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Using Scale, Cover Type and GIS to Evaluate Nuisance Cattle Egret Colony Site Selection

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Abstract.—The establishment of large Cattle Egret (*Bubulcus ibis*) breeding colonies in upland residential areas of east central Texas has been observed since the early 1960s. To help understand why Cattle Egrets choose residential breeding sites and predict where these might occur in the future, the geographic extent and scale-dependent nature of the phenomenon was investigated. In east Texas and along the Texas Gulf Coast, Cattle Egret colonies were found in flooded forests or on islands. However, in east central Texas, colonies were often located in upland areas. A habitat suitability model was constructed at multiple scales, outlining land use classes thought to influence upland colony site selection: water, forest and development/residential. The model classified 79% of upland colony locations in high or very highly suitable habitat and 7% in low or very low suitable habitat. The distribution of classes was significantly different than expected considering the distribution of land cover suitability classes across the entire study area (p = 0.036). Cattle Egrets likely choose upland, residential sites to breed when suitable wetland habitats are limited. When flooded tree and shrub or island habitats are absent, egrets may choose the edges of development for breeding sites to limit potential disturbance from ground predators. *Received 12 April 2011, accepted 3 October 2011.*

Key words.—*Bubulcus ibis*, Cattle Egret, edge, habitat suitability, scale, wetlands, wildlife conflict.

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Since the Cattle Egrets' (*Bubulcus ibis*) apparent natural introduction to the western hemisphere from Africa circa 1900, and the first Texas observation in 1954, its North American range and population have expanded significantly (Telfair 1994; Telfair *et al.* 2000a). The Cattle Egrets' current range now encompasses most of the contiguous United States. Their range expansion has been global, with establishment of populations on all continents, except Antarctica, and many oceanic islands (Siegfried 1978). However, in the United States after an initial exponential increase, their population appears to have stabilized or may be declining (McCrimmon *et al.* 1997).

Beginning with the first inland Texas Cattle Egret breeding record in 1961, Cattle Egrets have established large colonies in upland, residential areas of east central Texas, mixing with native species of herons and egrets (Telfair 1981b; Mora and Miller 1998). These colonies can contain thousands of nests, the majority of which are usually Cattle Egret, with Little Blue Heron (*Egretta caerulea*) pairs, Snowy Egret (*E. thula*) pairs, or both, always present (Telfair 1981a; pers. obs.). Additional species of wading birds nest at some sites (Telfair *et al* 2000b; pers. obs.). Some residential colonies are labeled a nuisance due to high densities of nesting birds producing noise and odor problems for human residents and guano damaging or destroying nesting trees and shrubs (Dusi 1977; Dusi 1979; Telfair *et al.* 2000b). In residential colonies, presence of dead chicks and adults can lead to public perception of a human health risk. Nuisance egret colonies also have been reported in Alabama, Oklahoma, California and India (Dusi *et al.* 1971; Rao *et al.* 1996; pers. obs.).

Management of nuisance colonies has been difficult. Nesting herons and egrets are protected by the Federal Migratory Bird Treaty Act and harassment of nesting birds is illegal unless permits are secured (http://www.fws.gov/permits/ltr/ltr.html, consulted 07/24/2011). Most techniques employed in discouraging reuse of established colonies have involved disturbance of birds arriving at colonies before nesting has initiated, or altering or removing nesting vegetation in the absence of breeding birds (Telfair *et al.* 2000b; pers. obs.). These tactics have had variable amounts of success in preventing reestablish-

ment of colonies and disturbed birds may establish new colonies in suitable sites nearby or recolonize sites in future years. Management techniques have not been developed to adequately address concerns of residents, remedy nuisance problems without displacing birds, treat birds humanely and keep nesting vegetation intact (Telfair 1994; Telfair *et al.* 2000b).

