The Potential of Sea-level Rise on Florida's Coastal Ecosystems[1]

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Sea-level rise is already having an effect in Florida. Subtle, and not-so-subtle, changes are being noticed, especially by people who live, work, and play at the coasts. Tide gauges around the state have measured sea-level rise, including up to 9.3 inches (237 mm) since 1913 in Key West (Figure 1).

Sea-level rise may have significant effects on Florida's coastal ecosystems. These ecosystems are the foundation upon which much of Florida's natural beauty and economy are based. Understanding what changes may happen in the future can help us plan for those changes and, to the extent possible, lessen the impacts of those changes.

Seagrass, mangroves, salt marshes, beaches, dunes, coastal forests, and estuaries are important coastal ecosystems. Each provides breeding and nursery grounds, food, and cover for a wide variety of animals. Many commercially and recreationally valuable species of fish such as spotted seatrout, redfish, tarpon, and snook depend on seagrass, mangroves, or salt marsh for part or all of their life cycles. Beaches and dunes are home to threatened species, such as beach mice, snowy plovers, and gopher tortoises, and provide nesting sites for shorebirds and sea turtles. Coastal forests, commonly containing oaks, pines, and/or palms, provide habitat for upland species like scrub jays, red-cockaded woodpeckers, white-tailed deer, and pine snakes. Estuaries, where fresh water, often from rivers, enters semi-enclosed bodies of salt water, are some of our most productive ecosystems. Oysters, clams, shrimp, and many other species of marine vertebrates and invertebrates thrive in estuarine waters, as do the myriad bird species that prey upon them. In addition to providing value for wildlife, mangroves, beaches, and dunes also help protect homes and inland habitats from storm damage.

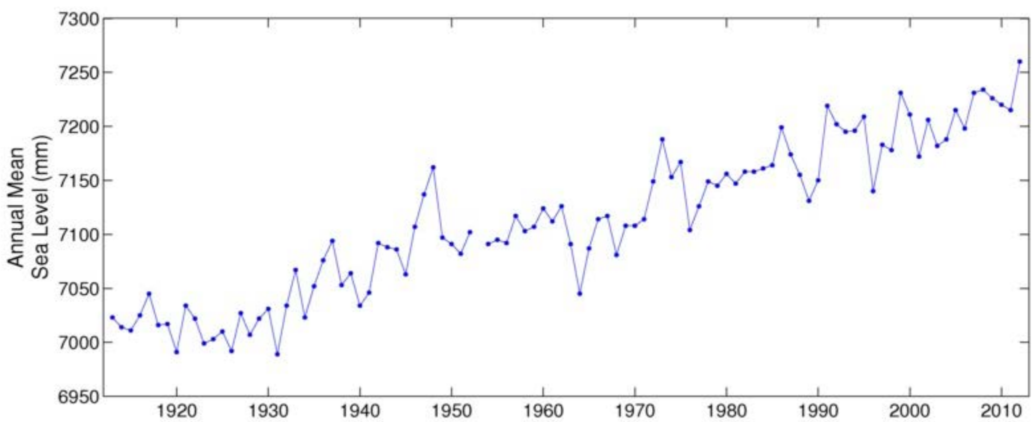

Figure 1. Graph of Annual Mean Sea Level Data 1913-2012 for Key West (from the Permanent Service for Mean Sea Level, http://www.psmsl.org/data/obtaining/, date extracted February 2013/December 2013)

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Coastal Squeeze

Coastal squeeze occurs when an ecosystem, faced with rising sea level, runs out of room to move into shallower waters or drier areas. This can occur in seagrass, mangrove, salt marsh, beach, dune, and coastal forest ecosystems (Figure 2).

Seagrass growth depends on light penetrating through the water. This is affected by the clarity and depth of the water (Corbett and Hale 2006). Sea-level rise will increase the depth of the water at the deep end of a seagrass meadow, potentially putting it out of the reach of the sun's rays. If seagrass meadows do not have room to move to shallower waters, they could be "squeezed out" by sea-level rise.

