Hydrologic Processes in a Patterned Peatland:

The role of patch anisotropy on discharge competence and hydroperiod in the Everglades

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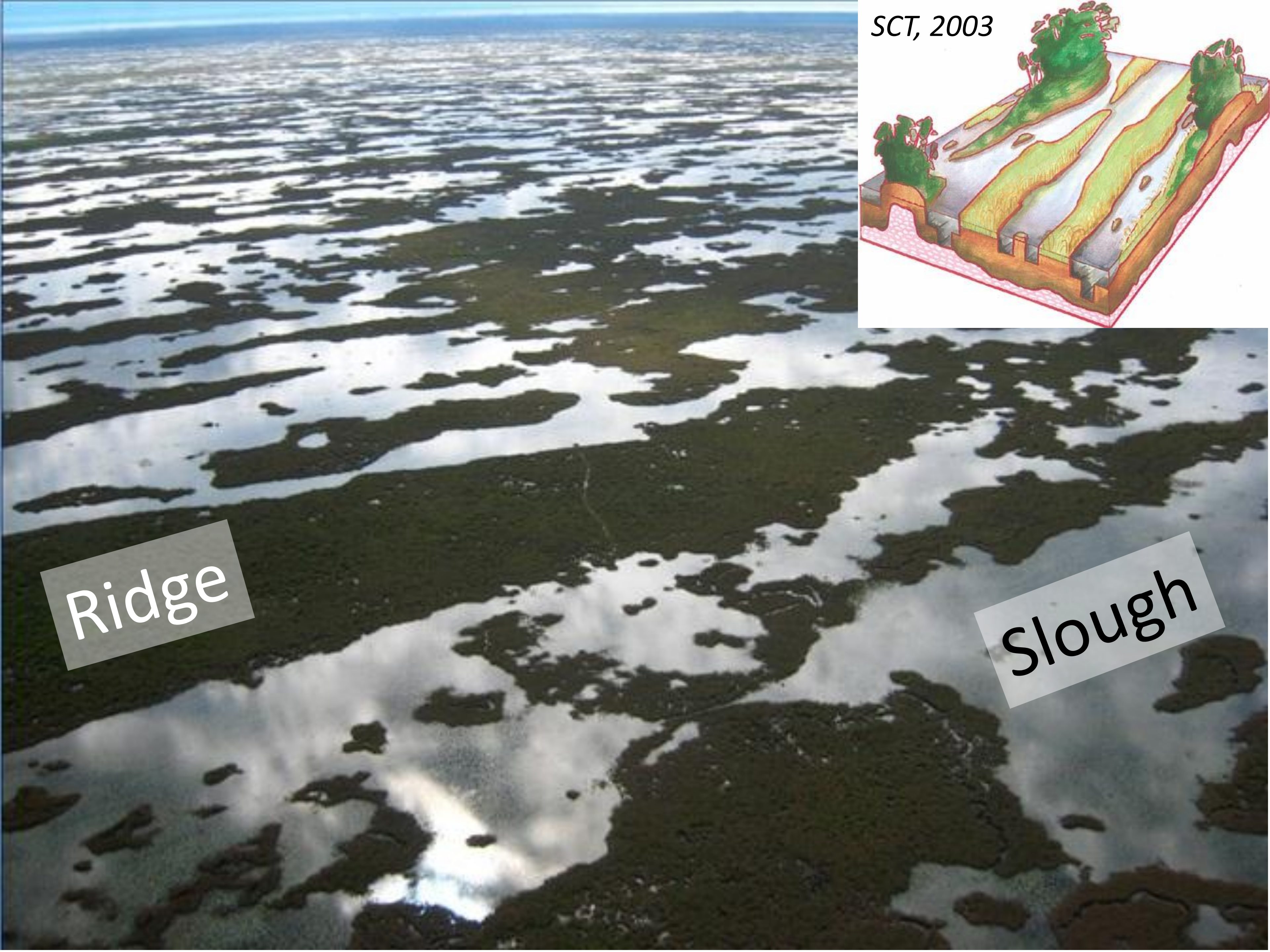