The primary objective of this research was to explore and describe the historic and current geographic extent of residential Cattle Egret colonies in east central Texas and evaluate relevant factors in colony site selection. Repeated colonization and use of residential areas for breeding in east central Texas suggests an adaptive advantage of these areas over surrounding areas of other types (Orians and Wittenburger 1991). A GIS-based model was developed to identify landscape factors that influence where upland colonies become established and under what circumstances they might be expected to form in the future.

METHODS

Sampling and Data Collection

An extensive effort was made to collect records of colony locations with a minimum of 100 Cattle Egret breeding pairs in Texas. The minimum number was set considering that colonies with less than 100 nesting pairs would probably not represent a nuisance. Main sources for these records were the Atlas of Texas Waterbird Colonies (TXCWBS 1982), data provided by Texas Parks and Wildlife Department and direct knowledge from scientists. These colonies were discovered by various methods including aerial and ground surveys as well as opportunistically by birders and agency personnel. In addition to these historic records, an extensive ground survey for active colonies was performed during the breeding seasons of 2005 and 2006 by the authors, mostly in the Post Oak and Blackland Prairie ecoregions of east central Texas. The sampling effort was intended to gather the information necessary to appropriately reflect the types of habitats where colonies become established throughout Texas.

Colonies were categorized into five types: flooded tree and shrub (natural swamps and artificially created impoundments), freshwater island, coastal island, upland, and unknown. A shapefile reflecting the coordinates of these colonies was produced using ArcGIS 9.1 (ESRI Redlands CA).

A 30 m resolution land use data set, National Land Cover Database (NLCD) 2001, was obtained (U.S. Geological Survey 2001) and classified into eleven classes; forest, open water, wetland, residential, developed open space, pasture, shrub, grassland, and none of the above (Homer *et al.* 2004). The study area contains portions of five NLCD zones. Accuracy of two of the zones was formally evaluated and reported as 84% accurate. Accuracy of the other three zones using cross validation averaged 85% (U.S. Geological Survey 2001).

Land Use/Land Cover Surrounding the Colonies

The spatial area for an evaluation of land use surrounding colonies was determined by bounding geographic locations of upland colonies in a shapefile then buffering it 10,000 m (Fig. 1). Upland colony locations collected in 2005 and 2006 for sites established after 2000 were used with NLCD 2001 to evaluate land use surround-

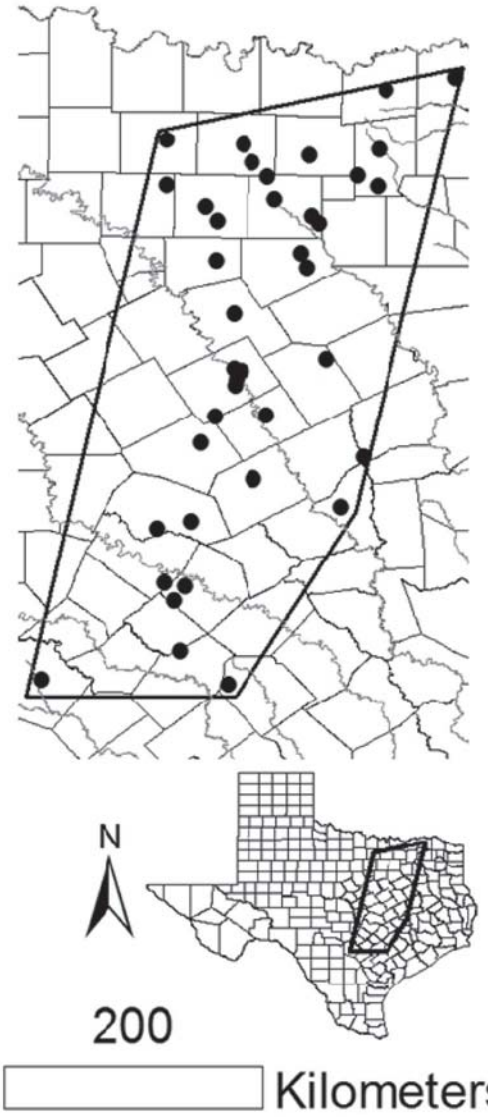

Figure 1. Minimum convex polygon of all upland colonies with geographic location records in Texas, buffered 10,000 m.

