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

**Abstract**

**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).

**2. Materials and methods**

***2.1 Study Area***

Our study area is located on the west-central Florida coastline off the Cedar Key, Florida. The area includes small islands and one major island, Deer Island. Deer Island is

***2.2 Satellite imagery selection***

|  |  |  |  |
| --- | --- | --- | --- |
| Direction Marker | Easting | Northing | Zone |
| NW | 297275.29 m E | 3236711.74 m N | UTM Zone 17 R |
| SW | 297139.13 m E | 3235238.06 m N | UTM Zone 17 R |
| NW | 298773.41 m E | 3236506.25 m N | UTM Zone 17 R |
| SE | 298573.79 m E | 3235038.31 m N | UTM Zone 17 R |

Table – Northing and Eastern UTM coordinates of the markers to georectify Google Earth Pro satellite imagery

|  |  |  |  |
| --- | --- | --- | --- |
| Date | Median River Discharge | 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/>

Deer Island –

Deer Island is a beautiful barrier island with elevations as high as 14 ft above sea level. The parcel is 90 acres in total area, but approximately 45 acres lie below the mean high tide mark and are sovereign. Of the balance, approximately 25 acres are upland and 20 acres are wetland.

Standout features include a sandy beach facing the open Gulf, wooden dock, water well and storage tank/tower with treatment system, and two small storage buildings. A small camper is on the island for overnight stays.

The island is located inside the Big Bend Aquatic Seagrass Preserve and adjoins the Lower Suwannee National Wildlife Refuge. The historic fishing villages of Cedar Key and Suwannee are 8 miles south and north of the island, respectively. Gainesville, home of the University of Florida, is 50 miles to the east. Access is by boat only, with deep water access on the northeast corner of island (the existing dock is on the southeast corner in shallower water).

A shallow-water ramp suited for launching kayaks and airboats at any tide is located at Shell Mound, 1.5 miles south of Deer Island, but larger boats should be launched at Cedar Key or Suwannee except at high tide. Most of the run from Suwannee to Deer Island is down the East Pass, which is protected from high winds that sometimes blow off the Gulf. And the fresh water of the Suwannee flushes salt from the motor upon return to the mainland.

Redfish, black drum, trout, and blue crab are abundant. The bay side of the island is fringed with salt marsh and oyster bars. The island is densely forested with large oaks, pines, cedars, and palms with an understory of coonties, wild coffee, palmettos and more. Approximately 1 acre on the south end of the island near the dock has been cleared (except for the trees) for the camp. A narrow unimproved road (a glorified trail!) runs north and south along the spine of the island.

According to an archeology professor at the University of Florida, Deer Island was inhabited at least intermittently by native Americans beginning several thousand years ago, and early Florida settlers reportedly camped and lived on the island, too. Four hearty souls identified Deer Island as home in the 1880 Levy County, Florida census. A house or cabin on the south end of the island that probably served as their home is depicted on the 1951 USGS Cedar Key Quadrangle map; only traces of the old structure remain. The current storage buildings occupy the sites of a former bunkhouse and shed, whose remains were carted off the island.

Power is currently supplied by generator, with plans for solar in the works. A 30-foot deck barge is included in the sale (it was used to bring the camper to the island and is rated to carry up to 12,500 pounds). The county will permit at least one house with no size limit, so long as an advanced secondary treatment septic system is used.

(<https://www.privateislandsonline.com/united-states/florida/deer-island>)

Enjoy the unique opportunity to own your own white, sandy beach on the Gulf of Mexico. Deer Island is a beautiful barrier island with elevations as high as 14 feet above sea level. It is situated between the historic fishing villages of Suwannee and Cedar Key and is only 50 miles east of Gainesville, home of the University of Florida. This gorgeous, pristine island consists of approximately **25 acres** of forested upland, 20 acres of marsh and 45 acres of sovereign bay bottom. The island is located inside the Big Bend Aquatic Seagrass Preserve and adjoins the Lower Suwannee National Wildlife Refuge, thus making it the perfect getaway destination to find peace and solitude.

Access is by boat only. While it is about a 20 minute ride from either Cedar Key or Suwannee, it is only a 10 minute boat ride from the launch at the nearby Shell Mound Camp Ground. For landing, a sturdy wooden dock is located on the southeast corner of the island; however deeper water access can be found on the northeast corner of the island, if necessary.

Besides the outstanding beauty of the sandy beach facing the open Gulf, other amenities of the island include a water well, a storage building and a bath house. Power is currently supplied by a generator, with plans for solar power in the works. The sale also includes a 30 ft. deck barge which will accommodate up to 12,500 pounds. That is what ferried over the building supplies, as well as the vehicles used on the island. The County will permit at least one house with no size limit, so long as an advanced secondary treatment septic system is used.

