Pattern and Process in the Everglades Ridge-Slough Landscape

Matthew Cohen, David Kaplan, Subodh Acharya, Stephen Casey, James Heffernan, James Jawitz, Jing Yuan, and Danielle Watts

Affiliations and Acknowledgements

Institutions:

UF | UNIVERSITY of FLORIDA

Duke UNIVERSITY

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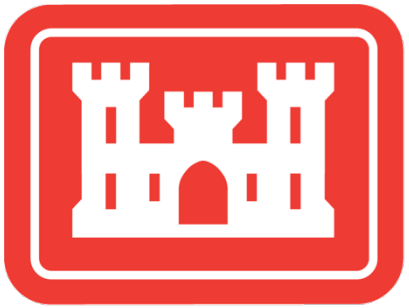
Funding:

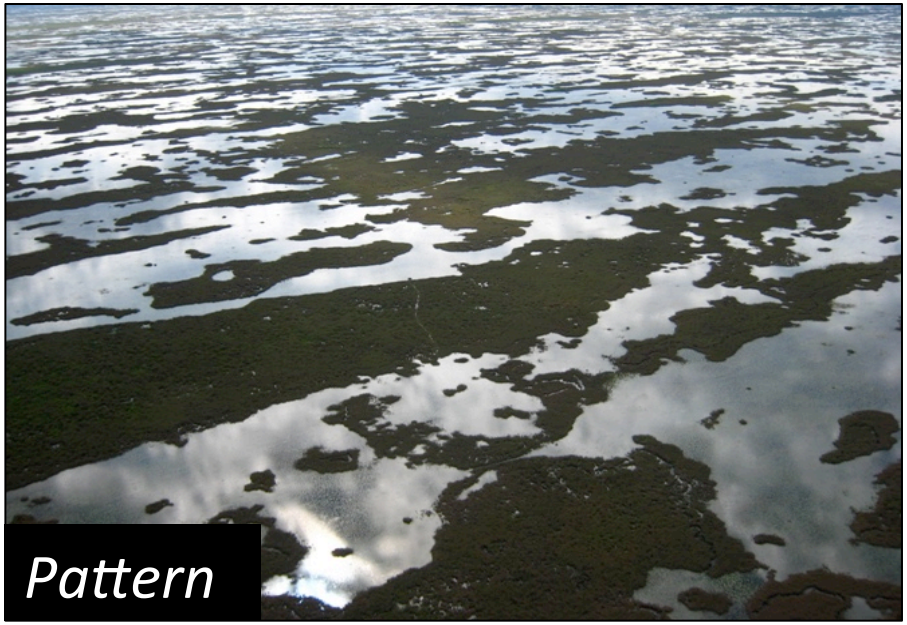


Additional Research Collaborators: Todd Osborne (UF), Laurel Larsen (UC Berkeley), Martha Nungesser (SFWMD)

Pattern + Process → Performance/Thresholds?

<u>Landscape-scale</u> target outcomes in the R-S landscape?

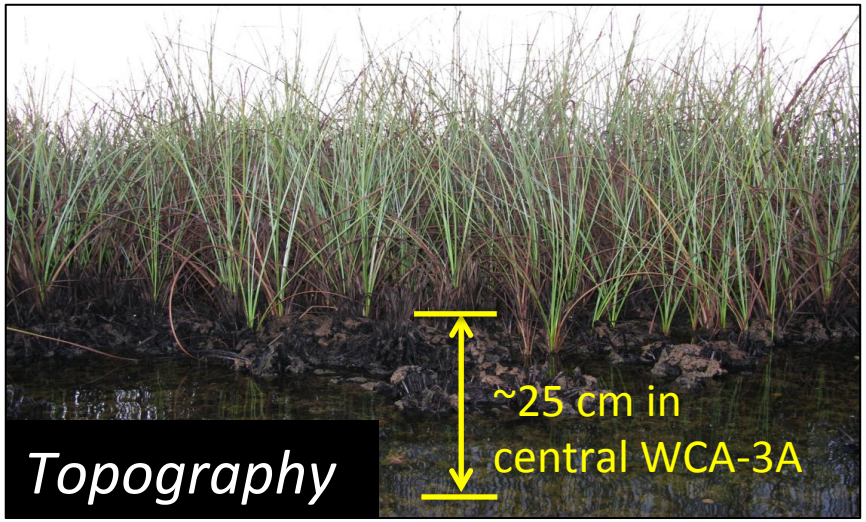
- **Pattern** → How to quantify? *How to interpret?*
- **Topography** → Critical, but more difficult to detect
- (How) are these indicators **linked**?
- Can we link these to **hydrology** to guide restoration?

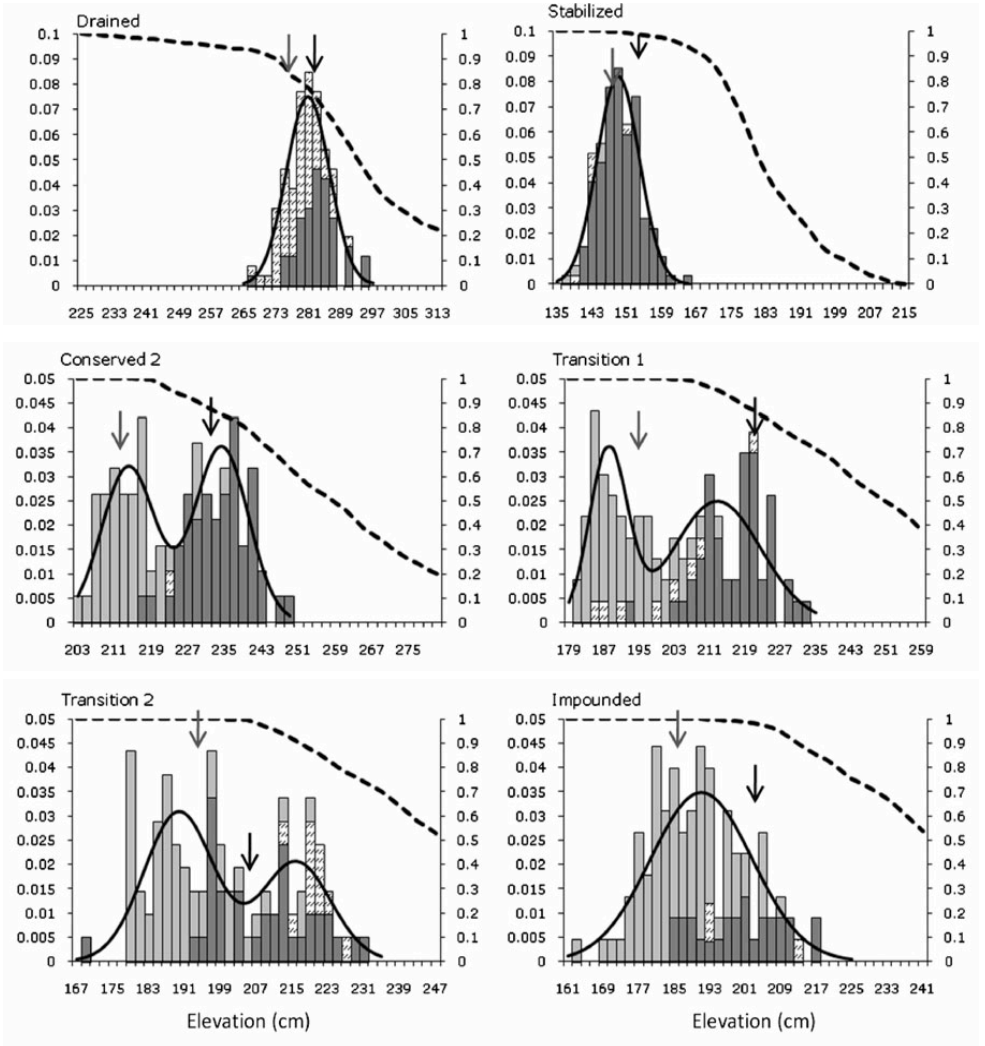


Topography: R-S Elevation Divergence*

"How high are the ridges?"

