A remote sensing based approach for a spatially explicit, multi-criteria decision support model for loggerhead sea turtle nesting habitat suitability

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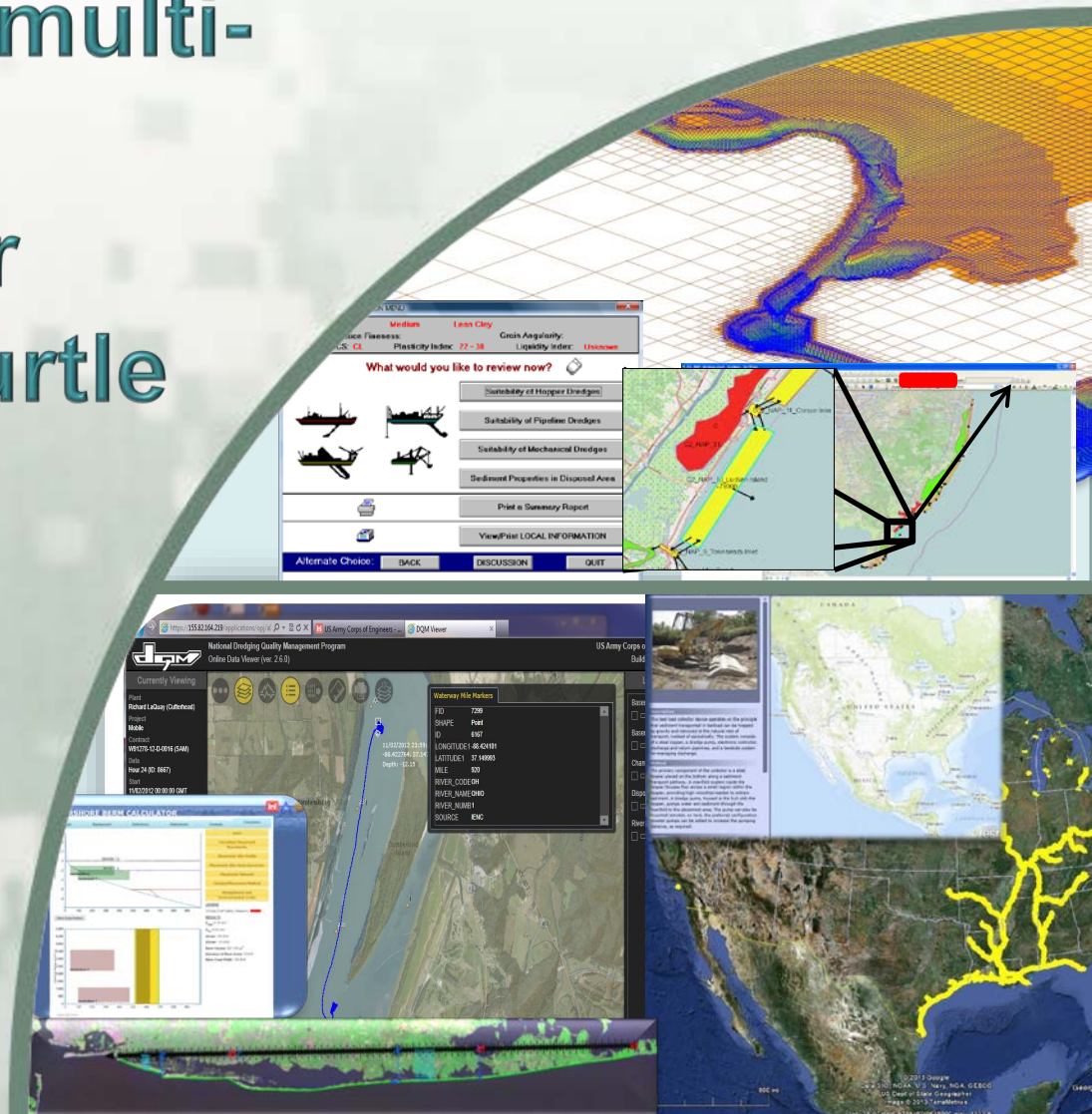