Whether your desire is to find the ideal fishing location, immerse yourself in nature, or both, this is without a doubt the property you need to own. The rare opportunity of owning your own island with a white, sandy beach on the Gulf doesn’t come often—take advantage of this unique adventure!

(<http://www.beachrealtyfla.com/DeerIsland.htm>)

0/8+/- Mile of gulf of Mexico white sand beach

0.8 +/- mile of waterfront facing the mainland

<https://images1.loopnet.com/d2/Z4L1-alqEsAlhPT_YJ25N8OMkXU3L_mAPAZYXiq2OVg/document.pdf>

Deer Island is an island that can provide relief from storm events and storm surges. Briefly comparing imagery from 1994 to 2017, it can be observed that there are some shape changes to the island. Unlike Derrick Key, Deer Island is still visible and still available for use by people and habitat use by animals. Between the 34 years, between the imagery, there are some observable shoreline differences but not nearly as drastic as the shoreline differences of Derrick Key.

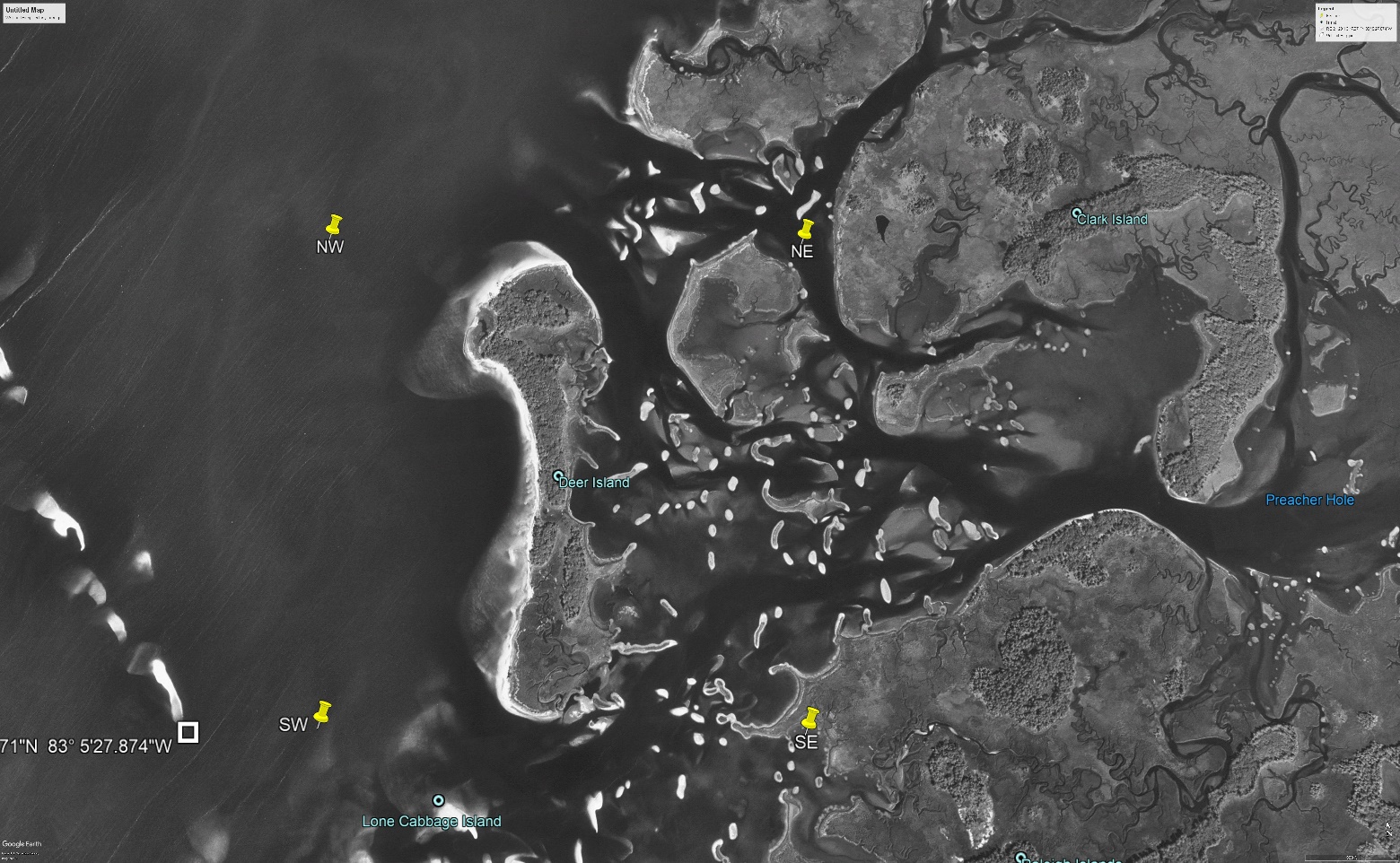




Figure- Google Earth Pro imagery of Deer Island, from 1994 (left) to 2017 (right).