- Two stable C equilibria → R-S elevation differences
- Preserved only under "best-conserved" hydrology
- Wet, dry, stable: bimodality loss
- Loss *precedes* pattern loss → important diagnostic



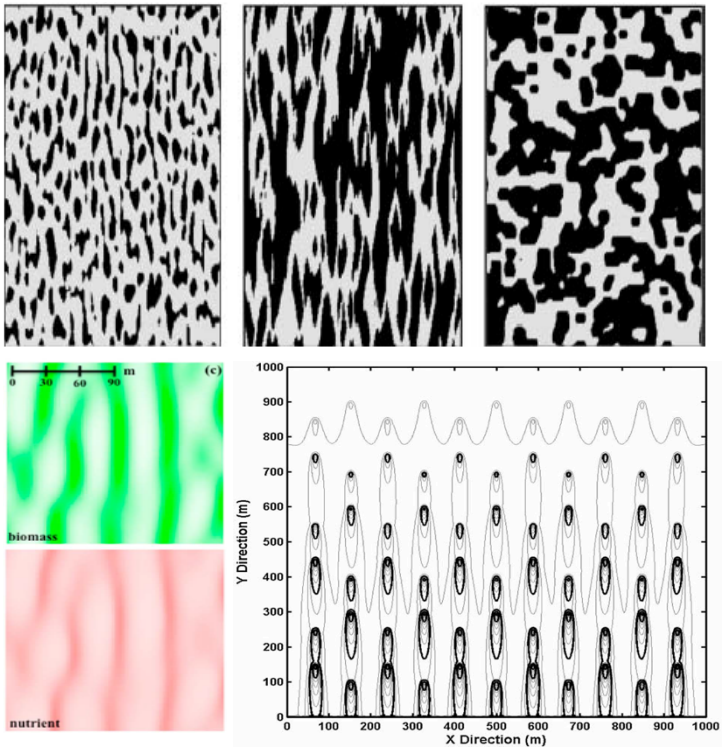


*Watts, D. L., Cohen, M. J., Heffernan, J. B., & Osborne, T. Z. (2010). Hydrologic modification and the loss of self-organized patterning in the ridge–slough mosaic of the Everglades. ***Ecosystems***, *13*(6), 813-827.

Pattern: Spatial Organization of the R-S Mosaic

"Just how is this landscape patterned?"

- Required to detect loss, understanding loss mechanisms, ***and test models***
- ***Flow-parallel*** bands of higher-elevation ridges within a matrix of lower-elevation sloughs (SCT, 2003; McVoy et al., 2011)



Top: Larsen et al., 2010; **Bottom left**: Cheng et al., 2011; **Bottom right**: Ross et al., 2006

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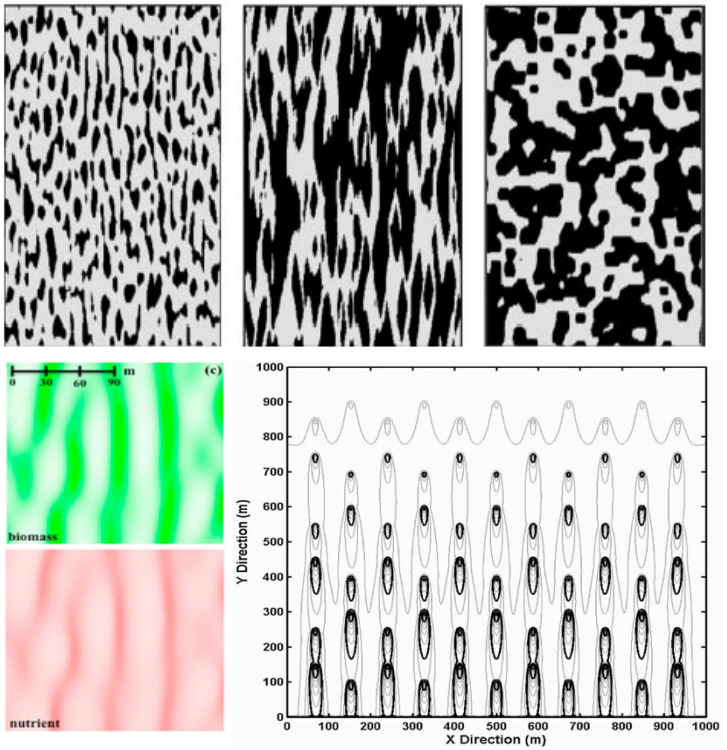
Previous Pattern Metrics

- **Wu et al., 2006:** Avg. length straight flow, avg. slough width, L:W, patch %, lacunarity
  - *"Condition" based on logistic regression*
- **Nungesser, 2011:** L:W ratio, # of ridges, perimeter:area ratio
  - *Historical patterning = higher quality*
  - *Good: many, long ridge patches*
  - *Bad: fewer, large, and irregular patches*
- **Our Challenge:** Use existing and new metrics to link pattern, topography, and hydrology



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Two Goals:

1. Better characterize R-S pattern in *across hydrological/condition gradient*
2. Propose metrics for quantification of observed and modeled landscapes

*Casey, S., M.J. Cohen, S. Acharya., D. Kaplan, and J. Jawitz. 2015. On the spatial organization of the Ridge-Slough Patterned Landscape, **Hydrol. Earth Syst. Sci. Discuss.**, 12, 2975-3010.

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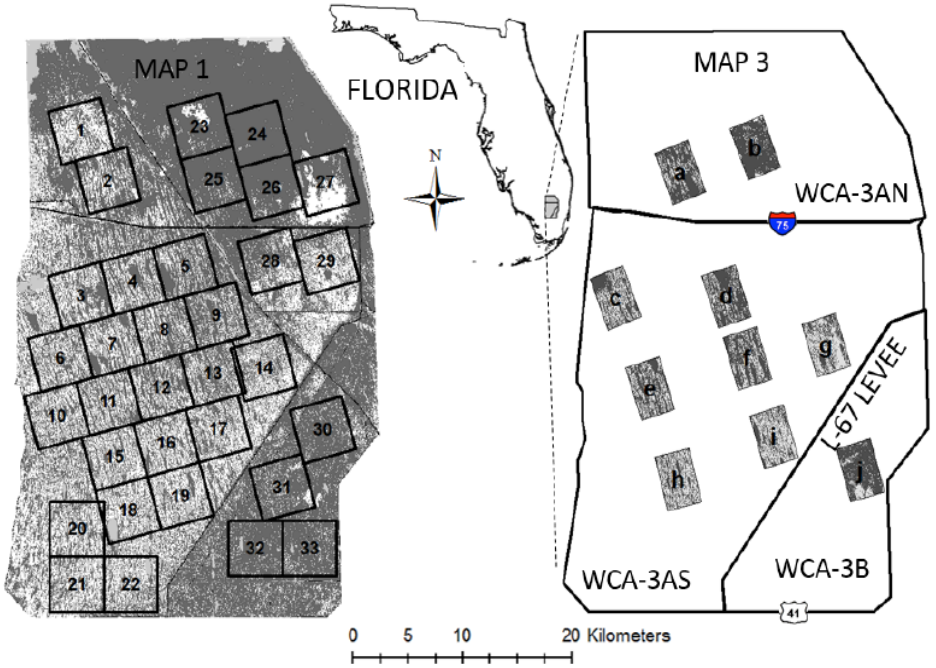
Approach

- 33 sites, multiple maps…
- **Prevalence statistics**: patch %, complexity (perimeter), elongation
- **Spectral characteristics**: 2-D periodicity → "is the landscape regularly patterned?"
- **Patch scaling relationships**: patch size distributions → inform underlying formation processes
- ***Hydrologic controls on pattern?***



