Hydrological influences on ecolgoical zonation in a salt marsh tidal creek basin: Crab Haul Creek, South Carolina, USA

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http://www.geol.sc.edu/swhite/Helikite/Helikite.html

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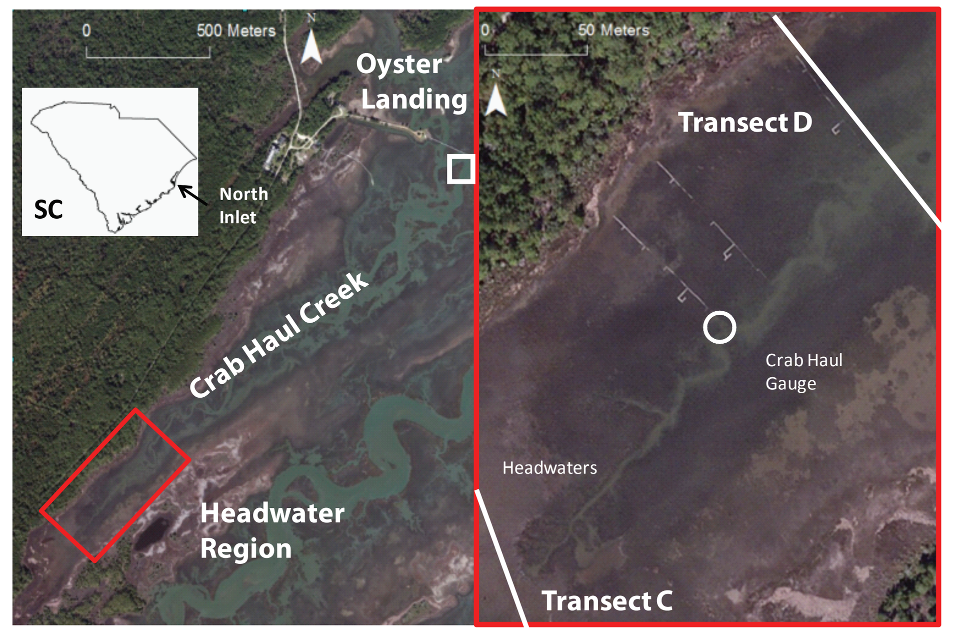
Purpose and objectives

Salt marshes show distinct ecological zonation that is often linked to elevation or hydroperiod (period of flooding influenced by the wetland storage capacity, water budget, and landscape contours). There are 4 types of hydroperiods (Mitsch and Gosselink, 2007): irregularly flooded (High marsh), regularly flooded (Mid-low marsh), irregularly exposed (high creek), and subtidal (creek thalweg). This project is designed to gather high resolution aerial images to improve the understanding of the relationship between hydroperiod, elevation, and zonation. Objectives include:

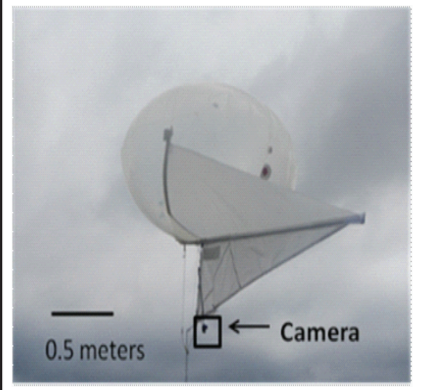
» Collect images from a Helikite and resolve the hydroperiod at relevant spatial scales
» Create a sub-meter scale digital terrain model (DTM) of the marsh surface
» Classify ecological zones based on automatic pixel maximum likelihood classification
» Compare ecological zones to hydroperiod and elevation

Location and geology

- North Inlet, National Estuarine Research Reserve, SC
- Oyster Landing NOAA tide gauge (square)
- Flanked east by Pleistocene beach ridge, west by a forest, and closed south by a causeway
- Formed more than 3,500 ago, transgressing over beach terrain
- Study area between Transects C and D, (Thibodeau et al., 1998)
- Semi-diurnal tide range of 1.2 m
- Main species: *Spartina Alterniflora*
- Local tide data measured from Crab Haul Gauge (circle)



