The Status of Colonial Nesting Wading Bird Populations Within the Chesapeake Bay and Atlantic Barrier Island-Lagoon System

BILL WILLIAMS[1], DAVID F. BRINKER[2] AND BRYAN D. WATTS[1]

[1]Center for Conservation Biology, College of William and Mary, Williamsburg, VA 23187-8795, USA
Internet: jwwil2@wm.edu

[2]Natural Heritage Program, Maryland Department of Natural Resources, 580 Taylor Ave., Annapolis, MD 21401, USA

Abstract.—Colonially nesting wading birds (herons, egrets, and ibis) are a highly visible, biologically significant component of the mid-Atlantic coastal avifauna. Populations of these species were decimated by extensive market hunting in the late nineteenth century, recovered, and additional species colonized the region. Herein, we summarize changes in species, numbers of breeding pairs, and colony sites for ten species of wading birds surveyed four times over a 26-year period (1977 to 2003) within the Chesapeake Bay and Atlantic coastal barrier island region. Over the period of surveys, wading bird breeding colonies increased 246% (to 537) and numbers of breeding pairs increased 67% (to 26,589). Expansion among Great Blue Herons (*Ardea herodias*), Great Egrets (*Ardea alba*), Yellow-Crowned Night-Herons (*Nyctanassa violacea*) and Glossy Ibis (*Plegadis falcinellus*), primarily accounted for the dramatic increase, while declines were recorded for Snowy Egrets (*Egretta thula*), Cattle Egrets (*Bubulcus ibis*) and Black-crowned Night-Herons (*Nycticorax nycticorax*). Rapid loss of breeding wading birds along the Atlantic coastal lagoon system during the last decade is of particular conservation concern.

Key words.—Colonial nesting wading birds, Chesapeake Bay, herons, egrets, ibises, breeding colonies, population growth.

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Thirteen wading bird species breed within the Virginia-Maryland Atlantic coastal barrier islands lagoon system, and the Chesapeake Bay tributaries network (Fig. 1). These species constitute a diverse and significant component of the region's avifauna. The status and condition of the populations of these top-tier food web consumers serve as effective reference points for assessing the health of the Bay ecosystem (Custer and Osborn 1977). Prior to the mid-1970s there was no systematic assessment of the number of each wading bird species, their breeding status, breeding locations, or population dynamics within the region. A 1977 comprehensive survey of all Atlantic coastal colonial nesting waterbird species (Erwin and Korschgen 1979) provided the first definitive summary of the mid-Atlantic region's colonial nesting wading birds. From 1977-2003 regular, periodic wading bird surveys were conducted providing the context for an analysis of population trends.

Before the turn of the 20th century, wading bird populations were severely impacted by the millenary trade (Bent 1926; Ogden 1978). Many species recovered following the passage of protective legislation (Ogden 1978). Population increases and continent-wide breeding range expansions from the 1940s-1970s were complex and varied among species (Byrd 1977; Kushlan and Bildstein 1992; Davis 1993; Telfair 1994; Watts 1995; Rogers and Smith 1995; Frederick 1997; Davis and Kricher 2000; Parsons and Master 2000; McCrimmon *et al.* 2001). Periodic surveys for breeding waterbirds within the Chesapeake Bay region began in 1976-1977 (Erwin and Korschgen 1979). For the purpose of this paper the comprehensive regional surveys of 1977 (Erwin and Korschgen 1979), 1986 (Byrd *et al.* 1986; Gates *et al.* 1992), 1993 (Brinker *et al.* 1993; Watts and Byrd 1998), and 2003 (Watts 2004; Watts and Byrd 2006; D. F. Brinker, unpubl. data) serve as benchmarks to assess trends among ten of the region's 13 wading bird populations. Because of their proclivity to nest singly, the Green Heron (*Butorides virescens*), Least Bittern (*Ixobrychus exilis*), and American Bittern (*Botaurus lentiginosus*) were not included in these surveys. This paper describes changes in status for ten colonial nesting wading birds from the mid-1970s to the present, discusses potential threats to these populations, and offers recommendations for stewardship.

