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When is a Heronry Crowded: A Case Study of Huckleberry Island, New York, U.S.A.

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ABSTRACT

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Biologists working with colonial species often record basic data on how herons use space in a nesting colony. Such data are often too complex to analyze succinctly. Yet understanding how species pack in colonies is critical to determining whether a colony is full, whether expansion is possible, and whether new recruits to the colony will have to seek space elsewhere. Herein we present data on tree use on Huckleberry Island, New York, hope to stimulate discussion concerning when and how a heronry is packed, and suggest a methodology for evaluating crowding in mixed species colonies. At Huckleberry Island the dominant nesting species are double-crested cormorant (*Phalacrocorax auritus*), great egret (*Egretta alba*), snowy egret (*E. thula*), and black-crowned night-heron (*Nycticorax nycticorax*). Of the 331 trees censused, 52% were occupied by at least one nest. All cherry, locust and hickory trees had at least one nest, whereas only 30% of privet clumps were occupied. Taller trees had more nests than shorter trees, and most trees had 2 to 4 available but unused, sites suitable for supporting nests. Cormorant nests mostly in dead trees whereas the other species usually nested in live trees. Cormorant nests were more clustered than nests of other species. Using the number of unused trees within and adjacent to the heronry, the number of available but unused nest sites, and nest height characteristics, we develop a method of determining the degree of crowding and whether a heronry has room for new pairs. We conclude that the heronry at Huckleberry Island is not crowded at present.

ADDITIONAL INDEX WORDS: *Coastal, birds, colonies, Ciconiiformes, management, Pelecaniformes, New York.*

INTRODUCTION

Herons (Ardeidae), ibises (Threskiornithidae) and cormorants (Phalacrocoracidae) often nest in mixed species colonies. In developing a model for the evolution of mixed species colonies of Ciconiiformes, BURGER (1981) presented a set of general hypotheses concerning the relationship of breeding synchrony, social facilitation, food availability, information transfer, and competition which can be used to partially explain species occurrence, abundance, and spacing. BURGER (1978, 1981) suggested that the space required by nesting Ciconiiformes often relates to body size. Patterns of species occurrence have been explored by SPENDELOW *et al.* (1989). They concluded that the 11 species of colonial Ciconiiformes nesting on the Atlantic coast formed two species groups: larger species that nest in the tops of large trees, and smaller species that nest lower in bushes or trees, or on the ground.

The spacing, and resulting packing patterns of Ciconiiformes, and other species they nest with, are of particular interest because, unlike many other colonial birds that nest only on the ground, they occupy three-dimensional space. Packing patterns determine the available space for reproductive activities such as courtship, uninterrupted copulation, incubation, and brood rearing. Presumably, nesting too close together leads to increased energy demands from territorial aggression, loss of nesting material to neighbors, and potential egg or chick losses due to territorial squabbles or cannibalism. Furthermore, nesting too close together can contribute to a high guano load which may ultimately kill trees (WIESE, 1978) or the understory. Nesting too far apart might decrease the social stimulation (DARLING, 1938) and early warning advantages (KREBS, 1978) of coloniality.

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Spacing and packing patterns are also of interest in determining whether a heronry has reached its population limits. When is a heronry so crowded that no other new recruits can find a suitable nest site? The answer will no doubt depend on multiple factors such as species composition of the existing heronry, physical features and physiognomy of the habitat, and the species attempting to establish themselves within the heronry.

