Proximity of Waterbird Colonies to Development in Maryland

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Abstract: We evaluated the proximity to development of 2 representative groups of colonial waterbirds present in Maryland's coastal plain, active in 1985 through 1988, to determine the influence of land and water development on the distribution of waterbird nest sites. Thirty of 38 known common tern *(Sterna hirundo)* and Forster's tern *(S. forsteri)* colonies were located on marsh islands. All 23 great blue heron *(Ardea herodias)* colonies were located in forested areas usually along shorelines. The distance to and quantity of various man-made structures (e.g., buildings, roads, piers, agricultural areas) within 1 km of each colony were quantified from aerial photographs. Similar measurements were taken from randomly selected sites of potential nesting habitat. Development around the colonies was compared to the random sites using *t*-tests. Most of the 8 variables in the analysis were useful in differentiating between colony and random sites. Mean distances between colonies and all development categories exceeded 0.7 km. Both tern and heron colonies, on average, nested further from man-made structures and in areas less densely developed compared to random sites. We recommend establishing minimum buffer zones of 0.7 km and 1.5 km around great blue heron and common tern colonies, respectively to development. These buffers were based on the minimum average distance to the nearest building.

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Colonial waterbirds occur throughout all coastal regions of North America. Coastal areas provide the necessary foraging and nesting habitats for survival. These same coastal areas are experiencing increasing development pressures from humans. Development can cause colony disturbance, abandonment, and limit the availability of nesting sites (Greer et al. 1985, Watts and Bradshaw 1994, Clements 1995). Few studies have attempted to determine the effects of land and water development on colonial waterbirds.

Several studies have evaluated the reaction of waterbirds to human intrusion near and directly into nesting colonies (e.g., Manuwal 1978, Burger 1981*a*, Vos et al. 1985, Erwin 1989, Bratton 1990, Klein 1993, Rodgers and Smith 1995). Response to intrusion appears to vary with species. Herons were more tolerant than terns of human intrusion once they were on nests (Mueller and Glass 1988, Erwin 1989, Rodgers and Smith 1995). Colonial waterbirds were reported most vulnerable to disturbance during colony establishment and egg laying (Tremblay and Ellison 1979, Hand 1980, Burger 1981*b*). However, some colonial nesting waterbirds habituate to repeated types of human activity, such as frequent handling by researchers, chronic boating activity, increased noise and aircraft activity (Grubb 1978, Parsons and Burger 1982, Vos et al. 1985).

Great blue heron *(Ardea herodias)* colonies in Maine (Gibbs et al. 1987) and Virginia (Watts and Bradshaw 1994, Clements 1995) were located farther from man-made structures than random locations. The need for disturbance tolerance information on all waterbird species is increasing as development continues in coastal areas. Resource managers routinely assess development proposals without adequate knowledge of the distances to structures or densities of development tolerated by colonial nesting waterbirds. The Chesapeake Bay Critical Area Law in Maryland provides protection to colony sites from adverse impacts related to new development (Therres et al. 1988), but information is needed to guide decisionmaking.

The purposes of this study were to: (1) evaluate the influence of development on the distribution (i.e., location) of common tern *(Sterna hirundo)* and Forster's tern *(S. forsteri)* colonies nesting on saltmarsh islands and great blue heron colonies nesting in forested areas; and (2) estimate adequate distance to buffer (mitigate reproductive impacts) colonies from encroaching development. Both common and Forster's terns occupied saltmarsh islands and were often found nesting together making identification of nests virtually impossible (Brinker 1996). Combining both tern species increased sample size for analysis. Great blue herons and the 2 terns were the only groups of waterbirds out of 19 species that nested in Maryland with adequate sample sizes and limited variability in nesting habitat for meaningful analysis.

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Methods

Aerial and ground surveys were conducted from 1985 through 1988 to locate tern and great blue heron nesting colonies in the coastal plain of Maryland (Gates et al. 1992). Any site occupied in at least 1 of these years was considered an active colony site. The locations of these colonies were plotted on U.S. Geologic Survey

(OSGS) 7.5-minute quadrangle maps. All 23 great blue heron colonies were found in forested areas located near open water. Thirty of 38 common and Forster's tern colonies occurred on saltmarsh islands composed primarily of *Spartina patens* and *S. alterniflora.* These islands were uninhabited by humans. The remaining 8 colonies nested on various beach substrates and did not constitute a valid statistical sample.

