SPATIAL PATTERNS OF ECOSYSTEM SERVICES ACROSS LANDSCAPE GRADIENTS: APPLICATION TO FLORIDA

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What are Ecosystem Services?

“Ecosystem services” are the benefits that humans obtain from ecosystems. Ecosystem functions are biological and system processes. Ecosystem services are derived from ecosystem functions.

Supporting

- Provisioning
  - Food
  - Freshwater
  - Wood and Fiber
  - Fuel
- Regulating
  - Climate Regulation
  - Pollutant Abatement
  - Water purification
- Cultural
  - Aesthetic value
  - Educational value
  - Tourist recreation
  - Spiritual fulfillment

Ecosystem Service Data

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<tr>
<td>Citrus Production</td>
<td>Percent of land in each county in production of citrus trees</td>
<td>USDA National Agriculture Statistics Service (2007)</td>
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<tr>
<td>Timberland</td>
<td>Percent of land in each county in production in timberland (land capable of producing 20 cu ft of industrial wood per acre/yr and maintained &gt;50% stocking level)</td>
<td>United States Forest Service: Forest Inventory &amp; Analysis (2007)</td>
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<tr>
<td>Cattle Inventory</td>
<td>Density of cattle (head/ha) per county (inventory of total cattle: beef, dairy, male, female, and calves)</td>
<td>USDA National Agriculture Statistics Service (2007)</td>
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<td>Carbon Sequestration</td>
<td>Mg/ha above-ground and soil carbon accumulation per year (based on land cover type within county)</td>
<td>USDA Forest Inventory &amp; Analysis Data, F. E. Eckbo unpublished data (2010)</td>
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<td>Groundwater Nitrate Quality</td>
<td>Groundwater nitrate concentration (mg/L) (derived from nitrate concentrations at well sites in each county; high water quality = low nitrate)</td>
<td>Water Solutions, Inc. (2010)</td>
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<td>Biodiversity Hotspots</td>
<td>Percent of land in each county identified as important habitat, based on rarity and richness of plants and animals (242 spp)</td>
<td>Florida Natural Areas Inventory/ UF Geospatial Center (2008)</td>
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<td>Outdoor Recreation</td>
<td>Percent of land in each county designated for parks and conservation management</td>
<td>Florida DCP: Florida State Parks (2010), Half: Florida Managed Areas (2011)</td>
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</table>

Methods

1. Visually evaluated distribution:
   - ArcGIS
2. Compared spatial patterns of service clustering across Florida:
   - Moran’s I (with polygon contiguity)
3. Spatial correlation between pairs of services:
   - Pearson Correlation Test
4. Estimated predictability service groups by the presence of others:
   - Linear Regression
5. Identified patterns and sources of variation of services across Florida:
   - Principle Components Analysis
   - K-Means Cluster Analysis

Objectives

To increase our understanding of the spatial patterns, correlations, and clusters of “ecosystem services” in Florida

Objective 1: Map the distribution of selected ecosystem services for each county in Florida

Objective 2: Determine the degree of association or interaction among ecosystem services

Objective 3: Determine the spatial pattern of clusters of ecosystem services and associations of all services across the state

References:
2. Florida Department of State (http://sdms.do.state.fl.us/) accessed 1/24/2011
5. Florida County Boundaries data layer source: US Census Bureau (1990)

Acknowledgements:
This project was initiated during a graduate course on “Pattern and Process in Landscape Ecology” (Department of Wildlife Ecology and Conservation, University of Florida) with guidance from Dr. Robert Flather. We also thank Chris Cateaux for his assistance with programming in R and Peng Li for assistance with ArcGIS.

Discussion

We found distinct spatial patterns for almost all of services; in particular, services were geographically clustered on the landscape related to the underlying biophysical characteristics and human activities occurring at the county level, with observed change in services among both latitudinal and agricultural gradients.

A visual assessment of the service values by county, as well as the PCA and cluster analysis, support the explanation of distribution of services on a latitudinal gradient. The PCA identified a north-south gradient as cause for 40% of the variation in the services. South central Florida had a concentration of the agricultural services (i.e. citrus and cattle production), whereas, northern Florida displayed high values for timberland. Carbon sequestration and biodiversity had less distinct patterns, but were clumped in areas containing grass- and marshlands, including Everglades National Park and Big Cypress in southern Florida.

This latitudinal gradient of services was likely influenced by environmental conditions which favor particular land uses. As a result, the second most influential environmental gradient, described by the PCA (explaining 17% of the variation) and supported by the cluster analysis, was a human-designated agricultural to non-agriculture gradient. Due to the strong influence of these gradients on the distribution of services, some services were highly correlated and may be viewed either as ecosystem bundles (e.g., citrus and cattle) or tradeoffs (e.g., timber and citrus). For example, timber was clumped with higher water quality and biodiversity, and these areas overlap more with National and other public forestland managed for mixed use.

The implications for effective ecosystem management, conservation planning, and future management decisions from this analysis are limited; given that distinct land use is unlikely to change at the scale analyzed regardless of demand for specific ecosystem services, it is our recommendation that this analysis more appropriately be conducted at a finer grain with opportunity for land use change given demand. This study does, however, illustrate an empirical assessment of spatial patterns, correlations, and bundles of multiple ecosystem services, adding to the general literature on ecosystem service tradeoffs.