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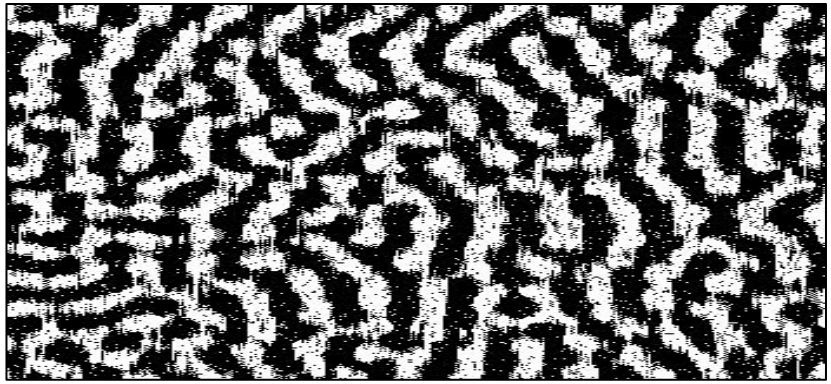
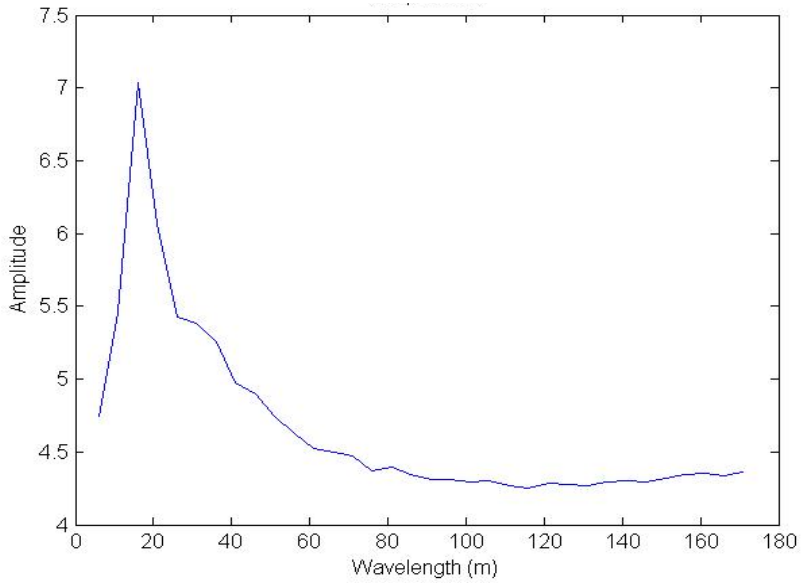
Regularly patterned landscapes have R-spectrum peaks:





SCT, 2003

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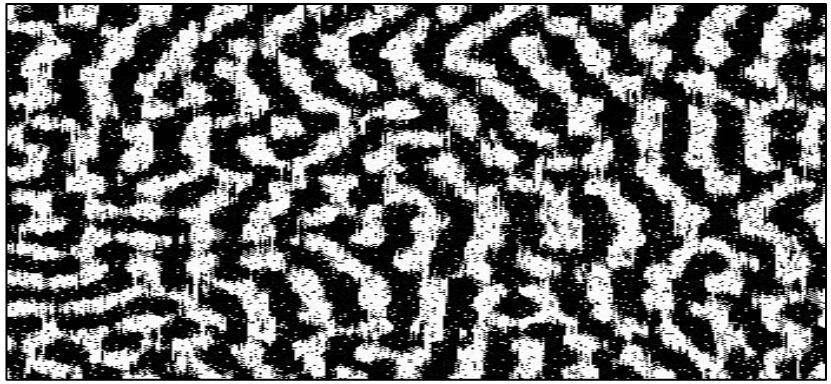
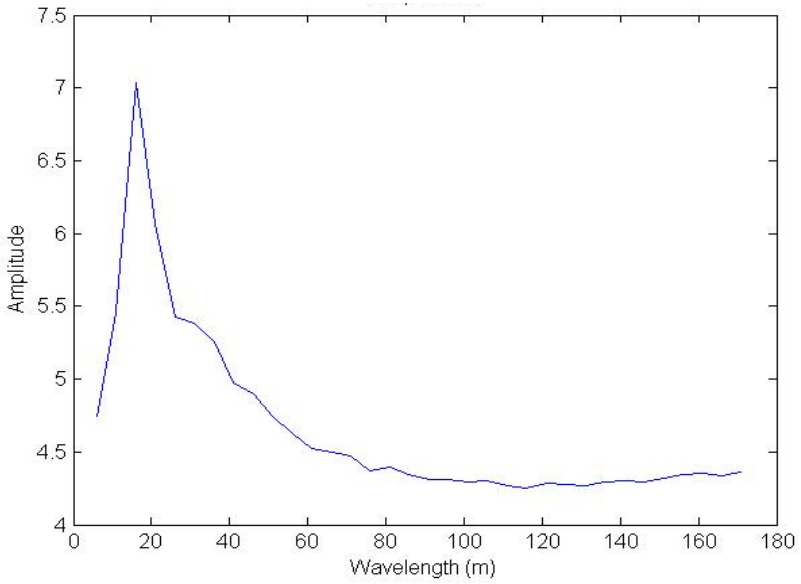
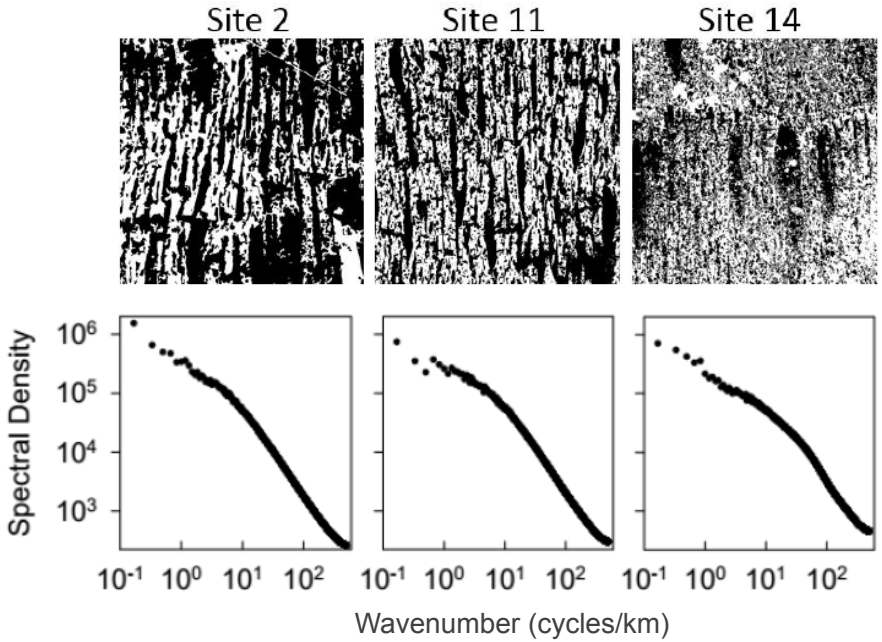




Everglades R-S Landscape Lacks Characteristic Wavelength:



- Consistent across all sites → wide range of hydrology/quality
- **Suggests global- not intermediate-scale negative feedbacks**

Casey et al., 2015

Pattern: Spatial Organization of the R-S Mosaic

Global-scale feedbacks → No regular patterning → Power-law patch scale distributions

