

The Status and Distribution of Wading Birds in South Carolina, 1988 - 1996

*Biologists Report Results of Years of Research
Into These Popular Species*

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INTRODUCTION

In this paper, we present an overview of recent trends in the status and distribution of wading birds in South Carolina. Although historic information is available on wading bird nesting in the Carolinas, it is almost exclusively qualitative in nature. In addition, it is found primarily in unpublished reports and letters which are difficult for researchers to access. Due to their limited scope and qualitative nature, these historic records seldom provide useful information for assessing the size and distribution of wading bird populations during the early part of this century.

The first attempt to determine the status and distribution of wading birds in South Carolina was initiated by the U.S. Fish and Wildlife Service in 1975 as part of an overall survey of the Atlantic coast (Custer and Osborn 1978). Survey efforts were restricted to the coastal zone, and the Service only checked historic inland colonies for activity. Consequently, only 22 colonies were located in South Carolina.

Because of the lack of information on the size of wading bird populations and the increasing threat to foraging and nesting habitat from residential and industrial development, the South Carolina Department of Natural Resources initiated a study in 1988 to determine the status and distribution of wading bird nesting on the coastal plain. In this paper, we summarize and report the results of the 1988, 1989, 1994, and 1996 surveys and compare the status of 13 species of wading birds. In addition, we rank colonies by their relative importance using a numerical scoring system.

METHODS

Beginning in 1988, we conducted aerial surveys of all known wading bird colonies in the coastal plain of South Carolina to determine nesting status (Post and Gauthreaux 1989). We documented colonies from published literature (Custer and Osborn 1978), the Colonial Bird Register (1989), the South Carolina Colonial Waterbird Database (1996), and 10 years of incidental data collected by the Wildlife Diversity Section of the South Carolina Department of Natural Resources.

Because Great Blue Herons and Great Egrets initiate nesting earlier than other wading birds in South Carolina, we began surveying for these species in mid-late April. We surveyed all other species beginning in the 2nd week in May. In 1989 and 1996, we also located colonies during aerial surveys flown on transect lines parallel to the Atlantic coast. In 1989, we flew transects at 5 nm intervals from the coastline to 40 miles inland and at 10 nm intervals from 40 to 80 miles inland. In 1996, we reduced transect spacing to 5 km intervals from the coastline to 70 km inland. In addition, we flew all major river drainages from 70 km to 135 km inland. We conducted transect surveys in May, when nesting had begun in all colonies.

Once located, we obtained an aerial count or estimate (Dodd and Murphy 1995) for each active colony. During the 1988, 1989, 1994, and 1996 nesting seasons, we visited all colonies containing more than 30 nests on the ground, with the exception of between 2 - 4 colonies for which we could not obtain landowner permission. During this visit, we conducted a complete ground count (Dodd and Murphy 1995) of wading bird nests.

We included thirteen species of colonial wading birds and related tree and shrub-nesting waterbird species in our surveys (Table 1). However, several species (Black-crowned Night-Herons, Yellow-crowned Night-Herons, and Anhingas) are semi-colonial and are often found nesting on the periphery of colonies (M. Dodd, pers. observ.). We recorded nests of these species when located, but our statewide totals represent only a fraction of the nesting attempts.

We visited colonies between the peak of incubation and when chicks are capable of climbing from the nest structure. In some multi-species colonies, we made an additional visit to account for the difference in nesting chronology between large and small wading bird species (Table 2). In addition, we revisited all known White Ibis colonies in July to account for any late nesting attempts. We distinguished wading bird nests by their relative size and placement in the canopy (McCrimmon 1978). Because the nests and eggs of Little Blue Herons, Tricolored Herons, and Snowy Egrets are difficult to identify to species, we timed census visits so that nestlings were visible.

Table 1. Waterbird species nesting in South Carolina colonies, 1988-96.

Common name	Scientific Name
Anhinga	<i>Anhinga anhinga</i>
Black-crowned Night-Heron	<i>Nycticorax nycticorax</i>
Cattle Egret	<i>Bubulcus ibis</i>
Double-crested Cormorant	<i>Phalacrocorax auritus</i>
Glossy Ibis	<i>Plegadis falcinellus</i>
Great Blue Heron	<i>Ardea herodias</i>
Great Egret	<i>Casmerodius albus</i>
Little Blue Heron	<i>Egretta caerulea</i>
Snowy Egret	<i>Egretta thula</i>
Tricolored Heron	<i>Egretta tricolor</i>
White Ibis	<i>Eudocimus albus</i>
Wood Stork	<i>Mycteria americana</i>
Yellow-crowned Night-Heron	<i>Nyctanassa violacea</i>

Because Little Blue Heron nests are often clumped in a single area in a colony, the relative distribution of nests in the colony was also used to aid in the identification of nests (M. Dodd pers. observ.).

Assessment of Nesting Trends

Although we report minimum statewide nest counts for each species, we often used estimation techniques with our ground counts to obtain statewide totals. The variability of these estimation techniques (see Dodd and Murphy 1995) must be taken into account when assessing trends in wading bird nesting populations. Therefore, we adjusted nest estimates and calculated approximate 95% confidence limits for the statewide nesting effort based on the regression relationship between ground counts and corresponding technique estimates (Dodd and Murphy 1995). Overlap of approximate confidence limits indicates that annual estimates are not different. If we did not use estimation techniques and conducted only ground counts to obtain statewide totals, we made no adjustments to nest counts and did not calculate confidence limits.

Table 2. Census dates for South Carolina wading bird colonies, 1988-1996. Wading bird species are combined into groups to facilitate the planning of census visits. The interval roughly corresponds to the time between the peak of incubation and when chicks are able to leave the nest (Post 1985, M. Dodd, pers. observ.).

Nesting species by group	Optimal census dates
Great Blue Heron	April 1 - April 21
Great Blue Heron- Great Egret	April 21 - May 1
Great Egret-Wood Stork- small waders ^a	May 1 - May 14
Small waders	May 14 - May 31
Small waders- Cattle Egrets- Ibis spp.	May 21 - June 7
Cattle Egrets- Ibis spp.	June 7 - June 21
Great Egrets- small waders- (2 censuses)	April 21 - May 1
Cattle Egrets- Ibis spp.	June 7 - June 21

a The small wader group includes Anhinga, Little Blue Heron, Snowy Egret, Tricolored Heron, Black-crowned Night-Heron, and Yellow-crowned Night-Heron.

We used aerial photographic counts, point counts, or perimeter counts (Dodd and Murphy 1995) when a colony was discovered late in the season and potential nest disturbance prevented us from conducting a complete ground count. Unfortunately, these counting techniques were found to be so highly variable in estimating Great Blue Heron nests (Dodd and Murphy 1995) that our confidence limits were often wider than the total population estimate. Because the number of nests counted with aerial photographic, point, or perimeter techniques generally accounted for less than 5% of the total statewide nesting anyway, we excluded from our assessment of nesting trends the counts we obtained using those techniques.

Nesting Distributions

We used distribution-free, multi-response permutation procedures (MRPP) (Mielke 1976, Slauson *et al.* 1991) to calculate the probability of the annual colony distributions being the same. We chose Euclidean distance measures

(deviations) for MRPP statistics because of their greater power to detect differences between skewed, non-normal distributions.

Size Class Distributions

For each survey year, we calculated the proportion of colonies in each of seven size classes. We used a Chi-square Test of Homogeneity to test for differences in the proportion of colonies in size classes between survey years.

Colony Rankings

We ranked colonies for relative importance according to a system developed by Runde (1991). This ranking scheme is based on colony size, species richness, history of activity, and the combined biological score of each nesting species (Appendix A). Because the ranking system required a history of nesting, we did not calculate rankings for 1988, the first year of our study.

RESULTS AND DISCUSSION

Abundance and Distribution of Wading Birds (All Species Combined)

We found 96 - 180 active wading bird colonies from aerial surveys conducted from 1988 to 1996 (Table 3). The increase in the number of colonies during our study does not necessarily represent a real increase in colonies but is partly a result of the cumulative effects of the surveying program. Although we were not able to quantify the accuracy of our survey technique, we occasionally failed to locate very small colonies and colonies containing only dark-colored birds. In 1994 and 1996, we found that several of the newly discovered small colonies had been active in previous survey years. We suspect, however, that we were more efficient at locating large colonies. For example, we located only 1 large colony (more than 250 nests) which we could verify as having been active in a previous survey year. The increase in the number of colonies during the study is primarily a result of the addition of small colonies.

We located colonies throughout the coastal plain of South Carolina, as far inland as Aiken, Kershaw, and Marlboro counties (see Figure 1). However, 64 - 80% of the colonies were found in the 6 coastal counties (Figures 2-5). In addition to the coastal nesting, a large number of colonies were associated with the Cooper and Wateree river drainages and lakes Marion and Moultrie. With the exception of Cattle Egrets, the distribution of wading bird colonies in South Carolina can at least be partially explained by the distribution of wetland habitats. Wading bird nesting was grossly correlated with total wetland area in coastal counties (Dodd and Murphy, in prep.). Although high quality

Table 3. Summary of colonial waterbird (all species combined) nesting sites in South Carolina, 1988, 1989, 1994, and 1996.

	1988	1989	1994	1996
Number of colonies	96	108	143	180
Minimum nest estimate	36,647	59,483	46,510	52,587
Average size (nests)	340	551	325	292
SD	927.9	1,684.0	1,125.9	1,554.4
Minimum size	2	1	1	1
Maximum size	6,115	11,682	9,462	20,356

nesting sites appear to be limited in some areas, the pattern of nesting is consistent with the availability of foraging habitat.

The spatial distribution of colonies did not differ between survey years ($P = 0.80$), suggesting that there were no large scale shifts in colony location. The stability of the distribution of wading bird colonies was likely a result of the relative stability of wetland habitat during our study.

The total number of wading bird nests fluctuated during our study with high counts of 59,483 and 52,587 in 1989 and 1996, respectively (Table 3). The fluctuations in nest totals were primarily a result of a single species, White Ibis. Average colony sizes were similar for all survey years, but nearly doubled in size during the 1989 nesting season. Maximum colony size ranged from 6,115 to 20,356 nests.

Between forty-one and 53% of the colonies were in the smallest size class (< 30 nests, Figure 6). Less than 5% of the colonies contained >3000 nests. There was no difference in colony size class distributions between survey years ($\chi^2 = 14.89$, $df = 18$, $P = 0.67$).

The lack of change in the spatial distribution of colonies and the colony size class distributions suggest that wading bird nesting populations in South Carolina were stable during our study. However, because we included species in the statewide nesting totals for which we have incomplete surveys, assessments of trends in wading bird nesting populations will be made on a species by species basis.

