2017

The Inception of a Long-Term Study of Elevation Change and Sediment Accretion in Three Forested Tidal Freshwater Wetlands and in the Restored Freshwater Marsh at Kimages Creek

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The Inception of a Long-Term Study of Elevation Change and Sediment Accretion in Three Forested Tidal Freshwater Wetlands and in the Restored Freshwater Marsh at Kimages Creek

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Introduction

Sediment accretion and the corresponding ability to keep pace with sea level rise in both mature forested tidal freshwater wetlands and restored wetland sites represent significant data gaps in the current body of literature pertaining to wetland sustainability. In order to address these data gaps, Surface Elevation Tables (SETs) were installed along with feldspar marker horizons to measure contemporary sediment accretion rates in three mature forested tidal freshwater wetlands, as well as accretion within a tidal marsh currently undergoing restoration. These are the first SETs installed in tidal forests in the James River watershed, and establish VCU Rice Rivers Center as a contributing partner in the NOAA Chesapeake Bay Sentinel Sites Cooperative.

Methods

Surface Elevation Tables (SETs): 18 SETs were installed in 4 wetland ecosystems to measure elevation change over time (See Figure 1).

Feldspar Marker Horizons (MH): In each SET sampling station, 4 feldspar marker horizons were established to measure sediment accretion. MHs were sampled via liquid nitrogen cyro-coring.

Aboveground Biomass: Vegetation surveys were conducted during peak growing season and at mid-winter to assess vegetation density in each sampling station.

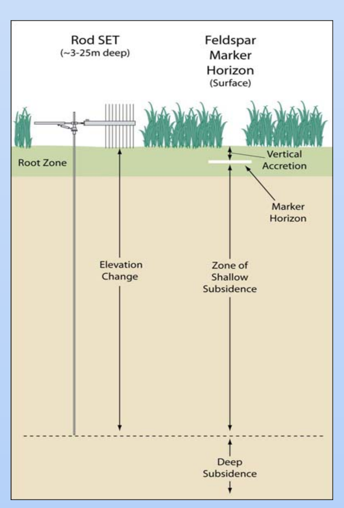


Figure 1: Diagram of a Surface Elevation Table (SET) and corresponding Marker Horizon. Image from http://www.pwrc.usgs.gov/set/theory.html.

Distance to Sediment Source: GPS points at each SET coupled with GIS spatial mapping analysis gives us distance from each SET to the nearest stream channel.

Total Suspended Solids (TSS): Sampling for TSS gives us a measure of suspended sediment concentration in each channel that could be available for deposition and subsequent accretion.

Figure 2: Taking pin measurements at a SET in JRNWR.

Tidal Inundation Extent: Periodic measurements of highest mean water levels were taken at each sampling station.

Study Locations

Presquile National Wildlife Refuge (PQNWR): Forested tidal freshwater wetland upstream from the Rice Rivers Center.

James River National Wildlife Refuge (JRNWR): Downstream of the Rice Rivers Center, forested tidal wetlands here mimic closely those of Harris Creek and Presquile.

Harris Creek: Adjacent to the Kimages Creek drainage at the Rice Rivers Center, this mature tidal forest that represents a reference and benchmark against which the Kimages Creek wetland restoration success is measured.

Kimages Creek: Located at the Rice Rivers Center, this second order coastal plain stream previously existed as a forested tidal freshwater wetland but currently exists as freshwater marsh. Kimages has been logged at least twice, and subsequently impounded to form Lake Charles in 1927. In 2010 the dam was partially removed to restore tidal communication between Kimages Creek and the James River, and the site is currently maintained as a restored wetland (See Figure 3).

