**Case Study: Shoreline changes in Cedar Key, Florida using Google Earth Pro and DSAS**

**Abstract**

The perpetuation of climate change and sea level rise have led to concerns in shoreline dynamics in the Gulf of Mexico. Shoreline dynamics in areas of coastal development have been intensely studied, however many under-developed shorelines have yet to be analyzed. In this study we used eight NAIP (National Agriculture Imagery Program) aerial images, from 1994 to 2019, of our study area near Cedar Key, FL. The cloud-free images were collected during relatively similar mean river discharge levels and during (mostly) the same season. We assessed the shoreline changes using the ArcMap extension DSAS (Digital Shoreline Analysis Systems). The DSAS analysis is a transect- based approach and is used to quantify shoreline changes on a linear ocean shoreline. From this analysis we have been able to determine the greatest areas of impact and speculate on possible factors that may be contributing to an escalated shoreline change rate during this brief selected time frame.

**1. Introduction**

Shorelines changes can occur due to multiple factors including anthropogenic, natural, hurricane intensity, and sea level rise (Yu et al., 2011). The combination of these processes can influence erosion and accretion. These shoreline changes may affect the resilience to storm surges including flooding and species diversity implications (Desantis et al., 2007). It was observed by USGS (US Geological Survey) that shoreline changes along the Gulf of Mexico, specifically in Florida, were relatively steady between the 1800s and 1990s (Morton et al., 2005). Since then, the Gulf of Mexico coastline, with its low relief geomorphology particularly along the west coast of Florida, has been noted to be vulnerable to coastal erosion (Geselbracht et al., 2011).

***1.2 Reason for effort***

In the mid-1960s the US Army Corps of Engineers constructed spoil islands as part of the cross Florida barge canal project. These spoil islands consist of a straight line of islands perpendicular to the coast (Fredrick et al., 2019). An example of habitat analysis was conducted by Vitale (2019) and investigated how some of these spoil islands were and and are severely eroded or currently inundated, thus reducing habitat for animals. Derrick Key is an example of a spoil island that was clearly visible in aerial photographs in 1982 and now the island is completely submerged (in 2016 photography). Major shoreline differences are noticeably observed in the 34 years, time between the imagery, for this specific spoil island.



Figure- Island degradation of Derrick Key in the Cedar Keys, Florida from 1982 (left) to 2016 (right), (Fredrick et al., 2019).

