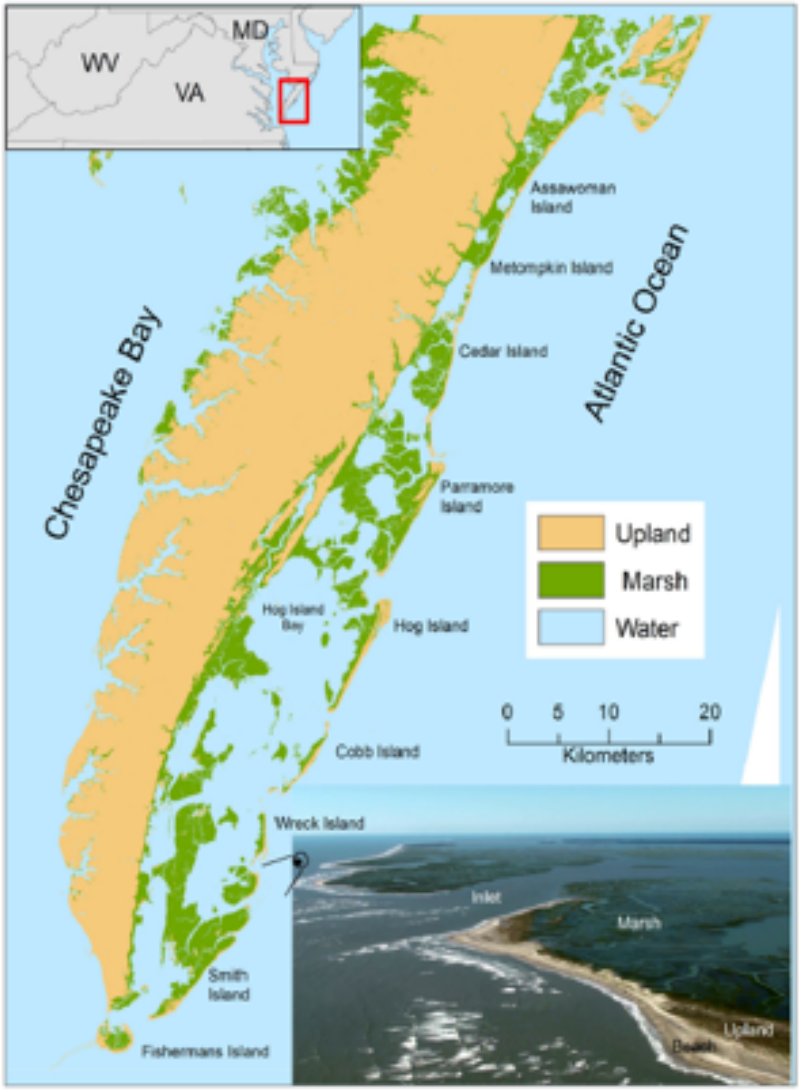
Virginia Coast Reserve:

Ecosystem state change in response to climate drivers: connectivity and coupled dynamics

Keryn Gedan, representing

Co-PIs Matt Kirwan, Sergio Fagherazzi, David Johnson, and Site Director Cora Johnston

