Analysis of Patch Geometry Characteristics in the Ridge Slough Patterned Landscape in the Everglades

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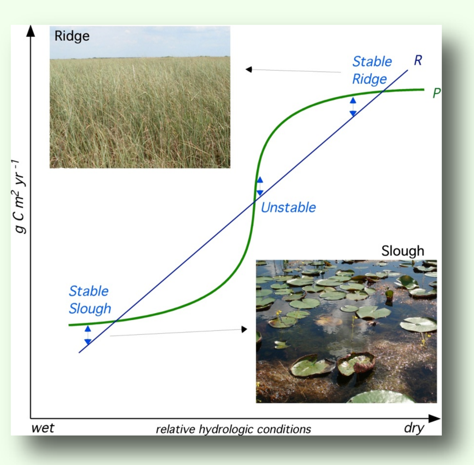
Introduction

- Everglades ridge slough patterning has several striking attributes:
  1. Patches are oriented parallel to historical flow, with elongated ridges embedded within a matrix of sloughs, and
  2. Ridges occupy higher elevation sites than sloughs (ca. 25 cm).
- These attributes fail to capture the apparent fractal nature of patch geometry, where ridges vary widely in size, and possess substantially convoluted margins.
- Our objective was to investigate pattern geometry, with a focus ridge patches as geometrically regulating landscape discharge.

Fig.1 Ridge and slough landscape , March 2012.
Photo credits: Robert Sobczak (www.gohydrology.org)

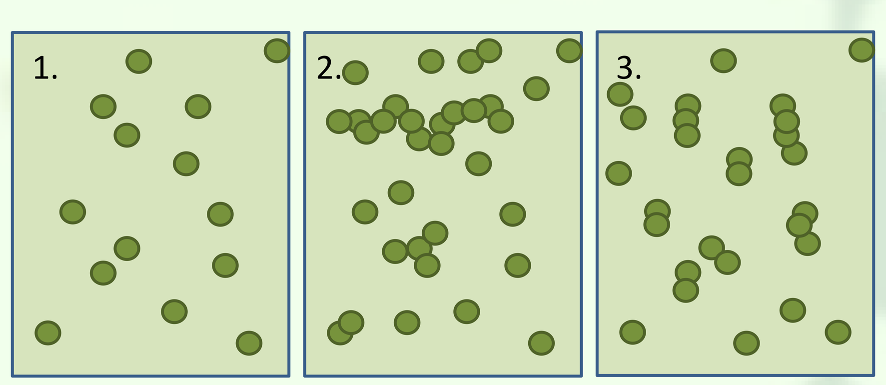
Hypotheses



1.The point scale model dictates peat elevation is purely a function of local hydrology ,unaffected by ridge size. Ridge elevations should be independent of mechanisms controlling patch size

Fig.2 Ridge and slough conceptual model at point scale (Watts et al. 2010).

2. Larger ridges have a greater probability of occluding flow and as a result, should be preferentially acted upon by the discharge competence mechanism, causing ridge elongation and orientation in the direction of flow to increase with ridge size.



1. Initial random propagation of ridge patches
2. Lateral expansion leads to inundation and stress to ridges
3. Ridges expand longitudinally with little impact on flow

Fig.3 Illustration of ridge patch expansion

3.While the ridge slough landscape has scale free attributes such as power law scaling in areas , it also appears to show scale dependent characteristics such as regular patterning. To reconcile this we propose that the distal negative feedback only acts in the width dimension, allowing power law distributions in the length dimension and regular patterning laterally.

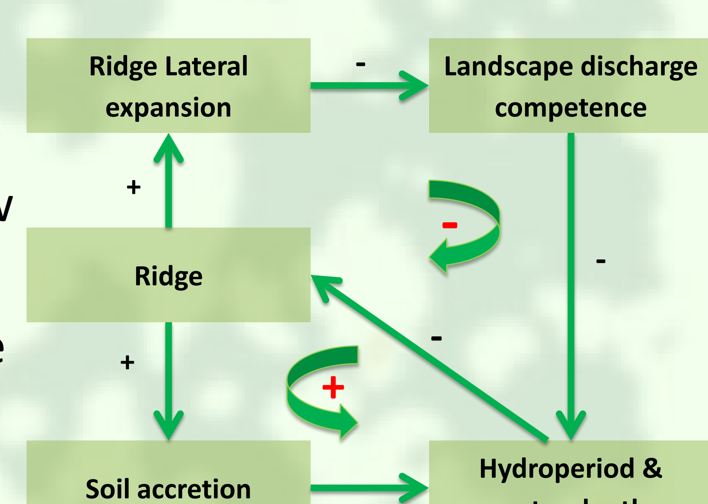


Fig.4Conceptual model of the discharge competence mechanism.
(Cohen et al.2011)