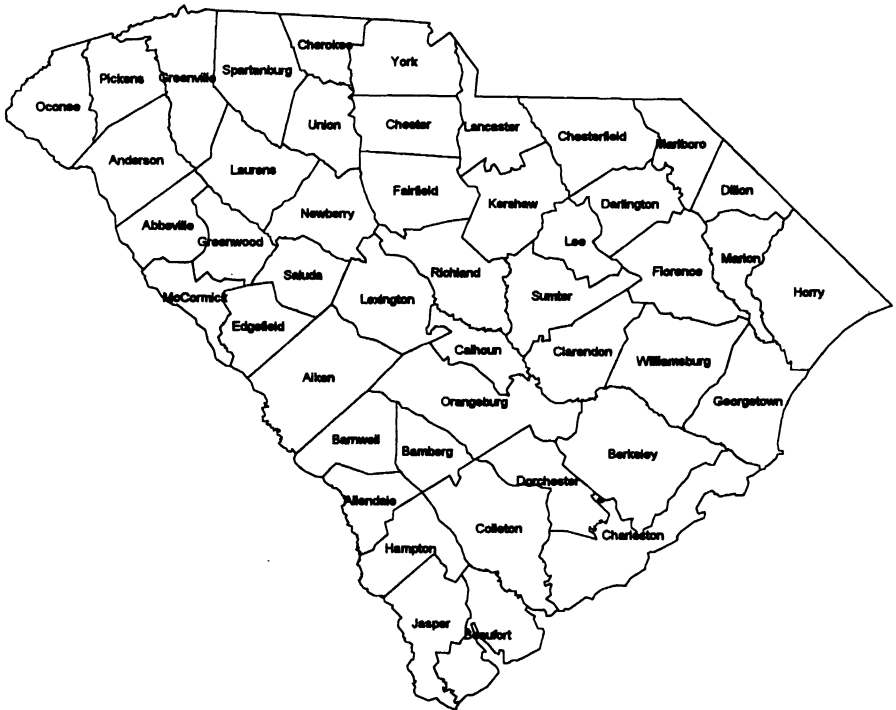


Figure 1. Locations of South Carolina counties

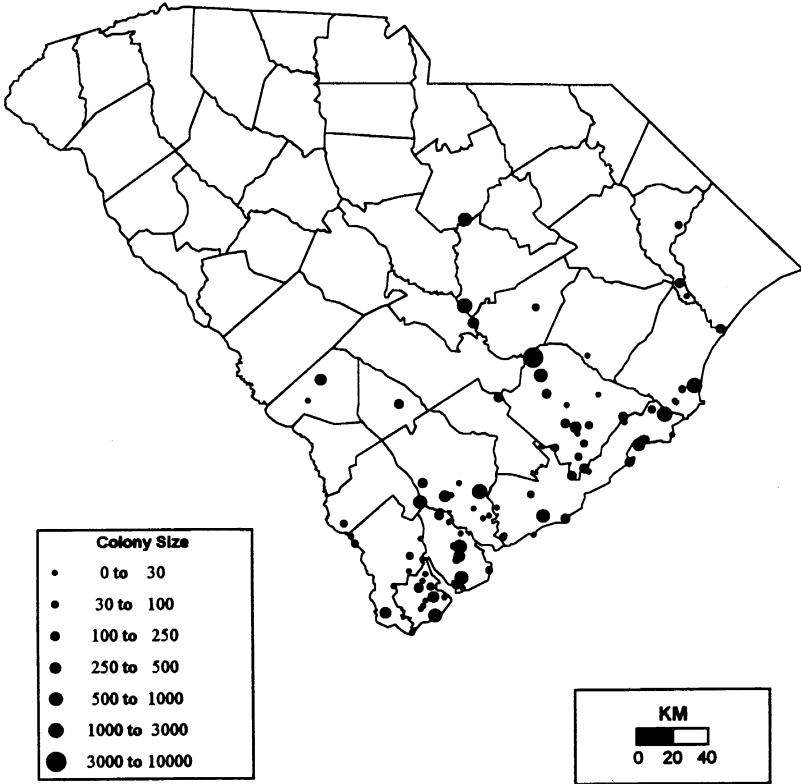


Figure 2. Wading bird nesting locations in South Carolina, 1988.

n = 96

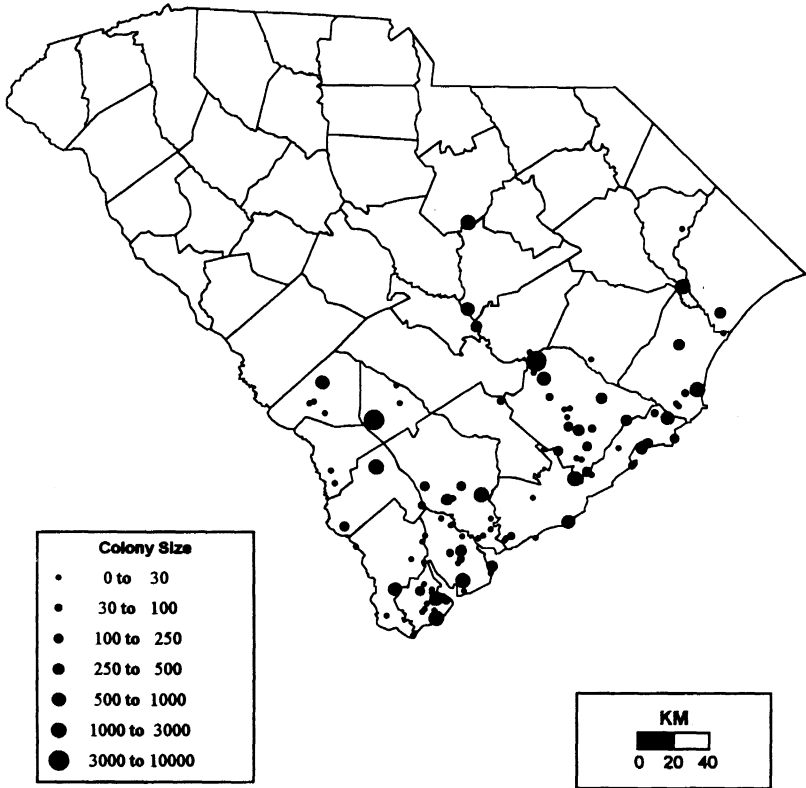


Figure 3. Wading bird nesting locations in South Carolina, 1989.

n = 108

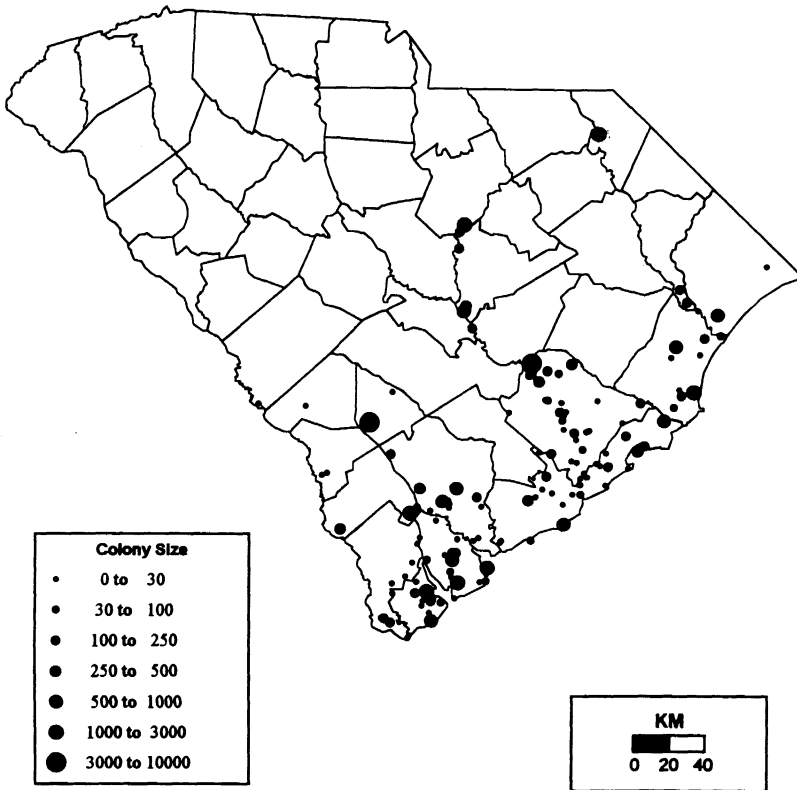


Figure 4. Wading bird nesting locations in South Carolina, 1994.

n = 143

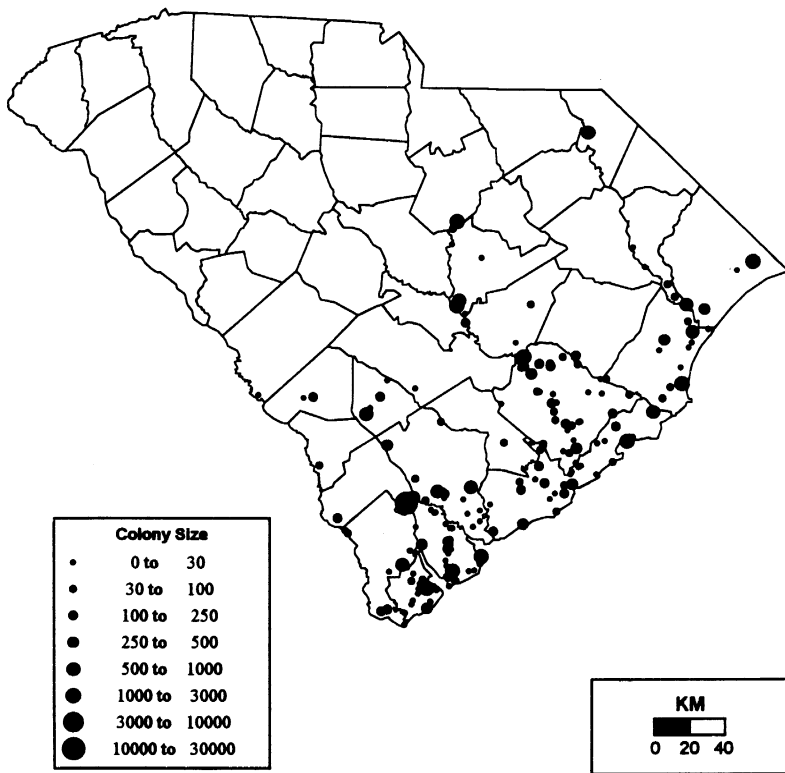


Figure 5. Wading bird nesting locations in South Carolina, 1996.

n = 180

Abundance and Distribution of Individual Species

All wading bird species found nesting in South Carolina occur in multi-species colonies (S. C. Colonial Waterbird Database 1996). In the following section, colony characteristics such as average colony size will refer to a individual species rather than the entire multi-species colony. However, an individual species' nesting totals may represent only a small portion of the total colony size.

White Ibis

Historically the two largest White Ibis colonies in South Carolina were located in coastal estuaries (Bildstein *et al.* 1990, S. C. Colonial Waterbird Database 1996). During our study, the majority of nesting was found in large inland colonies associated with freshwater habitats (Figure 7). We did not detect a change in the spatial distribution of colonies between 1988 and 1996 ($P = 0.999$).

White Ibis were the most abundant ciconiiform nesting in South Carolina, with a 4-year minimum nest total of 56,294 (Table 4). Although estimation techniques were used during colony censuses, insufficient samples were available to establish a regression relationship between technique estimates and complete ground counts. Therefore, we rely on minimum nest counts to assess changes in the nesting population. These minimum nest counts must be viewed with caution because they usually represent an undercount of nesting attempts (Dodd and Murphy 1995). Based on minimum counts, White Ibis nesting populations fluctuated extensively between years, with nest totals ranging from 9,476 to 20,798 nests (Table 4).

Average and maximum colony sizes were more than twice as large as other wading bird species included in our study. Average colony size fluctuated with nest totals. Nesting was generally concentrated in fewer than 10 colonies in which White Ibises were the dominant species. Over 50% of nesting attempts in a given year were in colonies containing over 1,000 nests (Figure 8). We found a significant difference in the proportion of colonies in size classes between years ($\chi^2 = 242.69$, $df = 18$, $P < 0.0001$). Although White Ibis used many of the same nesting sites during our surveys, nest totals within these sites fluctuated greatly.

White Ibis nesting fluctuated extensively during our surveys. The variability in annual nesting makes it difficult to assess nesting trends. Despite this variability, South Carolina appears to maintain a minimum nesting population of approximately 10,000 pairs annually. However, due to their nomadic nature (Frederick *et al.* 1996), it may be necessary to examine nesting

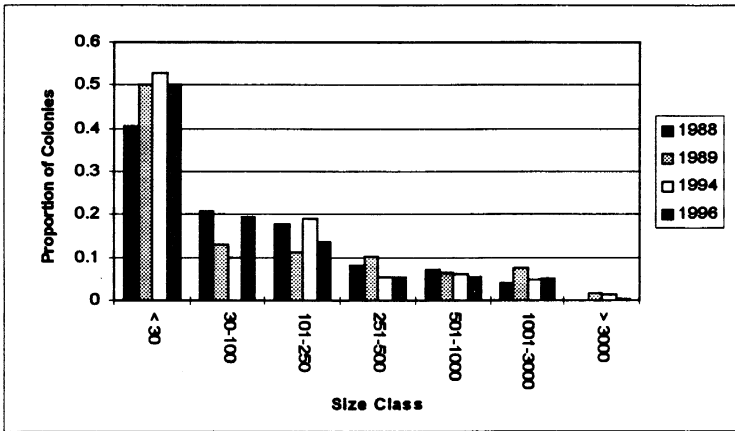
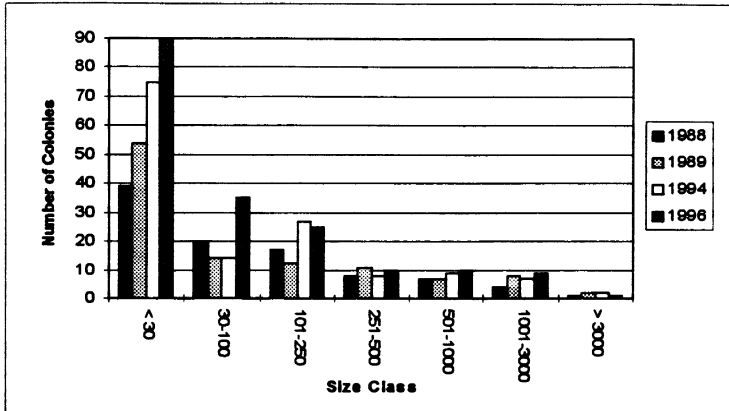


