ROOKERY ISLAND
SUITABILITY ANALYSIS

Kiersten Stanzel, Ph.D.
GREEN WING ENVIRONMENTAL, LLC
www.greenwingenvironmental.com

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Kiersten Stanzel, Ph.D.
Green Wing Environmental, LLC
337 Champlain Street
Victoria, Texas 77901
Phone: 361.813.1401
Email: kiersten.stanzel@gmail.com
www.greenwingenvironmental.com

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SUBMITTED TO:

Jace Tunnell, Reserve Manager
Mission-Aransas National Estuarine Research Reserve
University of Texas Marine Science Institute
Phone: 361.749.3046
E-mail: jace.tunnell@austin.utexas.edu
www.missionaransas.org

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INTRODUCTION

The Coastal Bend area along the mid-Texas coast provides a relatively productive and diverse range of aquatic habitats favored by waterbird species. These include riparian fringes, riverine deltas and freshwater marshes, salt marshes, seagrass beds, wind-tidal flats, calm shallow waters, and open bay waters. More than 20 species of migratory colonial waterbirds currently nest on islands between the mainland and barrier islands of the Texas Coastal Bend, and in various nearshore freshwater environments (CBBEP, 2010). Colonial waterbirds utilize the Texas coast as a nursery area and require plentiful nesting habitat and food supply. Nesting colonies can range in size from a few birds to thousands of nesting pairs. The nesting season along the Texas coast occurs annually from February to August (HARC, 2011).

Colonial waterbird populations were decimated prior to the early 1900s, mainly for the plume trade. Some species suffered nearly to the point of extinction. Since then, populations have been struggling to rebound. Further coastal development and other human impacts have limited their ability to recover to pre-settlement abundance (CBBEP, 2010).

Data used to describe colonial waterbird status and trends comes from annual surveys of rookeries coordinated by the Texas Colonial Waterbird Society (TCWS). The TCWS is a scientific group dedicated to monitoring colonial waterbirds in Texas and is made up of staff from Texas Parks and Wildlife Department, Texas General Land Office, Texas A&M University, U.S. Fish and Wildlife Service (USFWS), Audubon Texas, The Nature Conservancy, Coastal Bend Bays & Estuaries Program, and Welder Wildlife Foundation. Surveys are performed annually during the first two weeks of June. The TCWS has been collecting data since 1973, but participation of various groups has varied annually depending on staff interest, availability, and budgets. Surveys attempt to collect data along the entire Texas coast, and the data collected includes: number of adults, number of nests, and estimated number of breeding pairs. The survey excludes waterfowl and solitary nesters, such as Osprey and kingfishers, but includes the herons, egrets, gulls, terns, ibises, etc. (Hardegree, 2014).

Analysis of data from 1973-2008 show that of 14 species for which the Coastal Bend hosts at least 25% of the state's coastal population, seven showed significant decreases (Great Blue Heron, Great Egret, Tricolored Heron, Snowy Egret, Black-crowned Night-heron, Black Skimmer, and Gull-billed Tern), while three showed significant increases (American White Pelican, Brown Pelican, and Laughing Gull). However, more recent short-term data shows that in the past 5 to 10 years, some of these trends may be reversing for some species (CBBEP, 2010).

Current challenges to waterbird recovery include habitat loss (both of nesting and feeding areas), proliferation of human-subsidized predatory mammals (e.g., raccoons and coyotes), spread of the imported red fire ant, invasion of non-native trees and shrubs, increased human disturbance, pollution, scarcity of adequate nesting substrate, erosion and subsidence. It is thought that suitable nesting habitat is the most limiting factor for most of the waterbird species in the area. Colonial-nesting waterbirds within the coastal zone require islands for breeding that provide suitable nesting structure (such as shrubs for wading birds, bare ground for terns, etc.), are free from predators and disturbance sources, and are relatively close to feeding areas. Rookery islands, in contrast to barrier islands, are typically smaller and free from predators. Rookeries in the Coastal Bend range in size from mere spits of shell hash which are sometimes submerged at the highest tides, to the

approximately 300-acre Pelican Island in Corpus Christi Bay. Vegetative structure ranges from unvegetated bare ground to well-developed hackberry (*Celtis laevigata*) and mesquite (*Prosopis glandulosa*) mottes. Approximately 185 islands exist within the Coastal Bend region that have at some time in the last 30 years been used by nesting waterbirds (CBBEP, 2010).

