Mangrove Carbon Flux Monitoring Project

National Park Service
U.S. Department of the Interior

South Florida Natural Resources Center
Everglades and Dry Tortugas National Parks

As an element upon which all life depends, carbon is in a constant state of flux between our atmosphere, oceans, and land. Such movements are cyclical—alternating between capture and release as carbon fuels the growth and development of living organisms everywhere. Science has revealed, however, that levels of carbon dioxide in our atmosphere presently exceed historic concentrations, slowly altering our climate in previously unimaginable ways. Recent studies in the mangrove community of Everglades National Park help reveal the important role these forests play in regulating global carbon cycles.

Mangrove forests have earned fame for the economic value of the various services they provide to humanity and coastal ecosystems. Growing along the subtropical shorelines of south Florida, they provide vital habitat for a variety of marine life, help stabilize coastal soils, and serve as a first line of defense against tropical storms. The dense mangrove labyrinth that sprawls along the edges of Everglades National Park represents the largest such forest protected in the northern hemisphere.

Many fear these low-lying forests are imperiled by climate change and rising sea levels. Current research in the mangrove ecosystem is shedding new light on how these forests are presently responding to environmental stressors and hurricane disturbance. Recent data suggest the role of mangroves in regulating global carbon cycles far exceeds their aerial extent. The potential loss of these forests due to climate change and sea level rise represents a threat to tropical coastal ecosystems around the world.

Towering Above

Several years ago, park scientists set out to better understand the uptake and storage of atmospheric carbon dioxide (CO_2) in the coastal forests of the Everglades. In June of 2003, a nearly 90-foot research tower was constructed deep in a tangle of mangroves near the Little Shark River. The tower houses several instruments that collect a continuous stream of data spanning an array of environmental variables, including temperature, humidity, wind speed and direction, and solar irradiance. Specialized sensors also record the concentrations and vertical flows of CO_2 every half hour. Long-term measurements of this carbon "flux" provide data on how CO_2 moves between the forest and the atmosphere above.

This research is helping to answer key questions about how mangrove forests around the world will respond to, and interact with, a changing climate. Recent findings suggest these mangrove ecosystems are highly productive and act as carbon "sinks"—removing large amounts of CO_2 from the atmosphere.

Instruments in and above the canopy measure quantities of carbon removed from the atmosphere (top) while mangrove roots, foliage and peat soils store much of this carbon near the ground (below).
Photos by Jordan Barr and Joy Brunk, Everglades National Park

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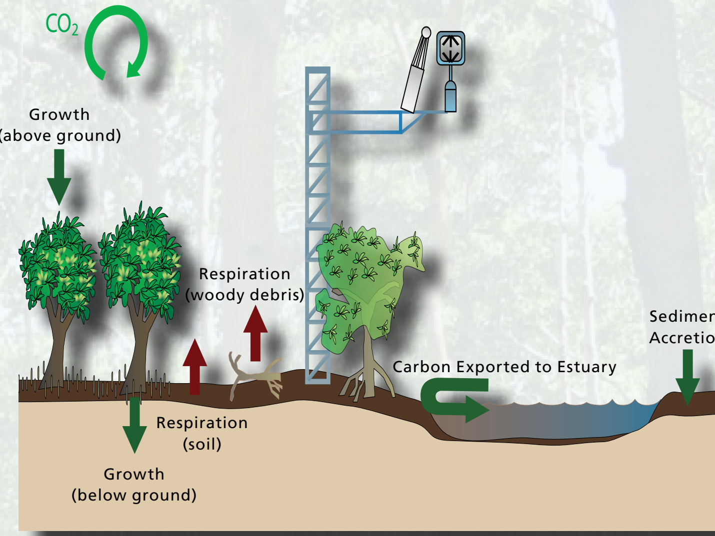
Carbon Cycling Along the Coast