ing colonies (N = 7). Undoubtedly, other colonies formed and went undetected or unreported within the study area before this study was initiated (2005) as there was no systematic search for colony locations from 2000 to 2004. Colony locations were recorded on the ground using a handheld Global Positioning System and are of known accuracy. Land uses surrounding these sites were compared with 60 random points within the analysis area. Colonies and random points were buffered at distances ranging from 25 to 20,000 m to evaluate scale effects on land use types surrounding colonies. An inspection of these graphs revealed no obvious patterns in percent cover of similar land use classes with differing scales. From this preliminary evaluation, an extensive literature search, and personal observation, factors and their scales thought to drive the establishment of residential colonies were chosen.

Of the 19 colony locations that were ground truthed, nests were found in twelve different tree and shrub species; post oak (*Quercus stellata*), live oak (*Quercus virginiana*), yaupon (*Ilex* sp.), ash juniper (*Juniperus ashei*), eastern red cedar (*Juniperus virginiana*), mesquite (*Prosopis glandulosa*), elm (*Ulmus* sp.), hackberry (*Celtis* sp.), chinaberry (*Melia azedarach*), mulberry (*Morus* sp.), black willow (*Salix nigra*), eastern cottonwood (*Populus deltoides*) and ash (*Fraxinus* sp.).

Habitat Suitability Model

Based upon the findings of our land use/land cover analysis, we then chose classes most relevant to the colony locations: water, forest and developed/residential areas. Output maps were created for each of these three classes and resampled to 90 m resolution using the median technique. The resampling provided data on dominant land cover types at a slightly larger scale reducing potential fine scale inaccuracies in cover classification.

Proximity to water has been established as an important factor in the formation of all heron and egret colony types, including upland colonies (Dusi and Dusi 1968; Ogden *et al.* 1980; Bancroft *et al.* 1988; Bryan *et al.* 2003). Normally upland colonies are within sight of water or have small water bodies adjacent to the nesting substrate (Dusi *et al.* 1971; pers. obs.). Total edge of water classes at fine scales was selected as a model parameter due to its importance for both nesting and feeding, as flooded nesting substrate or foraging do not occur in deep water.

Upland colonies occur mainly in trees or shrubs, and often these patches are fragmented tracts of forest. Frequently, these upland sites are at the interface of roads or railroad tracks and forest patches, on the edges of towns of all sizes (Telfair *et al.* 2000b; pers. obs.). Thus, the parameters for total forest edge and total developed edge were included in the model.

For each parameter, the FRAGSTATS program was used to calculate the amount of total habitat edge surrounding each cell using a moving window (McGarigal and Marks 1995). The window size was 180 m for forest and water classes and 270 m for the developed class.

The habitat suitability model was constructed using the Spatial Analyst extension of ArcGIS 9.1. Resolution was increased to 270 m to ensure each cell encompassed the phenomenon being modeled, upland Cattle Egret colonies, which average approximately 10,000 m^2 in area. An annulus operation was performed onto the water edge layer, assigning each cell the amount edge 540 m surrounding the cell, but disregarding the edge within the cell itself. We used this procedure because upland colonies by definition are not in water, but often have water nearby.

Each cell of each raster type was assigned a value of 0, 1, or 2. Cells containing no edge were assigned 0. The remaining cells were split into three classes using the natural breaks method, resulting in groups of data with minimal variance within a group and maximum variance between groups. The lower class was assigned a value of 1 and the upper classes a value of 2.