Many islands, and a greater total acreage of islands, were created in the mid- to late-20th century associated with dredging activities for navigation and oil/gas development. Large islands are typically unsuitable for nesting by waterbirds because they support permanent populations of predators such as raccoons and coyotes. Most rookery activity takes place on smaller islands or ones which have been aggressively managed to remove predators. Erosion has led to the complete loss of several islands, and the partial (and ongoing) loss of almost all others. Deepening of adjacent waters for navigation channels, increased ship traffic, loss of oyster reef structure due to commercial harvesting, and relative sea level rise have resulted in increased wave energy battering rookery island shorelines, and a net loss of island area (CBBEP, 2010).

Increased and focused management efforts have been underway to improve existing habitat and create new habitat over the past 15 years by US Fish & Wildlife Service, Texas Parks & Wildlife Department, Coastal Bend Bays & Estuaries Program, Audubon Texas, The Nature Conservancy, and local academic institutions (CBBEP, 2010). One way to address the loss of rookery islands is the creation of new, strategically located islands. For example, New Island was created in Nueces Bay in 2001 and has provided several thousand pairs of birds a nesting opportunity in subsequent years. Another option is restoration/enhancement of existing rookery islands to expand the area available for nesting. For example, several rookery islands within the Coastal Bend have benefited from the placement of dredge material in areas where the islands are eroding.

Island creation and restoration projects are expensive, requiring extensive engineering, permitting, dredging, and equipment mobilization. Therefore, it is important that funding resources are utilized wisely and rookery islands are created and restored strategically in areas with the highest likelihood for success and greatest benefit for colonial nesting waterbirds. Identifying sites for island creation/restoration has typically involved consultation with experts to identify the locations that best meet a list of pre-determined criteria. However, the application of Geographic Information Systems (GIS) provides a more effective methodology for identifying potential sites for island creation/restoration and can help remove much of the uncertainty which is sometimes involved in the site selection process. The aim of this study was to develop a "rookery island creation and restoration suitability index" that characterizes locations within the Coastal Bend based on their potential for successful island creation/restoration and benefit to colonial waterbirds.

METHODOLOGY

GIS provides an effective methodology for identifying and prioritizing conservation targets. For the current study, a GIS software extension called *NatureServe Vista* was used to develop an index that characterizes the bays of the central Texas coast based on their suitability for rookery island creation and restoration. The boundary for the study encompassed much of the central Texas coast and included the following bay systems: Corpus Christi, Redfish, Aransas, Copano, Mission, Mesquite, San Antonio, and Espiritu Santo bays (Figure 1).