SCT, 2003
Ridge
Slough

Patterning/Pattern Loss in the Everglades

Historic Flow

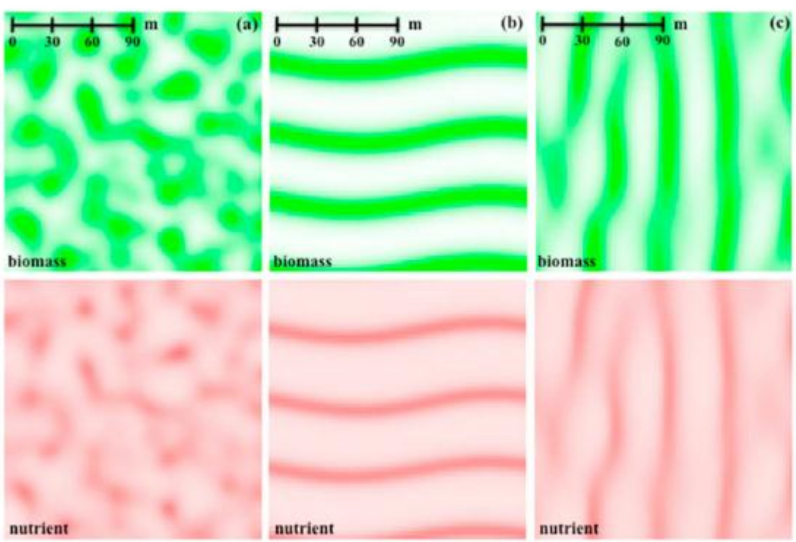
Ridges and sloughs existed in an organized pattern, oriented parallel to the flow direction, on a slightly sloping peatland

Contemporary Flow

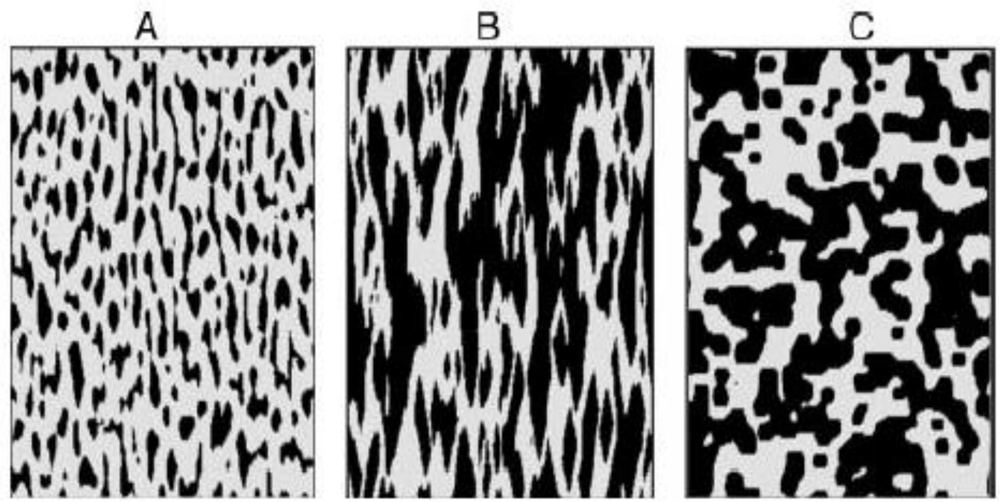
Compartmentalization and water management activities are resulting in a landscape that is more uniform → detrimental ecological effects (*SCT, 2003*).

Hypotheses for Landscape Formation and Degradation

- Sediment redistribution (*Larsen et al., 2007; Larsen and Harvey, 2010, 2011*)
- Subsurface nutrient redistribution (*Ross et al., 2006; Cheng et al., 2011*)
- Coupled feedbacks between hydrology, vegetation, and carbon: The "Self-Organizing Canal" Hypothesis (*Cohen et al., 2011*)

