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Changes in Vegetative Land Cover in Rhode Island between 1999 and 2011

Problem Statement

After 20% of the land area in Rhode Island was slowly developed over 334 years, another 9 percent of the state was developed in the 25-year period from 1970 to 1995. The Rhode Island Department of Administration Division of Planning responded to increasing urbanization by including “sustaining the urban-rural distinction” and “statewide systems of green space, community design and infrastructure” as two major concepts in the Statewide Planning Program released in 2006 (Land Use 2025: Rhode Island State Land Use Policies and Plan, 2006). Addressing these themes protects the green space and rural areas that are valued by citizens of the state. The purpose of this work is to explore **how the extent of vegetative land cover has changed in the past ten years in Rhode Island.**

Data Set

Landsat TM scenes (level L1T) containing Rhode Island (figure 1) were obtained through EarthExplorer (http://earthexplorer.usgs.gov/). Images from summer months in the years surrounding the years 2000 and 2010 were explored to find scenes with low cloud cover. Of the summer scenes with low cloud cover, dates were checked to find scenes as close to anniversary dates as possible. July 15, 1999 and July 16, 2011 were selected for analysis. The scenes were subset to the region that includes only Rhode Island and southeastern Massachusetts and reviewed in true color. Ground truthing was performed for the town of Bristol, RI (yellow box in figure 1) based on Google Earth (http://www.google.com/earth/index.html) and my personal experience with the area.

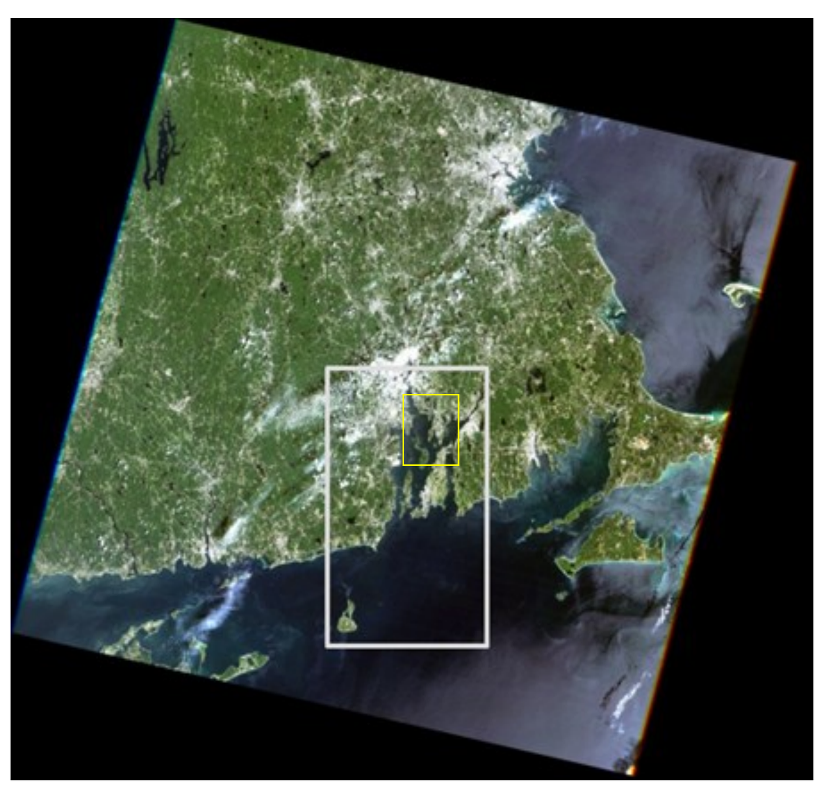
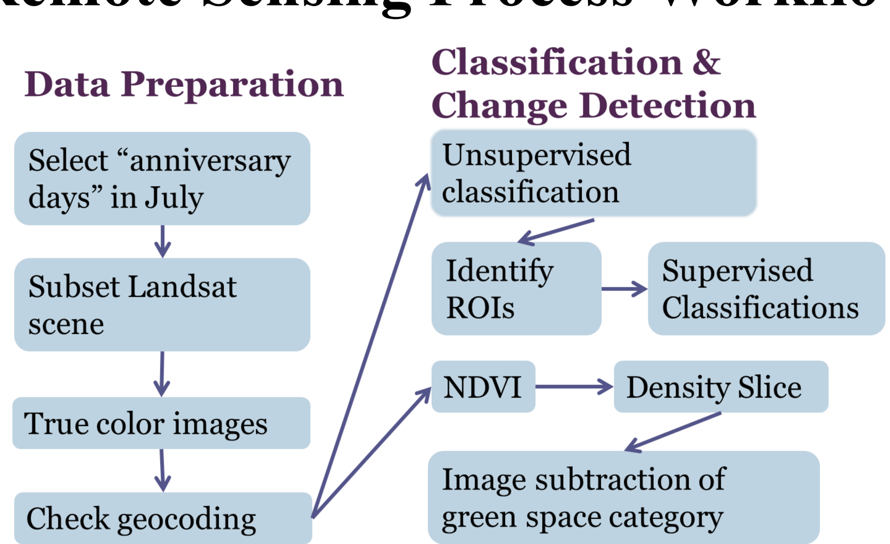