Methods

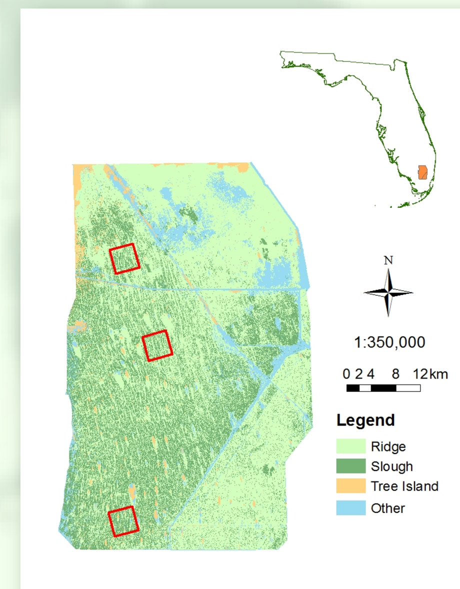


Fig.5 Research site map

Red square is 4 ×4 km sampling block. From north to south is hydrologically dry, conserved and impounded

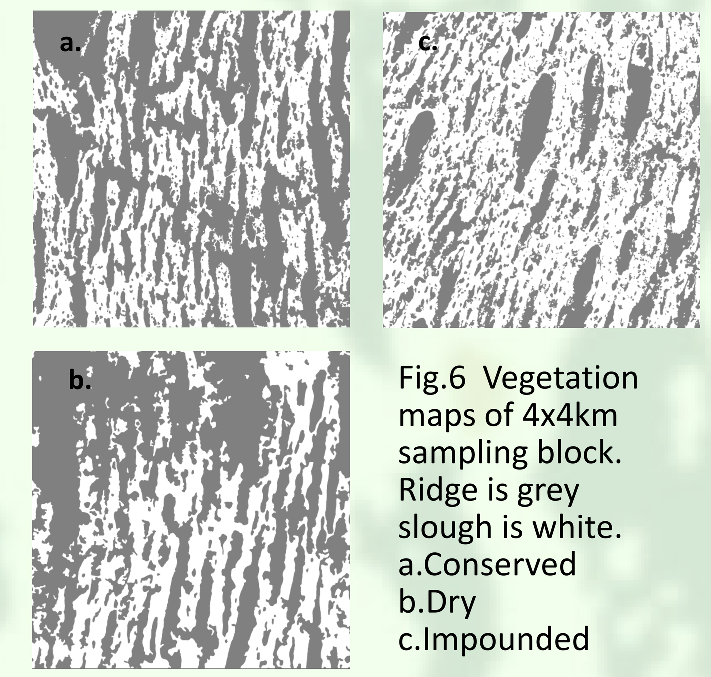
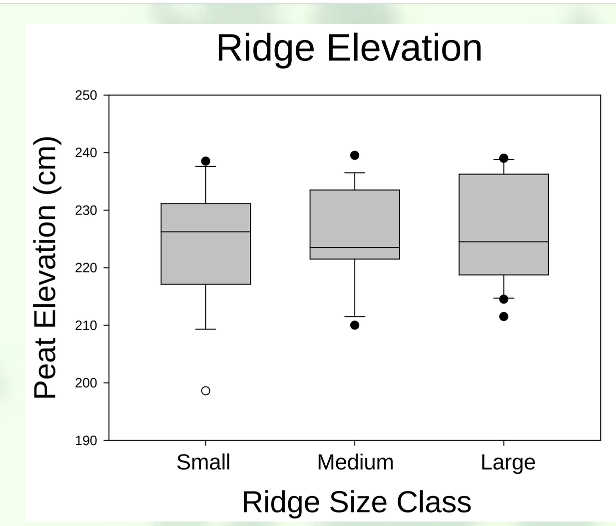


Fig.6 Vegetation maps of 4x4km sampling block. Ridge is grey slough is white.
a.Conserved
b.Dry
c.Impounded

Data process

- Binary maps were created designating sloughs as 0's and ridges as 1's.
- Ridges were then grouped according to the whether ridge cells are adjacent to one another and various statistics were gathered for each plot
- The number of cells belonging to each ridge was summed across individual rows and columns to generate length and width statistics

Results - Size and elevation



Size classes
Small 1-1000m²
Medium 1001-10000m²
Large 10001-100000m²

Fig.7 The three size classes of ridges showed no statistical difference in mean peat elevation.

This supports our hypothesis that elevations are independent of size (1.)

