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THE VALUE AND VULNERABILITY OF SMALL ESTUARINE ISLANDS FOR CONSERVING METAPOPULATIONS OF BREEDING WATERBIRDS

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Abstract

Compelling arguments for preserving large habitat 'islands' have been made for a number of animal groups, but most commonly for terrestrial birds. We argue that, for many species of waterbirds nesting in coastal estuaries, maintaining numerous small islands may be a more effective management strategy than maintaining larger islands or reserves. In this study, the number of great white heron Ardea herodias *nests over a 5-year period (1986–91) was negatively correlated with island area in the Florida Keys, USA. Nest densities were highest in the 2–10 ha island size range and lowest for islands larger than 100 ha. These small islands also attract nesting black skimmers* Rynchops niger, *brown pelicans* Pelecanus occidentalis, *and several species of terns and gulls. Small estuarine islands are vulnerable to sea level rise, erosion from watercraft, and, for dredge material islands, lack of sufficient maintenance because of competing needs for beach nourishment. Managers need to enforce more buffering and protection of these islands and argue for more dredged material allocations in some areas.*

Keywords: Ardea herodias, breeding waterbirds, coastal estuaries, Florida Keys, great white heron, human disturbance, sea level rise, island biology.

INTRODUCTION

In the avian conservation literature, debate continues over the comparative values of different forest tract sizes in avian conservation. Most conservationists favor fewer, larger preserves, arguing that large or rare species are typically lost when large areas are fragmented or subdivided (Cody, 1983; Harris, 1984; Robbins *et al.*, 1989, and references therein). This formula may apply in forested habitats, but not necessarily in wetlands. In the past 20 years it has become increasingly apparent that small islands are important to the conservation of a diverse group of nesting waterbirds. More than 30 species of colonial waterbirds, including gulls, terns, skimmers, herons, egrets, and ibises, depend heavily on both natural and man-made islands smaller than 20 ha for nesting; this has been documented in the Great Lakes (Scharf, 1978), the Gulf Coast from Texas to Florida (Landin & Soots, 1978), along the Atlantic Coast from New York and New Jersey (Burger & Lesser, 1978; Burger & Gochfeld, 1990, 1991) to Virginia (Erwin, 1979, 1980) and south to Florida (Osborn & Custer, 1978). Nesting on these islands has increased steadily as human disturbance and coastal development renders many of the larger barrier islands unsuitable (Erwin, 1980; Burger & Gochfeld, 1990, 1991). At the same time, however, the birds inhabiting these small islands have become vulnerable to certain other types of disturbance, inundation and erosion with sea level rise, and lack of adequate maintenance of their nesting habitat (in the case of man-made islands).

Here we present an example of such a situation in the Florida Keys to demonstrate the selection of small islands (or keys) by nesting great white (a race of great blue) herons *Ardea herodias* and to indicate their vulnerability. We then review the value and vulnerability of small estuarine islands as nesting sites in other geographic locations.

STUDY AREA AND METHODS

As part of its biological inventory program, the National Key Deer Wildlife Refuge supports aerial surveys of great white heron nesting colonies during the fall and winter, November to February. The survey is conducted within the boundaries of three adjacent national wildlife refuges, National Key Deer, Great White Heron, and Key West in extreme southern Florida (Fig. 1). A fixed aerial transect was flown from Money Key Channel (81°10' Long.) west to Marquesas Keys

*Formerly US Fish and Wildlife Service.