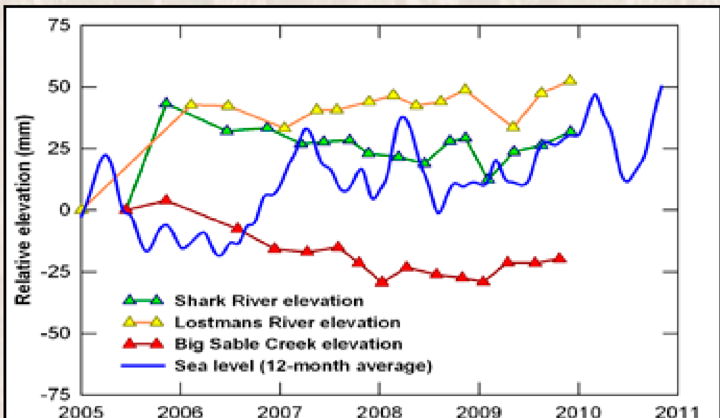
The growth of mangrove forests assimilates CO_2 into plant tissues. Though some of this CO_2 is eventually returned to the atmosphere through decomposition and respiration, regular tidal inundation slows the rate of these processes, trapping carbon within the biomass and peat of the forest floor. Alternating tides also help to export carbon to the estuaries, where it enters aquatic food webs.

Over time, mangrove forests remove large amounts of CO_2 from the atmosphere, thereby reducing the greenhouse effect and ameliorating impacts from land use changes and the burning of fossil fuels. Locally, south Florida's mangrove forests may also serve to delay the effects of sea level rise. As mangroves grow, roots, leaves, and woody debris from the trees enter the soil and are stored in the peat, resulting in an increase in surface elevation that acts as a barrier to salt water intrusion.



Various ecosystem processes contribute to yearly net CO_2 exchange.
Image courtesy of Jordan Barr & Larry Perez, NPS

Soil Accretion vs. Sea Level Rise



Years of elevation data from three sample sites in Everglades National Park show distinct differences in how each is responding to environmental change in the mangrove forest.
Data courtesy of Tom Smith III, USGS

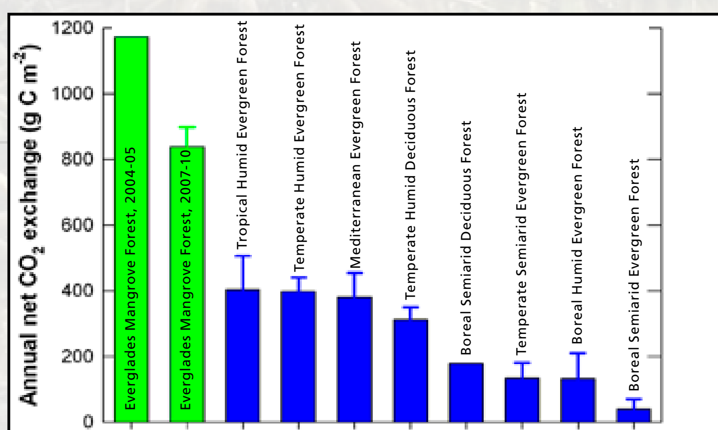
South Florida's coastal communities are in the midst of rapid change. For nearly a century, the region has experienced an average rise in sea level of 2.3 millimeters per year—a rate far faster than that which originally allowed for the formation of the mangrove forest. The impact of rising seas may also be compounded by the actions of stronger and/or more frequent tropical storms brought about by a changing climate.

Can the mangrove forest successfully keep pace with sea level rise? When elevation is viewed against recorded sea level, data from three sample sites reveals some variability. Some sites, aided by sediment deposits from passing storms, are faring well. But storm damage, erosion, and soil compaction noted in other areas closer to the Gulf of Mexico suggest some cases where the forests are not regenerating. Long-term studies are critical for gauging the ongoing response of mangrove forests in south Florida to climate change.

Net CO_2 Uptake and Salinity

Mangrove forests have been observed to remove CO_2 from the atmosphere at rates much greater than those known from other terrestrial ecosystems. Because they are typically inundated twice daily by high tides, mangrove peat substrates are often anaerobic environments that suppress the decomposition of soils, leaves, and woody debris, and reduce the release of CO_2 back into the atmosphere. Thus, mangrove systems are uniquely capable of retaining large amounts of the carbon they absorb.

However, research in Everglades National Park reveals that the productivity of south Florida's mangrove coast decreases as the forest is exposed to greater salinity. The continued capacity of the mangrove system to trap carbon in the sediments of the forest floor and keep pace with the effects of a rising tide may well depend upon continued Everglades restoration efforts aimed at sending additional freshwater flows to the coast.



Net CO_2 exchange (the difference between how much carbon dioxide is captured and how much is returned to the atmosphere) is notably higher in mangrove forests than many other ecosystems.
Mangrove data courtesy of Joran Barr, Vic Engel, & Jose Fuentes, NPS
All other data courtesy Luyssaert, et al., 2007