**2. Materials and methods**

***2.1 Study Area***

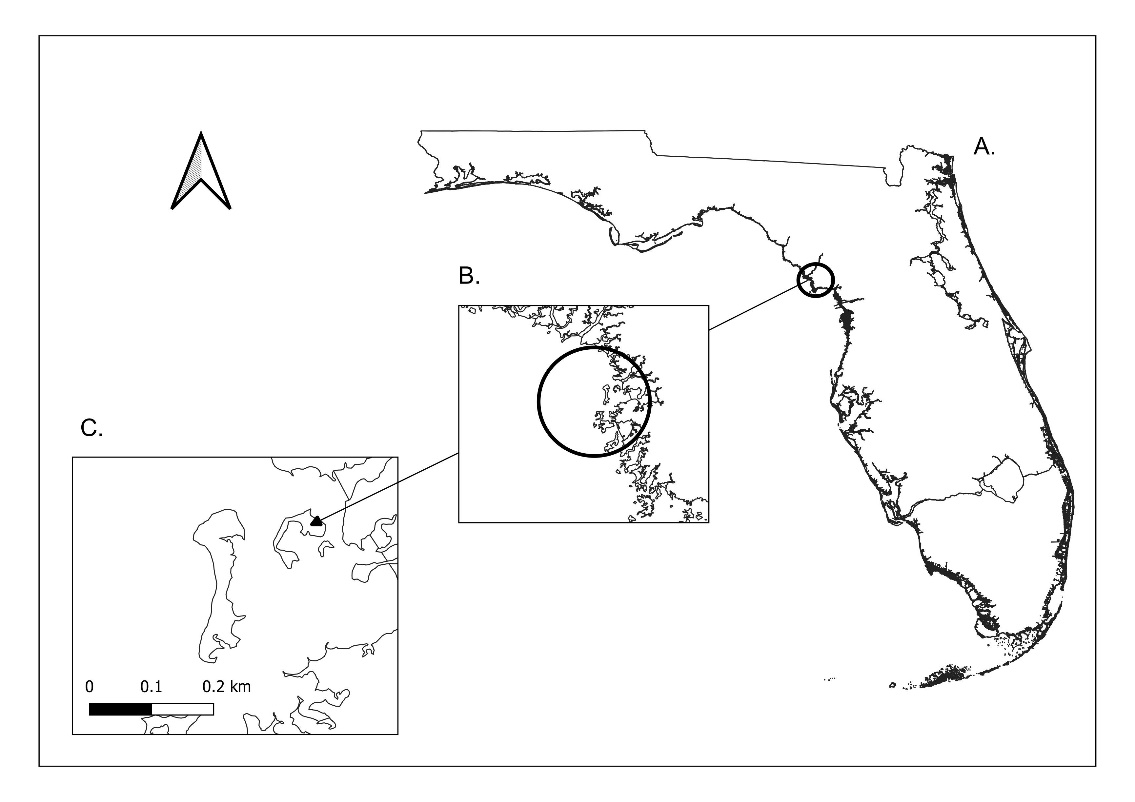
Our study area is located on the west-central Florida coastline. The selected shoreline is a small barrier island called Deer Island. Deer island is a privately owned uninhabited island approximately 8 miles north of the main villages of Cedar Key, Florida. Historically, Native Americans intermittently inhabited Deer Island for thousands of years. Early Florida settlers were reported to live and camp on the island as well. The 1800 Florida census registered only 4 people to have identified this island as their home. There is a cabin near the south of the island depicted on a 1951 USGS Cedar Key Quadrangle map (USGS, 1955). This island is specifically located in the Big Bend Aquatic Seagrass Preserve and connects with the Lower Suwannee National Wildlife Refuge (http://www.beachrealtyfla.com/DeerIsland.htm). Deer Island is approximately 90 acres of total area and consists of 25 upland acres and 20 wetland acres with elevations as high as 14 feet. The island is densely forested with large pines, cedars, palms, oaks, palmettos and many more plant species (<https://www.privateislandsonline.com/united-states/florida/deer-island>). The shoreline attributes reported on Deer island is about 0/8+/- mile of Gulf of Mexico white sand beach and approximately 0.8 +/- mile of waterfront facing the mainland ( <https://images1.loopnet.com/d2/Z4L1-alqEsAlhPT_YJ25N8OMkXU3L_mAPAZYXiq2OVg/document.pdf>).

Figure- Location of Deer Island, Florida. A) Map of the entire state of Florida; B) Zoomed into map scale of 2.3758 to location; C) Zoomed into map scale of 0.03 to Deer Island with a scale bar in kilometers

***2.3 Imagery selection process***

Selecting cloud-free imagery of a specific location can be time consuming. Since our study location is not populated nor contains any historic landmarks, there are not frequent aerial or satellite passes of this area.