Results - Size and anisotropy

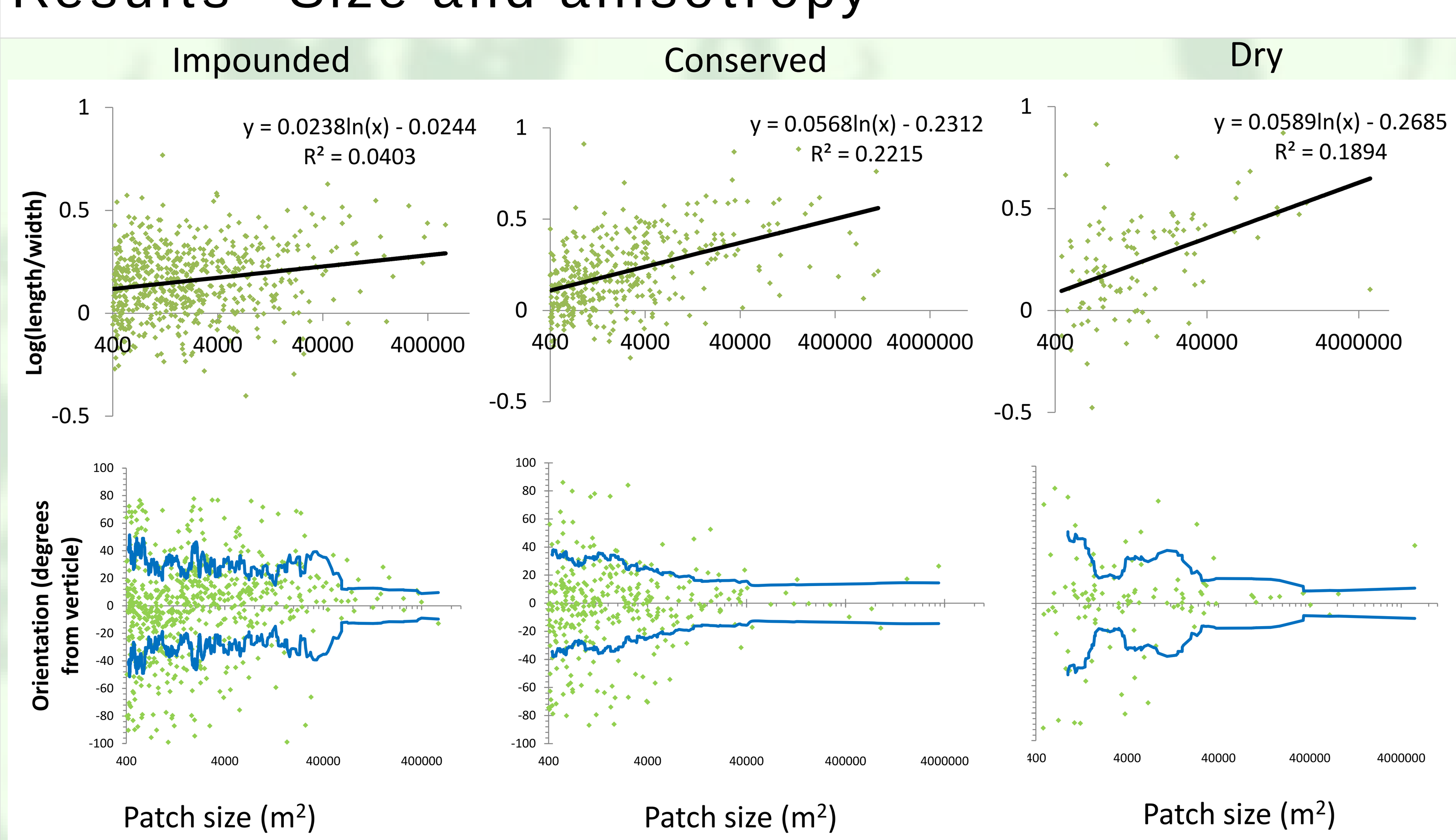


Fig.8 (Upper panel)Log transformed ridge patch average length to average width ratio as a function of patch size across hydrological conditions.(Lower panel)Ridge patch orientation as a function of patch size. Orientation is the angle formed by the major axis of the ellipse which has the same 2nd moment of inertia as the ridge patch (0 = in direction of flow, -/+90=perpendicular to flow).Both metrics support hypothesis 2 indicating that both patch elongation and alignment in the direction of flow become greater with increasing patch area. However, the impounded site shows a weaker response in patch elongation.