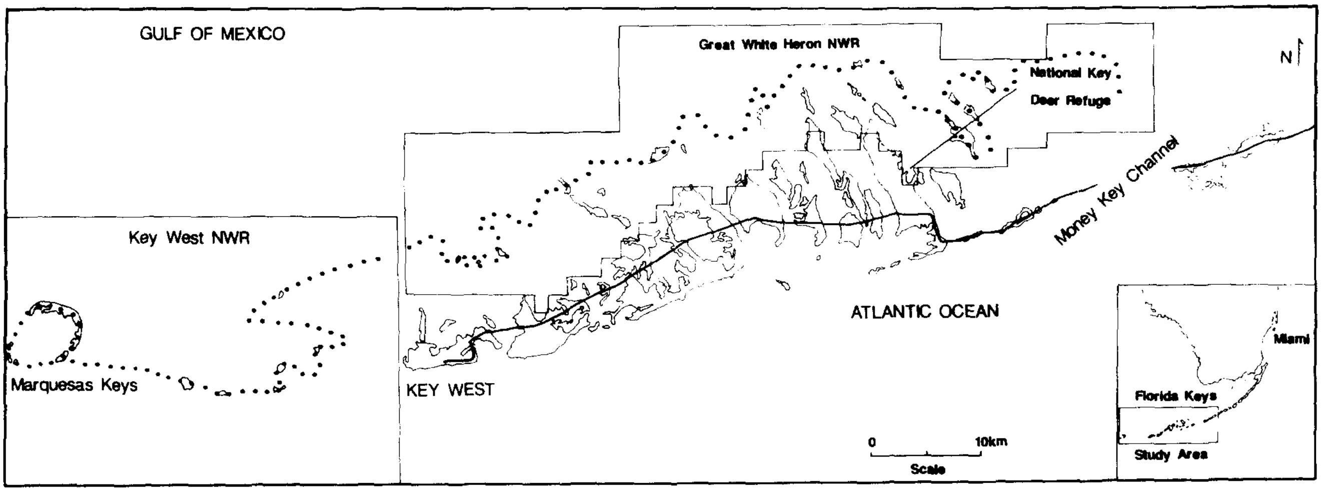

Fig. 1. Study area in the lower Florida Keys showing the fixed aerial census route (heavy line) followed annually during great white heron censuses 1986–1991.

(see Fig. 1). Numbers of nesting pairs were estimated by an experienced observer yearly from November 1986 to February 1991. We did not include large keys with roads because human disturbance and development probably render them unsuitable as nesting habitat for wading birds. When more than one count was made in a winter, the peak estimate was used to compile summary tables of nesting.

To evaluate how nesting colonies were distributed with respect to key size, we estimated the area of each of the keys surveyed using a grid-cell overlay over nautical charts of the area. Each grid cell covered approximately 1·1 ha. Complexes of small keys that were separated by channels averaging < 100 m were treated as one 'island' since birds nesting in such close proximity usually are treated as a single social unit, i.e. a colony (Erwin, 1979; Burger & Gochfeld, 1991).

For statistical analyses, we used the Spearman rank correlation coefficient (Lehmann, 1975) to compare island size and colony size. We also used one-way ANOVA procedures to test for differences in nest densities among size categories of islands. Island size categories were based on size ranges similar to those reported by earlier investigators (Burger & Gochfeld, 1990, 1991; Parnell & Shields, 1990) of waterbird colonies; < 2 ha, 2·0–9·9 ha, 10–19·9 ha, 20–99·9 ha, and > 100 ha. Nest densities were computed in two ways: first, where the total number of nests for the 5 years was divided by the total area of all islands in each particular island size class (this treats each nest as being independent of all other nests) and, second, dividing the nest totals for each island by its size (this assumes independence of islands but not nests). A few (n = 8) of the islands never had nesting herons and were therefore excluded from our analyses.

RESULTS

A total of 34 heron colonies was found during the 5-year study period; 22 averaged less than five nests per year, while 12 averaged more than five. The largest colony, Cottrell Key, had an average of 31·6 nests per year (Table 1).

A clear pattern relative to island size emerged when nest totals were investigated over the 5-year period. Intermediate-sized islands (2–100 ha) were more attractive to nesting herons than either the smallest or largest islands (Table 1). The Spearman rank correlation coefficient yielded $R = -0{\cdot}39$, $p = 0{\cdot}02$ when comparing island area with the total number of nests on each island during the 5-year study period and $R = -0{\cdot}55$, $p = 0{\cdot}001$ when the smallest island sizes (< 2 ha) were excluded from the analysis. Thus, a strong negative relationship between island size and number of nests was found (Fig. 2).

When nest densities were compared with ANOVA, the results were similar ($p < 0{\cdot}0001$). Densities were lowest on the largest islands and highest on the islands between 2 and 10 ha (Table 2). Multiple comparison

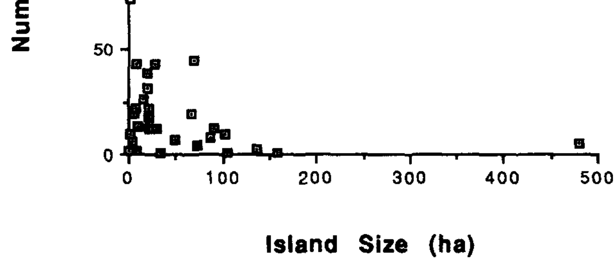

Fig. 2. Relation of island size (ha) and numbers of great white heron nests in a fixed transect within three national wildlife refuges in the Florida Keys. Data are from November through February censuses, 1986–1991.