Field equipment and methods



Helikite

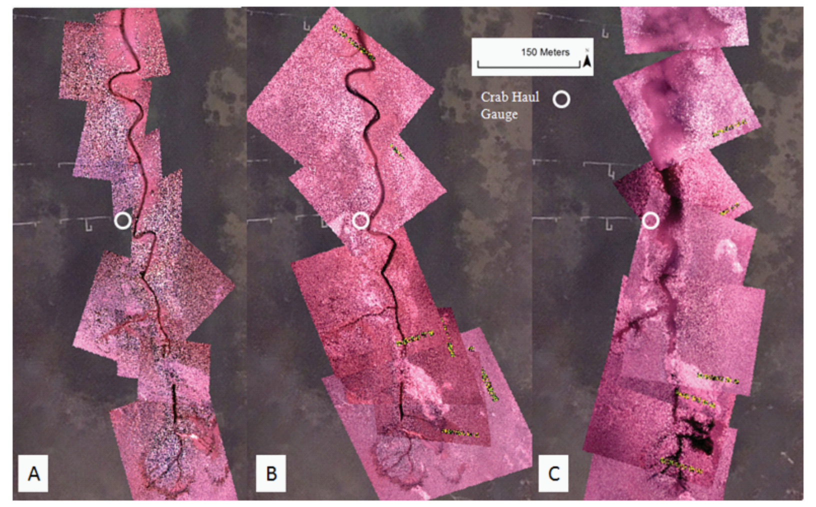
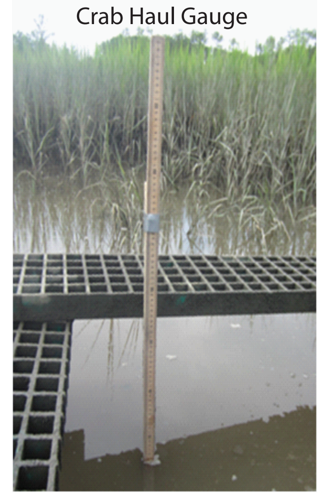
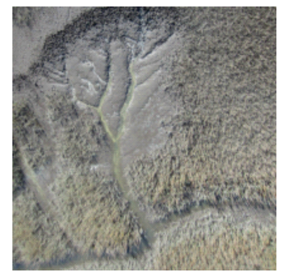


Photo mosaic of IR images of 3 tidal elevations. Panel A is low tide, B is mid tide, and C is high tide during a neap tide.



Crab Haul Gauge

Tide height photographed every 5 minutes



Canon Powershot ELPH 300 visible light

Canon S95 Extreme Color Near Infrared

Control Points
25 cm diameter bucket lids mounted to PVC pipe

Acknowledgements

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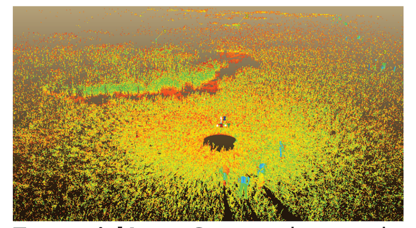
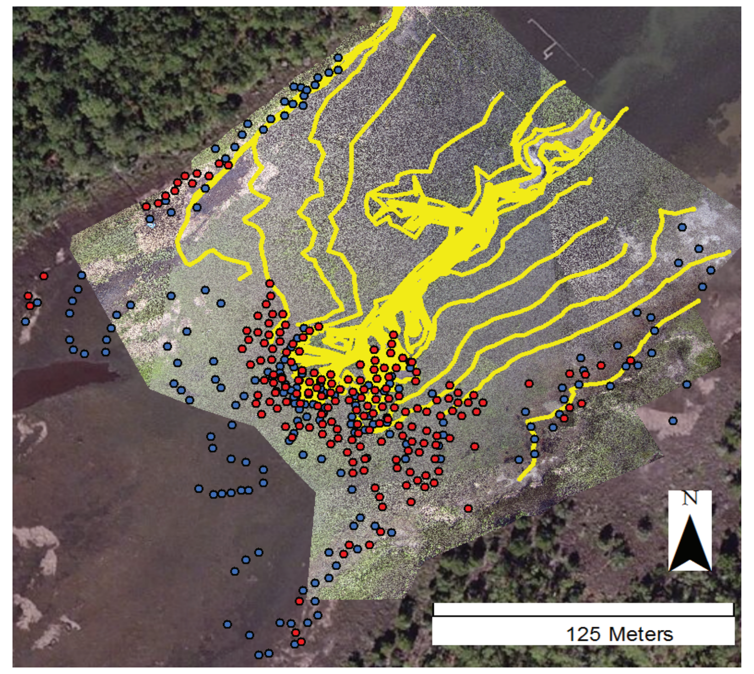
Digital terrain model