Mangrove and salt marsh communities are also affected by coastal squeeze. Although mangroves are often seen growing in the water, they are trees that require variation in water levels. They will not survive with their roots completely underwater for extended periods of time because this prevents oxygen from reaching the deeper roots (Odum and Mclver 1990). Salt-tolerant grasses such as smooth cordgrass and black needlerush that are found in salt marshes have similar requirements. As a result, mangrove and saltmarsh communities may disappear as sea level rises if they are unable to migrate landward.

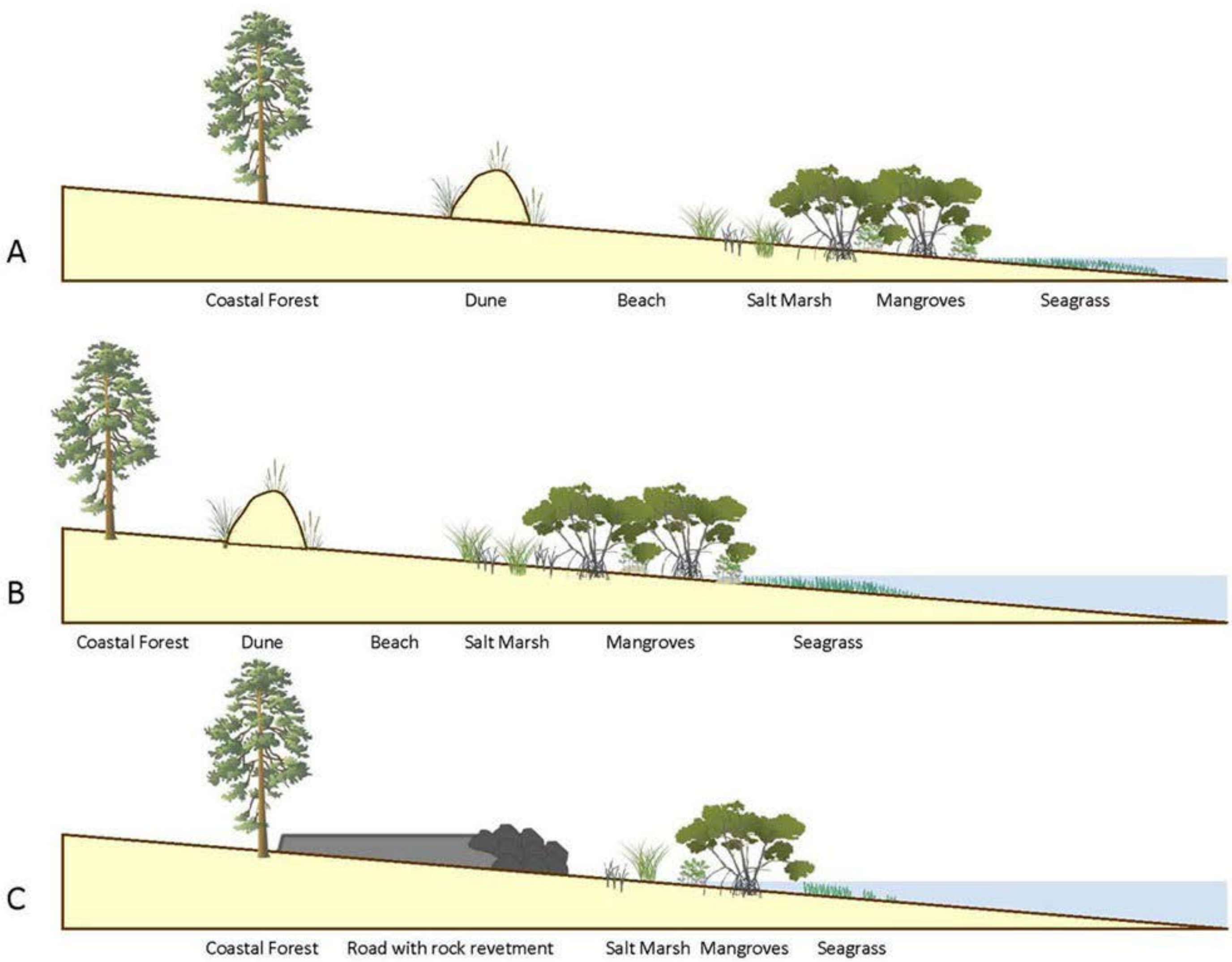

Figure 2. Coastal ecosystem migration is blocked by a road with a *revetment* (a sloping structure on the shore to absorb wave energy). Panel A shows current conditions in an idealized coastal profile. Panel B shows how ecosystems migrate inland as sea level rises. Panel C shows how migration can be blocked by a barrier, such as a road, trapping ecosystems between rising water and the barrier and reducing or eliminating them.
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Erosion