The question of when a heronry is full is important to conservationists, biologists, wildlife managers, and developers who may need to determine how much habitat must be protected, acquired, or managed to maintain a viable heronry for decades. Coastal colonies are particularly vulnerable to development pressures because of the high demand for coastal properties and direct human disturbance (KURY and GOCHFELD, 1975; TREMBLAY and ELLISON, 1979). Although the location of a colony may be stable, the space actually used by birds may change due to vegetation succession, habitat alterations and changing age and species structure of the population. Using past census data to model future population growth should allow us to predict whether the heronry can accommodate future growth. The question is particularly relelvant to the Northeastern United States, where several egret and heron species have recolonized former breeding areas (OGDEN, 1978). For example, great egret (*Egretta alba*) first recolonized New Jersey in 1928, and New York in 1952; and snowy egret (*E. thula*) recolonized in New Jersey in 1939 and New York in 1949 (OGDEN, 1978). In the 1990 aerial survey of coastal New Jersey, snowy egrets bred in 24 colonies, great egrets bred in 18 colonies, and black-crowned night-herons (*Nycticorax nycticorax*) bred in 28 colonies (JENKINS *et al.*, 1990). On Long Island in 1989 great egrets bred in 14 colonies, snowy egrets bred in 14 colonies, and black-crowned night-herons bred in 20 colonies (DOWNER and LIEBELT, 1990).

In this paper we examine habitat use by three species of herons and double-crested cormorant (*Phalacrocorax auritus*) nesting on Huckleberry Island, New York, in 1990. We were interested in determining whether the heronry was crowded. This involved examining how many nests of each species were in different types of trees, how many trees were unoccupied, and whether there appeared to be available but unused sites in these trees.

Although spacing data from heronries are available for a number of heronries and species (see BURGER, 1979), these data are usually presented as nearest neighbor distances and there are few published data examining nests per tree. Yet we know from discussions with biologists that these data exist in field notebooks. Thus, we hope our data will encourage our colleagues to publish their data, allow us all to consider the question of how herons use space over time, and how heronries evolve with changing species composition and abundance.

STUDY AREA AND METHODS

Huckleberry Island (5 ha) in New Rochelle, Westchester County, New York, is a rocky island located in Long Island Sound (40°54′N, 73°47′W). It is covered with deciduous trees (KUNSTLER and CAPAINOLO, 1987; SEATUCK, 1988). A rocky shoreline (about 15% of island area) is used by herring gull (*Larus argentatus*) and great black-backed gull (*L. marinus*) for nesting. The heronry occupies most of the interior.

Huckleberry Island is an oval island with a number of small coves. Rocky sloping beaches border most of the island, with the deciduous trees in the interior. Much of the edge of the island is fringed with elongated clumps of privet. In the interior are old, tall trees, most of which are alive. The center of the cormorant colony contains 6–7 dead trees. Although the fringes of the island have an understory that includes poison ivy (*Rhus radicans*), there is little understory vegetation under the main part of the heronry. The barren ground, covered with dead branches, fallen trees and guano, is used for nesting by some herring and great black-backed gulls.

In 1975 the heronry contained only three pairs of great egrets, five pairs of snowy egrets, and eight pairs of black-crowned night-herons (KUNSTLER and CAPAINOLO, 1987). By 1978 there were 89 pairs and by 1987 there were 157 pairs of these species along with one pair of green-backed herons (*Butorides virescens*) and 92 pairs of cormorants (KUNSTLER and CAPAINOLO, 1987). The 1989 Colonial Waterbird Survey reported 513 pairs of herons (DOWNER and LIEBELT, 1990), and 230 pairs of cormorants. Thus Huckleberry Island represents a new and rapidly growing heron and cormorant colony. Currently the heronry covers about 4 ha. The question of space limitations is important because there are few other uninhab-

Table 1. *Abundance and use of different tree species by herons, egrets and cormorants nesting on Huckleberry Island. Shown are means ± one standard error.*

Tree Taxa	Percent Occurrence in Heronry[a]	Percent Live Trees	Height (M)	Percent Used for Nesting	Average Number of Nests[b]	Number of Suitable Nest Sites[c]
Maple	38	99	9.0 ± 0.3	52	1.8 ± 0.3	3.1 ± 0.4
Privet clumps	30	100	4.3 ± 0.09	27	3.1 ± 0.8	3.4 ± 0.1
Ash	4	88	10.2 ± 0.4	88	3.8 ± 1.1	11.0 ± 2.2
Black Locust	4	33	11.2 ± 0.6	100	5.4 ± 1.2	3.4 ± 0.5
Pine	4	62	8.1 ± 1.0	62	3.2 ± 1.3	3.4 ± 0.9
Cherry	3	71	7.1 ± 0.3	100	4.0 ± 0.9	4.2 ± 0.2
Hickory	3	42	14.3 ± 1.0	100	5.1 ± 0.9	2.6 ± 0.9
Sassafras	6	14	14.7 ± 0.4	86	6.4 ± 0.9	3.4 ± 0.6
All species	100	74	10.2 ± 0.4	64	3.0 ± 0.4	3.8 ± 0.6
χ^2[d]	188	209	151.3	50.8	70.9	20.2
P <	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