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| --- | --- | --- | --- |
| Date | Median River Discharge (cfs)  Station ID= 02323500 | Observed weather | Metadata (USGS Earth Explorer) |
| January 20, 1994 | Value= 9710 | Avg Temp (F)- 38.15 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 12 | Found DOQ in Earth Explorer  Entity ID:DI00000000018672  Acquisition Date 1994/01/21  Production System GIS/MAGIC  Production Date 1996/08/14  Primary Source Date 1994/01/21  Coordinate System Universal Transverse Mercator (UTM)  Coordinate Zone 17  Photo Source(s) NAPP 7000 057  Cell ID 134545  ODB Prod ID 18672  Resolution 1  Band Type RGB  DOQ Format Band Interleaved by Pixel File (BIP)  Standards Version DOQ 12/96 Standard Spec.  Primary H Datum North American Datum of 1983  XY Unit Meters |
| December 30, 1998 | Value= 6370 | Avg Temp (F)- 48.75 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 16 | Found as DOQ in Earth Explorer  Entity ID:DI00000001164809  Acquisition Date 1998/12/31  Production Date 2001/09/07  Primary Source Date 1998/12/31  Coordinate System Universal Transverse Mercator (UTM)  Coordinate Zone 17  Photo Source(s) NAPP 11018 073  Cell ID 134545  ODB Prod ID 1164809  Resolution 1  Version 2  Band Type RGB  DOQ Format Band Interleaved by Pixel File (BIP)  Standards Version DOQ 12/96 Standard Spec.  Primary H Datum North American Datum of 1983  XY Unit Meters |
| November 02, 2007 | Value= 2350 | Avg Temp (F)- 66.76 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 14 | NAIP Entity ID N\_2908356\_NW\_17\_1\_20071102  State FL  Agency USDA  Vendor USDA-FSA-APFO  Map Projection UTM  Projection Zone 17N  Datum NAD83  Resolution 1.000000000000000  Units METER  Number of Bands 3  Sensor Type CLR  Project Name 200707\_FLORIDA\_NAIP\_1X0000M\_CLR  Acquisition Date 2007/11/02 |
| September 19, 2010 | Value= 4240 | Avg Temp (F)- 77.57 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 15 | NAIP Entity ID M\_2908356\_NW\_17\_1\_20100919  State FL  Agency USDA  Vendor USDA-FSA-APFO  Map Projection UTM  Projection Zone 17N  Datum NAD83  Resolution 1.000000000000000  Units METER  Number of Bands 4  Sensor Type CNIR  Project Name 201004\_FLORIDA\_NAIP\_1X0000M\_CNIR  Acquisition Date 2010/09/19 |
| October 13, 2013 | Value= 8200 | Avg Temp (F)- 71.83 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 10 | NAIP Entity ID M\_2908356\_NW\_17\_1\_20131013  State FL  Agency USDA  Vendor USDA-FSA-APFO  Map Projection UTM  Projection Zone 17N  Datum NAD83  Resolution 1.000000000000000  Units METER  Number of Bands 4  Sensor Type CNIR  Project Name 201305\_FLORIDA\_NAIP\_1X0000M\_CNIR  Acquisition Date 2013/10/13 |
| November 12, 2015 | Value= 6070 | Avg Temp (F)- 66.68 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 9 | NAIP Entity ID M\_2908356\_NW\_17\_1\_20151112  State FL  Agency USDA  Vendor USDA-FSA-APFO  Map Projection UTM  Projection Zone 17N  Datum NAD83  Resolution 1.000000000000000  Units METER  Number of Bands 4  Sensor Type CNIR  Project Name 201504\_FLORIDA\_NAIP\_1X0000M\_UTM\_CNIR  Acquisition Date 2015/11/12 |
| October 26, 2017 | Value= 7990 | Avg Temp (F)- 54.68 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 9 | NAIP Entity ID M\_2908356\_NW\_17\_1\_20171026  State FL  Agency USDA  Vendor USDA-FSA-APFO  Map Projection UTM  Projection Zone 17N  Datum NAD83  Resolution 1.000000000000000  Units METER  Number of Bands 4  Sensor Type CNIR  Project Name 201710\_FLORIDA\_NAIP\_1X0000M\_UTM\_CNIR  Acquisition Date 2017/10/26 |
| November 10, 2019 | Station ID= 02323500  Value = 5190 | Avg Temp (F)- 57.42 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 7 | NAIP Entity ID M\_2908356\_NW\_17\_060\_20191110  State FL  Agency USDA  Vendor USDA\_FSA\_APFO  Map Projection UTM  Projection Zone 17N  Datum NAD83  Resolution 0.600000000000000  Units METER  Number of Bands 4  Sensor Type CNIR  Project Name 201911\_FLORIDA\_NAIP\_0X6000M\_UTM\_CNIR  Acquisition Date 2019/11/10 |

Table- <https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/APFO/support-documents/pdfs/fourband_infosheet_2017.pdf>

wunderground.com/history/daily/us/fl/gainesville/KGNV/date/2012-1-8

|  |  |
| --- | --- |
| Sensor Type | Bands and wavelength (µm) |
| CLR/ RGB | Blue 400–500  Green 500–600  Red 600–700 |
| CNIR | Blue 400–500  Green 500–600  Red 600–700  Near Infrared 800–900 |

Table- National Agriculture Imagery Program (NAIP) aerial imagery band wavelength ranges in units (µm)

(<https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/APFO/support-documents/pdfs/fourband_infosheet_2017.pdf>)

***2.3. Digital Shoreline Analysis System (DSAS)***



**Figure -** DSAS generates transects that are cast perpendicular to the reference baseline at a user-specified spacing alongshore.  There are no restrictions on where the reference baseline is drawn, it may be positioned completely to one side of the shoreline data or be placed between the historical shoreline positions.  DSAS measures the distance between the baseline and each shoreline intersection along a transect, and combines date information, and positional uncertainty for each shoreline, to  generate the following change metrics (<https://www.usgs.gov/centers/whcmsc/science/digital-shoreline-analysis-system-dsas?qt-science_center_objects=0#qt-science_center_objects>):

