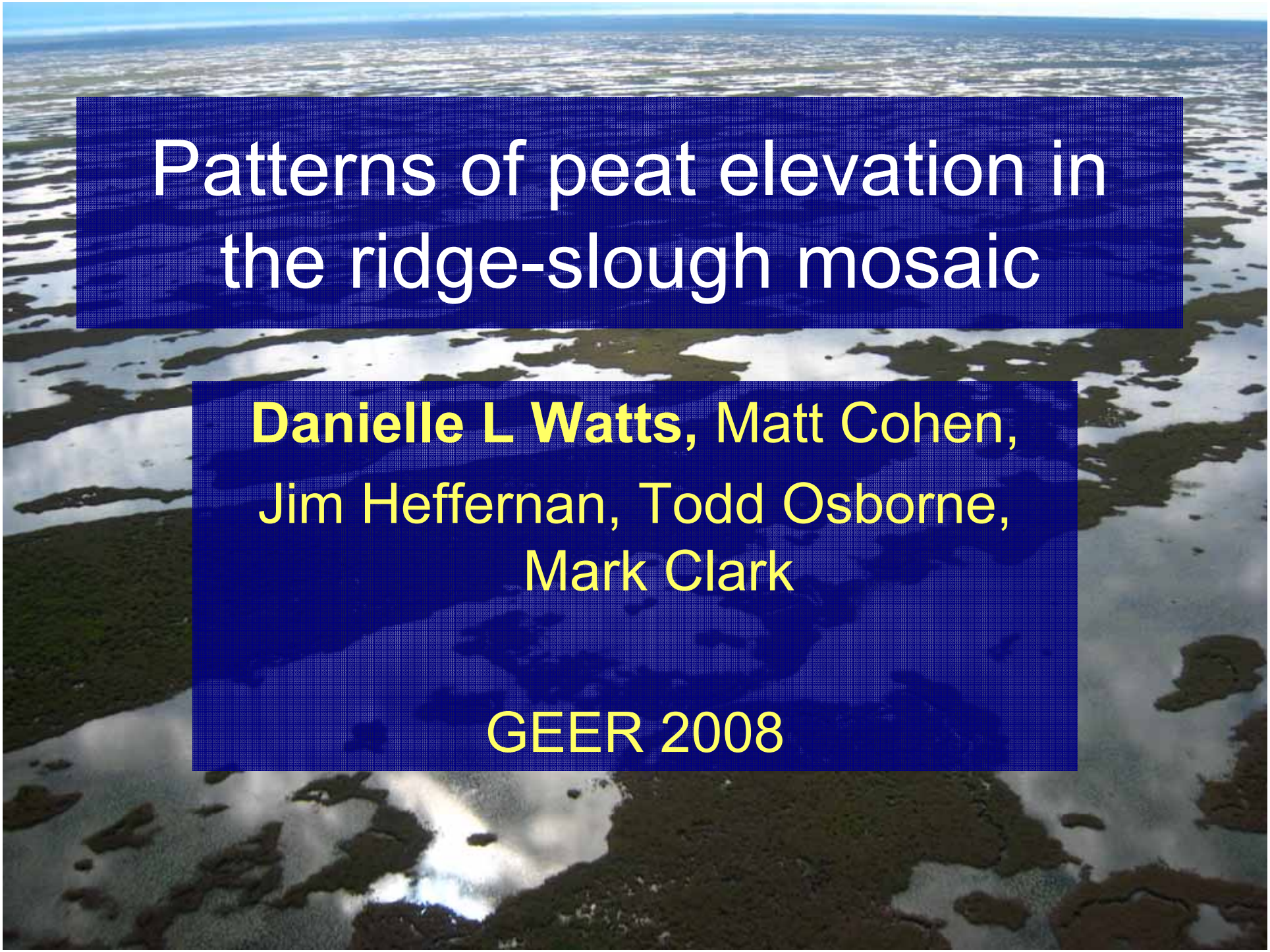
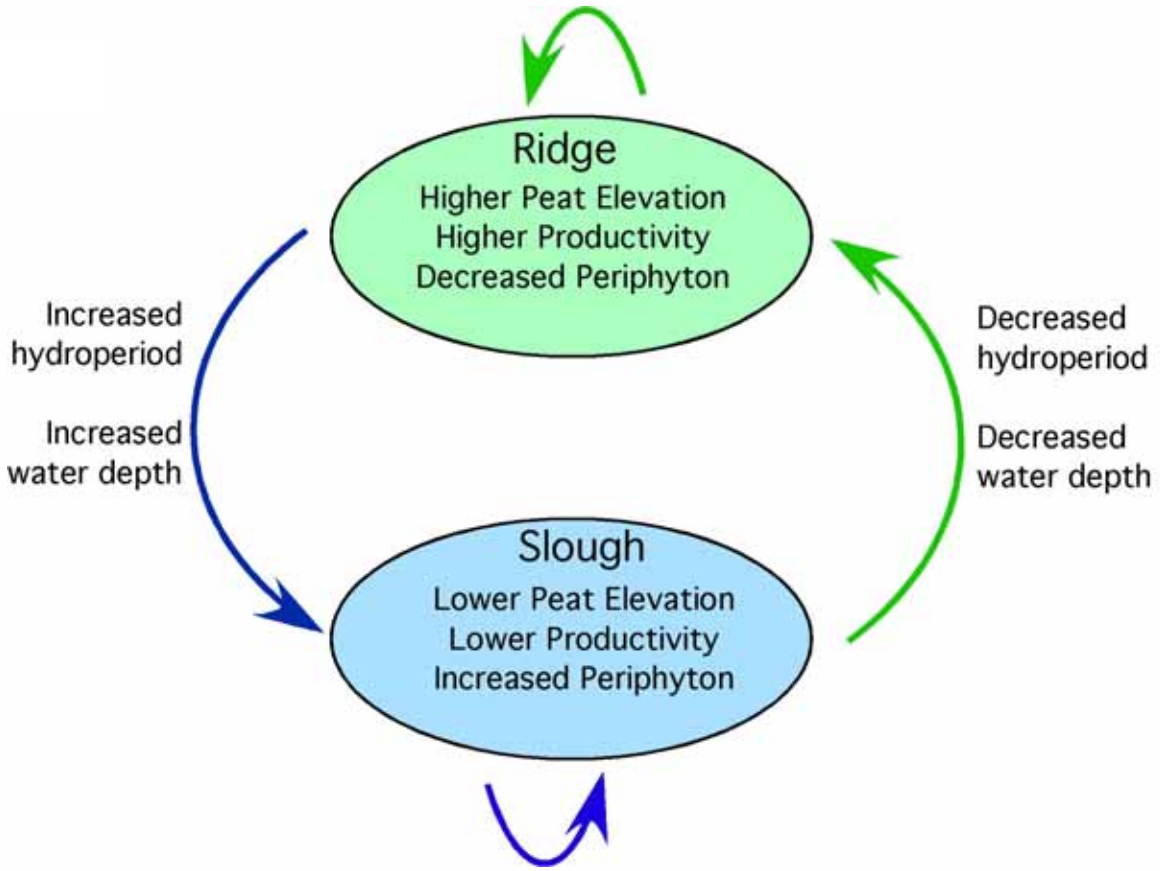