[a]By number of trees, not space they occupy. Does not add up to 100% because not all tree species are shown
[b]For the trees with nests
[c]Suitable but not currently used
[d]Given are Kruskal-Wallis χ^2

ited islands without predators nearby. We undertook our investigation to determine whether the heronry is full.

In 1989 we visited Huckleberry Island twice in mid-June to assess population numbers and location of the heronry. We walked a transect through the long axis of the heronry, marking 20 trees and recording the number of used nesting sites (N = 64), and sites that appeared usable (N = 105). A usable nesting site was defined as a branch configuration that resembled the ones used for nests. Included in this determination was the number of cross branches, size of the limbs, and distance from used nest sites (available and unused nesting sites had to be at least 0.5 m from an active nest). Sites generally consisted of a fork of at least 2 branches with one of the branches having a slope less than 30° (estimated visually) and a branch at least 3 cm in diameter.

In 1990 we revisited these trees to determine if used nesting sites continued to be used, and if any of the unused nesting sites were used. Over 90% of the previously used nesting sites were reused, and 14% of the unused 1989 nesting sites were used in 1990. We confirmed our prediction that some sites we classified as usable would be usable, and thus assume that this is a reliable method.

On 1 and 14 June and 6 July 1990 we walked on transects through the long axis of the heronry (approximately 250 m), recording data on each tree within 3 m of our path. We covered approximately 70–90% of the heronry. We recorded tree species and height (using a rangefinder), species of bird nesting in the tree, nearest neighbor distance for all nests, minimum and maximum height of the nests in the tree, and number of unused, available nesting sites.

On subsequent visits we rechecked trees and counted new nests. Some unused nesting sites classified as usable on our first visit were occupied by a nest on the second visit. We use individual trees as our measure of spatial use because the method can be easily replicated. Privets (*Ligustrum vulgare*) presented a problem in that they grew in clumps with multiple stems, and the canopy area of a large deciduous tree is far greater than that of a privet clump. We therefore used individual clumps, and measured height as a partial surrogate for three dimensional space.

We used Kruskal-Wallis χ^2 tests to distinguish differences in the distribution of variables, and Kendall tau correlations to examine the correlation among variables. We used non-parametric tests because the distributions are not necessarily normal.

RESULTS

A few large and tall trees such as ash (*Fraxinus* spp.), black locust (*Robinia pseudoacacia*), hickory (*Carya* spp.), and sassafras (*Sassafras albidum*) grow in the center of the island, surrounded by numerous smaller, shorter trees such as maple (*Acer* spp.) and privet (Table 1). The birds did not nest in all the trees. Indeed, the most abun-

Table 2. *Used and availability of trees by height on Huckleberry Island. Shown are the percent of trees that have or do not have nests. Given are means ± standard error.*

Height (m) (%)	1989 Trees with Nests (%)	1989 Trees without Nests (%)	1990 Trees with Nests (%)	1990 Trees without Nests (%)	Mean Number of Nests in Used Trees (1990)	Mean Number of Available Sites in All Trees (1990)
0–3	2	5	1	0	0	2.0 ± 0.1
3.1–6	15	45	13	43	1.5 ± 0.4	3.2 ± 0.1
6.1–9	20	30	21	25	1.5 ± 0.2	3.9 ± 0.3
9.1–12	25	25	22	26	2.2 ± 0.3	3.8 ± 0.4
Over 12	38	5	43	6	5.4 ± 0.4	4.3 ± 0.2

dant trees (by number but not by space) were used less frequently for nests (privet, maple) than the least abundant species (the taller hardwoods, Tables 1 and 2). The birds are selecting particular tree species or structure.

