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NEW JERSEY'S DISTINCTIVE PUBLIC UNIVERSITY

Tasks 2 & 3: MARSH CONDITION ASSESSMENT, FEASIBILITY, & SPATIAL DATA REPORT

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Project Overview

The Stockton University Coastal Research Center (CRC) was tasked by The Nature Conservancy (TNC) to conduct a reconnaissance-level mapping project to assess the condition of New Jersey's coastal marshes and the potential for marsh restoration through the reuse of dredged materials. This desktop study investigated the 2012 public tidal marsh conditions in the Atlantic back bays from the Manasquan River to Cape May City (Figure 1).

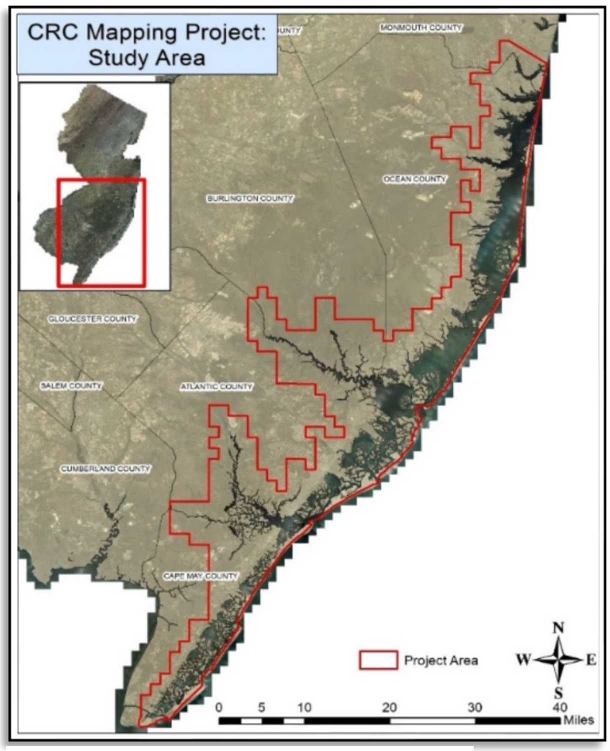


Figure 1. Project area overview.

The goals of this project were to (1) assess and rank the condition of New Jersey's coastal marshes using readily available geographic information system [GIS] data, and (2) identify and compile GIS data that could be used to assess the feasibility of a potential beneficial use of dredged material project. This mapping effort was not to definitively say whether a wetland habitat was degraded or not, but conversely to be used as a tool to locate a broad area for more in-depth assessment. The compiled datasets will be included in TNC's *Coastal Resilience* mapping portal (http://maps.coastalresilience.org/network/). This planning tool can be used for a regional and preliminary examination of marsh condition and project feasibility, and can identify areas where a more detailed, on-the-ground survey would be of most benefit.

To complete this desktop analysis, geospatial data were compiled from multiple sources including the New Jersey Department of Environmental Protection Bureau of GIS, New Jersey Geographic Information Network, and the United States Geological Survey (see GIS Data Citations). In addition, the CRC created data layers where data gaps existed. The CRC used *ESRI Arc Desktop* mapping software suite and *Blue Marble Global Mapper* to produce the assessments. This report details the spatial data compiled and created by the CRC to aid TNC in the development of a tool to identify areas for potential marsh enhancement through the addition of sediment.

1. Marsh Condition Assessment

To assess marsh conditions, the CRC compiled existing and created new GIS data layers that represent factors known to negatively impact the health of salt marshes. These datasets were analyzed and used to develop a matrix for ranking the level of impacts and relative health condition of the marsh. This matrix can be used to identify potential hot spot. The goal of this mapping effort was to provide a screening-level tool for future on-the-ground review.