Waterlines: georeference infrared photographs and digitize waterline at known tide height.

A DTM of the marsh basin was created by combining elevation points from:
1. Trimble GeoXH DGPS and waterlines
2. Sokkia 30R Total Field Station (TFS)
3. Leica Terrestrial Laser Scanner (TLS)

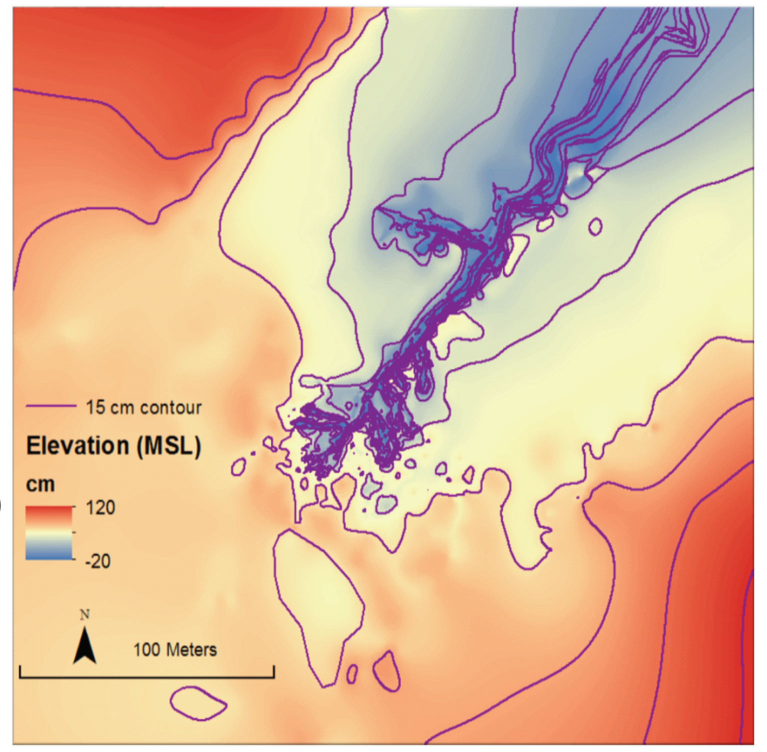


Terrestrial Laser Scanner: bare earth returns from the headwaters and between stalks of vegetation



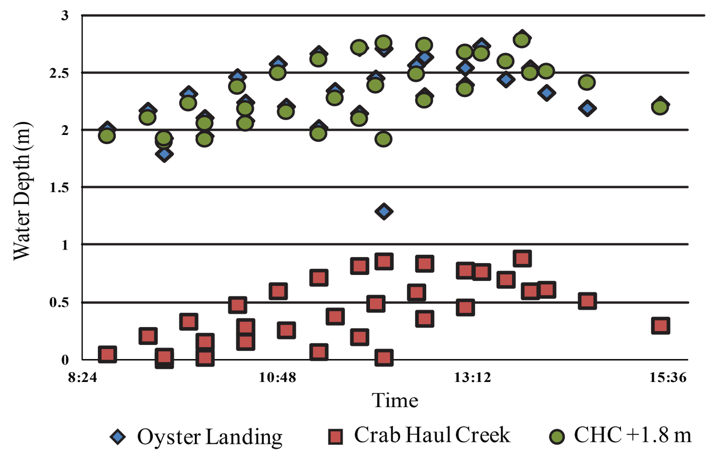
yellow = waterlines (± 3 cm)
red = TLS bare earth returns(± 17 cm)
blue = TFS (± 2 cm)
GPS accuracy for ground control points (± 10 cm)

Elevation data was combined and interpolated with the ADUDEM (Hutchinson, 1988) algorithm. The surface represents a natural drainage and combines local interpolations (IDW) with global methods (spline and kriging) resulting in a connected drainage pattern with ridge and stream representations.

