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1 Introduction

The Catlett Islands are located approximately 35.2 kilometers (21.9 miles) from the mouth of the York River in Gloucester County, Virginia (Figure 1) and represent mesohaline conditions (8-18 parts per thousand (ppt)). The Islands lie within the lower estuarine reaches of the York River and are offshore of Timberneck Farm between Timberneck and Cedarbush Creeks on the north shore of the York River. They are separated from the Farm by tidal wetlands and creeks. The islands consist of parallel ridges of forested wetlands surrounded by extensive saltmarshes. The purpose of this project is to assess shoreline rates of change, estimate area of land loss over time, estimate change in upland tree line position and area, and describe habitat zones based on elevation.

2 Setting

2.1 Physical Setting

The Catlett Islands are composed of two separate ridge and swale complexes that are subaerial stratigraphic, depositional Holocene sequences. For the purpose of this report, the upriver island is designated the NW Island, and the downriver island, the SE Island (Figure 1). The two islands are separated by Poplar Creek. The NW Island has ridge and swale features running north-south while the SE Island has ridge and swale features oriented east-west. The upland ridges were deposited as point bars, and the adjacent swales developed as low-lying, tidal marshes. As sea level has risen over the past 15,000 years, the marshes have developed and slowly encroached upon the upland ridges. A series of short cores illustrates the depositional facies showing the marsh transgressing the uplands (Figure 2) (Finkelstein and Hardaway, 1988). The mainland side of the Catlett Islands marshes transitions to the adjacent uplands which are older geologically, Pleistocene in age. This shore edge has trees that give way to farmlands that which existed as early as 1937.

Old surveys from 1857 show the extent of the Catlett Islands (Figure 3). A review of early maps (Stephenson and Mckee, 2000) shows that this was the first time the name “Catlett Islands” was applied to this series of geographic features perhaps because the Catletts were not considered islands until this time. In 1857 much of the island was under cultivation. By 1937 (Figure 4), most of the fields had reverted back to woodland. Additional selected images of the Catlett Islands are shown in Figures 5, 6 and 7 for 1953, 1978, and 2007. These images were used in the data analysis.

Catlett Islands are comprised of a series of sand ridges and valleys. The ridges are covered with maritime forest dominated by *Juniperous virginiana* (eastern red cedar) and *Pinus taeda* (loblolly pine). The valleys are dominated by salt marsh communities; however several large saltmeadow communities exist in the high marsh zone. Numerous small, monotypic stands of saline black needlerush are dispersed in the upper end of the salt marsh community. *Iva frutescens* (salt bushes) forms a thin ecozone (approximately 2 m (Laird, 2001)) between the tidal marshes and maritime forest. Erosion is common on the south and southeast side of the Islands and, therefore, the saltmeadow communities may dominate to the waters' edge (Perry and Atkinson, 1997).

Spartina alterniflora (salt marsh cordgrass) is the most common species in the tidal marshes with co-dominants *Distichlis spicata* (salt grass), *Spartina patens* (saltmeadow hay), and *Juncus roemerianus* (black needlerush) (Perry and Atkinson, 1997). The Catlett Island marsh communities are very similar in distribution and composition to those of Goodwin Islands. Perry and Atkinson (1997) found only six species along a series of five wetland vegetation transects. Missing were the halophytes found in the more saline tidal marshes (e.g. *Borrichia frutescens)* (Perry and Atkinson, 2009; Laird, 2001).

2.2 Hydrodynamic Setting

2.2.1 Wave Climate

The Catlett Islands are exposed to a variety of fetch exposures from small exposures within the creeks to greater exposures along the York River shoreline. The York River shoreline of the NW Island complex has fetch exposures to the south, southwest, and west of 3.5 km (1.9 nautical miles (nm)), 3.1 km (1.7 nm), and 5.4 km (2.9 nm), respectively. Several long, oblique fetches occur to the west-northwest, about 10.4 km (5.6 nm) up the York River. The SE Island complex has fetch exposures to the west, southwest, and south of 5.2 km (2.8 nm), 3.5 km (1.9 nm), and 3.5 km (1.9 nm), respectively. The SE Island has a long, oblique fetch to the south-southeast of 7.2 km (3.9 nm). Wind-driven waves produce the forces that result in shoreline erosion which, on a daily basis, is minimal. It's during periods of high water and winds, especially hurricanes and northeasters, that significant shore change can occur.

The mean tide range (mean low water (MLW) to mean high water (MHW) at Gloucester Point, Virginia is 0.725 m (2.39 ft) while the relationship of NAVD88 to MLLW is 0.452 m (1.48 ft). The spring tide range (mean lower low water (MLLW) to mean higher high water (MHHW) is 0.79 m (2.58 ft). According to FEMA (2010), storm surge frequencies for Gloucester County, relative to

NAVD88 are 1.2 m (3.9 ft), 1.6 m (5.4 ft), 1.9 m (6.2 ft), and 2.5 m (8.2 ft) for the 10%, 2%, 1% and 0.2% return intervals.

2.2.2 Sea level

Sea level rise (SLR) at the long-term tidal station at Gloucester Point, Virginia (NOAA, 2012) is 3.81 mm/yr. +/-0.47mm.yr. If we translate this back through time from 2012, then mean sea level was 19 mm (0.06 ft) lower in 2007, 130 mm (0.4 ft) in 1978, 225 mm (0.7 ft) in 1953 and 286 mm (0.9 ft) lower in 1937.