Patterns of peat elevation in the ridge-slough mosaic

Danielle L Watts, Matt Cohen, Jim Heffernan, Todd Osborne, Mark Clark

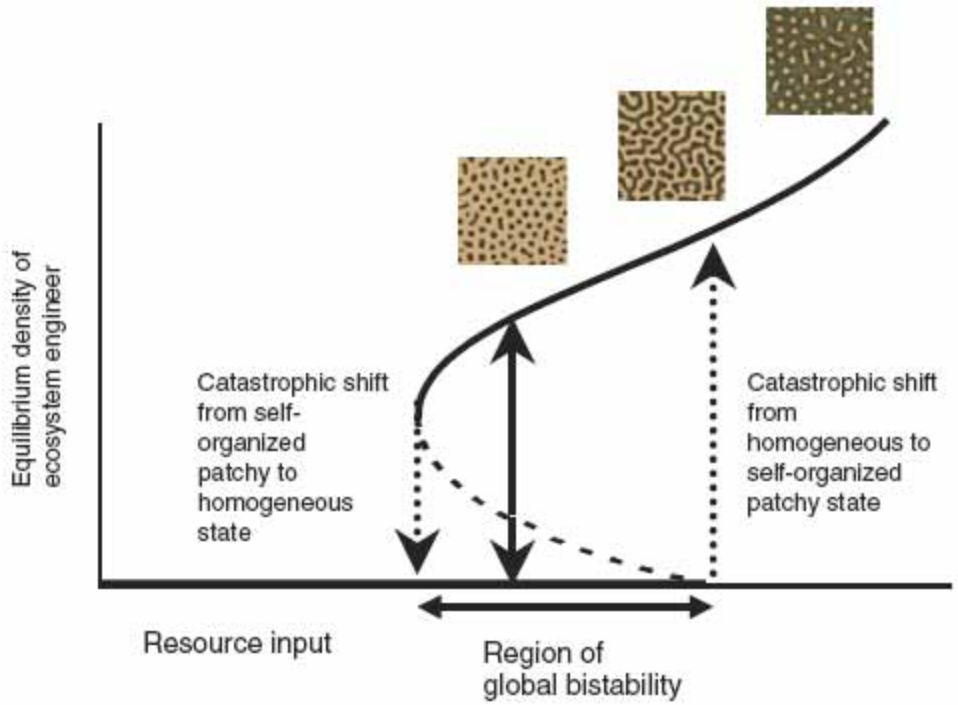
GEER 2008

Alternative States



Spatial Alternative Stable States

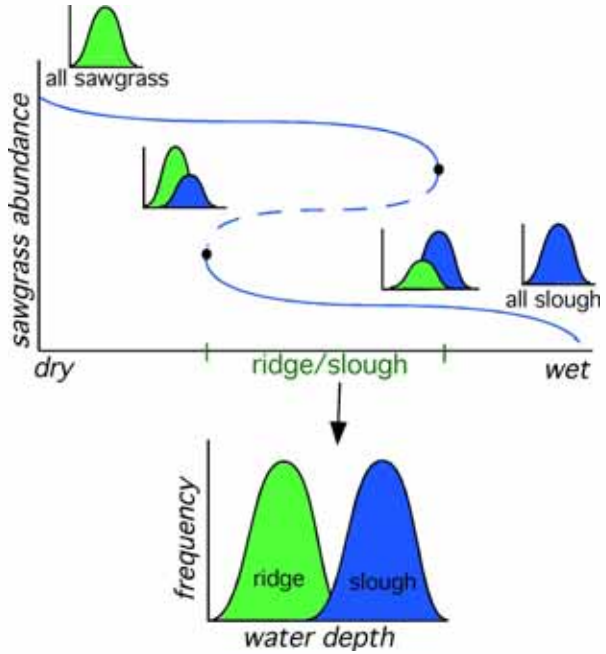
Homogenous vs. self-organized patchiness



Rietkerk, M., et al. 2004. Self-organized patchiness and catastrophic shifts in ecosystems. Science **305**:1926-1929.

