions were such as to provide a full view of the major flight lanes associated with the roost, and also of the roost itself. Double-crested Cormorants present at the roost when the observer arrived for evening counts or remaining after morning counts were enumerated and recorded on a field data sheet along with times of the first evening arrivals and morning departures. Numbers of cormorants in flights were recorded at 10-min intervals to facilitate determination of peak arrival and departure times. Flock size and cardinal direction of flight were recorded as they passed a predetermined point. When needed, 7×50 binoculars were used for identification and counting. Direct counts of Double-crested Cormorants were made whenever possible; however, in some situations (i.e., massive movements), estimates were used (after Arbib 1972) and recorded as such.

Numbers of Double-crested Cormorants at all roosts, during a census period, were totaled. The assumption was made that no interchange of cormorants occurred between a censused roost and a non-censused roost during the census periods. Kruskall-Wallis one-way analysis of variance by ranks was used to determine differences for population totals within years and among months and sites.

Adjacent Evening and Morning Counts

We censused Double-crested Cormorants in three roosts randomly selected from those active during monthly counts, once in the evening and again the following morning. These counts were made at monthly intervals, at mid-month during the 1990-91 season. We assumed that cormorants do not leave or enter a roosting area during non-daylight hours. The Wilcoxon matched-pairs signed-ranks test was used to determine if evening and morning counts were different. Pairs with zero differences were eliminated from the analysis and the N value in the analysis was reduced accordingly (Daniel 1990).