These three rasters were combined to obtain the final model raster with cell values between 0 and 6. The model was evaluated using 14 upland colony locations active between 1996 and 2006. Due to the small number of colony locations, differences between the observed ratio of habitat suitability classifications of these colonies and habitat suitability classifications of the entire study area were tested using Fisher's Exact test ($\alpha = 0.05$).

RESULTS

Colony Biogeography

A total of 224 colonies with verifiable locations, active between 1973 and 2006, and containing a minimum of 100 breeding pairs of Cattle Egrets in at least one year was found. Of these, 132 (59%) were in flooded trees and shrubs, 29 (13%) were on coastal islands, nine (4%) were on freshwater islands, 41 (18%) were considered upland, and 13 (6%) records did not contain enough information for colony type to be ascertained confidently (Fig. 2).

The extent of upland colonies containing significant Cattle Egret breeding was restricted to east central Texas. Sixty two percent of colonies were located either in the Pineywoods or Coastal Plain ecoregions, but no records of upland colonies were discovered for those ecoregions (Omernik 1987; Table 1). Forty nine percent of colony records in the Blackland Prairie and Post Oak Savannah ecoregions and 88% of records in the Cross Timbers ecoregion were upland colonies.

Land Use/Land Cover Surrounding the Colonies

Figure 3 suggests multiple factors, at various scales, are most influential regarding upland colony site selection by Cattle Egrets.

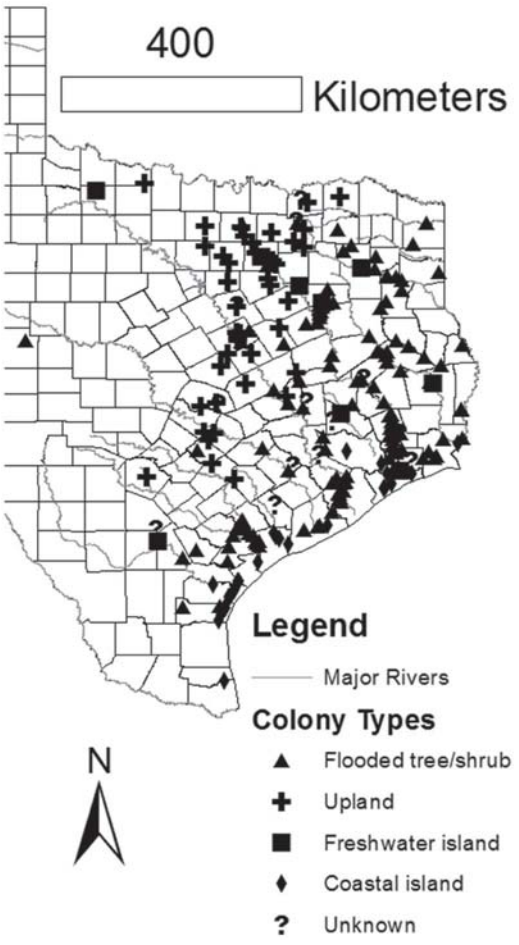

Figure 2. Locations of Cattle Egret colonies with a minimum of 100 breeding pairs of Cattle Egrets during at least one breeding season categorized by colony habitat type.

At buffer distances under 1500 m, land uses surrounding colonies (observed) showed a marked difference when compared with random points (expected) (Fig. 3a). With the exception of the water classes these differences became tempered at buffer distances greater than 1500 m (Fig. 3b). Land use classes with large discrepancies between what was observed and what was expected included developed/residential, water and forest classes. Developed classes were of a much higher proportion than random points at fine scales, becoming especially high between 100 and 1,000 m from colony sites before leveling off. At very fine scales, water classes were of a lower proportion than surrounding random points as the colonies are at upland sites. The proportion of water classes became much higher around colonies than random points with increased buffer distance, peaking at over five observed/expected between 2,000 and 7,500 m, before declining at larger distances. Forest had a much higher proportion than in the land cover surrounding the random points at distances less than 500 m, reflecting the egrets' nesting substrate. There were less crop and pasture than expected across all distances, especially at less than 500 m for pasture and less than 5,000 m for crop.

