RESEARCH

Climate Adaptation at Kennedy Space Center: How Can Wetlands Help NASA Adapt to Warming Temperature and Rising Seas?

Samantha Chapman[1], Heather Tran and Cheryl Doughty, Department of Biology, Villanova University, Villanova, PA

Figure 1. Kennedy Space Center and surrounding marshes and mangrove swamps along Florida's east coast. (Photo: Carlton Hall)

Looming above the coastal wetlands at the Kennedy Space Center (KSC) is the Vehicle Assembly Building (VAB), a reminder of the close proximity between these protective ecosystems and NASA's important facilities and infrastructure. The impacts of climate change and associated sea level rise on places like KSC are yet unknown, but NASA is taking steps to ensure that they are ready to adapt to climate change. The NASA Climate Adaptation Science Investigators Workgroup is comprised of NASA scientists, university scientists, facilities managers, and institutional stewards. As part of this group, we are investigating the impacts of climate change on the wetlands and their protective capacities at KSC. We are working closely with NASA facilities managers to better understand how the land-building marshes and mangroves that surround the buildings at KSC can assist the center in adapting to climate change (Figure 1).

Mangroves marching northward: The future of subtropical wetlands in the United States

From butterflies to trees, increasing temperatures due to climate change are likely to shuffle species existing ranges on Earth (Parmesan and Yohe 2003). The coastal wetlands of subtropical southeastern U.S. are currently undergoing dramatic plant community shifts due to the expansion of mangroves (Figure 2). Coastal wetlands in this region were historically identified as salt marshes but have been increasing in mangrove abundance over the past century (Giri et al. 2011; Raabe et al. 2012; Cavanaugh et al. 2014). Recent findings suggest that poleward mangrove expansion is primarily driven by declining frequency in severe freezing events where temperatures remain at -4°C for several days (Cavanaugh et al. 2014). Both salt marshes and mangroves provide key ecosystem services, such as creating habitat for fauna, improving water quality and acting as buffers to oceanic forces (Zedler and Kercher 2005), but do so in very different ways given the distinct architectures of mangroves versus marshes. Any potential change in the vegetation of these systems may have far-reaching social and ecological impacts.

At KSC, we, along with Ilka Feller (Smithsonian Environmental Research Center) have been measuring salt marsh-mangrove interactions for over five years (Figure 3). KSC and the overlying Merritt Island National Wildlife Reserve (MINWR), lie in the center of the salt marsh-

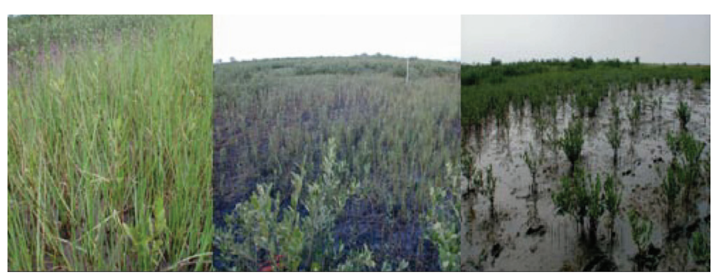

Figure 2. Changes from salt marsh to black mangroves in coastal Louisiana following sudden dieback of smooth cordgrass (*Spartina alterniflora*). (Source: U.S. Geological Survey; McKee 2014)

1. For additional information, contact samantha.chapman@villanova.edu

mangrove ecotone - the transitional area between the two systems on the Atlantic Coast. In order to understand how these vegetation shifts might influence the capacity for these wetlands to absorb storm surges and keep up with rising sea levels, we are examining how these plants “build land.” Key parameters for measurement include plant growth, soil chemistry, and the elevation of the land relative to sea level. To predict the effect of climate change we will simulate future conditions.

Simulating the future at Kennedy Space Center: How will these wetlands function 100 years from now?

To simulate local climate conditions in 100 years, Villanova postdoctoral associate Glenn Coldren has built chambers that warm the air surrounding marsh plants and mangroves. These structures were constructed of PVC and film and instrumented with micrometeorological equipment that measures climatic factors like temperature and humidity. For the past year, warming chambers have been placed in patches of marsh where mangrove seedlings have established (Figure 4). This experiment is allowing us to assess how the invasion of mangroves into marshes is progressing under a warmer climate. To date, survivorship of mangroves has been higher in the warmer chambers than in the control plots. If this pattern continues, these results suggest that the structurally larger mangroves may come to dominate these communities and may alter the ecosystem services they provide.