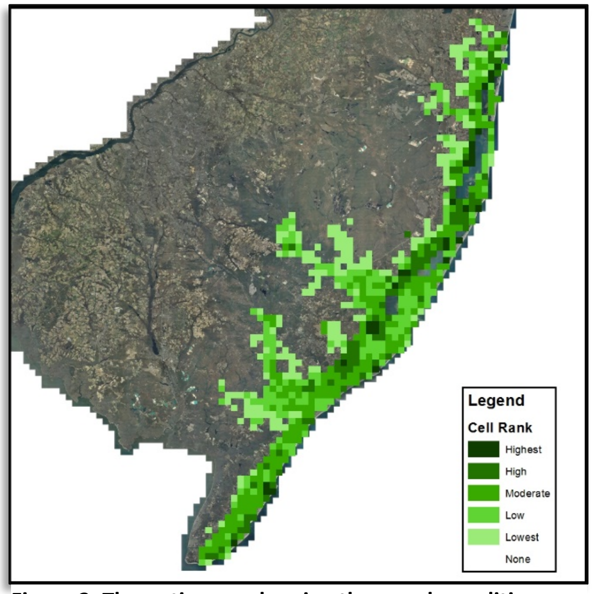


Figure 2. Thematic map showing the marsh condition ranking of 1 square mile cells in the study area.

The parameters that were used to assess the 2012 marsh condition were developed through meetings and discussions with coastal marsh experts who were working with TNC on the National Fish and Wildlife Foundation (NFWF) Hurricane Sandy Coastal Resiliency Competitive Grant (titled *Beneficial Reuse of Dredge Material to Restore Salt Marshes*).

The metrics chosen for the marsh condition analysis include:

a) Miles of manmade ditching/canals
b) Acres of dredged lagoons/borrow pits
c) Acres of marsh shoreline erosion/loss
d) Acres of non-vegetated coverage

Figure 3. Map showing locations of ditching/canals.

Manmade Ditching/Canals

The ditching/canal data layer was created to identify the presence and quantity of manmade ditching on coastal marshes (ex. mosquito control). The quantity of ditching is summarized in miles of ditching per one-mile cell, and further quantified by estimating the density of ditching per acre of marsh. The vector dataset does not identify all ditching features on the coastal marshes but is the most complete data set found that proved delineations of these features.

This data layer was identified and extracted from the United States Geological Survey's (USGS) National Hydrography High Resolution (NHD-HR) vector dataset for New Jersey, NHD_H_34. These features were selected by querying ‘CANAL/DITCH’ in the ‘FType’ attribute field. The USGS ‘Standards for National Hydrography Dataset – High Resolution’ document defines ‘CANAL/DITCH’ as, “An artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft.” (12/19/20111 NHD Standards).

Non-Developed Dredged Lagoons

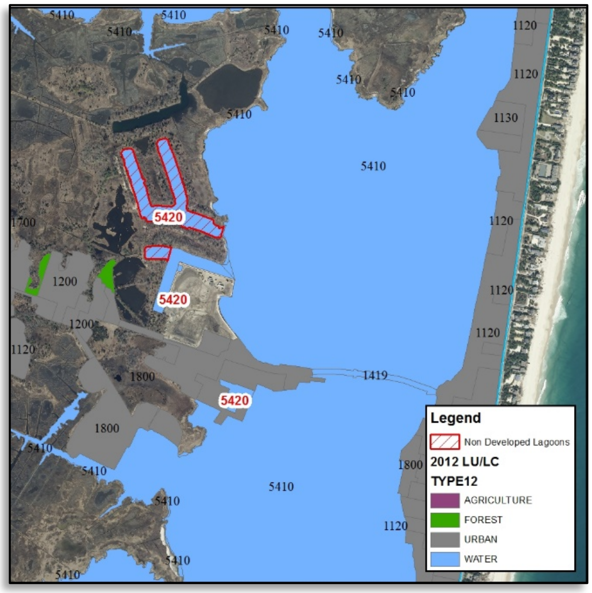


Figure 4. Map showing lagoons within coastal marshes

Dredged lagoons or borrow pits are subaqueous areas where sediment was previously mined and used to raise the elevation of adjacent land. In some cases, areas were dredged but the surrounding marshes were never developed. These marshes could potentially be reclaimed and restored through placement of dredged material.

This data layer was identified and extracted from the NJDEP 2012 LU/LC vector data set by selecting features labeled as ‘5420’ in the ‘LU12’ attribute field. Once extracted, a buffer analysis was conducted to determine if the dredged lagoon polygons were adjacent to or fronting developed urban areas. Areas that fell within this buffer were visually inspected and if identified correctly, were removed from the dataset. Upon visual inspection, dredged lagoons that appeared to be used as navigational waterways to personal docks were removed. In addition, in certain situations if a section of a dredged lagoon feature was near developed land and a section was not the cell ranking was split using the ArcMap split feature tool.