Habitat Suitability Model

Eleven of the 14 upland colonies (79%) were classified by the model as being in high or very highly suitable habitat for upland Cattle Egret breeding, while only one colony was classified as being low or very low suitability (7%) (Table 2). The distribution of suitability classifications for upland colony locations was significantly different from the expected distribution based upon the composition of the model for the entire study area ($p = 0.036$). Model results would benefit from further validation using future colony locations and NLCD type data corresponding to those breeding events.

DISCUSSION

The Cattle Egret colony locations analyzed in this study were restricted in geographic extent to east central Texas, mostly

Table 1. Cattle Egret colonies in Texas summarized by colony habitat type and ecoregion.

Ecoregion	Flooded tree/shrub	Freshwater island	Coastal island	Upland	Unknown
Pineywoods	50	3	0	0	2
Coastal Plain	49	1	29	0	5
Blackland Prairies and Post Oak Savannah	30	3	0	33	5
Cross Timbers	1	0	0	7	0
South Texas Plains	1	1	0	0	1
Central Great Plains	1	1	0	1	0

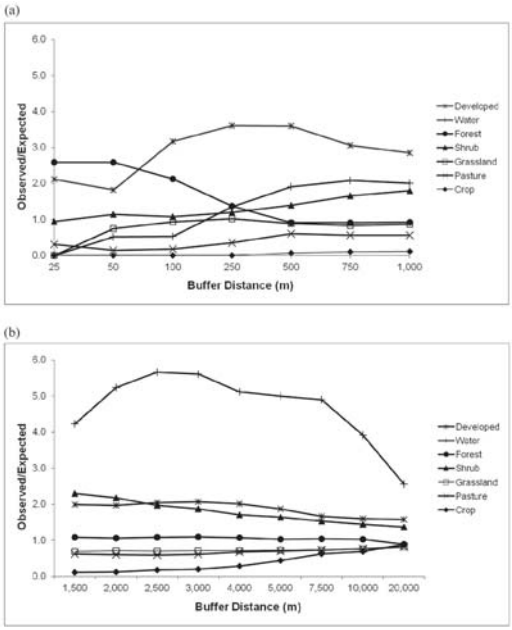

Figure 3. Ratio of observed land cover/expected land cover at (a) fine and (b) coarse scales surrounding Cattle Egret colonies.

in the Post Oak Savannah, Blackland Prairies and Cross Timbers ecoregions. Few records of colonies were found west of the Cross Timbers (Texas Parks and Wildlife, unpublished data). There is a greater predominance of heronries in east Texas, most likely because of the increased precipitation in the region (Telfair 1983). The annual precipitation pattern in Texas decreases significantly from east to west (http://www.texasalmanac.com/topics/environment/rainfall, consulted 07/24/2011, Fig. 4a). Telfair (1983) suggests that although Cattle Egrets may not be as water dependent as other aquatic birds, the presence of droughts in Texas has possibly affected their spread within the state. During the breeding season, Cattle Egrets feed more near margins of cattle tanks, temporary pools, sloughs and creeks (Telfair 1983). Hence, Cattle Egret colony habitat type distribution seems to follow a pattern reflecting availability of aquatic habitat in both latitude and longitude. Our study suggests that large, upland egret and heron nesting colonies only occur where there is sufficient availability of water resources for foraging and prey production at coarse scales, but preferred nesting habitat such as swamps and islands are limited at fine scales. The distribution of Cattle Egrets in east central Texas appears somewhat similar to what has been reported in Africa where breeding and foraging Cattle Egrets mainly rely upon freshwater wetland habitats that are ephemeral, depending upon seasonal variation in precipitation (Siegfried 1978). In east central Texas, most permanent wetlands are limited to major river systems and ephemeral freshwater wetland creation is dependent upon seasonal and annual fluctuations in precipitation (Telfair 1983).