Figure 1. Map of study area. Yellow line indicates the project boundary.
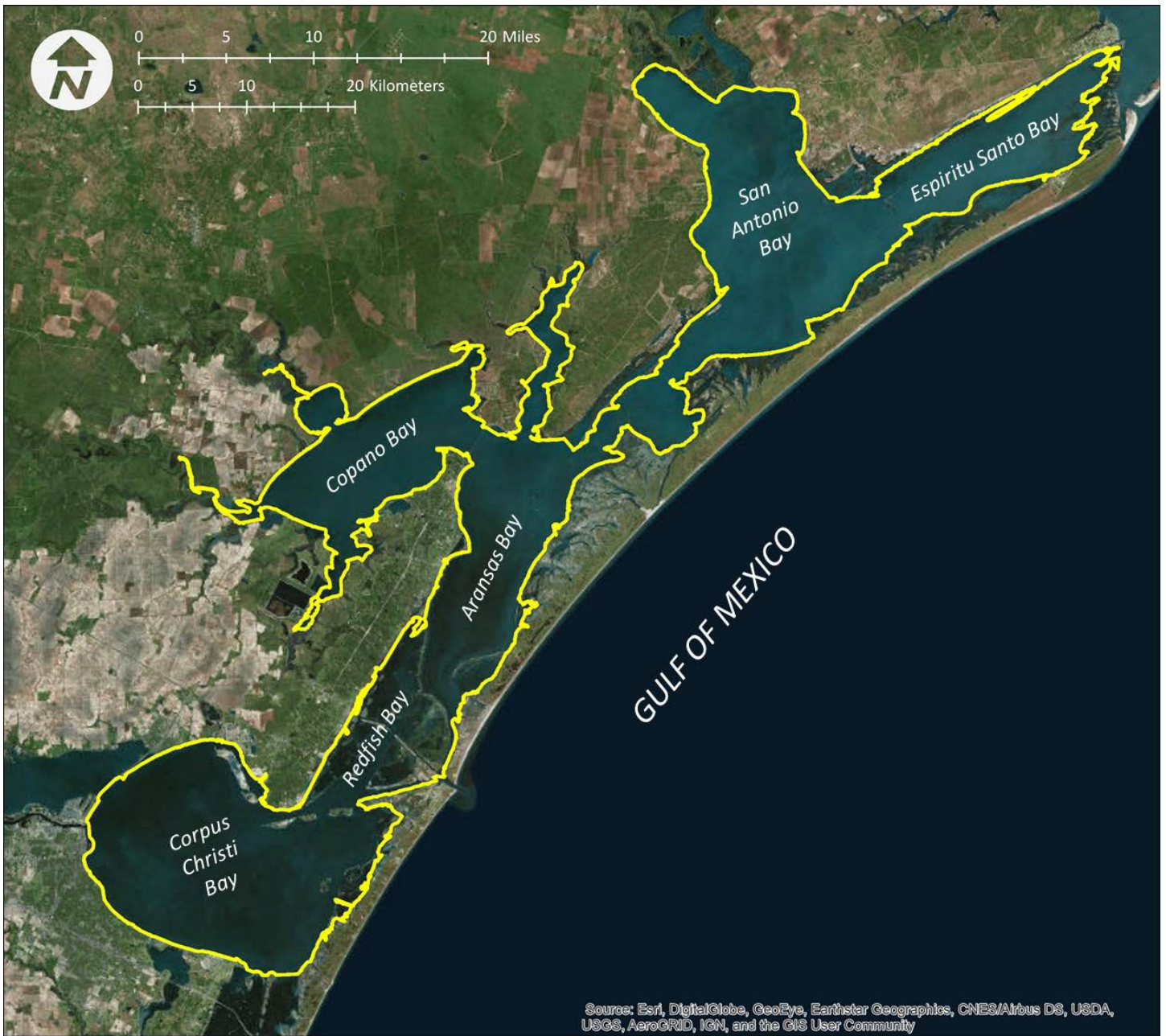
Suitability Analysis Software

NatureServe Vista is a broad assessment and planning decision support tool focused on conservation of specific mapped features or "conservation elements." It facilitates capturing spatial and non-spatial information and conservation requirements for elements, defining scenarios of land use, management, conservation, disturbance, etc., and evaluating the impacts of scenarios on the elements. Vista as a decision support system makes it far easier to build and conduct spatial analyses, track data inputs and outputs, manage databases, and create reports than are possible with GIS alone (Crist et al., 2009).

Central to the Vista assessment approach is the identification of "conservation elements" in the planning area. These could include threatened and endangered species or local environments, such as wetlands, that fall under environmental regulation. They could also include certain species, habitats, and open space values of high local priority. Once conservation elements are clearly defined, users must define the spatial distribution of those elements. By creating maps that accurately describe the location of these elements, users can see where many elements are found together, and where they occur in isolation. In the case of the rookery island suitability analysis, conservation elements can be

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thought of as "suitability factors" that depict the suitability of conditions related to rookery island creation (e.g., water depth, distance from shoreline, etc.) across the landscape. NatureServe Vista can help determine where the most suitable factors for rookery island creation are found together. Detailed and realistic GIS layers permit more precise evaluation and planning solutions.

For every conservation element (or suitability factor) an Element Conservation Value (ECV) raster must be created that depicts its spatial distribution within the planning region and a single conservation value must be assigned to each grid cell based on the values for viability/integrity (or suitability) and confidence in that cell. Vector distribution layers comprised of occurrences of elements of interest in the planning region, which may have associated values for viability/integrity and/or confidence, serve as inputs to the ECV creation process. Thus, an Element Conservation Value (ECV) layer reflects a particular element's suitability across the planning area.