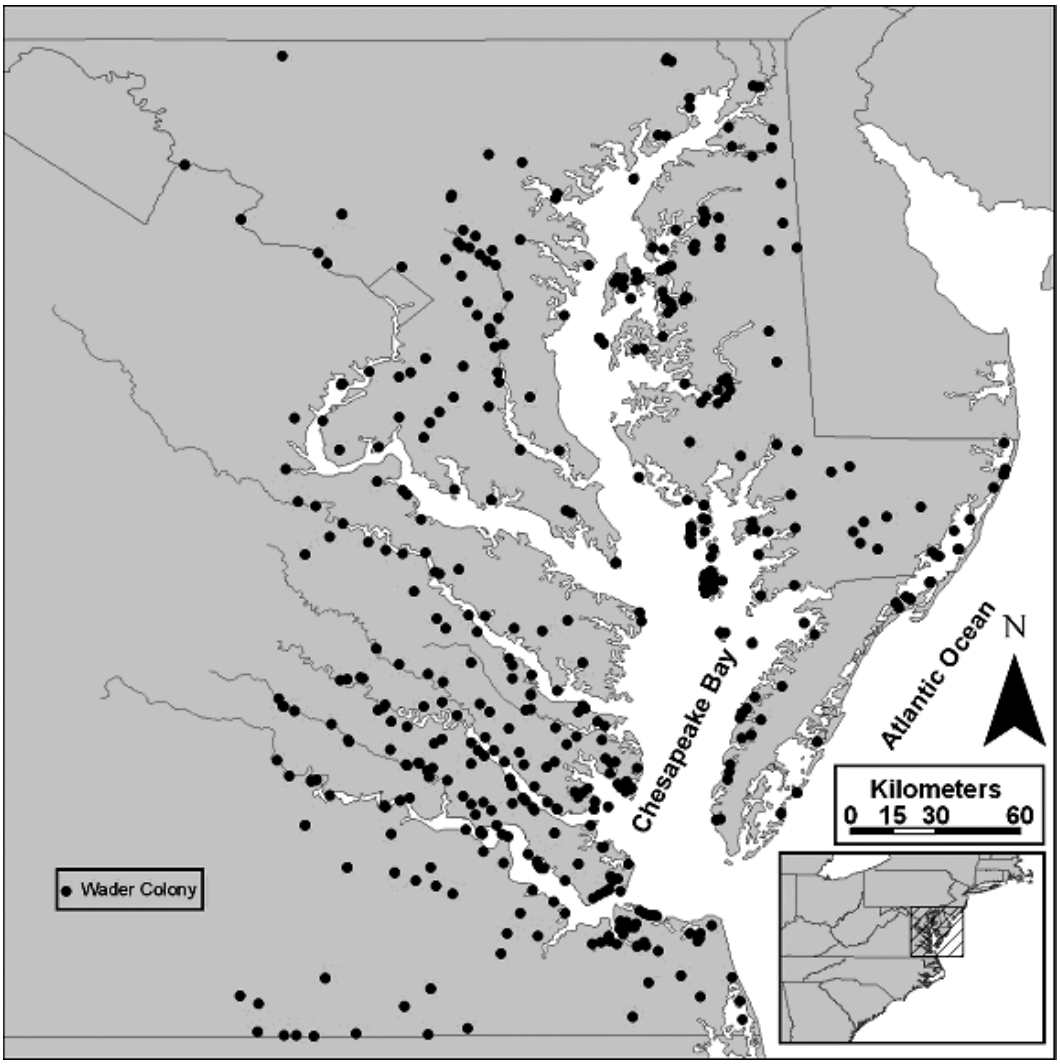

Figure 1. Composite map of wading bird colony sites (all species) located and surveyed during 1986, 1993, and 2003. Colony sites were widely distributed throughout the region.

METHODS

Surveys of breeding wading bird populations were conducted throughout the coastal plains of Virginia and Maryland from late May through June (1977-2003). During each benchmark survey, a variety of survey techniques was used to systematically locate active colonies of wading birds (see Erwin and Korschgen 1979; Brinker *et al.* 1993; Watts and Byrd 2006). All colonies were given a unique alpha-numeric code and plotted on 7.5 min topographic quadrangles. Groups of breeding pairs were considered independent colonies if they were: (1) separated from other groups within a continuous habitat by at least 400 m, (2) separated from other groups by a distinctive barrier, or (3) separated from other groups by a significant habitat discontinuity.