Figure 6. Numbers and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

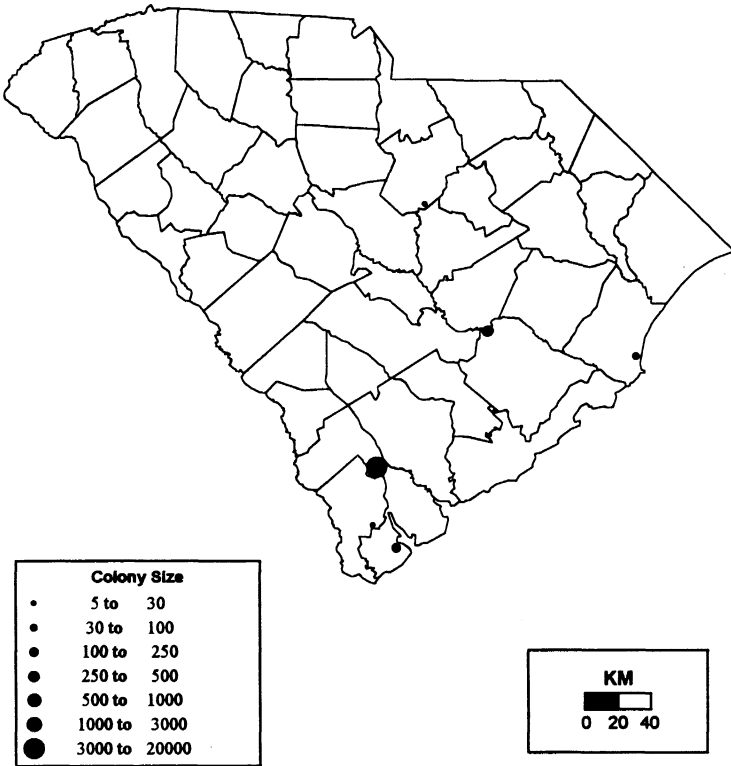


Figure 7. White Ibis nesting locations in South Carolina, 1996.

Table 4. Summary of nesting sites for 13 species of colonial waterbirds in South Carolina, 1988, 1989, 1994, and 1996.

Species	Year	No. colonies	Minimum ^a nest est.	Avg. ^b colony size	SD	Min nests	Max. nests
White Ibis	1988	6	9,618	1,603.00	1,414.50	60	3745
	1989	8	20,798	2,599.75	2,822.26	9	7789
	1994	5	9,476	1,895.20	3,076.41	1	7296
	1996	6	16,402	2733.67	6415.53	5	15,827
Cattle Egret	1988	26	8,283	318.58	694.30	1	3528
	1989	27	19,206	711.33	1,274.30	1	5003
	1994	26	15,957	613.73	1,383.69	2	6454
	1996	29	11,035	380.52	673.90	2	3323
Great Egret	1988	54	4,796	88.81	165.00	1	779
	1989	53	5,111	96.43	179.73	1	820
	1994	57	6,980	122.46	258.24	1	1711
	1996	70	8,798	125.69	266.76	1	1987
Snowy Egret	1988	30	3,233	107.77	141.43	1	470
	1989	24	4,606	191.92	243.48	1	842
	1994	35	3,691	105.46	179.71	1	813
	1996	38	3,912	102.95	185.46	1	870
Great Blue Heron	1988	52	2,777	53.40	143.62	1	837
	1989	59	2,506	42.47	116.05	1	693
	1994	90	2,547	28.30	77.02	1	619
	1996	110	2,655	24.14	58.51	1	549
Tricolored Heron	1988	22	1,736	78.91	162.30	1	741
	1989	22	2,412	109.64	190.75	1	767
	1994	27	2,071	76.70	128.38	1	570
	1996	31	2,318	74.77	159.60	1	673
Little Blue Heron	1988	27	782	28.96	33.44	1	115
	1989	32	2,693	84.16	88.38	1	303
	1994	32	2,058	64.31	85.98	1	334
	1996	42	2,125	50.60	86.45	1	466
Anhinga	1988	34	921	27.09	42.22	1	164
	1989	28	937	33.46	58.40	1	238
	1994	49	1,397	28.51	36.26	1	155
	1996	74	1,879	25.39	40.17	1	241
Wood Stork	1988	3	179	59.67	42.34	23	106
	1989	3	376	125.33	136.64	21	280
	1994	7	712	101.71	127.74	2	372
	1996	7	953	136.14	128.92	3	398

Species	Year	No. colonies	Minimum ^a nest est.	Avg. ^b colony size	SD	Min nests	Max nests
Double-crested Cormorant	1988	2	72	36.00	43.84	5	67
	1989	4	58	14.50	9.11	5	26
	1994	8	515	64.38	125.33	2	368
	1996	10	895	89.50	134.55	4	447
Yellow-crowned Night-Heron	1988	0	0	0	0	0	0
	1989	5	35	7.00	3.74	4	13
	1994	4	507	126.75	228.29	5	469
	1996	11	973	88.45	259.48	1	870
Black-crowned Night-Heron	1988	15	153	10.20	12.13	1	48
	1989	24	489	20.38	52.12	1	257
	1994	26	311	11.96	19.17	1	89
	1996	29	284	9.79	17.79	1	96
Glossy Ibis	1988	3	97	32.33	42.19	6	81
	1989	4	256	64.00	107.54	1	224
	1994	4	288	72.00	117.33	13	248
	1996	2	358	179.00	229.10	17	341

a Statewide nest estimate based on minimum counts. Counts were not adjusted using the regression equation for the relationship between census technique estimates and ground counts.

b Average number of nests/colony.

trends on a larger scale (regional) to assess the health of White Ibis populations.

Cattle Egret

Cattle Egret colonies were widely distributed throughout the study area, however, all large colonies were located in the upper coastal plain (Figure 9). In large colonies, Cattle Egrets were the dominant species accounting for up to 99% of a colony's nesting. In colonies closer to the coast they often accounted for a small portion of the total nesting. We found no difference in the spatial distribution of Cattle Egret colonies between years ($P = 1.0$).

Cattle Egrets were the second most abundant wading bird species nesting in South Carolina during our study. Average colony sizes were larger than all other species except White Ibis. Approximate confidence limits for nest estimates indicated an increase in nesting between 1988 and 1989, and a small decrease between 1994 and 1996 (Figure 10). The increase in nesting between 1988 and 1989 was partially a result of a large colony of approximately 2,500 nests which was not located in 1988 and later determined to be active from observer accounts. In addition, we suspect we missed another large colony in Bamberg County in 1988, but we could not confirm this from eyewitnesses.

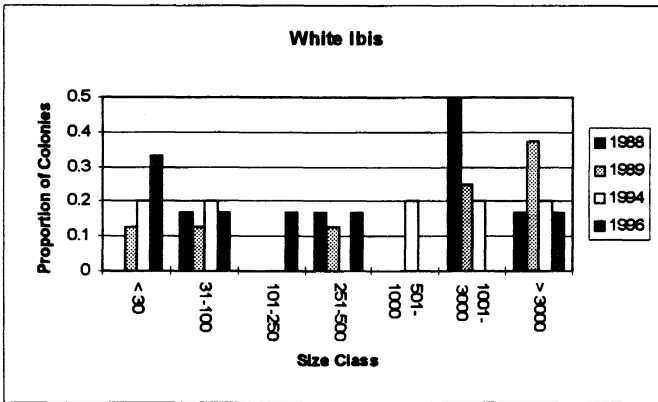
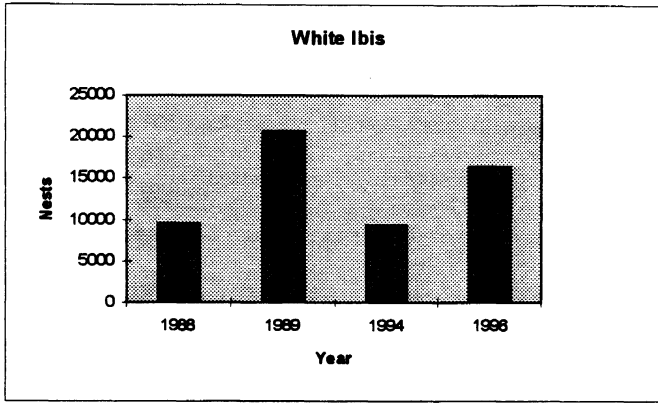


Figure 8. White Ibis nesting trends and relative proportion of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

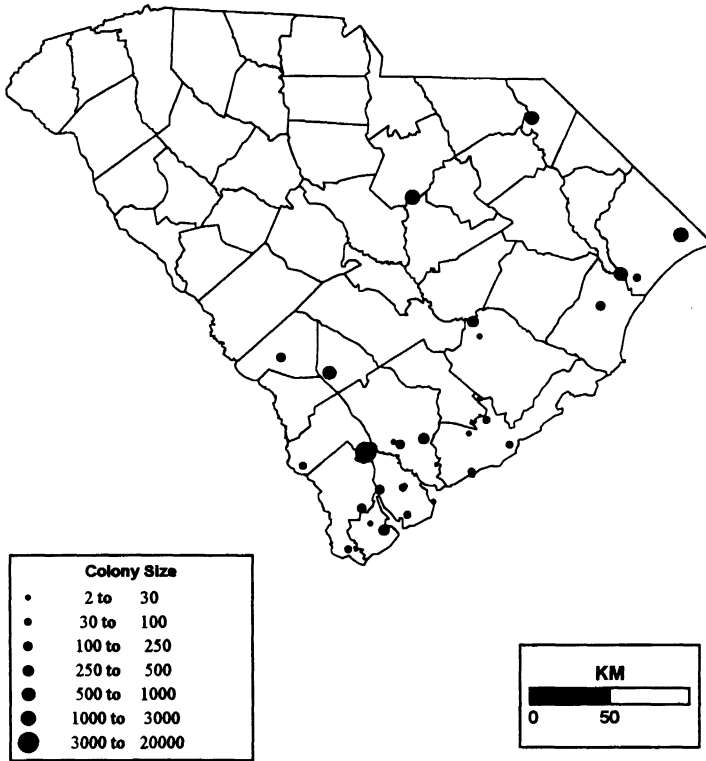


Figure 9. Cattle Egret nesting locations in South Carolina, 1996.

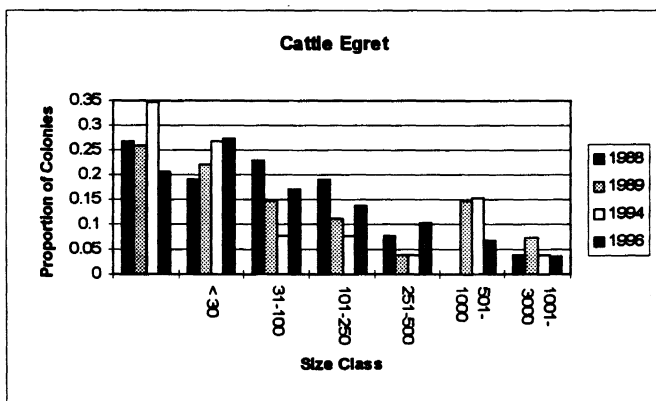
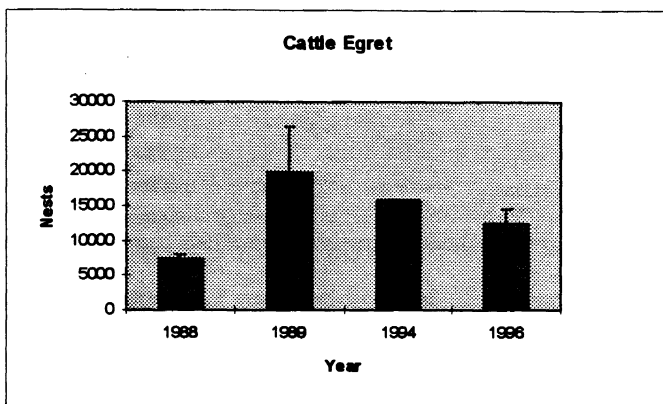


Figure 10. Cattle Egret nesting trends and their relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

Even if these 2 colonies were included in 1988 totals, we would still see an increase of approximately 5,000 nesting pairs in 1989.

Compared with other wading bird species, there was a higher proportion of colonies in the medium and large size classes (the class comprising more than 250 nests). In addition, we found a significant difference in the proportion of colonies in size classes between survey years ($\chi^2 = 43.37$, $df = 18$, $P = 0.001$). This difference is likely a result of a larger proportion of colonies in the smallest size classes in 1994 and relatively higher proportions of colonies in the middle size classes in 1996 (Figure 10). Colony sizes ranged from 1 to 6,454 nests.