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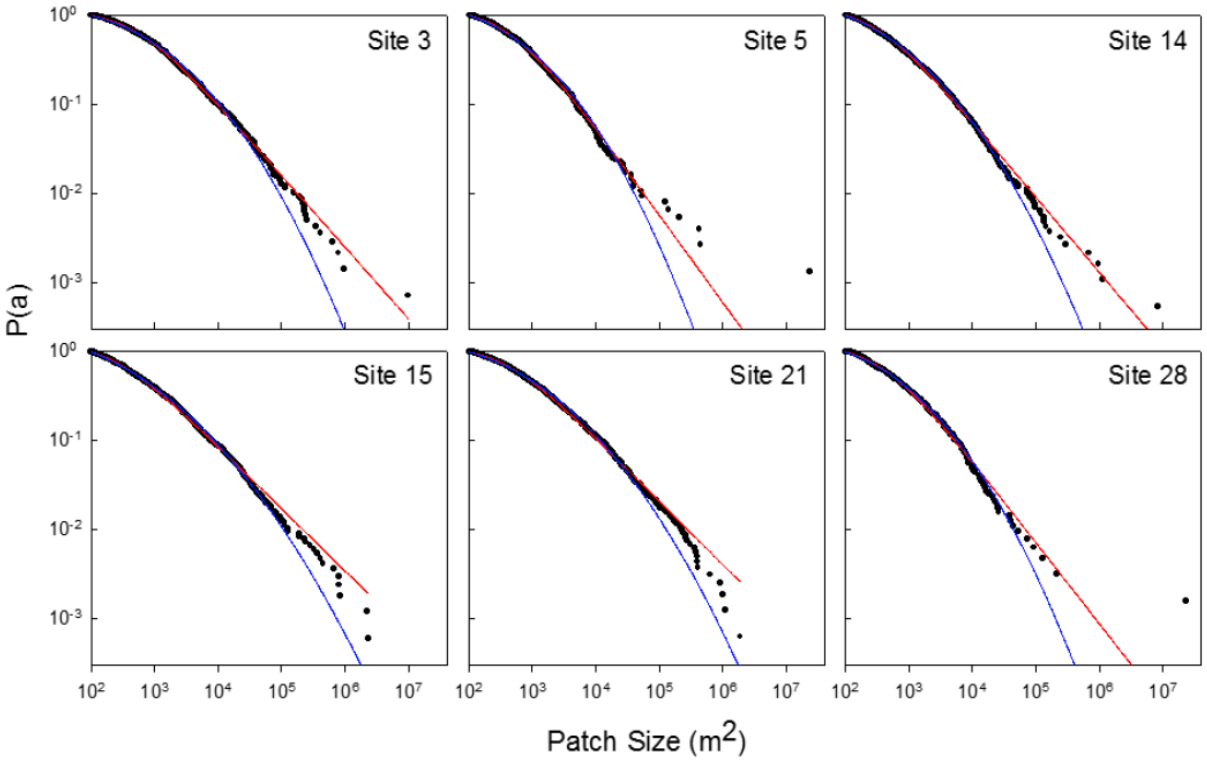
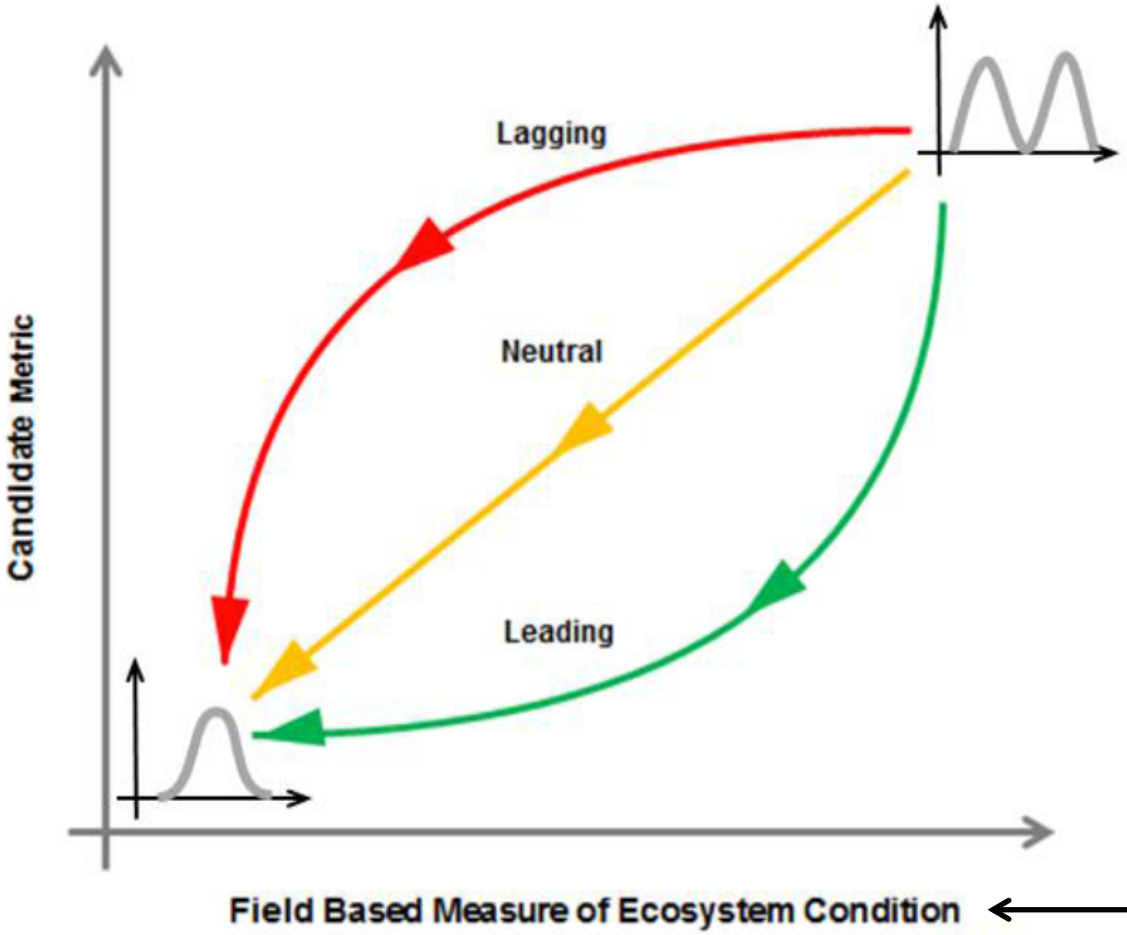


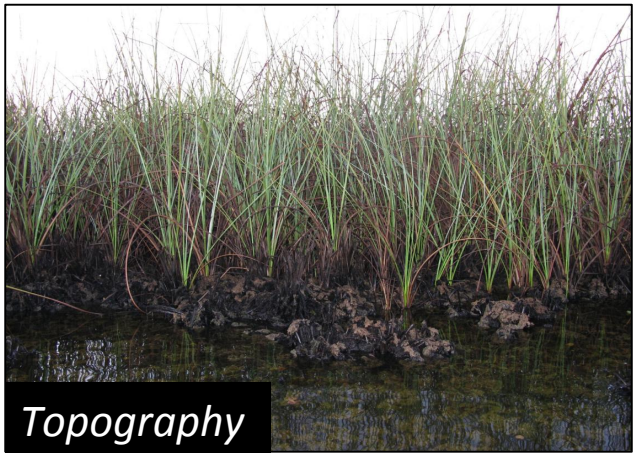
- Power-law patch size distribution **(red lines)** consistent with scale-free patterning
- Rounding at low end: missed small features or lognormal distribution **(blue lines)**
- Suggests ***robust criticality*** as organizing phenomenon: local facilitation + global negative feedback

Casey et al., 2015

Pattern + Topography: Leading Indicators?*

SEE JING YUAN'S POSTER #93!