Lauren Dunkin

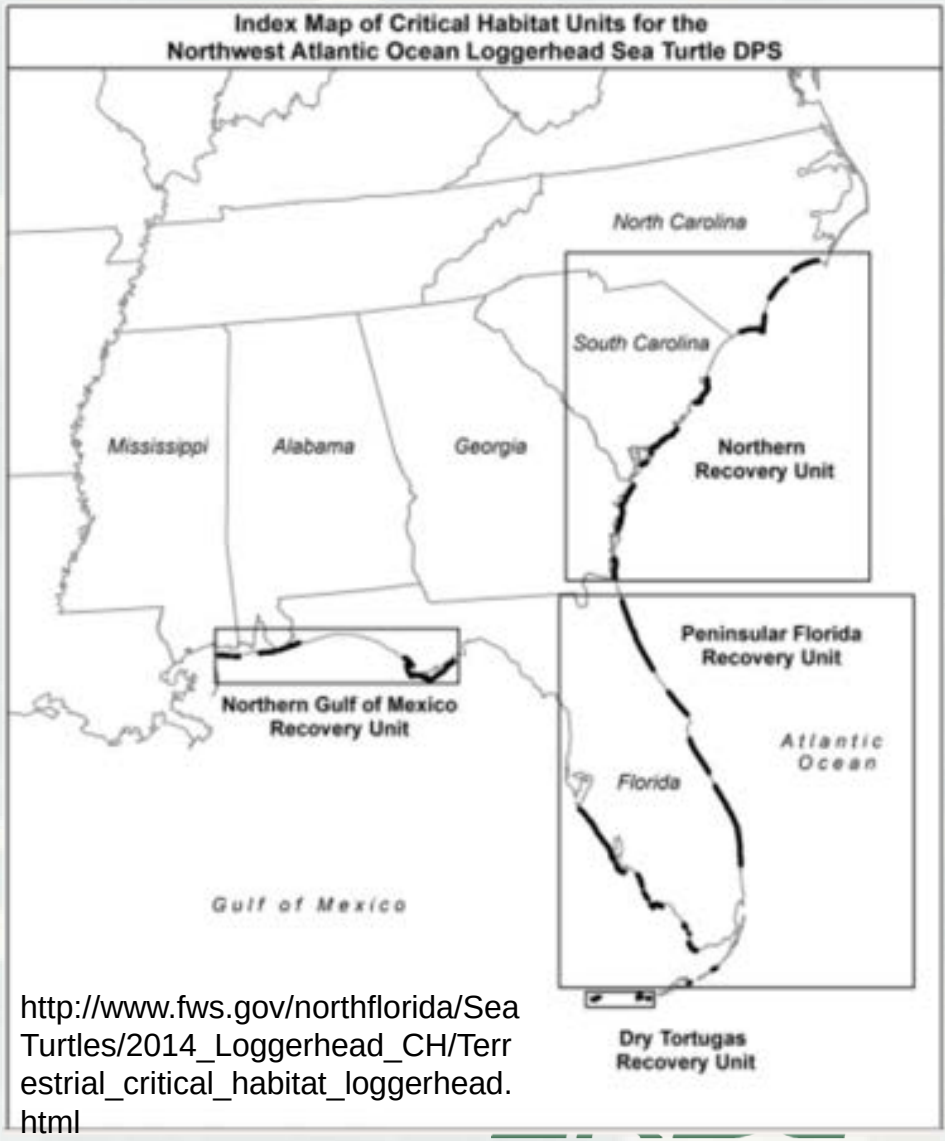
7/19/2016

The Team

- USACE – Molly Reif, Safra Altman, & Todd Swannack
- Collaboration with NOAA[1], SAJ[2], FWC[3], Broward County, FL[4], Palm Beach County, FL, and Sea Turtle Conservancy
  - [1]National Marine Fisheries Service, Southeast Fisheries Science Center
  - [2]Biologist and Coastal Engineer
  - [3]Florida Fish and Wildlife Conservation Commission
  - [4]Natural Resource Specialist

Overview

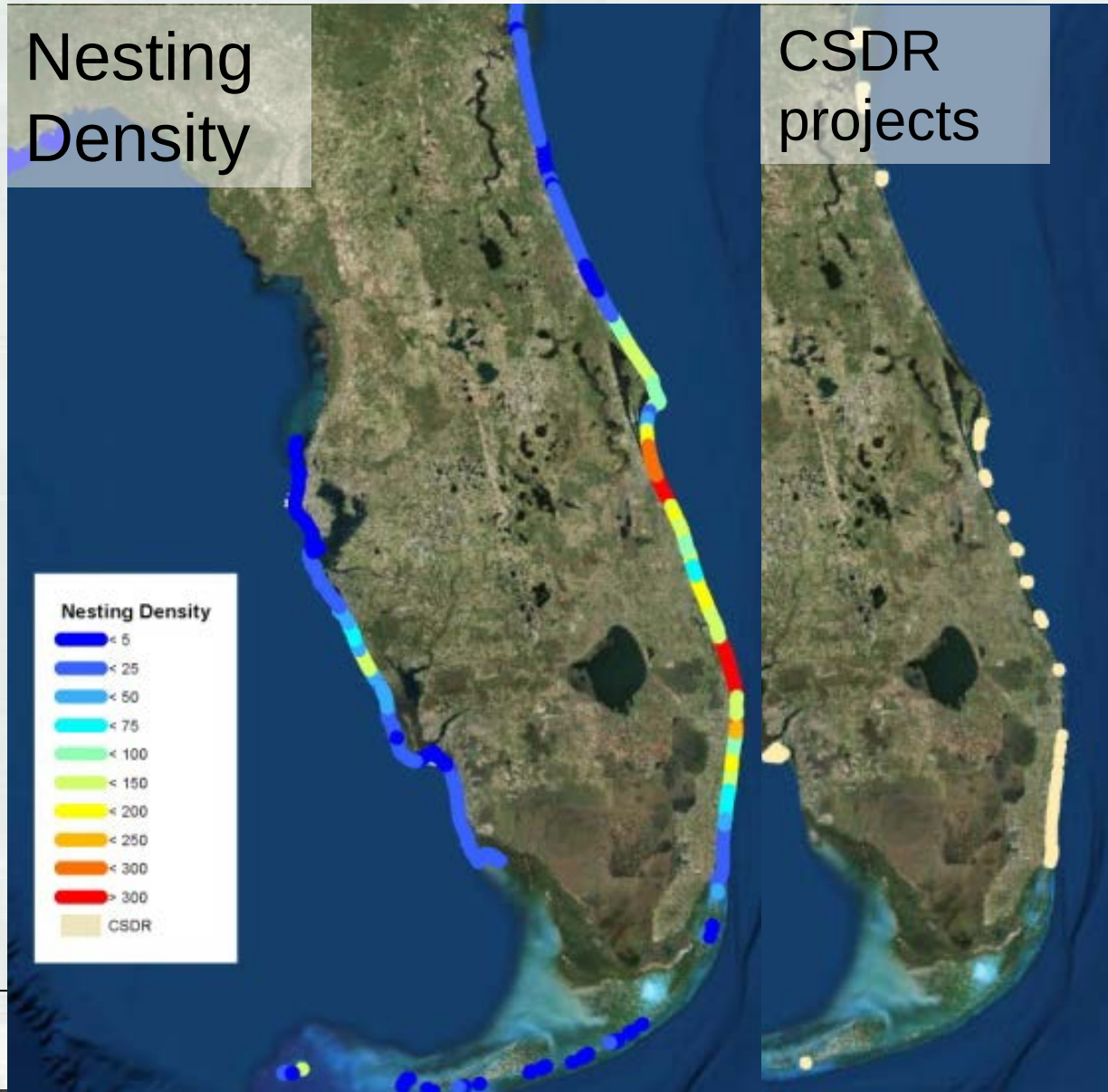
- 700 miles of coastline designated as critical habitat (CH) for loggerhead sea turtle (*Caretta caretta*) conservation.
- Areas overlap/adjacent to USACE Navigation or Costal Storm Damage Reduction (CSDR) projects.
- Decision support tools needed to address integrated resource management concepts.