Based on analysis of nesting trends, colony distribution and size class information, the Cattle Egret nesting population appears to be stable or slightly declining in South Carolina. Annual fluctuations ranged from approximately 11,000 to 19,000 nesting pairs. Additional surveys will be necessary to better understand annual fluctuations in Cattle Egret nesting.

Great Egret

Great Egrets were ubiquitous and had the widest nesting distribution of any of South Carolina's waterbirds. Although they were widely distributed, most nesting was found in the 6 coastal counties (Figure 11). In addition, Great Egret nesting was found to be correlated with total wetland area in the coastal counties (Dodd and Murphy, in prep.). However, with the loss of the Drum Island colony in Charleston Harbor in 1988, there was a conspicuous lack of a medium or large colonies on the central coast. We found no difference in the spatial distribution of Great Egret colonies between survey years ($P = 1.0$).

Great Egrets were the most numerous of the fish-eating heron and egret species nesting in South Carolina. Approximate confidence limits for statewide nest estimates indicated that nesting increased from approximately 5,400 nests in 1988 and 1989 to 9,100 nesting pairs in 1996 (Figure 12). Average colony size increased from 89 nests in 1988 to 126 nests in 1996.

As with other wading bird species, the largest proportion of colonies were in the smallest size class (fewer than 30 nests). There was no difference in the proportion of colonies in size classes between survey years ($\chi^2 = 18.82$, $df = 15$, $P = 0.22$).

During our surveys, the spatial distribution of Great Egret colonies and the proportion of colonies in size classes did not differ. Nevertheless, the Great Egret nesting population increased significantly during our study from approximately 5,400 to 9,100 nesting pairs.

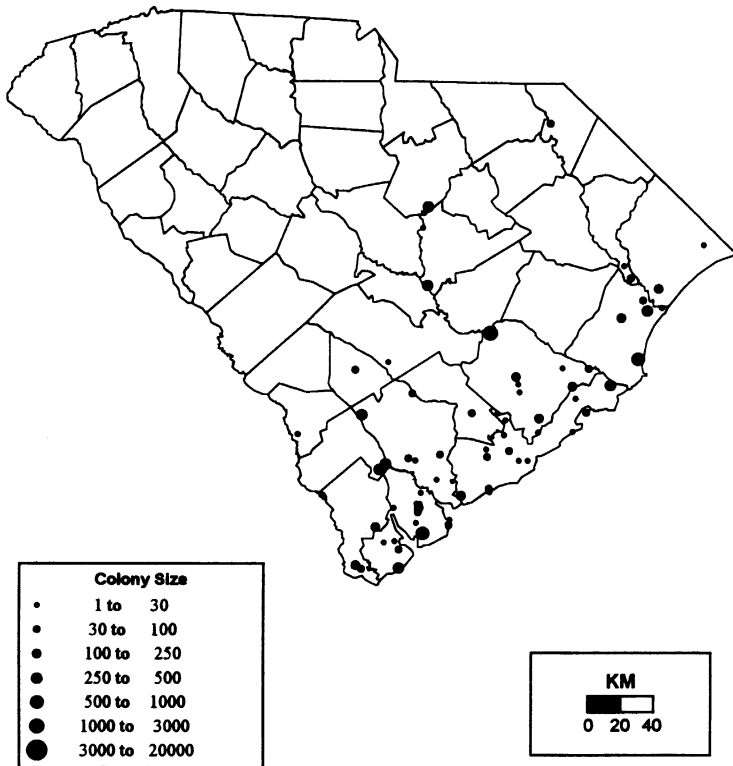


Figure 11. Great Egret nesting locations in South Carolina, 1996.

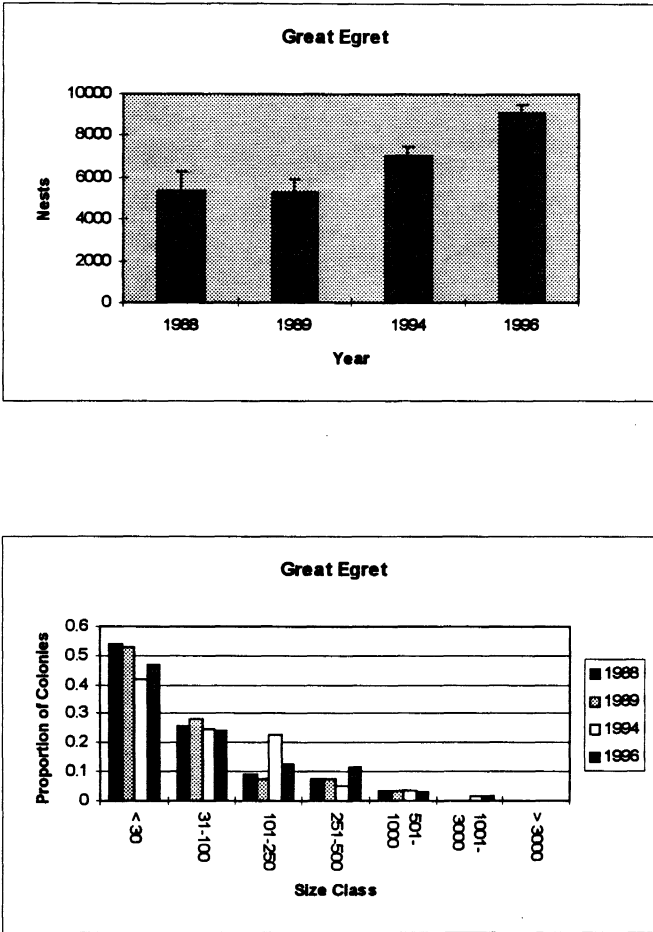


Figure 12. Great Egret nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

Snowy Egret

Overall, the distribution of Snowy Egret nesting was coastal, with the larger colonies located near the major estuary systems (Figure 13). A few Snowy Egrets nests, though, were found as far inland as Kershaw County. The lack of nesting north of Georgetown is probably due to the absence of large estuaries in this portion of the state. There was no difference in the spatial distribution of Snowy Egret colonies between survey years ($P = 0.57$).

Snowy Egrets were the most numerous small day-heron nesting in South Carolina during our study (Table 4). Minimum nest estimates increased by over 1,000 nests from 1988 - 1989 and then decreased to previous levels in 1994 and 1996 (Table 4). Aerial nest estimates which were included in 1988 statewide nest totals inflated confidence intervals, so it was difficult to evaluate trends in census data (Figure 14). We did, however, detect a slight decrease in nesting between the 1989 and 1994 surveys. Mean colony size was similar in 1988, 1994, and 1996 but nearly doubled in size during the 1989 nesting season. We found a significant difference in the proportion of colonies in size classes between survey years ($\chi^2 = 37.63$, $df = 12$, $P < 0.0001$). This difference appears to be due to the small number of nests in the <30 nest size class and a higher proportion of nests in the 501-1,000 nest class during 1989 (Figure 14).

Based on analysis of nesting trends, colony distribution and size class information, Snowy Egret populations fluctuated slightly but appeared stable at approximately 3,500 nesting pairs during our study.

Great Blue Heron

Great Blue Herons nested throughout the entire coastal plain in association with saline, brackish, and freshwater habitats (Figure 15). Over 50% of the annual Great Blue Heron nesting was located in three large colonies on lakes Marion and Moultrie. The remaining colonies were small and widely distributed. There was no difference in the spatial distribution of colonies between survey years ($P = 0.51$).

Great Blue Heron minimum nest estimates remained remarkably stable at approximately 2,500 nests during our study (Table 4). Despite relatively small approximate confidence limits for statewide nest estimates, we did not detect any differences in nesting attempts between survey years (Figure 16).

The number of colonies increased from 52 in 1988 to 110 in 1996. The increase in the number of nesting sites was partially due to the cumulative effects of our long-term survey effort, but also represents a real increase in the number of Great Blue Heron colonies. One possible reason for the increase in the number of colonies includes the destruction of nesting habitat due to

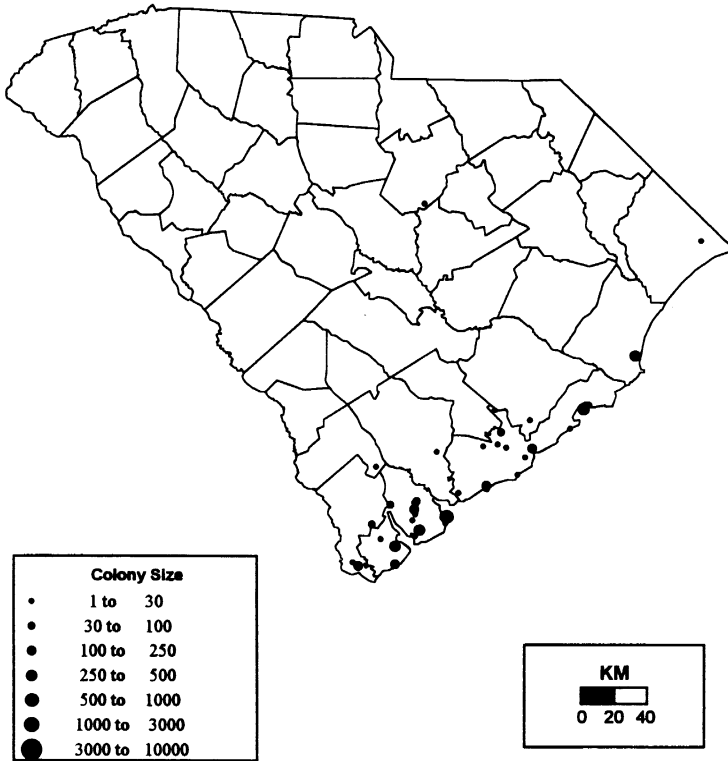


Figure 13. Snowy Egret nesting locations in South Carolina, 1996.

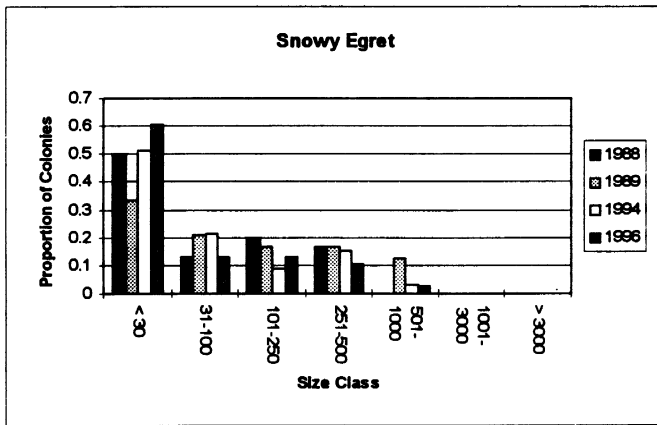
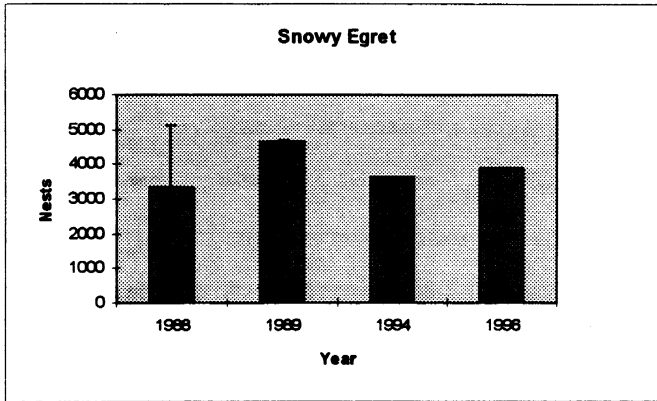


Figure 14. Snowy Egret nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

Hurricane Hugo in 1989. Although nesting habitat in historic colonies was not completely destroyed, many colonies were reduced in size and excess birds were forced to form new colonies.

Between 77 and 88% of Great Blue Heron colonies contained <30 nests (Figure 16). The largest colony contained 837 nests. Despite the increase in small colonies, there was no difference in the colony size class distributions between survey years ($\chi^2 = 11.37$, $df = 12$, $P = 0.50$).

Based on statewide nest estimates, South Carolina's Great Blue Heron population is stable at approximately 2,500 nesting pairs. The trend, however, toward more numerous small colonies may indicate a problem with the availability of nesting habitat and should be monitored more closely in the future.

