Dataset: Total live mangrove coverage and annual NDVI classifications for the mangrove die-off region based on Landsat 5 and 7 transformed imagery.

Project(s): An interdisciplinary approach to elucidating the causes of widespread mangrove die-off (Mangrove Die-off)

Abstract: These data were compiled to better determine when the mangrove die-off began. NDVI values of 0.2 or greater correspond to live mangrove cover. These data suggest the mangrove die-off may have started in 2008 and was exacerbated in following years with some recovery in 2013. Live area was calculated by determining the area of the die-off region with NDVI values greater than 0.2. For a complete list of measurements, refer to the supplemental document 'Field_names.pdf', and a full dataset description is included in the supplemental file 'Dataset_description.pdf'. The most current version of this dataset is available at: http://www.bco-dmo.org/dataset/720270

Description: Total live mangrove coverage and annual NDVI classifications for the mangrove die-off region.

These data were compiled to better determine when the mangrove die-off began. NDVI values of 0.2 or greater correspond to live mangrove cover. These data suggest the mangrove die-off may have started in 2008 and was exacerbated in following years with some recovery in 2013. Live area was calculated by determining the area of the die-off region with NDVI values greater than 0.2.

Acquisition Description: Landsat 5 and 7 annual NDVI composites from 1989 to 2013 were acquired from the Google Earth Engine website. Handheld GPS units (Garmin etrex 20) were used to outline and ground truth the mangrove die-off area in June 2014. Historical hurricane tracks were acquired from the National Oceanic and Atmospheric Administration (NOAA) Digital Coasts website.

Die-off GPS outline.CSV: This file consists of GPS coordinates collected by a handheld GPS of the die-off area. This was used to create a shapefile of the die-off area in GIS.

Processing Description: For Landsat NDVI composites: Years with severe cloud cover were removed from the dataset resulting in the exclusion of 1990 and 2003. Images were transformed to Normalized Difference Vegetation index (NDVI) following Chander, *et al.* [22] by USGS. We used coordinates from handheld GPS units to create an outline of the die-off area as a shapefile using ArcMap 10.3.1. This shapefile was checked against a basemap of the Caribbean produced by the U.S Geological Survey (USGS) and high-resolution imagery from WorldView-2 (http://www.satimagingcorp.com/satellite-sensors/worldview-2/). Annual NDVI composites from each year were clipped to the shapefile in ArcMap 10.3.1. NDVI was reclassified into five categories (Table I). Area of each reclassified NDVI

category was calculated for every year in the die-off region using R (version 3.4.1). NDVI values categorized as yellow and pale yellow (0.2-0.5, 0.5-0.7, respectively) were considered as live mangrove. Historical hurricane tracks were filtered such that only storms that directly passed over Abaco Island between 1984 and 2013 were included in our study (Table II). We constructed a time series of live mangrove vegetation cover and of maximum annual NDVI from 1989-2013 in R (version 3.4.1). Maximum annual NDVI was chosen to ensure minor cloud cover did not affect the overall values and reflects the maximum NDVI value over the entire die-off area. We then superimposed hurricane events on the time series to determine if a pattern between storm events and changes in mangrove cover and maximum NDVI were evident.

BCO-DMO Data Processing Notes:
-Reformatted column names to comply with BCO-DMO standards
-Replaced blanks with nd

Project Information

An interdisciplinary approach to elucidating the causes of widespread mangrove die-off