Lead PI: Karen McGlathery



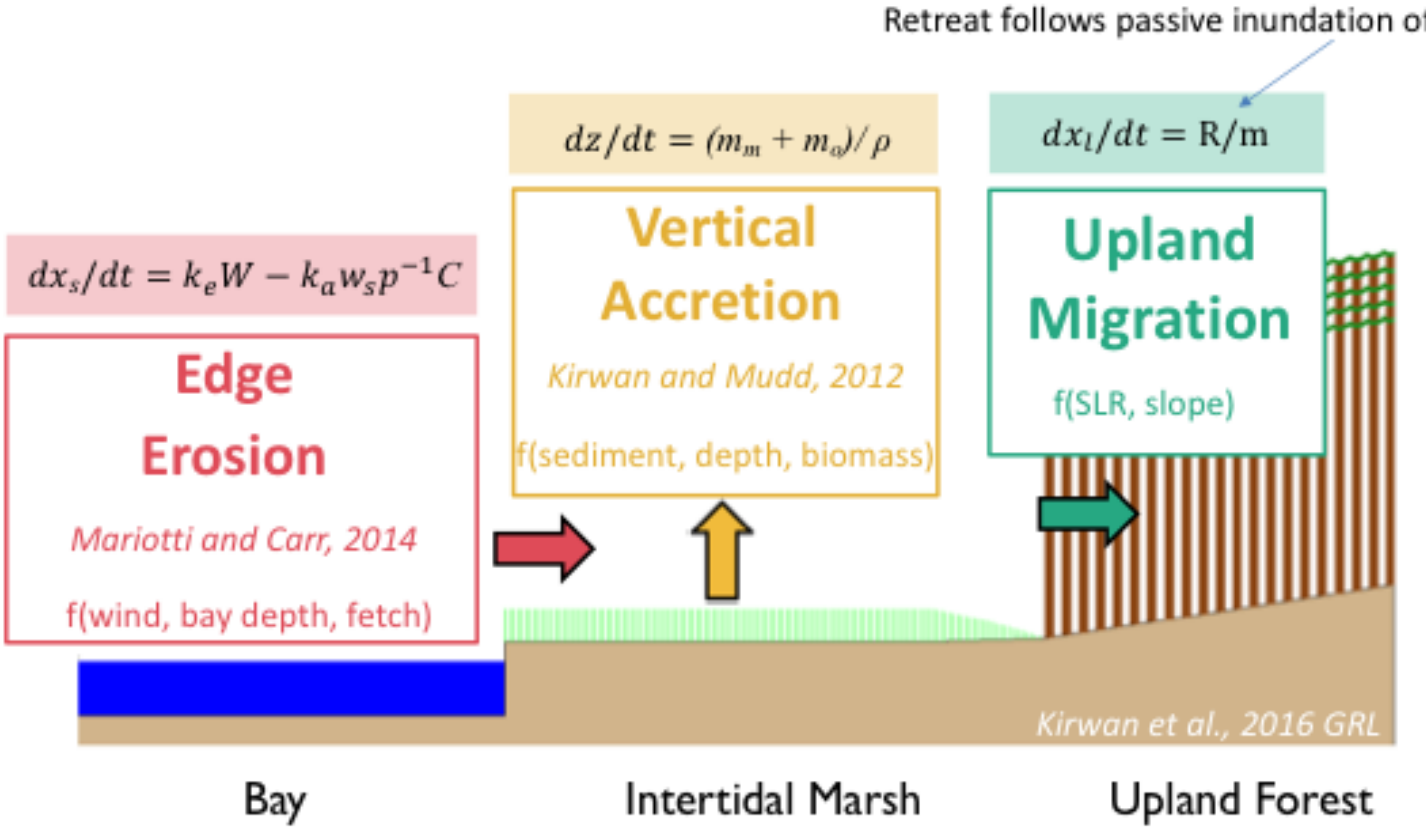
The VCR LTER began in 1987. We are in our seventh cycle, approaching a midterm review. I joined the LTER two years ago, and it's been an exciting location and fantastic scientific community to be a part of. The focus of the site has long been about ecosystem state change. The setting is a string of 14 uninhabited barrier islands, and their associated backbarrier and coastal mainland environments. The entire land and seascape is shaped by marine transgression, or the landward movement of coastal and shallow marine habitats in response to sea level rise. In our most recent cycle, we've continued to focus on state change, with an added component of connectivity between and among elements of the land and seascape. I think the theme of cross-ecosystem linkages will become clear as I present on a new large scale, long term experiment.