Each ECV must have a viability/integrity score stored in polygon attribute table or in a float raster. Scores must range from 0.0 – 1.0, with 1.0 indicating higher suitability. Confidence values (also ranging from 0.0-1.0) can also be assigned to each ECV to indicate the spatial and temporal confidence associated with each element. Confidence values are optional and are not required to determine the conservation value of the grid cells in each ECV.

After creating ECVs, users may generate a Conservation Value Summary (CVS) for the planning area – in the case of our analysis the CVS is the "suitability index." CVS combines the suitability scores of individual ECV layers to produce an overall summary of suitability for rookery island placement across the planning region. The summary aggregates all of the individual conservation elements, including their associated viability/ecological integrity (and confidence scores, if used), and weights them according to their relative conservation importance as defined by a selected weighting system. The result of this aggregation is a raster layer of "hotspots" highlighting the most important places for rookery island placement in the region.

Rookery Island Suitability Analysis

In the case of rookery islands, the CVS can also be thought of as creating a "suitability index" that identifies "hotspots" for rookery island creation and restoration. Table 1 provides a summary of the conservation elements (or suitability factors) that were included in the rookery island suitability analysis (i.e., CVS). The table includes information about: (1) rationale for inclusion, (2) assignment of suitability score (i.e., viability/integrity value), and (4) assigned weightings. Maps of conservation elements and their suitability scores are available in Appendices A and B.

Table 1. Summary of conservation elements included in rookery island suitability analysis.

Conservation Element	Rationale	Suitability	Weighting
Water Depth	Water depth has an impact on the cost/feasibility of rookery island creation (i.e., as the water gets deeper, it is just gets too costly and difficult to create a rookery island).	Water depth < 2 ft = 1.0 Water depth of 2-4 ft = 0.7 Water depth of 4-6 ft = 0.2 Water depth > 6 ft = 0.0	1.0
Distance from Shoreline	Distance of the rookery from mainland shorelines will affect the ability of predators to reach the island – the farther an island is from other shorelines, the less likely it is to be invaded by predators.	Distance of rookery from shoreline < 0.5 mi = 0.0 Distance of rookery from shoreline > 0.5 mi = 1.0	1.0
Direction from Shoreline	Because of the dominant southeasterly winds, the direction from mainland shoreline is important in determining the ability of predators to smell rookeries.	Southeast = 1.0 East = 0.8 South = 0.5 All other directions = 0.0	0.5
Habitat	The presence of seagrass and oysters will result in mitigation, which will increase project costs. Locating islands in areas where mitigation potential is lower is a high priority.	Seagrass Present = 0.0 Oyster Present = 0.0 Unconsolidated Bottom = 1.0 Unknown = 0.8	1.0
Location of known rookery islands	Locations of both active and inactive rookeries could provide good opportunities for restoration or enhancement.	Active Rookery = 1.0 Inactive Rookery = 0.5	1.0

RESULTS

The CVS results produced a raster layer that can be used to identify "hotspots" for rookery island creation or restoration/enhancement (Figure 2). The conservation value of selected grid cells within the raster layer can then be examined using the Site Explorer tool. To simplify the results, point locations were assigned to the grid cells that were identified as having the highest suitability using the Site Explorer tool (Figure 3).