Figure 1. *The Landsat scene from path 12, row 31 contains Rhode Island and most of eastern Massachusetts. The white box marks the part of the scene being studied and the yellow box marks Bristol, RI.*

Remote Sensing Process Workflow



Classification of Vegetation

Traditional Classification Methods

Unsupervised Classification:

Regions of major land cover types in this image were first classified using the K-means and ISODATA unsupervised classification algorithms. These methods classify pixels into clusters of similar pixel values and identify potentially important land cover classes.

ROI Selection and Supervised Classification:

Regions of interest (ROIs) were selected from the major land classes including man-made structures, grass, water, and clouds to train the supervised classification algorithms. Each supervised classification method in ENVI was tried in turn to find the classification algorithm that provided the most accurate classifications. ROIs were iteratively combined or deleted to improve the supervised classifications.

Traditional Classification Results

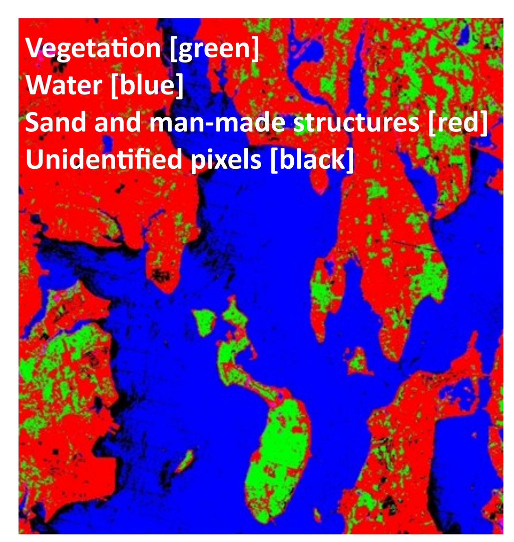


Figure 2. *Parallelepiped classification.*

Both unsupervised and supervised classification methods overestimate the coverage of sand, buildings, and roads and underestimate the extent of vegetation. The parallelepiped supervised classification, which had the best performance of the traditional classifications demonstrates this issue (figure 2). The issue of misclassification using traditional methods was not resolved by changing the number of ROIs or iterations, making these classifications of little use in the application of vegetation change analysis.

NDVI Classification Method

The Normalized Difference Vegetation Index (NDVI) was used to improve the ability to separate healthy vegetation from other land cover types. The NDVI is defined as:

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}}$$

where ρ_{NIR} is the near-infrared reflectance (TM band 4) and ρ_{RED} is the red reflectance (TM band 3). High NDVI indicates vigorous vegetation and low NDVI indicates unhealthy vegetation or the absence of vegetation ("Vegetation Indices", 2005). The NDVI for each Landsat image was calculated using the ENVI NDVI tool, and a manually density slice of three classifications was used to identify the key land cover types of “vegetation”, “water”, and “other”. The density slice ranges were manually adjusted to define each NDVI class.

NDVI Classification Results

Vegetation classification in this region based on NDVI performed better than the unsupervised and supervised classifications. The grey-scale image of the July 2011 NDVI (figure 3) clearly shows water (darkest), developed land (lighter), and vegetation (lightest). 40 All individual pixels that were checked were correctly classified as “vegetation” or “other”.