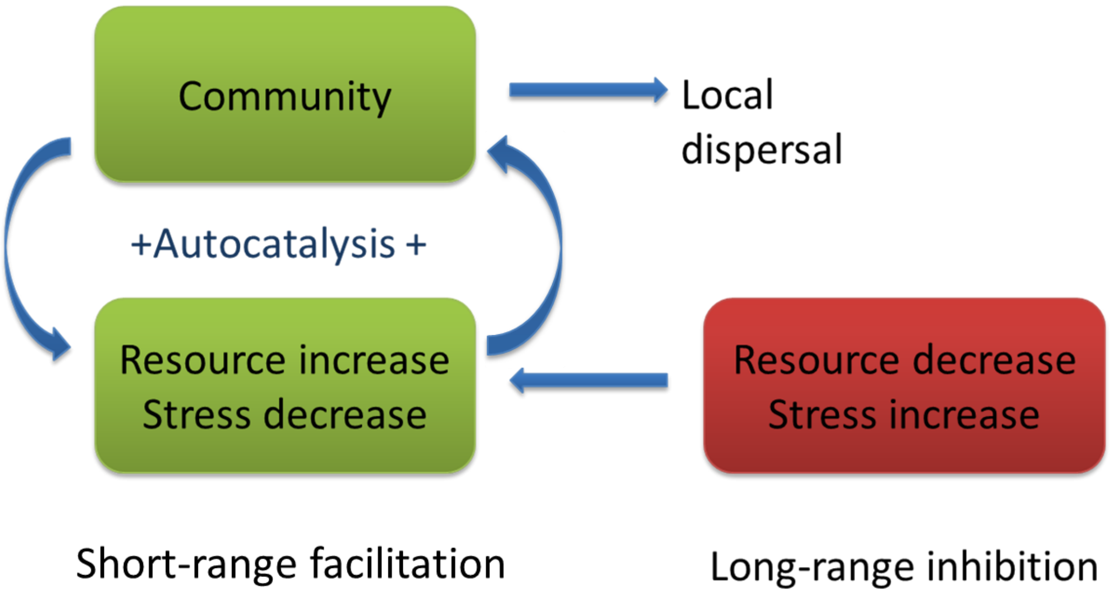


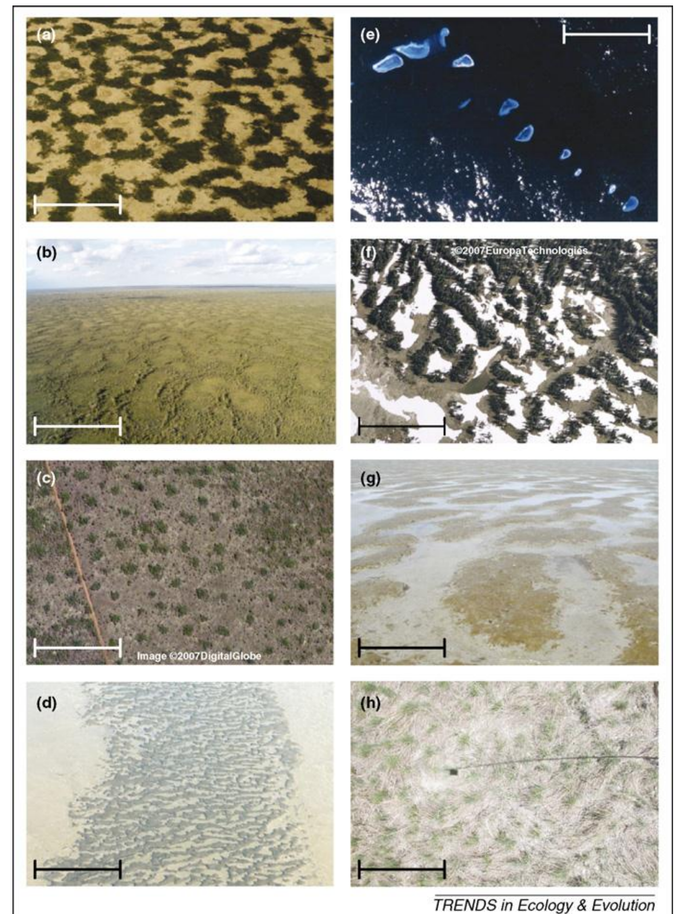
Cheng et al., 2011



Larsen et al., 2011

Self-Organization and Scale-Dependent Feedback

