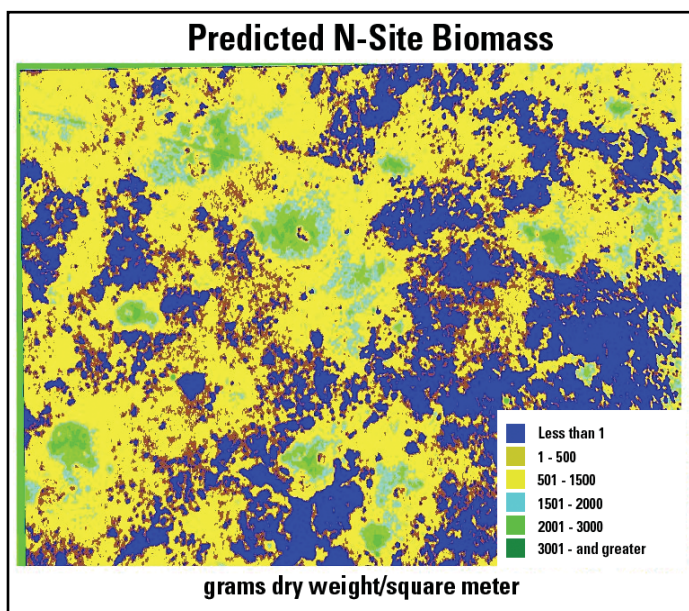# Land Surface Analysis of the Florida Everglades

Collaborative efforts to improve the functioning and value of the Greater Florida Everglades Ecosystem require accurate information on the status and dynamics of South Florida land surfaces. The goal of this project is to produce and distribute scientific techniques, geographic information, and understanding of Everglades land surfaces to improve adaptive management of South Florida ecosystem resources. Field-based activities are providing data needed for the development and testing of image-based spatial models. The creation of multi-scale, multi-sensor remotely sensed databases is providing the foundation for innovative land cover mapping and change detection. Geospatial analysis of image-derived products is creating baselines for land surface monitoring, yielding insights regarding land surface processes, and improving restoration-relevant modeling efforts.

Field methods development and data collection

Data collected at key points or along important environmental gradients help us understand microscale processes and advance techniques for characterizing South Florida's land surface using imagery collected from the air or space. This project is developing rapid, non-destructive protocols for vegetation assessment (Figure 1) to create models that estimate biophysical characteristics of vegetation from airborne and satellite imagery (Figure 2). Similarly, the project has provided experience in using instruments that collect high spectral resolution data about the reflectance of South Florida land cover types (Figure 3). This experience has been used to create a library of Everglades land cover spectra (Figure 4) that provide useful information about subtle variations in the reflectivity of different land surfaces or the same land surfaces over time. Data from this instrument can be used for biophysical modeling and can be manipulated to portray the types of measurements made by broader-band sensors. This allows us to experiment with algorithms to extract biophysical parameters from multi-spectral image data collected from aircraft and satellite platforms. It also yields information we can use to suggest future sensing system requirements. Thus, project field-based measurements allow more precise map-making, provide for complex experiments with remote sensing procedures, and suggest future remote sensing system specifications required to meet particular science needs.
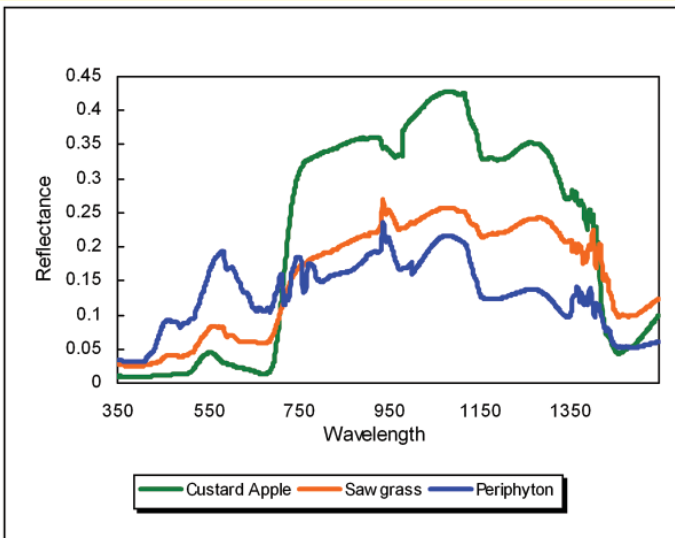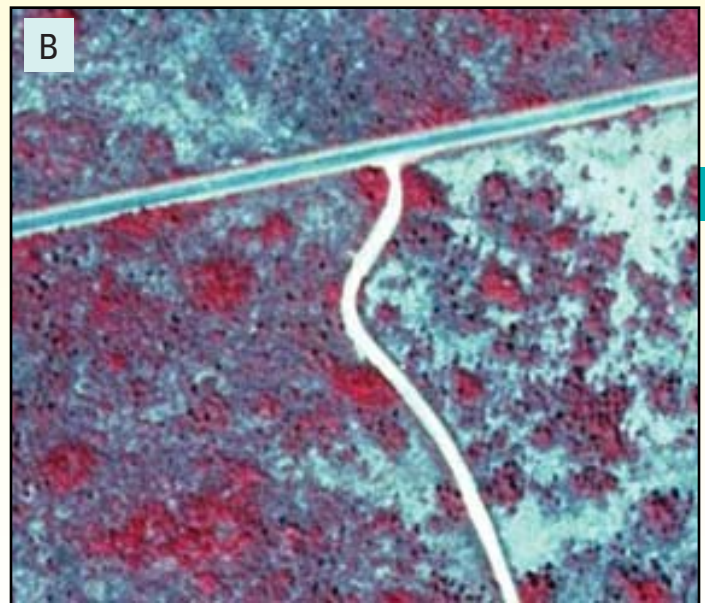