Question 1

Does the ridge-slough mosaic express alternative stable states?



Predictions

- $P_{1\text{-}1}$: There is a bimodal distribution of water depths.
- $P_{1\text{-}2}$: Veg communities show fidelity to discrete water depth distributions.
- $P_{1\text{-}3}$: Spatial autocorrelation is high at near-point neighbors, decreases with increasing distances.

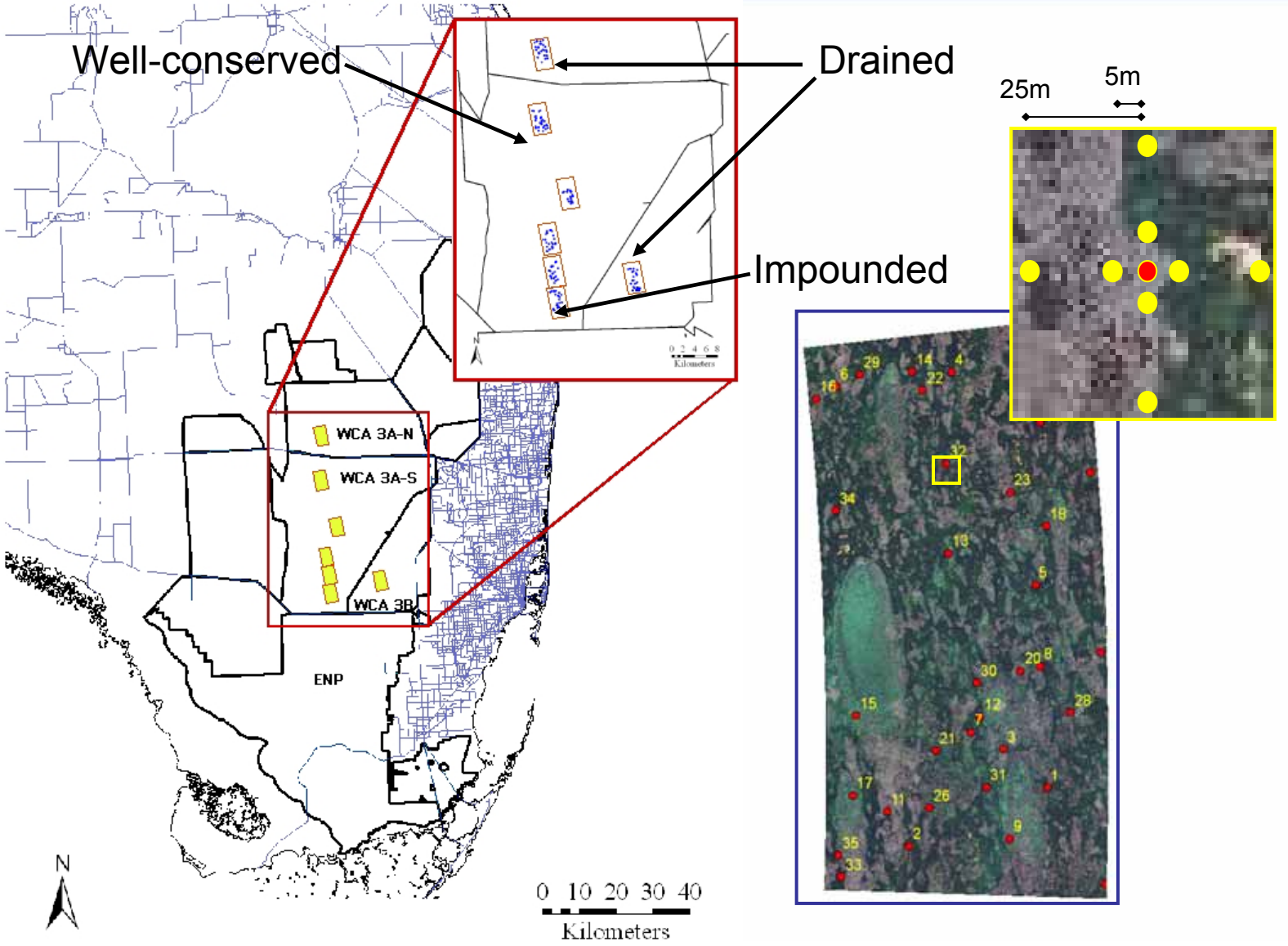
Question 2

- How do the underlying characteristics of ridge-slough change with hydrologic modification?

Predictions

- $P_{2\text{-}1}$: Bimodality is lost with increasing hydrologic impairment
- $P_{2\text{-}2}$: Occurrences of communities alters with hydrologic modification.
- $P_{2\text{-}3}$: Water depth variance increases with hydrologic impairment within communities.
- $P_{2\text{-}4\&5}$: Anisotropy and spatial structure decline with hydrologic impairment.

Sampling


Well-conserved
Drained
Impounded
25m
5m
WCA 3A-N
WCA 3A-S
WCA 3B
ENP
N
0 10 20 30 40
Kilometers