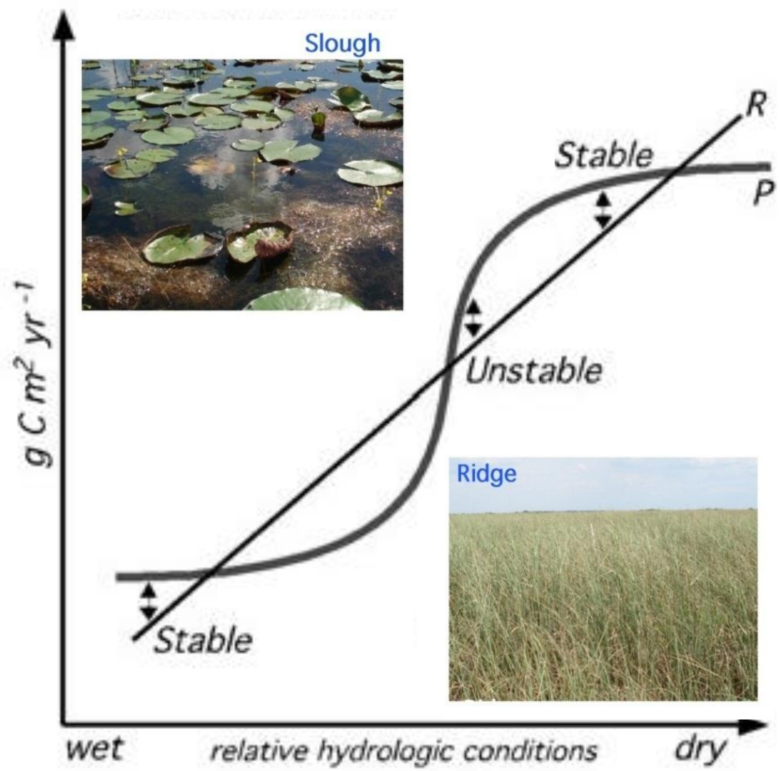




Rietkerk and van de Koppel, 2008

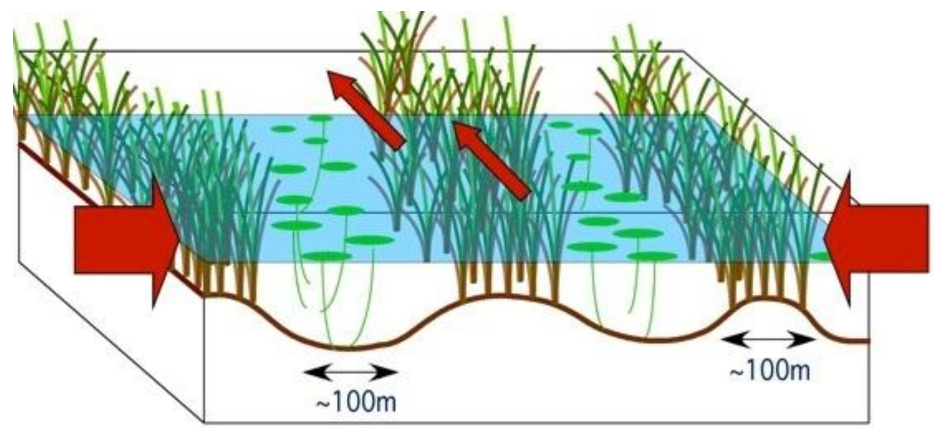
The "Self-Organizing Canal" (SOC) Hypothesis