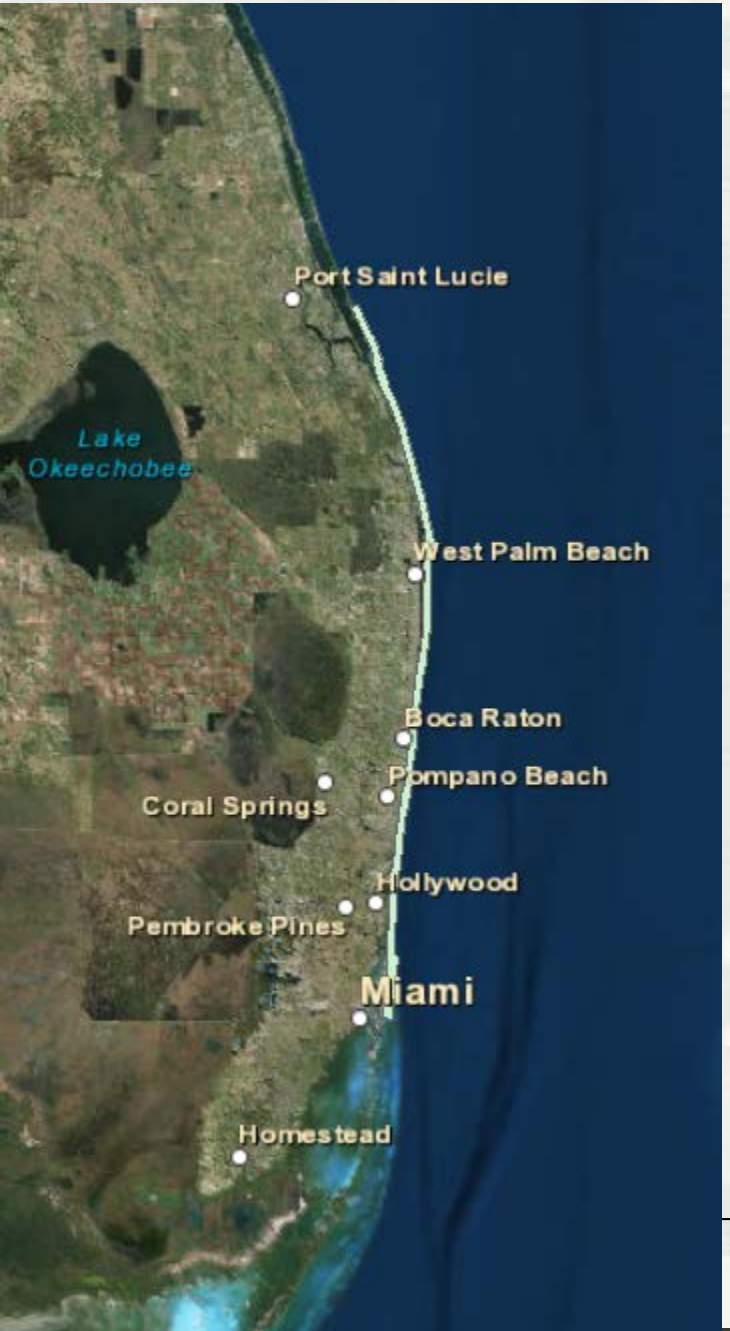
http://www.fws.gov/northflorida/SeaTurtles/2014_Loggerhead_CH/Terrestrial_critical_habitat_loggerhead.html

Approach

- Focus on parameters extracted from remote sensing data to use as input to the model
  - Support at regional scale using remote sensing data
- Demonstrate relative suitability of selected sites within the critical habitat zone for C. caretta by developing a spatially-explicit ecological model



Site Selection



South East FL chosen as study site:

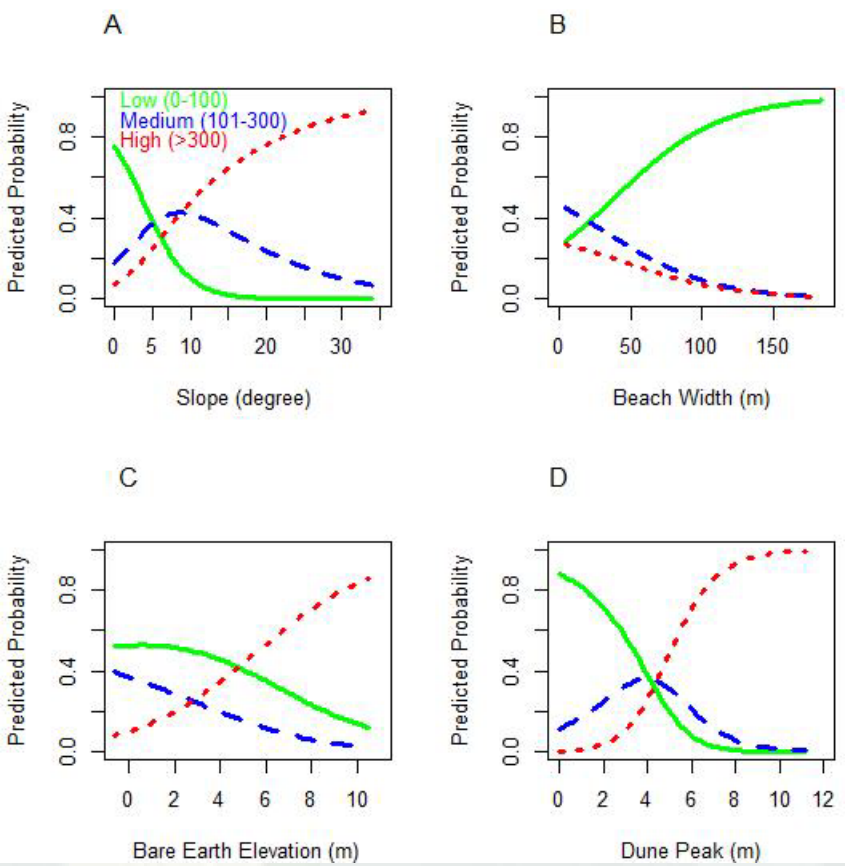
- 175-km stretch of FL coast
- 4 counties - Martin, Palm Beach, Broward, and Miami-Dade
- Nesting density classified from medium to high
- Coastal Storm Damage Risk Reduction projects in area
- Navigation Projects in area

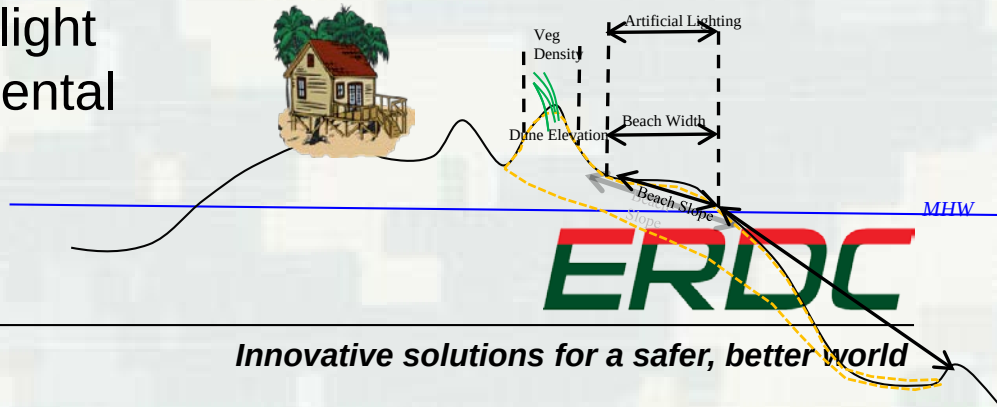
Remote Sensing Data:

- 2009 USACE lidar survey
- 2009 USACE hyperspectral imagery

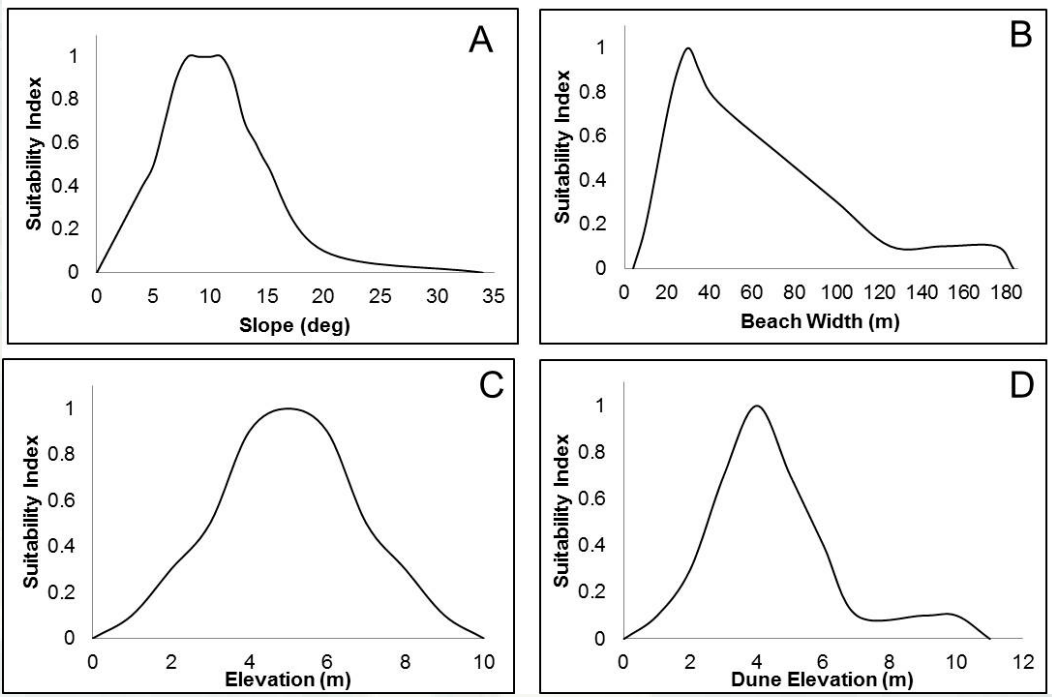
Parameter Analysis – Regression Analysis

- Focused on 4 morphological parameters:
  - Slope
  - Beach width
  - Dune peak
  - Bare earth elevation
- Environmental and anthropogenic parameters not included in regression analysis
  - Dune vegetation and artificial light parameters used as environmental benefit indicators



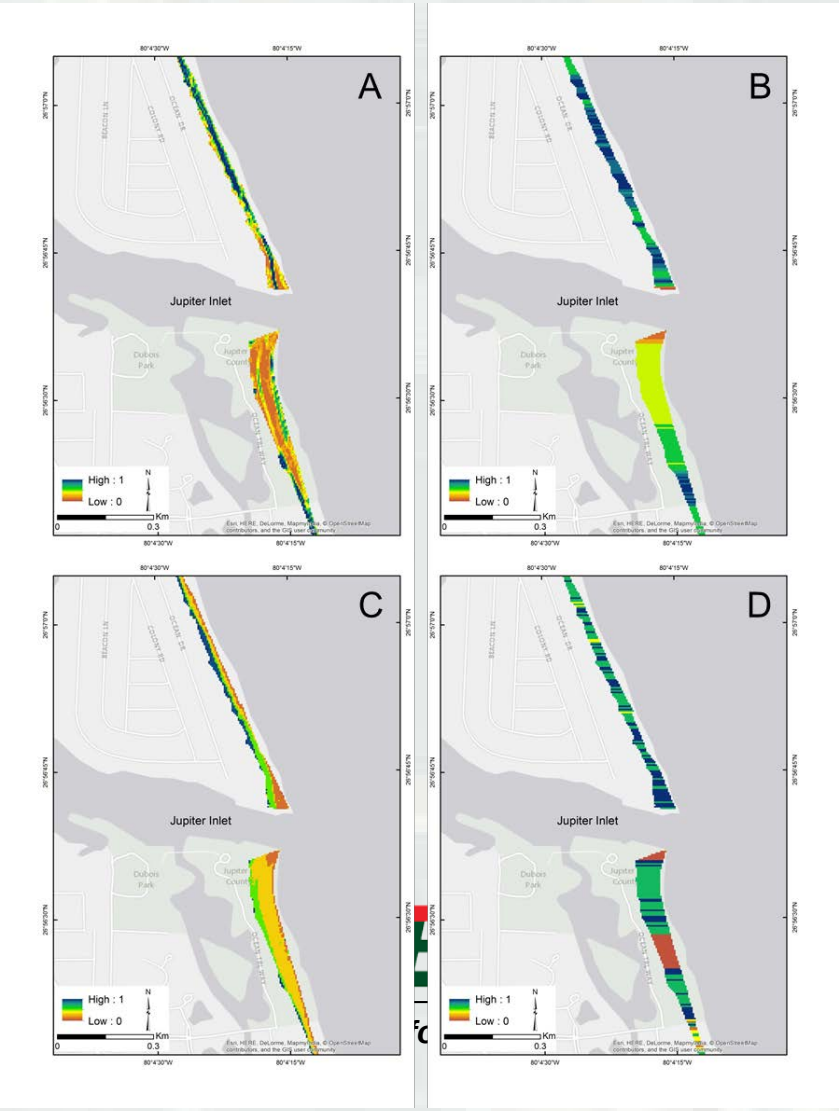


Model Development



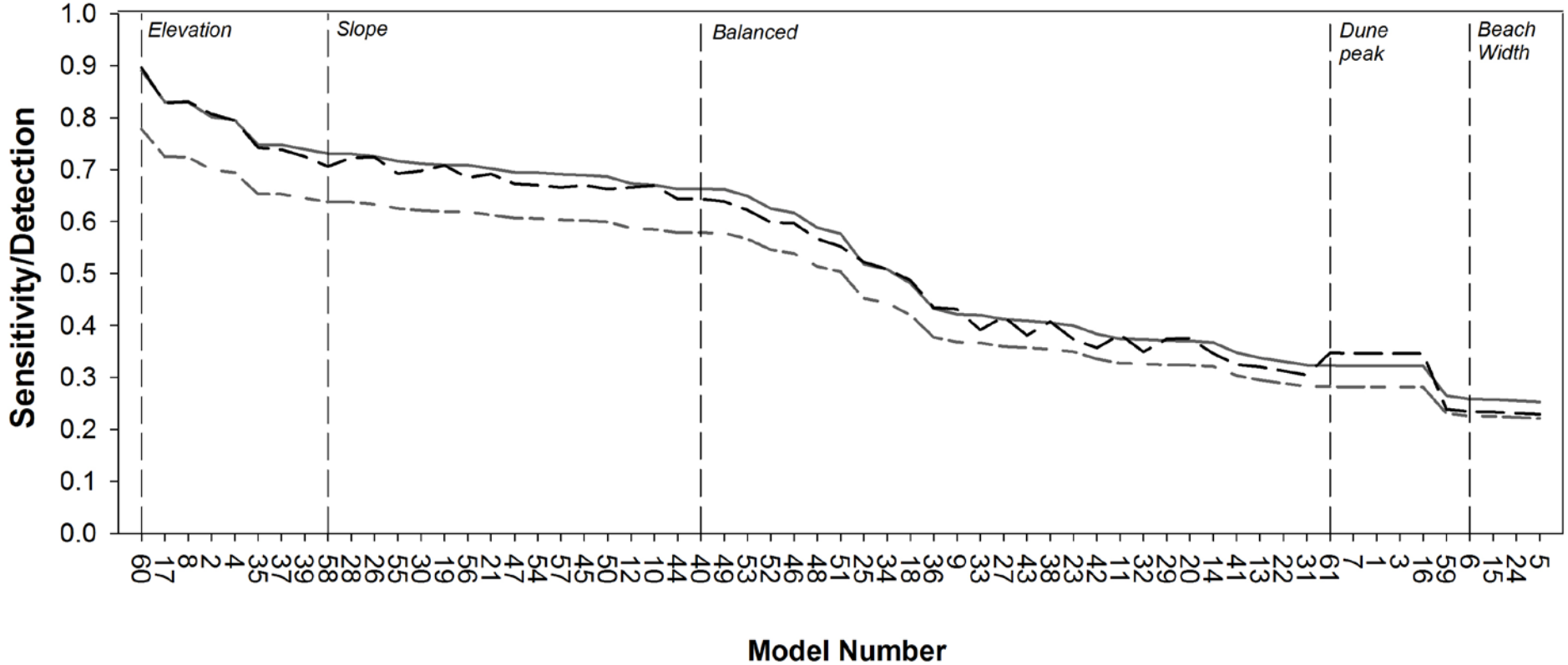
- Suitability index for each morphological parameter:
  - 0 to 1 (unsuitable to highly suitable)
  - Regression analysis, value ranges from literature, SME feedback