Analyses- Vegetation

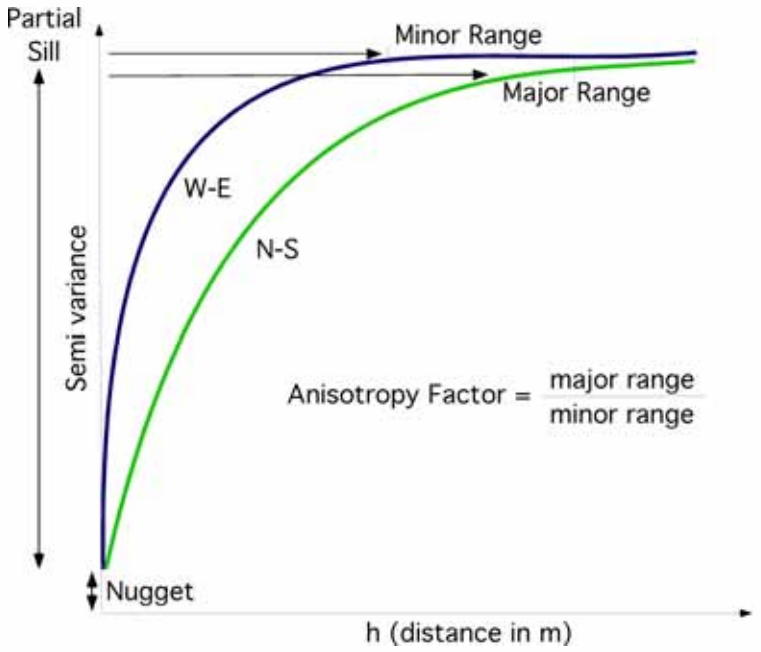
Ridge:
C. jamaicense

Wet Prairie:
Various graminoids, rushes, sedges

Slough:
N. odorata, Utricularia spp

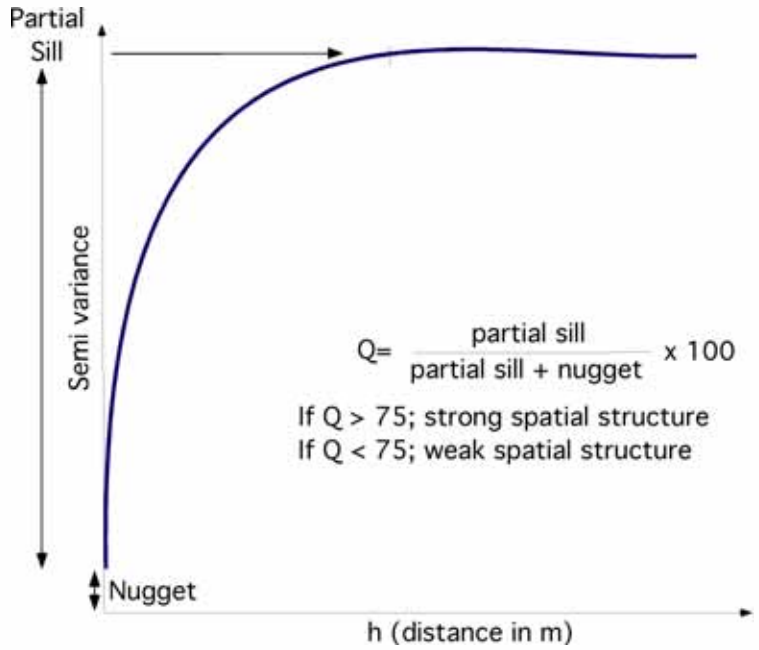
Anisotropy

- Property of being directionally dependent
- Difference in a variable when measured along different axes.



Spatial Structure

- Principle of organization
- Amount of spatial variability not explained by human or natural error



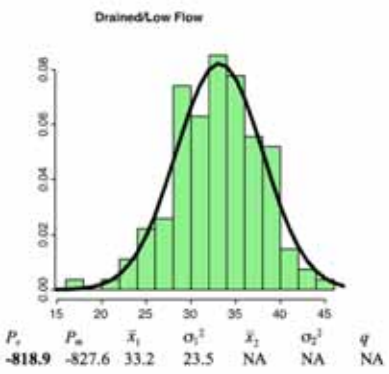
Cambardella, C.A. et al. 1994. Field-scale variability of soil properties in central Iowa soils. Soil. Sci. Soc. Am J. **58**:1501-1511.

Autocorrelation

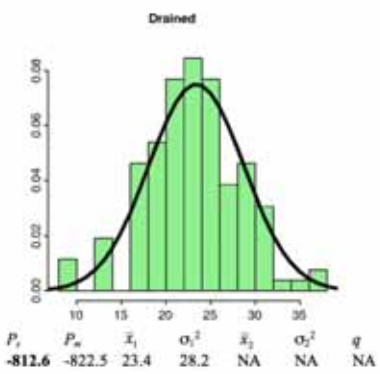
- Tool for finding repeating patterns
- Correlations between points over distances
- (-1,1) indicate perfect negative correlation and positive correlation

Results

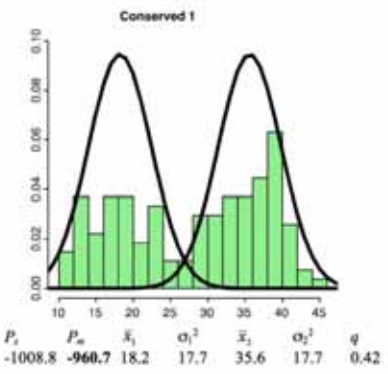
Bimodality



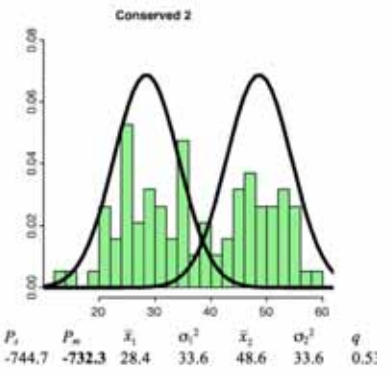
P_s	P_m	$\bar{x}_1$	σ_1^2	$\bar{x}_2$	σ_2^2	q
-818.9	-827.6	33.2	23.5	NA	NA	NA