Figure 5. Map showing areas/acres of marsh loss after comparing 1977 and 2012 shoreline positions.

Marsh Loss

The marsh loss vector data layer was created to identify, quantify, and visualize erosional changes in the footprint of New Jersey’s coastal back bay marsh lands from 1977 to 2012. This layer focused on loss of marshes and did not examine areas that advanced through sediment accretion.

Marsh erosion and acreage losses were identified by comparing the geographic extent of the New Jersey Department of Environmental Protection, Bureau of Tidelands Management (NJDEP) Tidelands claim line and the NJDEP 2012 Land Use/Land Cover (LU/LC) vector shapefiles. Erosional polygons were defined by areas classified as “Unclaimed” in the Tidelands layer (not flowed [covered by water] at or below mean high water) These “Unclaimed” polygons were classified as water in the 2012 LU/LC.

Marsh Vegetation Analysis

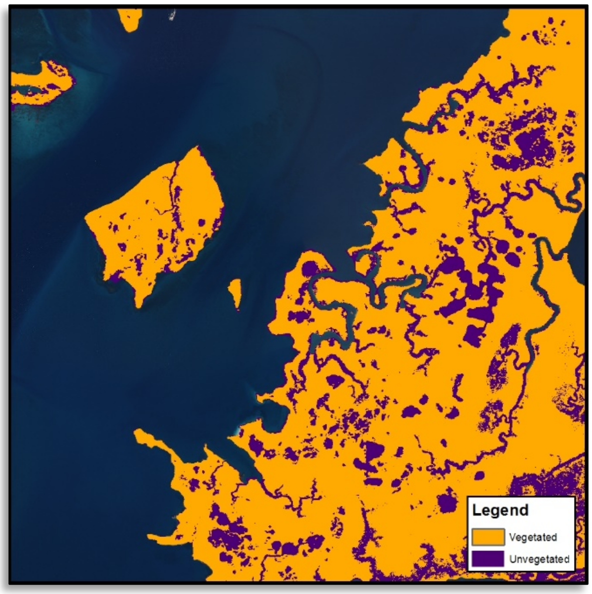


Figure 6. Map showing vegetated (yellow) and non-vegetated (purple) coastal marshes as determined using NDVI classification.

The non-vegetated data layer was created to present the ratio of vegetated to non-vegetated coastal marshes. The CRC input 2012-2013 high-resolution orthophotographs, separated the hyperspectral imagery, and removed classified urban, forest, agricultural, barren lands, and water. The Normalized Difference Vegetated Index (NDVI) was calculated and used to classify each image pixel as either vegetated or non-vegetated. The NDVI formula utilizes the visible red (600 – 700nm [VIS]) and infrared red (800-1100nm [NIR]) wavelengths for the classification. Healthy vegetation absorbs a large percentage of visible light and reflects a large percentage of near-infrared light. The NDVI formula uses the following equation: NDVI =(NIR-VIS)/(NIR + VIS)

This process outputs a raster with values ranging from -1 to 1. Low reflectance (or low values) in the red (VIS) channel and high reflectance in the NIR channel will yield a high NDVI value and vice versa (http://gisgeography.com/how-to-ndvi-maps-arcgis/). A higher NDVI indicates the presence of greener vegetation coverage. All imagery was obtained from the NJGIN website and combined into mosaic datasets within Esri's ArcMap. The following groups were created to reduce file size and increase efficiency: Atlantic Section 1, Atlantic Section 2, Atlantic Section 3, Burlington Section 1, Cape May Section 1, Cape May Section 2, Monmouth Section 1, Ocean Section 1, Ocean Section 2, Ocean Section 3 and Ocean Section 4. Each group contained roughly 120 Mr.SID format raster images. The image analysis window within ArcMap was used to run the NDVI processing algorithm on each of the raster datasets.

Upon completion of the NDVI, the demarcation value between the vegetated and non-vegetated surface was determined through visual analysis. This NDVI value averaged around 0.1. Each raster was then reclassified using Esri's ArcMap Reclassify Raster tool to create a surface with two classifications: vegetated and non-vegetated and later visually verified with the 2012 imagery. For each classification, a percentage was calculated to assess the overall accuracy. All but one of the final raster outputs received a 90% or greater on the check (36/40 point correctly classified).

