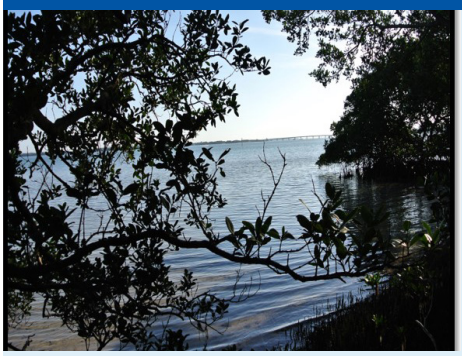


Using Advanced Mapping to Measure Changes in Mangrove Habitat Over Time

Project Location

Rookery Bay National Estuarine Research Reserve, Florida

Project Duration

September 2018 to November 2019

Project Lead

Frank Muller-Karger
University of South Florida
carib@usf.edu

Matt McCarthy
University of South Florida
mjm8@mail.usf.edu

Brita Jessen
Rookery Bay Reserve
brita.jessen@dep.state.fl.us

Project Type

Catalyst – Targeted investment for advancing collaborative science

Products

- Habitat maps that show habitat change over time
- Training manual and guide to create habitat maps from WorldView and Landsat satellite imagery
- Story map about habitat mapping at Rookery Bay

Project Partners

- Rookery Bay National Estuarine Research Reserve
- University of South Florida

Project Webpage

nerrssciencecollaborative.org/project/MullerKarger18

Overview

In recent years, coastal vegetation loss has accelerated in the Rookery Bay National Estuarine Research Reserve and other parts of southern Florida. These losses are a result of chronic stresses from watershed alterations, sea level rise, and invasive species, along with acute impacts from extreme events like hurricanes. Reserve managers seeking to build the resiliency of these habitats expressed a need for new ways to determine the location and extent of gradual habitat changes and storm-related damage. Traditional methods of habitat mapping that rely on field work and human interpretation are often unable to provide quick and accurate maps to guide watershed-scale management actions.

In this project, a team of University of South Florida College of Marine Science researchers and Rookery Bay Reserve staff tested a new high-resolution, automated mapping technique. The team updated habitats for the 110,000-acre Rookery Bay Reserve, evaluated habitat change over the period of 2010 to 2018, and assessed the effects of Hurricane Irma, which hit the reserve in 2017. These maps have enabled reserve staff to better understand the extent of mangrove decline resulting from chronic stress and extreme events.

Project Approach

The project team piloted a mapping technique that combines high-resolution satellite images, field observations, and high-speed computation. Researchers from the University of South Florida used high-resolution WorldView-2 satellite images, medium-resolution Landsat satellite imagery, and LiDAR data to map habitats over an eight-year period. A field survey of the reserve was conducted from September to December 2018 to collect ground reference points of specific target habitats (i.e., healthy mangrove, degraded mangrove, upland, soil, and water) to validate the habitat maps. The team used Python and MatlabTM software on high-speed computers to process these massive data quickly. Existing habitat maps were used to refine existing University of South Florida algorithms to create annual terrestrial habitat maps for 2010, and for 2016 to 2018, that were then used to assess habitat change.

An advisory group made up of representatives from the Rookery Bay National Estuarine Research Reserve, Ten Thousand Islands National Wildlife Refuge, Collier-Seminole State Park, Collier County Stormwater Management, South Florida Water Management District, and the Institute for Regional Conservation guided objectives, discussed management applications, and reviewed results.