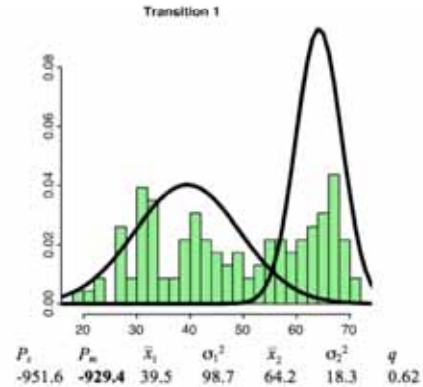
P_s	P_m	$\bar{x}_1$	σ_1^2	$\bar{x}_2$	σ_2^2	q
-812.6	-822.5	23.4	28.2	NA	NA	NA



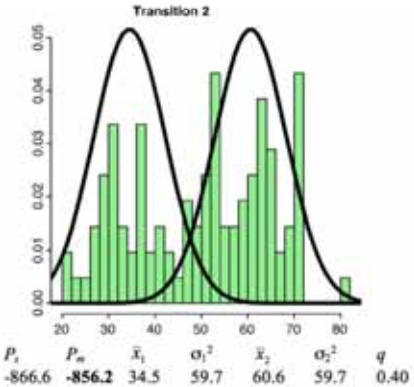
P_s	P_m	$\bar{x}_1$	σ_1^2	$\bar{x}_2$	σ_2^2	q
-1008.8	**-960.7**	18.2	17.7	35.6	17.7	0.42



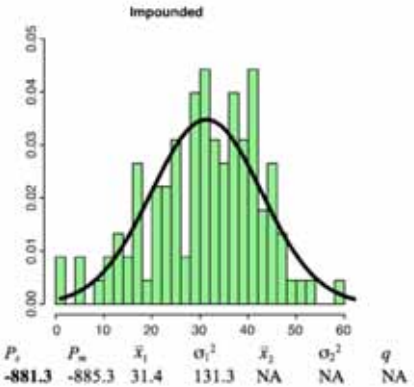
P_s	P_m	$\bar{x}_1$	σ_1^2	$\bar{x}_2$	σ_2^2	q
-744.7	**-732.3**	28.4	33.6	48.6	33.6	0.5



P_s	P_m	$\bar{x}_1$	σ_1^2	$\bar{x}_2$	σ_2^2	q
-951.6	**-929.4**	39.5	98.7	64.2	18.3	0.62



P_s	P_m	$\bar{x}_1$	σ_1^2	$\bar{x}_2$	σ_2^2	q
-866.6	**-856.2**	34.5	59.7	60.6	59.7	0.40



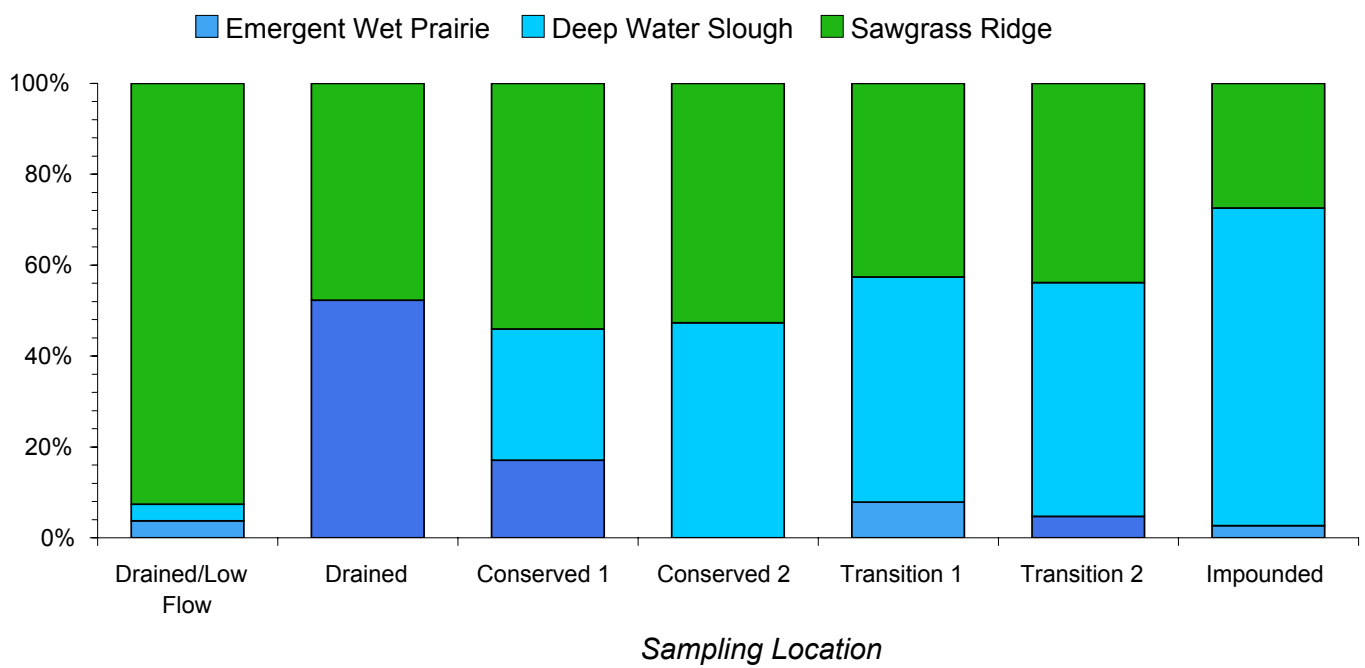
P_s	P_m	$\bar{x}_1$	σ_1^2	$\bar{x}_2$	σ_2^2	q
-881.3	-885.3	31.4	131.3	NA	NA	NA