While dunes and beaches can also be "squeezed out," erosion may be more of an immediate threat to these ecosystems. Sea-level rise will raise all tide levels, from low tide to storm surge. Wave action at higher tide levels may cause erosion of sandy beaches. Higher storm surges, which may be accompanied by stronger storm winds, could wash over the tops of sand dunes, flooding the burrows of dune-nesting animals. The combined effects of wind and waves could damage dunes, leaving the beachfront more vulnerable (Figure 3).

Salt Wedge

The combination of fresh water and salt water in estuaries helps make them some of Florida's most productive ecosystems. The height of sea level can affect how fresh water comes down rivers into estuaries. Rising sea level means salt water travels farther upriver, pushing back and intruding into fresh water and increasing the salinity of the river and the estuary (Dixon 2013). If there is a decrease in rainfall, then even less fresh water will flow down the river. This will make both the estuary and the river more salty (Figure 4), affecting the kinds of plants and animals

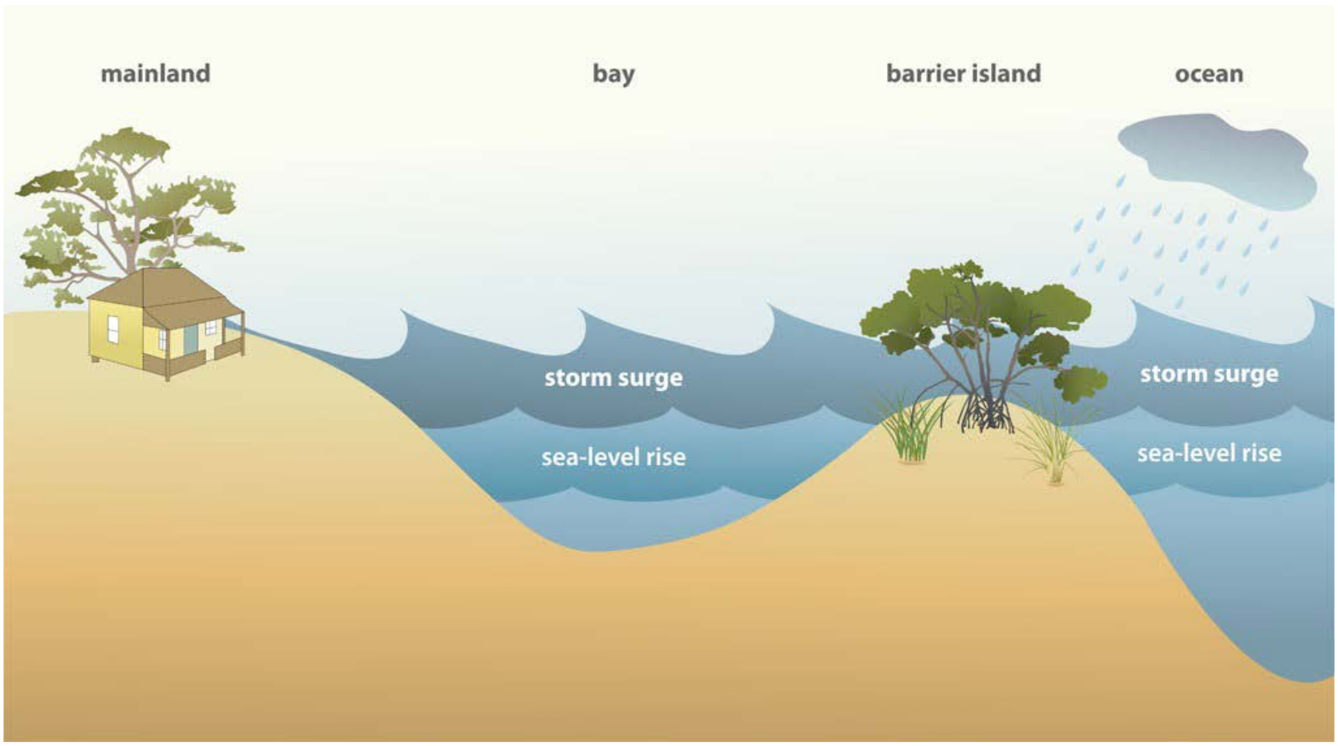

Figure 3. Sea level rise and storm surge could cause erosion of beaches and dunes.
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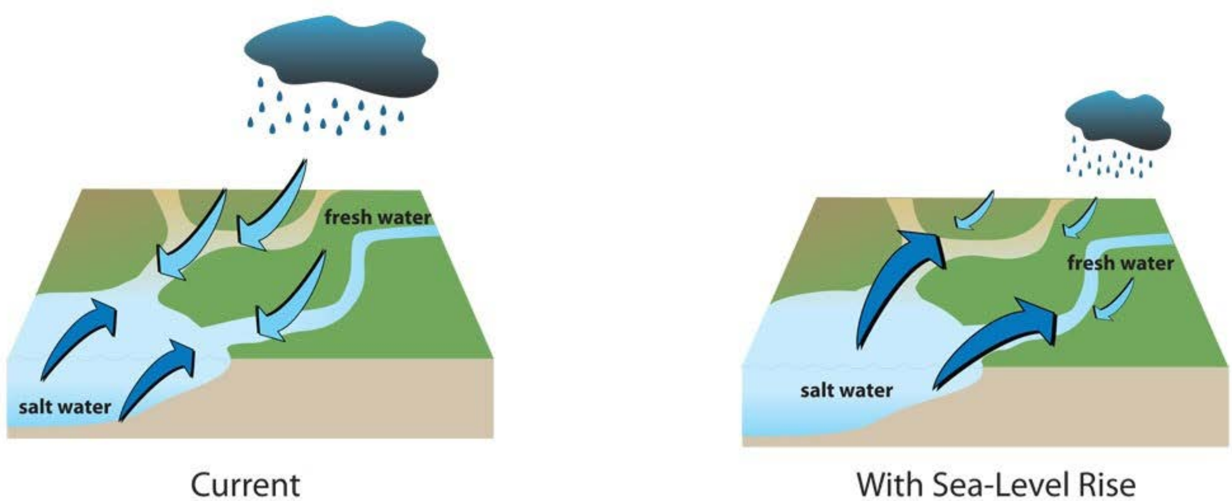

Figure 4. Rising sea level combined with reduced rainfall could make estuaries and rivers more salty.
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that live there. For example, oysters depend on a flow of fresh water to keep predators, such as crown conchs, which cannot tolerate fresh water, at bay. With less fresh water flowing downriver, crown conchs can thrive and decimate the oyster population.

Coastal Forests