Marsh loss and marsh migration

- 40-yr rate of RSLR: 5.4 mm/yr
- Historical marsh loss at the VCR: 63 km^2 or 19% between 1851 and 2010 due barrier island transgression and edge erosion (Deaton et al. 2017)
- Marsh migration into uplands can offset marsh habitat losses due to SLR (Kirwan and Gedan 2019)

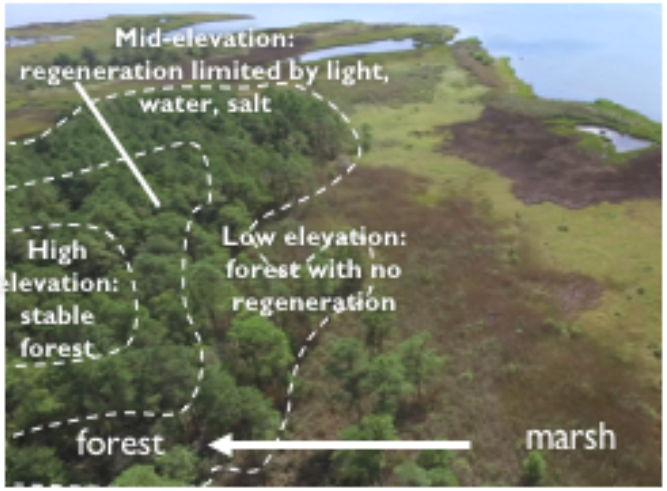
In October, we had some nice coverage of our work in a NY Times article describing the emergence of ghost forests, or salt-killed coastal forests, in response to sea level rise, and the implications for marsh migration and persistence.

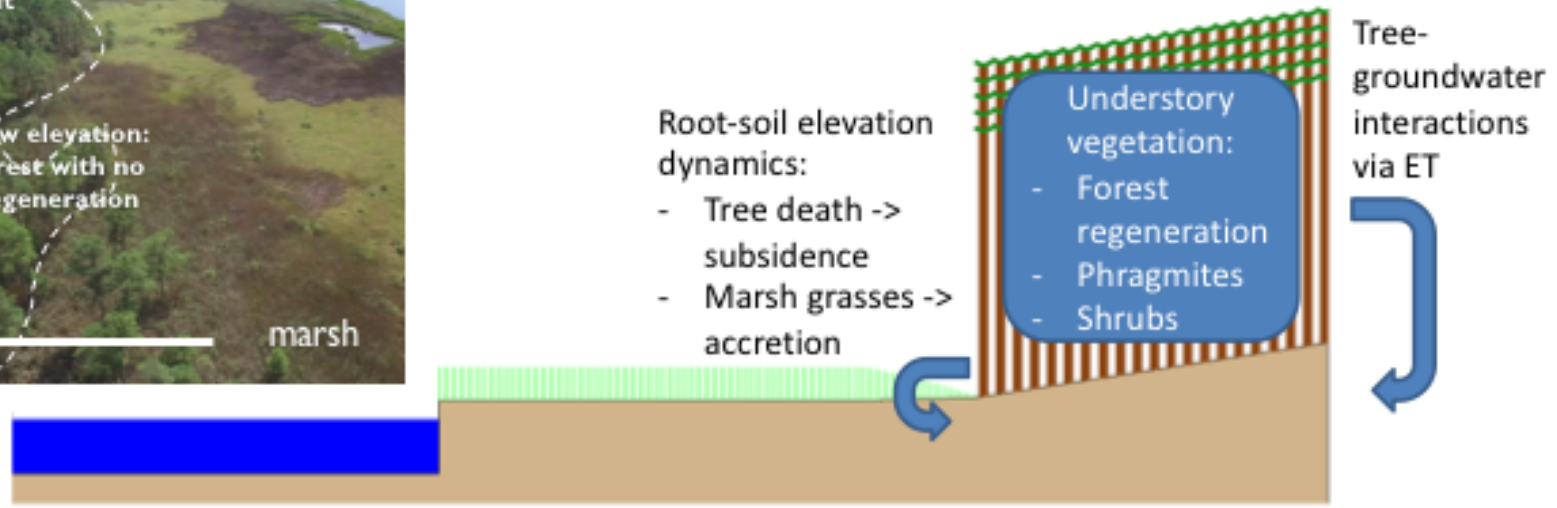
Modeling marsh response to sea level rise



We are actually trying to link all of the ecosystems in the system from barrier islands to the mainland, but here I am showing you a subportion of that larger model that includes the coastal bay, intertidal marsh, and forested upland. Without getting into the weeds in this short talk, the main point I want to make here is that the current model has forest retreat as a passive process due to inundation as sea level rises. It is a function only of the rate of sea level rise and the slope of the upland.