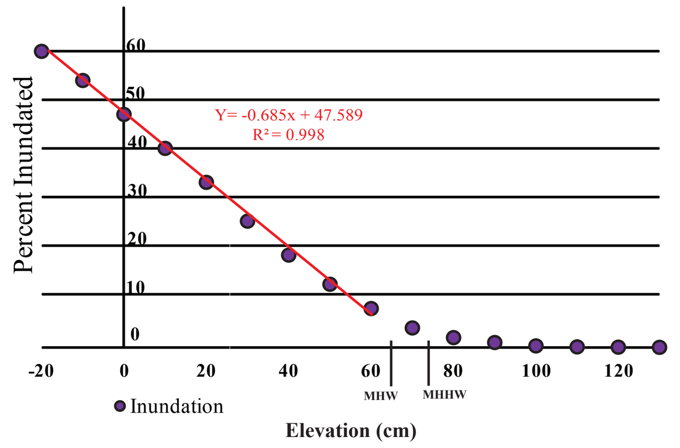


All TFS ,TLS, and waterline contours fall within the correct area of the interpolated surface

Inundation frequency



Between Oyster Landing tide gauge (2.031 m below MSL) and Crab Haul Gauge there is a 1.8 m vertical offset. We correct this and apply tidal records from Oyster Landing to Crab Haul Creek, located 0.231 m below MSL.



Averaging 5 yrs of monthly inundation from Oyster Landing (2012-2008.) Annual percentage of tide heights were determined from -20 to 130 cm MSL. Elevation and inundation have a linear relationship until MHW (64 cm)where inundation is <5% annually.

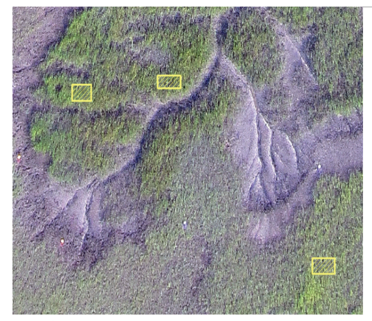
References

- Hutchinson, M. F., (1988). Calculation of hydrologically sound digital elevation models. Paper presented at Third International Symposium on Spatial Data Handling at Sydney, Australia.
- Mitsch, W. J., and Gosselink, J. G., (2007). Wetlands Fourth Eidition. John Wiley and Sons, Inc. Hoboken, New Jersey, pp. 111-112.
- Thibodeau, P. M., Gardner, L. R., and Reeves, H. W., (1998). The role of groundwater flow in controlling the spatial distribution of soil salinity and rooted macrophytes in a southeastern salt marsh, USA. *Mangroves and salt marshes, Vol.* 2, pp. 1-13.
- Wilson et. al., Groundwater controls ecological zonation of macrophytes in salt marshes. In review at *Ecology,* submitted Nov 2013.

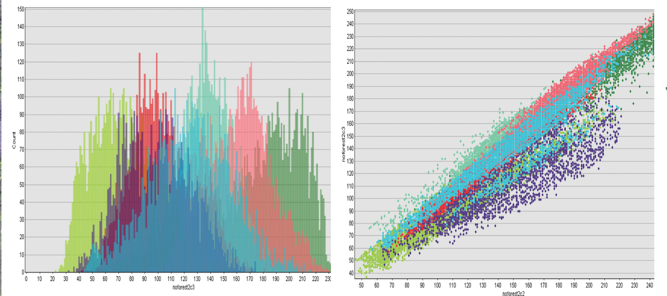
Ecological Zonation

Salt marshes display zonation influenced by tidal frequency, bank height, soil salinity, groundwater flow, competition, and nutrient/oxygen availability (e.g. Thibodeau et al., 1998). We use Helikite images and automated classification to identify the ecological zones because a spatially comprehensive map can be made with quantitative accuracy. Photographs taken during peak primary production have distinct pixel RGB values for the 7 main groundcover types.