Table 1. Results of aerial survey of great white heron nests in the Florida Keys, November–February 1986–91

Name[a]	Area (ha)	Number of nests						
		1986–87	1987–88	1988–89	1989–90	1990–91	Total	Mean
Little Crane Key	0·8	2	0	0	0	0	2	0·4
Friend Key	1·6	1	0	2	3	4	10	2·0
Little Spanish Mangrove	2·2	22	4	21	16	11	74	14·8
Little Pine Key Mangrove	3·2	0	0	1	5	0	6	1·2
Upper Harbor Key	3·2	24	14	7	24	8	77	15·4
Mule	5·8	0	0	3	10	6	19	3·8
Little Mullet Key	7·0	0	5	15	0	2	22	4·4
Crane key	7·4	20	18	8	14	28	88	17·6
Crawl Key	7·9	16	12	4	8	3	43	8·6
Big Mullet Key	8·3	0	0	0	0	2	2	0·4
W Bahia Honda Key	9·5	14	12	24	16	19	85	17·0
Riding Key	9·5	9	0	4	0	0	13	2·6
Marvin Keys	15·8	7	0	0	11	8	26	5·2
Barracuda Keys	18·9	5	1	2	11	13	32	6·4
E Bahia Honda Key	20·0	3	0	18	8	10	39	7·8
Bay Keys	21·3	36	4	2	28	14	84	16·8
Cayo Agua	21·3	3	0	6	3	0	12	2·4
Archer	21·4	0	2	5	8	7	22	4·4
Big Spanish Key	22·1	0	4	4	7	3	18	3·6
Cottrell	22·2	60	6	34	40	18	158	31·6
Sawyer Key	28·4	7	3	6	13	14	43	8·6
Man Key	29·3	0	0	5	3	4	12	2·4
Woman Key	34·5	0	0	1	0	0	1	0·2
Baracouta Key	50·3	0	0	2	4	1	7	1·4
Lower Harbor	67·3	2	6	2	5	4	19	3·8
Horseshoe Keys	68·4	10	0	2	24	9	45	9·0
E Content Keys	73·7	0	0	0	4	0	4	0·8
Mud Keys	86·3	0	3	1	4	0	8	1·6
Boca Grande	90·2	0	1	2	3	6	12	2·4
Snipe Point	103·2	8	2	0	0	0	10	2·0
W Content Keys	105·3	0	0	0	0	1	1	0·2
Johnston Key	136·8	3	0	0	0	0	3	0·6
Johnson Keys	157·9	0	1	0	0	0	1	0·2
Marquesas	480·0	0	1	1	3	0	5	1·0

[a]Includes only occupied islands (keys) with ≥1 nest during the five-year period. The Spearman rank correlation yielded $R = -0{\cdot}39$, $p = 0{\cdot}02$ when comparing the five-year total number of nests with island area. When the smallest islands (< 2 ha) were dropped from the analysis, $R = -0{\cdot}55$, $p = 0{\cdot}001$.

procedures showed that nest densities on the largest islands, two orders of magnitude smaller than those on the other size categories, were significantly different ($p < 0{\cdot}05$) from the 20–100 ha and 2–10 ha categories. We conducted the multiple range test on the mean nest densities where nest totals for each island are divided by its size so that individual nests are not treated independently on islands. However, the sample sizes then were too small to yield a powerful evaluation of the smallest and the 10–20 ha island size categories.

Table 2. Summary statistics of the number of great white heron nests and nest density for each occupied island category[a], during 1986–1991

Island area (ha)	Number of nests over 5 years	Number of islands	Total area (ha)	Overall nest density[b] (Nest/year)	Mean nest density[c,d] (Nest/year)
h < 2	12	2	2·4	1·0000	0·8750 ab
2–<10	429	10	64·0	1·3406	1·8777 a
10–<20	58	2	34·7	0·3343	0·3339 ab
20–<100	484	15	656·7	0·1474	0·2497 b
≥100	20	5	983·2	0·0041	0·0058 c
All islands	1003	34	1741·0	0·1152	0·7344

[a]An occupied island is defined as any island with at least one nest during the 5-year study period.
[b]Calculated as: number of nests/total area/5 years for each category.
[c]Calculated as the mean over islands of: (number of nests)/(island area, ha)/5 years for each category.
[d]One-way ANOVA on the transformation: log [(number of nests + 1)/(island area, ha)] resulted in $p \leq 0{\cdot}0001$. $F = 15{\cdot}05$, $r^2 = 0{\cdot}67$. Densities with the same letter are not significantly different using Tukey's multiple comparison procedure ($\alpha = 0{\cdot}05$).

DISCUSSION

Size and use

This study demonstrated the value of small, but not the smallest, keys in the Florida Key archipelago to nesting great white herons. Similar results have been reported by other investigators with other estuarine waterbirds (Table 3). Burger and Gochfeld (1990) reported that, in central coastal New Jersey, more than 75% of black skimmers *Rynchops niger* nested on small bay islands between 0·25 and 10 ha, with almost none on islands smaller than 0·5 ha or larger than 20 ha. They stated that more than half of all the islands available in the bay were smaller than 0·5 ha.