Coastal forests, found at the drier, upland edges of coastal zones, may seem to be the least vulnerable to sea-level rise, but saltwater intrusion, longer periods of root inundation, salt spray, and coastal erosion have already had an impact. Putz and others have investigated coastal forest decline and replacement by saltmarsh since the mid-1990s (Putz 2012). They found that coastal forest trees are stressed by increasing amounts of salt in the soil resulting from sea-level rise. Coastal forests may also become refuges for people moving out of more vulnerable waterfront areas. Development of these uplands would reduce the acreage, increase the fragmentation, and decrease the quality of habitat available for animals and plants.

Adaptation

Though sea-level rise may do significant harm to coastal ecosystems, there are actions people can take to help coastlines adapt to new conditions. One activity is planting mangrove and marsh grass buffers along the water's edge. Mangroves and marsh grasses help anchor sand and sediments, keeping the shoreline in place. Mangrove trimming rules and guidelines help property owners keep view corridors intact while preserving habitat for wildlife. Mangroves and marsh grasses also provide a storm buffer between the water and the land.

Waterfront property owners can also transition away from sea walls, eroded shorelines, and other hardscapes to ”living” shorelines. Living shorelines incorporate natural elements like plants, oyster shells, and riprap to absorb wave energy without causing erosion, all of which helps the shoreline to adapt to sea-level rise. Successful living shoreline projects have been completed in Florida. In the Pelican Island National Wildlife Refuge, an island in the Indian River Lagoon, oyster shells were used to create a submerged breakwater, allowing areas to be filled and planted with marsh and mangrove vegetation. These planted areas then expanded naturally, restoring an acre of shoreline that had eroded previously (Figure 5).