Figure 2. Rookery island suitability analysis results for entire project area.
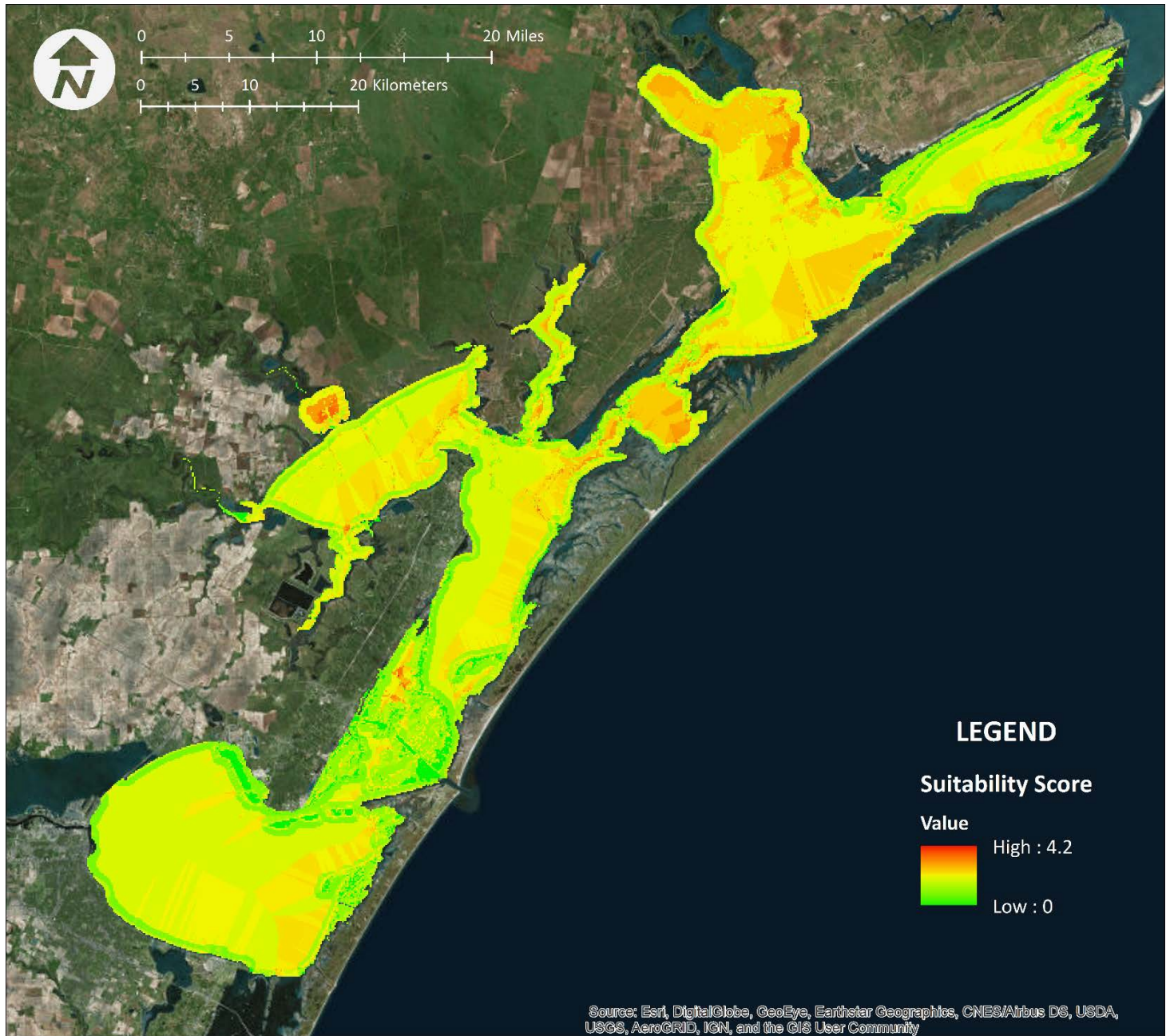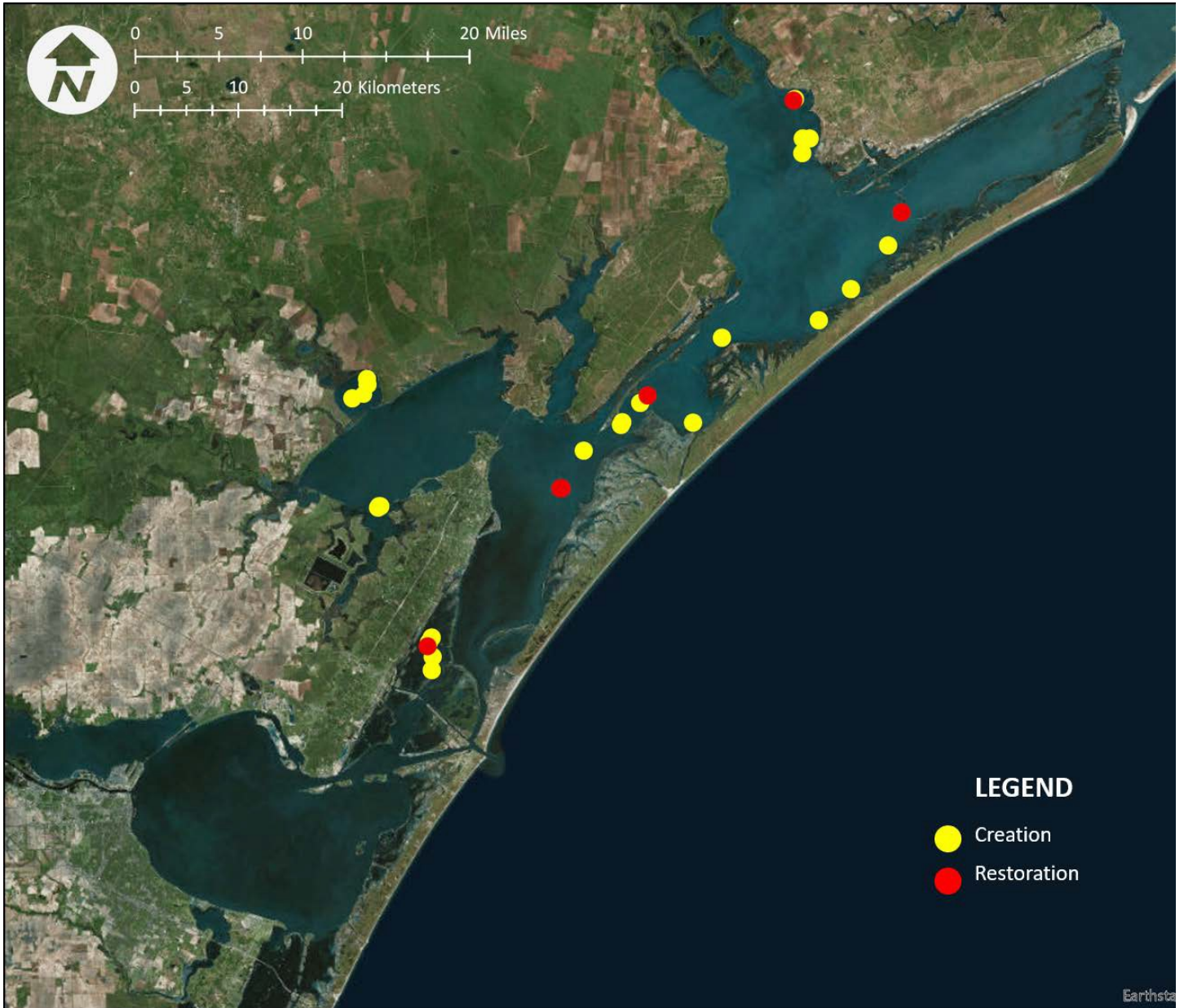