Figure 1. Non-destructive, field collection of vegetation biomass along transects for remote sensing algorithm development and evaluation.

Figure 2. Vegetation biomass estimated by combining field vegetation data and airborne multispectral imagery.

Figure 3. A library of South Florida land cover spectra is being built using handheld and laboratory spectroscopy.
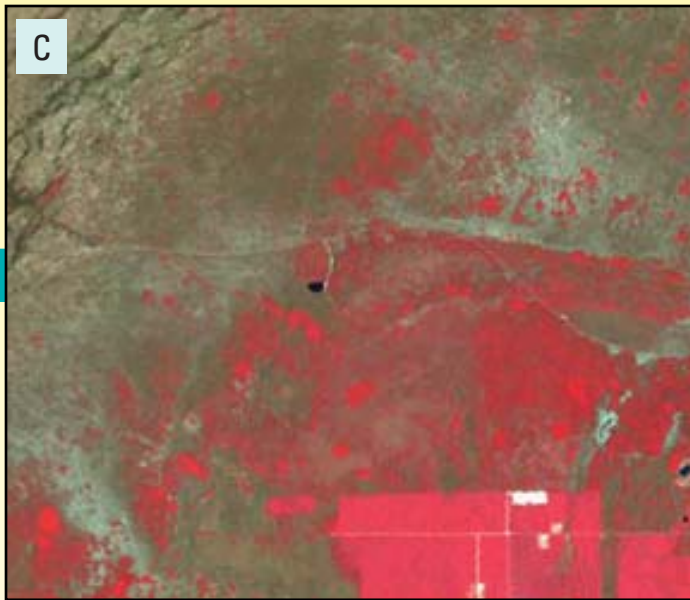

Figure 4. Examples of field-collected spectra.

Multi-scale, multi-sensor image data collection

Remote sensing technologies provide attractive capabilities for land surface and other process monitoring in large, fragile, and logistically challenging environments like the Everglades (Jones and Desmond, 1998). They also yield synoptic views up to regional levels at relatively low cost and allow for non-destructive scientific sampling. However, the high-humidity and often cloudy subtropical climate of South Florida, combined with rapidly varying substrate conditions (e.g., changing water levels), makes the South Florida region a difficult one in which to use remote sensing. These difficulties are exacerbated by needs on the part of scientists and land managers to document very subtle differences in vegetation and water composition that are often difficult to recognize – even while standing on the ground. The fusion of multiple types of remotely sensed data may help to overcome these challenges and provide the best information possible for research aimed at adaptive resource management. The USGS is meeting these challenges through the collection and development of a multi-scale (Figure 5), multi-sensor, and multi-temporal (Figure 6) database for remote sensing research and ecosystem monitoring. Evaluating the efficacy of atmospheric corrections and minimum calibration requirements for particular data uses are primary research areas. As a result, a flexible, rich archive of image data is being developed.