- Rasterized model grids from suitability curves



Model Optimization

- Detailed nesting data: Palm Beach County
  - Presence only data available
  - 57 model scenarios w/ adjusted weighting scheme
- Sensitivity (true positive rate), detection rate, and detection prevalence

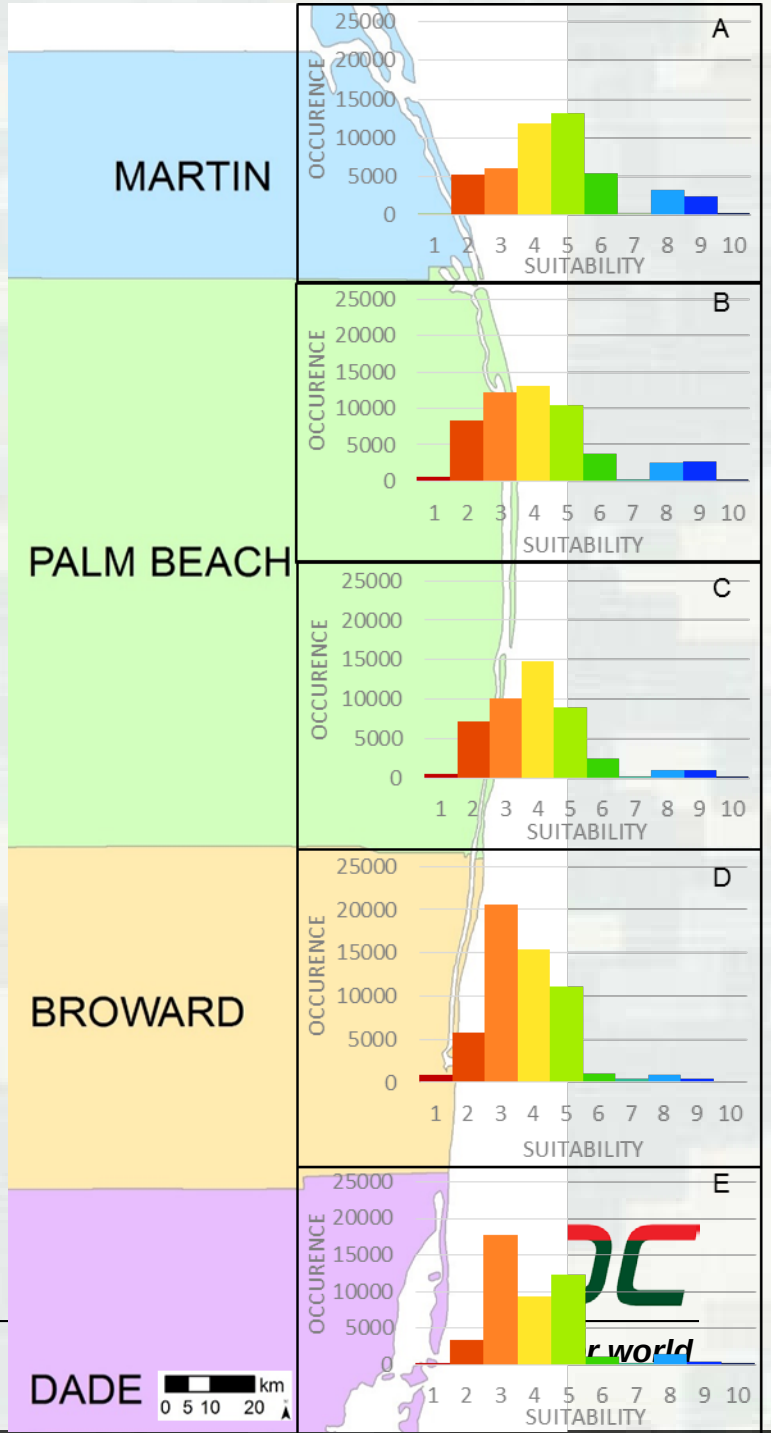


Model Results

Model	Weighting Structure				Sensitivity	Detection Rate	Detection Prevalence
	Slope	*Beach Width*	*Elevation*	*Dune Peak*			
17	0.13	0.06	0.75	0.06	0.830	0.725	0.828
8	0.08	0.08	0.76	0.08	0.830	0.724	0.831
2	0.06	0.06	0.75	0.13	0.802	0.700	0.807
4	0.06	0.13	0.75	0.06	0.795	0.695	0.795
35	0.25	0.08	0.5	0.17	0.748	0.653	0.742
Balanced (40)	0.25	0.25	0.25	0.25	0.663	0.579	0.644
Elevation (60)	0	0	1	0	0.891	0.778	0.896
Slope (58)	1	0	0	0	0.731	0.638	0.706
Dune Peak (61)	0	0	0	1	0.323	0.282	0.347
Beach Width (59)	0	1	0	0	0.265	0.231	0.239