Marsh Impact Ranking

The CRC combined the four metric datasets to develop a ranking system for impacted coastal marshes. To do this, the ArcMap natural neighbor classification schema was used to separate each metric into five classes. These classes were used to rank the cells on a scale of 1 (lowest impacted) to 5 (highest impacted). After the statistics and rankings were calculated, the scores were summed into a final ranking column.

The final product for the marsh condition analysis is a 1-mile square grid covering the study area. The grid is symbolized to show areas that rank highest using the combined metrics and in turn, have the highest potential of being an impacted marsh. The four ranked metrics were not weighted due to an inability to assess which metric should be of higher or lower priority. Final ranking were calculated for all possible combinations of metrics. This allows the user to find impacted marshes that meet the requirements for specific restoration project types.

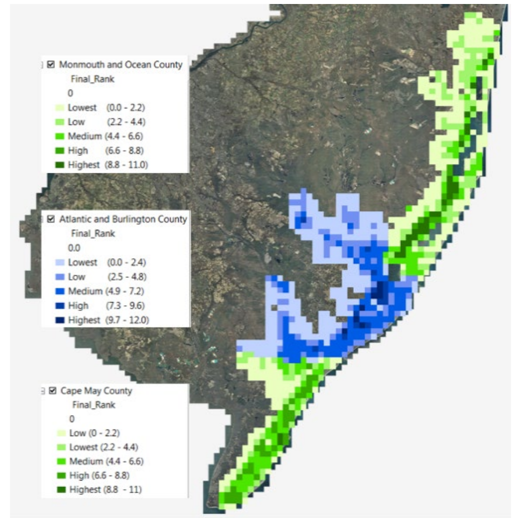


Figure 7. Table showing the ranking system for each metric used to determine marsh impact and map showing the ranked Ditching areas.

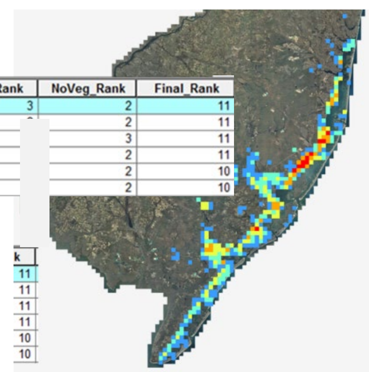
Natural Break (rounded to whole number)

	Rank	Score	Miles of Ditching	# of cells	Percentage
Ditching	Highest	**5**	13 - 25	11	1.0
	High	**4**	7 - 13	33	3.1
	Medium	**3**	3 - 7	72	6.7
	Low	**2**	1 - 3	97	9.0
	Lowest	**1**	0 - 1	174	16.1
	None	**0**	0	693	64.2

	Rank	Score	Dredged Lagoon Acres	# of cells	Percentage
Dredged Lagoon	Highest	**5**	8 - 25	1	0.1
	High	**4**	5 - 8	5	0.5
	Medium	**3**	2 - 5	8	0.7
	Low	**2**	1 - 2	5	0.5
	Lowest	**1**	0 - 1	12	1.1
	None	**0**	0	1049	97.1

	Rank	Score	Wetlands Lost in Acres	# of cells	Percentage
Shoreline Erosion	Highest	**5**	111 - 280	6	0.6
	High	**4**	44 - 111	10	0.9
	Medium	**3**	16 - 44	66	6.1
	Low	**2**	5 - 16	233	21.6
	Lowest	**1**	0 - 5	342	31.7
	None	**0**	0	423	39.2

	Rank	Score	Non Vegetated Acres	# of cells	Percentage
Non Vegetated	Highest	**5**	154 - 305	2	0.2
	High	**4**	63 - 154	37	3.4
	Medium	**3**	32 - 63	82	7.6
	Low	**2**	10 - 32	183	16.9
	Lowest	**1**	0 - 10	671	62.1
	None	**0**	0	105	9.7



NAME	DL_Rank	Ditch_Rank	Erosn_Rank	NoVeg_Rank	Final_Rank
H_0047	4	2	3	2	11
U_0043	3	4		2	11
BD_0041	0	5		3	11
BP_0031	3	4		2	11
I_0046	4	2		2	10
T_0043	3	3		2	10