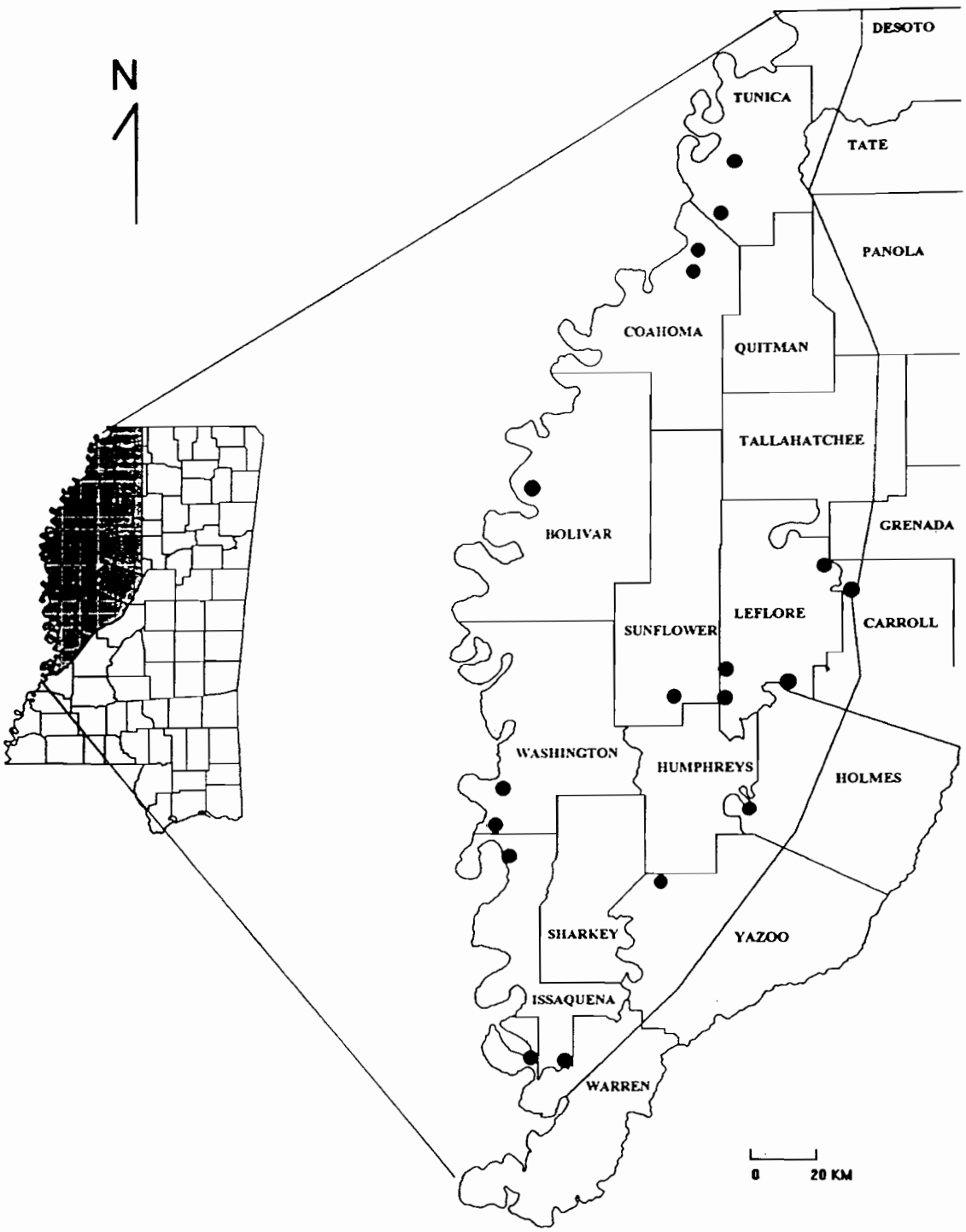

Figure 1. Double-crested Cormorant night roost locations in the Delta region of Mississippi.

Photographic Counts

When time and conditions permitted, a series of overlapping photographic records (slides) were taken at each roost site from a suitable observation point. Photographs of roosts were made with 500 mm telephoto lens, either early in the morning before most of the Double-crested Cormorants had departed, or late in the evening after most cormorants had arrived. Developed slides were projected on a white background (image size: 0.93 m × 1.35 m) and the cormorants counted. Projected images were segmented along convenient separations (trees) and the cormorants in each section were counted and recorded after the same number was ob-

Table 1. Numbers of Double-crested Cormorants counted monthly in night roosts in the Delta region of Mississippi, 1989-90.

	Date									
Roost	Oct 26-27	Nov 10-12	Nov 21-24	Dec 14-18	Jan 05-08	Feb 01-04	Mar 01-05	Apr 03-08	May 04-08	Jun 04-06
Beaver Dam L.	NC[1]		0	—[3]	—	2	0			
Phillips Bayou	UNK[2]	UNK	UNK	UNK	UNK	UNK	UNK	7200	205	0
L. Bolivar Co.	1290	NC	1500	46	—	1844	813	108	9	—
Goose Pond	NC	18	1000	0	0	339	3800	0	0	NC
Lightline L.	UNK	UNK	UNK	UNK	UNK	UNK	4032	5343	51	—
Mathews Brake	NC	201	3410	2000	0	6351	2819	2281	0	1
Ellison L.	UNK	UNK	UNK	UNK	UNK	UNK	4394	0	30	NC
L. Washington	NC	5190	4432	13659	0	0	0	0	0	0
Swamp R.	UNK	UNK	UNK	UNK	UNK	301	3141	6314	423	0
Bee L.	NC	1543	450	800	1754	2802	2194	1803	0	—
Whittington R.	50	—	—	0	0	0	0	2331	53	0
Issaquena R.	UNK	UNK	UNK	30	22	200	190	0	0	NC
Eagle L.	NC	NC	NC	25	0	1135	984	0	0	NC
Totals	1340	6952	10792	16560	1776	12972	22369	24660	771	1

[1]NC = Not censused.

[2]UNK = Unknown roost.

[3]— = No cormorants present (reliable source).

tained consecutively three times. The Wilcoxon matched-pairs signed-rank test was used to detect differences between census and photographic counts. Subsequently, Kendall's tau was used to determine if photographic counts and the corresponding census counts were correlated. Additionally, regression analysis was used to predict Double-crested Cormorant numbers actually present, from the photographic slides. Significance for all tests was determined at alpha = 0.05.

RESULTS

Roost Locations

Through varied approaches, a total of 18 night roosts were located during the two years (Tables 1 and 2). Four sites that contained roosts during 1989-90 were vacated in 1990-91. A majority of the roosts were in permanently flooded forested wetlands (Cowardin *et al.* 1979) of baldcypress (*Taxodium distichum*) or mixes of baldcypress and tupelo gum (*Nyssa aquatica*).