The highest priority sites within the study area were identified using the Site Explorer tool. These sites had suitability scores that ranged from 3.3 to 4.2. If the high suitability grid cells were located adjacent to another high suitability grid cell with the same score, multiple cells were grouped together. This resulted in 30 high-suitability sites. To allow for better visualization of the high priority sites, each of the 30 sites was distinguished using a single point (Figure 3).

To help users better understand the rookery island suitability index and its results, each of the 30 high-suitability sites were characterized using the following information: (1) suitability score, (2) size (number of acres) (3) latitude/longitude,

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(4) general location, (4) average water depth, (5) habitat types present, (6) average distance from shoreline, (7) average direction from shoreline, (8) water with depth of four feet located within 800 feet of site, and (9) presence of existing rookery (Table 2). These characteristics may be helpful to managers as they prioritize within the list and determine which sites should be further explored. For example, "4 ft water depth within 800 feet" indicates which sites may be more accessible by barges carrying material for island creation/restoration, and "habitat" can help determine the likelihood that mitigation for damage to seagrass or oysters would be required. The descriptive characteristics listed above are summarized in Table 2 and a map of each site is provided in Appendix C. The high suitability sites are also available in KMZ format by contacting the author and can viewed in the open access Google Earth software. Descriptive characteristics can be viewed in Google Earth by clicking on each site.

Figure 3. Map of 30 high priority sites identified in the rookery island suitability index. Yellow dots indicate locations for creation of a new rookery island, while red dots indicate locations where an existing rookery could be restored/enhanced.