Tricolored Heron

The nesting distribution of Tricolored Herons was similar to Snowy Egrets, with most colonies being located close to the coast. We did not find any nesting inland of Berkeley County (Figure 17). Most large colonies were associated with the major estuary systems. And we did not find any nesting north of Winyah Bay in Georgetown County. We found no difference in the spatial distribution of colonies between survey years ($P = 0.95$).

The dark coloration of Tricolored Herons and their tendency to nest in dense vegetation makes them virtually impossible to locate from aircraft. Although they are difficult to survey, they always nested in association with conspicuous (white-colored) species during our study. Therefore, our survey efficiency for locating Tricolored Heron colonies is probably equivalent to that of Great and Snowy egrets. Because all nests for this species were censused using a complete ground count, we used minimum nest counts to assess nesting trends (Figure 18). Minimum nest totals indicated a slight fluctuation (< 30% of total) in nesting from 1,736 to 2,412 nests (Table 4). The mean colony size appeared stable with the exception of 1989. Maximum colony sizes were similar to other heron and egret species. We detected a significant change in the proportion of colonies in size classes during our surveys ($\chi^2 = 39.85$, $df = 12$, $P < 0.0001$). This difference appears to be due to the larger proportion of colonies in the smallest size class (< 30 nests) and the corresponding lack of colonies in the middle size classes (31-500 nests) in 1996 (Figure 18).

As with Snowy Egrets, the Tricolored Heron nesting population fluctuated slightly during our study but appeared to be relatively stable at approximately 2,000 -2,400 nesting pairs.

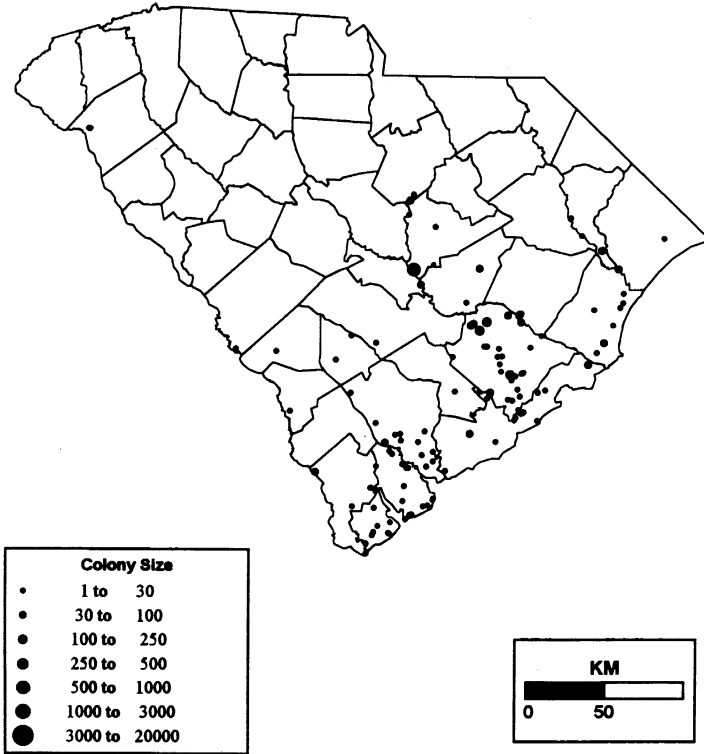


Figure 15. Great Blue Heron nesting locations in South Carolina, 1996.

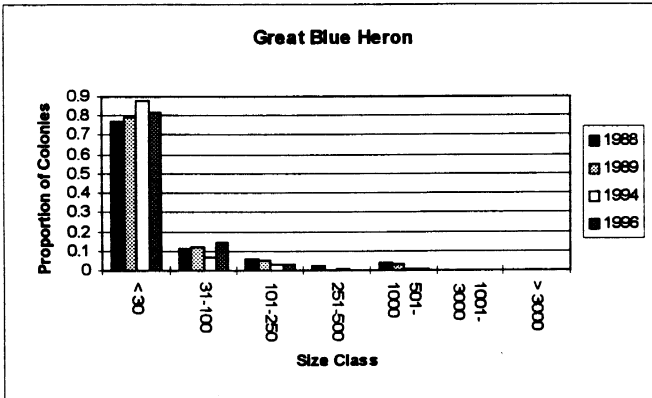
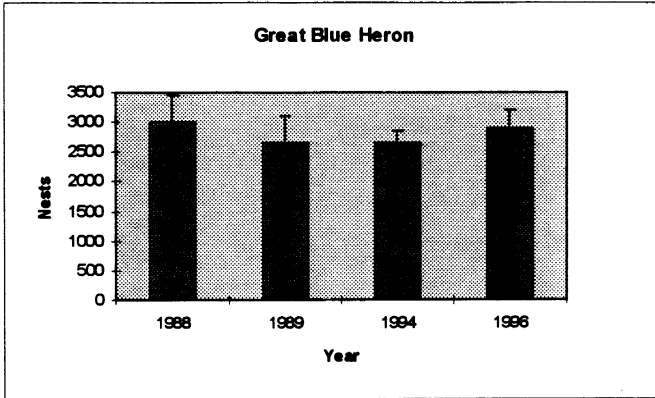


Figure 16. Great Blue Heron nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

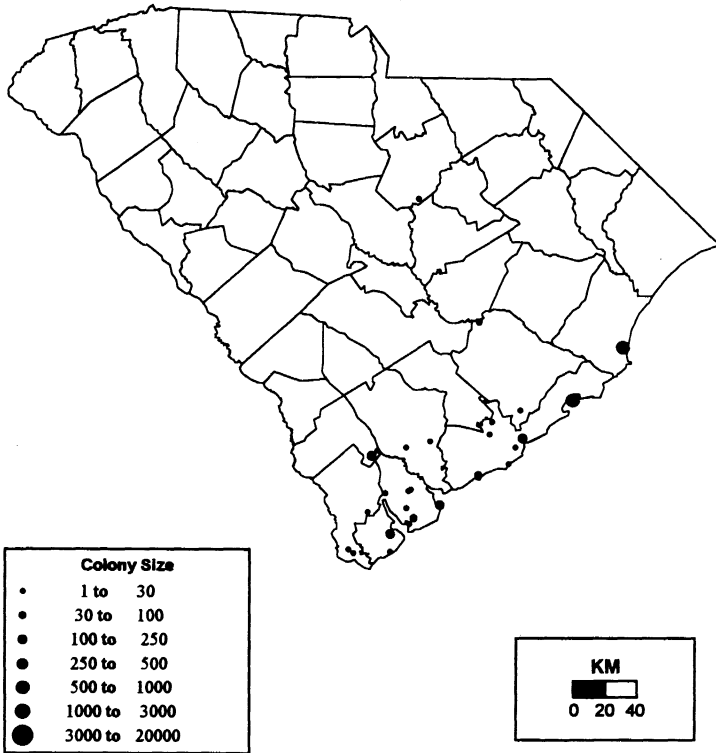


Figure 17. Tricolored Heron nesting locations in South Carolina, 1996.

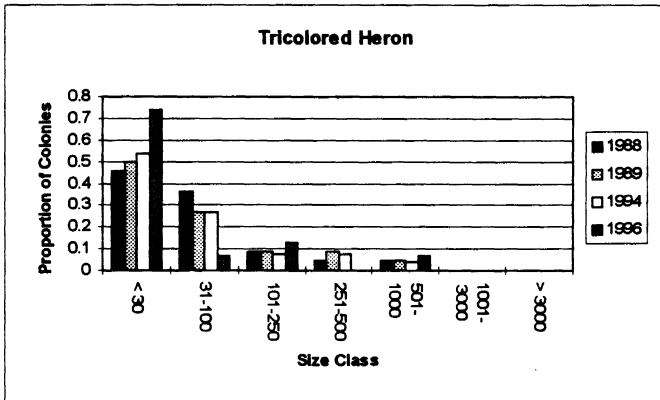
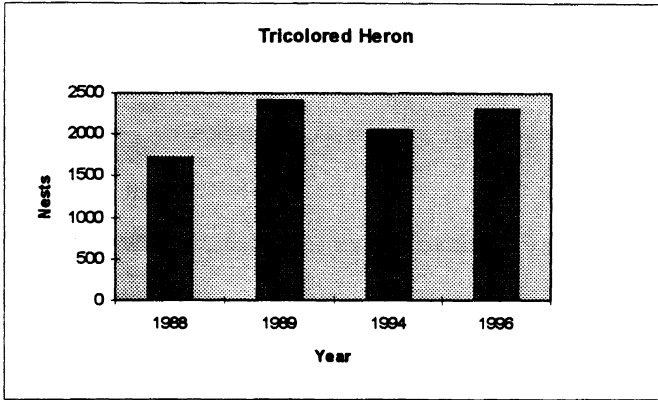


Figure 18. Tricolored Heron nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

Little Blue Heron

Little Blue Herons had a wide nesting distribution, but with the exception of Beaufort County, they were absent from the immediate coast (Figure 19). This distribution is probably a reflection of their preference for feeding in freshwater habitats (Post 1985). We found no difference in the spatial distribution of colonies between survey years ($P = 1.0$).

Based on minimum nest totals, the Little Blue Heron nesting population increased in size during our study. However, the low number of nests found in 1988 was due to incomplete surveys. As with Tricolored Herons, the dark coloration of these birds and their tendency to nest in dense vegetation makes them virtually impossible to locate from aircraft. Although Little Blue Herons often nest in association with other wading bird species, they also form colonies in which they are the only species present (S. C. Colonial Wading Bird Database 1996). Colonies containing exclusively Little Blue Herons were located from historic records and personal communications. Little Blue Heron nest totals must be viewed with caution because of the poor survey efficiency associated with this species.

Little Blue Heron nesting numbers appeared to be stable over the last 3 survey years (Table 4). However, wide confidence limits on statewide nest estimates make it difficult to assess nesting trends (Figure 20). Both mean and maximum colony sizes were small compared with other heron and egret species (Table 4). No large colonies (those with more than 466 nests) were found during our surveys. We found a significant difference in the proportion of colonies in size classes between survey years ($\chi^2 = 38.32$, $df = 9$, $P < 0.0001$).

Historic records indicate that Little Blue Herons were the dominant heron in South Carolina colonies during the 1930's (Ogden 1978). Although no longer the most common wading bird on the coast, our data suggests that the Little Blue Heron nesting population is stable at between 2,000 and 2,600 nesting pairs. However, development of more efficient survey techniques will be necessary to increase our confidence in the accuracy of nest estimates.

Anhinga

Anhingas were widely distributed, nesting throughout the coastal plain of South Carolina (Figure 21). Nests were located in colonies less than 100 m from the Atlantic Ocean and as far inland as Aiken, Kershaw, and Marlboro counties.

Anhinga minimum nest totals increased during the study, however, the average colony size remained approximately the same (Table 4). Although minimum nest estimates indicated an increase in nesting attempts from 1989 to 1996, this was more likely a result of the cumulative effect of 3 years of

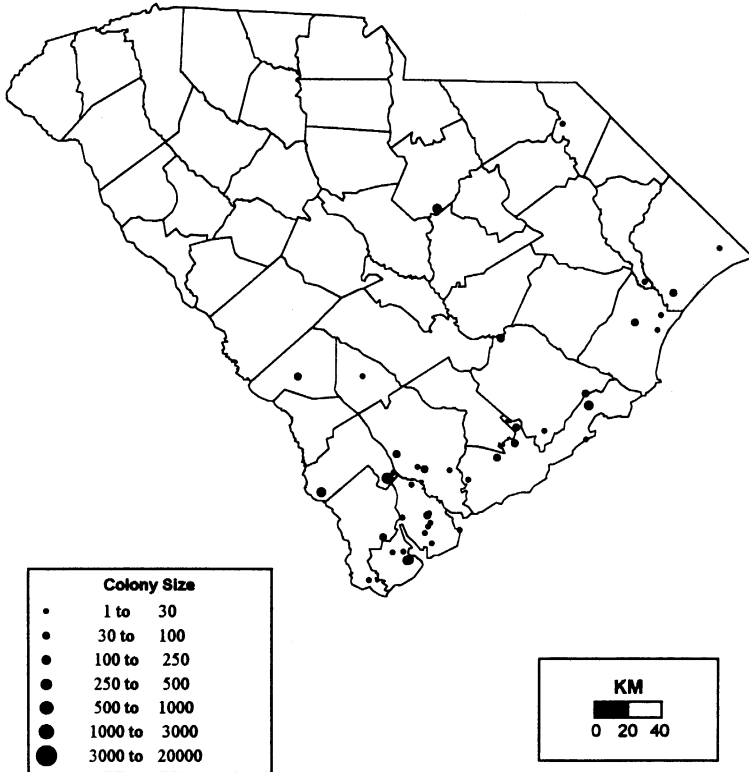


Figure 19. Little Blue Heron nesting locations in South Carolina, 1996.