Monthly Counts

The maximum numbers of Double-crested Cormorants counted in any month were 24,660 in April 1990 and 26,893 in March 1991. A mid-winter survey on 26 and 27 February 1990, revealed a total of 28,259 Double-crested Cormorants present in the Delta region of Mississippi. A similar survey conducted on 12 and 13 February 1991, indicated 28,050 cormorants present. Both surveys were conducted within a 24-hour period. The average monthly totals from October through May at all roosts were 11,165 and 13,673 for 1989-90 and 1990-91, respectively. Numbers of cormorants differed significantly among roosts during 1989-90 (N=13, P=0.016) and 1990-91 (N=17, P=0.0004). Total numbers of cormorants differed among monthly counts (N=9) in 1989-90 (P=0.037), whereas in 1990-91 they (N=8) did not (P=0.9637).

Adjacent Evening and Morning Counts

Twenty-one pairs of evening and morning counts were made; 18 pairs were usable for analysis. Wilcoxon matched-pairs signed-rank analysis indicated no difference (0.1323>P>0.1231) between an evening count and the adjacent morning count. Evening counts ranged from four to 10,819 Double-crested Cormorants while morning counts ranged from four to 13,355 birds. Numbers of cormorants in evening counts were greater than in their corresponding morning counts on 10 occasions, and eight

Table 2. Numbers of Double-crested Cormorants counted monthly in night roosts in the Delta region of Mississippi, 1990-91.

	Date							
Roost	Oct 04-08	Nov 01-05	Dec 05-08	Jan 04-09	Feb 01-06	Mar 03-08	Apr 04-11	May 03-09
Beaver Dam L.	710	1165	1508	254	1239	8273	2367	3
Phillips Bayou	0	0	0	0	0	0	582	69
Moon L.	UNK[1]	UNK	UNK	UNK	UNK	UNK	300	0
Long L.	UNK	1465	62	0	65	0	0	0
L. Bolivar Co.	1229	3032	344	662	1811	712	26	95
Goose Pond	149	570	0	0	0	1673	16	28
Lightline L.	—	—	—	—	8877	4180	7451	6
Mathews Brake	64	91	5791	0	2850	5987	18	3
Little Mossy L.	0	0	0	2663	0	0	0	0
Ellison L.	0	10	0	0	0	0	0	5
Duncan R.	106	0	0	0	0	0	0	14
L. Washington	2145	1132	0	5682	3616	0	0	0
River Chute	UNK	UNK	UNK	UNK	UNK	UNK	855	118
Bee L.	73	142	1524	7977	1262	5381	528	28
Whittington R.	347	191	0	0	0	687	1273	37
Issaquena R.	0	0	184	5500	0	0	0	0
Eagle L.	0	15	2443	500	1216	0	0	2
Totals	4823	7813	11856	23238	20936	26893	13416	408

[1]UNK = Unknown roost.

[2]— = No cormorants present (reliable source).

morning counts had a greater number of birds than in corresponding evening counts. Three pairs yielded no difference and were not used in the analysis. As might be expected, the greater the number of cormorants using a roost, the greater the difference between the evening and morning totals.

Photographic Counts

Twenty-eight separate photographic series of roosts (11 morning, 17 evening) were taken during this study (Table 3). Wilcoxon matched-pairs signed-rank analysis indicated a significant difference ($0.0002>P>0.0001$) between the photographic total and the census total; however, Kendall's tau indicated a high correlation ($\tau=0.947$, $P<0.005$). Regression analysis yielded the equation:

$$y = -111 + 1.36x$$

where x is the number of cormorants counted on slides and y is number present, based on direct counts. Totals for the photographic counts ranged from three to 6,106 while census counts ranged from three to 8,371 DCC. Six pairs yielded no difference and were not used in the matched-pairs analysis.

DISCUSSION

Roost Locations

Characteristics of roosts that appeared common among those studied were availability of suitable roosting trees surrounded by open water. Cormorants roosted in bald cypress almost exclusively. Exceptions include the use of hardwoods at the Issaquena Roost and the use of willow (*Salix* spp.) and cottonwood (*Populus* spp.) at the River Chute. It appeared that large, dead cypress trees, or those with dead limbs, were preferred over younger and healthier trees. Larger, less foliated limbs may have been more suitable for arriving, resting and departing birds.