NAME	DL_Rank	Ditch_Rank	Erosn_Rank	NoVeg_Rank	Final_Rank	DIST_Miles	DL_Acres	Erosn_Acre	NV_Acre	Veg_Acre	Wtld_Acre
BL_0035	0	5	2	2	9	19.409852	0	9.845253	23.831956	428.988958	452.820914
BL_0036	0	4	3	2	9	9.408422	0	16.974074	24.270156	392.170776	416.440932
BM_0033	0	5	2	2	9	15.133049	0	6.850887	12.175758	440.872567	453.048324
BM_0034	0	4	3	2	9	7.496105	0	22.745345	13.928122	288.731061	302.659183

Figure 8. Table and maps showing marsh impact rankings by 1-mile cell.

Social/Physical

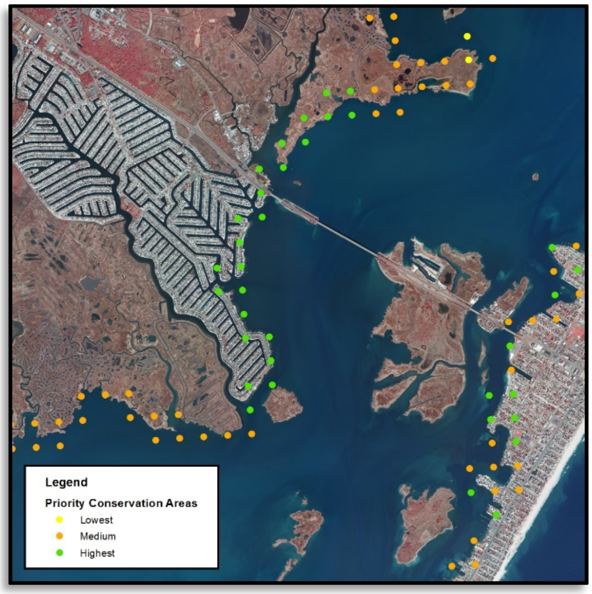


Figure 9. Map showing ranked conservation areas determined from TNC's *Coastal Resilience* mapping portal.

The TNC's *Coastal Resilience* mapping portal (http://maps.coastalresilience.org/network/) provides coastal vulnerability mapping tools for social and physical impacts. These data were used to rank the benefit that coastal communities derive from existing coastal habitats. The tool was used to identify the risk reduction associated with the presence of natural habitats and provides an indication as to where conservation and restoration of existing habitats have the greatest potential to protect coastal communities. The habitats reviewed in this analysis included: coastal forests, emergent wetlands, intertidal aquatic vegetation, and coastal dunes. This analysis created a 250m grid along all the coastal shorelines of NJ, including the coastal back bays and the Raritan/Delaware Rivers. The results from this analysis were refined to highlight which wetland habitats are likely to reduce current risk factors and are considered priority conservation areas. This evaluation was not incorporated as a metric in the marsh condition assessment.

2. Feasibility of Beneficial Use

The CRC met with staff from TNC, US Army Corps of Engineers (Philadelphia District), and NJ Department of Transportation (Office of Maritime Resources) to identify public datasets that could be combined with the marsh condition assessment in GIS to determine potential marsh enhancement projects using sediment. The public datasets compiled for this task included:

USACE Waterway Network – Federal channels in New Jersey
USGS NJ Coast Sediment Texture – 2014 Barnegat Bay and East Coast
CRC 2006 NJ Bay Floor Sediment Classification
NJDEP-HPO Historical/Archaeological Locations
NJDEP Shellfish Harvest Classification – Locations of prohibited, seasonal, and approved harvest areas
Rutgers University Mapped Submerged Aquatic Vegetation
NJ Waterway Access – Locations of Public Boat Ramps and Marinas
NJGIN – Road Network

Figures 10a and 10b show the potential use for the combined data. The blue box near Little Egg Harbor Township in Ocean County is an area of interest based upon its marsh condition ranking, proximity to roads and channels, and nearby sediment, and is a potential location for further analysis. The compiled datasets and metadata were submitted to TNC in April 2017 for inclusion in the *Coastal Resilience* tool.