3 Methods

3.1 Island Morphology

In order to determine the distribution and extent of different landscape features, a digital elevation model (DEM) was created from Light Detection and Ranging (LiDAR) data flown for USGS between April 8 and May 10, 2010. The DEM was clipped based on the 2007 shoreline in the area of interest. To calculate the area for each habitat zone based on elevation data, the clipped DEM was reclassified based on certain elevation ranges using the reclassify raster function in Spatial Analyst in ArcMap. The DEM vertical datum is ft NAVD88. The raster values were renamed 0, 1, 2 and 3, where zero is the area between the 2007 shoreline and the +1 ft NAVD88 contour (intertidal/low marsh habitat), one is the area between +1 and +2 ft NAVD88 contours (high marsh habitat), two is the area between the +2 ft and +3 ft NAVD88 contours (ghost tree and high marsh zones that transition to upland), and three is the area above +3 ft NAVD88 contour (maritime forest). The "zonal statistics as table" function was performed on the resulting raster to obtain the area for each zone created during the reclassification.

3.2 Shore Change

To determine the change in area between historical shorelines, three historical shorelines were edited to match close off points in creeks and the boundary of interest. The shorelines used were 1953, 1978 and 2007 and were digitized with the orthorectified mosaics in the background. The 1953 and 1978 mosaics and shorelines were created by Milligan *et al.* (2010). The 2007 images were obtained from the Virginia Base Mapping Program. Milligan *et al.* (2010) digitized the 2007 shoreline. All three shorelines were then retraced and closed off, and converted them to polygons to allow for area calculations.

Once the shoreline polygons were created, the area was calculated and used to compare the change in acreage between 1953, 1978 and 2007. The polygons for 1953 and 1978 were then combined using the “union” function in ArcMap to help determine the geometric intersection of both years. This was used to display a visual of the area gained, lost, or not changed. The years 1978 and 2007 were also combined to view the area changes in GIS as were 1953 and 2007.

3.3 Sea Level Rise Impacts

As sea level rises, the encroaching saltwater kills trees growing on the edges of maritime forests. To quantify the effect of sea level rise on the Catlett Islands, the change in maritime forest area was calculated using mosaics from 1953, 1978, and 2009. The tree lines were digitized as shapefile polygons, and the area of forest was calculated in acres for each year. The shapefiles were combined using the “union” function in ArcMap, and the resultant shapefiles were used to visualize the gains, losses, and no changes in tree area as was done for the shoreline area. The area data for each year also was exported to excel to compute the change in acreage between years. For these unions and calculations, 1953 was compared with 1978, 1978 was compared with 2007, and 1953 was compared with 2007.

To display the topography of the Island and visualize the location of sea level at different times in history, a cross section was constructed in ArcMap using digitized shoreline and DEM data. A 3D line shapefile was created and digitized using the 3D analyst toolbar, and a profile graph was created in ArcMap. The data from the profile was exported, converted from vertical datum NAVD88 to MLLW, and entered into Grapher™5 (Golden Software) to create the final profile.

4 Results

4.1 Island Morphology

Five basic landscape features occur at Catlett Islands and generally are based on elevation. These feature have evolved with time as sea level and shore erosion processes act upon the landscape.

1) upland ridges- These are characterized by mostly pine tree vegetation and cedar and are often referred to as hummocks. When no marsh fringe exists on the river side of these features, erosion of these ridges often accelerates because the natural wave buffer no longer exists. The eroding, low, upland ridges of Catlett are vertically exposed often with fallen trees and

stumps in the water. The fringe of the uplands often occurs as a zone of dead trees with high marsh species. This transition zone is the ghost forest of the hummocks and considered important bird habitat. The high marsh is migrating landward in response to sea level rise with a subsequent decrease in woody vegetation.

2) high marsh - This marsh transitions from upland to low marsh. It generally occurs between MHHW and 1.5 times the tide range.

3) low marsh - Intertidal *Spartina alterniflora* occurs along the creek drainages of the low marsh. The low intertidal marsh fringe the tidal creeks and occupy a zone from about meant tide level (MTL) to SHW.

4) tidal creeks and mud flats - These features generally are exposed at MLLW and below. The tidal creek channels within the Catlett Islands take on a more meandering morphology as one proceeds up the creek. Over time, these channels change slowly, some taking on features of riverine processes such as channel abandonment. Many of the channels appear to be getting wider over time, in part because of increase flooding due to sea-level rise.

5) nearshore - The nearshore extends from MLLW out to about the -6 ft contour. Here, submerged aquatic vegetation (SAV), clams, and an assortment of benthic species occur.

The aforementioned habitats, particularly elements 1 thru 4, are very sensitive to elevation relative to tidal flooding. Catlett Islands contours were plotted from LiDAR data and show the extent of each habitat zone (Figure 8). Table 1 shows the amount of each habitat zone which totals to about 281 acres.

Table 1. Habitat elevation ranges and area in acres calculated using a digitized shoreline and LiDAR data.

Elevation Range	Approximate Delineations	Habitat Zone	Area (acres)
0 to +1 ft NAVD88	MLW to MHHW	Intertidal habitat	45
+1 ft NAVD88 to +2 NAVD88	MHHW to 1.5x the tide range	High marsh	119
+2 ft NAVD88 to +3 NAVD88		Ghost tree transition area	65
>+3 ft NAVD88		Maritime forest	51

4.2 Shore Change

Shore change is most notable along the more exposed reaches of the Catlett Islands (Figure 9). The rates of shore change vary along the island shore ranging from very low erosion (0 to -0.3 m/yr) to high erosion (-1.5 to -2.4 m/yr). However, most of the "measurable" York River coast is low (-0.3 to -0.6 m/yr) to medium (-0.6 to -1.5 m/yr) erosion. The net amount of island reduction over time is probably a better assessment of shore change as seen in Figure 10 for 1953 to 2007. This acreage of loss over time is shown in Table 2, about 32 acres since 1953.

Table 2. Area of the Islands lost (acres) calculated using digitized shorelines.

Time Period	Area of Islands Lost (acres)
1953-1978	-3
1978-2007	-29
2007-1953	-32

4.3 Sea Level Rise Impacts

Beyond shore change, the most evident impacts of sea level rise are the ghost trees and the position of the living tree line through time. This line is the change/loss in tree cover shown in Figure 11. The amount of change, shown in Table 3, 29 acres, is almost the same as island loss over time. The cross section in Figure 12 shows the modern day habitat zones and the rise in sea level over time from 1937 to 2007.

