

INTRODUCTION TO REMOTE SENSING: Responses to Sea Level Rise in South Carolina

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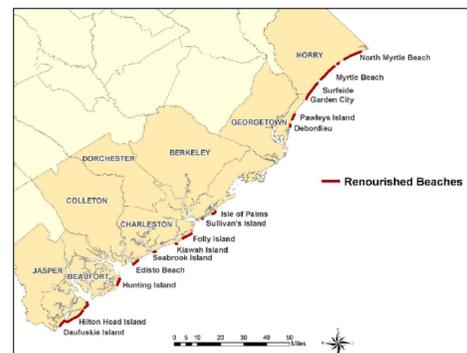
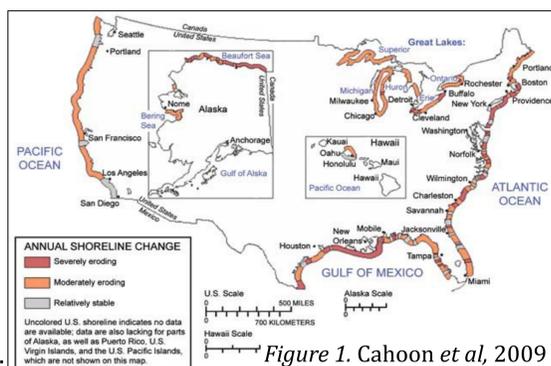
Project Objectives

This project will assess the effectiveness of the programs and mitigation strategies instituted by the coastal communities of South Carolina in response to sea level rise.

Background Information

Shorelines, barrier islands and wetlands along the Atlantic coastline have been migrating continuously landward over time due longshore wave currents, sea level rise, storms and other natural processes (Schwab *et al.*, 2009). However, due to rapid urbanization, the onset of fixed infrastructure has prohibited the migration of these geological features resulting in a net decrease in shoreline and wetlands area. These features as natural barriers to storms and flooding due to sea level rise (London *et al.*, 2009). Sea level rise increases a community's susceptibility to flooding, which can cause fatalities, property damage, ecosystem damage and impairment of drinking water supply (NAST, 2000).

South Carolina's shorelines can be characterized by its barrier islands and spits that populate much coast. The migration of these features inland can be attributed to seasonal changes in wave action. According to a USGS report, the South Carolina coastline is considered to be moderately to severely eroding (figure 1). Additionally the rate of sea level rise was approximately 3.28 mm/year (Cahoon *et al.*, 2009).



In response to rapid coastal erosion, the state of South Carolina developed the Beachfront Management Act in 1988, which has resulted in gradual development retreat landward and several beach renourishment programs as a form of erosion control (SCDHEC, 1988). Research has found that beachfronts included within the Beachfront Management Act has experienced a net increase area, while unincorporated beachfronts have experienced a net decrease in area (London *et al.*, 2009).

Figure 2. Beaches that have undergone renourishment projects (London et al, 2009).

Site Area

The area of study is the northern portion of the South Carolina coastline with a total area of a little over 3,000 mi², which includes eleven different counties. The population within the study area has increased by 66% from 1980-2007 (London *et al.*, 2009).

Research has shown that since the enactment of the Beachfront Management Act, coastlines have experienced a net increase of 646 acres of beachfront within the study area.

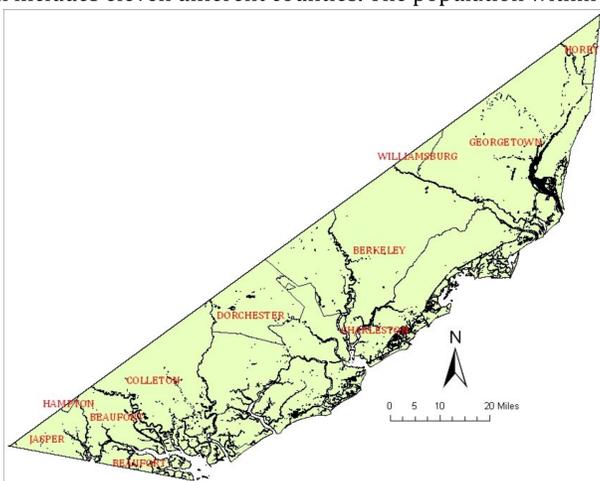


Figure 3. Counties in South Carolina that are within the boundaries of the study area.

Methodology

Landsat-TM images from 1984, 1994, 2001 and 2009 were obtained for a portion of the coastal region of South Carolina. The images obtained were classified for urban/bare soil, vegetation, wetland and water regions using Maximum Likelihood supervised classification techniques. Changes in these land use types were then calculated between each year. Post-classification comparison change detection techniques. All image processing was done using ENVI software.

To predict the land use distribution in 2025, simple linear regression models were developed using time and land use type. Model parameters were estimated using least squares regression.

The figures below show the original clipped images prior to classification for each year. The images are displayed in false color to highlight urban/bare soil and vegetative areas.