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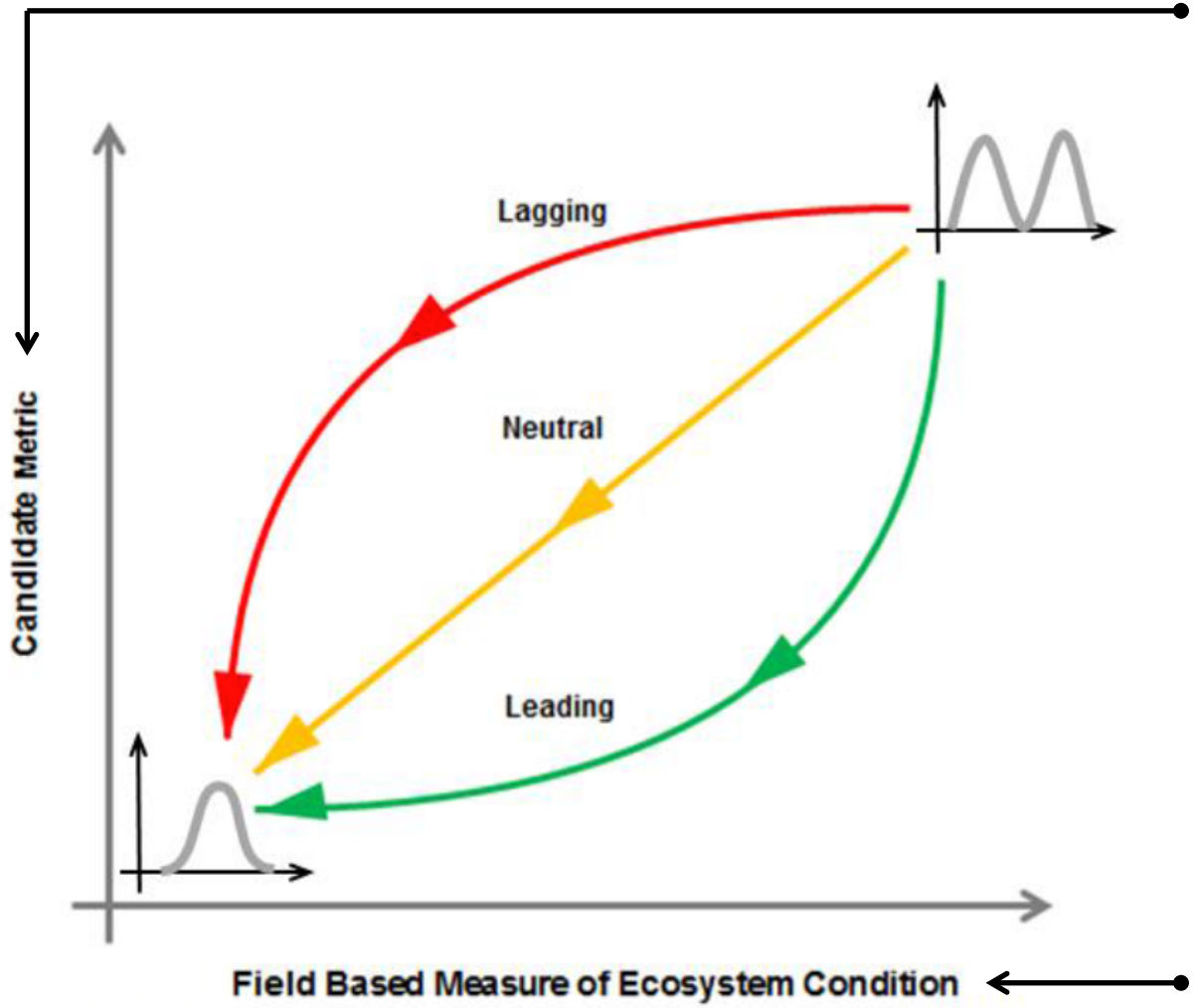
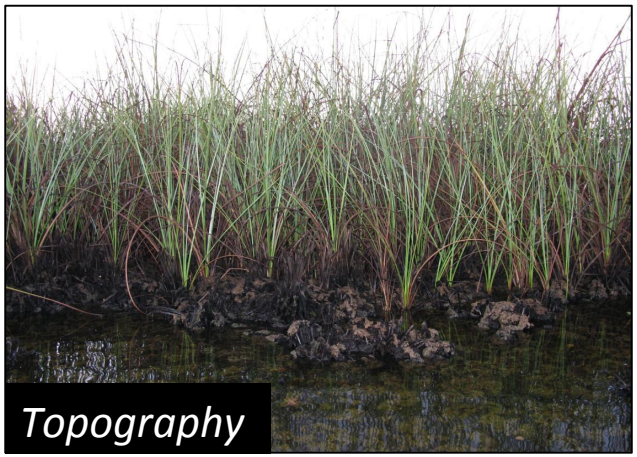


Pattern metrics:

- Wu et al., 2006
- Nungesser, 2011
- Casey et al., 2015
- Connectivity-based:
  - Kaplan et al., 2012
  - Larsen et al., 2012
  - Yuan et al., 2015
- RS vegetation indices



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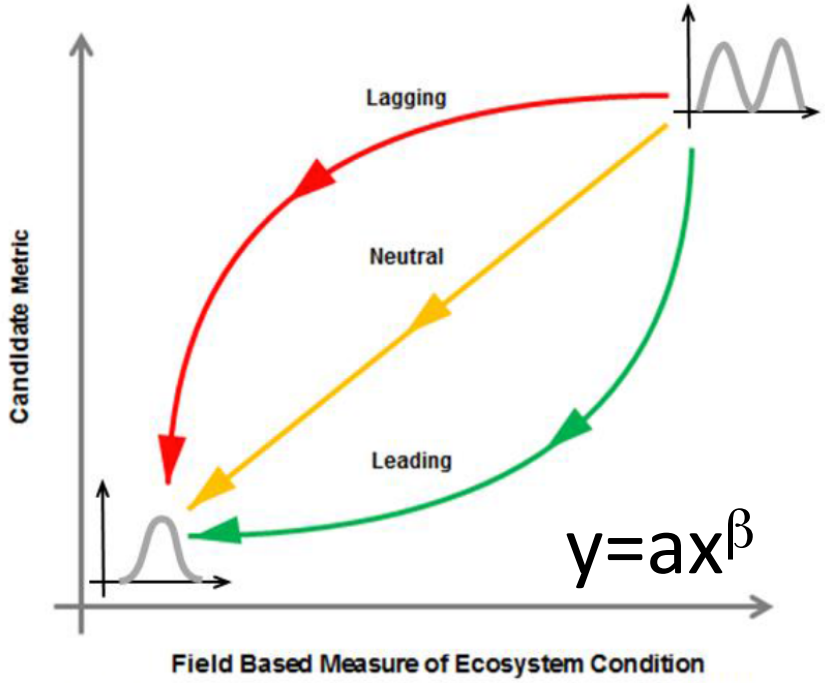
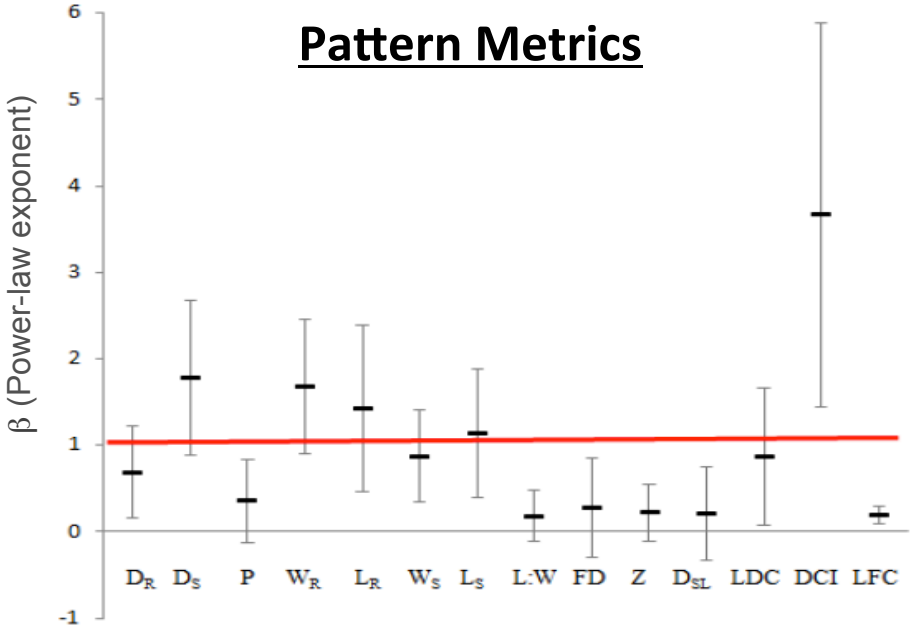
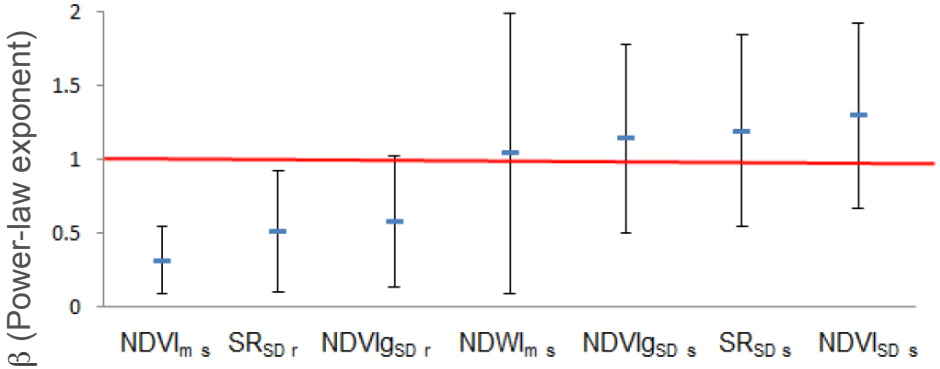


