Coastal Forests Retreat

That sea levels are rising is hardly new news–they have been doing so since the end of the last major glaciation some 18,000 years ago. The current rate of rise, a little more than a tenth of an inch per year, is also not that unusual–6000-8000 years ago the seas were often rising ten times faster. What is different today and the reason for concern is that back then in response to rapidly rising waters, coastal dwelling Floridians just picked up and moved uphill, leaving their villages, burrows, nests, and rooted parents behind. Today it is not so easy to move uphill, for humans nor the rest of the biota, but move we must.

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Left to right: Turtle Creek; Withlacoochee Gulf Preserve, Waccasassa Bay, Yankeetown, Florida. *Photos by Jennifer Seavey.*

As Sea Levels Rise

The effects of sea level rise are often difficult to differentiate from the myriad of other drivers of coastal change, but the expanses of dead trees looming over Gulf Coast marshes is compelling evidence. The story unfolds very clearly in Yankeetown's Withlacoochee Gulf Preserve (www.withlacoocheegulfpreserve.com) where saltwater intrusion due to over-pumping from the aquifer is not the confounding factor that it is near large cities. The comparatively small tidal fluxes in the Gulf also help in differentiation of the signal of sea level rise from the noise of tides. Another advantage of the Yankeetown marshes and coastal forests is that they are perched atop a stable limestone platform and not on subsiding mucks like in the Mississippi Delta. Finally, as a study site or the destination for an outing, Withlacoochee Gulf Preserve is startlingly beautiful.

What you first see when you approach the coast near Yankeetown are breathtaking expanses of saltmarsh dotted with forested islands of mostly cedars and palms. After gazing at these splendid vistas for a while, an over-abundance of dead trees may become evident. Those adventurous souls that venture out into the marsh might be surprised to stumble over tree stumps in dense swards of black needlerush or in the more sparse patches of glassworts and saltworts. Closer inspection of a forested island in the sea of saltmarsh will reveal many more dead trees, especially in low-lying areas. The really astute observer will notice that while the canopy on the healthier-looking islands might still be dominated by cabbage palms and red cedars, with perhaps even a few scraggly slash pines and live oaks, the understory is choked with marsh elder, lycium, and other saltmarsh shrubs, not tree seedlings and saplings.

Faculty and students from the University of Florida have been investigating coastal forest decline and replacement by saltmarsh in the Yankeetown area since the mid-1990s (Williams et al. 1999, Castaneda and Putz 2007, DeSantis et al. 2007). These studies revealed that the die-off described above is mostly a consequence of chronic stresses of sea level rise coupled with the punctuated disturbances of storms and droughts. Data from regularly monitored permanent sample plots on forested islands supported by field and greenhouse experiments reveal that salt is the principal culprit; the abundance of cabbage palms and red cedars is a consequence of

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Above: Declining cabbage palm forest, Turtle Creek, Waccasassa Bay. *Photo by Jennifer Seavey.*

their relatively high tolerance of salinity. That increased flooding is not the main driver of forest replacement by saltmarsh is made obvious by a drive west out State Road 40 towards the Yankeetown Boat Ramp.

South of State Road 40, the fresh waters of the Withlacoochee River wash away the salt, while areas to the north of the road are completely exposed to the effects of sea level rise. The health and diversity of the river side forests is testimony to this occasional cleansing by fresh water. At the same elevation, the northern forests are species-poor and obviously in declining health while those to the south are lush with live oaks, red maples, green ashes, slash pines, hop trees, slippery elms, and occasional cabbage palms and red cedars.

Greenhouse experiments involving potted plants grown in salt solutions in colorful plastic swimming pools confirmed the ranking of tree species' salt tolerance observed in the field. Cabbage palms and red cedar were tolerant of up to 8 parts per thousand salt, about quarter the strength of open ocean water. Other tree species were not nearly as tolerant, dying when exposed to concentrations as low as 2 parts per thousand. For salt-sensitive species, even the occasional sea surge, especially if followed by dry conditions, can be fatal. As sea levels rise, so do the impacts of surges along with soil salinities to the point that, one after another, these salt-sensitive species first fail to reproduce and then die out entirely, leaving the palms and cedar to flourish for a few decades before they too succumb.

To gauge how salt exposure affects trees in the field, we have been monitoring tree mortality, recruitment, and growth in permanent sample plots since 1994. Measuring the growth rates of most trees simply involves stretching a tape around their circumference every few years, but for palms the method is more exciting. Because palm stems do not grow in diameter once they emerge from their below-ground establishment-growth phase, changes in their above-ground stem diameter is not useful as an index of vigor. Fortunately, each palm leaf leaves a scar at its node when it falls; monitoring palm growth rates and estimating tree ages involves monitoring leaf production rates and measuring internode lengths. To keep track of which leaves were new, we dabbed paint on the youngest leaf present at the time of each census; for short palms this operation involved the use of a pole with a paint brush attached to the end, but tall ones needed be ascended with our handy tree bicycle.

Above: A tree bicycle provides researchers access to taller trees. *Photo by Jennifer Seavey.*

On the forested islands in the saltmarsh, as salinity increased, growth and survival rates declined in all species, including palms and cedars. We also noticed that in response to high but still tolerable salinities, the leaves that cabbage palms slowly produced were small, and the few fruits and seeds they managed to produce were also small.

Based on the absence of seedlings and saplings of tree species still present in the canopies of forested islands, we concluded that salt tolerance increases with tree size. For cabbage palms, we used the growth rate and internode count data to estimate how many years had elapsed since the last successful reproduction. In forests below about 25 cm elevation that are tidally flooded at least 50 times per year, the overstory palms are truly the living dead–their leaves are about half normal size, they grow at a small fraction of the rate of trees away from sea water, and they last produced seedlings way back in the 1940s (Williams et al. 1998).

While the death of huge swaths of forests along our coasts may seem like a bleak image and a harbinger of a dismal future, it is important to remember that the forests are being replaced by saltmarshes, which have their own virtues. Simultaneously, saltmarshes must in turn be replaced by mud flats, oyster bars, and sea grass beds, but those transitions have been less well studied. In any event, sea levels have risen and fallen repeatedly over the past few million years, inundating villages, forests and saltmarshes. Although we need to do all we can to reduce the accumulation of carbon dioxide and other heat-trapping gases in the atmosphere, we also need to adapt to the unavoidable impacts of global climate change including sea level rise.

Even if we stopped emitting greenhouse gases tomorrow, sea levels would continue to rise for at least the next century and coastal ecosystems would continue to need to adapt to these rapidly changing conditions. Given that emissions are increasing, not decreasing, and the rate of sea level rise is accelerating, not decelerating, the need for adaptation grows daily (Geselbracht et al. 2011). For now the best we can do for the species in our coastal ecosystems is to provide them unimpeded opportunities to move uphill. We also need to determine which species will require our assistance in their migration, but providing pathways for upslope migration should be the priority.

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About the Author

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