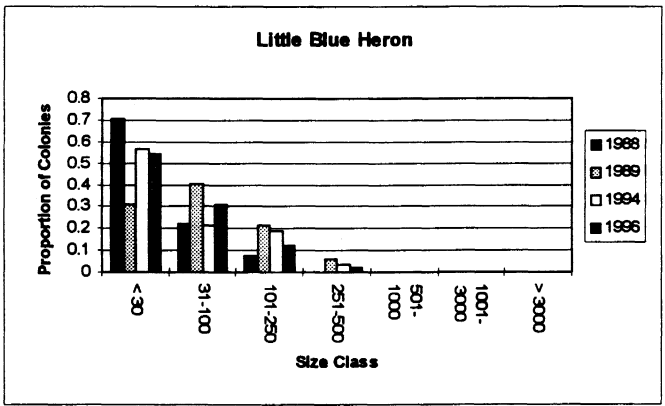
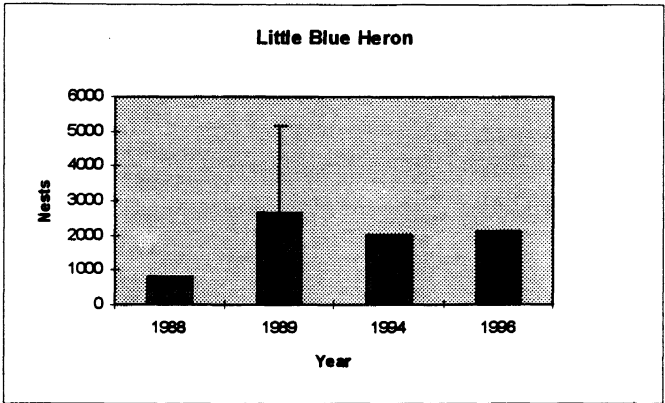


Figure 20. Little Blue Heron nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

surveying rather than a real increase in nesting. The average and maximum number of nests found in a single colony (241 nests) were small in comparison with other waterbird species. Over 70% of Anhinga colonies contained fewer than 30 nests (Figure 22). There was no difference in the colony size class distribution between survey years ($\chi^2 = 10.46$, $df = 6$, $P = 0.11$). Anhingas were often found nesting on the periphery of large mixed-species wading bird colonies. With the exception of the Potato Ferry colony in Marion County, Anhingas were never the dominant species in a colony.

we were able to gather valuable information on several aspects of Anhinga nesting in South Carolina, but incomplete surveys preclude the assessment of trends for this species.

Wood Stork

Wood Storks were found to nest in only 3 southern counties (Hampton, Colleton, and Charleston) during the 1988 and 1989 surveys. By 1996, we found two more colonies, on the Santee River in Charleston and Georgetown Counties (Figure 23). Although the distribution of colonies is coastal, nesting sites are generally associated with fresh and brackish feeding habitats. We found no difference in the spatial distribution of nesting colonies between years ($P = 0.74$). This result must be viewed with caution because of the small sample of colonies used in the analysis.

Wood Storks first nested in South Carolina in 1981 (S.C. Colonial Waterbird Database 1996). From 1988 to 1996, nesting totals increased from 179 nests in 3 colonies to 953 nests in 7 colonies (Table 4). Average colony size increased from 60 to 102 nests. As expected with an expanding population, we found a difference in the proportion of colonies in size classes between years ($\chi^2 = 145.93$, $df = 9$, $P < 0.0001$). In 1996, over half of the Wood Stork colonies were in the 101 - 250 nest size class (Figure 24).

Based on minimum nest counts, the Wood Stork nesting population increased from less than 200 to over 950 nesting pairs. In addition, they expanded their nesting range northward to the South Santee River near Georgetown.

Double-crested Cormorant

Double-crested Cormorants were found to have a limited nesting distribution in South Carolina. With one exception, all colonies were located on lakes Marion and Moultrie or in the Cooper River Drainage (Figure 25). In 1994, cormorants expanded their range to the south, nesting in a large-mixed species colony on Hilton Head Island.

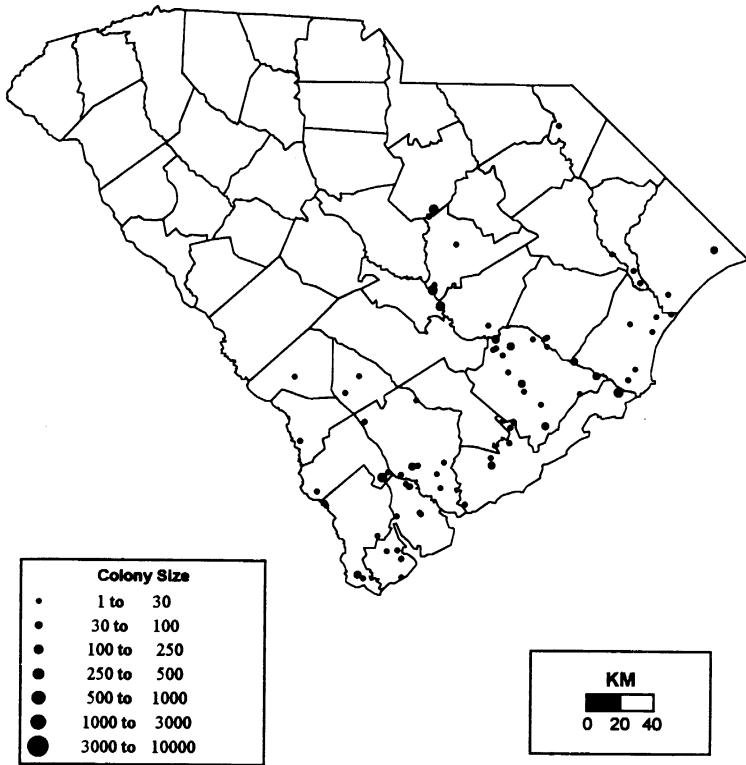


Figure 21. Anhinga nesting locations in South Carolina, 1996.

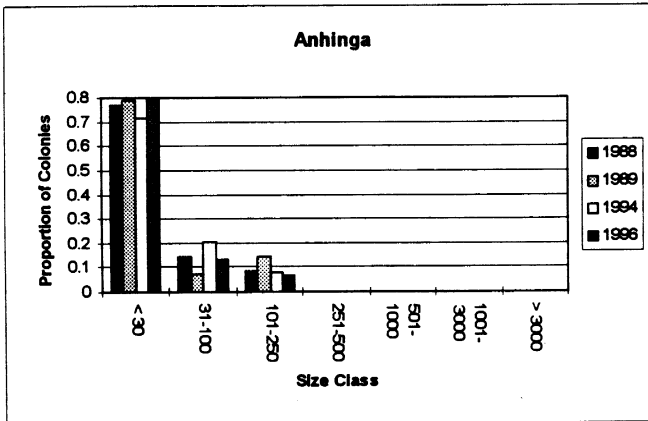
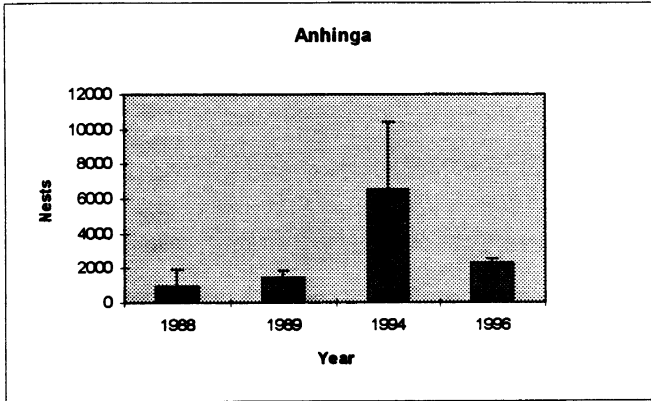


Figure 22. Anhinga nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

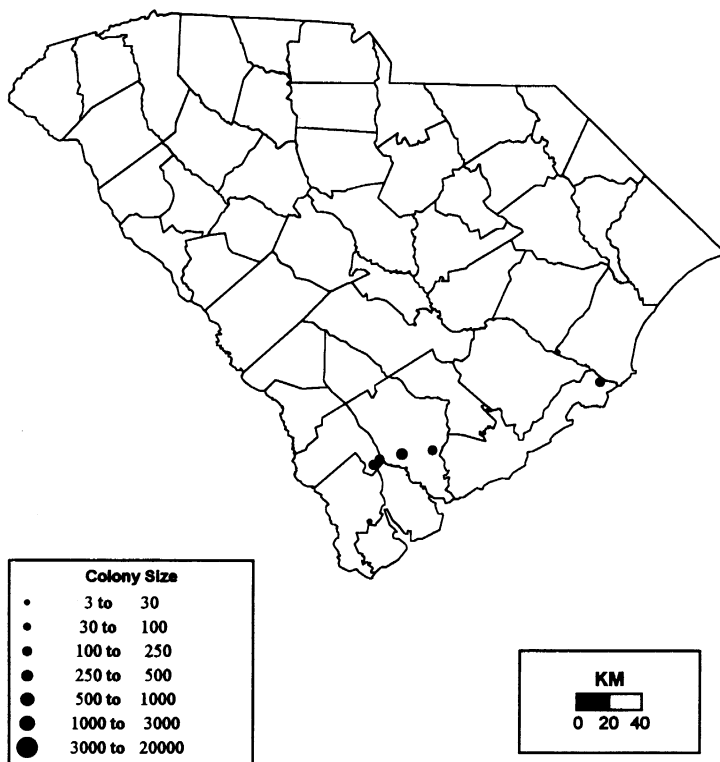


Figure 23. Wood Stork nesting locations in South Carolina, 1996.

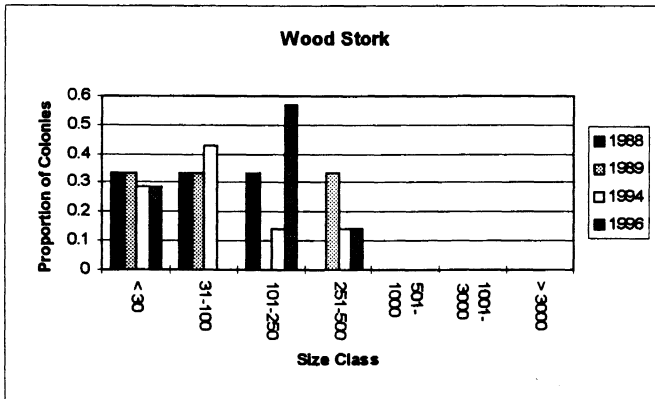
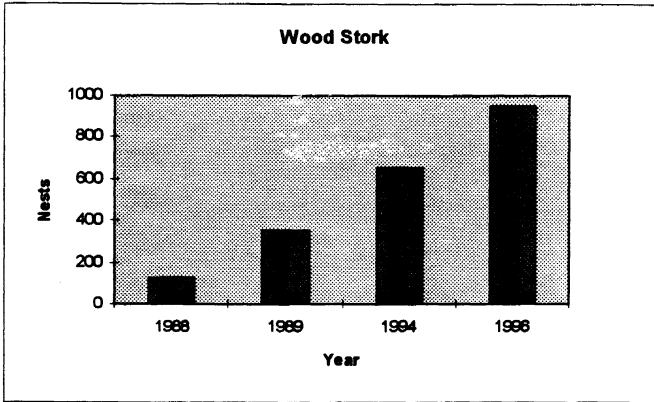


Figure 24. Wood Stork nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

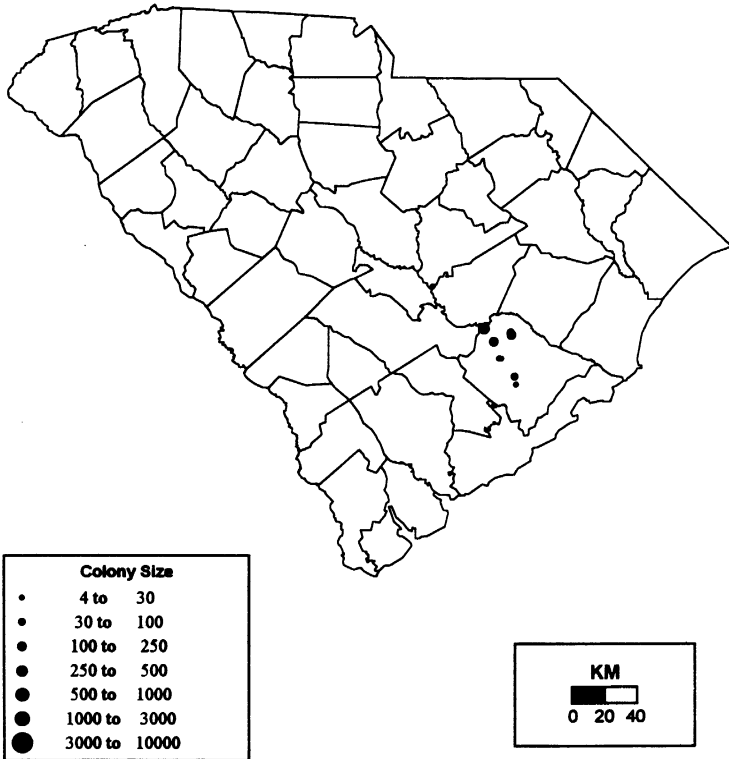


Figure 25. Double-crested Cormorant nesting locations in South Carolina, 1996.