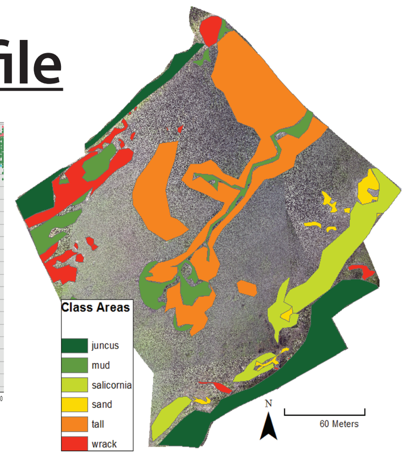
Classification signature file



Selecting 10 training sample groups, ~5 m^2 representing each ecological zone

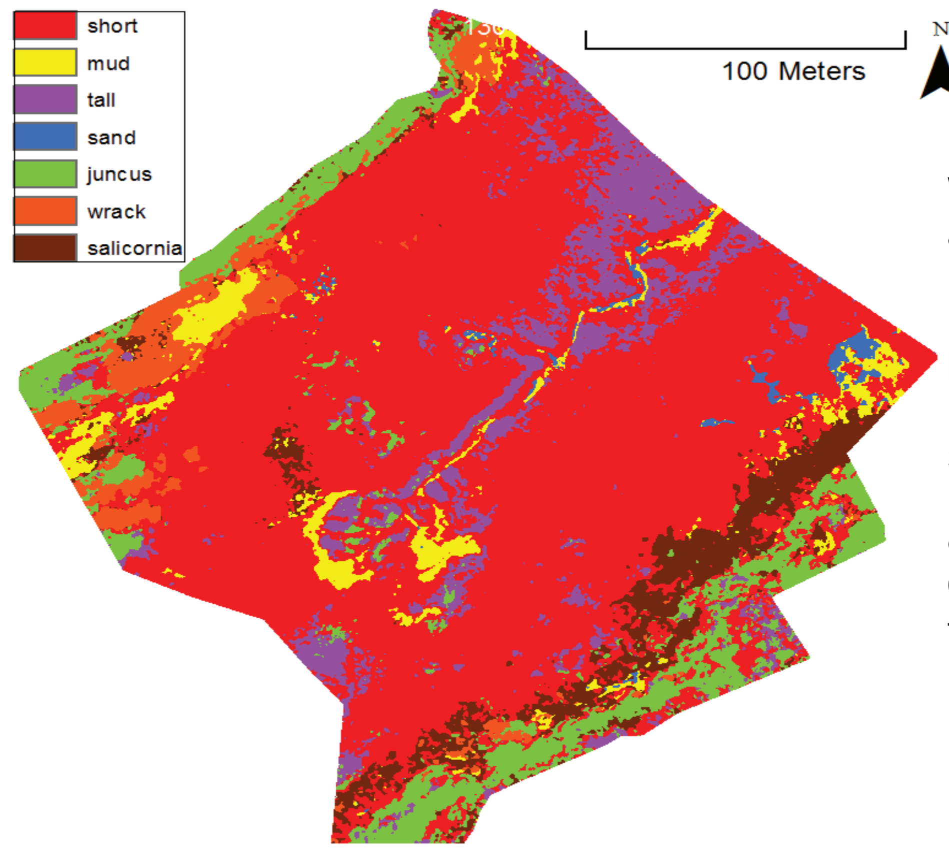


Combine all training sample groups into a single signature file. Using the scatter plots and histograms to determine separation between pixel groups.