Colony sites were plotted on full color aerial photographs (scale 1:13, 200) taken in 1985. Straight line distances (m) to the nearest building, road, pier, and agriculture field were measured from the edge of each colony on aerial photographs. Agriculture was included as potential disturbance to colony nesting because of its dominance on the Maryland landscape. The number of each kind of man-made structure within 1 km of each colony also was determined.

Random locations were selected to compare with occupied colonies. Great blue herons were known to nest in forested areas near water, while common and Forster's terns nested on the ground in saltmarsh areas or on open substrate (Burger and Lesser 1978, Custer and Osborn 1978, Erwin 1979, Beaver et al. 1980, Custer et al. 1980, Greer et al. 1985, Erwin et al. 1987). Habitat for random sites were based on these habitat requirements and the reported habitat occupancy of birds in Maryland. We limited potential habitat selection in this study for terns to saltmarsh islands because the vast majority of colonies occupied these habitats. Great blue heron habitat was defined as forested areas located within the coastal plain of Maryland. Potential, but unoccupied, sites were identified from aerial photographs and plotted on USGS 7.5-minute quadrangle maps. For each potential site, a single quadrangle map was selected at random from within the study area. Then x and y coordinates were randomly selected on the map. The closest marsh island or forest area to the intersection of the coordinates was considered a potential random site. Fifty-nine random sites (29 marsh island, 30 forest) were selected from within these mapped areas and identified on aerial photographs. Measurements of land and water development were quantified similar to that done for existing colony sites.

All of the variables were transformed to meet assumptions of normality and homogeneity of variances. A Box-Cox approach was used to determine the best transformation. Quantity measures were transformed using the inverse. The $\log_{10}$ was used to transform all distance measures. Differences between colony sites and random sites were determined by using *t*-tests. A Pearsons product-moment correlation was used to examine the relationship among individual variables. All statistical procedures were performed using SAS statistical software (SAS Inst. 1988).

Results

All known colony sites were located in the coastal portions of Maryland surrounding Chesapeake Bay, the tidal portions of the Potomac River, and Chincoteague, Sinepuxent and Assawoman bays along the Atlantic coast. Mean distances between colonies and the nearest land or water development for great blue herons, common and Forster's terns exceeded 0.7 km (Table 1). Most distance variables exceeded 1.0

Table 1. Mean (± SE) of 8 development variables comparing colonies to random sites for common and Forster's terns and great blue heron nesting in Maryland.

	Common and Forster's tern				Great blue heron			
	Colony	Random	F-value	*P*	Colony	Random	F-value	*P*
Nearest building (km)	1.5± 0.1	1.5± 0.4	3.41	<0.10	0.7± 0.2	0.4± 0.1	7.85	<0.01
Nearest road (km)	3.4± 0.5	1.6± 0.4	9.55	<0.005	1.0± 0.2	0.5± 0.1	4.93	<0.05
Nearest agriculture (km)	3.3± 0.4	2.2± 0.4	7.75	<0.01	1.1± 0.3	0.4± 0.1	3.63	<0.10
Nearest pier (km)	1.7± 0.2	1.7± 0.4	2.47	<0.15	3.9± 0.9	1.4± 0.3	6.91	<0.05
N of buildings ≤1 km	24.8± 12.8	40.7± 22.2	13.8	<0.001	25.2± 14.1	34.5± 6.0	1.41	<0.25
Length of roads (km)	0.5± 0.3	1.7± 0.5	14.7	<0.001	1.7± 0.5	3.0± 0.4	8.07	<0.01
Ha of agriculture ≤1 km	1.5± 0.8	14.0± 6.0	6.34	<0.05	60.0± 13.0	70.0± 11.0	2.50	<0.15
N piers ≤1 km	3.0± 2.0	4.0± 2.0	8.43	<0.01	2.0± 1.0	5.0± 1.0	3.02	<0.10

km. Tern colonies averaged 2.5 km from all development variables combined, while great blue herons averaged 1.7 km. Minimum and maximum distances for great blue heron colony sites ranged from 31 m from a road to 9.4 km from a pier. Terns ranged from 122 m from a pier to 8.7 km from a road.