Figure 3. Aerial images showing vegetation change at Merritt Island National Wildlife Refuge between 2003 and 2013. Note the darker green mangroves encroaching into the salt marsh in the orange box over this ten year period. (Source: Google Earth)

Mangroves and salt marshes must maintain a presence above sea level to avoid collapse (Nicholls 2004; Cahoon et al. 2006), and thus wetland ecosystem maintenance is dependent upon belowground processes such as sedimentation, the growth of roots, and the decomposition of organic matter (Middleton and McKee 2001). The effect of mangrove encroachment and warming on the resilience of coastal wetlands to sea level rise will depend partly on the balancing act between root productivity and decomposition. For instance, if warming accelerates decomposition, then elevation gain could fall below the rate of sea level rise, all else being equal. A series of larger warming chambers outfitted with soil elevation tables were erected this April and will allow us to examine how land-building (measured by soil elevation) is changed by warming. Graduate student Heather Tran will use these chambers to assess both root growth and root decomposition under control and warming conditions, providing a better understanding of how marshes and mangroves will maintain elevation when exposed to future climate. Figure 5 highlights our ideas on how belowground processes, warming and vegetation shifts interact to alter soil elevation change, and thus future wetland sustainability.

If mangroves keep invading marshes will a wetland’s ability to scrub carbon from the atmosphere change?

In a related project at KSC, we are working with Feller, Dr. Adam Langley (Villanova), and Dr. Wayne Walker (Woods Hole Research Center) to assess how much carbon mangroves and salt marshes scrub out of the atmosphere and store in solid form. Coastal ecosystems are highly efficient carbon sinks. Wetland vegetation sequesters carbon in living biomass and through high rates of organic and mineral carbon accretion in sediments, which persist for long periods of time (Chambers et al. 2001; Nellemann et al. 2009; McLeod et al. 2011). Further, carbon storage may serve as a proxy for other ecosystem services that are essential in sustaining wetlands against global climate change. For example, if mangroves are able to sequester carbon more efficiently than salt marsh, then the encroachment of mangroves into salt marsh systems may increase carbon sequestration and insure coastal stability in the face of sea level rise. Assessment of carbon stores in various vegetation types and changes in storage as vegetation shifts may aid management in predicting wetland resilience to future climate change.

Graduate student Cheryl Doughty has been coupling field measurements of carbon with land cover vegetation maps made by NASA scientist Ron Schaub to determine how much carbon is being stored at the landscape scale at KSC. Thus far, she has found that mangroves store more carbon in aboveground biomass than salt marsh plants. She is attempting to predict future mangrove distributions in a warming climate and under rising seas by using climate envelope modeling. Climate envelope models determine which environmental factors contribute most to the current distribution of mangroves and use those factors to determine where mangroves will migrate in response to future climate scenarios. These models will allow her to illustrate the potential impacts of shifting mangroves to landscape carbon storage (Elith et al. 2011).

Figure 4: Aerial view of small warming chambers at KSC.

How will this research be incorporated into management?

We expect that our collective findings will aid facilities managers at KSC in decisions on building sites, restoration, and planning for future storms by incorporating the buffering capacities of wetland vegetation. At the larger scale, wetland managers can use the data on rapidly changing wetlands, particularly on belowground processes, for planning restoration and mitigation to combat rising seas, severe storm events, and increasing levels of atmospheric CO2.

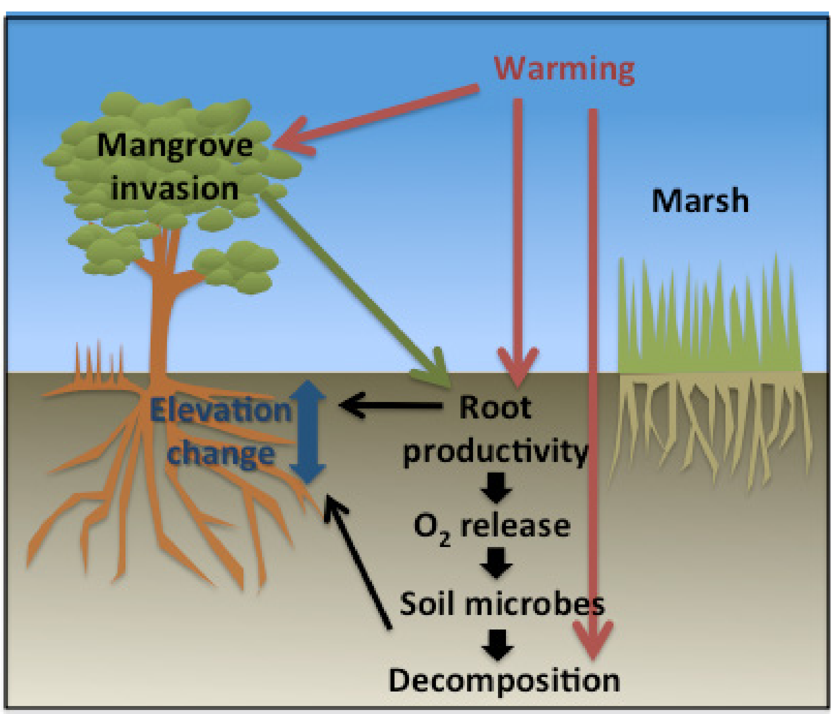

Figure 5. Conceptual schematic of influences of invasion and warming on belowground

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