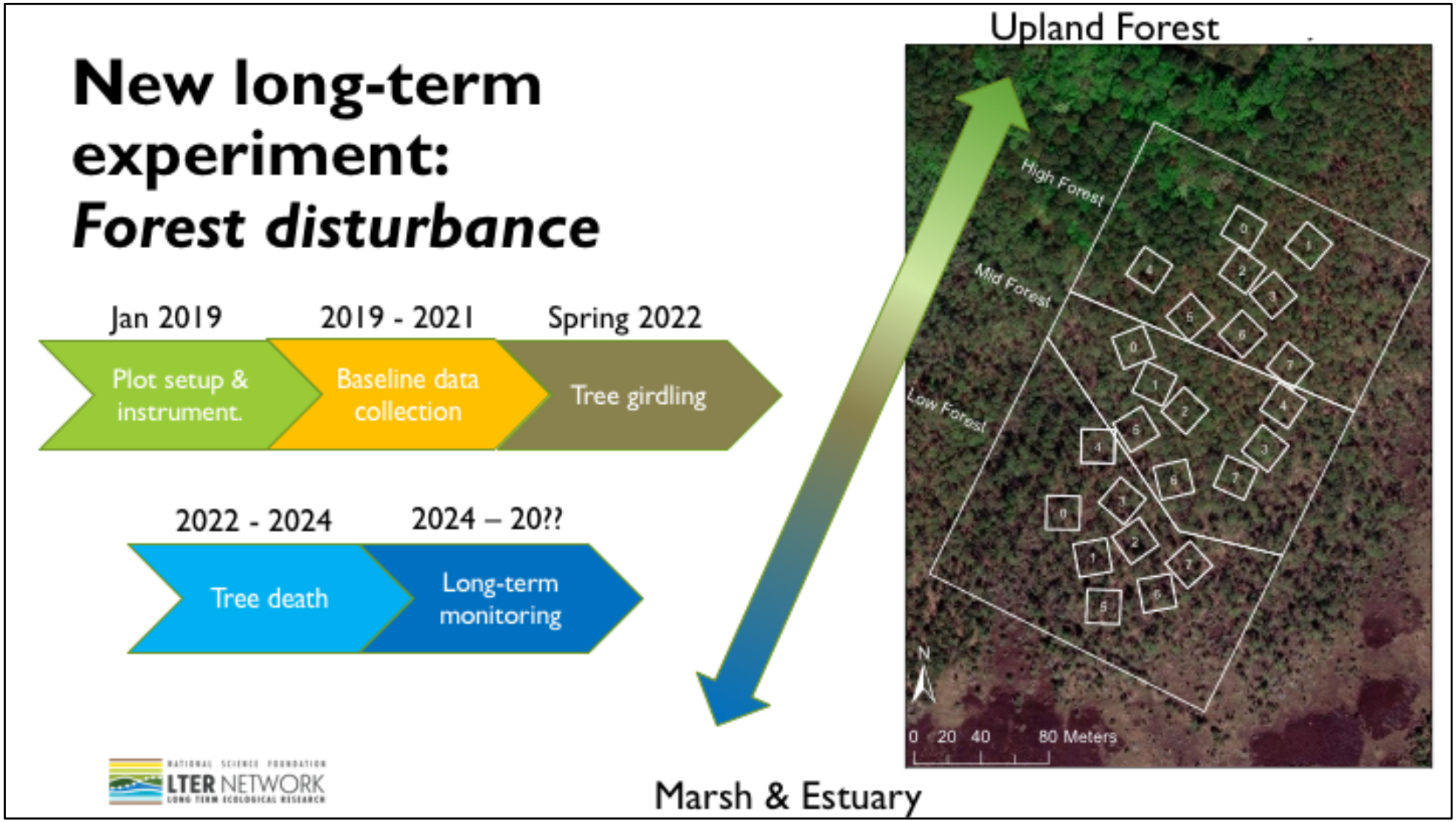
Incorporating plant-soil-water feedbacks into the model