Vegetation

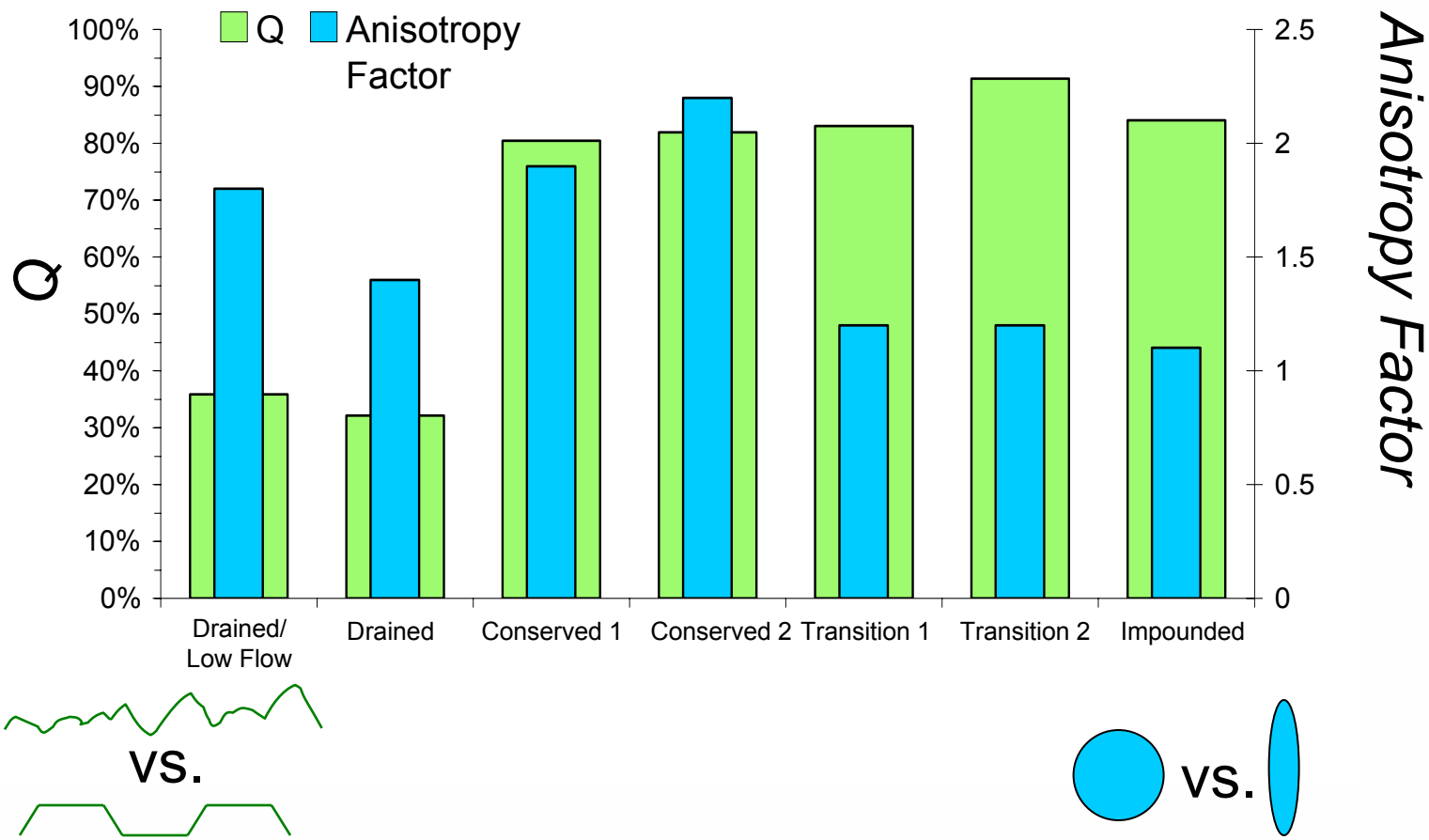
and water depth

Site designation	Community	t-value	p-value	mean (cm)	var (cm^2)
Drained/Low Flow		-3.98	0.004		
	Ridge			32.73	21.20
	Slough/Wet Prairie			39.38	20.98
Drained		-4.92	3.03E-06		
	Ridge			20.88	28.02
	Wet Prairie			25.32	21.34
Conserved 1		-17.33	< 2.2E-16		
	Ridge			20.94	41.62
	Slough			37.09	14.71
Conserved 2		-14.21	< 2.2E-16		
	Ridge			28.73	46.51
	Slough			48.43	41.00
Transition 1		-17.52	< 2.2E-16		
	Ridge			35.47	60.55
	Slough			61.03	54.89
Transition 2		-6.82	1.41E-09		
	Ridge			40.65	153.13
	Slough			57.88	143.25
Impounded		-7.01	1.26E-08		
	Ridge			21.07	118.51
	Slough			36.94	72.43