Point Scale: Carbon Balance



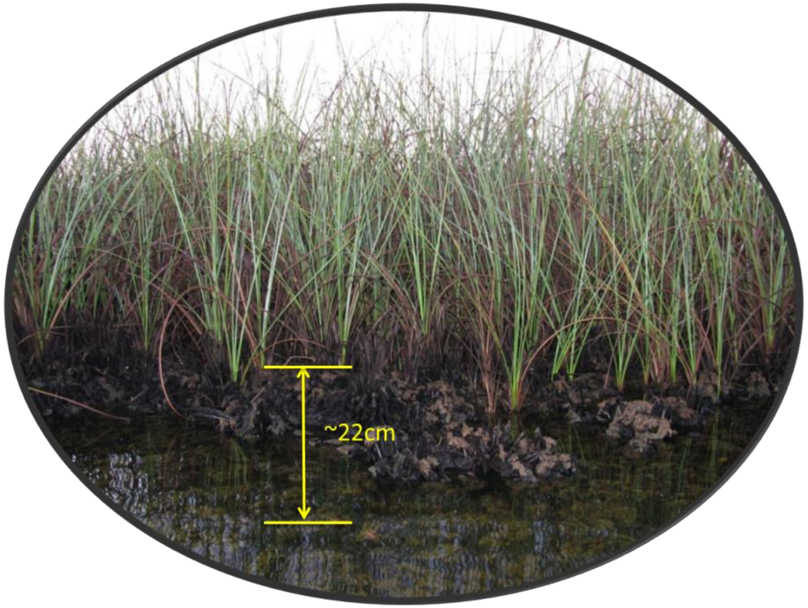
Watts et al. 2010

Landscape Scale:
Discharge Competence



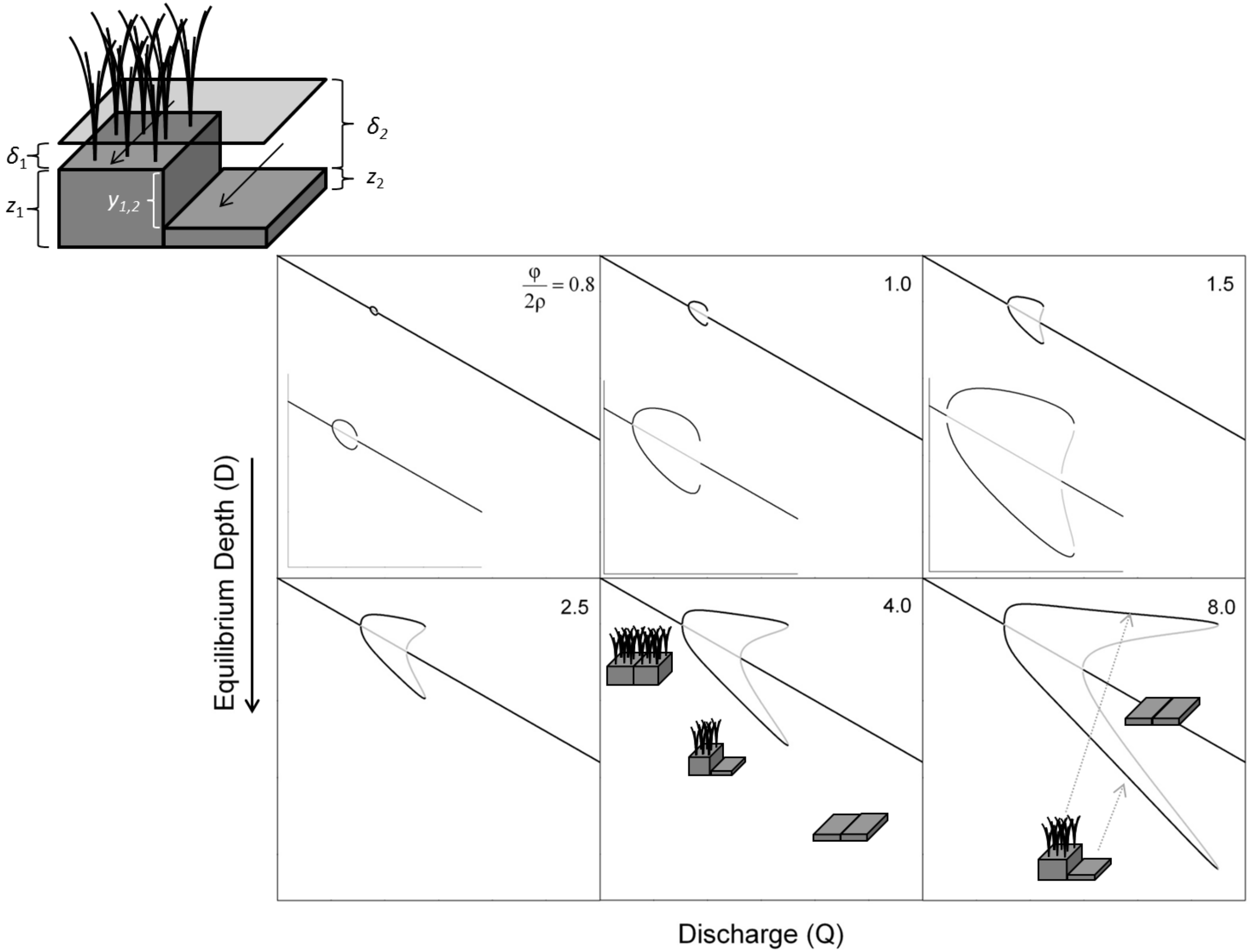
Cohen et al., 2011

The SOC Hypothesis – Linking Hydrology and the Carbon Budget



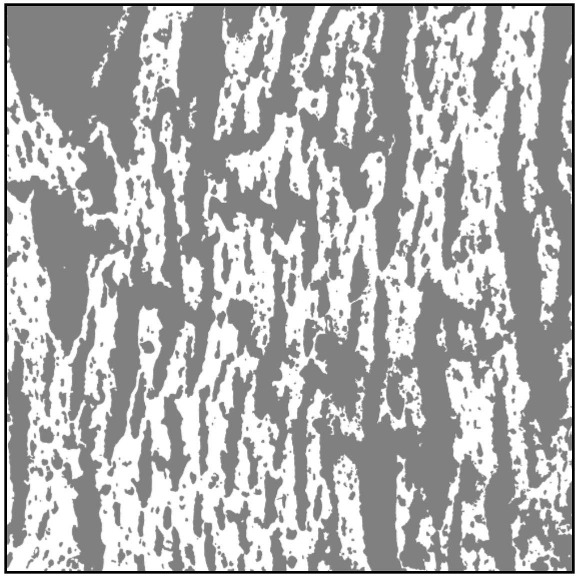
Danielle Watts: “Hydrologic Modification and Peat Dynamics in the Everglades Ridge-Slough Mosaic” (tropical@ufl.edu)