Colony size estimates were based primarily on counts of active nests, and occasionally on the number of adults present. The number of breeding adults was used when nest counts were impractical or when deemed inappropriate due to colony disturbance. Colony size was based on complete counts whenever possible. However, due to the large size of many colonies, estimates were derived for a large portion of the colonies. Population estimates are presented as breeding pairs. Breeding pairs were estimated on a colony by colony basis and compiled to generate an overall population estimate. For colonies surveyed using nest counts or estimates, a one-to-one relationship between nests and pairs was assumed. For colonies surveyed using count or estimates of adults, a one-to-one relationship between adults and pairs was assumed following Erwin (1979). Surveys were timed to maximize colony detections within the region and to ensure peak population counts. However, annual variations in nesting phenology and species-specific differences in time of peak breeding could be only partially accommodated in the surveys. More detail of survey and census methodolo-

gies can be found in Byrd *et al.* (1986), Gates *et al.* (1992), Brinker *et al.* (1993, 1996), Watts and Byrd (1998), and Watts (2004).

Colony growth rate was expressed using the time in years required for the nesting population to double in size where $t_{double} = \ln(2)/r$. The intrinsic rate of increase, r, was calculated using the exponential growth equation $N_t = N_0 e^{rt}$,where, N_0 is the population size when first surveyed in 1977, or the first year data were collected, N_t is the population size in 2003, e is the natural logarithm, and t is interval in years between population estimates N_0 and N_t.

RESULTS

During the 26-year period from 1977 to 2003, the number of wading bird colonies in the region increased 246% from 155 to 537. This growth was driven primarily by increases in colony sites occupied by Great Blue Herons (*Ardea herodias*), Great Egrets (*Ardea alba*), Yellow-crowned Night-Herons (*Nyctannasa violacea*) and Glossy Ibis (*Plegadis falcinellus*) (Table 1). Collectively for all species, the number of breeding pairs increased 67.5% from 15,869 to 26,589 (Table 2). Despite this community-wide increase, some species including Snowy Egrets (*Egretta thula*), Cattle Egrets (*Bubulcus ibis*), and Black-crowned Night-Herons (*Nycticorax nycticorax*) declined dramatically over the period.

Great Blue Heron

Great Blue Herons have likely nested within the region for a very long time and have been documented breeders since at least the late 1800s (Bailey 1876; Rives 1890; Richards 1891; McKearnan 1996). As with other large piscivores within the Chesapeake Bay, this species appears to have suffered dramatic declines due to DDT. Stewart and Robbins (1958) describe the Maryland breeding status of the Great Blue Heron as "fairly common locally in the Eastern and Western Shore sections" citing maximum breeding populations of 300 nests in Cecil County in 1943 and 100 nests in 1948 at the Pocomoke Swamp colony in Wicomoco County. In contrast, in Virginia there were only five known colonies in 1964 (Watts and Byrd 2006). Subsequently, the population increased dramatically from 16 colonies with 2,476 pairs in 1977 to 261 colonies with 14,774 breeding pairs by 2003. The average doubling time for the population and colonies was 10.1 and 6.5 years respectively. Recent increases have been attributed to the species' rapid expansion inland along Chesapeake Bay tributaries (Watts and Byrd 1998, 2006; D. F. Brinker, unpubl. data). Fragmentation of formerly large colonies into smaller satellite colonies and increased survey coverage of inland tributaries have both contributed to the increase in recorded number of colonies (McKearnan 1996). The factors responsible for the fragmentation of long-standing colonies are undetermined (Watts and Byrd 2006). Clearly the species is taking advantage of maturing riparian tree stands that were logged or otherwise impacted by human intrusion. The growth of the Great Blue Heron population is the dominant force driving the overall in-

Table 1. Numbers of colonies, percent change between 1977 and 2003, and the average doubling time for ten wading bird species breeding in the Maryland/Virginia Chesapeake Bay region.

Species	1977	1986	1993	2003	% Change 1977-2003	Doubling time (years)
Great Blue Heron	16	63	199	261	+1531	6.5
Great Egret	22	38	59	58	+163	18.6
Snowy Egret	24	21	24	32	+33	62.6
Little Blue Heron	10	17	20	22	+120	22.9
Tricolored Heron	17	18	19	25	+47	46.7
Cattle Egret	13	13	14	14	0	243.2
Black-crowned Night-Heron	23	28	22	35	+52	42.9
Yellow-crowned Night-Heron	10	13	46	57	+470	10.4
White Ibis	1	1	1	2	100	26.0
Glossy Ibis	19	17	18	31	+63	36.8
All Species	155	229	422	537	+246	14.5

Table 2. Number of breeding pairs (N), percent of the overall wading bird community and percent change of each population from 1977-2003, for ten species of wading birds breeding in the Maryland/Virginia Chesapeake Bay region.