Suitability Score	Size	Lat/Long	General Location	Average Water Depth	Habitat	Average Distance Shoreline	Average Direction Shoreline	4 ft Water Depth Within 800 ft	Existing Rookery
4.2	5 ac	-97.097784 27.931202	Northern Redfish Bay (Causeway Island Platforms)	0.45 ft	Unconsolidated Sediment (4.97 ac) Seagrass (0.03 ac)	1,223 m (0.76 mi)	E	No	Causeway Island Platforms (Active)
4.1	5 ac	-96.962029 28.065477	Aransas Bay (Deadman Reef)	-0.08 ft	Unknown (2.67 ac) Oyster (2.02 ac) Unconsolidated Sediment (0.23 ac)	2,122 m (1.32 mi)	SE	Yes	Deadman Reef (Active)
4.0	5 ac	-96.723402 28.397383	San Antonio Bay (Seadrift Island)	-1.30 ft	Unknown (3.47 ac) Oyster (1.32 ac) Marsh (0.21 ac)	1,127 m (0.70 mi)	S	No	Seadrift Island (Active)
3.6	5 ac	-96.875468 28.144189	Aransas Bay (Third Chain of Islands)	-0.41 ft	Unknown (3.74 ac) Oyster (1.26 ac)	814 m (0.51 mi)	NW	No	Third Chain of Islands (Active)
3.5a	100 ac	-97.153616 28.152177	Mission Bay	-1.48 ft	Unconsolidated Sediment (88.87 ac) Oyster (11.13 ac)	1,288 m (0.80 mi)	SE	No	No
3.5b	125 ac	-97.163799 28.147318	Mission Bay	-1.04 ft	Unconsolidated Sediment (120.73 ac) Oyster (4.27 ac)	1,210 m (0.75 mi)	S	No	No
3.5c	10 ac	-97.143376 28.053059	Port Bay / Copano Bay	-0.80 ft	Unconsolidated Sediment (8.61 ac) Seagrass (1.39 ac)	914 m (0.57 mi)	S	No (within 1,500 ft)	No
3.5d	5 ac	-97.093204 27.938873	Northern Redfish Bay	0.95 ft	Seagrass (2.60 ac) Unconsolidated Sediment (2.40 ac)	930 m (0.58 mi)	SE	No	No
3.5e	30 ac	-97.093673 27.922092	Northern Redfish Bay	-0.99 ft	Unconsolidated Sediment (23.88 ac) Seagrass (6.12 ac)	1,192 m (0.74 mi)	SE	Yes (but patchy)	No
3.4a	5 ac	-97.150358 28.164869	Mission Bay	0.35 ft	Unconsolidated Sediment (4.97 ac) Oyster (0.03 ac)	894 m (0.56 mi)	S	No	No
3.4b	125 ac	-97.150645 28.156000	Mission Bay	-0.57 ft	Unconsolidated Sediment (116.48 ac) Oyster (8.52 ac)	1,163 m (0.72 mi)	SE	No	No
3.4c	5 ac	-97.140515 28.054247	Port Bay / Copano Bay	-0.84 ft	Unconsolidated Sediment (3.16 ac) Unknown (1.82 ac) Seagrass (0.02 ac)	905 m (0.56 mi)	SE	Yes	No
3.4d	70 ac	-97.096248 27.935030	Northern Redfish Bay	0.33 ft	Unconsolidated Sediment (69.22 ac) Seagrass (0.78 ac)	1,479 m (0.92 mi)	SE	No	No
3.4e	5 ac	-97.094088 27.910618	Northern Redfish Bay	-1.42 ft	Unconsolidated Sediment (2.99 ac) Seagrass (1.98 ac) Oyster (0.03 ac)	931 m (0.58 mi)	E	Yes (but patchy)	No
3.3a	20 ac	-96.721971 28.398651	San Antonio Bay (near Seadrift)	-0.78 ft	Unknown (18.5 ac) Oyster (1.5 ac)	983 m (0.61 mi)	SE	No	No
3.3b	165 ac	-96.715852 28.363828	San Antonio Bay (near Falcon Point Ranch)	-0.93 ft	Unknown (164.17 ac) Oyster (0.84 ac)	1,319 m (0.82 mi)	SE	No	No
3.3c	5 ac	-96.708645 28.363592	San Antonio Bay (near Falcon Point Ranch)	0.23 ft	Unknown (4.51 ac) Oyster (0.49 ac)	894 m (0.56 mi)	SE	No	No
3.3d	15 ac	-96.716271 28.350998	San Antonio Bay (near Falcon Point Ranch)	-0.04 ft	Unknown (15 ac)	1,020 m (0.63 mi)	E	No	No
3.3e	10 ac	-96.634903 28.269067	San Antonio Bay (near Long Lake)	-1.93 ft	Unknown (10 ac)	967 m (0.60 mi)	SE	Yes	No

Table 2. Summary of the top 30 high suitability sites for rookery island creation and restoration.