The mean number of nests in trees that are used varies significantly by tree species (Table 1). Proportionally more nests were in the taller trees (sassafras, hickory, locust), and the fewest were in the maple saplings (Table 2). Our estimation of the number of unused but suitable nesting sites also varied by tree species (Table 1). There were more available sites in ash than in the other tree species (Table 1).

The main concentration of birds nested in large, dead trees. This was not the geographical center of the habitat, and there were some large, dead trees throughout the island. Most herons nested in live trees, whereas most cormorants nested in dead trees (Table 3). Similarly, the number of nests per tree was higher for dead than live trees overall. Significantly more snowy egrets and night herons nested in each live tree, whereas there were more cormorants per tree in dead trees than live trees. The mean height and number of unused, available sites did not differ between live and dead trees used by the nesting birds.

Used and unused trees, however, varied significantly with respect to tree height; used trees were almost twice as tall as unused trees (Table 4). Used trees also had more suitable sites with nests plus available nesting sites than trees where no birds nested (Table 4; total nesting sites).

The nesting pattern differed between species (Table 5). Cormorants nested in groups of almost five nests per tree, whereas the herons nested in smaller groups. Snowy egrets nested in the shortest trees, and cormorants nested in the tallest trees. Great egrets and cormorants nested in the tops of their trees, whereas snowy egrets nested halfway down from the tops of their nest trees.

DISCUSSION

Huckleberry Island is a relatively new heronry that is expanding in both numbers of nesting pairs and species diversity (KUNSTLER and CAPAINOLO, 1987). It also has a variety of tree species, with many of the tallest trees in the center, fringed by

Table 3. *Relative use of live and dead trees by nesting herons, egrets and cormorants for trees that had at least one active nest.*

	Live Trees	Dead Trees	χ^2 (P)
Percent occurrence	75	25	
Percent used by			
Great egrets	67	33	NS
Snowy egrets	75	25	NS
Black-crowned night-heron	9	10	9.2 (0.002)
Double-crested cormorant	38	62	105.1 (0.0001)
Mean number of nests/trees	3.5 ± 0.4	4.5 ± 0.4	7.42 (0.006)
Great egrets	0.1 ± 0.05	0.07 ± 0.04	0.29 (NS)
Snowy egrets	0.7 ± 0.2	0.2 ± 0.08	4.29 (0.03)
Black-crowned night-heron	1.0 ± 0.1	0.1 ± 0.04	33.9 (0.0001)
Double-crested cormorant	1.6 ± 0.3	4.2 ± 0.4	40.0 (0.0001)
Mean height (m)	9.9 ± 0.4	10.9 ± 0.4	2.6 (NS)
Number of available unused sites	4.8 ± 0.5	4.5 ± 0.4	0.18 (NS)

Table 4. *Characteristics of live trees that were used and unused for nesting by herons, egrets and cormorants.*

	Used Trees	Unused Trees	χ^2 (P)
Number of trees	211	119	
Mean height (m)	9.9 ± 0.4	5.9 ± 0.2	94.3 (0.0001)
Available sites	4.8 ± 0.5	3.5 ± 0.2	0.5 (NS)
Used sites	3.5 ± 0.4	0	0
Total sites	8.3 ± 0.5	3.5 ± 0.2	133 (0.001)

smaller and shorter trees or shrubs. The mixture of tree species, sizes, and shapes provides a diversity of nesting opportunities. Nest site selection in these species has been extensively studied (BURGER, 1978; MCCRIMMON, 1980).

Overall the birds did not nest randomly but selected particular trees, preferring the taller hardwoods in the center of the island. These trees not only contained more nests, but had more available, unused nest sites. Although our method of estimating available nesting sites is somewhat subjective, we used the same methods with all trees. Further, we recognize that the birds may not choose to use all of these potential nest sites, and that there are no doubt avian species differences in how suitable these potential sites are. At this stage we did not try to distinguish sites suitable for one species but not for another. Nonetheless, it was noteworthy that most trees had seemingly usable sites that were unoccupied (see below), and that some of those unused sites in 1989 were used in 1990.