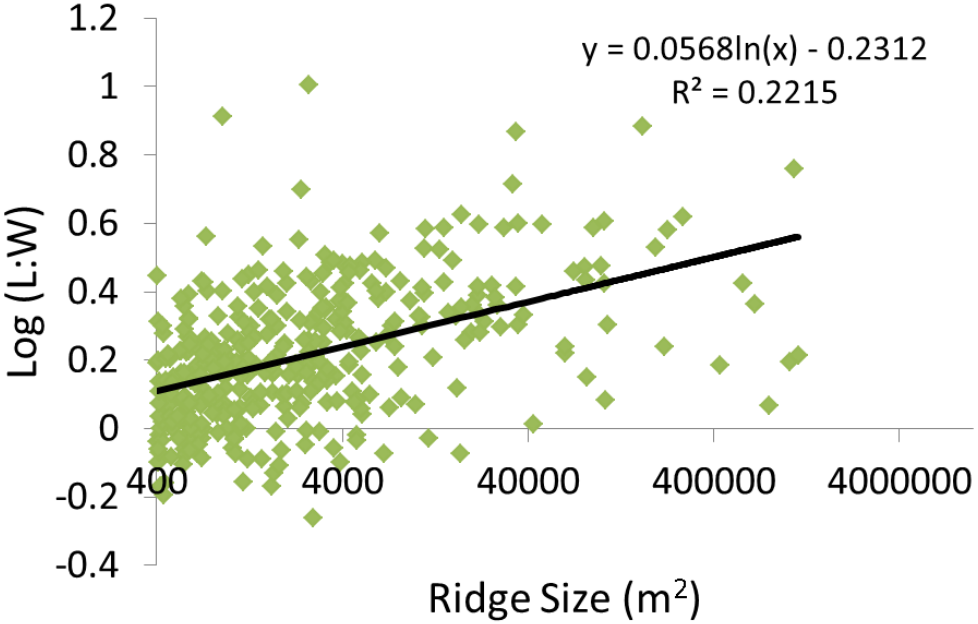
The SOC Hypothesis – Analytical Modeling



James Heffernan: "Discharge Competence as a Mechanism for Peatland Pattern Formation"
(james.heffernan@duke.edu)

The SOC Hypothesis – Pattern Metrics

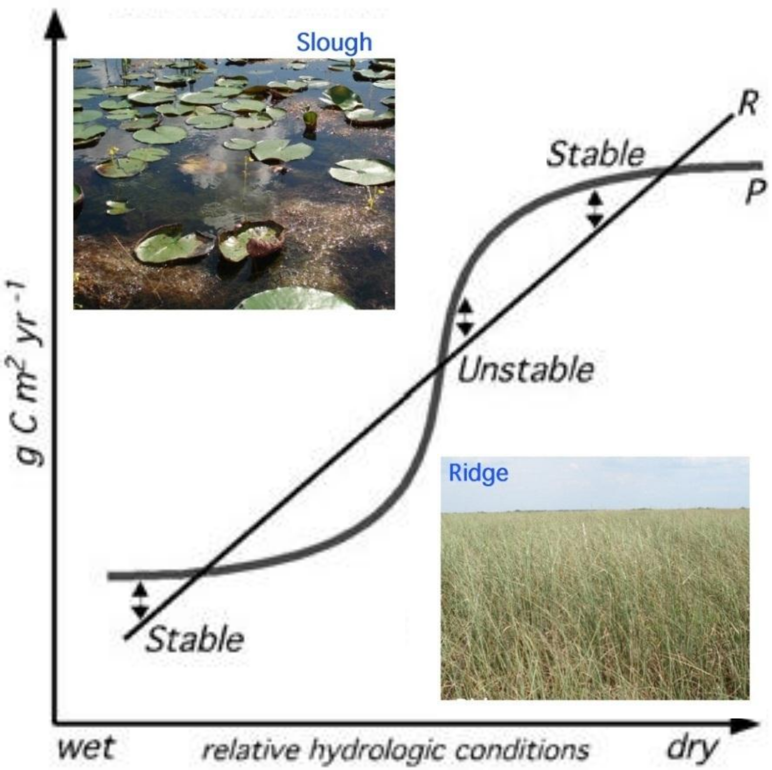




Jing Yuan: "Analysis of Patch Geometry Characteristics in the Ridge-Slough Patterned Landscape in the Everglades" (yj@ufl.edu) – **Poster # 269, Session 2**

