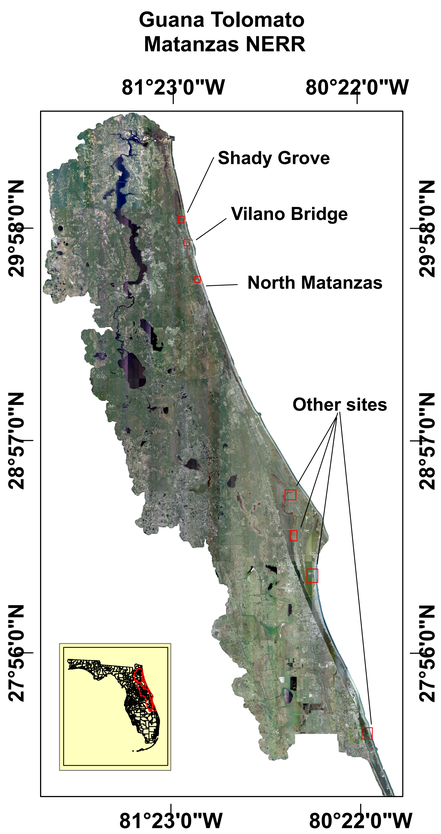
Changes in Mangrove/Saltmarsh Ecosystems and Their Upscale to Regional Levels in a Changing Climate

Wilfrid Rodriguez, Ilka C. Feller, Kyle Cavanaugh
Smithsonian Environmental Research Center, Edgewater, MD

Figure 1.



MANGROVE EXPANSION AT NORTH MATANZAS

Figure 2.

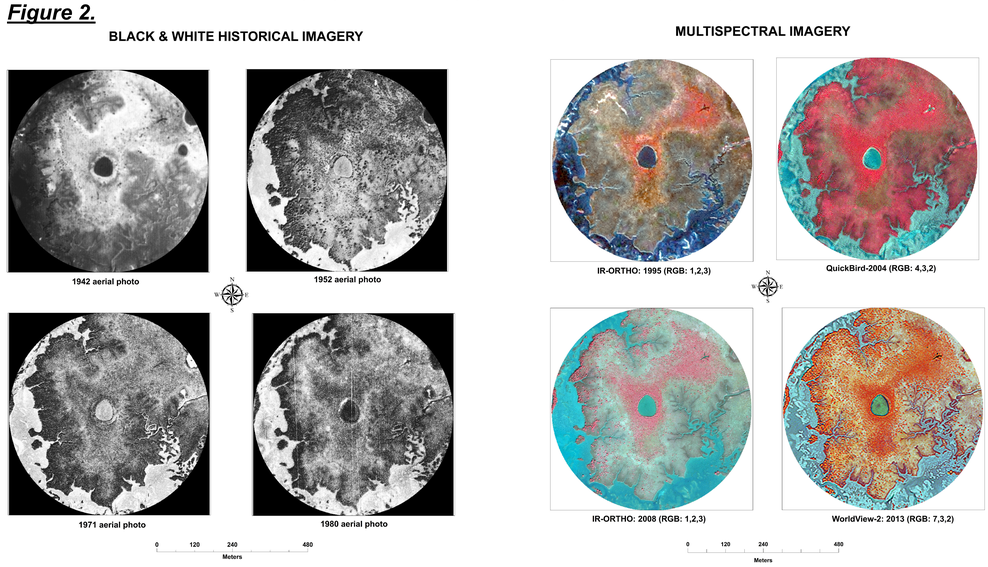


Photo-interpretation and mapping
Average Overall Accuracy = 91.0 %
Average Kappa Statistics = 89.5 %

NDVI computation, ISODATA classification, and mapping
Average Overall Accuracy = 83.0 %
Average Kappa Statistics = 87.0 %

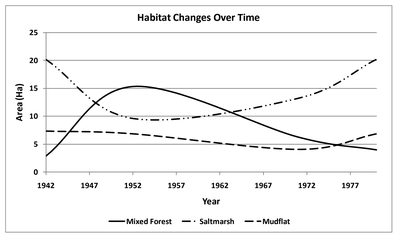


Figure 3.

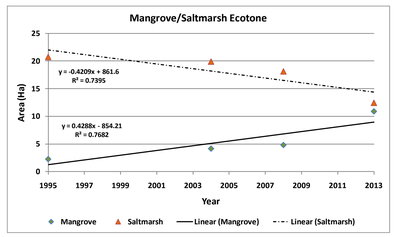
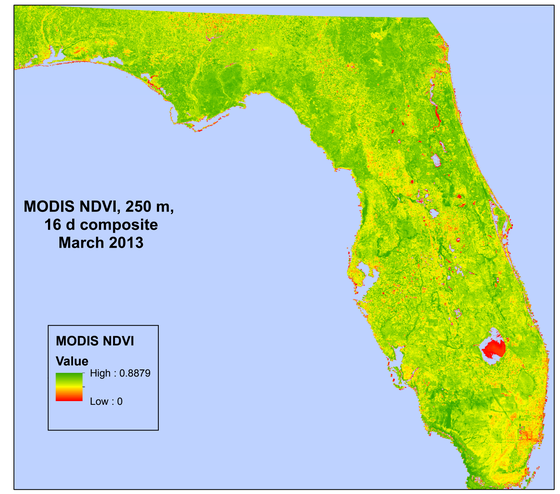


Figure 4.