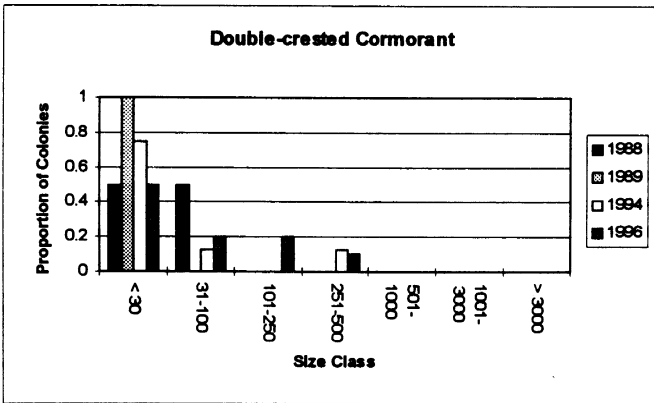
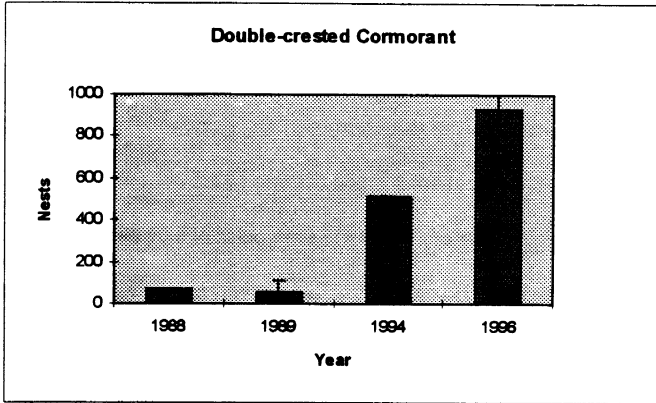


Figure 26. Double-crested Cormorant nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

Double-crested Cormorants first nested in South Carolina in 1985 (Post 1988). During our study, nesting increased from 2 colonies containing 72 nests to 10 colonies containing 895 nests (Table 4). Despite their dark coloration, Double-crested Cormorants are relatively easy to locate from the aircraft due to their tendency to nest in the top of vegetation. Approximate confidence limits for statewide nest estimates indicated an increase in nesting in 1994 and 1996 (Figure 26). Overall, the average colony size has increased from 14 to 90 nests, with the largest colony in 1996 containing 447 nests. We found a significant difference in the proportion of colonies in size classes between survey years ($\chi^2 = 173.66$, $df = 9$, $P < 0.0001$). This difference was probably due to a higher proportion of colonies in the larger size classes in 1994 and 1996. The proportion of colonies containing fewer than 30 nests ranged from 50 to 100% during our surveys (Figure 26).

Cormorants nested in large single-species colonies as well as in association with other wading bird species.

Data from our surveys suggests that Double-crested Cormorants are slowly expanding both their nesting population and geographical range in South Carolina.

Yellow-crowned Night-Heron

Yellow-crowned Night-Herons are semi-colonial and often nest on the periphery of colonies or singly in river swamps. Consequently, our colony map and minimum nest estimates represent a small fraction of the statewide nesting distribution and totals (Figure 27, Table 4). One point of interest is a colony in Sparkleberry Swamp. It contained 973 Yellow-crowned Night-Heron nests in 1996 and may be the largest colony on the Atlantic coast.

Black-crowned Night-Heron

The distribution of Black-crowned Night-Heron colonies was primarily coastal, indicating this species' preference for estuarine wetland habitats (Figure 28). Most nests were found in the 6 coastal counties, but a few were found in colonies as far inland as Kershaw and Marlboro counties.

Because no estimation techniques were used to count nests, we used minimum nest counts to assess population trends. Minimum nest totals increased in 1989 and then decreased slightly during 1994 and 1996 (Table 4). Because Black-crowned Night-Herons are semicolonial, changes in statewide nest totals may be a result of poor survey efficiency rather than real changes in the nesting effort. The average colony size was smaller than all other species in the study. More than 80% of Black-crowned Night-Heron colonies

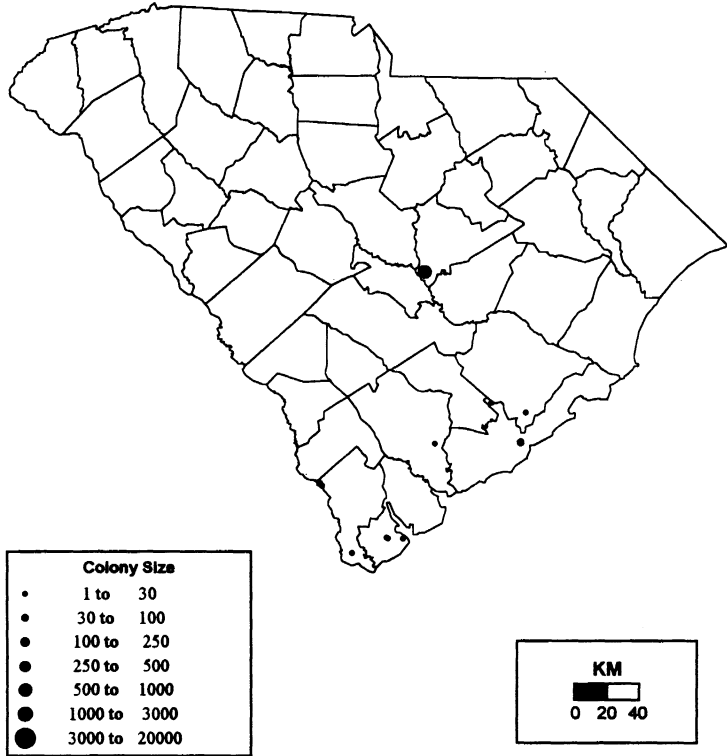


Figure 27. Yellow-crowned Night-Heron nesting locations in South Carolina, 1996.

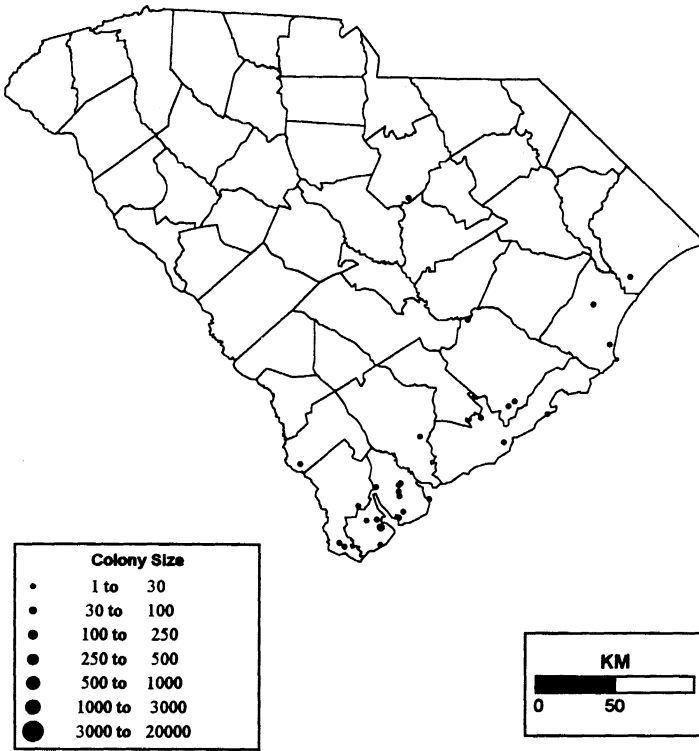


Figure 28. Black-crowned Night-Heron nesting locations in South Carolina, 1996.

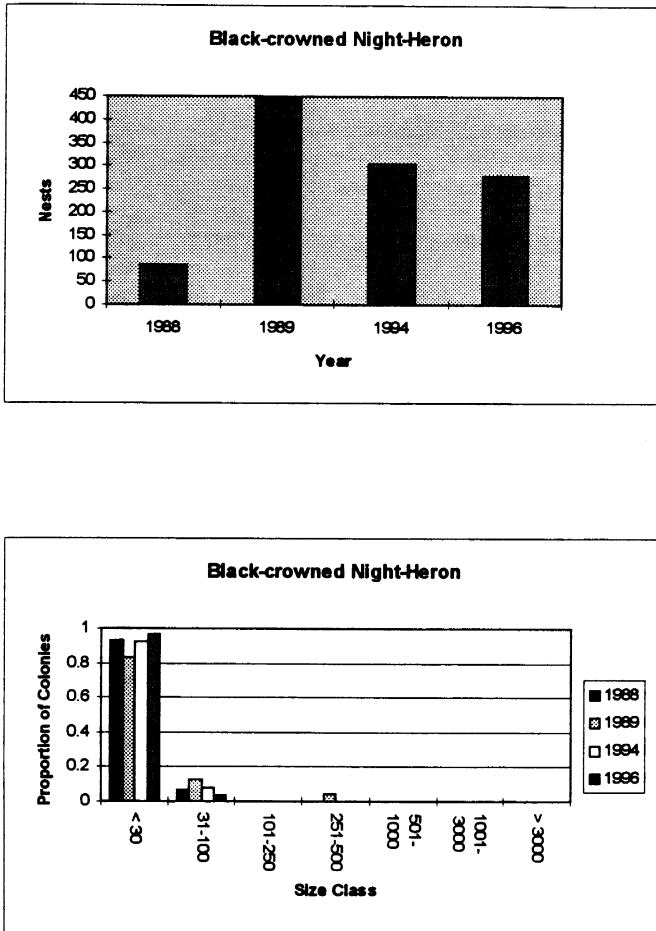


Figure 29. Black-crowned Night-Heron nesting trends and the relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

contained fewer than 30 nests (Figure 29). We found a significant difference in the colony size class distribution between survey years ($\chi^2 = 19.06$, $df = 6$, $P = 0.004$). This difference appeared to be at least partially a result of the addition of several colonies in the 251-500 nest size class in 1989.

Black-crowned Night-Herons nested in association with almost all other wading bird species in large colonies. They also nested, though, in small isolated colonies in which they were the dominant species.

As with Anhingas, incomplete surveys and the tendency of these birds to nest in small isolated colonies precludes analysis of nesting trends.

Glossy Ibis

Compared to other species, Glossy Ibises nested in relatively few colonies, all of which were located within 2 km of the coastline (Figure 30). Colonies were located in association with 3 large estuary systems including: Charleston Harbor, Bull's Bay, and Winyah Bay. In 1994, their nesting range decreased slightly with the loss of a nesting site in the Charleston Harbor area.

Glossy Ibises were first recorded nesting in South Carolina in 1947 (Sprunt and Chamberlain 1977). Glossy Ibis nesting attempts increased during each year of the study, but the relative numbers nesting in South Carolina were low compared with other wading bird species. Average colony size increased from 32 in 1988 to 179 in 1996. We found a significant difference in the proportion of colonies in size classes between survey years ($\chi^2 = 306.18$, $df = 9$, $P < 0.0001$) caused by a trend toward a larger proportion of colonies in the medium (101-250 nests) size class (Figure 31). Sixty-five to 75% of the colonies in a given year contained fewer than 30 nests.

Based on analysis of nesting trends, colony distribution and size class information, the Glossy Ibis nesting population appears to be stable or slightly increasing at approximately 250-350 nesting pairs.

Relative Importance Index

The top 20 ranked colonies in the 1989, 1994, and 1996 nesting seasons were similar, with seven colonies being common to all three lists (Table 5). The top 10 colonies in 1994 had been active an average of 29.1 years. However, this number was inflated slightly by the Washo reserve colony, which has been continuously active since 1823 (Sprunt and Chamberlain 1977, S.C. Colonial Waterbird Database 1996). Fourteen of the top 20 ranked colonies in 1994 and 1996 were in impounded wetlands with stable water conditions.