Foundation species are those that form the basis for entire ecosystems, substantially altering the physical and biological characteristics of the areas in which they are found. Mangroves are one of the most conspicuous groups of foundation species, providing numerous ecosystems services which we highly value, e.g., habitat for ecologically and economically important species, shoreline stablilization and carbon storage. As such, global declines in mangroves is of upmost concern. For example, an extensive die-off of dwarf red mangrove has been identified in a remote area on the west side of Abaco Island, The Bahamas. Because of its remote nature of the site, the die-off is unlikely to be directly due to human activities. Despite its largely inaccessible nature, the area is ecologically and economically important, e.g., it is the primary bonefishing area on Abaco - an industry worth more than $150 million annually in The Bahamas. Therefore, it is of pressing concern for stakeholders in The Bahamas to identify the underlying cause(s) of decline and assess potential threat to mangroves in other areas. To do so, a series of activities will be carried out, included widespread surveys for a recently identified fungal pathogen, laboratory efforts to isolate and identify this pathogen, satellite imagery mapping activities, and simulated grazing experiments. The area in which the die-off is occurring is currently being considered for designation as a national park by the Bahamian National Trust (BNT). The results of the study will be directly communicated to the BNT and will be used to make immediate management decisions. In collaboration with two Bahamian environmental NGOs, Friends of the Environment and Bahamas Reef Environmental Education Foundation (BREEF), a citizen science-based survey for fungal lesions, as well as an educational module on mangrove ecology, will be designed. The data from the citizen-science

and student surveys will be integrated in a map of the incidence of the lesions across The Bahamas. The citizen-science component, and interaction with bonefish guides, provides the opportunity to further integrate science and education. The educational module will be introduced at the BREEF summer teaching training workshop in July. This annual event typically includes 30 teachers from 10 islands. The investigators will continue to make all of our research findings immediately available and accessible to the public through the Abaco Scientist website (http://appliedecology.cals.ncsu.edu/absci/). Provisioning of ecosystem services in the coastal realm is largely mediated by foundation species, such as mangroves, coral and salt marsh grasses. Many of these species are undergoing substantial declines throughout the world. These declines are often driven by complex, interacting, stressors that may be difficult to identify and elucidate. Despite the difficulty, unraveling such mechanistic drivers is essential for stemming declines and developing management strategies for these ecosystems. Mangroves provide many highly valued ecosystem services to coastal communities, yet worldwide these forests are rapidly declining. Much of this loss is related to various human activities along coastlines, but natural ecological mechanisms contribute to declines in many areas as well. An extensive die-off of dwarf red mangrove (Rhizophora mangle) was observed in a remote area on the west side of Abaco Island, The Bahamas. Preliminary observations suggest the die-off may be due to a combination of fungal pathogens, grazing, and physical stress. This combination of stressors is strikingly parallel to the drivers of salt marsh decline on the East and Gulf coasts of the U.S. To date, different fungal strains from mangrove leaves have been identified. One fungus is a species of Pestalotiopsis, an Ascomycete fungus, and members of this genus are known plant pathogens. There are also high densities of a nocturnally active herbivorous cricket (Tafilasca eleuthera) in die-off areas. It is unclear whether this species has recently colonized the area, is increasing in density, or both. In addition, high salinities in the sediment porewater in the die-off area suggest another potential stressor for the plants. A series of observations and experimental studies will be used to examine potential mechanistic drivers of the mangrove die-off. First, the extent of the die-off areas will be mapped using aerial surveys conducted with a GPS-integrated drone equipped with a video camera. Progression of the die-off will be examined with historical spectral profiles of mangroves from 1980s-present (on an annual basis) using Landsat satellite data. Second, the incidence of lesions on mangroves across Abaco Island and throughout The Bahamas will be explored using a series of citizen science initiatives. Third, identification of fungi will require DNA sequencing and examination of the morphology of fungal spores/conidia at North Carolina State University. Fourth, maintenance of a grazer exclusion experiment near the die-off location will provide an assessment of the role of herbivory in this system. Finally, simulated grazing scar experiments will be used to assess if grazing can indeed facilitate fungal infections.

Deployment Information

Deployment description for shoreside Abaco_Island Mangrove_dieoff

These coordinates compose the outline of the die-off area. These points were collected with a Garmin eTrex handheld GPS by walking or boating along the edges of the die-off region.

Instrument Information

Instrument	Garmin etrex 20
Description	Handheld GPS unit used to outline and ground truth the mangrove die-off area
Generic Instrument Name	GPS receiver
Generic Instrument Description	Acquires satellite signals and tracks your location.