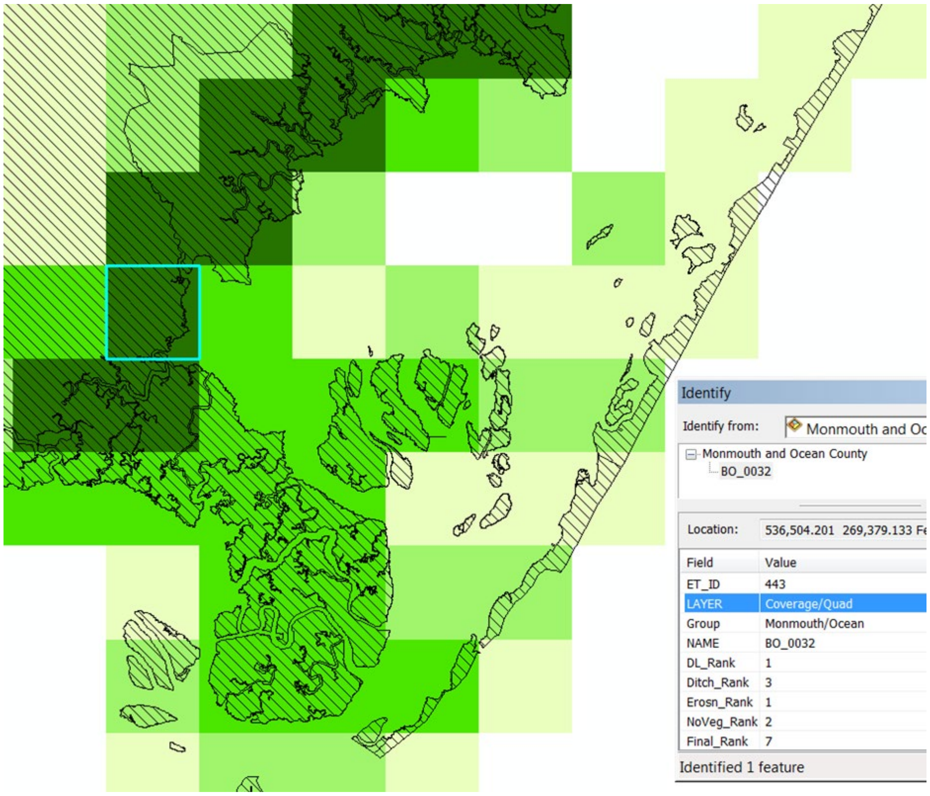


Figure 10a. shows the marsh condition ranking and highlighted area in Little Egg Township, NJ.