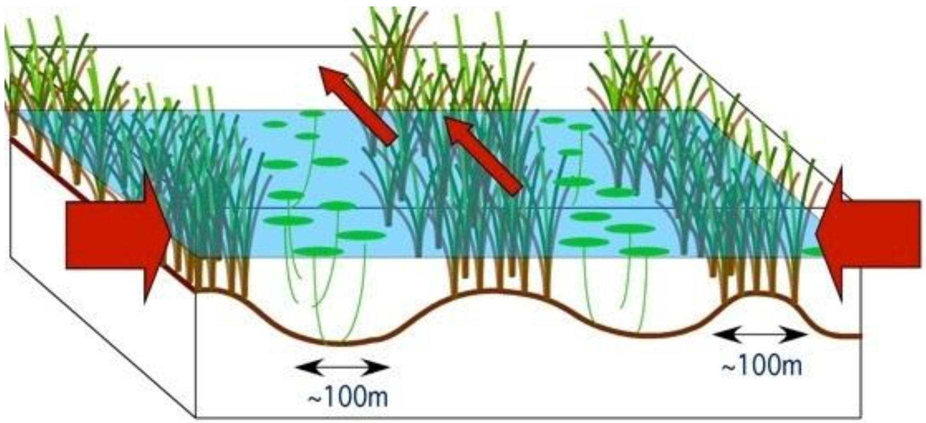
The "Self-Organizing Canal" (SOC) Hypothesis

Point Scale: Carbon Balance



Watts et al. 2010

Landscape Scale:
Discharge Competence

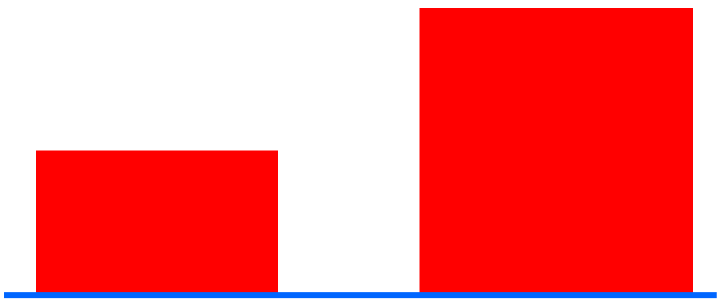


Cohen et al., 2011

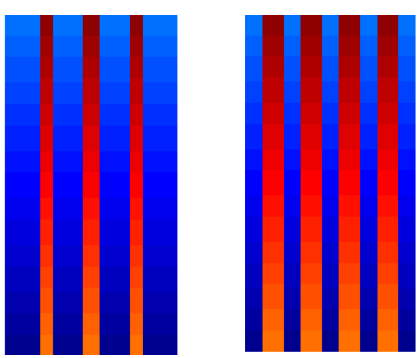
Hydrological Modeling: Methods

Approach: 2-D finite-difference model (SWIFT2D; USGS, 2004) to model flow through ridge-slough landscapes.

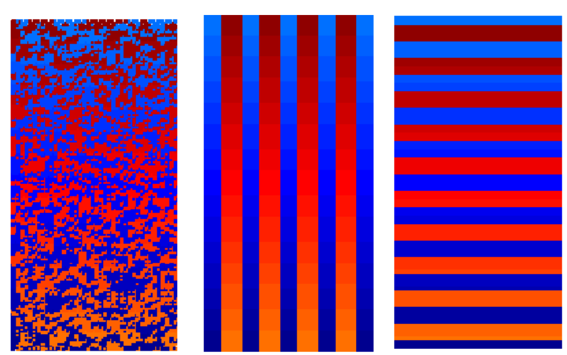
1. Topography (Ridge Height):