Results - Length and width distribution

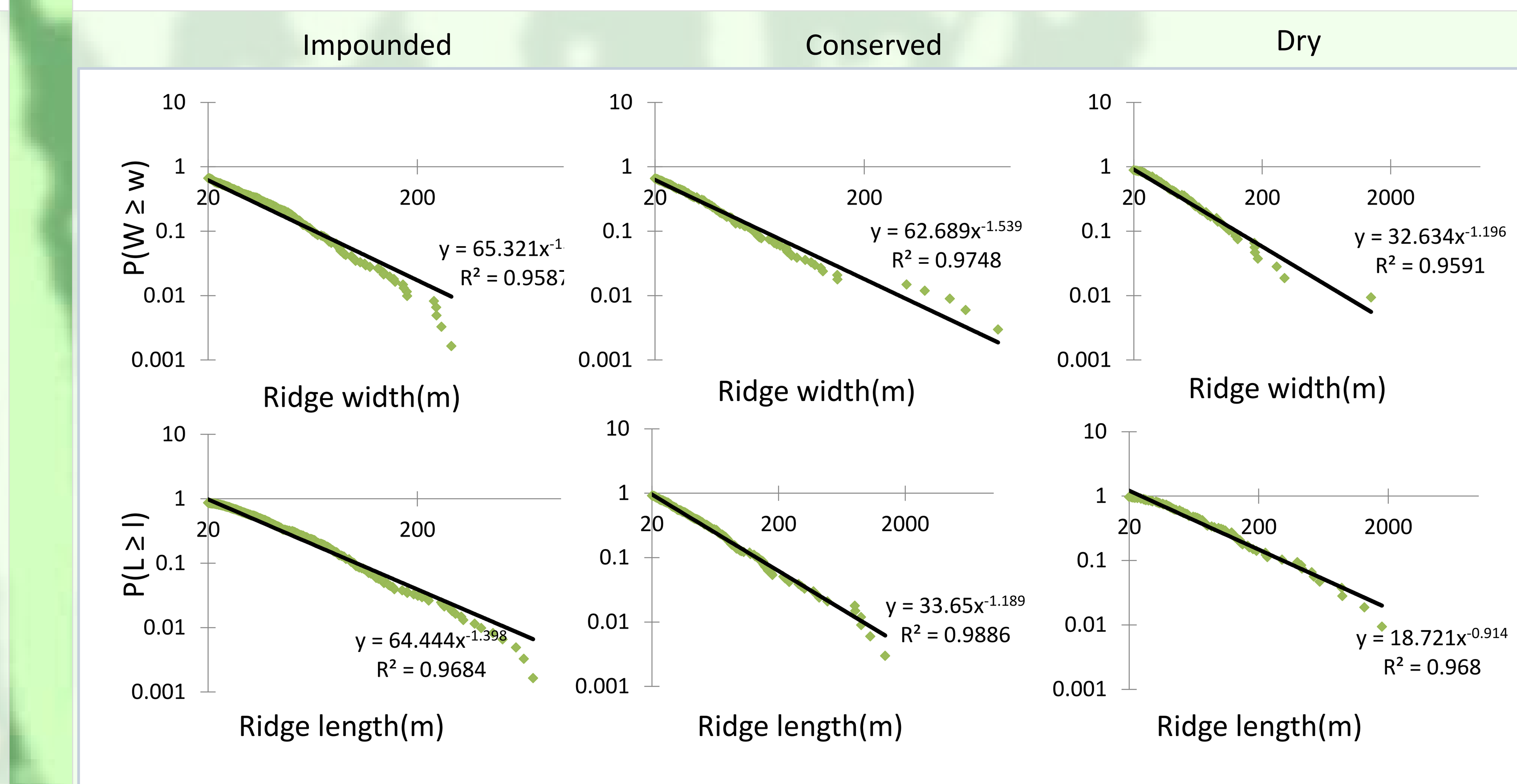


Fig.9 Cumulative distributions of average widths (w) and lengths (l). Both length and width appear to follow power law distributions. Preliminary results show larger ridges in the conserved and dry sites as being composed of groups of many smaller interconnected ridges. This inter-ridge connectedness may allow for the coexistence of scale-free distributions and scale-dependent distal negative feedbacks. The slope of the distribution appears to correspond to hydrologic conditions, with more inundated sites having steeper slopes and smaller ranges.

Conclusion

Our results suggest

- Elevations independent of spatial organization, supporting the point-scale conceptual model.
- Tentative support for scale dependent anisotropy, but further work is needed (size and anisotropy).
- Preliminary support for ridge lengths following power-law scaling.

Together, these results provide landscape geometric properties that can be used to evaluate simulation model performance of landscape pattern genesis.

Future directions

- Continue these analyses to span hydrological conditions on more sampling block across WCA 3A.
- Test whether power law distribution of patch size can serve as a earlier warning indicator of landscape degradation.

Reference

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