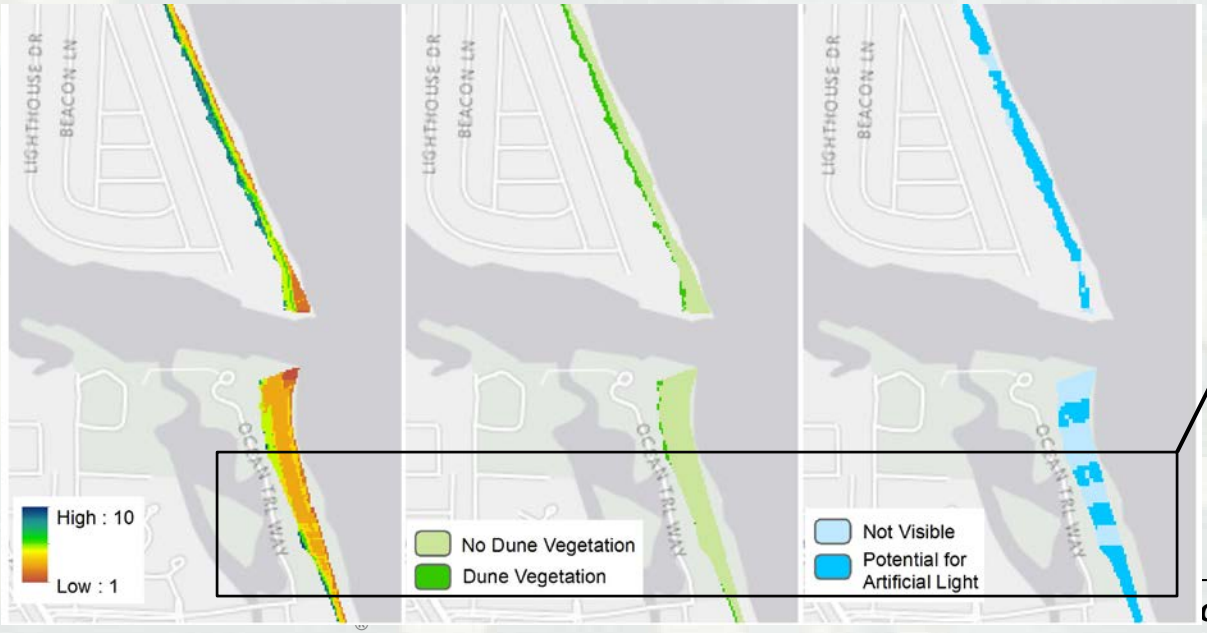
Model Results

- Model 17 applied to the entire study area
- Spatial interpretation of the nesting suitability



Discussion

- Elevation – most influential, followed by slope
  - Remote sensing – regional approach
- Equal weighting/balanced scenario
  - sensitivity and detection values ~ 0.6
  - model used with reasonable certainty with limited optimization required
- Environmental & anthropogenic parameters
  - evaluating habitat characteristics or quality, impacting site preference and mortality rates



Identify opportunities for habitat enhancement and improvement with maximum benefit to the species

lack of dune vegetation or potential for light pollution in areas that are highly suitable

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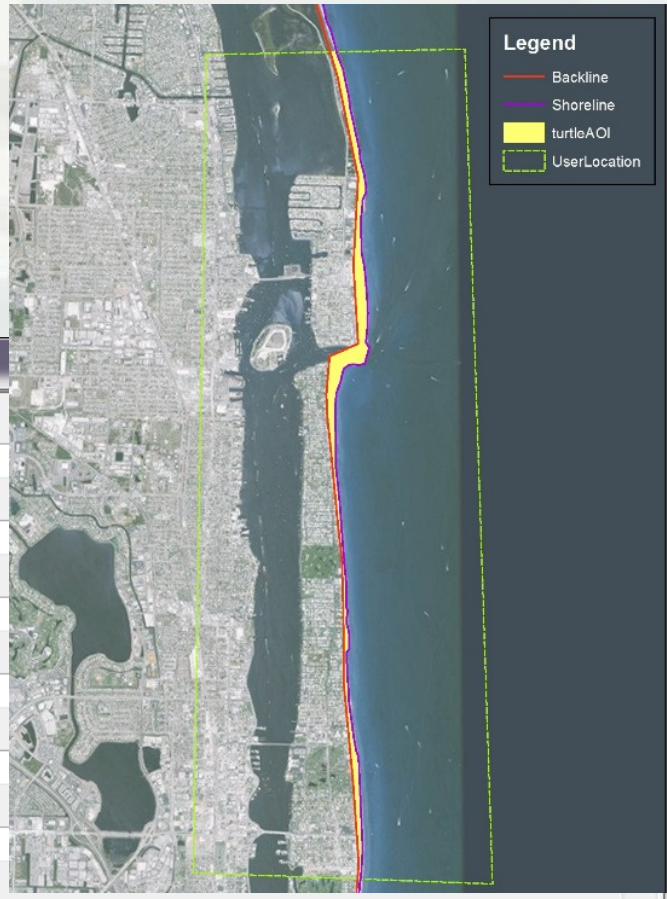
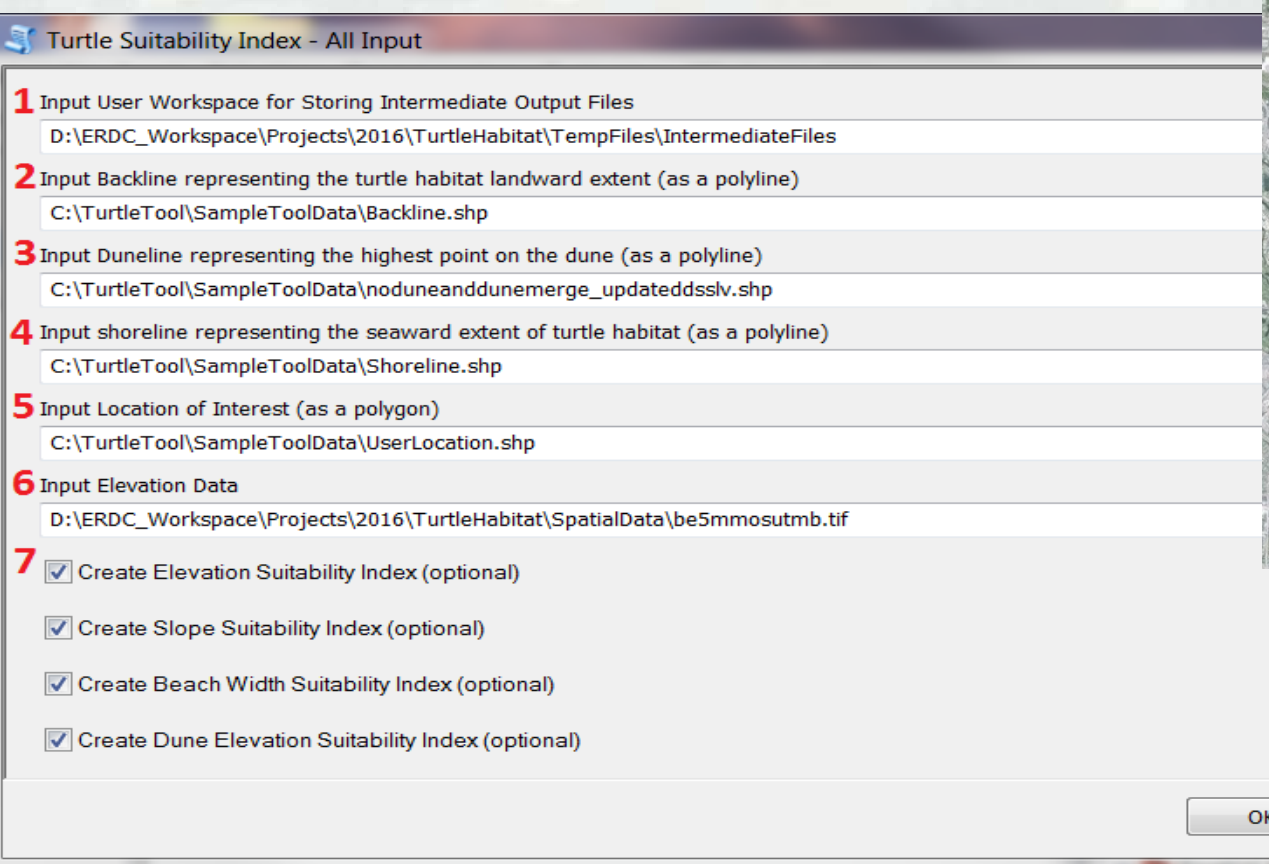
Nesting Habitat Toolbox