Results

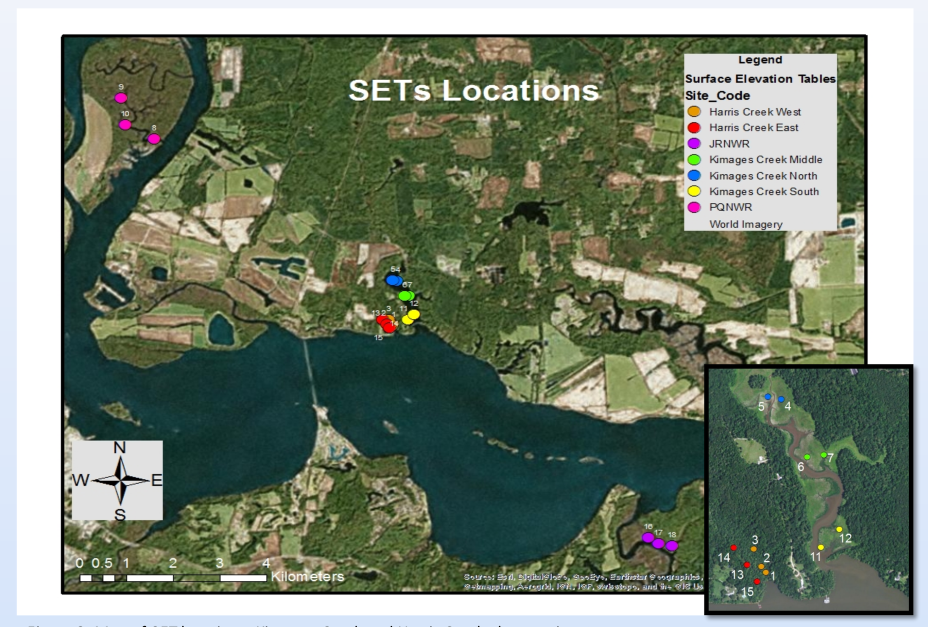


Figure 3: Map of SET locations; Kimages Creek and Harris Creek close-up inset.