Species	1977 N (% com)	1986 N (% com)	1993 N (% com)	2003 N (% com)	% Change 1977-2003
Great Blue Heron	2476 (16)	11997 (46)	11483 (40)	14774 (56)	+497.0
Great Egret	1421 (9)	1481 (6)	3291 (11)	3601 (14)	+153.0
Snowy Egret	5508 (35)	3069 (12)	4633 (16)	2336 (9)	-58.0
Little Blue Heron	295 (2)	745 (3)	658 (2)	644 (2)	+118.0
Tricolored Heron	926 (6)	2626 (10)	1452 (5)	1037 (4)	+12.0
Cattle Egret	1811 (11)	3468 (13)	3799 (13)	657 (2)	-64.0
Black-crowned Night-Heron	2703 (17)	945 (4)	668 (2)	935 (4)	-65.0
Yellow-crowned Night-Heron	55 (<1)	118 (1)	410 (2)	476 (2)	+765.0
White Ibis	1 (<1)	1 (<1)	3 (<1)	77 (<1)	+7600.0
Glossy Ibis	673 (4)	1488 (6)	2415 (8)	2052	+205.0
All Species	15869 (100)	25938 (100)	28812 (100)	26589 (100)	+67.5

crease of the wading birds within the region. Great Blue Herons accounted for 16% of all wading bird pairs in the region in 1977, and 56% of all pairs by 2003.

Great Egret

The generalist nature of the Great Egret for choices of nesting and foraging sites likely contributed to its rapid recovery from the era of late nineteenth century plume hunting (McCrimmon *et al.* 2001). In Maryland in the 1950s it was a rare breeder with only two known colonies (Stewart and Robbins 1958; McKearnan 1996). By 1977 the number of colonies had increased to 22 in five counties with 664 pairs (Erwin and Korschgen 1979). This accounted for 14% of the Atlantic Coast population (Spendelow and Patton 1988). Nesting concentrations of Great Egrets existed in lower Tidewater Virginia from at least the 1930s into the late 1980s when they became a nuisance in residential neighborhoods. In 1987, for instance, 50% of Virginia's Great Egrets nested in densely populated urban neighborhoods. In the spring of that year 61% of the urban breeding Great Egrets were dispersed with the assistance of the U.S. Department of Agriculture (Byrd *et al.* 1987). Despite a declining nesting population along the immediate coast (Watts and Byrd 2006), Great Egrets have increased colony sites (+163%) and population (+153%) from 1977 to 2003, in part by occupying the expanding inland colony sites of Great Blue Herons (Watts and Byrd 2004). The average population growth (t_{double} = 19.4 years) parallels its rapid exploitation of colony sites (t_{double} = 18.6 years), a trend reflective of population growth across its range (McCrimmon *et al.* 2001).

Snowy Egret

The Snowy Egret population suffered severe losses during the plume harvesting era (Parsons and Master 2000). Its recovery included a northward range expansion into Maryland by 1946 (Stewart and Robbins 1947). Although the number of colony sites within the region increased by 33% (from 24 in 1977 to 32 in 2003), the population declined by 58% (from 5,508 to 2,336 pairs) during the same period. This decline is directly linked to losses within coastal barrier island colonies, where the population decreased as much as 80% between 1993 and 2003 in Virginia (Watts and Byrd 2006). Similar population declines have been recorded across the northeast (Parsons and Master 2000). Causes for these declines include increased predation and loss of colony sites (Watts and Byrd 2006; Williams *et al.* 2003).

Little Blue Heron (*Egretta caerulea*)

The dark plumage of the Little Blue Heron probably spared it from direct targetting by plume hunters during the millenary harvest era (Rogers and Smith 1995). Within the region this species has shown a 120% in-

crease in colonies (from ten in 1977 to 22 in 2003) with a comparable 118% increase in population size (from 295 to 644 pairs). It should be noted, however, that a population decline of 14% from a maximum of 745 pairs in 1986 to 644 pairs in 2003, seems to have paralleled a broader range-wide decline for the species (Rogers and Smith 1995).