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).

***2.3. 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)

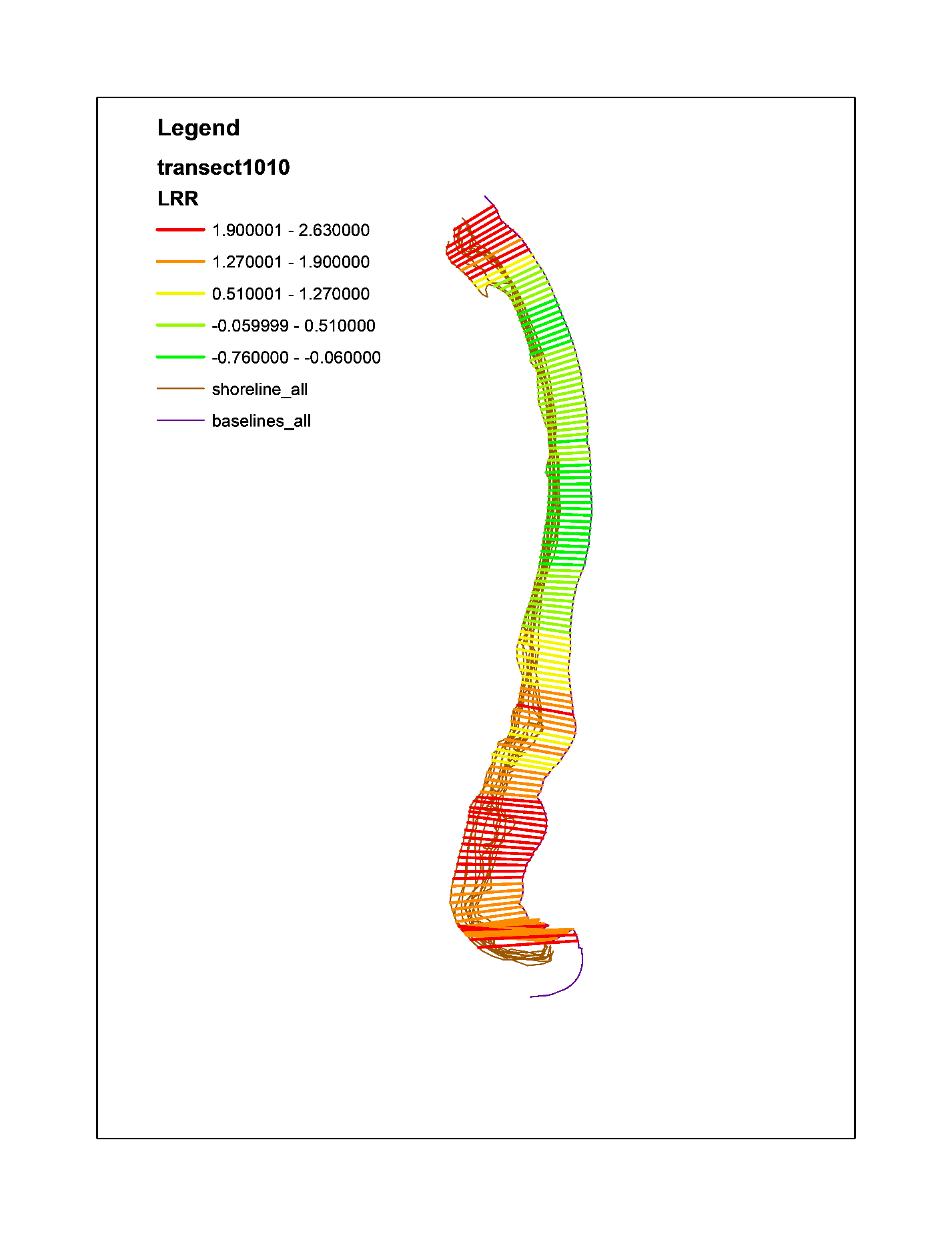
**Statistics:**

* 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**

****

**4. Discussion and conclusion**