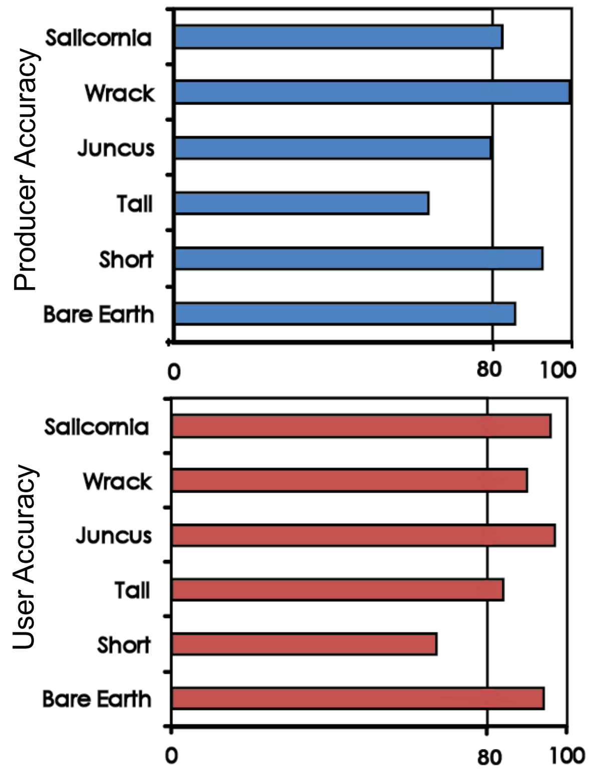
Create *a priori* probability file. Probability determined by zone area/ total area= % probability

Maximum likelihood classification



We applied the signature file to a Helikite visible-light photomosaic using maximum likelihood classification. Neighborhood focal statistics reduced speckle and smoothed boundaries between layers. We used a circle neighborhood with a 0.25 m radius (ca. size of each training sample group.)

Classification accuracy assessment

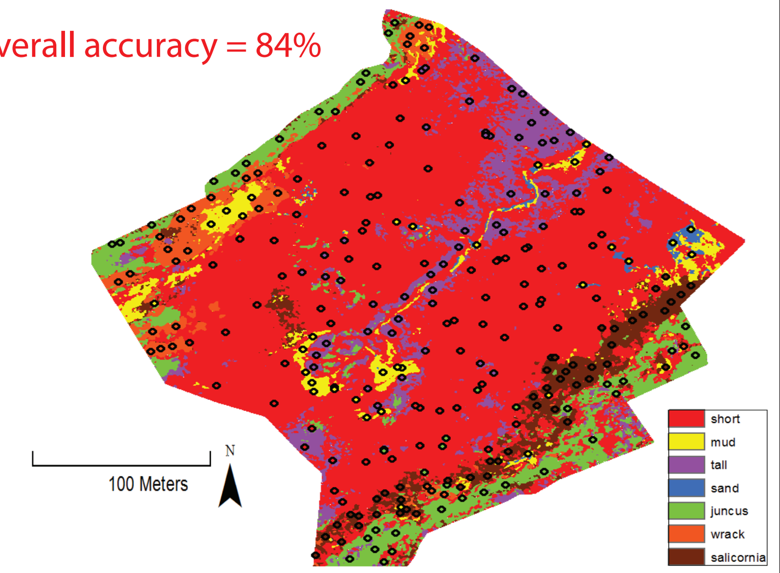


Accuracy was tested by comparing field observations of ecological zones to the classification raster.

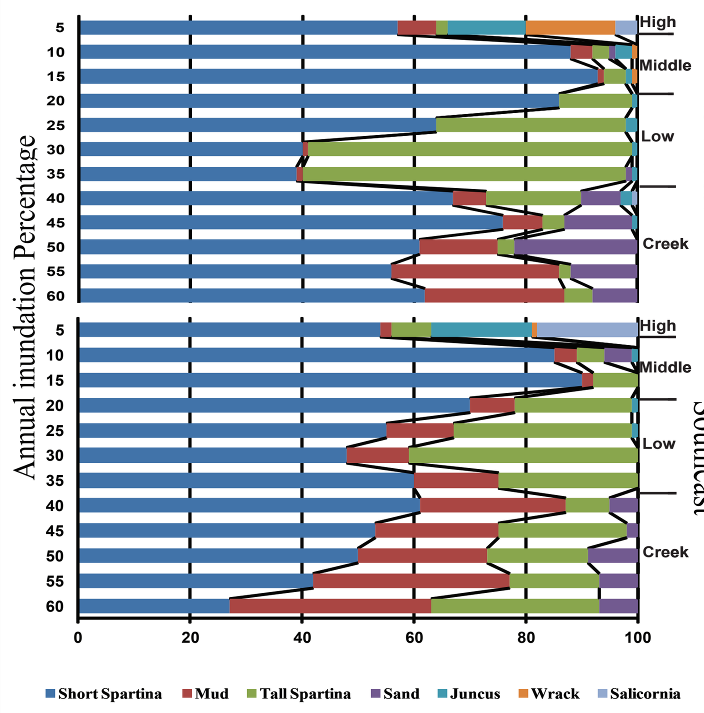
The ecological zone was recorded for each GCP and TFS point (250 points).