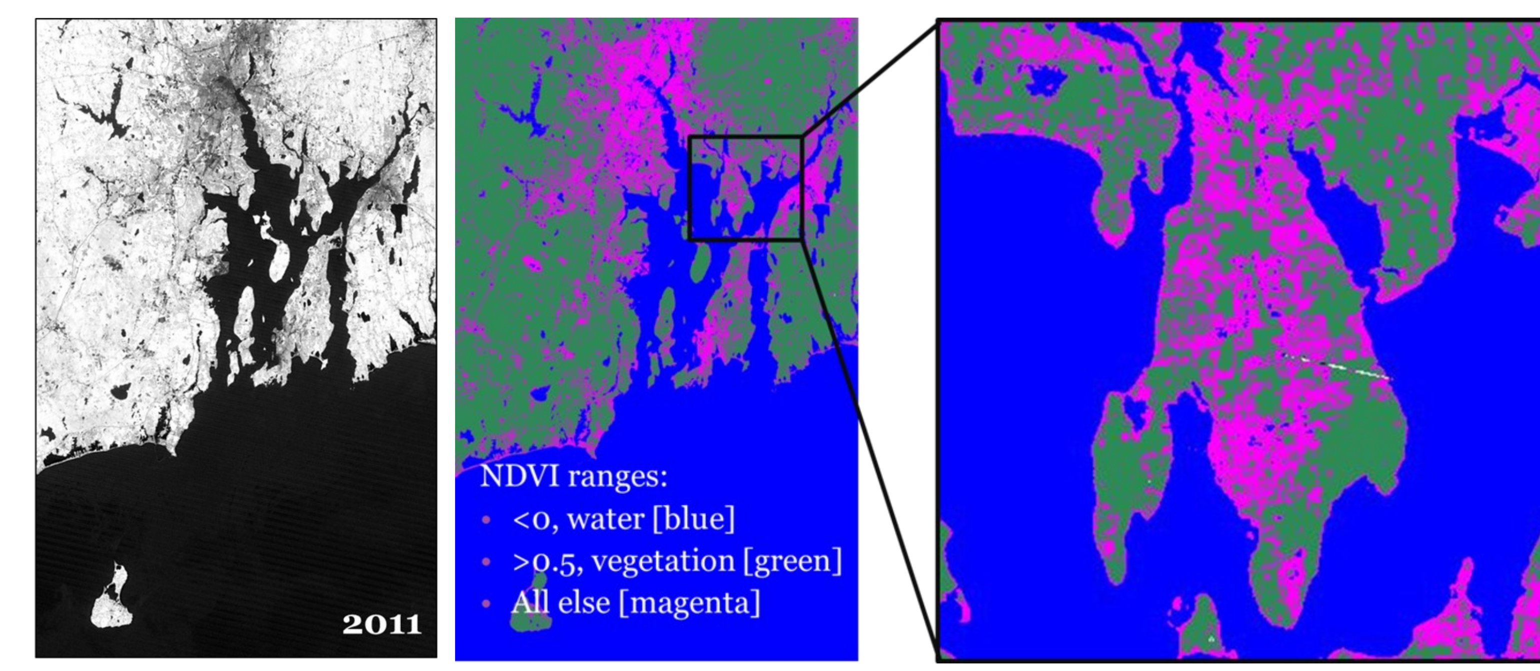


Figure 3. *The NDVI for July 15, 1999 was calculated (left) and assigned to land cover classes (center). A subset containing Bristol, RI (right) was used to ground-truth the classifications.*

Change Detection

Change detection of vegetative land cover extent was done by image subtraction of the vegetation class identified using the NDVI density slice. Healthy vegetation covered much more land in Rhode Island and southeastern Massachusetts in 2011 than in 1999 (figure 4). Apparent increases in vegetation in a grassy field in Colt State Park (yellow arrow) led to a search for reasons that the NDVI classification would miss vegetation. It turns out that Rhode Island experienced a classic short-term drought in 1999. This drought and others in the 1990s were the impetus for Rhode Island’s first drought management plan (Rhode Island Drought Management Plan, 2002).