- $|\beta| > 1$ → *Leading* Indicator
- $|\beta| < 1$ → *Lagging* Indicator
- Only DCI (Larsen et al., 2012) significant
- But…$R^2 < 0.5$ for ALL metrics
- Field topo. measurement…

Pattern Metrics



Vegetation Indices



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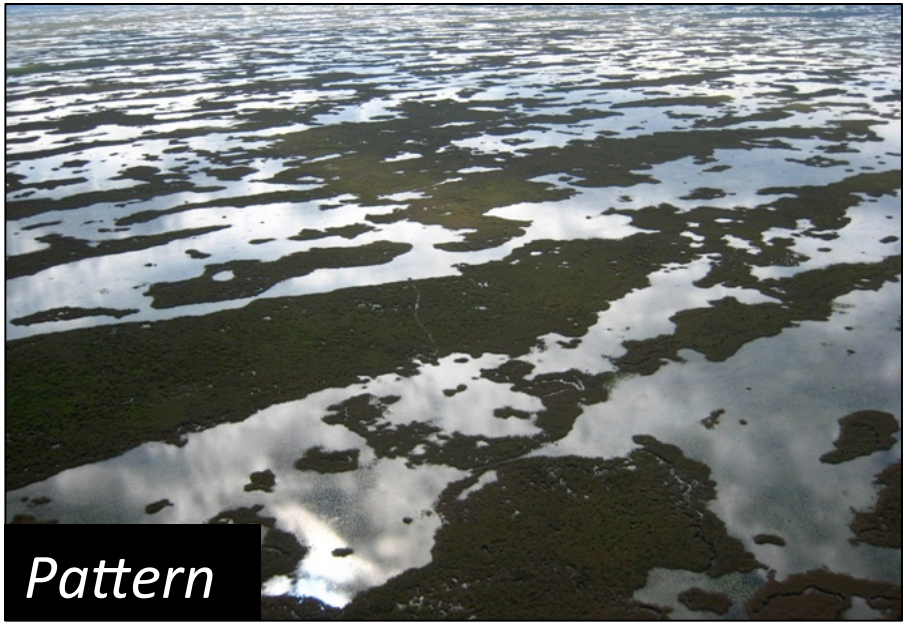
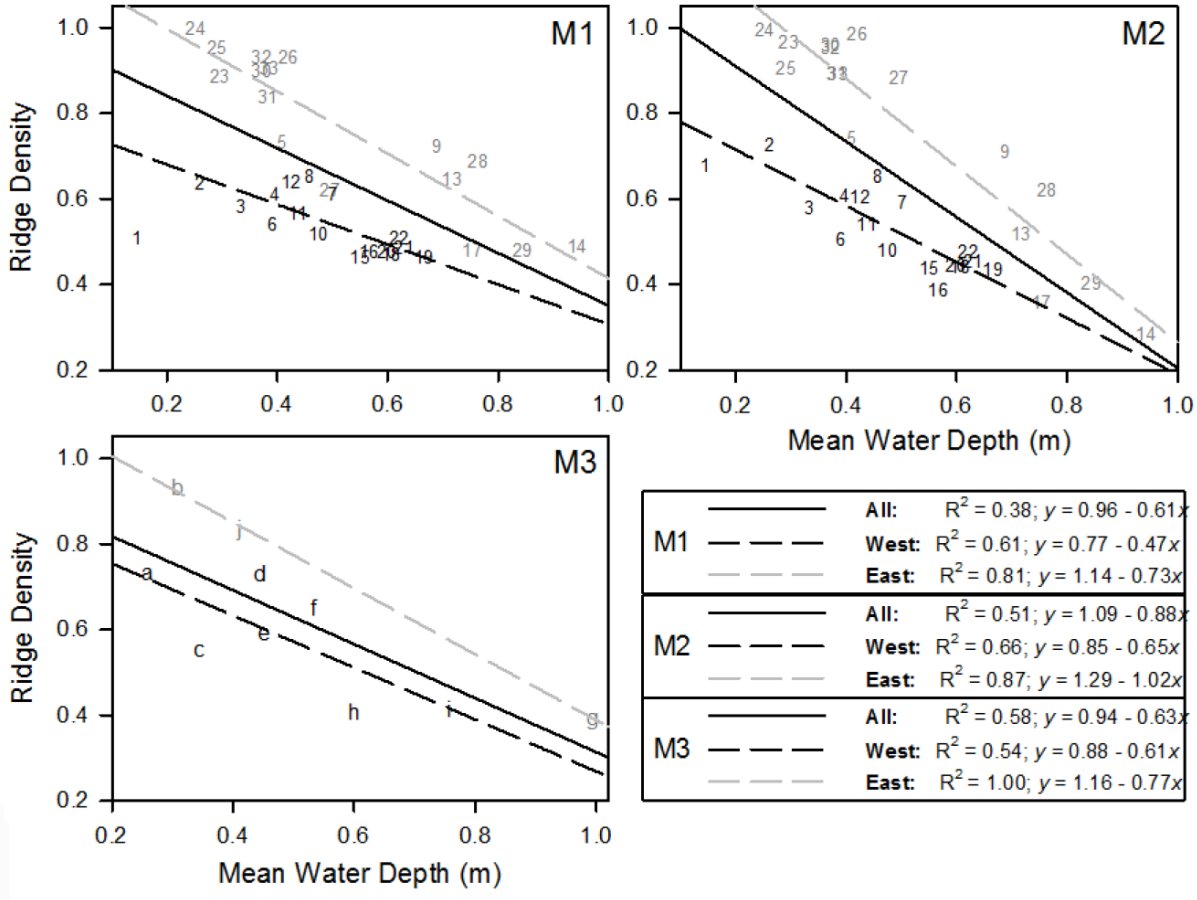