One factor which may have contributed to the expansion of large numbers of Cattle Egrets in east central Texas is the high density of cattle present in this part of the state (Telfair 1993; Fig. 4b). Because foraging cattle are known to flush out some of the favorite insect prey for Cattle Egrets; higher densities of cattle are likely to provide elevated foraging opportunities for egrets (Metz *et al.* 1991; Telfair 1994; Gerhardt and Taliaferro 2003). However, pasture and other agricultural land use classes were not present in large quantities surrounding colonies at fine scales and showed no trend at coarse scales. The habitat suitability model predicts that upland colonies form where edges of water, forest and developed/residential land occur in concert at local scales. In east central

Table 2. Model evaluation of number of colonies (N = 14) observed within each habitat suitability level versus the suitability levels across the entire study area.

Habitat suitability level (model value)	Proportion of study area within habitat suitability level	Expected # of colonies within habitat suitability level	Observed # of colonies within habitat suitability level	Observed/ Expected
Very low (0)	0.083	1.2	0	0.0
Low (1-2)	0.376	5.3	1	0.2
Moderate (3)	0.233	3.3	2	0.6
High (4-5)	0.283	4.0	8	2.0
Very high (6)	0.024	0.3	3	10.0

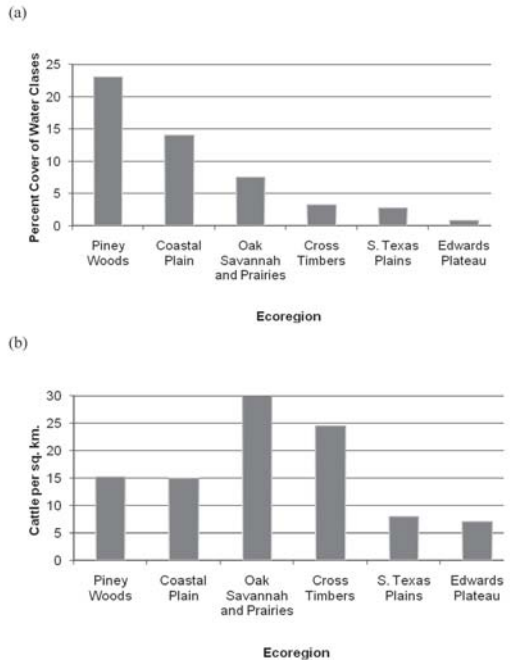

Figure 4. Percent cover from (a) aquatic land use classes and (b) cattle density for six ecoregions in Texas (U.S. Geological Survey 2001, Texas A&M Spatial Sciences Laboratory 2001).

Texas, wading birds, including Cattle Egrets, are attracted to trees within or surrounding ponds to roost. Small bodies of water near trees may expand during locally heavy rains, mimicking flooded trees and shrubs, potentially stimulating colony initiation.

The settlement of some Cattle Egret colonies on edges of developed/residential areas is not as well predicted by our model as is the preference for flooded sites. However, most upland colonies are located adjacent to roads or railroad tracks and these impervious surfaces may contribute to localized flooding. The main advantage in choosing flooded sites and islands for nesting may be protection from ground predators, especially Northern Raccoons (*Procyon lotor*) (Dusi *et al.* 1971; Frederick and Collopy 1989). Raccoons are known to cause severe amounts of nest predation and trigger sudden colony abandonment (Pratt and Winkler 1985; Rodgers 1987; Post 1990). Presence of predators has been shown to strongly influence colonization rates in some animals (Resetarits and Binkley 2009). Edges of development may provide protection from predators when flooded timber or islands are absent. Cattle Egrets may also select to nest in urban environments because of the proximity to food sources (Mora and Miller 1998) and potential for increased reproductive success. However, studies on effects of urban gradients on nest predation and survivorship have produced conflicting results. Some studies have found high nest survivorship in areas of intermediate disturbance, suggesting a nonlinear relationship between predation and development (Fernandez-Juricic *et al.* 2003; Blair 1996; Thorington and Bowman 2003).