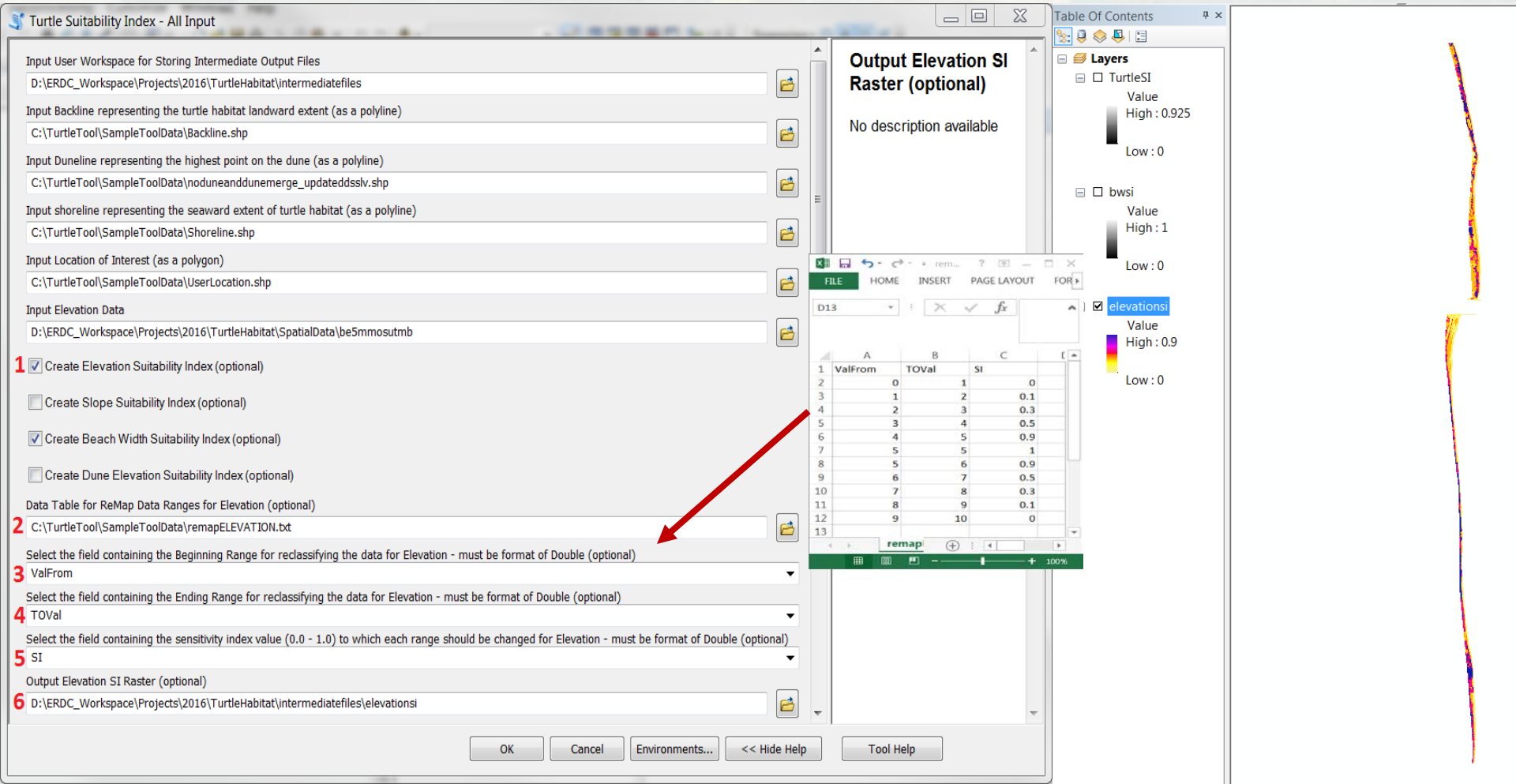
- Tool to assist the user with assessing relative suitability in their particular region of interest
  - Geospatial methods streamlined
    - Beach width, slope, clip grid
  - Desktop interface