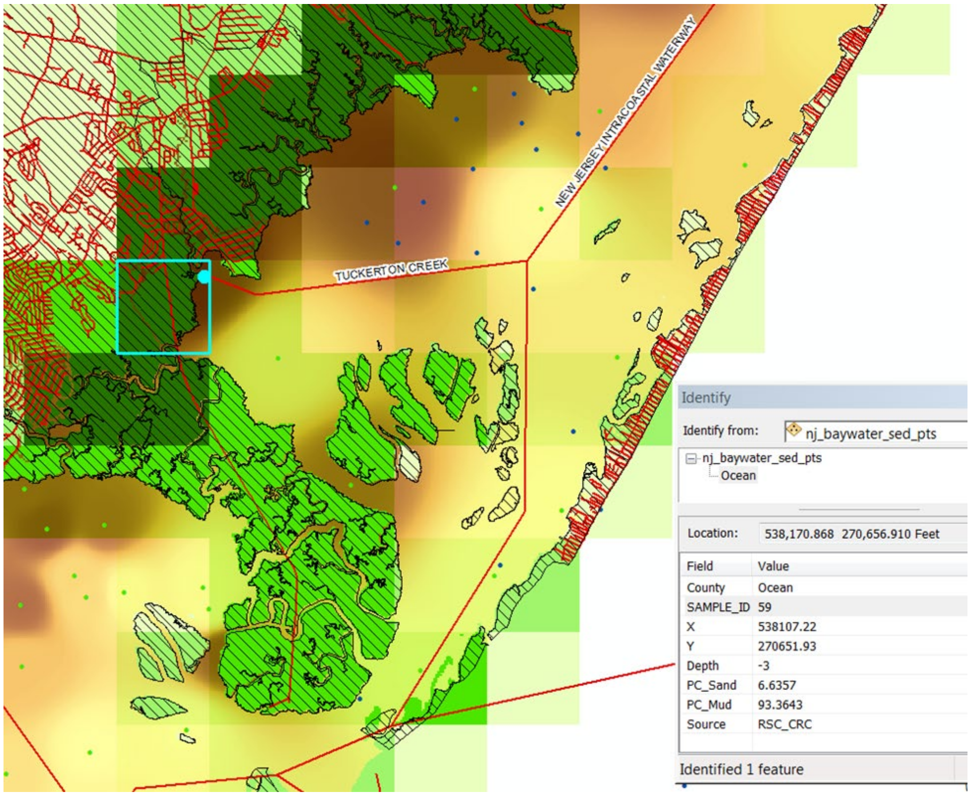


Figure 10b. shows the marsh condition ranking with additional data layers such as roads, channels, and interpolated grain size.

Conclusion

The Stockton University Coastal Research Center completed a marsh condition assessment by analyzing existing datasets of four metrics that would result in changing publically-owned coastal marshes (ditching, dredged lagoons, marsh loss, vegetated/non-vegetated). The produced GIS data layers were submitted to The Nature Conservancy for inclusion in its *Coastal Resilience* mapping portal. The CRC worked with partner agencies to determine additional public datasets that could be analyzed in GIS to determine potential feasibility of using dredged sediment for coastal marsh restoration. It is the intention that the marsh condition ranking and additional public data layers will enable TNC to refine its planning tool. Further refinements could include adding additional data layers (elevation, soil drainage, quantification of restoration/dredging needs, etc) in the analysis and weighting metrics to match management goals.

GIS DATA CITATIONS

National Hydrography Dataset- High Resolution, New Jersey Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS). 2010. National Hydrography Dataset (NHD) Waterbody 2002. NJDEP, Trenton, NJ. Vector digital data for NHD ID H34. Last Accessed March, 2017. https://nhd.usgs.gov/index.html

Land Use/Land Cover 2012, New Jersey Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS). 2015. Land Use/Land Cover 2012 Update. NJDEP, Trenton, NJ Vector Digital Data for Subbasins (HU8) 02040301 (Mullica – Toms River), 02040302 (Great Egg Harbor). Last Accessed March, 2017. http://www.state.nj.us/dep/gis/

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New Jersey 2012 - 2013 High Resolution Orthophotography, NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS). 2013. New Jersey 2012 - 2013 High Resolution Orthophotography. NJOIT, OGIS, Trenton, NJ. Raster Digital Data. Last Accessed March, 2017. https://njgin.state.nj.us

Addendum to Ferencz et al, 2017, Tasks 2 & 3: Marsh Condition, Assessment, Feasibility, & Spatial Data Report
October 2021 updates

The Stockton University Coastal Research Center under the direction of The Nature Conservancy was tasked to correct a few minor issues within the attribute table of the final *Marsh Conditions Ranking Matrix* that supports TNC's *Coastal Resilience- New Jersey Marsh Explorer* web application. Issues addressed include how data are displayed in the Percent Unvegetated Marsh Acres, Ditching per Marsh Acre, and Erosion per Marsh Acre datasets (figure A1). After corrections were made the CRC exported new datasets to TNC.