Suitability Score	Size	Lat/Long	General Location	Average Water Depth	Habitat	Average Distance Shoreline	Average Direction Shoreline	4 ft Water Depth Within 800 ft	Existing Rookery
3.3f	5 ac	-96.672341 28.231588	San Antonio Bay (near Cedar Lake)	-2.34 ft	Unknown (5 ac)	783 m (0.49 mi)	S	Yes	No
3.3g	5 ac	-96.705228 28.205456	San Antonio Bay (near Panther Point)	-2.08 ft	Unknown (5 ac)	722 m (0.45 mi)	SE	Yes	No
3.3h	10 ac	-96.801326 28.192499	Aransas Bay / San Antonio Bay	-2.21 ft	Unknown (10 ac)	776 m (0.48 mi)	SE	Yes (but patchy)	No
3.3i	5 ac	-96.882907 28.137989	Aransas Bay (south of Third Chain)	-1.91 ft	Unknown (4.54 ac) Oyster (0.46 ac)	922 m (0.57 mi)	SE	No	No
3.3j	5 ac	-96.900850 28.121794	Aransas Bay (near Cape Carlos Dugout Island)	-1.78 ft	Oyster (2.85 ac) Unknown (2.15 ac)	958 m (0.60 mi)	SW	No	No
3.3k	20 ac	-96.831367 28.120056	Mesquite Bay	-1.58 ft	Unknown (20 ac)	868 m (0.54 mi)	SE	No	No
3.3l	5 ac	-96.902382 28.119168	Aransas Bay (near Cape Carlos Dugout Island)	-1.54 ft	Unknown (4.06 ac) Oyster (0.94 ac)	925 m (0.57 mi)	SE	No	No
3.3m	10 ac	-96.939373 28.098299	Aransas Bay	-3.57 ft	Unknown (10 ac)	1,765 m (1.10 mi)	SE	Yes	No
3.3n	5 ac	-96.963430 28.065472	Aransas Bay (Deadman Reef)	-0.82 ft	Oyster (1.90 ac) Unknown (1.68 ac) Unconsolidated Sediment (0.92 ac)	2,234 m (1.39 mi)	SE	Yes	Deadman Reef (Active)
3.3o	5 ac	-97.141897 28.054262	Port Bay / Copano Bay	-0.88 ft	Unknown (3.71 ac) Unconsolidated Sediment (1.29 ac)	1,006 m (0.63 mi)	SE	Yes	No
3.3p	5 ac	-96.620904 28.297068	San Antonio Bay (South Pass Islands)	-2.53 ft	Unknown (3.74 ac) Oyster (0.94 ac) Unconsolidated Sediment (0.9 ac)	789 m (0.49 mi)	N	Yes	South Pass (Active)

Table 2 (cont'd). Summary of the top 30 high suitability sites for rookery island creation and restoration.

CONCLUSION

As populations of colonial waterbirds continue to decline along the Texas coast, resource managers are looking for more opportunities to restore eroding islands or create new islands. Therefore, it is important that they have the tools needed to identify locations in the landscape that provide the best opportunities for providing additional nesting habitat. The purpose of the rookery island suitability index was to remove some of the uncertainty involved in selection of potential locations for rookery island creation and restoration. The 30 priority sites identified in this study provide a tool for resource managers and conservation organizations that are considering the creation of new islands or the restoration of existing islands along the mid-Texas coast.

It is important to remember that the results of the suitability index are limited by the quality and availability of data used to characterize and prioritize the landscape. Before final decisions are made about creating or restoring rookery islands at the sites identified, steps must first be taken to gather additional information about project feasibility and likelihood of success. However, the tool does serve as an effective screening tool that can be used to systematically focus in on specific sites.

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