The DSAS is a GIS-based system created and maintained by USGS (United States Geological Survey). For this analysis the DSAS ArcGIS extension was used. The DSAS extension casts transects along the baselines (starting point for transects) and measures the gaps between the shoreline positions during defined years. These shoreline positions provide the basic data needed to calculate their shifts. The calculations are based on shoreline geometry indicators. In this study both LRR (Linear Regression Rate) and NSM (Net Shoreline Movement) were selected. A linear regression rate-of-change can be ascertained by fitting a least-squares regression line to every shoreline point in a transect. The regression line is positioned so that the sum of the squared residuals is at its most minimal (<https://pubs.usgs.gov/of/2018/1179/ofr20181179.pdf>). The linear regression rate is the slope of the regression line. The NSM is the distance between the oldest shoreline portion to the youngest shoreline position for each transect, calculated in meters.

The DSAS calculations require an operational workflow to gather and create the necessary components. The components needed are shoreline baselines, additional shorelines of interest (varying in different time periods), DSAS transects (which are cast some the baseline and intersect the additional shorelines positions), measurement distances, measurement points, and shoreline uncertainty. All objects used in the DSAS are stored in an ArcGIS Personal Geodatabase, as per USGS requirements for this extension. The DSAS operational workflow includes the following steps: (1) Set default parameters and fields to created shoreline and baseline layers, transects, shoreline calculations, metadata and file output locations; (2) Cast transects and select their maximum search distance, transect spacing, and smoothing distance; (3) Calculate change statistics such as confidence intervals, shoreline intersection threshold, rate of output display, and summary report; (4) Create data visualization for LRR and NSM; and (5) (Optional) Shoreline forecasting for a 10 and/or 20 year forecast.