In the same region, Burger and Lesser (1978) reported that common terns *Sterna hirundo* nested on bay islands averaging 17·7 acres (about 7 ha) in a region where about half the islands, those smaller than 2·5 ha, remained unused. Later, Burger and Gochfeld (1991) reported that common terns selected small (< 20 ha) islands, 'but not tiny islands, and not very large islands...' in Long Island and New Jersey estuaries.

Similarly, in summaries of extensive surveys of nesting habitat use by all colonial waterbirds along coastal waterways of the United States, Landin and Soots (1978) reported that, for ground-nesting terns, gulls, and brown pelicans *Pelecanus occidentalis* in the Wilmington, North Carolina region, the 'optimal island sizes were 2·1–6·1 ha although islands up to 10·1 ha may be suitable' (their Appendix B8).

At least two reasons seem to account for these area-related patterns of island nesting. First, birds tend to avoid islands large enough to harbor mammalian predators on a year-round basis. In New Jersey and New York (Burger & Gochfeld, 1990, 1991), North Carolina, Texas (Landin & Soots, 1978), and the Florida Keys (Strong *et al.*, 1991), larger bay islands and mangrove keys tended to support populations of raccoons *Procyon lotor* and other predators. Second, the smallest islands may be unsuitable because they tend to be lower and more susceptible to washing over by storm tides (Burger & Gochfeld, 1990, 1991) or may offer inadequate habitat.

Vulnerability of small estuarine islands

Small estuarine islands, especially in the range of 2 to about 40 ha, are highly vulnerable to both erosion and boating disturbance. Wading birds often nest along the periphery of islands where woody vegetation is densest, yet this exposes them to boat intrusion in many areas (T. Wilmers, personal observations). Although empirical data on disturbance effects on nesting wading birds are not extensive (but see Vos *et al.*, 1985; Erwin, 1989), the recommended perimeter buffer distance of 250 m for great blue heron colonies (Short & Cooper, 1985) is often quoted and used by natural resource personnel. Even discounting the area occupied by the colony, this requires that an island be at least 20 ha to minimize disturbance, assuming that the birds nested in the very centre of a circular island with a radius of 250 m. In our data, 14 of the 34 colonies were on islands equal to or smaller than 20 ha and thus were quite vulnerable to human disturbance. Some of the larger island colonies are also susceptible because they have small beaches that attract picnickers and even campers (T. Wilmers, personal observations). The recent increase in small personal watercraft (e.g. jet skis) in the lower Florida Keys has caused more frequent human disturbance near and on many of the keys in what were formerly remote (also known as 'backcountry') areas of the wildlife refuges. Management plans are now being reviewed by federal, state, and private agencies and groups that attempt to zone the public lands and adjacent waters to protect sensitive fish and wildlife resources (J. Andrews, US Fish & Wildlife Service, pers. comm.).

Another source of vulnerability of these small islands is erosion. In many parts of the Atlantic and Gulf coastal areas, most of the estuarine islands have been created by deposition of dredged material as a by-product of the intracoastal waterway (Landin & Soots, 1978). These man-made islands harbor more than half of the colonies of all seabirds and wading birds in coastal North Carolina, Atlantic Florida and Texas (Landin & Soots, 1978). Although some of the islands have been diked to reduce erosion, many have soft, unconsolidated shorelines that are highly vulnerable to wave action. In North Carolina, Virginia, and Maryland in some places, sandy dredged materials that would formerly be deposited to maintain these fast-eroding islands are now being diverted to outer recreational beaches as 'beach nourishment' projects (Parnell

Table 3. Relative attractiveness of estuarine island size to nesting waterbirds

Species (location)[a]	Islands available	Islands selected	Source
Black skimmers (NJ)	< 0·1–*c*. 20 ha (50% < 0·5)	75% on islands 0·25–10 ha	Burger & Gochfeld (1990)
Common terns (NJ)	50% of islands < 2·5 ha	Average 7 ha	Burger & Lesser (1978)
Brown pelicans, Laughing gulls, Royal terns, (NC)	< 1–> 30 ha	'optimal 2·1–6·1 ha'	Landin & Soots (1978)
Great white herons (F)	0·8–480 ha	2–10 ha	This study

[a]NJ, New Jersey; NC, North Carolina; F, Florida.

& Shields, 1990; S. Leatherman, University of Maryland, pers. comm.). Because some islands are lost over time or for many reasons become unsuitable to nesting waterbirds (Burger & Gochfeld, 1990, 1991), it is essential to maintain a network of such islands as alternatives for a dynamic breeding population (Erwin *et al.*, 1981). Annual colony site attendance, especially for small colonies, can be quite variable (see Table 1). Thus, if a metapopulation of great white herons, or any other waterbird, can be defined, its long-term viability may depend on maintaining a network of small, undisturbed 'patches' whose suitability varies over time (Pickett & Thompson, 1978). These small patches become more critical to wildlife as human populations continue to grow on the larger coastal landmasses.

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