Table 3. Decrease in area of maritime forest (acres) calculated using digitized aerial photography.

Time Period	Tree cover area lost (acres)
1953-1978	-8
1978-2007	-22
1953-2007	-29

5 Discussion

One of the measurable elements of coastal change due to a rising sea level is shore change. Shorelines can be erosional, depositional or even stable over time. Numerous elements effect a shoreline, but, most often, fetch exposure and the impinging wind/wave climate are primary factors. This is true of Catlett Islands where the most significant amount of shore change is along the open York River coasts. Although not specifically described herein, when marsh/spit features erode, the tidal creek shorelines they once protected are exposed to more wave action. This can adversely impact various habitats that were once sheltered.

Overall land loss is related to shore change, and more than 12.5 hectares (ha) (31 acres) of the Catlett Islands have eroded between 1953 and 2007. The relative rates vary between time periods with an increase from 0.05 ha/yr (0.12 acres/yr) (1953 to 1978) to 0.4 ha/yr (1.0 acres/yr) (1978 to 2007). These rates both differ from the long-term rate of 0.2 ha/yr (0.6 acres/yr) (1953 to 2007). These losses have impacted all the habitats above MLW, and, once eroded, that area of loss turns to tidal flat or nearshore habitat. So while there is loss of one habitat type there is a gain in another.

The ghost trees are a reflection of how sea-level rise is impacting the upland region as high marsh moves landward and upward. A decrease in tree cover of 3.0 ha (0.1ha/yr) (7.51 acres, 0.3 ac/yr) between 1953 to 1978 and 8.8 ha (0.3ha/yr) (21.7 acres, 0.7 ac/yr) between 1978 to 2007 occurred. The long-term change, between 1953 to 2007, indicates a loss of 11.7 ha (29 acres) or an average of 0.2 ha/yr (0.5 ac/yr).

The habitat measured (Table 1) shows that most of the Catlett Islands (42%) have an elevation between 1 and 2 feet (NAVD88) which is high marsh. The least amount is low marsh, 16%. The transition/ghost tree zone is 23% and upland 18%. We know the shore is eroding and the uplands are shrinking but will high marsh become an even larger percentage of island habitat?

6 Conclusion

Are these rates of upland reduction and shoreland loss real or a function of the inherent error in the methodology of estimating the tree line and shore position? Or perhaps a bit of both? Either way, the ongoing changes and trends along and within the Catlett Islands are those of a reduction in upland hummocks and land loss, as creek widths and the nearshore are on their own path of expansion and habitat juxtaposition. The latter trends will be subjects of future inquiry.

7 References

Federal Emergency Management Agency, 2010. Flood Insurance Study: Gloucester County, Virginia and Incorporated Areas. Summary Report. Flood Insurance Study Number 51073CV000A, 31 p.

Finkelstein, K, and C.S. Hardaway, Jr. 1988. Late Holocene Sedimentation and Erosion of Estuarine Fringing Marshes, York River, Virginia. Journal of Coastal Research. Charlottesville, Va. P447-456.

Laird, R., 2001. Spatial and Temporal Variation in Plant Communities of Three Tidal Salt Marshes along the york River, Virginia. M.S. Thesis. College of William and Mary, Virginia Institute of Marine Science. Gloucester Point, VA. USA, 71p.

Milligan, D.A., K.P. O'Brien, C. Wilcox, and C.S. Hardaway, Jr., 2010. Shoreline Evolution: Gloucester County, Virginia, York River, Mobjack Bay, and Piankatank River Shorelines. Data Report. Shoreline Studies Program, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia. http://web.vims.edu/physical/research/shoreline/docs/dune_evolution/Gloucester/1Gloucester_Shore_Evolve.pdf

NOAA, 2012. Tides and currents website. http://www.tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8637624

Perry, J.E. and R.B. Atkinson, 1997. Plant diversity along a salinity gradient of four marshes on the York and Pumunkey Rivers in Virginia. *Castanea,*62(2), 112-118.

Perry, J.E. and R.B. Atkinson, 2009. York River Tidal Marshes. *Journal of Coastal Research,* SI (57), 43-52.

Stephenson, R.W. and M.M. McKee, 2000 (editors). Virginia in Maps, Four Centuries of Settlement, Growth and Development. The Library of Virginia, Richmond, 2000.