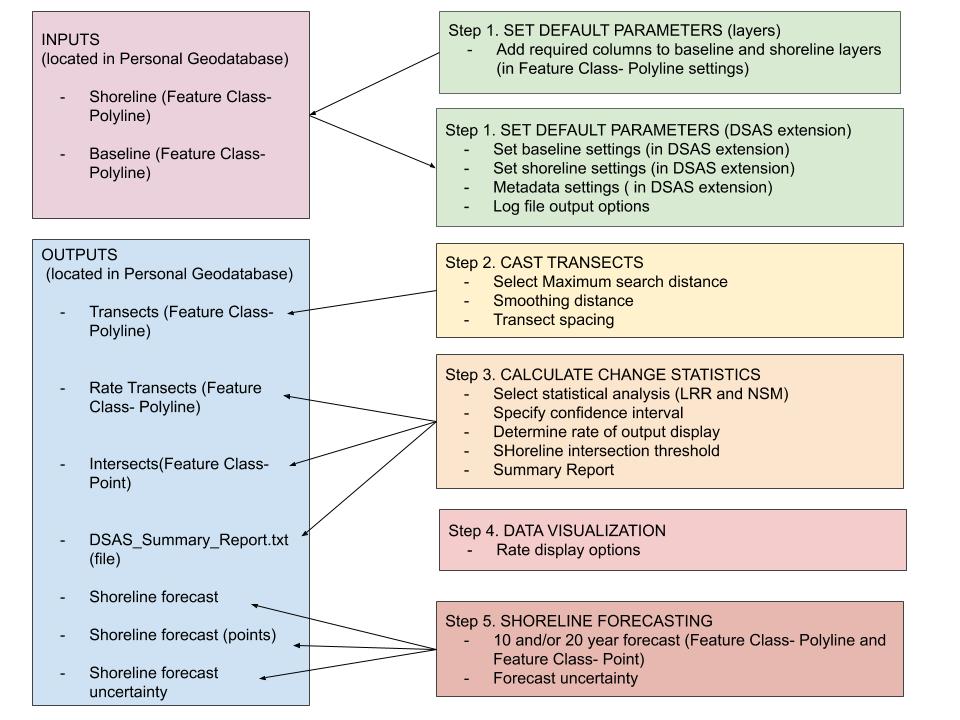
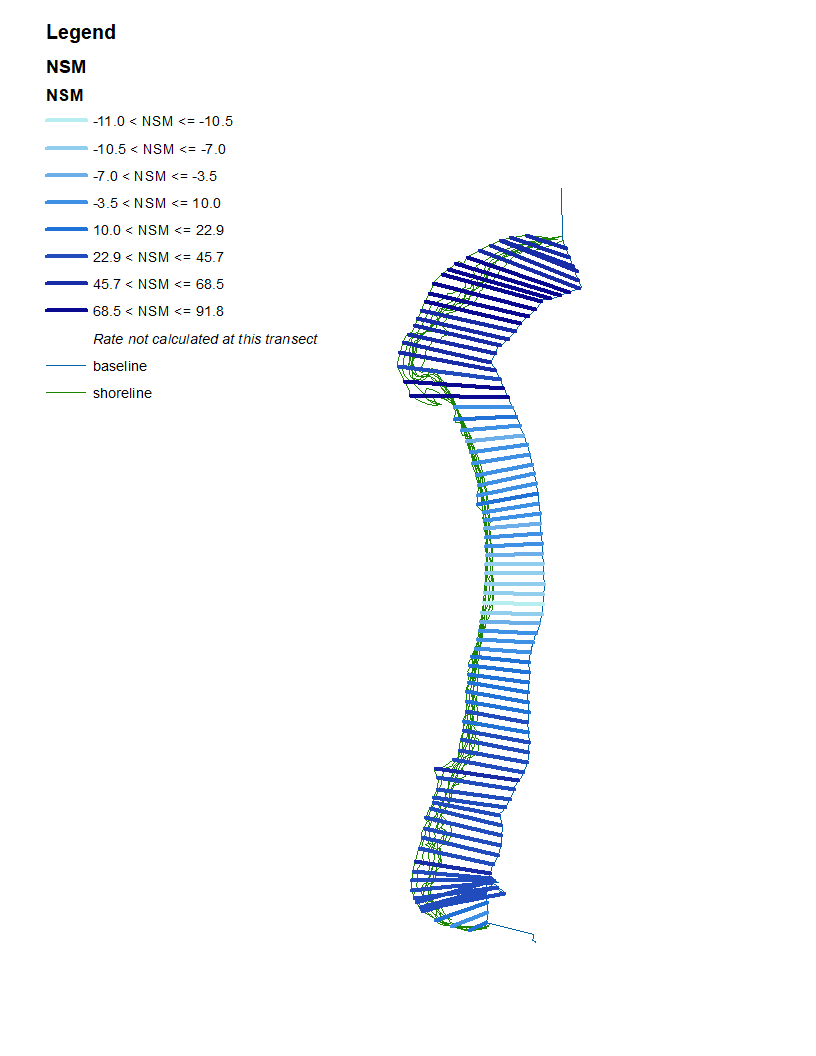
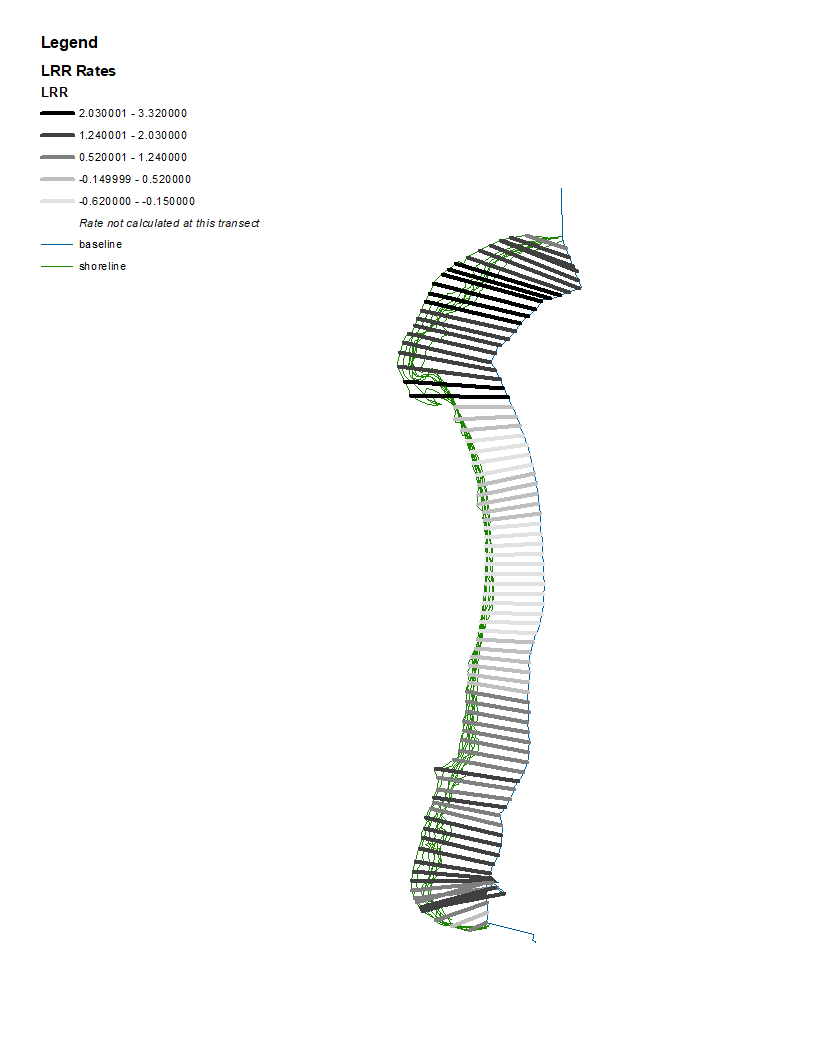