The question of whether a heronry is crowded is challenging not only because it is important to managers and conservationists, but because it addresses the issue of use of space, site tenacity, future colony growth, and recruitment. Some heronries have been occupied for decades, if not centuries. Other heronries are less stable, shifting sites from year to year even without apparent habitat alteration. In New Jersey, some of the small (less than 100 pairs) heronries on salt marsh islands may exist for only one to three years before shifting sites (J. BURGER, *unpublished data*). Yet in our view these shifts are due to habitat changes (high tides may destroy nesting structure or cover) and predation pressures (red fox *Vulpes fulva* sometimes arrive on these islands or crows *Corvus* spp. discover the heronry). Nesting in tall trees provides protection from some of these pressures.

We consider that the following factors enter any consideration concerning the ability of a heronry to maintain a stable or increasing population:

(1) Maintenance of suitable vegetative structure.
(2) Maintenance of a predator-free environment.
(3) Maintenance of negligible human disturbance.
(4) Availability of unused, but suitable trees.
(5) Availability of unused, suitable nest sites on both used and unused trees.

The first three factors can operate at any heronry. Suitable vegetation can be altered by the birds themselves through excessive guano deposits (WIESE, 1978). This may be occurring at Huckleberry Island because where the birds nest there is almost no understory, and a few of the large, central trees are dead or partially dead. Whether it will continue to happen will depend on how fast the cormorants increase in numbers since they clearly are the most numerous.

The presence of available, suitable nest sites is obviously critical to establishment and maintenance of a viable heronry.

We make several assumptions about tree usage:

Table 5. *Nesting characteristic of the herons, egrets and cormorants on Huckleberry Island.*

	Great Egret	Snowy Egret	Black-Crowned Night-Heron	Cormorant
Number of nest trees	12	33	59	104
Percent of live trees	67	75	90	38
Mean number of conspecific nests in trees[a]	1.6 ± 0.3	2.8 ± 0.6	1.9 ± 0.2	4.7 ± 0.4
Maximum number of conspecifics nests/trees[a]	4	5	8	18
Mean total number of nests	2.7 ± 0.6	3.9 ± 0.9	3.6 ± 0.5	4.9 ± 0.4
Tree height (m)	10.3 ± 1.1	6.4 ± 0.6	10.5 ± 0.5	12.2 ± 0.3
Mean nearest neighbor distance (m)	3.5 ± 0.6	3.4 ± 0.7	2.7 ± 0.4	2.2 ± 0.1
Mean minimum height of nests	8.4 ± 0.5	1.6 ± 0.3	7.1 ± 0.6	9.72 ± 0.4
Mean maximum height of nests	10.2 ± 0.6	3.5 ± 0.5	9.1 ± 0.8	11.9 ± 0.5
Mean number of available nesting sites	6.6 ± 1.4	4.7 ± 0.5	5.2 ± 0.8	5.2 ± 0.6

