**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 of our study area in Cedar Key, FL from 1994 to 2019. 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 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***

Derrick Key-

In the mid-1960s the US Army Corps of Engineers constructed the 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 (Vitale, 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***

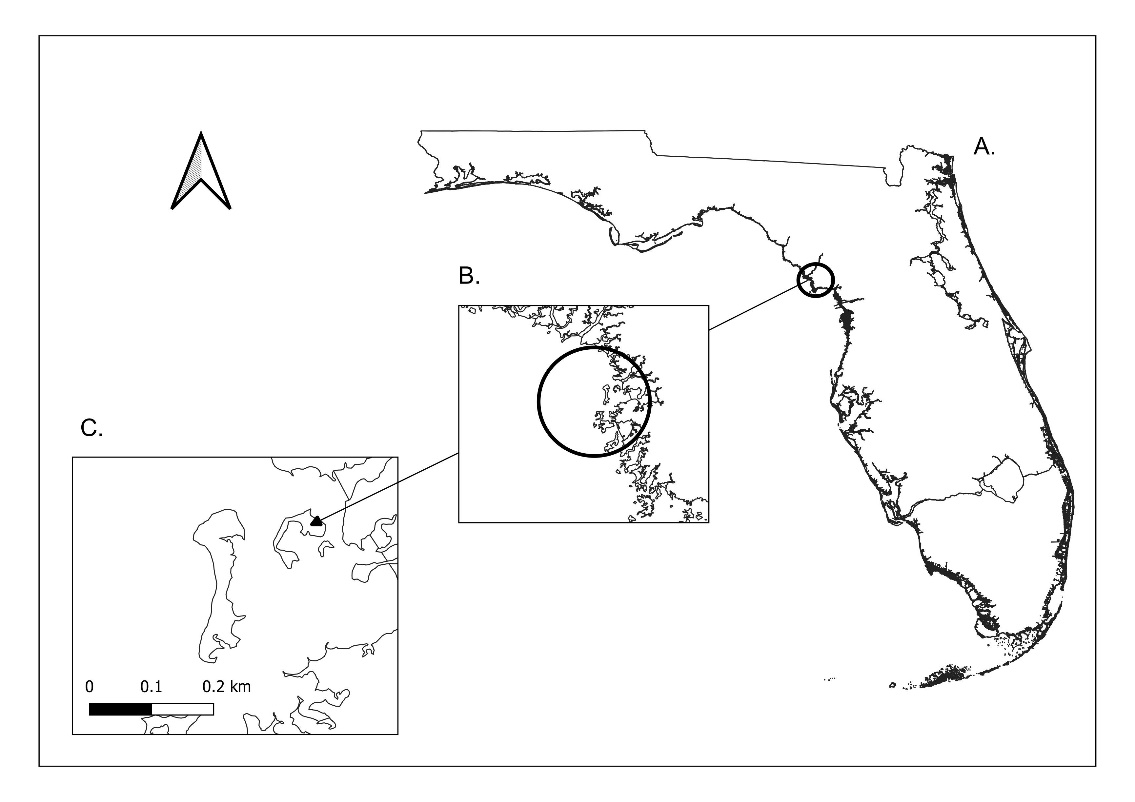
Our study area is located on the west-central Florida coastline off of Cedar Key. The selected shoreline is on a small barrier island called Deer Island. Deer island is a private uninhabited island approximately 8 miles north of the main villages of Cedar Key, Florida. Historically Deer Island was intermittently inhabited by Native Americans 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](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***

Earth Pro satellite imagery

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| --- | --- | --- | --- |
| Date | Median River Discharge (cfs) | Observed weather | Metadata |
| January 20, 1994 | Station ID= 02323500  Value= 9710 | Avg Temp (F)- 38.15 Precipitation (inches)- 0.00  Max Wind Speed (MPH)- 12 | Found DOQ in Earth Explorer  Entity ID:DI00000000018672  Entity ID DI00000000018672  Map Name CEDAR KEY  Acquisition Date 1994/01/21  State FL  Quadrant NW  Status Historical  Product Group 3.75-MIN CIR  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  Version 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  Submitting Agency Western Mapping Center (WMC)  Oversight Agency Western Mapping Center (WMC) |
| December 30, 1998 | Station ID= 02323500  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  Entity ID DI00000001164809  Map Name CEDAR KEY  Acquisition Date 1998/12/31  State FL  Quadrant NW  Status Recommended Version  Product Group 3.75-MIN CIR  Production System DVx.x xx/xx0Vx.x xx/xx(USGS)  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  Submitting Agency Western Mapping Center (WMC)  Oversight Agency Western Mapping Center (WMC) |
| November 02, 2007 | Station ID= 02323500  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 | Station ID= 02323500  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 | Station ID= 02323500  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 | Station ID= 02323500  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 | Station ID= 02323500  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

Table

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

The National Agriculture Imagery Program (NAIP) acquires aerial imagery during the agricultural growing seasons in the continental U.S. A primary goal of the NAIP program is to make digital ortho photography available to governmental agencies and the public within a year of acquisition.

NAIP is administered by the USDA's Farm Service Agency (FSA) through the Aerial Photography Field Office in Salt Lake City. This "leaf-on" imagery is used as a base layer for GIS programs in FSA's County Service Centers, and is used to maintain the Common Land Unit (CLU) boundaries.

NAIP:

NAIP imagery is acquired at a one-meter ground sample distance (GSD) with a horizontal accuracy that matches within six meters of photo-identifiable ground control points, which are used during image inspection.