Figure- DSAS components and operational workflow.

**3. Results**



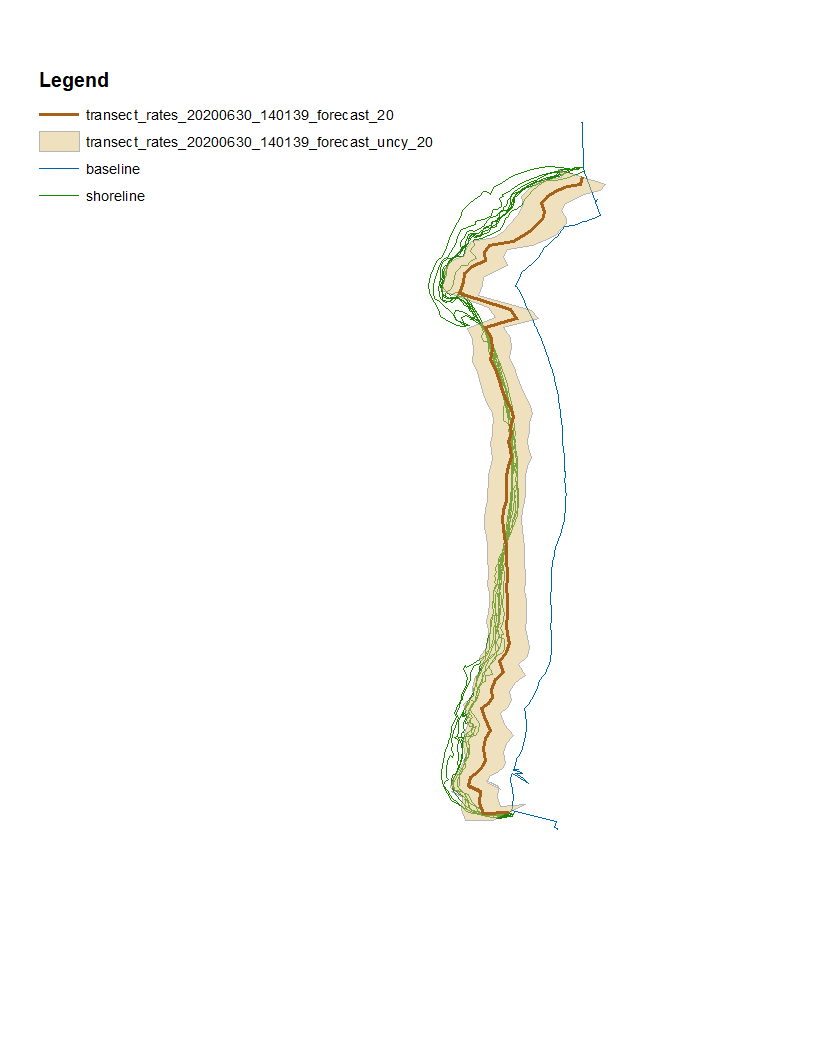
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**4. Discussion and conclusion**

**References**

U.S. Geological Survey, 1955, USGS 1:24000-scale Quadrangle for Cedar Key, FL 1955: U.S. Geological Survey. (<https://www.sciencebase.gov/catalog/item/5a8a3ffbe4b00f54eb3ec75e>)