Sand and mud were combined into a single bare earth category.

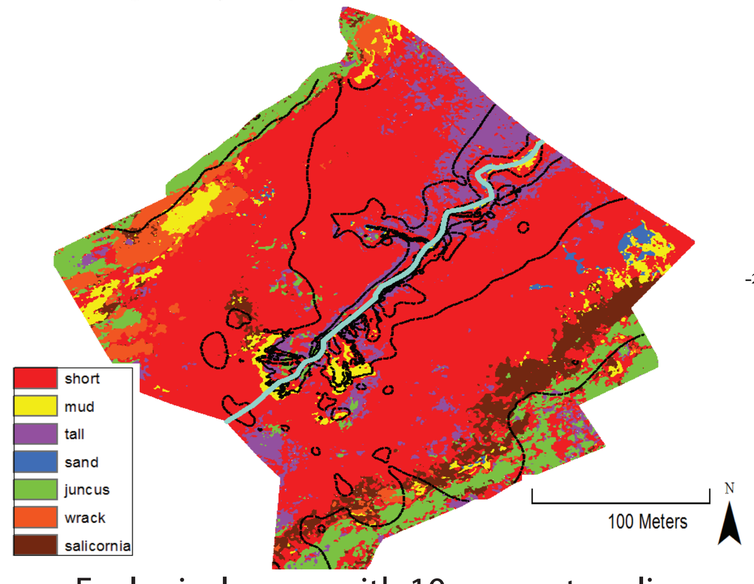
Overall accuracy = 84%



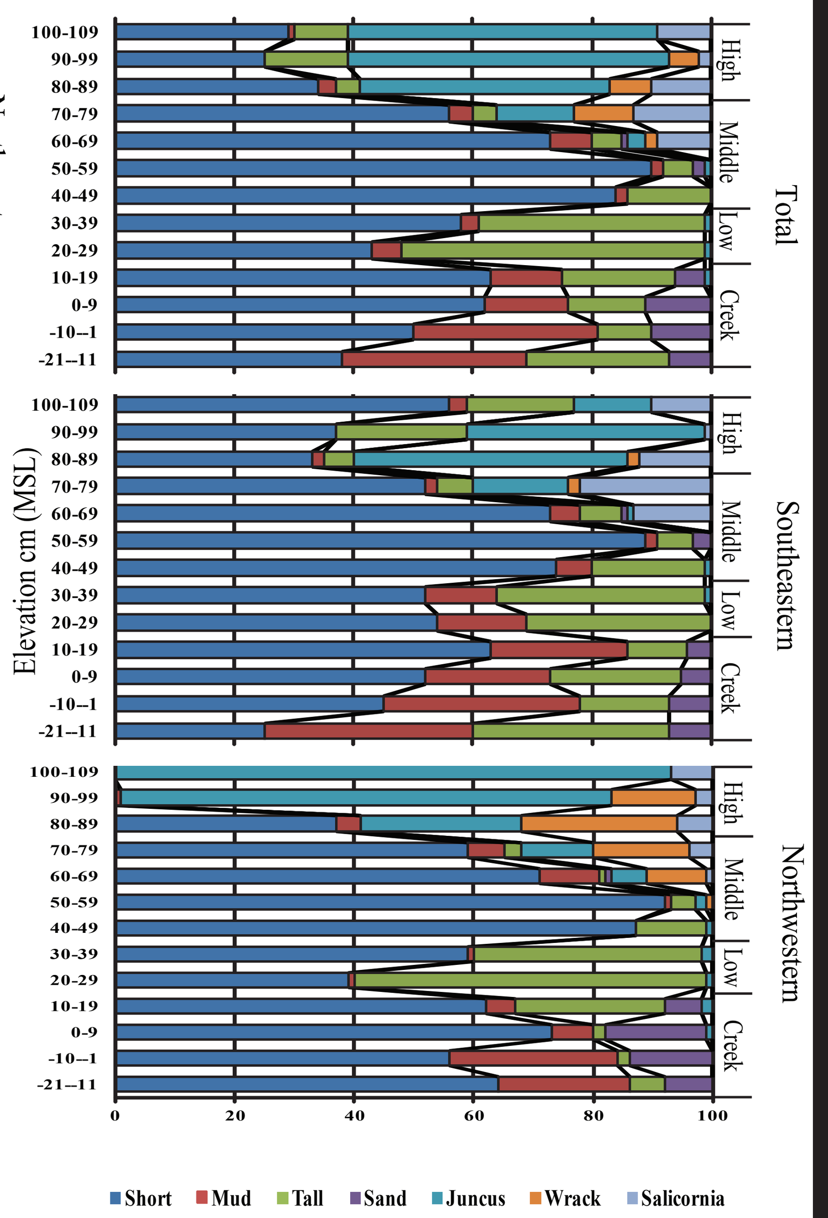
Zonation vs. inundation and elevation



Ecological zones within annual inundation percentages (hydroperiod).

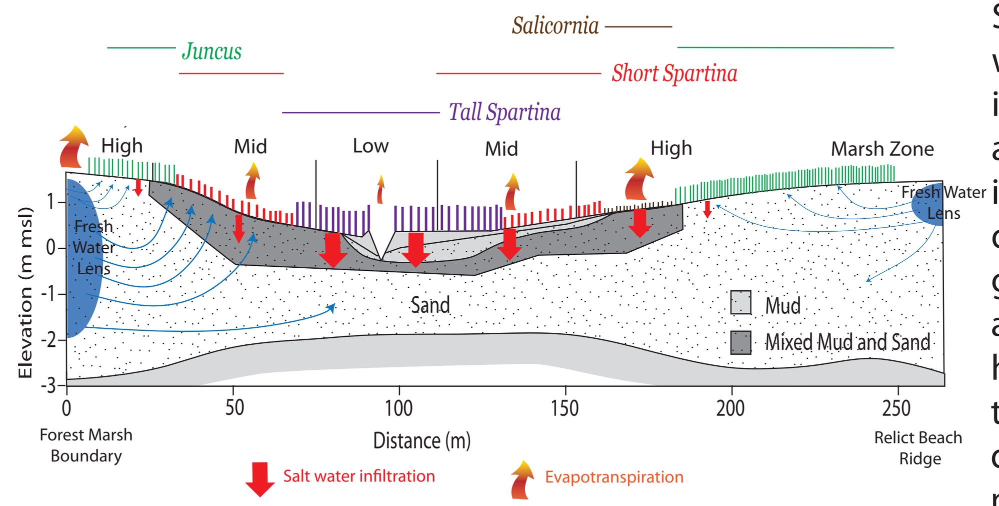


Ecological zones with 10 cm contour lines.



Symmetry of ecological zones (split by the creek drainage divide) is not seen across the basin. This would be expected if elevation or hydroperiod were the major driving factor of zonation.

Hydrological controls on zonation



Salt water infiltration increases with longer and more frequent inundation periods. Tidal ranges and zonation correspond but are influenced by fresh groundwater discharge related to topographic gradients. More ET occurs in areas of less inundation and hypersaline areas develop where there is not enough freshwater discharge to reduce salinity in the marsh root zone.

Conclusions

» Classification of ecological zones produced accuracy of >80% in 6 of 7 classes. Largest classification errors occur between tall and short form Spartina.
» The tidal basin is assymetrical in ecological zones across the creek.
» **Hydroperiod is a driving factor of ecological zonation but does not fully explain zonation.**
» **Elevation and hydroperiod have a linear relationship until MHW.**
» **Groundwater flow influences the development of hypersaline zones and zonation.**