[a]Of trees with nests

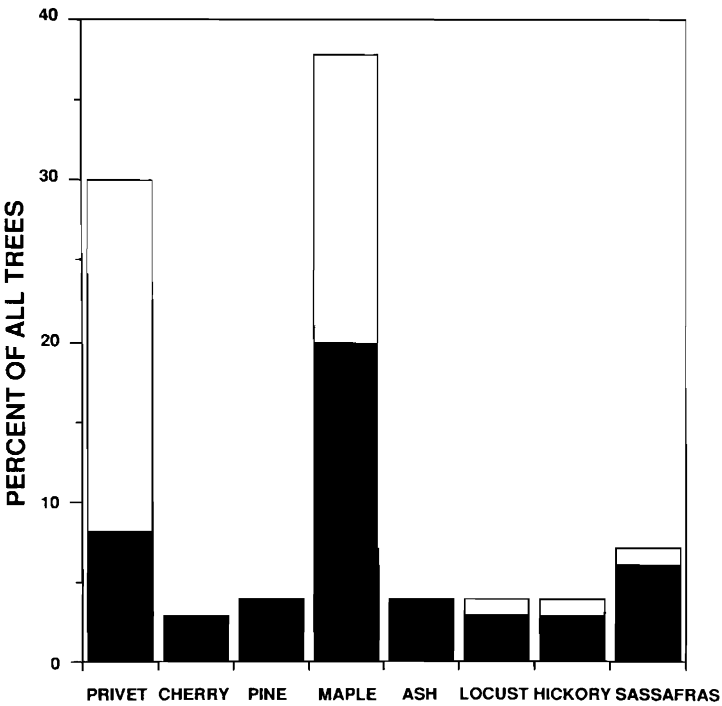

Figure 1. Percent presence by tree species in order of increasing size, with the percent currently used for nesting shown in black.

(1) Trees of similar height and of the same species as trees used, that are not currently used for nesting, are probably suitable for nesting.
(2) Sites with branch configurations (slope, structure, strength) similar to those used as nest sites by herons, egrets or cormorants represent suitable nest sites.
(3) Social factors (distance to nearest neighbors) and nest height preferences (see BURGER, 1978, 1979; MCCRIMMON, 1980) influence the actual use of suitable sites of each species.

We suggest there are at least three levels of evidence concerning the availability of suitable sites. These three criteria can be used as a methodology by managers to assess whether a heronry is crowded, or whether there is still room for expansion.

(1) The presence of unused but otherwise suitable trees within the heronry.
(2) The presence of unused, but suitable nest sites in used trees.
(3) The presence of unused trees with suitable nest sites in or adjacent to the heronry.

Some tree species were entirely used by herons (*i.e.*, cherry, pine, ash), whereas others (particularly privet and maple) had many unoccupied trees (Figure 1). This suggests that there are available nesting trees within the heronry. There are some available, unused trees that are tall and large. Further, some maple trees were used in 1990 that were not used in 1989.

Since a short maple may be less desirable for nesting than a tall maple, we examined the height classes of available and unused trees. This was based on the data on actual nest site usage by the different species as an indication of preferences (refer to Table 5). There were unused trees in all height categories, but the number of unused trees decreased with increasing tree height (Figure 2). Plotting the nest heights of the different avian species against available, unused trees indicates there are more available trees for snowy egrets than for the other species. Nonetheless, there are unused trees in all height classes at the heights used by the herons and egrets for nesting. Thus we conclude that there are available, suitable, unused trees within the heronry for nesting by all four species.

Even assuming that the used trees are entirely full, the unused trees of similar height and structure should provide suitable nest sites. In both used and unused nesting trees there were suitable, but unused nest sites. However, most trees that were used for nesting had suitable sites (Table 2).

Further, some species can be packed more densely than they are. For example, in 1987 KUNSTLER and CAPAINALO (1987) reported that only one tree had as many as five cormorant nests, the other trees had fewer than five nests. Yet three years later we found that the average tree with nesting cormorants had 4.7 nests, and the maximum was 18 nests in one tree. Thus the larger nest trees used by cormorants no doubt can absorb more nests.

Most snowy egrets nested in privet, and they often nested in groups of 2–3 nests per privet clump. Yet over half of the privet clumps had no nests. Clearly there is more than enough room for the expansion of snowy egrets well beyond their current numbers.

Finally, the current heronry does not cover the entire island, and there is a fringe of unused trees on the southwest side of the island. These trees are of similar height and species composition, and presumably the heronry could expand into these areas.

We have presented these results partly to describe spatial use of a heronry, to examine whether the Huckleberry Island heronry is full, and to develop a method to evaluate the spatial and temporal use of a heronry. The method involves three determinations: (1) the presence of unused trees of similar height and structure to trees that are used for nesting; (2) the presence of suitable, unused nest sites on all trees (used and unused nest sites); and (3) comparison of the sites used by the nesting species and available places. Managers can thus use data from a given heronry to evaluate its status. We have presented a method of analysis in the hopes of stimulating further research on spatial use and packing in heronries. We conclude that the Huckleberry Island heronry is not "crowded."