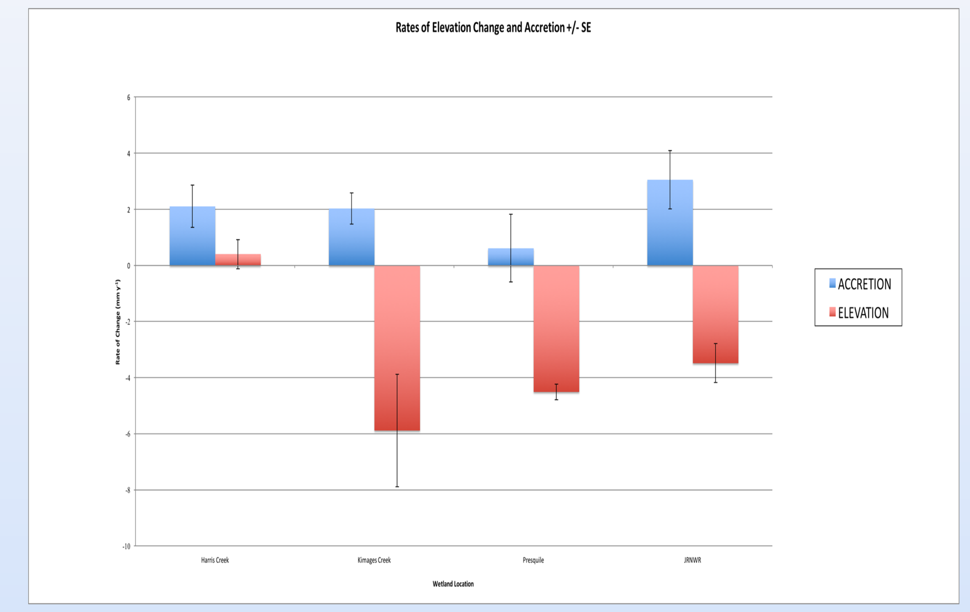
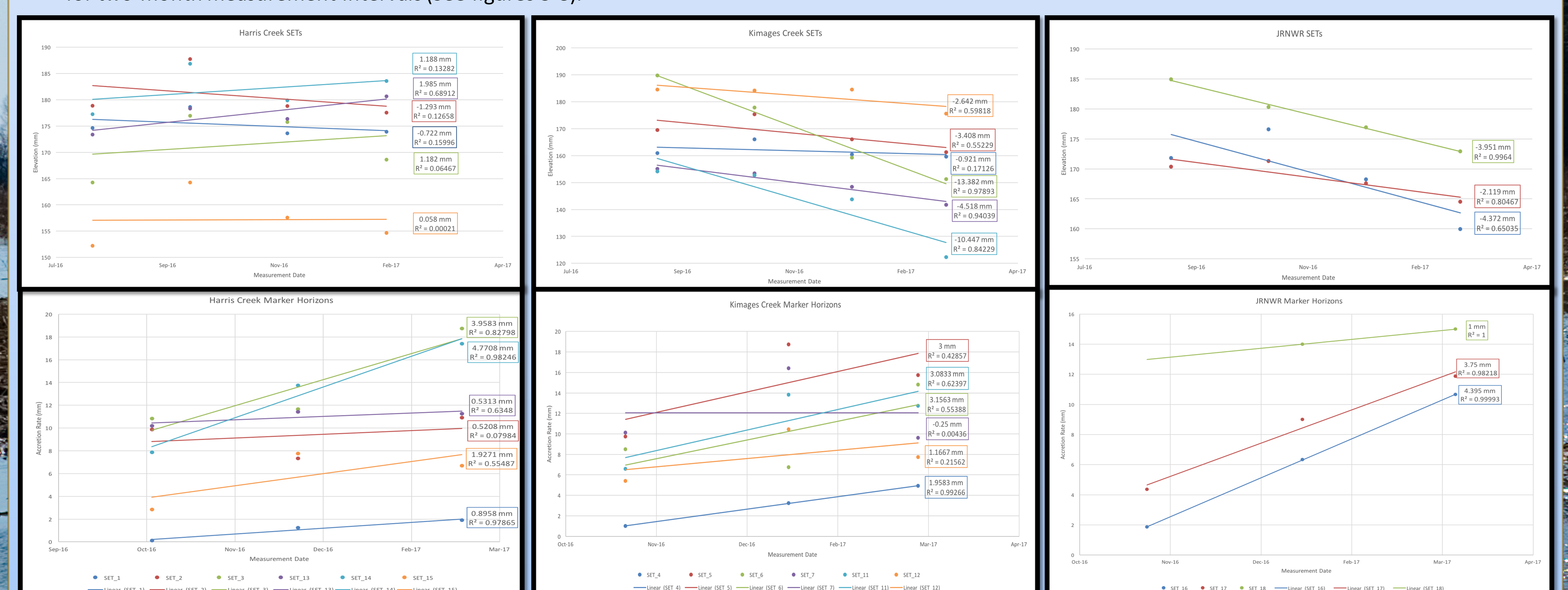
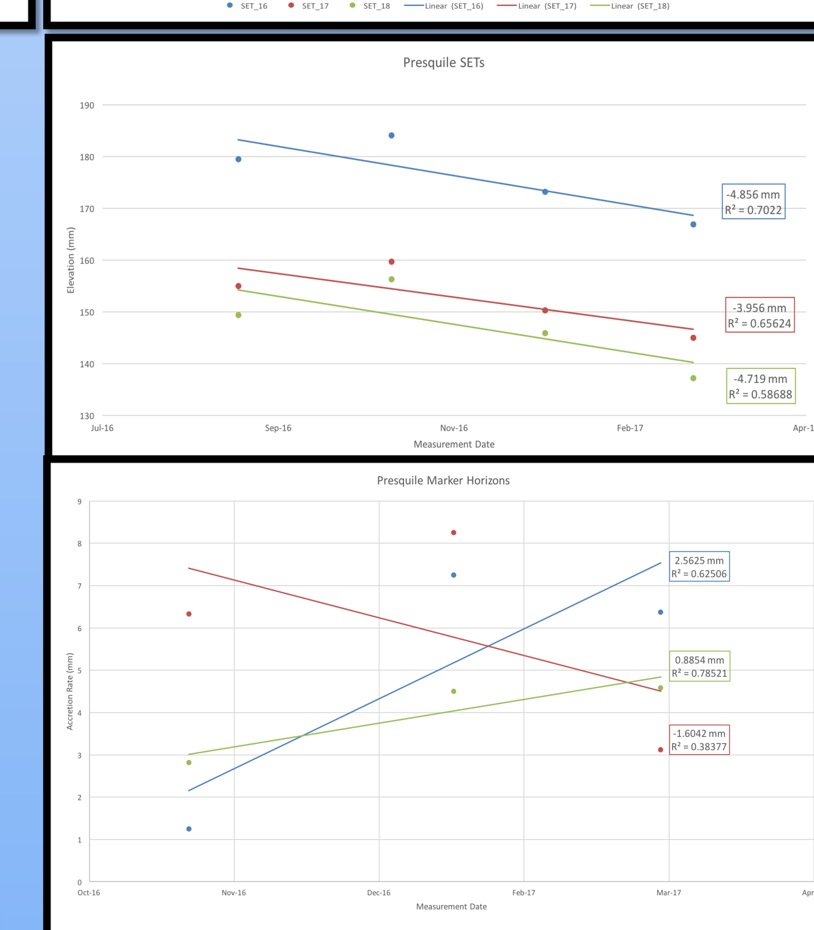