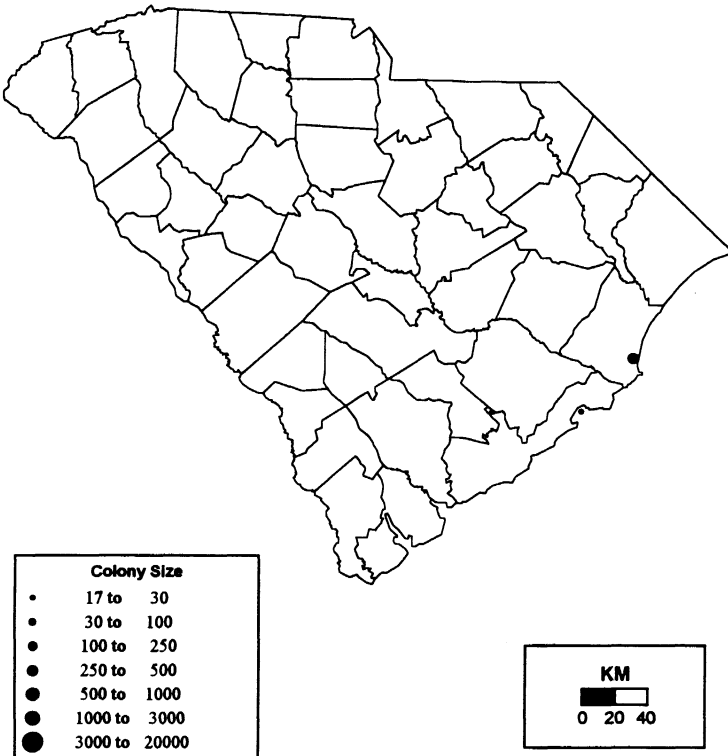


Figure 30. Glossy Ibis nesting locations in South Carolina, 1996.

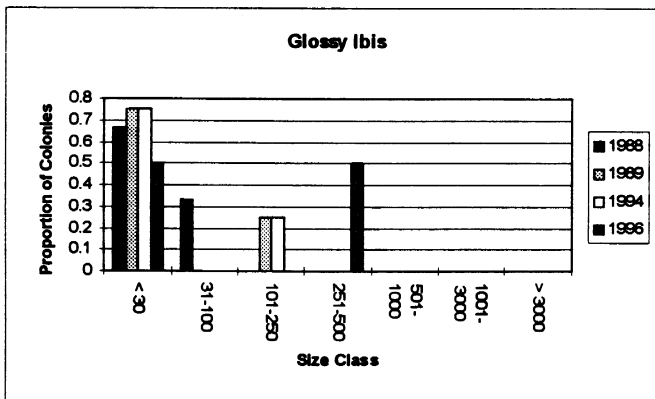
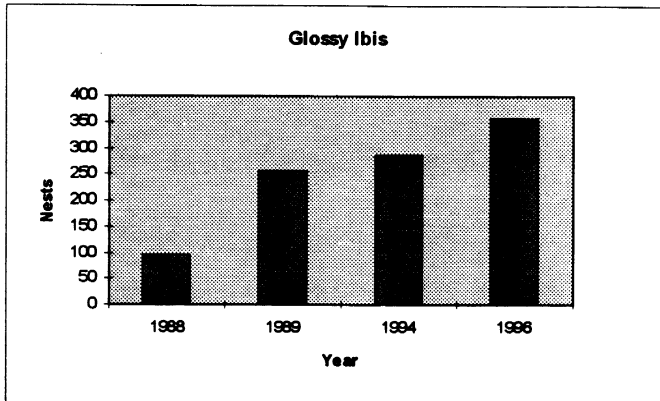


Figure 31. Glossy Ibis nesting trends and relative proportions of colonies in each of 7 size classes in South Carolina, 1988, 1989, 1994, and 1996.

Table 5. Top 20 ranked wading bird colonies in South Carolina, 1989, 1994, and 1996 (for data see Appendix A.).

1989			1994			1996					
Site No.	Site Name	Index	Site No.	Site Name	Index	Site No.	Site Name	Index			
1	SC-CO-014	Jacksonboro	45.89	1	SC-BE-002	Bird Is., L. Marion	43.88	1	SC-HA-005	Buckfield	45.13
2	SC-JA-011	Two Bridge Swamp	45.44	2	SC-BU-004	Colleton Neck	43.29	2	SC-KE-001	Boykin Mill Pond	44.78
3	SC-GO-003	Pumpkinseed Is.	43.71	3	SC-BU-013	St. Helena Is.	43.29	3	SC-BU-036	Pinckney Is., Osprey	43.88
4	SC-CH-053	Drum Is. IV, Shipyard	43.63	4	SC-KE-001	Boykin Mill Pond	42.43	4	SC-CO-014	Jacksonboro	43.30
5	SC-BU-013	St. Helena Is.	43.29	5	SC-GO-003	Pumpkinseed Is.	41.67	5	SC-BE-002	Bird Is., L. Marion	42.71
6	SC-BU-032	Sea Pines Pktn.	43.29	6	SC-BM-001	Olar	41.40	6	SC-BU-013	St. Helena Is.	42.17
7	SC-BE-002	Bird Is., L. Marion	42.71	7	SC-HA-005	Buckfield	40.67	7	SC-BU-048	Harbor Is.	42.17
8	SC-MA-003	Potato Ferry	41.83	8	SC-CO-018	Whitshell II	39.50	8	SC-HO-004	Bear Grass	41.80
9	SC-KE-001	Boykin Mill Pond	41.50	9	SC-CO-003	Ritter	38.83	9	SC-JA-005	Whig Swamp	41.67
10	SC-BM-001	Olar	40.75	10	SC-CH-001	Washo Reserve	39.50	10	SC-GO-003	Pumpkinseed Is.	41.67
11	SC-BU-029	Rose Hill Pktn.	37.29	11	SC-BU-032	Sea Pines Pktn.	37.57	11	SC-CH-007	Marsh Is.	41.00
12	SC-BU-038	Pinckney Is., Osprey	37.17	12	SC-CH-015	Magnolia Gardens	37.29	12	SC-SU-001	Spartanberry Sw.	40.00
13	SC-CO-018	Whitshell II	37.00	13	SC-MB-001	Marlboro	37.17	13	SC-HA-001	Yemassee I	39.83
14	SC-CH-054	Cape Is., Pond	36.80	14	SC-BU-048	Harbor Island	36.80	14	SC-CO-018	White Hall II	39.50
15	SC-BU-027	Pinckney Is., Ibis Pd.	36.17	15	SC-MA-004	Russ Creek	36.67	15	SC-CH-001	Washo Res.	38.50
16	SC-BU-034	Wilkins I	36.17	16	SC-BM-002	Lemon Creek	36.50	16	SC-GO-023	Sandy Is.	38.50
17	SC-CH-001	Washo Reserve	36.00	17	SC-CH-040	Tea Farm	36.50	17	SC-BU-059	Pinckney Is., W. Stork	37.67
18	SC-SU-001	Spartanberry Swmp	36.00	18	SC-CO-014	Jacksonboro	36.50	18	SC-JA-016	Monkey John Sw	37.33
19	SC-CH-007	Marsh Island	35.20	19	SC-BU-029	Rose Hill Pktn.	36.17	19	SC-BU-084	Brickyard Pt. II	37.29
20	SC-BE-017	Pipeline	35.00	20	SC-SU-001	Spartanberry Swp	36.00	20	SC-CH-015	Magnolia Gardens	37.29
								21	SC-JA-015	Turnbridge Pktn.	37.29

CONCLUSIONS

For most species, wading bird populations fluctuated slightly but were generally stable or increasing. White Ibis was the only species in which we found large decreases in nesting population.

Overall, nesting was concentrated in the 6 coastal counties. Both Wood Storks and Double-crested Cormorants significantly expanded their nesting range and population. Several species, including Anhingas, Black-crowned and Yellow-crowned Night-Herons, and Little Blue Herons were difficult to locate from the aircraft because of cryptic coloration and a tendency to nest in dense vegetation. Due to poor survey efficiency, we were unable to assess nesting trends for these species. White Ibis populations were highly variable between years. Due to their nomadic nature (Frederick *et al.* 1996), it will be necessary to examine annual nesting patterns on a regional scale to determine their status.

Although historic records provide little quantitative information concerning the size of wading bird populations, it may be useful to use the relationship between wading bird nesting and wetland area to speculate on the relationship between current and historic nesting populations. Heron and egret nesting has been found to be grossly correlated with total wetland area on the Atlantic Coast (Custer and Osborn 1977) and in South Carolina (Dodd and Murphy in prep.). Because South Carolina has lost approximately 27% of its wetlands (Dahl 1990), we can speculate that current wading bird nesting represents approximately 73% of historic levels. The majority of recent wetland loss in South Carolina has been primarily forested paulustrine wetlands (Hefner *et al.* 1994). Species which are more dependent on estuarine habitats, such as Snowy Egrets, Tricolored Herons, and Black-crowned Night-Herons, were probably minimally effected by wetland loss. For these species, historic and current nesting populations are probably comparable. Species more dependent on freshwater habitats, such as Little Blue Herons and Yellow-crowned Night-Herons, have probably shown decreases which correspond more directly with overall wetland loss. Finally, ubiquitous species which are widely distributed and utilize all available wetland habitats have probably shown slight decreases in nesting populations from historic levels because only a portion of their range has been affected.

Overall, we are cautiously optimistic concerning the health of South Carolina's wading bird nesting populations. In all likelihood, we are currently supporting a large portion of the historic nesting population. With careful management, we should be able to maintain these populations indefinitely.

Appendix A. Variables and scores used to rank wading bird colonies in South Carolina, 1989, 1994, and 1996 (from Runde 1991).

Variables and categories	Points
Colony Size Class	
< 100	0
100-499	4
500-1000	6
> 1000	10
Species Richness	1-13
Biological Score^a	
Anhinga	17
Black-crowned Night-Heron	13
Cattle Egret	8
Double-crested Cormorant	11
Glossy Ibis	15
Great Blue Heron	15
Great Egret	19
Little Blue Heron	23
Snowy Egret	17
Tricolored Heron	17
White Ibis	13
Wood Stork	23
Yellow-crowned Night-Heron	21
Colony History	
Colony located in previous survey	10
Colony located in present survey	5

^a Millsap et al. (1990). Score is average of species present

Appendix B. Minimum and adjusted statewide nest estimates for South Carolina wading birds, 1988, 1989, 1994, and 1996. (excluding point, perimeter, and aerial photo. counts).

Species	1988				1989				1994				1996			
	Min. est.	Adj. ^a est	Conf. ^b limit	% ^c	Min. est.	Adj. est	Conf. limit	%	Min. est.	Adj. est	Conf. limit	%	Min. est.	Adj. est	Conf. limit	%
Anhinga	830	909	±1,056	232	933	1,470	± 360	49	1,397	6,477	±3,876	120	1,875	2,272	± 250	22
Black-crowned night-heron	85				449				305				279			
Cattle egret	6,540	7,479	± 641	17	18,421	19,889	± 6,561	66	15,905				11,035	12,394	±2,207	36
Double-crested cormorant	72				58	60	± 53	177	515	518	± 1	0.4	895	927	± 73	16
Glossy ibis	97				256				288				358			
Great egret	4,796	5,360	± 921	34	5,111	5,283	± 654	25	6,980	7,016	± 458	13	8,798	9,068	± 453	10
Great blue heron	2,777	2,995	± 445	30	2,506	2,664	± 450	34	2,547	2,659	± 190	14	2,655	2,913	± 283	19
Little blue heron	782				2,611	2,656	±2,498	188	2,048				2,125			
Snowy egret	3,183	3,352	± 1,740	104	4,606	4,664	±11	0.5	3,630				3,893			
Tricolored heron	1,723				2,412				2,050				2,312			
White ibis	9,079				20,798				9,476				16,402			
Wood stork	129				355				655				953			
Yellow-crowned night-heron	0				35				507				973			

a Minimum number of nests adjusted using regression equations for technique or a combination of techniques used in statewide nest total.

b 95% confidence limits for statewide nest estimate (Dodd and Murphy 1995).

c Approximates the % change in nesting population necessary to detect change in nesting population (Dodd and Murphy 1995).

d Although estimation techniques were used to obtain nesting total, insufficient samples were available to establish relationship between tech. and ground counts. Minimum number of nests is reported but represents an undercount of total nests.

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