Figure 5. The same location imaged at three different spatial resolutions (a: project-generated orthophotoquad – 1ft resolution; b: USGS digital orthophotoquad – 1m resolution; and c: project-generated satellite image map – 15m resolution).
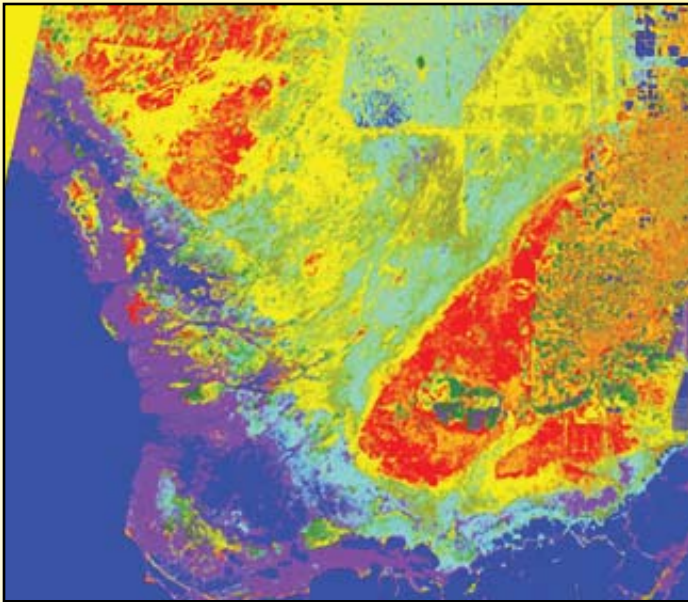

Figure 6. Changes in land use west of Fort Lauderdale are captured in satellite data from 1992 (A) and 2001 (B).

Monitoring and change detection

Monitoring the progress of Everglades resource management requires the establishment of baseline information about current conditions, the development of intelligent (i.e. cost effective, but rigorous) ground sampling frameworks, and the capability to detect changes at regional scales for more detailed investigations. Through this project, a set of satellite image maps covering the entire South Florida area have been developed (Jones and Thomas, 2004). Interpretations of these image maps and other images in the database are providing baseline information. The multi-scale nature of the remote sensing database also provides a foundation for determination of sampling requirements (Jones, 2001). And, the multi-temporal aspect of the image database is increasing our understanding of land surface dynamics such as urban expansion (Figure 6), fire, and other disturbance events.
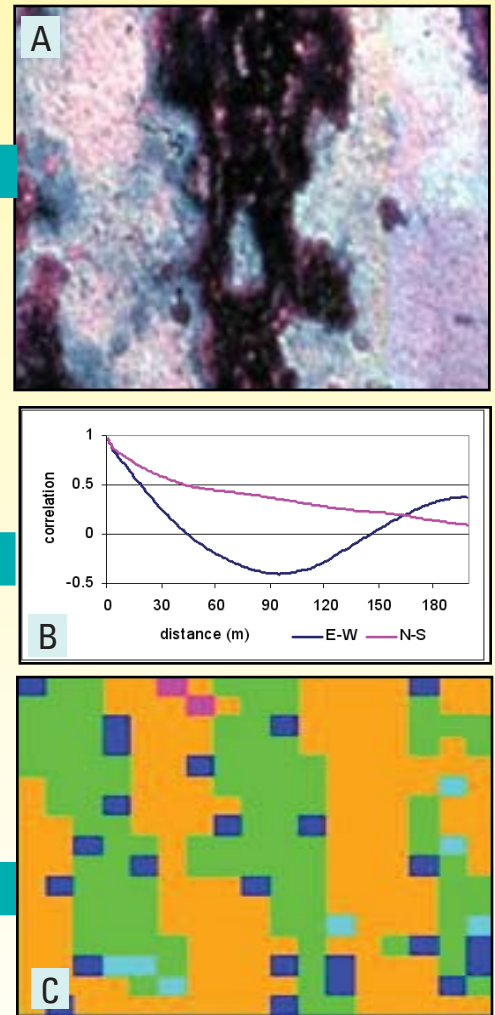
Landscape-scale modeling

The interpretation of remotely sensed data and the spatial analysis of information derived from the imagery are improving the effectiveness of Everglades hydrodynamic models. Maps of land surface characteristics important in processes like resistance to surface water flow (Figure 7) are being analyzed using spatial statistics and concepts of landscape ecology (Figure 8) to yield more spatially and temporally complex model parameterizations. Once sufficient archives of calibrated data are developed, correlations among land, climate, social processes, and land surface characteristics will provide insights regarding impacts of natural and anthropogenic drivers and habitat characteristics.

Figure 7. Vegetation classes grouped according to flow resistance characteristics have been mapped for various study regions using archived satellite imagery to parameterize hydrodynamic models.

Figure 8. Fine-resolution imagery (a) is being analyzed for directional spatial autocorrelation (b) to yield insights regarding spatial configuration of vegetation and (c) that can be used to parameterize hydrologic and other process models.

SUMMARY

USGS research is developing and applying innovative techniques to map the distribution of vegetation characteristics and related hydrologic, geologic, and biologic variables through space and over time in South Florida. With a goal of enabling more effective landscape monitoring, resource management, and restoration impact assessment, the USGS is developing and applying remote sensing, spatial analysis, and other geo-processing tools to increase our understanding of Everglades land surface dynamics, biophysical processes, and ecosystem functioning.

-J.W. Jones and J. Neubauer

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