Pattern metrics and the early detection of ecosystem degradation in the ridge-slough landscape

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Introduction

- Pattern metrics are quantitative tools to describe spatial heterogeneity and enumerate landscape condition. They are integral to successfully monitoring large landscapes.
- Indicators of condition need to meet the following criteria: 1) sensitive 2) specific 3) easy to measure
- What is the timing of landscape metrics vs. landscape condition change; are they leading or lagging?

Ridge and slough regular patterning background

- Two distinct vegetation patches: ridges (sawgrass) at higher elevation within a matrix of slough (water lily, bladderwort). Patches are elongated parallel to historical flow.
- Patterning is decoupled from underlying limestone and suggesting genesis from autogenic and self-organized processes.
- The loss of patterning happens in two dimensions: 1) Blurring of the distinctive, directional pattern (Fig.2-1, 2-2 and 2-3) and 2) flattening of the landscape (Fig. 2-4).
- Changing soil elevation patterns (high variation, bimodal) is a crucial signal of landscape degradation.

Methods

- Vegetation maps for pattern metrics
  - 25 2 X 2 km Primary Sampling Units (PSU) vegetation maps were categorized into binary maps. Ridge = sawgrass, spike-wah sawgrass marsh, swamp forest, swamp shrubland and swamp scrub. Slough = waterlily marsh, spikerush marsh, panisgrass marsh. All other vegetation types (e.g., cattails, cypress swamps, upland shrubs) were excluded from our analysis.
  - Subset of 13 PSUs consists only of sites south of I-75.
- Ridge and slough condition from soil elevation
  - Soil elevation were derived from water elevation (EDEN) by subtracting local water depth measurements from water elevation. Each PSU consists 80 randomly located water depth sampling sites.
  - Two measures were extracted from each elevations for each PSU: 1) bi-modality based on the comparative fit of a single vs. two normal distributions. Bimodality of soil elevation (BiE) has a value of 1 where soil elevations are fit by two normal distributions, and 0 for where a unimodal fit was better. 2) The standard deviation of soil elevation (SD_E), which provides a measure of elevation variation and divergence

Results and Conclusion I

- Pattern Metrics and Soil Elevation Bimodality Distribution (BiE) Logistic regression between pattern metrics and soil elevation bimodality distribution
  - Global data, slough width (W_s) and DCI are the only two significant predictors (p<0.05).
  - Subset data, only ridge density (D_r) is significant at p < 0.05. However, at p < 0.1, slough density (D_s), ridge length (L_r), slough width (W_s), lateral slough density (D_l), and directional connectivity index (DCI) are significant.

Results and Conclusion II

- Pattern Metrics vs. Soil Elevation Distribution Standard Deviation (SD_E) Subset data (n = 13 from WCA3) were better fit than the global data (n = 25 across the Greater Everglades).
- Composition metrics (Ridge density D_r and Slough density D_s) were strong predictors
- Geometry metrics (e.g., lacunarity - LAC, fractal dimension - FD) has limited utility for assessing landscape condition
- Metrics that consider connectivity (LDC, DCI, LFC) exhibited the strongest predictions of soil elevation variance
- DCI (Directional Connectivity Index) was the only leading indicator of soil elevation variance

Discussion

- Are the metrics specific? The pattern metrics to diagnose landscape condition are relatively effective only if the metrics measure the specific ecosystem driver dynamic.
- Are the metrics sensitive? While patch composition and geometry changes are relatively easy to visualize and intuitive, they are not as sensitive as the connectivity metrics indicating the foundational importance of hydrological connectivity to landscape and its assessment.
- Leading or lagging? Only DCI (Directional Connectivity Index) showed promise as a leading indicator.
- Action items to water management and restoration assessment in the Everglades ridge-slough landscape: 1) Soil elevation monitoring is replaceable. Contining large area soil surveillance is vitally important. 2) Pattern metrics almost universally lag behind soil elevation changes.

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