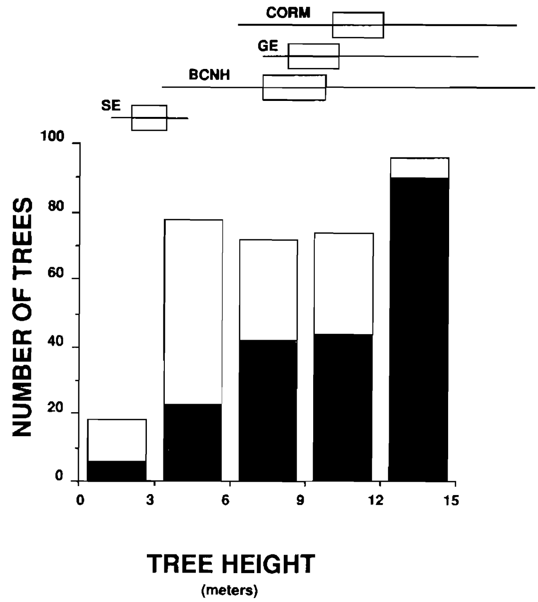

Figure 2. Number of trees used (solid bar) and not used (open bar) for nesting as a function of tree height. Shown also is the range of heights that nests of each species were found (thin line) and the average high and low nests per tree (box). Corm = cormorant, GE = great egret, BCNH = black-crowned night-heron and SE = snowy egret.

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LITERATURE CITED

BURGER, J., 1978. The pattern and mechanism of nesting in mixed-species heronries. National Audubon Society. *Wading Birds Research Report 7*, 45–48.

BURGER, J., 1979. Resource-partitioning: Nest site selection in North America herons and egrets. *American Midland Naturalist*, 101, 191–210.

BURGER, J., 1981. A model for the evolution of mixed species colonies of Ciconiiformes. *Quarterly Review Biology*, 56, 143–167.

DARLING, F.F., 1938. *Bird Flocks and the Breeding Cycle.* London: Cambridge University Press.

DOWNER, R.H. and LIEBELT, C.E., 1990. *1989 Long Island Colonial Waterbird and Piping Plover Survey.* Islip, New York: NYDEC, Stonybrook, New York and Seatuck Research Foundation, Inc.

JENKINS, D.C.; NILES, L.J., and WESSEL, J., 1990. Survey of colonial nesting waterbirds on the Atlantic coast of New Jersey 1989. *Report of the NJ DEP Endangered and Nongame Species Program.* Trenton, New Jersey, 41p.

KREBS, J.R., 1978. Colonial nesting in birds, with special reference to the Ciconiiformes. New York: National Audubon Society. *Wading Birds Research Report 7,* 299–314.

KUNSTLER, D.S. and CAPAINOLO, P., 1987. Huckleberry Island: Premier waterbird colony of Western Long Island Sound. *Kingbird,* 39, 177–188.

KURY, C.R. and GOCHFELD, M., 1975. Human interference and gull predation in Cormorant colonies. *Biological Conservation,* 8, 23–34.

MCCRIMMON, D.A., 1980. The effects of timing of breeding, distribution of nests, and habitat selection on nesting success of colonial waterbirds. *Transactions Linnean Society* NY, 9, 87–102.

OGDEN, J.C., 1978. Recent population trends of colonial wading birds on the Atlantic and Gulf coastal plain. New York: National Audubon Society, *Wading Birds Research Report 7,* 137–153.

SEATUCK, 1988. *Long Island Colonial Waterbird and Piping Plover Survey.* Islip, New York: Research report of Seatuck Research Program.

SPENDELOW, J.A.; ERWIN, R.M., and WILLIAMS, B.K., 1989. Patterns of species co-occurrence of nesting colonial Ciconiiformes in Atlantic Coast estuarine areas. *Colonial Waterbirds,* 12, 51–59.

TREMBLAY, J. and ELLISON, L.N., 1979. Effects of human disturbance on breeding of black-crowned night herons. *Auk,* 96, 364–369.

WIESE, J.H., 1978. Heron nest-site selection and its ecological effects. New York: National Audubon Society, *Wading Birds Research Report 7,* 27–34.