Tricolored Heron (*Egretta tricolor*)

The Tricolored Heron was considered one of the most abundant of North American wading birds (Frederick 1997). Although its plumes were of limited commercial value to the millenary trade, it probably suffered from its common nesting in association with species that were heavily exploited (Frederick 1997). A recent arrival to the region, the Tricolored Heron was first detected as a breeder in Virginia in 1941 (Montagna and Wimsatt 1942) and in Maryland in 1946 (Stewart and Robbins 1958), The Maryland population tripled during the 1970s (McKearnan 1996; Frederick 1997) and continued to grow from 926 pairs in 1977 to 2,626 pairs in 1986, a 64% increase. By 2003, the population had declined 60% (to 1,037 pairs), despite a 47% increase in the number of colonies (from 18 to 25) Presently, throughout its range the Tricolored Heron is thought to be "probably declining, perhaps rapidly" (Frederick 1997).

Cattle Egret

The recent arrival and complex range expansion of this species into North America, decades after the end of plume hunting era, has been well documented (Telfair 1994). Its first confirmed nesting for Maryland was in 1957 (McKearnan 1996) and for Virginia, 1961 (Scott and Cutler 1961). Subsequently, it underwent a significant population increase through the mid-1990s before declining significantly in Virginia (Watts and Byrd 2006). The number of colonies occupied by this species within the region has remained static since 1977 at 13 to 14. However, the region's breeding population has declined by 64% from 1,811 pairs in 1977 to 657 in 2003.

Black-crowned Night-Heron

Black-crowned Night-Herons have long been common among the region's breeding wading bird community, although the species historical status, especially near the coast, remains unclear (Rives 1890; Murray 1952; Stewart and Robbins 1958; Davis 1993; McKearnan 1996). Atlantic coast Black-crowned Night-Heron populations decreased through the 1940s and 1950s due to habitat loss from drainage of wetlands and further declines occurred into the late 1960s as a result of DDT exposure (Davis 1993). In Virginia during the period 1975-1998, Black-crowned Night-Herons declined by more than 80% (Watts and Byrd 2006), yet the number of colonies within the region increased 52% (from 23 in 1977 to 35 in 2003). Overall in the region, the number of breeding pairs declined from 2,703 pairs in 1977 to 935 in 2003. Because these birds are high on the food chain, accumulate contaminants, and have a wide geographic distribution, they serve as an indicator of environmental quality (Davis 1993; Erwin and Custer 2000).

Yellow-crowned Night-Heron

The first Yellow-crowned Night-Heron breeding record for Maryland was in 1921 (McKearnan 1996), and for Virginia 1944 (F. M. Jones, unpubl. data). These dates coincided with a broader northward range expansion noted for the species between 1925 and 1960 (Watts 1995). Overall within the region there has been an increase in the number of breeding pairs (from 55 in 1977 to 476 in 2003, $t_{double} = 8.4$) and number of colonies (from ten in 1977 to 57 in 2003, $t_{double} = 10.4$) despite a recent 38% decline in the population in Virginia between 1993 and 2003 (Watts and Byrd 2006). The ability of this species to nest in urban settings (Watts 1989), typically in the absence of other wading birds, may partially explain the species' population growth during the survey period.

White Ibis (*Eudocimus albus*)

As one of North America's most abundant wading bird species (Kushlan and Bild-

stein 1992), the White Ibis only recently colonized the region, and has yet to nest in Maryland. The White Ibis was first detected breeding in Virginia in 1977 (Frohring and Beck 1978), and remains a limited breeder with only one or two colonies along Virginia's seaside (Williams *et al.* 1990; Watts and Byrd 2006). Despite sensitivity of young to salt stress (Kushlan and Bildstein 1992), the Virginia breeding population has increased exponentially (t_{double} = 4.1) from one pair in 1977 to 77 in 2003 (Watts and Byrd 2006; Williams *et al.* 2004) on barrier islands in high- salinity environments.

Glossy Ibis

The Glossy Ibis is another recent addition to the region's breeding wading bird community. Its northward range expansion began in the 1950s (Davis and Kricher 2000) and the first nesting for both Virginia and Maryland occurred in 1956 (Terborgh 1956; Stewart and Robbins 1958). It has been found nesting as far inland as St. Catherine's Island on the Potomac River in St. Mary's County, Maryland (Weske 1963). From 1977 and 2003, the number of colony sites within the region increased from 19 to 31 (63%), and the number of breeding pairs increased from 673 to 2,052 (205%) (Andrews 1990), despite a more than 18% decline in the number of pairs in Virginia between 1993 and 2003 (Watts and Byrd 2006).