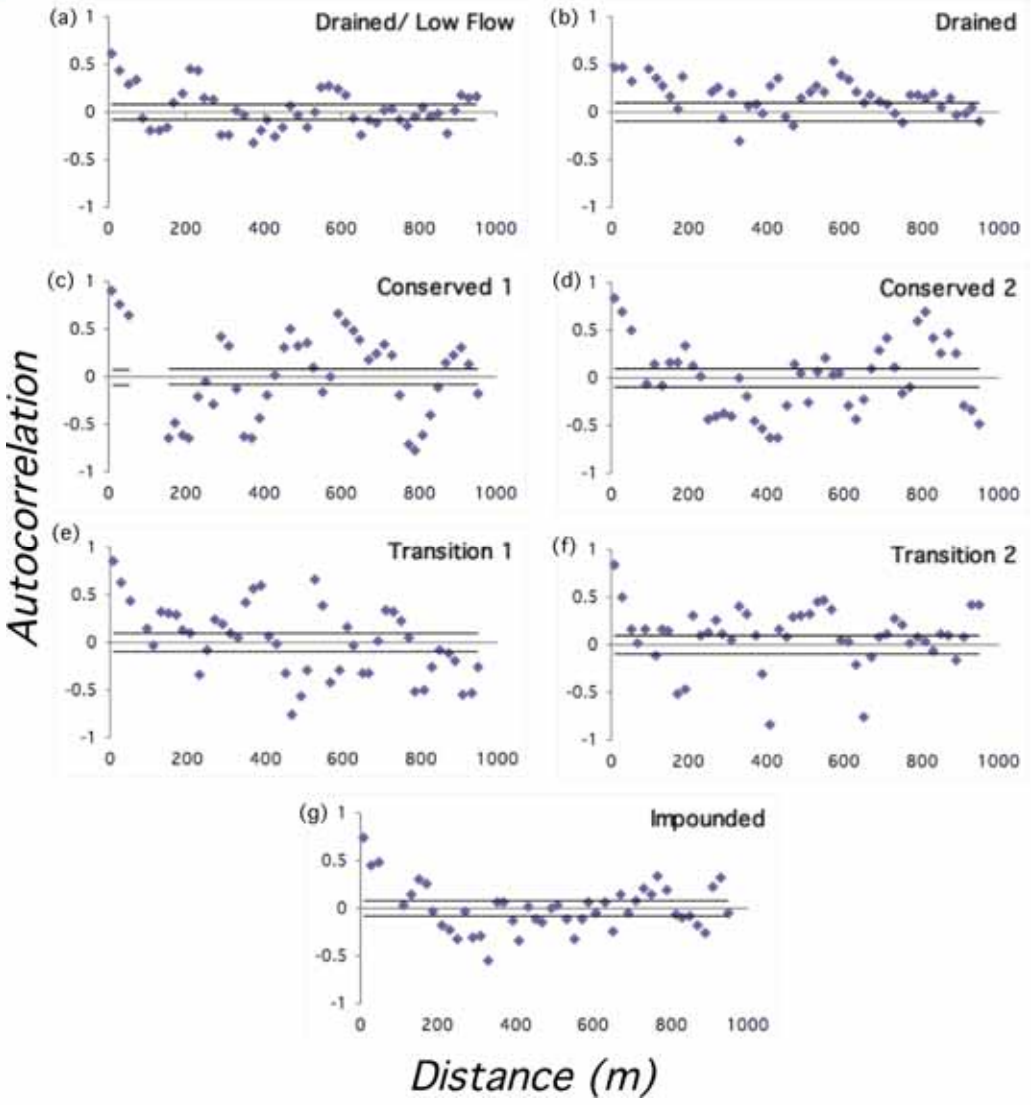
Vegetation Occurrence



Spatial Analyses



Autocorrelation



Conclusions

1. The ridge-slough mosaic exhibits bimodal patterns.
2. Hydrologic modification is associated with a convergence of ridge-sloughs, increases in variance.
3. Drained areas lose spatial structure; impounded areas lose directional anisotropy.
4. Community abundance shifts with altered hydrology, as does the type of slough vegetation.

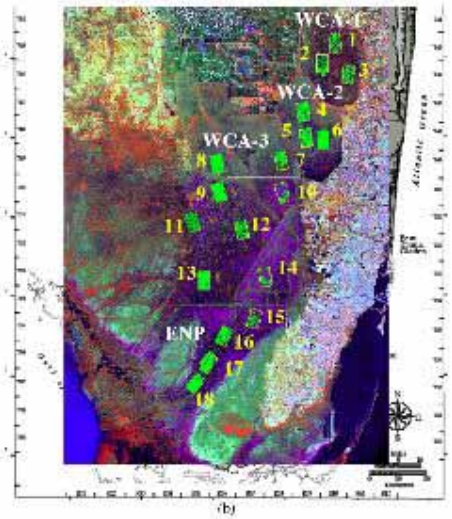
Further…

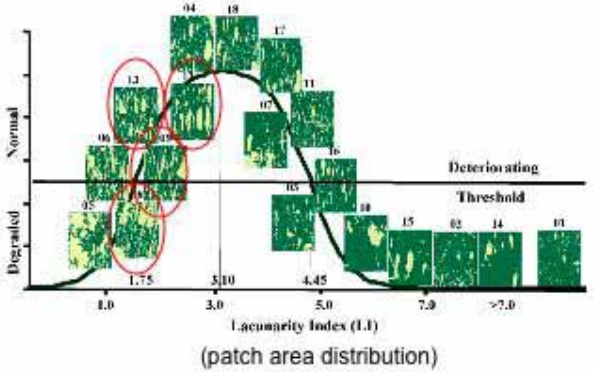
- Evidence highly suggestive of alt. stable states
- Hydrologic modification alters:
  - State stability
  - Pattern dynamics
- Discrete set of hydrologic conditions for R-S patterning
- Multi-level responses for patterning

So….

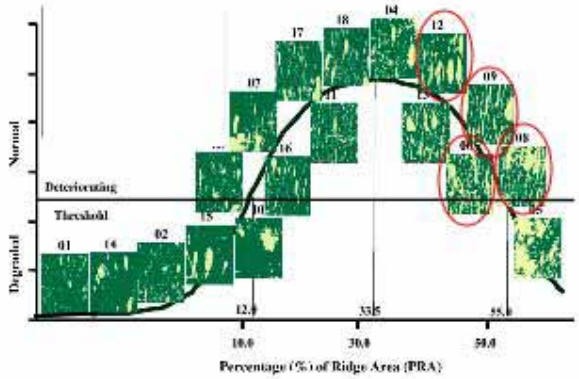
- Soil elevation key indicator of ridge-slough stability and loss.