During the study, several individuals commented that the cormorants were killing the bald cypress trees in their lakes. Cypress trees are dormant from mid November to mid March, the time period when cormo-

Table 3. Date, time, location and numbers of Double-crested Cormorants (DCCO) counted on photographic imagery (slides) and numbers of cormorants present when counted entering or leaving roosts in the Delta region of Mississippi between October 1989 and May 1991.

Date	Time	Roost location	No. DCCOs Photo	No. DCCOs Count
27 Oct 1989	morning	L. Bolivar Co.	1196	1290
1 Feb 1990	evening	L. Bolivar Co.	1065	1444
6 Apr 1990	evening	Phillips Bayou	4720	6203
6 Oct 1990	morning	L. Bolivar Co.	915	1229
8 Oct 1990	morning	Duncan Roost	88	106
19 Oct 1990	evening	L. Bolivar Co.	1550	2096
23 Nov 1990	evening	L. Bolivar Co.	1062	1081
6 Dec 1990	morning	L. Bolivar Co.	288	304
18 Dec 1990	evening	Eagle Lake	257	239
2 Feb 1991	evening	Lightline Lake	6106	8371
3 Feb 1991	evening	Beaver Dam L.	1067	1078
4 Feb 1991	evening	L. Bolivar Co.	1798	1811
15 Feb 1991	evening	L. Washington	1859	1850
3 Mar 1991	evening	Whittington R.	831	886
5 Mar 1991	morning	L. Bolivar Co.	728	711
8 Mar 1991	morning	Whittington R.	640	687
6 Apr 1991	morning	Goose Pond	19	19
7 Apr 1991	morning	Phillips Bayou	126	155
14 Apr 1991	evening	Phillips Bayou	1198	1822
15 Apr 1991	morning	Phillips Bayou	1133	1404
15 Apr 1991	evening	Lightline Lake	3741	5374
3 May 1991	evening	Mathews Brake	3	3
4 May 1991	morning	Duncan Roost	13	14
4 May 1991	morning	Ellison Lake	5	5
4 May 1991	evening	Lightline Lake	6	6
5 May 1991	evening	Beaver Dam L.	3	3
6 May 1991	evening	L. Bolivar Co.	87	95
18 May 1991	morning	Bee Lake	4	4

rants are present. Given the high amount of precipitation during the spring, it is doubtful that guano on the limbs has any adverse affects on tree growth. The increased enrichment of the water in and around the roost may even have a positive effect on tree growth. However, cormorants were observed on several occasions to "clear" the limb on which they were roosting of any green twigs. On numerous occasions dead limbs broke under the weight of cormorants on them. The combined loss of many green twigs and broken branches may possibly contribute to the death of limbs or trees, but this is uncertain.

Size of the water body did not seem to influence roost site selection, and the degree of seclusion among selected roost sites also seemed variable. Some roosts appeared protected from most human disturbances, whereas others were within 0.5 km of busy highways and could be easily seen by passing motorists. Two sites, Eagle Lake and Lake Washington, contained active roosts and had high recreational and commercial use.

Given the high mobility and feeding characteristics of this species (see Mendall 1936, Palmer 1962, Johnsgard 1993), close proximity to feeding sites would not appear to be an important determinant for roost locations. High stocking densities and shallow depths of catfish ponds, would appear to offer ideal foraging sites for cormorants. With their high mobility (King *et al.* 1995), cormorants were capable of roosting on one side of the Mississippi River while feeding at distances of 20 km on the other.

Characteristics of day roosts were even less restrictive than night roosts. Double-crested Cormorants were observed roosting in short (<3 m) willows bordering flooded cotton fields, on floating logs, on powerline

poles over water, and in temporarily flooded cypress stands.

Monthly Counts

The monthly totals presented in Tables 1 and 2 represent minimum estimates. Information obtained after each period indicated that there were a few other uncounted roosts. During the February 1990 census, the Lightline, Ellison Lake and Swamp roosts were believed to be active, and each may have contained 3,000-4,000 cormorants. During the March 1990 census, the Phillips Bayou and River Chute roosts may have contained 3,000 to 6,000 and about 3,000 birds, respectively.