DISCUSSION

Although we have documented the varied and complex changes among late twentieth century wading bird populations in the Chesapeake Bay region, lack of information of population status and distribution of species prior to the devastation of the plume hunting era limits our understanding of the nature of current trends. Determinants for range and population expansion within the wading bird community include habitat availability, i.e., the importance of available colony sites and foraging resources (Gibbs *et al.* 1987; Gibbs and Kinkel 1997; Custer and Galli 2002; Witt 2006), and the negative influences exerted on productivity from multiple disturbance factors and predation. Because no region-wide assessment of habitat availability existed prior to and even after the mid-1970s, we can only infer that ample habitat existed given the range and population expansion observed during the period of surveys.

The northward dispersal of recently fledged wading birds (Berger 1961) appears important for the broad and rapid wading bird expansion documented in the Chesapeake Bay region during the last quarter of the last century. Although it was quite likely that new heronries went undetected in the early 1900s (Murray 1932), anecdotal evidence readily demonstrates the rapidity with which expansion occurred and the Chesapeake Bay region's wading birds became established. For example, a large mixed species heronry formed on the south end of Mills Island in Chincoteague Bay, Worchester County, Maryland in 1945-1946 (Stewart and Robbins 1947) and another was established in Westmoreland County, Virginia, on the western shore of the Chesapeake Bay by at least 1951 (Abbott 1955). That heronry relocated across the Potomac River to St. Catherine's Island, St. Mary's County, Maryland in 1960 (Scott and Cutler 1960), then returned to its former Virginia location in 1962 (Davis 1962). A large mixed species heronry was found on Pea Patch Island in New Castle County, Delaware, in 1964 (Scott 1968). Small colonies became established in the Virginia barrier islands lagoon system in the late 1960s (M. A. Byrd, College of William and Mary, pers. comm.) and expanded, as evidenced by the June 1970 discovery of a large previously unknown heronry in Shelly Bay near Chincoteague, Virginia (Scott 1971), a colony that flourished through the late 1970s. Club House Point, a marsh island east of Wachapreague, Accomack County, Virginia, has been occupied by nesting waders almost continuously for more than five decades (Scott 1956).

Successful Great Blue Heron colony sites are typically predator free (Butler 1992) and away from man-made structures and human disturbance (Watts and Bradshaw 1994). More importantly, the colony locations must

have significant foraging habitat near the colony sites (Gibbs *et al.* 1987; Butler 1992; Gibbs and Kinkel 1997; Custer and Galli 2002; Witt 2006). Such conditions in bottomland forests, non-tidal wetlands, and riparian corridors, all currently protected by Bay-wide legislative mandates, have contributed to the current exponential population growth for Great Blue Herons and, its increasingly close nesting associate, the Great Egret.

Four of the ten species covered herein are recent arrivals to the region's breeding wading bird community, and all expanded into previously unfilled feeding niches (Kushlan and Bildstein 1992; Telfair 1994; Davis and Kricher 2000). In the case of the Glossy Ibis, this represents a potentially unique nesting strategy (Williams 1975; Warren 1977). The positive population trends of the two ibis species indicate successful integration into the region's wading bird community facilitated by their occupancy of a unique foraging niche.

The arrival of the Cattle Egret into the region was met with caution for it was predicted the species might compete with other wading birds for nest sites (McKearnan 1996), a contention that has proven to be uncorroborated (Telfair 1994). Its rapid regional expansion was likely due to the combination of exploitation of a readily available food supply and its proclivity to occupy areas converted to pasture where foraging along shorelines was available (Telfair 1994). The causes for the species subsequent precipitous population decline are unclear, although the explanation may be as straight forward as it is "unlikely it would breed successfully in areas where cattle are absent or scarce" (Telfair 1994).

Throughout its range, the Tricolored Heron seems to be highly fish dependent and selective of prey different in size from that of Snowy Egrets or Little Blue Herons (Frederick 1997). However, studies conducted in New Jersey found no difference between the foraging habitat preference or prey size among these species (Willard 1977; Frederick 1997). Habitat loss is especially stressful to the medium-sized herons and egrets that have specialized foraging strategies, e.g., the Snowy Egret (Kent 1986). Ardeids are known to degrade nesting habitat after successive years of use (Jenni 1969; Telfair 1994), forcing relocation of colony sites until the former site recovers. This dynamic appears to have little if any adverse long-term effect on wading bird productivity.