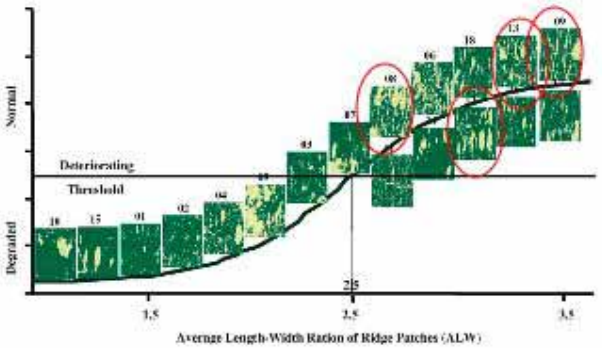
Visual Pattern Disconnect





(patch area distribution)





Wu, Y., et al. 2006. An analysis of spatial complexity of ridge and slough patterns in the Everglades ecosystem. Ecological Complexity **3**:183-192.

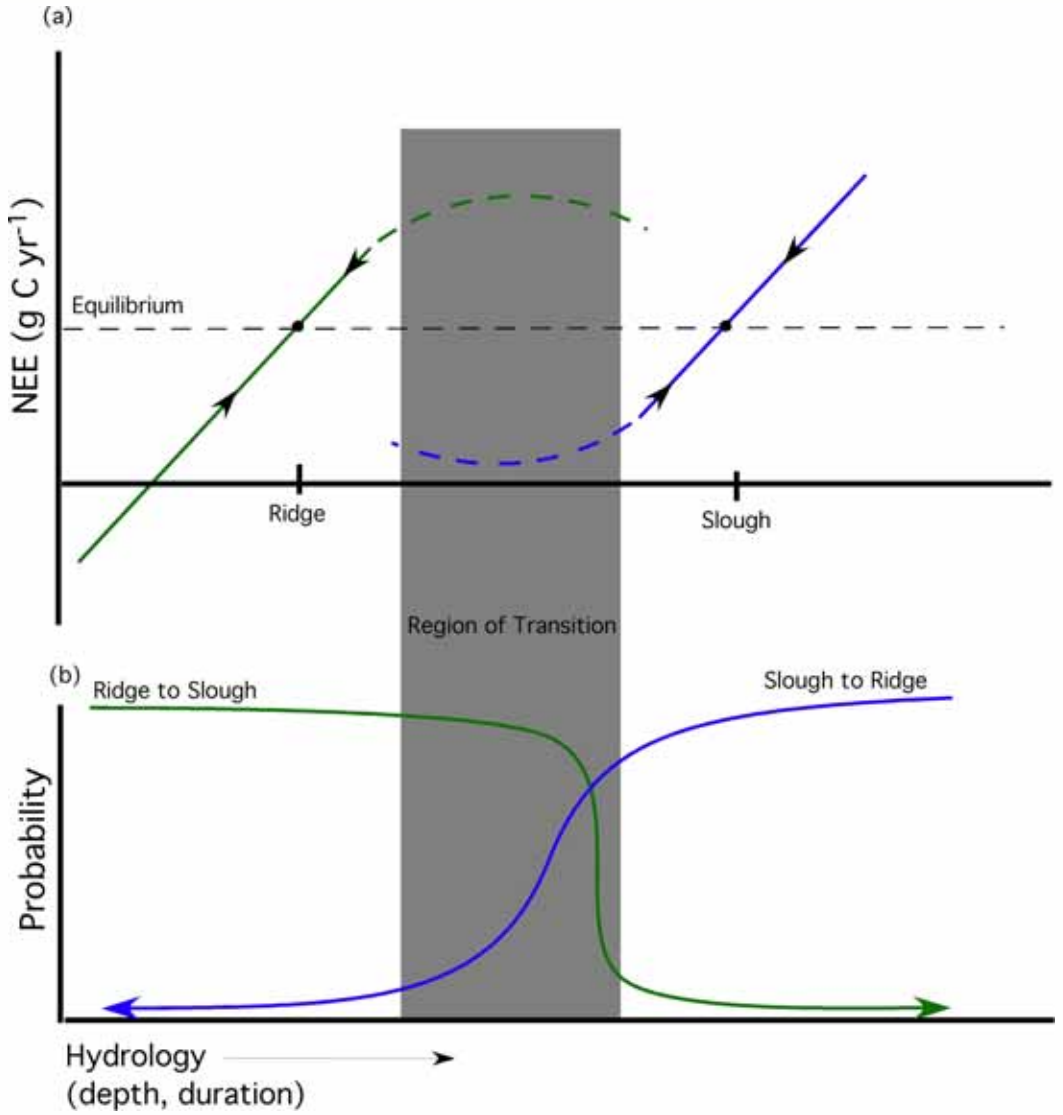
Potential Mechanisms

1. Nutrient subsidy
2. Floc/sediment transport

   (Larsen et al 2007)
3. Locally positive feedbacks (productivity and respiration) and landscape negative feedbacks (hydrology)

   (Scheffer et al 2008)

Multiple Equilibria



Next Steps

- Test predictions regarding potential mechanisms for patterning.
- Quantify carbon budget for ridge and sloughs along hydrologic gradients.
- Partition carbon budget (respiration, production, photolysis) to understand peat accretion drivers.

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- Justin Vogel
- Adam Watts

Thank-you.

Photo credit: Tyler Jones