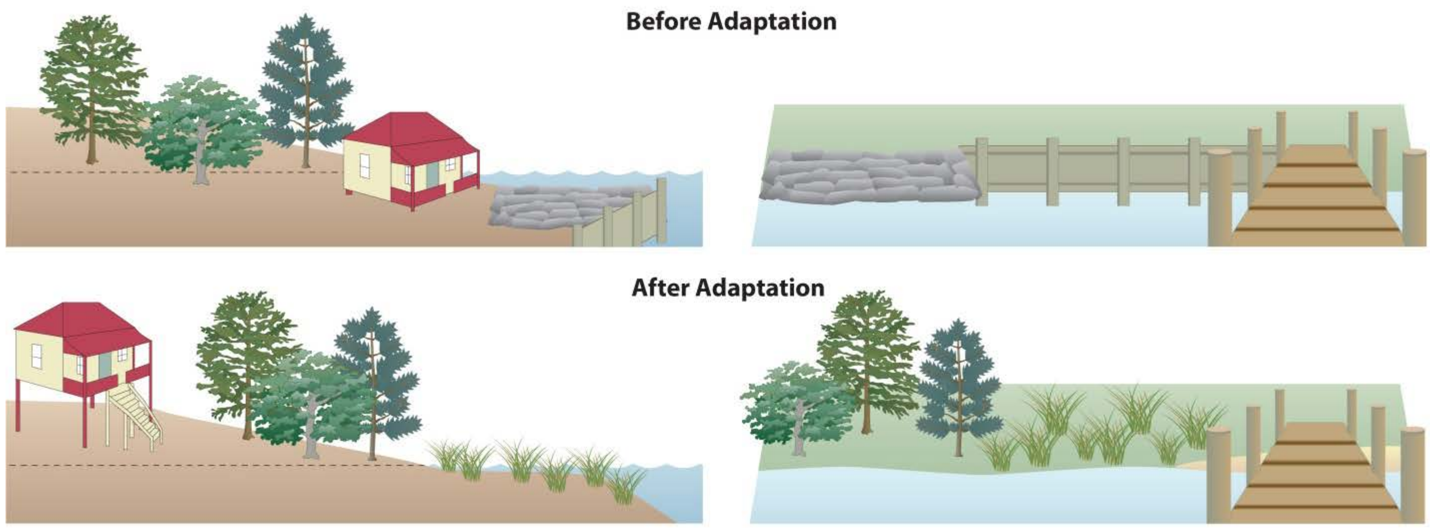

Figure 5. Elevating existing structures and installing living shorelines can help waterfront owners protect their property from climate change while cooperating with nature. Living shorelines accumulate natural sediments that enable coastal ecosystems to migrate inland, away from rising seas.
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Oyster reef restorations can also reduce erosion and help create new habitat. Mesh bags are filled with old oyster shells. When these bags are piled up in the water in locations that are good for oysters, oyster larvae, which float around in the water, land on the shell-filled bags and begin to grow. These new oyster reefs add valuable habitat for other wildlife and create living breakwaters that help reduce erosion.

Making it easier for the natural environment to adapt to sea-level rise is something people can do about the negative impacts of climate change. Coastal clean-ups, for example, remove trash and other man-made debris that can be pulled off the land and into the water by higher high tides and storm tides. Using porous paving materials and features like rain gardens around homes can help stormwater soak into the ground and reduce the runoff that contributes to decreased water clarity and harmful algal blooms.

Communities can take action through comprehensive plan language or land purchases to set aside space where plants and wildlife can migrate unimpeded into open space. University of Florida's Levin College of Law has identified many areas where coastal communities can be proactive. The law school's conservation clinic has provided a series of model policies that can be written into comprehensive plans. http://www.law.ufl.edu/academics/clinics/conservation-clinic/program-areas/coastal-development-ecosystem-change/

Perhaps one of the most important things people can do is to conserve water. If we reduce the amount of fresh water we take out of our lakes and rivers, we reduce the impact of saltwater intrusion.

References

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