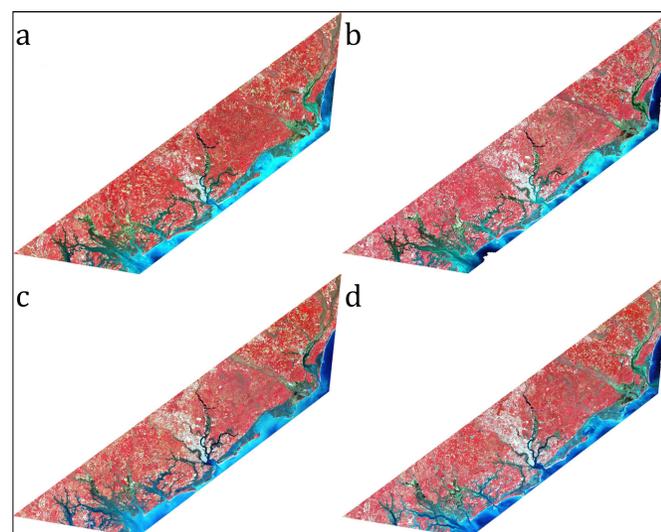


Figure 4. The clipped images for years a) 1984, b) 1994, c) 2001, and d) 2009. The areas in red indicate vegetative areas, while regions of light blue and white are regions of urban/bare soil.

Classification

Figure 4 displays each of the images classified. The images show the migration of each land use type. Urban/bare soil areas are moving landward and there is an apparent increase in wetlands along streams and the coastline. The accuracy of the 1994, 2001, and 2009 images were over 90%, while the accuracy of the 1984 image was only 83%.

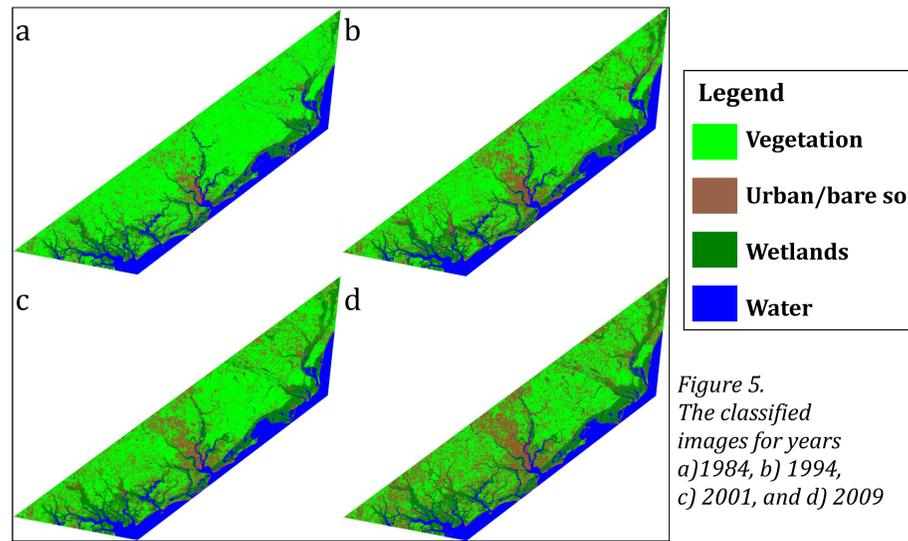


Figure 5. The classified images for years a) 1984, b) 1994, c) 2001, and d) 2009

Results

The changes are quantified using change detection methods. The table below lists the total area of land, vegetation and wetlands for each year and the net change over the entire 25 year period. It was found that the wetland and urban/bare soil area has increased from 1984-2009, while the amount of vegetation has decreased during this time period.

Year	Urban/bare soil (mi ²)	Vegetation (mi ²)	Wetlands (mi ²)
1984	367	2373	568
1994	712	1990	597
2001	701	1972	655
2009	981	1677	690
Net change (mi ²)	614	-696	122
Net change (%)	167%	-23%	22%

Predictions for 2025

For this initial study, simple linear models were developed for each of the land use types relating land use (y) to time (x). The models are listed in the table below along with their R² values as well as the projected areas for the year 2025.

Land use type	Model	R ²	Area in 2025 (mi ²)
Urban/bare soil	$y = 25.114x - 49482$	0.8873	1374
Vegetation	$y = -28.855x + 59648$	0.9091	1216
Wetlands	$y = 5.7976x - 10955$	0.9817	785

The models were used to estimate approximate values of each land use in the year 2025, assuming a linear temporal relationship.

Based on the spatial patterns seen in figure 5, it may be assumed that the urban/bare soil areas would continue to expand landward and wetlands would develop along the coastlines; however, a spatial model would help planners forecast regions of future development and determine regions prone to flooding. A more extensive analysis on the dynamic relationship between land use development over time would also greatly improve the models. Factors such as population, economics and ecological growth rates should be considered to develop a more accurate model.

Conclusions

The findings of this study and previous research suggest the Beach Management Act has had a tremendous effect on the coastline of South Carolina. Urbanization and a tourist economy has promoted the migration of development shoreward, increasing risks of flooding from hurricanes and sea level rise. However, with the beach nourishment and retreat of development, the coastline has been able to build up its wetlands, a natural barrier to floods and extreme hydrological events, as well as its beachfronts, which will undoubtedly have a positive effect on the livelihood of coastal communities and tourist economy.

References

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