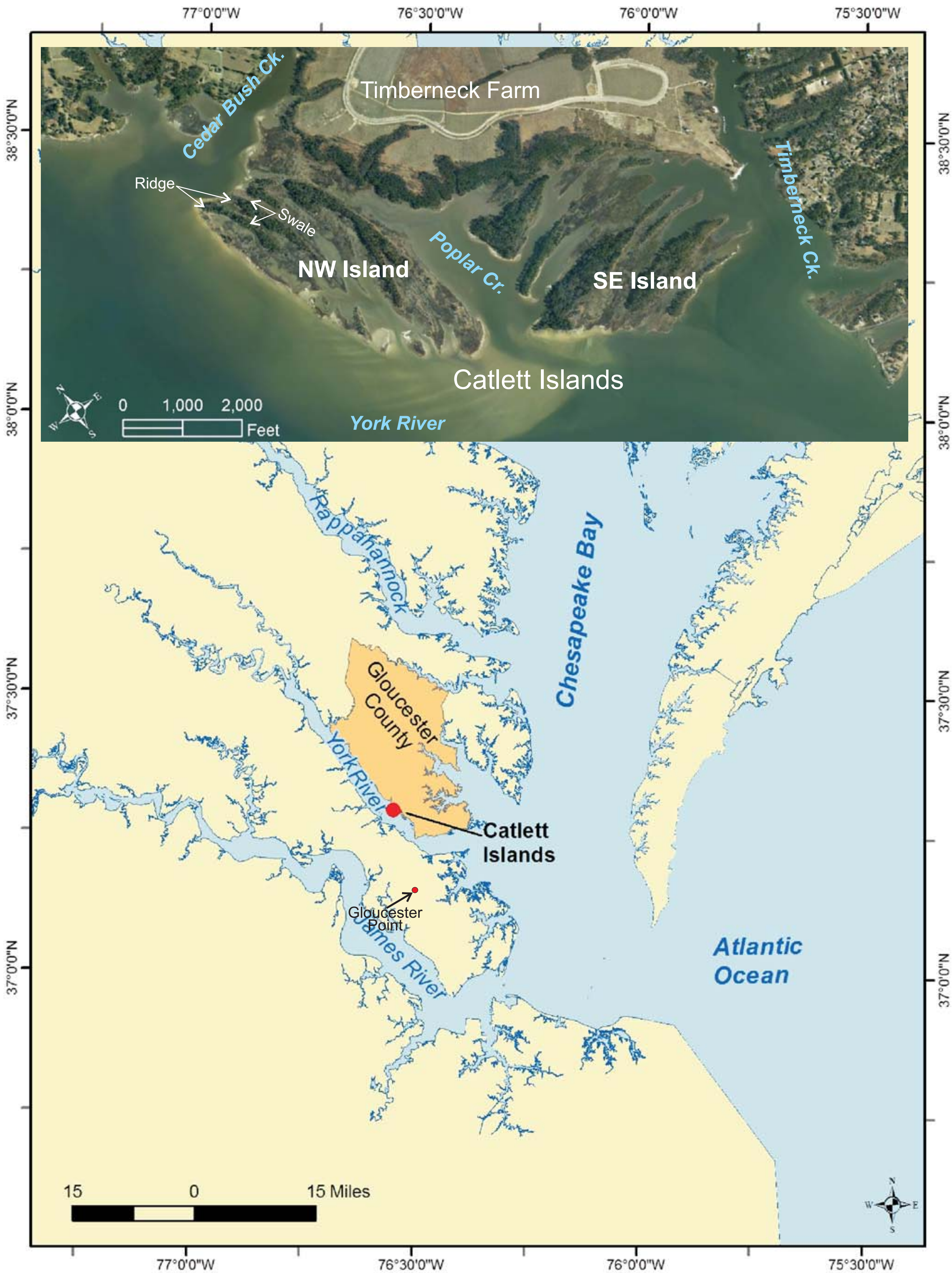


Figure 1. Location of Catlett Islands within the Chesapeake Bay estuarine system.

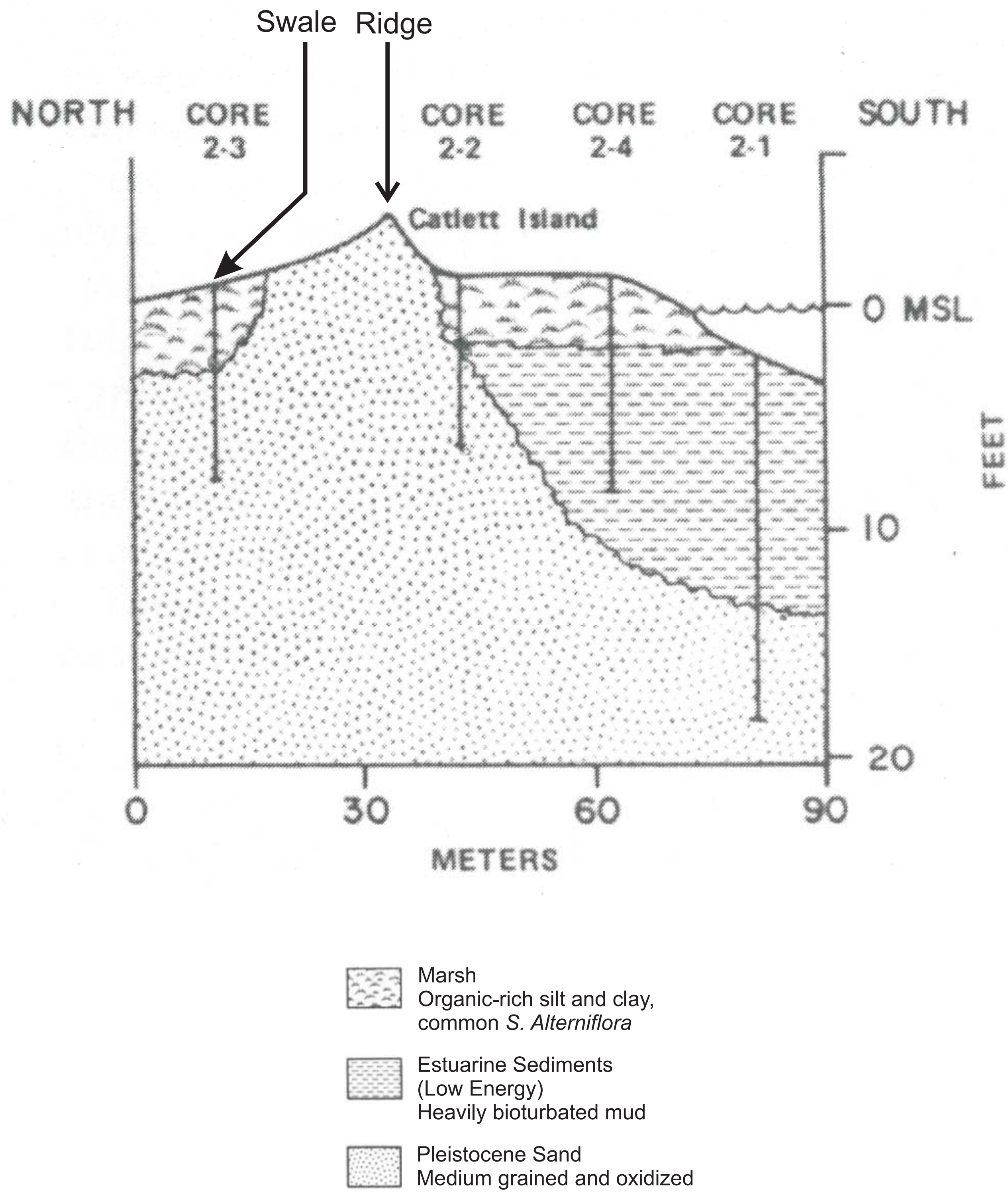


Figure 2. Catlett Island stratigraphy from Finklestein and Hardaway (1988).