See:
Kearney et al. 2019
Fagherazzi et al. 2019

In reality, we know that the process of forest retreat and marsh migration is more dynamic. Sergio Fagherazzi and his students have found a “persistent zone” where there is no tree recruitment or forest regeneration but adult trees persist, likely until a storm surge or wind kills adult trees, which potentially makes the process more punctuated than gradual. We are particularly interested in some likely feedbacks within this ecosystem transition between plants, soil, and water. First, tree root death may lead to soil compaction and subsidence. As marsh grasses move in, they can build organic matter and elevation. Second, when trees are salt-stressed or die, they transpire less, which may affect soil moisture and groundwater. The water table is often very shallow and can be brackish. Lastly, there are interesting dynamics in the understory that may affect soil water balance and organic matter accumulation.

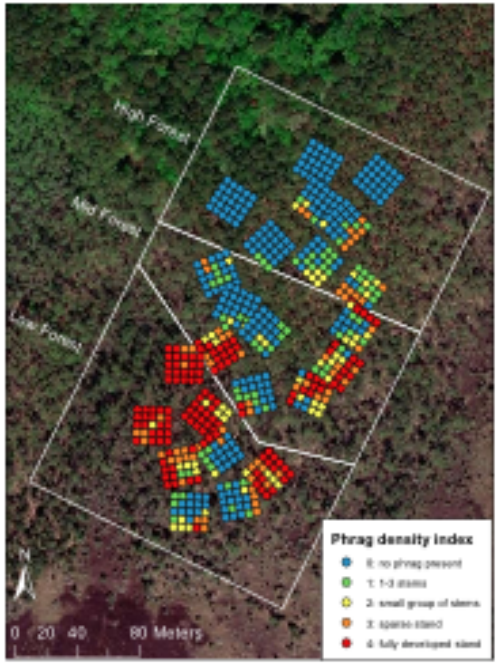


To better understand these dynamics and potential feedbacks, we have set up a new long term forest disturbance experiment. Plots are 20 x 20 m and arranged in three zones, which we call low, mid, and high forest, which is sort of a coastal ecology joke because the gradient only spans roughly 1 m in elevation.

We are currently in the baseline data phase collection. We will disturb half of the plots by girdling the trees in spring 2022, and expect that it will take months to years for the trees to die and the canopy to fully open.