The variability in numbers of cormorants among monthly counts (Tables 1 and 2) suggests that there is substantial movement among birds in the Delta region of Mississippi. The Lake Washington roost contained more cormorants (2,145) than any other roost during October 1990. A month later about half as many were present, and none were present in December. However, a roost developed just across the border in Arkansas.

In early January 1991, Lake Washington was the second largest roost with 5,682 Double-crested Cormorants present. An evening and morning comparison on 19 and 20 January 1991 revealed an average of 12,087 birds present, the largest number of cormorants counted at a roost for the 1990-91 season. Two weeks later this number had decreased to 3,616, and no cormorants were seen in March. Mott *et al.* (1990) noted great fluctuations in cormorant numbers at Lake Washington, Mathews Brake, Little Mossy and Bee lakes, from November 1988 through March 1989.

Several factors seem to have influenced these movements. Obviously, numbers increased as more cormorants migrated from other areas. Weather factors may have been partially responsible for variations in total monthly numbers of cormorants. The cold weather of December 1989 was thought to have been responsible for the decrease in cormorant numbers in January. Beaver Dam Lake, the northernmost roost in the study area, was almost completely covered with ice on 18 December 1989; Eagle Lake, a large lake in the southern part of the study area, froze on 25 December. Many catfish ponds in the central part of the study area were also frozen at this time. It appears that cormorants migrated out of the Delta region once ice conditions made feeding impossible.

Harassment at the roosts and at feeding areas also probably influenced cormorant movements. Human activity often frightened the birds away from roosts. Much of the disturbance (i.e., fishing, checking trotlines, duck hunters going to or from blinds, and commercial fishermen checking their nets) appeared unintentional, but deliberate harassment may have occurred.

Collecting efforts to assess the diets of roosting Double-crested Cormorants (Glahn *et al.* 1995) also were a source of harassment. For example, after the initial shotgun blasts at Goose Pond roost, all the cormorants present (*c.* 1,000) departed and did not return. Roost counts five days after collection revealed that such disturbance usually caused a decrease in numbers of cormorants at a site. Efforts at night to capture cormorants at roosts also reduced bird numbers. Mott *et al.* (1990) also noted a decrease in the numbers of roosting Double-crested Cormorants following nighttime harassment activities.

Adjacent Evening and Morning Counts

Knowledge of the similarities in numbers of cormorants counted in the evening and the following morning at the same roost makes it possible to estimate bird numbers at separate roosts morning and evening with confidence that the estimates are reasonably accurate.

Photographic Counts

Estimates of the size of roosting cormorant populations by photographic analysis usually underestimates bird numbers and require compensation. However, advantages of photographing cormorant roosts include: (1) photo counts of birds can be repeated

several times, at leisure, and by different people; (2) photos provide factual evidence of the presence of cormorants and shows their pattern of distribution and abundance; and (3) photo counts of the birds are usually highly correlated with the actual population size.

Differences between direct counts of birds and counts from photos may have been attributable to underestimating the numbers of cormorants present in roosts when counts were begun. Also, Double-crested Cormorants on the water did not show up in the photos. The stand of trees in the Lightline Lake roost, for example, were fairly dense and some cormorants hidden by trees could not be seen in the photos. Also some roosts were virtually impossible to photograph because of their configuration. For example, Bee Lake is quite narrow (<150 m) and when a large number of cormorants are present, the roost extended up to 3 km in length. Other problems included the weather, a stable and dry site from which to take the photographs (for those roosts that must be accessed by boat), behavior of the birds, technical problems with cameras and film developing, and the time required to execute photo counts of roosts containing more than 3,000 cormorants.

CONCLUSIONS

Wintering populations of Double-crested Cormorants in the Delta region peaked during April 1990 and March 1991, and they roosted primarily in 18 randomly scattered and mostly isolated baldcypress swamps and wetlands. The largest changes in population numbers appeared to be associated with weather changes, particularly cold temperatures that froze feeding areas. Paired morning/evening counts of Double-crested Cormorants entering and leaving several roosts suggest that there was little movement between roosts after darkness. This information is basic to understanding the dynamics, daily movements, and roosting behavior of wintering populations of cormorants that prey on farm-raised catfish and other aquaculture products in the lower Mississippi Valley. Moreover, it is critical to the development of nonlethel strategies that will reduce depredation losses.

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