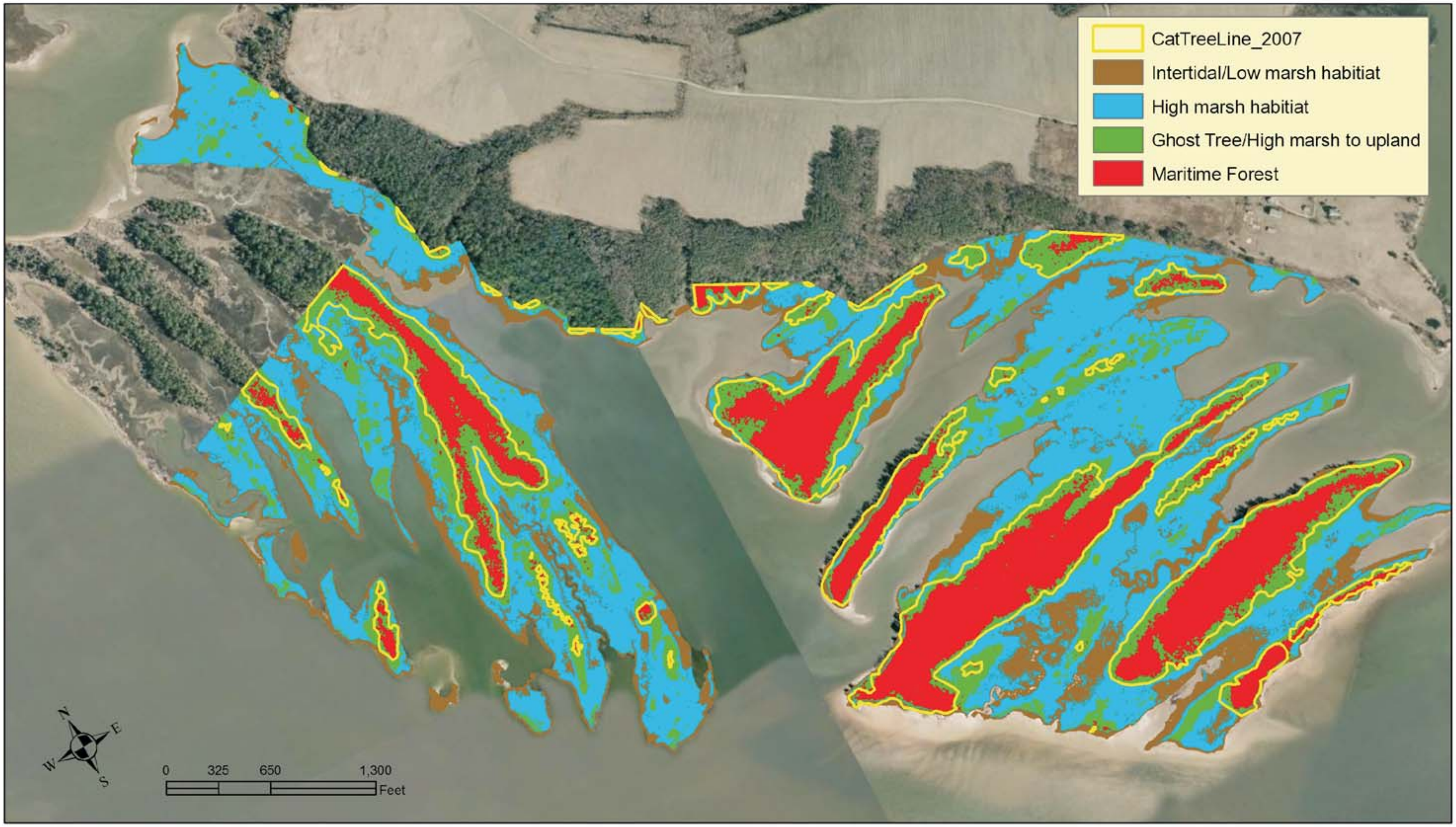
Figure 3. Catlett Islands from NOAA’s 1857 topographic sheet.

Figure 4. Orthorectified aerial photo mosaic of Catlett Islands in 1937.

Figure 5. Orthorectified aerial photo mosaic of Catlett Islands in 1953.

Figure 6. Orthorectified aerial photo mosaic of Catlett Islands in 1978.

Figure 7. Aerial photo mosaic of Catlett Islands in 2007 from the Virginia Base Mapping Program.



Data analysis uses 2010 LIDAR DEM data.
Intertidal habitat includes the area between the SSP 2007 digitized shoreline (assumed to be MLW) and +1 ft NAVD88 (MHHW).
High Marsh is the area covered by grid cells between +1 ft NAVD88 (MHHW) and +2 ft NAVD88 (app. 1.5x the tide range).
Ghost Tree transition area is between +2 and +3 ft NAVD88.
Maritime Forest includes cells with elevations greater than +3 ft NAVD88.

Catlett Islands

Figure 8. Habitat zones calculated from 2010 LiDAR data.