Significant *t*-test differences occurred between colony and random sites for both groups of species (Table 1). Every variable on average showed that colonies were located farther from development and in areas where the quantity of development was less when compared to random sites; however, not all were significant. Significant differences between great blue heron colonies and random forest sites appeared to be primarily distance dependent measures (Table 1). For example, there was a lower frequency of heron colonies (22%) within 0.3 km of a building compared to random sites (57%) (Fig. 1). Beyond 300 m there was little difference in the frequency of colony and random sites to buildings. For great blue herons, distance variables were fairly independent of each other ($r < \pm 0.7$). However, they were generally highly correlated with quantity measures. The quantity of roads, agricultural areas and piers were highly correlated with distance measures.

Tern colonies had significantly fewer man-made structures near them than did random sites. Only 5 of 30 common and Forster's tern colonies (17%) had any type of development within 1.0 km of the colony (Fig. 2). Excluding these 5 sites, there would have been no buildings, roads, or piers within 1.0 km of tern colonies and all distance categories would have increased an average of 0.3 km. Distance to the nearest building for terns appeared similar ($P < 0.10$) to random sites. This was an artifact of sampling (3 random samples >5.6 km accounted for these equivalent means). The higher standard error (SE) for the random samples indicate this variability. Without these samples the average distance to the closest building would have been 0.9 km for random sites. Twenty of the 29 random marsh islands (69%) had some type of development within 1.0 km of sample points and contributed most to the differentiation.

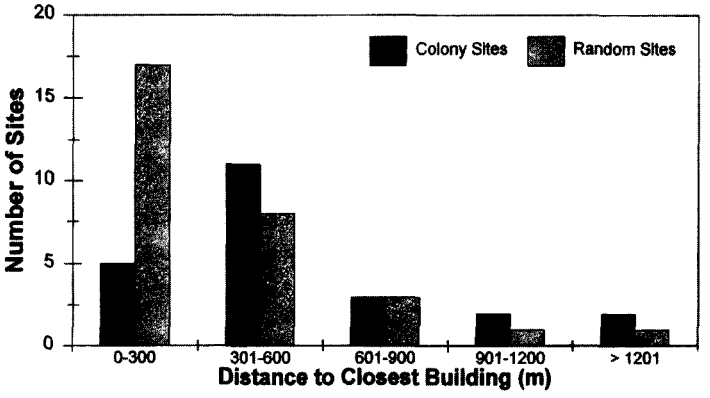

Figure 1. The number of great blue heron colonies and random sites relative to the distance ot the closest building.

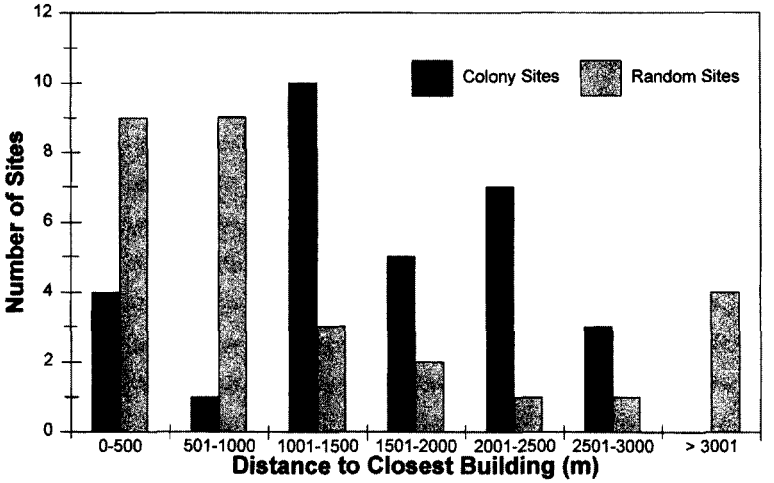

Figure 2. The number of common and Forster's tern colonies and random sites relative to the distance to the closest building.