Hydrology → Pattern (Observations)*

Ridge prevalence, anisotropy, and perimeter correlated with depth



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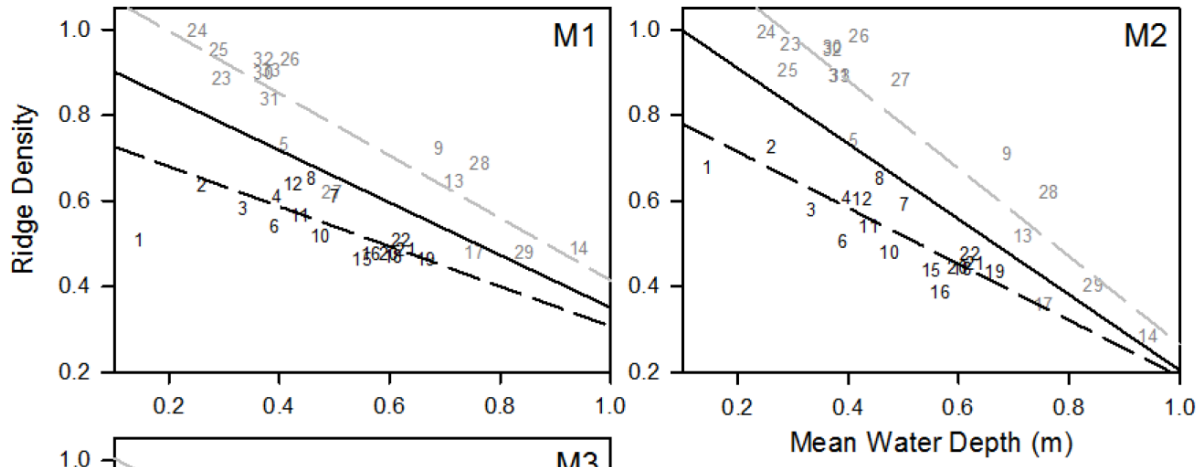
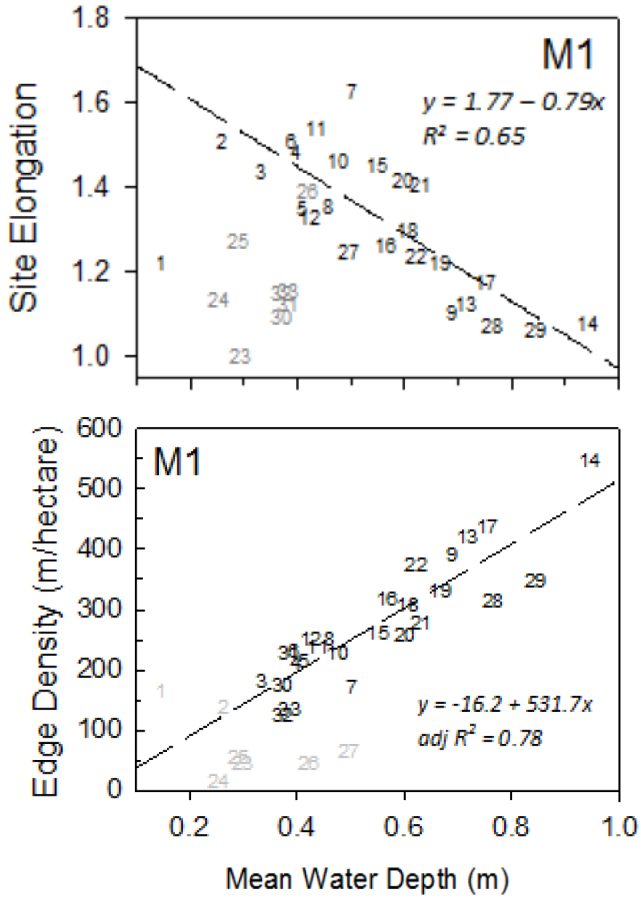


M1	All:	$R^2 = 0.38$; $y = 0.96 - 0.61x$
	West:	$R^2 = 0.61$; $y = 0.77 - 0.47x$
	East:	$R^2 = 0.81$; $y = 1.14 - 0.73x$
M2	All:	$R^2 = 0.51$; $y = 1.09 - 0.88x$
	West:	$R^2 = 0.66$; $y = 0.85 - 0.65x$
	East:	$R^2 = 0.87$; $y = 1.29 - 1.02x$
M3	All:	$R^2 = 0.58$; $y = 0.94 - 0.63x$
	West:	$R^2 = 0.54$; $y = 0.88 - 0.61x$
	East:	$R^2 = 1.00$; $y = 1.16 - 0.77x$



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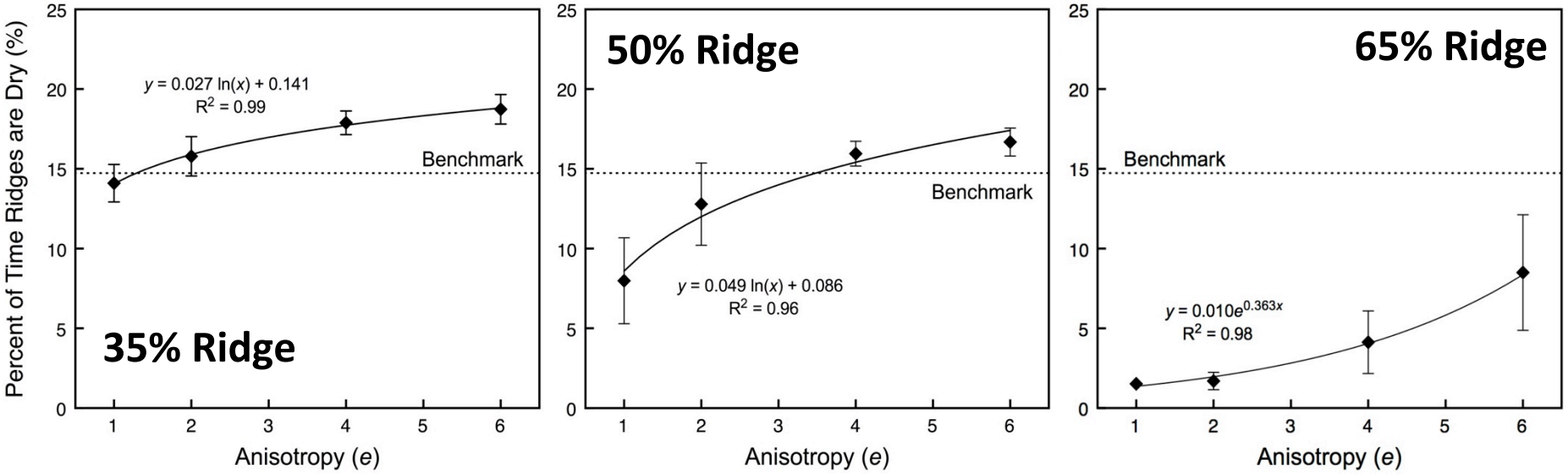
Ridge prevalence and anisotropy combine to control hydroperiod