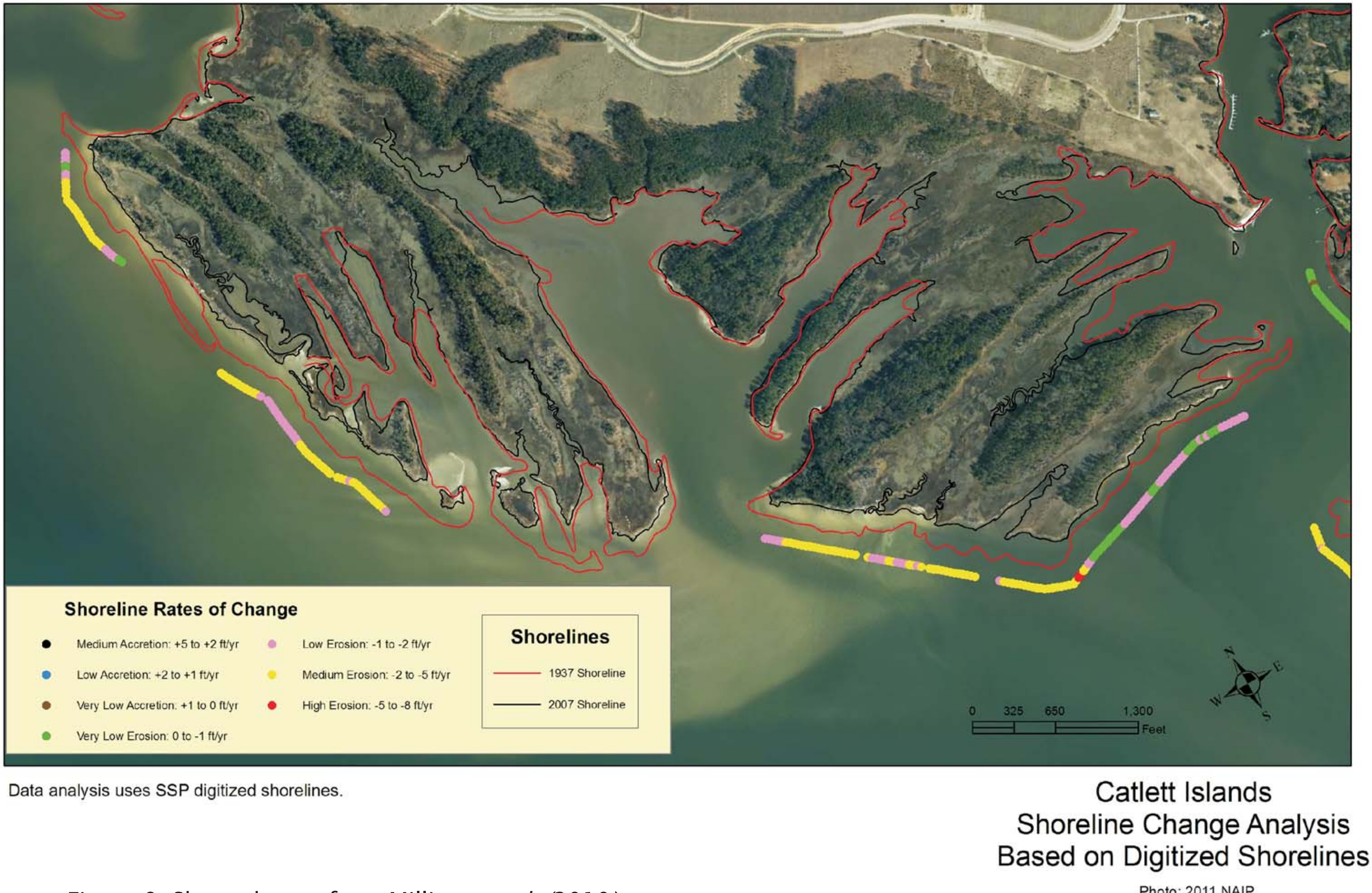


Figure 9. Shore change from Milligan *et al. (*2010*).*