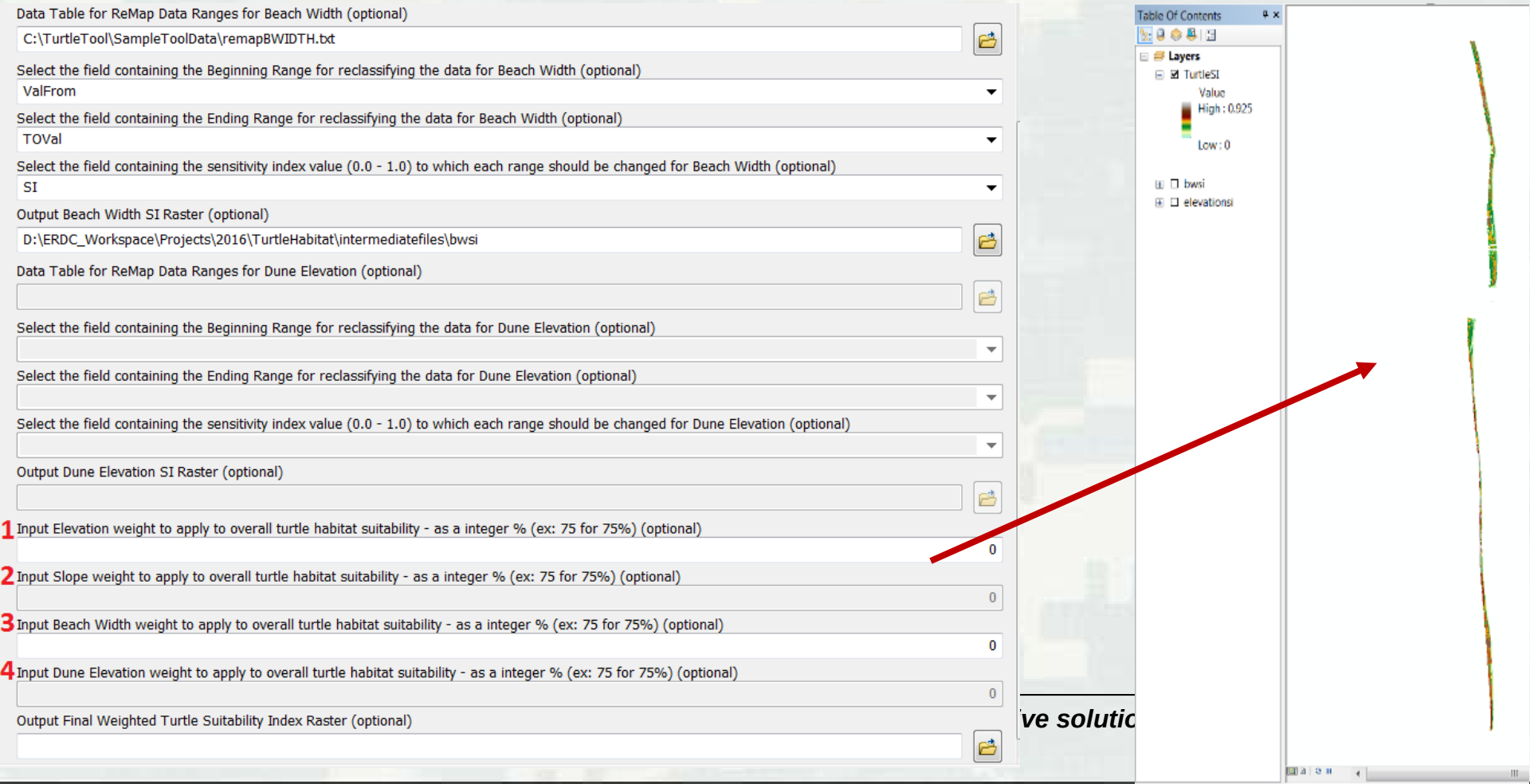
Nesting Habitat Toolbox

- Suitability index grids
  - Create rasters used as input for weighted overlay model



Nesting Habitat Toolbox

- Weighted overlay model
  - Flexible weighting scheme



Project Value

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- **Operations**: evaluate potential impacts of operational activities to nesting habitat and track changes through time (Engineering with Nature, Regional Sediment Management)
- **Planning**: improve coordination between agency partners to identify priority areas that would benefit from beneficially using sediment obtained through dredging activities
- **R&D**: evaluate beaches for better understanding of physical parameters needed to support nesting habitat

remote sensing

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Article

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A Spatially Explicit, Multi-Criteria Decision Support Model for Loggerhead Sea Turtle Nesting Habitat Suitability: A Remote Sensing-Based Approach

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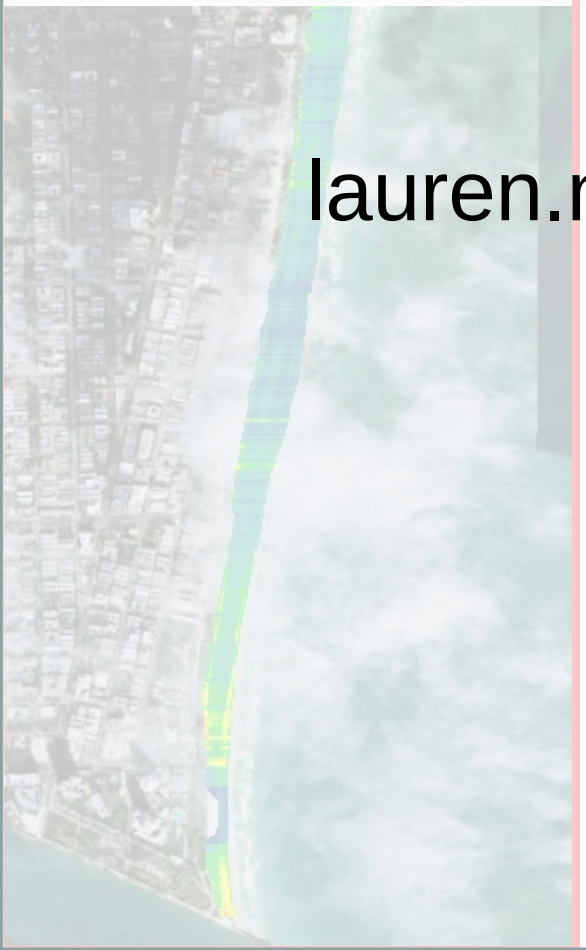
Abstract

Nesting habitat for the federally endangered loggerhead sea turtle (*Caretta caretta*) were designated as critical in 2014 for beaches along the Atlantic Coast and Gulf of Mexico. Nesting suitability is routinely determined based on site specific information. Given the expansive geographic location of the designated critical *C. caretta* nesting habitat and the highly dynamic coastal environment, understanding nesting suitability on a regional scale is essential for monitoring the changing status of the coast as a result of hydrodynamic forces and maintenance efforts. The increasing spatial resolution and temporal frequency of remote sensing data offers the opportunity to study this dynamic environment on a regional scale. Remote sensing data were used as input into the spatially-explicit, multi-criteria decision support model to determine nesting habitat suitability. Results from the study indicate that the morphological parameters used as input into the model are well suited to provide a regional level approach with the results from the optimized model having sensitivity and detection prevalence values greater than 80% and the detection rate being greater than 70%. The approach can be implemented in various geographic locations to better communicate priorities and evaluate management strategies as a result of changes to the dynamic coastal environment.

Low Nesting Density

$$= \frac{1}{1 + e^{L_{Nest\ Class\ 2}} + e^{L_{Nest\ Class\ 3}}}$$



Medium Nesting Density

$$\ln\left(\frac{p(NestClass2)}{p(NestClass1)}\right) = -1.423 - 0.026\ (Beach\ Width) - 0.073(Bare\ Earth\ Elevation)$$

$$= \frac{e^{(L_{Nest\ Class\ 2})}}{1 + e^{L_{Nest\ Class\ 2}} + e^{L_{Nest\ Class\ 3}}}$$

High Nesting Density

$$\ln\left(\frac{p(NestClass3)}{p(NestClass1)}\right) = -5.234 - 0.025\ (Beach\ Width) + 0.208(Bare\ Earth\ Elevation) + 1.220(Dune\ Peak) + 0.189(Slope)$$

$$= \frac{e^{(L_{Nest\ Class\ 3})}}{1 + e^{L_{Nest\ Class\ 2}} + e^{L_{Nest\ Class\ 3}}}$$

Questions

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