The establishment of nuisance Cattle Egret colonies in east central Texas is likely associated with a combination of factors which include large cattle densities in the region combined with enough wetland habitat to also support Little Blue Heron and Snowy Egret foraging species that also may contribute to the colony site selection (Telfair *et al.* 2000b). Within the study area, Cattle Egrets have been observed nesting in conjunction with these and other aquatic bird species, including White-Faced Ibis (*Plegadis falcinellus)* and Great Egrets (*Egretta alba)* (Mora pers. observ.). These wetland-dependent species initiate breeding earlier in the spring than Cattle Egrets and may be selecting the colony sites (Telfair 1981a). Increased development, the resulting habitat fragmentation, and limitation of water resources likely exacerbate the development of nuisance Cattle Egret colonies and elevate the visibility of their effects. Our study provides additional information useful to determine the most likely habitat for the establishment of Cattle Egret breeding colonies in east central Texas. Our study suggests that Cattle Egrets are more likely to use upland sites for nesting in east central Texas than in other parts of the region; however, a more complete analysis, including many other colonies established along the coast, would be useful to better determine differences and similarities in nest choices among regions and within the state.

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LITERATURE CITED

Bancroft, G. T., J. C. Ogden and B. W. Patty. 1988. Wading bird colony formation and turnover relative to rainfall in the corkscrew swamp area of Florida during 1982 through 1985. Wilson Bulletin 100: 50-59.

Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. Ecological Applications 6: 506-519.

Bryan J. C., S. J. Miller, C. S. Yates and M. Minno. 2003. Variation in size and location of wading bird colonies in the Upper St. John's River Basin, Florida, USA. Waterbirds 26: 239-251.

Dusi, J. L. 1977. Impact of egrets on an upland colony area. Proceedings of the Colonial Waterbird Group 1: 128-130.

Dusi, J. L. 1979. Heron colony effects on man. Proceedings of the Colonial Waterbird Group 3: 143-144.

Dusi, J. L. and R. T. Dusi. 1968. Ecological factors contributing to nesting failure in a heron colony. Wilson Bulletin 80: 458-466.

Dusi, J. L., R. T. Dusi, D. L. Bateman, C. A. McDonald, J. J. Stuart and J. F. Dismukes. 1971. Ecological impacts of wading birds on the aquatic environment. Water Resources Research Institute Bulletin 5, Auburn University, Alabama.

Fernandez-Juricic, E., A. Sallent, R. Sanz and I. Rodriguez-Prieto. 2003. Testing the risk disturbance hypothesis in a fragmented landscape: Nonlinear responses of house sparrows to humans. Condor 105: 316-326.

Frederick, P. C. and M. W. Collopy. 1989. The role of predation in determining reproductive success of colonially nesting wading birds in the Florida Everglades. Condor 91: 860-867.

Gerhardt, F. and E. H. Taliaferro. 2003. Density-dependent patch selection by foraging Cattle Egrets. Waterbirds 26: 364-369.

Homer, C., C. Huang, L. Yang, B. Wylie and M. Coan. 2004. Development of a 2001 national land cover database for the United States. Photogrammetry Engineering and Remote Sensing 70: 429-850.

McCrimmon, D. A., Jr., S. T. Fryska, J. C. Ogden and G. S. Butcher. 1997. Nonlinear population dynamics of six species of Florida ciconiiformes assessed by Christmas birdcounts. Ecological Applications 7: 581-592.

McGarigal, K. and B. J. Marks. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. USDA Forest Service General Technical Report, PNW, 351.

Metz, K. J., K. A. Prior and M. L. Mallory. 1991. Do Cattle Egrets gain information from conspecifics when foraging? Oecologia 86: 57-61.