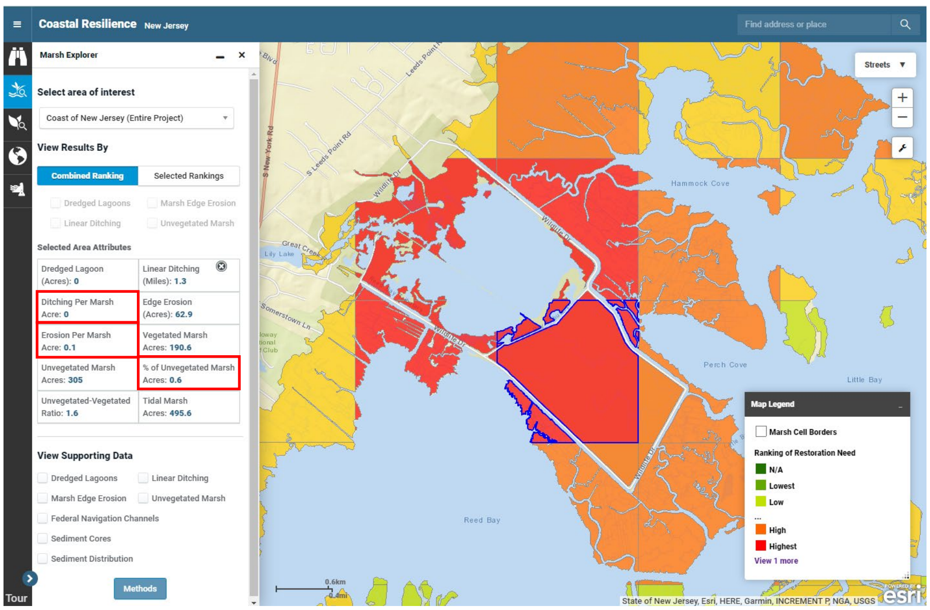

Figure A1. Area attributes highlighted in red have been updated.

<u>Final Product – Marsh Condition Ranking Matrix Updates</u>

Attribute Updates:

1) Percent Unvegetated Marsh acres, shapefile attribute field **UV_Percent** –

Recalculated statistics to show as a percentage. This percentage describes the total marsh area that is unvegetated within the 1-mile square index cell figure (A2).

$$\text{Unvegetated Percent (per 1-mile square cell)} = \frac{Area\ classfied\ as\ unvegetated\ marsh\ (acres)}{Total\ area\ classfied\ as\ Wetlands (acres)} * 100$$

NAME	UV_Percent	UVVR	Veg_Acre	UV_Acre	Wtld_Acre	LULC_Arce
BW_0028	61.5	1.6	190.588	304.983	495.571	495.603
BL_0039	58.6	1.41	0.084	0.119	0.203	0.202
DB_0008	43	0.76	22.866	17.276	40.142	40.132
BH_0033	41.5	0.71	91.021	64.677	155.698	155.709

Figure 2A. Unvegetated marsh percent column highlighted in the ArcMap attribute table.

2) Feet of Ditching per Acre of Marsh, shapefile attribute field **DT_per_Acr** -

Recalculated statistics, this is not a percentage. The result is a ratio that describes the average density of manmade ditching (in feet) per acre of marsh within the 1-mile square index cell.

$$\text{Feet of Ditching per Acre of Marsh (ft/acre per 1 mile cell)} = \frac{Total\ length\ \ of\ manmade\ ditching\ (feet)}{Total\ area\ of\ Wetlands\ (acres)}$$

This proxy works okay to show impacted marshes but may not highlight the most impacted marshes. Currently some of the highest ranked (highest restoration need) marshes are 1-mile cells with low total marsh areas (acres) and moderate to low ditching (miles). For example:

Marsh 1: Cell BW_0020
Total Marsh: 2.76 (acres)
Ditching: 1,267.2 (feet)
Ditching feet per acre: 459.3
Ditch Rank: Highest (5)

Marsh 2: Cell BD_0041
Total Marsh: 481.02 (acres)
Ditching: 21,542.4 (feet)
Ditching feet per acre: 237.9
Ditch Rank: High (4)

3) Marsh Erosion per Acre, shapefile attribute field **ER_perAcr –**

Recalculated statistics to show as a percentage. This percentage describes the acreage of marsh lost between the 2012 Land Use Land Cover mapping and the 1970's tideland claim line when compared to the remaining wetlands mapped in the 2012 LU/LC.

$$\text{Marsh Erosion since 1977 (per 1 mile cell)} = \frac{Area\ eroded\ or\ lost\ between\ 1977\ to\ 2012\ (acres)}{Total\ area\ classfied\ as\ Wetlands\ 2012\ (acres)} * 100$$

In hind sight, it might be more helpful to assess the condition of the 2012 marsh by comparing the mapped acreage of marsh in 2012 LU/LC to the acreage in the Tidelands Claim dataset. This would provide the user with a look at how much of the marsh mapped by the tidelands claim data remained as wetlands in 2012 mapping. For example:

$$\text{Remaining 1977 Marsh (\% per 1 mile cell)} = \frac{Total\ area\ classfied\ as\ Wetlands\ by\ 2012\ LU/LC\ (acres)}{Total\ area\ classfied\ as\ Wetlands\ by\ Tidelands\ Claim\ data\ (acres)} * 100$$