Figure 4: Total mean accretion and elevation change rates for each wetland ecosystem (Rates forecasted to 1 year).

- Accretion and Elevation change rates across all habitats varied significantly from one another (Paired T-Test, p<.0001).
- Elevation change rates and accretion rates were calculated via linear regression, the slopes of the trend lines gives rates of change for two-month measurement intervals (See figures 5-8).



Figures 5 – 8: Trend lines displaying rate of change and R^2 for elevation change and accretion at each SET sampling station, separated by wetland ecosystem.



- Elevation change generally trended towards the negative, while accretion rates were typically positive. The only positive elevation change rates occurred in Harris Creek.
- The positive marsh elevation change at Harris Creek varied significantly from the negative rates of elevation change at Kimages Creek (ANOVA, p<.02, Tukey's HSD, p<.01), but not with those of the wildlife refuges (See figure 4).
- Kimages Creek exhibited the highest rates of elevation loss, with the greatest losses occurring along the southern creek bank sites at SETs 6 and 11 (See figure 6 and figure 3 inset).

What factors influence Accretion and Elevation Change?

- Accretion rates and elevation change rates proved variable with eachother and across sampling stations. We sampled for tidal inundation extent, total suspended solids (TSS), aboveground vegetation density, and distance from sediment source, and ran these predictor variables through multiple regression to quantify which variables were most significant relative to one another in explaining accretion and elevation change.
- For explaining accretion, vegetation density and TSS were most significant (Multiple Regression, p<.02 and p<.04, respectively).
- Elevation change rates were not well explained by any of our predictor variables.

Keeping Pace with Rising Sea Levels

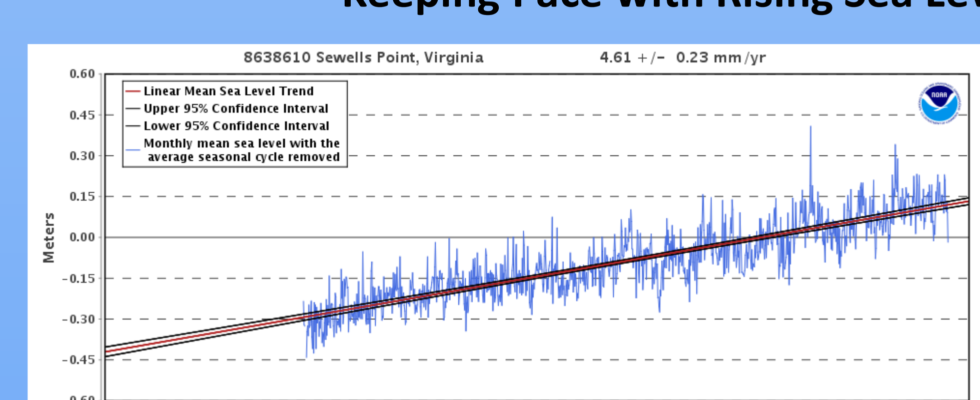


Figure 9: Mean sea-level rise at Sewells Point, VA, showing historical trend and rate of change. Image from https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8638610