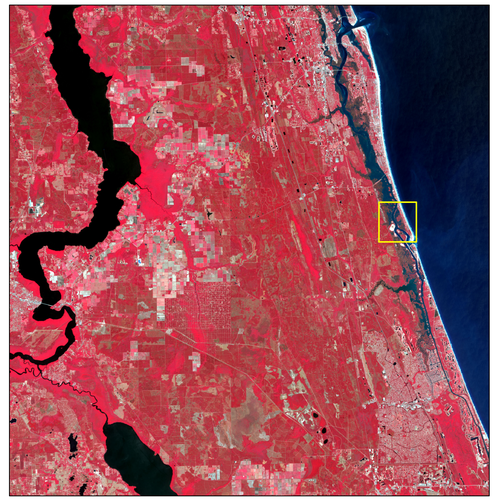
UPSCALE OF BIOPHYSICAL VARIABLES

Figure 5.

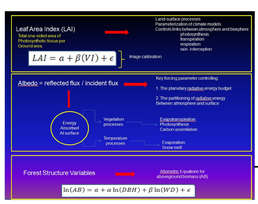
Regional Level
Coarse Resolution
MODIS
Pixel: 250 m - 1 km



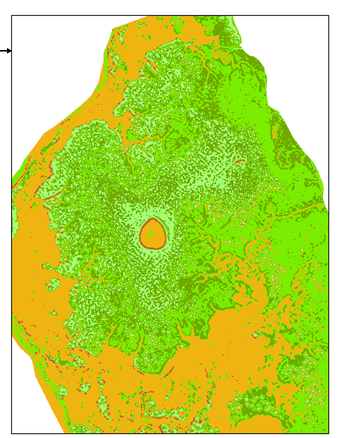
Landscape Level
Moderate Resolution
Landsat 8
Pixel: 15 - 30 m



Coarse Resolutions



Field/Forest Stand Level
High Resolution
WorldView-2
IKONOS, QuickBird
GeoEye
Pixel: 0.50 - 2.00 m



Y_lai = 1.8764 + 5.2002 (NDVI)

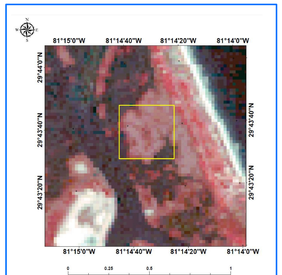
INTRODUCTION: Climate change at global and regional scales affects the spatial and temporal variability of temperature and precipitation. Both temperature and rainfall are known to influence the distribution of mangrove species (Duke et al. 1998). Recent studies have shown that the ongoing expansion of mangroves near their northern range limit is most probably due to reduction in the frequency of extreme cold events (Cavanaugh et al. 2014). Climate change impacts on biodiversity, structure and function, landscape fragmentation, and other ecological interactions between mangroves and saltmarsh ecosystems are not well quantified or understood. One of our goals is to characterize and quantify the effects of climate change on the relationships between landscape patterns and ecological processes in these important coastal ecosystems.

STUDY AREA: North Matanzas (Figs. 1, 2) on Anastasia Island is one of several field sites located within the mangrove/saltmarsh ecotone in Guana-Tolomato-Matanzas National Estuarine Research Reserve (Fig. 1).

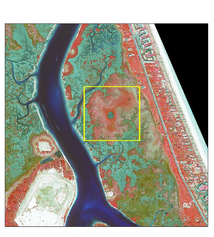
IMAGERY: Historical B&W aerial photography and multispectral/multisensor data (Fig. 2) were used to quantify mangrove/saltmarsh expansion and encroachment at local spatial scales. The Normalized Difference Vegetation Index (NDVI) was computed, using raw radiances (DN), to quantify and map the spatial distribution and areal changes of mangroves, saltmarsh, and non-vegetated areas from 1942 to the present (Figs. 3, 4).

REFERENCES
Cavanaugh KC, JR Kellner, AJ Ford, DS Gruner, JD Parker, W Rodriguez, and IC Feller. 2014. Poleward expansion of mangroves is a treshold response to decreased frequency of extreme cold events. Proceedings of the National Academy of Sciences 111:723-727.

Duke NC, MC Ball, JC Ellison. 1998. Factors influencing biodiversity and distributional gradients in mangroves. Global Ecology Biogeography 7:17-47.



Landsat TM (RGB:4,3,2), Pixel: 30 m



WorldView-2 (RGB:7,5,3), Pixel: 0.50 m

Coarse vs. High Resolution Data

METHODS: Calibration of ground measurements to large areas consisted of a multistep 'bottom-up' image aggregation and regression modeling at the patch level. Biophysical variables (LAI, fAPAR, Albedo) were upscaled from field level measurements to landscape and to regionall spatial scales (Fig. 5). To estimate LAI at the local level we used an empirical model that regressed LAI field measurements (LICOR LAI 2200) against NDVI derived from high-resolution data from the WorldView-2 sensor. The regression model was fitted to the NDVI image to calibrate LAI estimates at the North Matanzas site. For regional scales we are using MODIS NDVI and LAI time series. MODIS data were acquired from glovis.usgs.gov, mosaicked, subset, re-projected to UTM coordinates, rescaled, and mapped. WorldView-2 and Landsat 8 data were radiometrically corrected before computation of NDVI and subsequent estimation of LAI. Atmospheric correction was done using the dark pixel method, DN values were then converted to TOA radiance, followed by conversion to TOA reflectance.

RESULTS: Results of land cover classification showed an increase in mangrove extent of 79 % (8.61 ha), with a concomitant decrease in saltmarsh area of 67 % (8.28 ha) between 1995 and 2013. The rate of increase in the spatial extent of mangroves at the North Matanzas site was approximately 0.42 ha per yr (Fig. 4), which was equivalent to the rate of decrease in saltmarsh area. These data provide evidence that mangroves have expanded since 1995 at the expense of saltmarshes. Upscaling of biophysical variables is ongoing.

ACKNOWLEDGMENTS: Project funded by the NASA Climate and Biological Response Program (NNX11AO94G).