The default spectral resolution is natural color (Red, Green and Blue, or RGB) but beginning in 2007, some states have been delivered with four bands of data: RGB and Near Infrared

Contractually, every attempt will be made to comply with the specification of no more than 10% cloud cover per quarter quad tile, weather conditions permitting.

All imagery is inspected for horizontal accuracy and tonal quality.

NAIP imagery products are available either as digital ortho quarter quad tiles (DOQQs) or as compressed county mosaics (CCM). Each individual image tile within the mosaic covers a 3.75 x 3.75 minute quarter quadrangle plus a 300 meter buffer on all four sides. The DOQQs are geotiffs, and the area corresponds to the USGS topographic quadrangles.

CCMs are generated by compressing digital ortho quarter quadrangle image tiles into a single mosaic. The mosaic may cover all or portions of an individual final product. All individual tile images and the resulting mosaic were rectified in the UTM coordinate system, NAD 83, and cast into a single predetermined UTM zone. CCMs from 2003 - 2007 are all in a .sid format. . Beginning in 2008, CCMs with four bands were compressed into a .jp2 format.

Beginning in 2009, all NAIP CCMs are delivered with a "seamline" shapefile showing which image swath made up each part of a given image

Since the NAIP program began in 2003, vendors have been transitioning to digital sensors in imagery acquisition. In 2009, most NAIP imagery will be acquired with digital sensors rather than film cameras.

<https://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/>

***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>):

**Distance measurements:**

* Shoreline Change Envelope (SCE)
* Net Shoreline Movement (NSM)

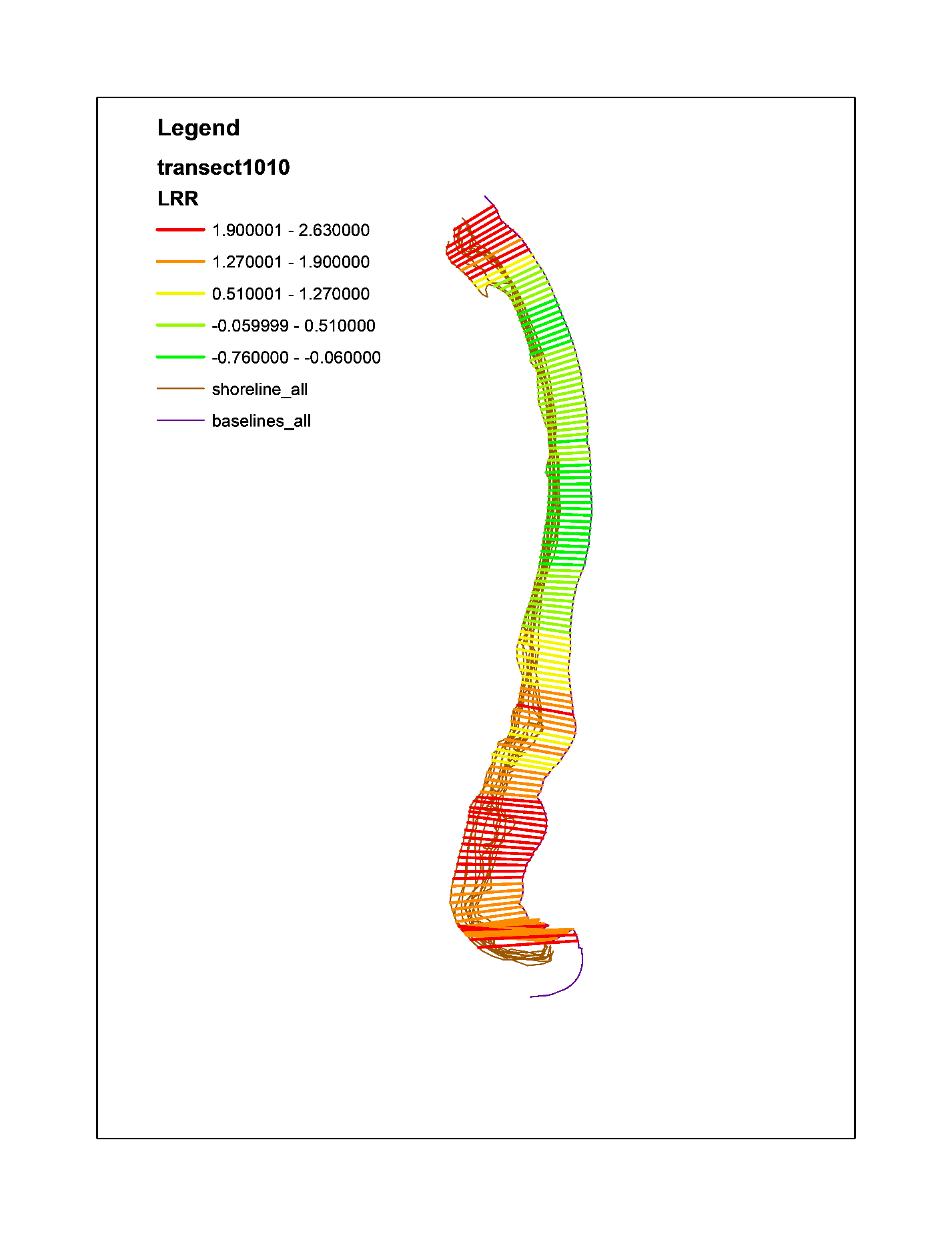
**Statistics:**

* End Point Rate (EPR)
* Linear Regression Rate (LRR)
* Weighted Linear Regression Rate (WLR)

**Supplemental statistics for Linear and Weighted regression:**

* Confidence Interval (LCI/WCI)
* Standard Error (LSE/WSE)
* R-squared (LR2/WR2)

**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>)