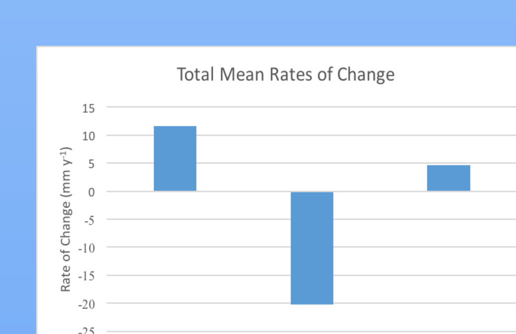


Figure 10: Total mean elevation change and accretion change rages for all wetland ecosystems in this study compared with RSLR observed at Sewells Point, VA.

NOAA tidal gauge data at Sewells Point, VA, suggests relative sea level rise (RSLR) in Virginia is occurring at a rate of 4.61 (+/- 0.23) mm/ yr. While average accretion in these wetlands appears to outpace RSLR, negative rates of elevation would suggest that these systems are not keeping pace with RSLR (See figure 10).

Conclusions

- These data represent the first year of a long-term study examining sediment accretion and elevation change rates. Ideally, these data are collected over a time span of 10 years, with a minimum study period of 3 years. With high levels of variability in elevation during the study period, we cannot establish long-term trends at this point. However, using the high-resolution dataset we have established for this period, we can make some short-term observations.
- The deficit between positive elevation gains and accretion observed during this abbreviated study period suggest shallow subsidence is occurring beneath the marker horizons. However, more data collected over a much longer sampling period is needed before we can generate more substantive trends.
- High levels of elevation loss at SETs 6 and 11 at Kimages Creek may be the result of lateral migration of the stream channel following the breach of the earthen dam. Relatively high rates of elevation loss observed at these sampling stations may not be representative of the entire Kimages Creek wetland ecosystem.
- The general pattern of elevation loss observed at most sites may be due in part to increased rates of microbial decomposition of organic matter resulting from a mild winter. This may be compounded by lower winter accretion rates, possibly a consequence of decreased vegetation densities during the winter months. The observed drop in vegetation density may also contribute to higher rates of erosion during the winter.
- A spike in positive elevation and accretion was observed between the first and second SET measurements, and may result from increased sedimentation introduced during the Hurricane Matthew tidal surge. The subsequent elevation loss observed may be in part due to natural processes towards achieving equilibrium.
- Short-term variability in sediment accretion rates would suggest that wetlands in our study are keeping pace with RSLR, however, the overall trend of elevation loss would suggest otherwise. Due to high levels of variability, we cannot confidently forecast trends for surface elevation this early in the study. Natural processes that dictate variation in accretion coupled with seasonal variability and externalities such as storm events result in an oscillating variability in surface elevation typical of these studies. We may be observing short-term fluctuations that do not necessarily reveal long-term trends. Consequently, a longer dataset is necessary to identify stronger trends in elevation change.

Future of the Study

- This is a high-resolution dataset meant to initiate a long-term study in sediment accretion dynamics in tidal forested freshwater wetlands. Measurements will be taken quarterly over the upcoming decades.
- Cesium^{137} core profiles will be taken from each wetland will be analyzed to establish decadal-scale historical accretion rates with which we can compare contemporary accretion rates.
- Real Time Kinematic (RTK) base stations will be used to collect actual elevations for each SET relative to the NAVD 88 datum.

Acknowledgements

Thanks to Drs. Crawford and Neubauer for appropriation of the initial funding for this study and for their work in its conception and initiation. Many thanks to the U.S.FWS, especially Cyrus Brame and Robert Gabay for allowing us to install in the refuges and for their help in installation. Thanks to Alex Demeo and Claudio Deeg from VIMs for their help with initial site selection and installation. Thanks to Melissa Davis for her tireless work and effort in the field, as well as to all of the undergraduate helpers; Jessie Powell, Sean Weber, Jacob Smith, and Chris Gattins. Finally, thanks to VCU Rice Rivers Center for their support of student research and for the funding opportunities made available.