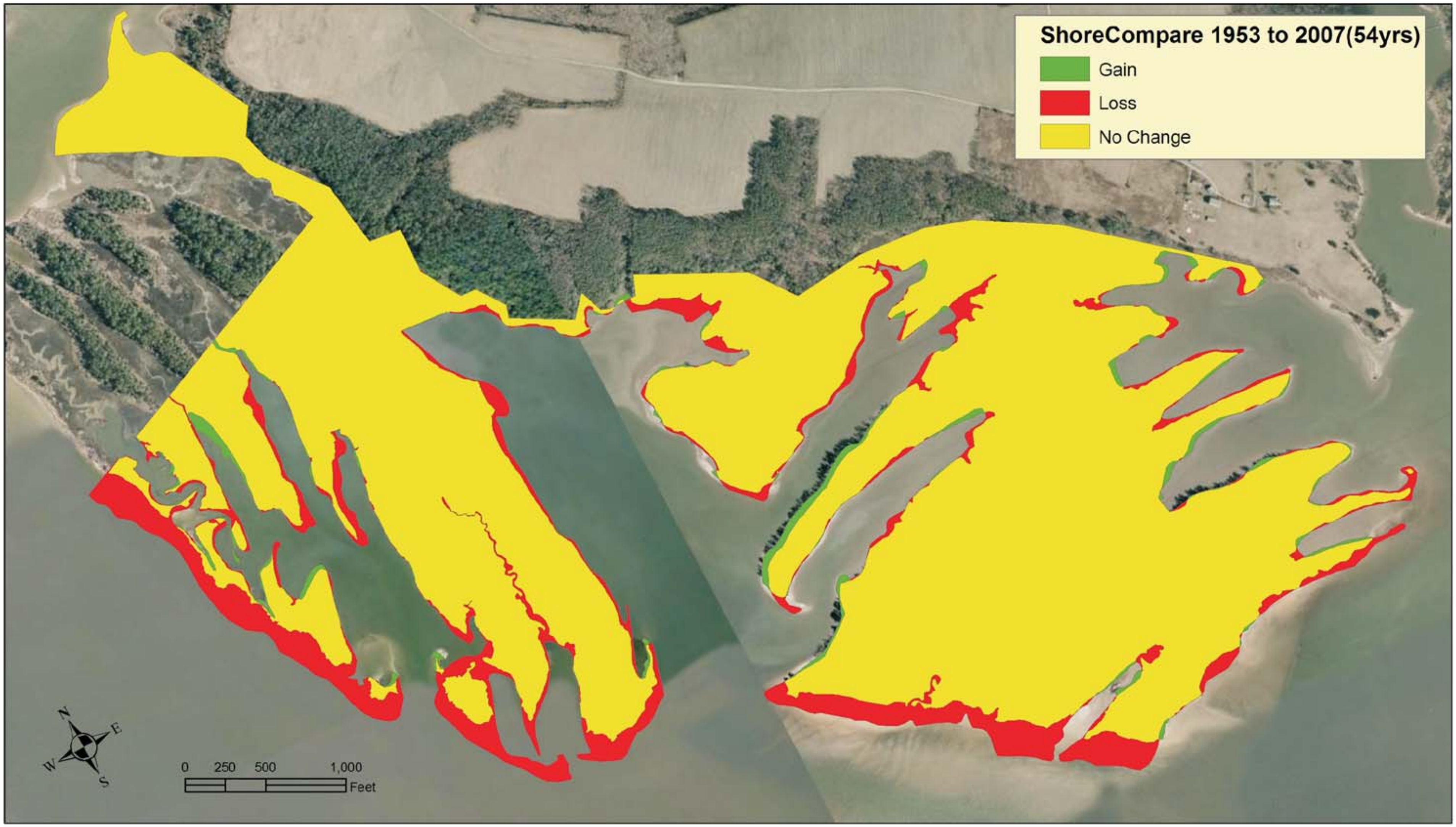
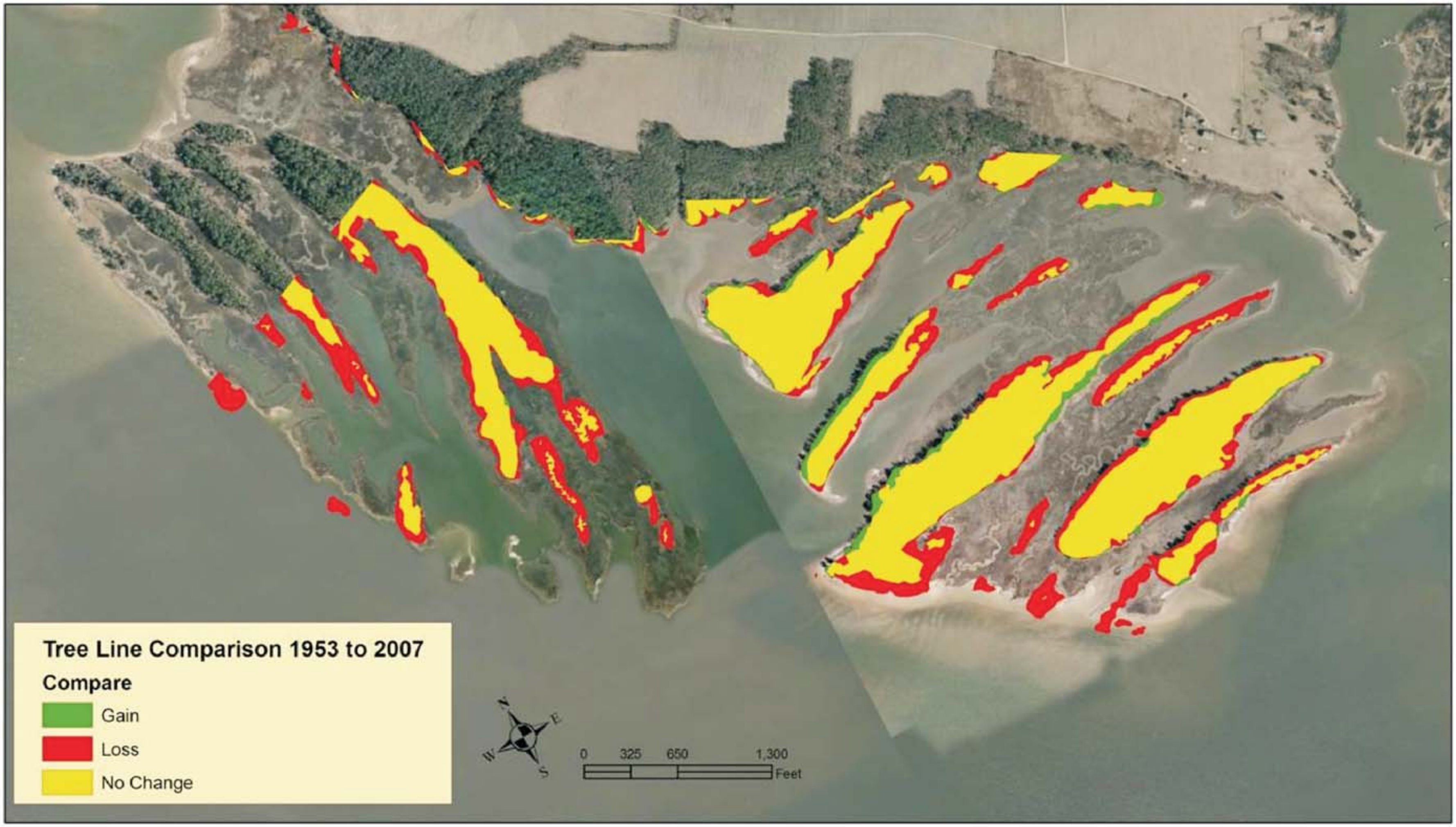