Mora, M. and J. M. Miller. 1998. Foraging flights, reproductive success, and organochlorine contaminants in Cattle Egrets nesting in a residential area of Bryan, Texas. Texas Journal of Science 50: 205-214.

Ogden, J. C., H. W. Kale, II and S. A. Nesbitt. 1980. The influence of annual variation in rainfall and water levels on nesting by Florida populations of wading birds. Transactions of the Linnaean Society of New York 9: 115-126.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). Annals of the Association of American Geographers 77: 118-125.

Orians, G. H. and J. F. Wittenburger. 1991. Spatial and temporal scales in habitat selection. American Naturalist 137: S29-S49.

Post, W. 1990. Nest survival in a large ibis-heron colony during a 3-year decline to extinction. Colonial Waterbirds 13: 50-61.

Pratt, H. M. and D. W. Winkler. 1985. Clutch size, timing of laying, and reproductive success in a colony of Great Blue Herons and Great Egrets. Auk 102: 49-63.

Rao, V. V., M. Anjaneyulu, S. H. Raza and V. Nagulu. 1996. Comparative ethological studies of Little Egret (*Egretta garzetta*) and Cattle Egret (*Bubulcus ibis*) in Andhra Pradesh. Acta Ecologica 18: 91-106.

Resetarits, W. J., Jr. and C. A. Binkley. 2009. Spatial contagion of predation risk affects colonization dynamics in experimental aquatic landscapes. Ecology 90: 869-876.

Rodgers, J. A. 1987. On the antipredator advantages of coloniality: A word of caution. Wilson Bulletin 99: 269-270.

Siegfried, W. R. 1978. Habitat and the modern range expansion of the Cattle Egret. Pages 315-324 *In* Wading Birds (A. Sprunt, J. C. Ogden and S. Winckler, Eds.). National Audubon Society, New York, New York.

Telfair, R. C., II. 1981a. Cattle Egrets, inland heronries, and the availability of crayfish. Southwestern Naturalist 26: 37-41.

Telfair, R. C., II. 1981b. The Cattle Egret in Texas: Range expansion and interrelations with other colonial waterbirds. Bulletin of the Texas Ornithological Society 13: 37-44.

Telfair, R. C., II. 1983. The Cattle Egret: Texas focus and world view. Kleberg Studies in Natural Resources. Texas Agricultural Experiment Station, College Station, Texas.

Telfair, R. C., II. 1993. Cattle Egret (*Bubulcus ibis*) population trends and dynamics in Texas (1954-1990). Texas Parks and Wildlife Department, Austin, Texas.

Telfair, R. C., II. 1994. Cattle Egret (*Bubulcus ibis*). *In* The Birds of North America, Inc. No. 113 (A. Poole and F. Gill, Eds.). Philadelphia, Pennsylvania.

Telfair, R. C., II, D. A. McCrimmon, Jr. and S. T. Fryska. 2000a. Population dynamics of the Cattle Egret in Texas, 1954-1999. Waterbirds 23: 187-195.

Telfair, R. C., II, B. C. Thompson and L. T. Shirhart. 2000b. Nuisance heronries in Texas: Characteristics and management. Second Edition. PWD-BK-W7000-134. Texas Parks and Wildlife Department, Austin, Texas.

Texas A&M Spatial Sciences Laboratory. 2001. http://ssl.tamu.edu/research.php. Retrieved June 2006.

Thorington, K. K. and R. Bowman. 2003. Predation rate on artificial nests increases with human housing density in suburban habitats. Ecography 26: 188-196.

TXCWBS. 1982. Texas Colonial Waterbird Society: An atlas and census of Texas waterbird colonies, 1973-1980. Caesar Kleberg Wildlife Research Institute, Kingsville, Texas.

U. S. Geological Survey. 2001. National land cover database land cover layer. Sioux Falls, South Dakota