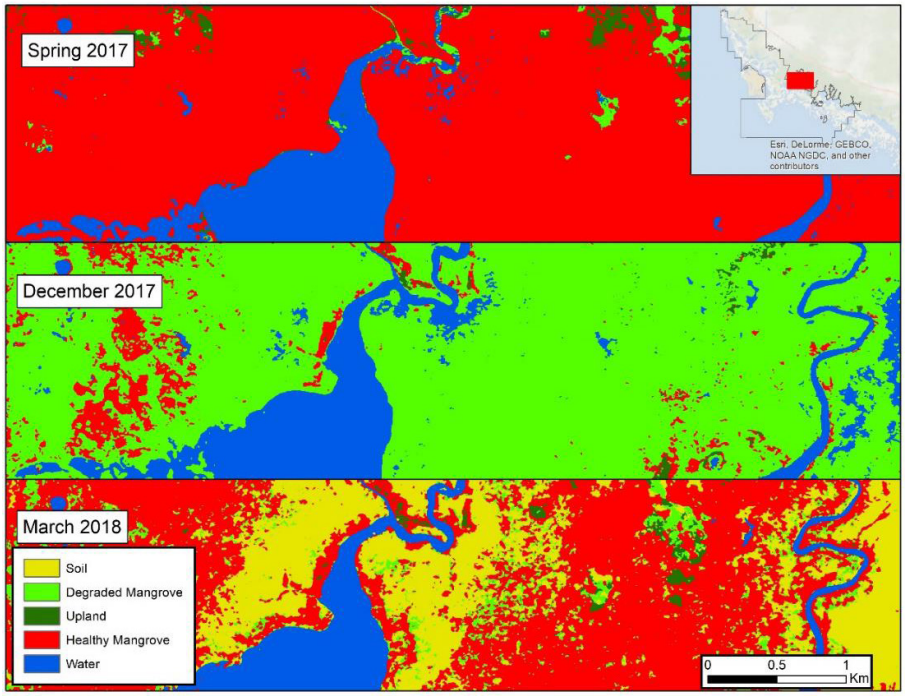
Results

The project demonstrated the capacity of advanced computational technology to complete habitat mapping at a rate of approximately six minutes per image, 200 times faster than traditional methods. Habitats were accurately identified (with an average accuracy of 82 percent) and could be mapped seasonally at two-meter resolution. Overall, the team found this method to be suitable to examine large-scale change after severe impacts like hurricanes, and to provide a snapshot of seasonal mangrove recovery and die-off patterns that can be used to guide habitat conservation and restoration efforts.

The team identified several limitations and challenges of this computational method of habitat mapping. Satellite imagery is limited to specific time frames and image quality can vary due to cloud cover or other factors. For instance, in addition to mangrove habitat, the project had intended to map seagrass, but was unable to do so as a result of extreme water turbidity. While habitats were accurately identified in satellite images 82 percent of the time, some habitat types were more accurate than others. Impacted mangrove habitat had the lowest accuracy, at 56 percent.

Time-series maps revealed patterns of decline throughout the reserve prior to Hurricane Irma, as well as event-induced damage, and subsequent recovery one growing season later. Within the Rookery Bay Reserve study area, the team found a net loss of healthy mangrove forest of 22 percent (6.85 km2) from spring 2016 to fall 2018. Hurricane-related damage accounted for approximately 73 percent (4.97 km2) of this total loss. The team found that one year after Hurricane Irma, 35 percent (1.73 km2) of the damaged mangrove forest had recovered, while 32 percent (1.6 km2) had converted to bare soil.

The maps also showed trends in storm damage and recovery that can help guide targeted resiliency planning. Mangrove islands appear to be exceptionally vulnerable to decline in low-elevation basins, but remain resilient along their fringes. Mainland mangrove stands, in contrast, were more vulnerable along some fringes that received large amounts of overwash deposits, whereas inland areas sheltered from the deposits recovered faster. Areas adjacent to tidal inlets also appear vulnerable, but displayed unexpected patterns of delayed mortality and recovery.



Satellite maps of this subset of the study area show healthy mangrove dominating the reserve in early 2017 (top), degradation following Hurricane Irma (center), and patterns of recovery or loss by the following spring (bottom)

Benefits

- The project demonstrated the potential of satellite and computational methods for habitat conservation and management applications. These methods can supplement traditional field-based habitat mapping processes and may be especially useful to perform quick assessments of habitat damage and recovery following extreme events like storms. As technologies advance to offer higher resolution mapping over larger scales, the groundwork laid by this and other projects opens the door for more effective habitat mapping that can be tailored to management needs.
- Staff from Rookery Bay Reserve and adjacent sites were trained in how to generate and interpret the new habitat maps. The manual will enable future applications of this approach, and a story map helps explain the patterns of habitat change to a broad audience.
- Rookery Bay Reserve managers improved their understanding of critical habitat change dynamics, particularly with respect to storm damage and recovery. The reserve has used the project's findings to inform additional research into long-term recovery and resilience and to guide management actions. For example, the maps have helped pinpoint the timing and causes of changes and informed plans for the Fruit Creek Restoration Site.
- The project fostered new and valuable relationships between the reserve system and University of South Florida researchers. For example, Rookery Bay Reserve recently became part of the South Florida Marine Biodiversity Observation Network.

What's Next

- University of Florida researchers are working to further evaluate project results compared to independent in-situ monitoring data from the Florida Fish and Wildlife Research Institute. They hope to develop methods to use satellites to map more habitat and vegetation types with greater specificity, including the ability to identify different mangrove species.
- The project team has submitted new grant proposals to expand this satellite mapping method to additional sites within the National Estuarine Research Reserve System, and to work with Jobos Bay Reserve in Puerto Rico to compare the effects of Hurricanes Irma and Maria.
- The project's new satellite mapping methods sparked new collaborations with other computational research groups.

About the Science Collaborative

The National Estuarine Research Reserve System's Science Collaborative supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is managed by the University of Michigan's Water Center through a cooperative agreement with the National Oceanic and Atmospheric Administration (NOAA). Funding for the research reserves and this program comes from NOAA. Learn more at nerrssciencecollaborative.org or coast.noaa.gov/nerrs.