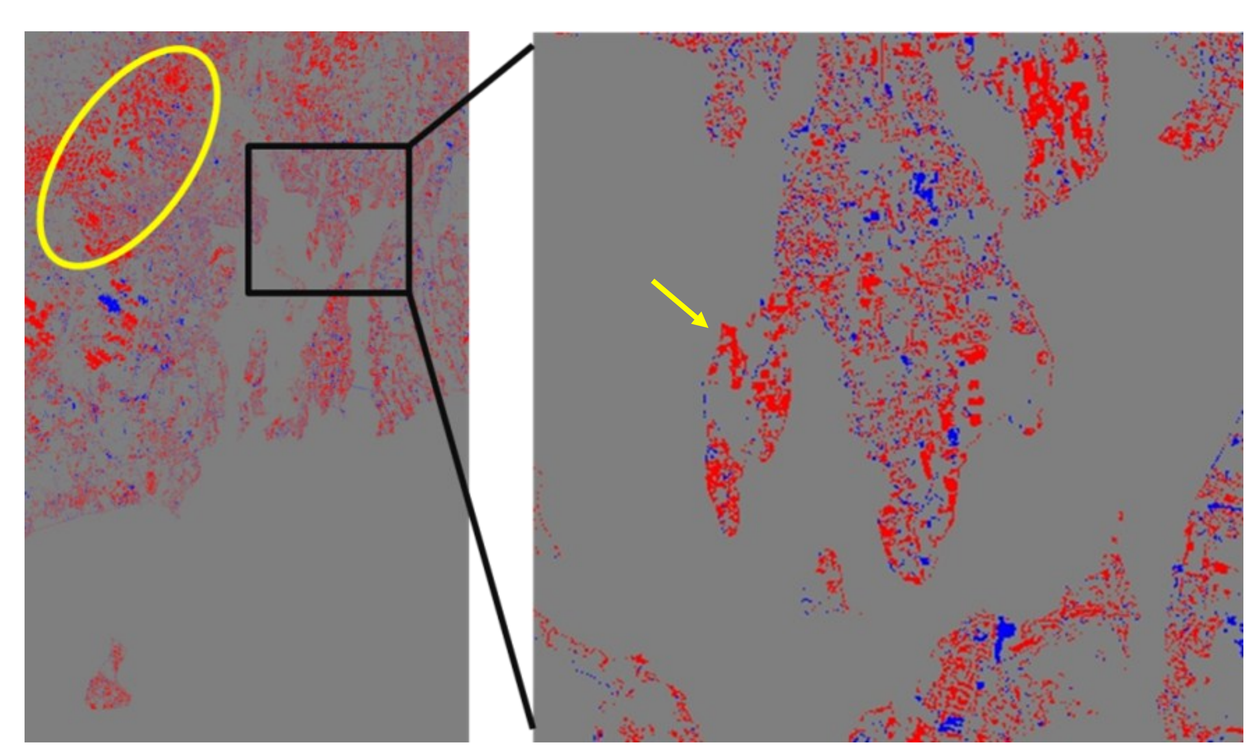


Figure 4. *Rhode Island had more areas of vegetation growth (red) than loss (blue) in 2011 as compared to 1999. The yellow oval marks regions where cloud cover may influence the NDVI.*

Limitations

1. The NDVI is much less sensitive to unhealthy vegetation or vegetation mixed with bare soil than it is to vigorous vegetation and may be inappropriate for drought conditions. Differences in the NDVI in two years should not be considered indicative of decadal trends in vegetation, especially if one of those years is a drought year.
2. Additional data sources (e.g., maps) are needed to differentiate between land uses that have the same type of land cover (e.g., parks and lawns which both have grass) but may have very different development implications.

Summary

1. Detection of vegetation in mid-July using NDVI demonstrated more vigorous vegetation in 2011 than 1999, but a severe drought in the summer of 1999 interfered with the comparison for the purpose of trend analysis.
2. The NDVI can be useful for change detection of vegetation in two years of similar precipitation or to detect droughts if zoning in a location has been relatively unchanged.
3. Future work to classify vegetation changes in this region, should take special care to classify each image as coming from a drought or nondrought year in order to separate short-term apparent changes in vegetative land cover from long-term trends.

References

Land Use 2025: Rhode Island State Land Use Policies and Plan. (2006). Retrieved from http://www.planning.ri.gov/landuse/121/landuse2025.pdf.
Rhode Island Drought Management Plan. (2002). Retrieved from http://www.planning.ri.gov/landuse/dmp.htm.
Vegetation Indices (2005). ENVI User's Guide. Retrieved from http://geol.hu/data/online_help/Vegetation_Indices.html