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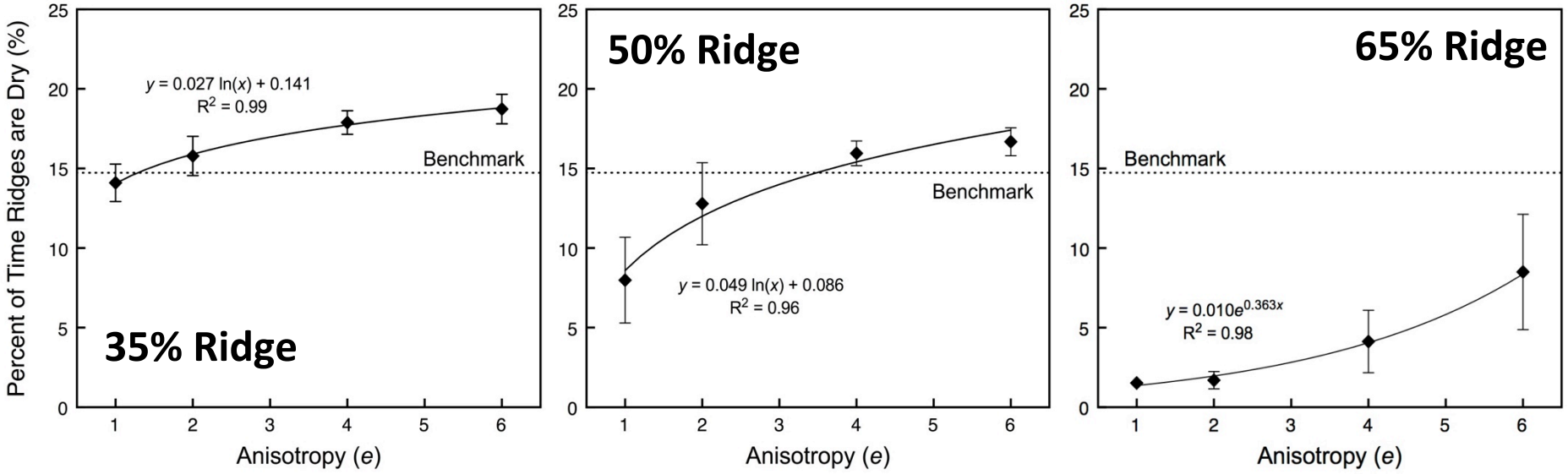
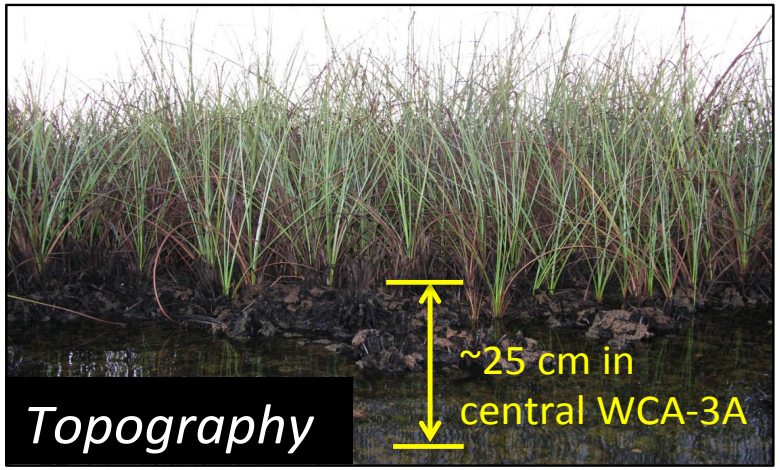


- Shown here for 25 cm ridges
- Same approach to estimate flows required to support 60-90 cm ridges **(SESSION 40, THURSDAY 3:30 PM!)**



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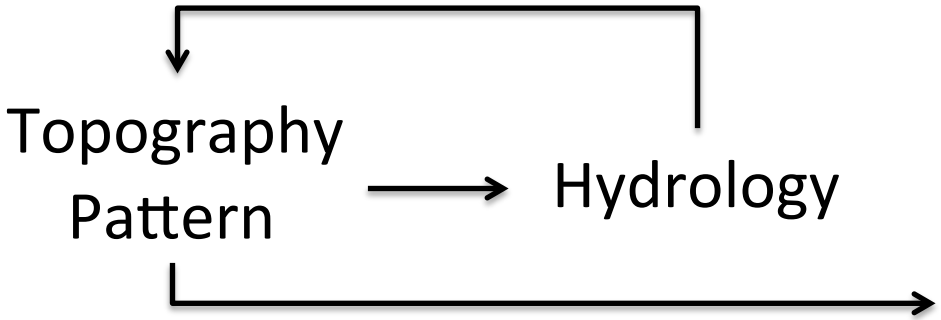
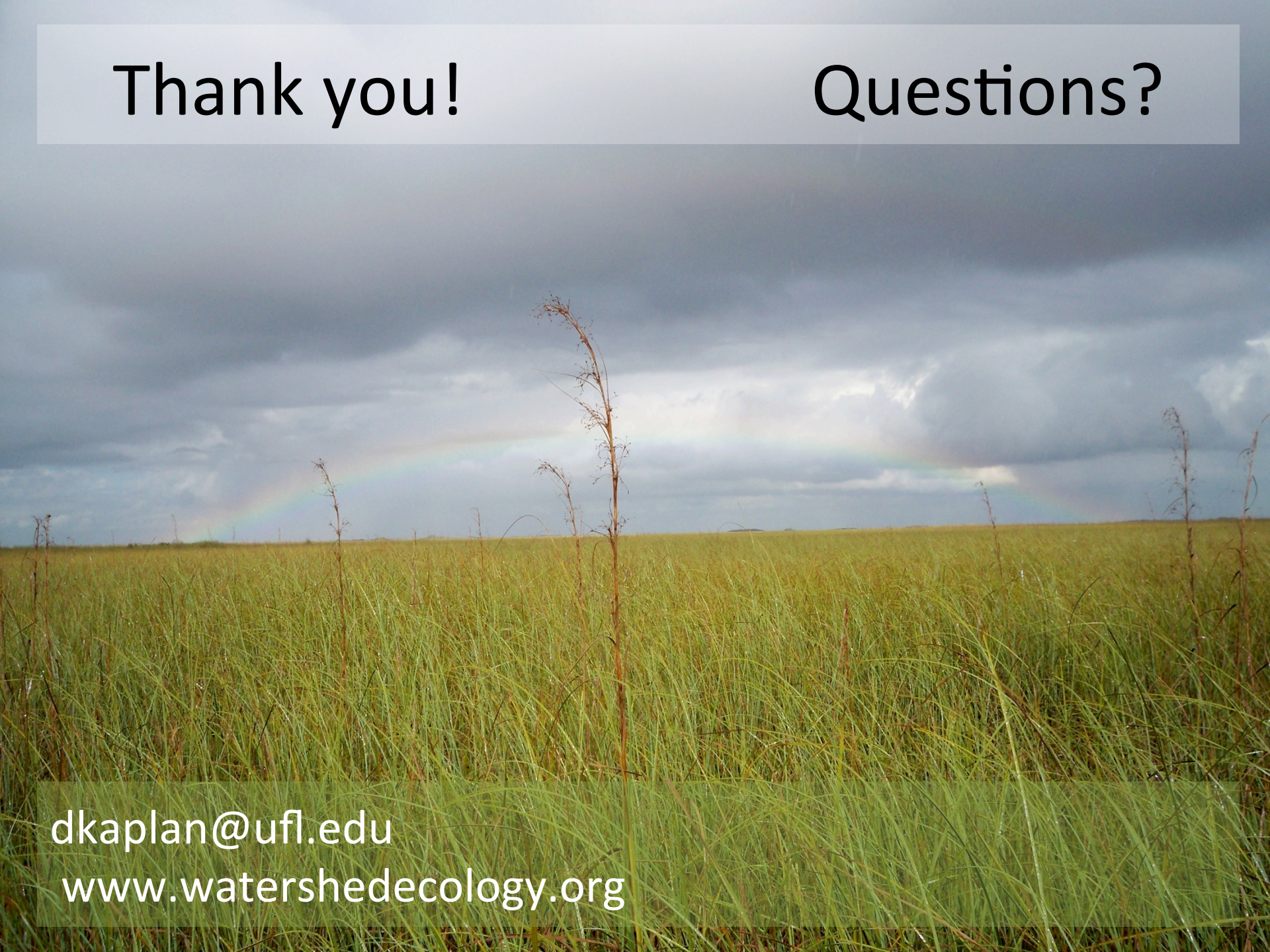


Acharya, S., D. Kaplan, S. Casey, M.J. Cohen, and J. Jawitz. 2015. Coupled local facilitation and global hydrologic inhibition drive landscape geometry in a patterned peatland, **Hydrol. Earth Syst. Sci.** Discuss., 12, 1247-1277


Thank you!
Questions?
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