Figure 10. Island reduction calculated using digitized 1953 and 2007 shorelines

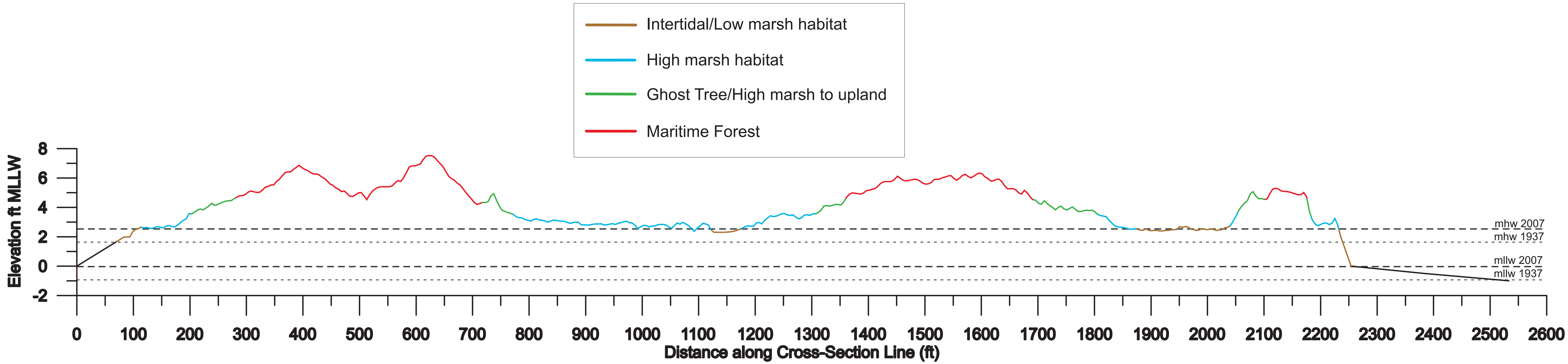


Data analysis uses SSP digitized treelines.
The treelines were visually identified on the orthorectified photos for each year and digitized.
The area encompassed by each treeline polygon was calculated.
The data were overlaid to determine areas of loss, gain, and no change.

Catlett Islands

Photo: 2007 VGIN

Figure 11. Tree cover change calculated using tree lines digitized from 1953 and 2007 aerial photographs.



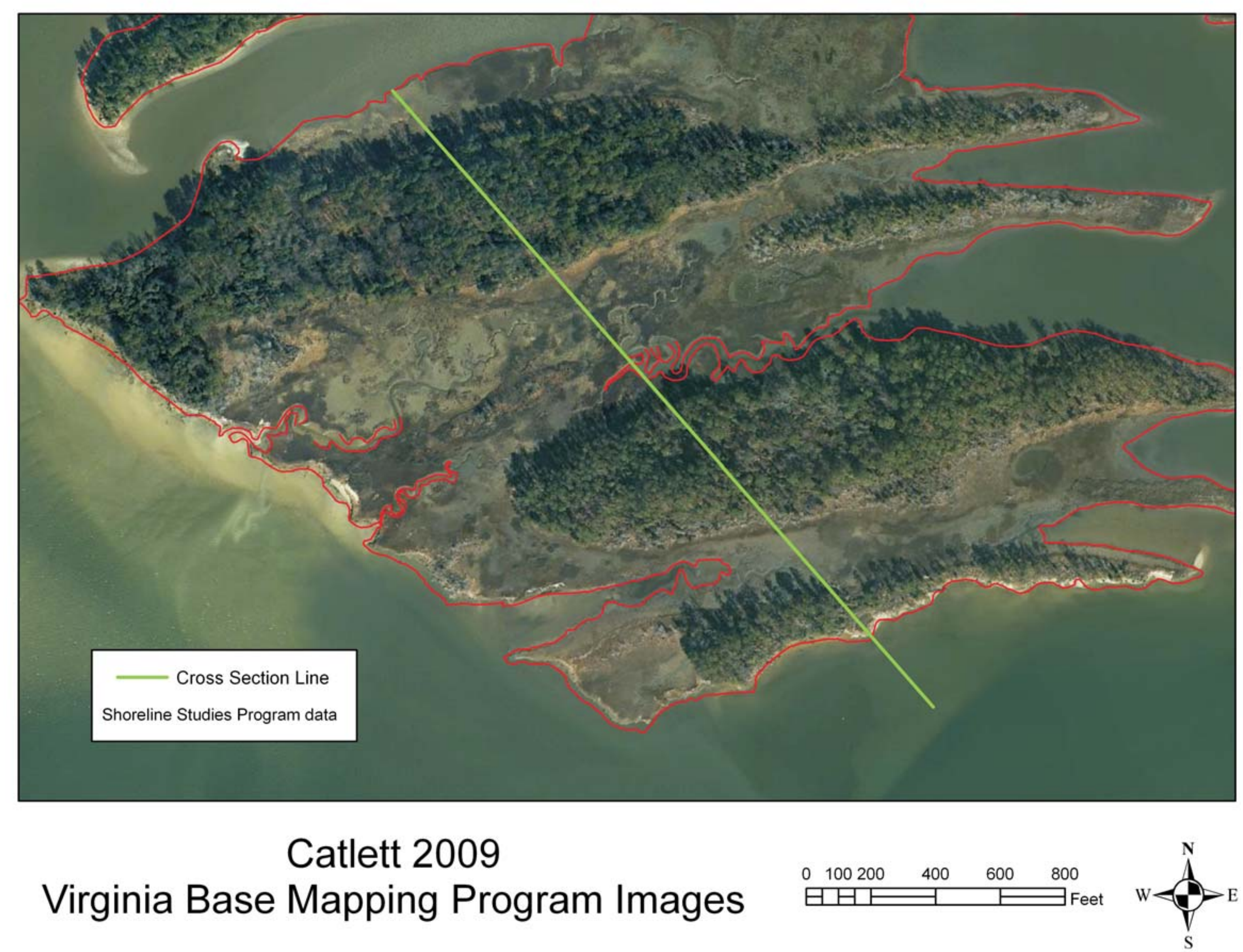


Figure 12. Cross-section of the SE Island created from LiDAR data showing habitat zones, based on elevation. Also shown is the present day MLLW and MHHW and the approximate position (based on a linear representation of sea-level rise) of MLLW and MHHW in 1937.