Discussion

Development in coastal areas of Maryland appears to have an influence on where some species of waterbirds select nesting sites. Overall, common and Forster's tern colonies on marsh islands and great blue herons on forested areas nested at sites farther from man-made structures and in areas less developed than random sites. These findings were similar to that of Watts and Bradshaw (1994) for great blue herons. Parker (1980) reported that great blue heron colonies in Montana averaged 0.62 km from roads and 0.71 km from urban development, and colonies closer to roads had fewer nests. In our study, terns, on average, established nesting colonies farther from man-made structures than did great blue herons. This corresponded with the findings of other investigators studying the flushing distances in response to human intruders. Terns tended to flush at much greater distances than wading birds (Erwin 1989, Rodgers and Smith 1995). However, when we examined the distribution of available habitat for each species (as measured via random points), the findings indicated that great blue herons were much more sensitive to man-made structures than terns. On average, great blue herons nested nearly 2.5 times farther from man-made structures compared to random forested sites. Terns nested about 1.5 times farther compared to random marsh islands.

Waterbird colony site selection was based partially on the requirement to have safe nesting sites (Carlson and McLean 1996). This minimized the influence of disturbance associated with intruders. Our study identified distance to development as one important component to great blue heron colony site suitability. Both distance and quantity of development appeared to be important for common and Forester's terns.

The level of isolation selected by each individual colony was variable. Some colonies were located much closer to development than others, even among colonies

of the same species. The inhabitants of an established colony may abandon the site if nearby development compromises their collective requirements for isolation (i.e., security). Carlson and McLean (1996) found that barriers, created by fencing and moat-like water formations which limited human foot traffic, increased colony isolation and fledgling rates. Isolation may be the bird's mechanism for identifying sites with a lower likelihood of disturbance. In this study, tern colonies on march islands averaged 3 times farther off-shore than random marsh islands (1.3 km vs 0.4 km). Islands farther off-shore were likely less prone to disturbances originating from the mainland. Well-established colonies may have a greater collective tolerance of nearby development than colonies only recently established, presumably because of previous nesting success.

Colonial waterbirds were known to nest in areas that limit predator access. However, predator avoidance was not evaluated in this study. Several tern colonies, for example, were located in saltmarsh island archipelagos extending from the mainland making predator access easier. Great blue heron colonies on the mainland were subject to predators but minimized predation by canopy nesting.

Though tern colonies are known to occur on roof tops, provided the type of roofing material is a suitable substrate for nesting (MacFarlane 1977, Fisk 1978), no common or Forster's terns nested on roofs in our study area. These roof top sites are not comparable to the more natural situations in this study. Colonies on marsh island habitats are isolated on a horizontal plane. Isolation on a roof is achieved on a vertical plane.

The amount of nearby foraging habitat around colony sites was not considered an important limiting factor in colony site selection. Nesting and feeding habitat within 1.0 km of colonies in Maryland was previously evaluated and no significant limitations were found (Bendel and Therres, unpubl. data). Colonial waterbirds are also known to forage great distances (10–20 km) from their colony sites (Custer and Osborn 1978). Gibbs et al. (1987) noted that the proximity to wetlands was not important for the establishment of great blue heron colonies in Maine and suggested that human disturbance may be more important in the selection of breeding sites.

Conservation decisions must be evaluated separately for each individual nesting colony, and development changes near colonies monitored closely. From this study, some general guidelines can be established. Development should be discouraged form encroaching too close to waterbird colony sites. Buffer zones restricting development around tern colonies on marsh islands should be greater than for great blue herons in forested areas because terns are less tolerant to intruders. We recommend establishing minimum buffer zones restricting development 0.7 km from the edge of great blue heron colonies and 1.5 km from tern colonies nesting on marsh islands. We based these buffer zones upon the variables with the shortest mean distances for each species. In both cases, this was distance to the nearest building. Development within these zones should be restricted or minimized. Distance restrictions will depend upon the shape of the colony. Further research relative to the effects of development on waterbird colonies is needed to refine management alternatives and protect colonies from encroaching development.

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