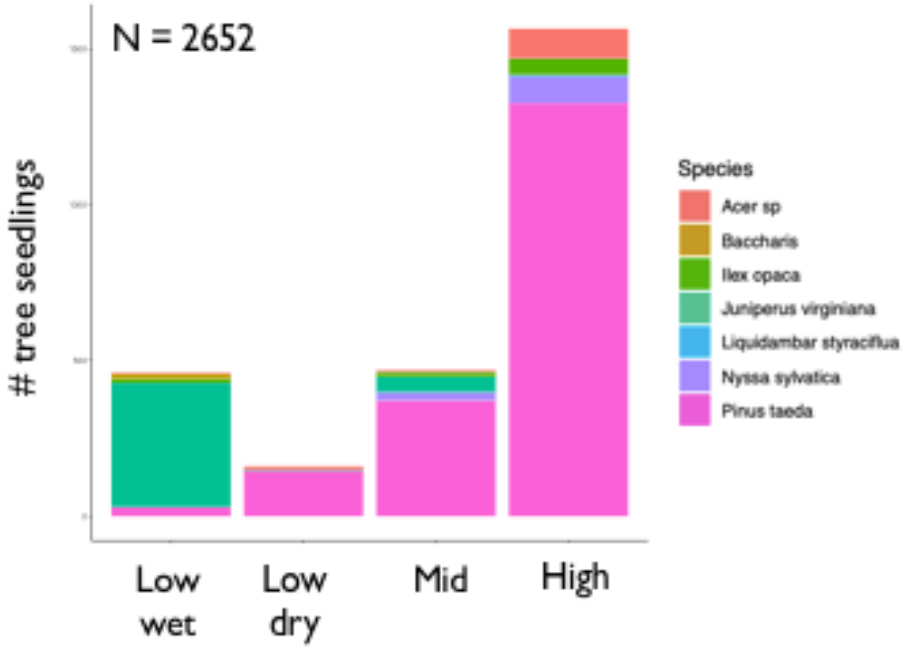
Patterns suggested in space-for-time

Invasive *Phragmites* recruits early, and becomes common at later stages



Wax myrtle shrubs dominate an intermediate phase in ghost forest formation

Tree recruitment shifts in composition from primarily loblolly pine in high forest, to red cedar in low, wet areas.



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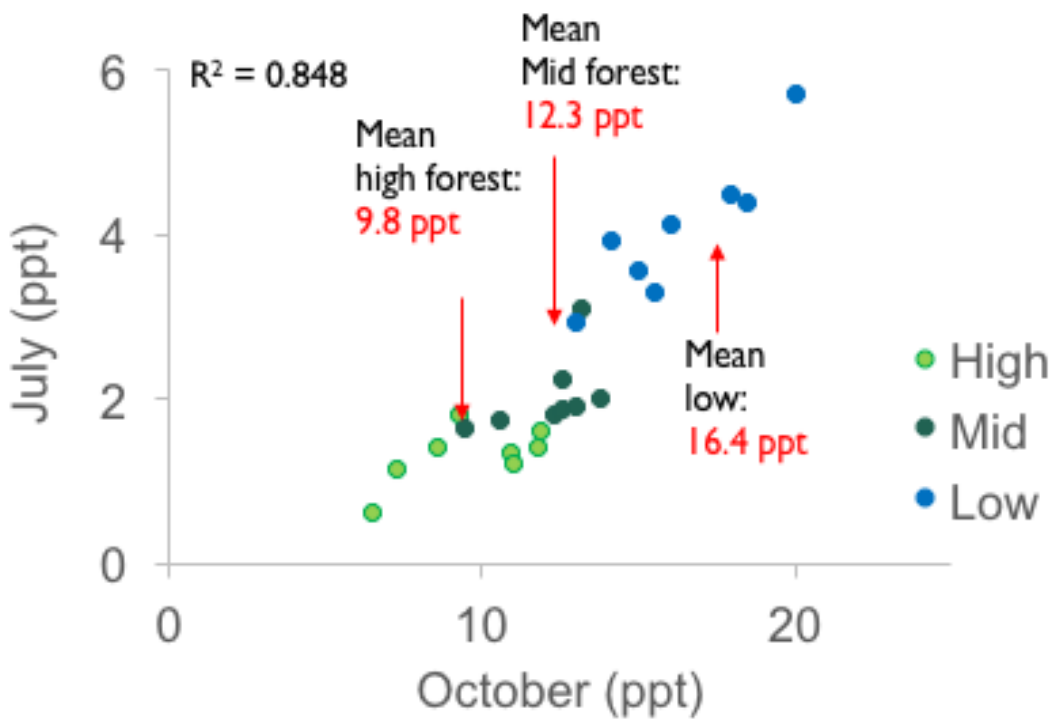
In our first year of data collection, we've already observed some very interesting patterns. I am look at these baseline data as a space-for-time design, as the low forest plots would have looked similar to the high forest historically. This perspective can provide predictions for the course of change during forest retreat. Looking across this gradient we see that…

Saltwater inundation event Oct 2019



LTER NETWORK

Due to offshore Tropical Storm Melissa, tides were 1m over predicted tide height. Saltwater reached even into the uppermost forest plots in this very shallow sloping area.

Ghost Forest Coastal Change Collective: A collaboration between scientists and artists

- Virtual site visits