Studies of colony sites and habitat used by many of the region's wading bird species (e.g., Williams 1975; Warren 1977; Beaver *et al.* 1980; Custer *et al.* 1980; Erwin and Spendelow 1991; Bentley 1994) have been useful to the extent that they have broadly characterized the parameters for colony and more restrictively, nest site selection. For management purposes these parameters provide benchmarks for habitat restoration and/or augmentation. However, a most cogent conclusion encapsulated by Warren (1977) offers insight into understanding mixed species heronries: "every colony in each year is an individual and unique community, with changes in vegetation and nesting species composition, density and timing of nesting, and subsequent division, if any, of the nesting resources all acting to create the unique community of that year." Despite the appearance that nesting substrate is available in many areas, including areas which previously supported active and productive wading bird colonies, many areas remain unused. The role of predator and prey populations in determining population trends and site use needs further study.

Inclement weather events during a nesting season have immediate negative effects among wading birds (Williams 1975; Witt 2006). Large-scale habitat loss from catastrophic storms (Williams *et al.* 2005) and the constant landscape changes inherent in the ephemeral barrier islands system have the potential to create more long-lasting effects on wading bird nesting and foraging habitats.

The arrival and proliferation of mammalian predators among the Virginia barrier islands has had dramatic negative effects on colonial-nesting birds, especially beach-nesting species (Erwin *et al.* 2001; Kiess 2001). The extent of this influence on the wading bird community remains unclear. Within the confines of Virginia's immediate coastal bar-

rier islands the number of mixed-species heronries has declined from eight in 1975 (Williams 1976) to only three by 2002 (Williams *et al.* 2003). Only those islands which lacked mammalian predators (Kiess 2001) retained mixed-species heronries. The disappearance of these colonies has had direct impacts on the population status of Snowy Egrets, Little Blue Herons, Tricolored Herons, Cattle Egrets, and Black-crowned Night-Herons.

CONSERVATION RECOMMENDATIONS

Three species: Snowy Egret, Little Blue Heron, and Tricolored Heron, are listed as High Concern (populations known or thought to be declining and have some other known or potential threat) in the Western Hemisphere (Kushlan *et al.* 2002). White Ibis and Yellow-crowned Night-Heron are considered of Moderate Concern, which means their "populations are declining with moderate threats or distributions; stable with known or potential threats and moderate to restricted distributions; or relatively small with relatively restricted distributions" (Kushlan *et al.* 2002). Consideration of the long-term health of these species' populations necessitates that colony sites must be monitored and surveyed annually to fully understand their regional dynamics in a timely manner. Currently little to no information is available that describes the reproductive success of the region's wading birds. Without these data a significant element in understanding species population change is absent, and therefore cannot be effectively addressed.

Loss of foraging and nesting habitat represents the most significant threat to wading bird species in the region (Kushlan *et al.* 2002). Federal and state agencies, research institutions, and non-profit organizations must collaborate to actively locate, define, and permanently protect areas used by wading birds for foraging and nesting. Protected areas should include a system of habitat buffers. Signage should be established at known wading bird colony sites to minimize human encroachment between 1 April and 31 July. Habitat enhancement projects which augment and/or create nesting and foraging habitat should be explored and encouraged. Wading bird nesting areas should be closely assessed for avian and mammalian predator impacts. Where the potential for colony disruption from predators is high or is observed, the threat must be curtailed as quickly as possible through appropriate predator control means.

The trophic position of wading birds places them in danger of contaminant exposure including toxic chemicals and metals mobilized through the food web (see Erwin and Custer 2000; Rattner and McGowan, this volume). Although the evidence for a direct cause and effect between pesticide poisoning and reproductive failure in wading birds is unclear (Kushlan and Bildstein 1992; Telfair 1994; Rogers and Smith 1995; Watts 1995; Frederick 1997; Davis and Kricher 2000; Parsons and Master 2000; McCrimmon *et al.* 2001), monitoring for contaminants and their effects should be implemented within the region on a regular basis. The potential for oil spills must also be assessed and include development of an intervention program in response to such an event.

A broad array of public education initiatives describing the life history, distribution, and habitat requirements of the region's wading bird populations should be designed and implemented. Such a program should promote citizen involvement in habitat monitoring, and where appropriate, specific data collection. Research on the potential economic effects of wading birds on the evolving aquaculture industry must be implemented and effectively communicated to all constituents.

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