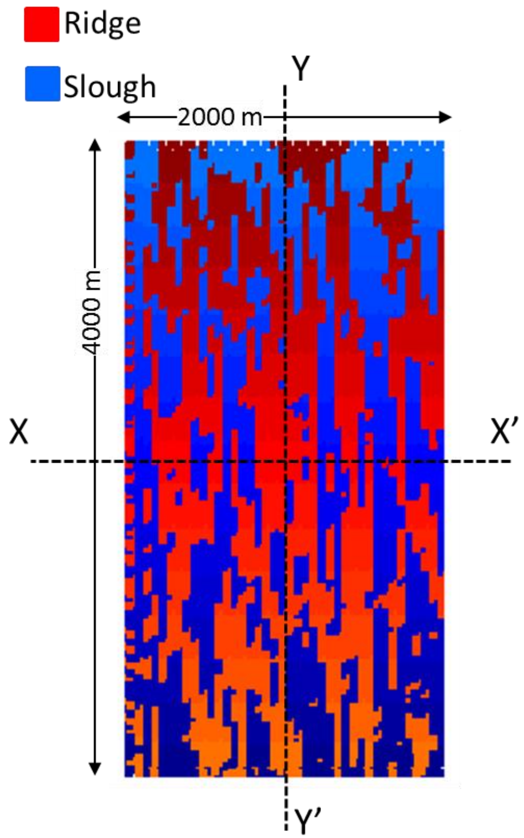


2. Ridge Prevalence



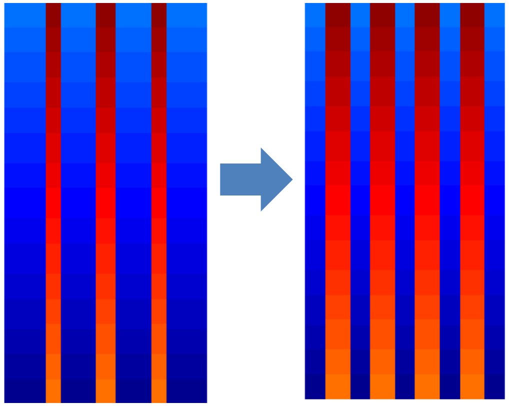
3. Anisotropy, Orientation





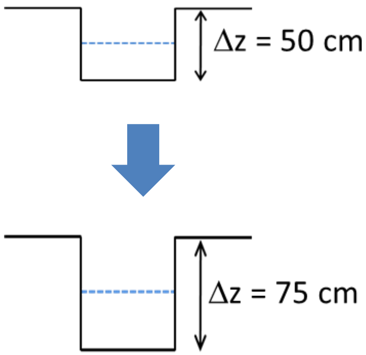
Hydrological Modeling: Test Domains

1. Effect of ridge prevalence:



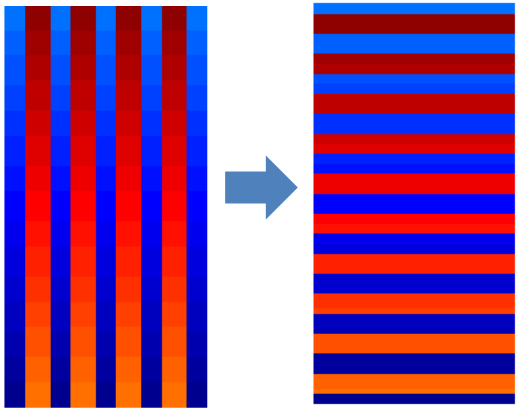
Greater ridge prevalence yields deeper flooding at same flow

2. Effect of ridge height:

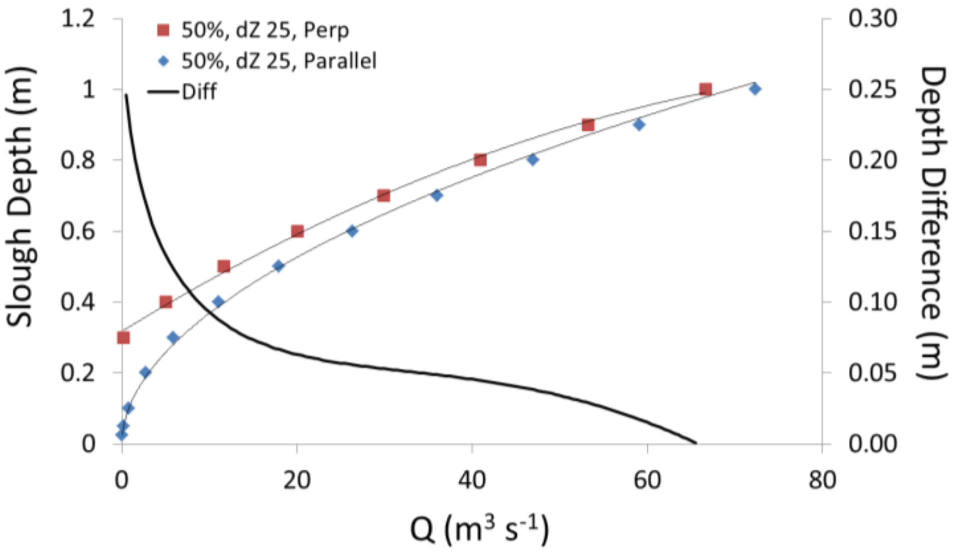


Taller ridges yield deeper flooding at same flow

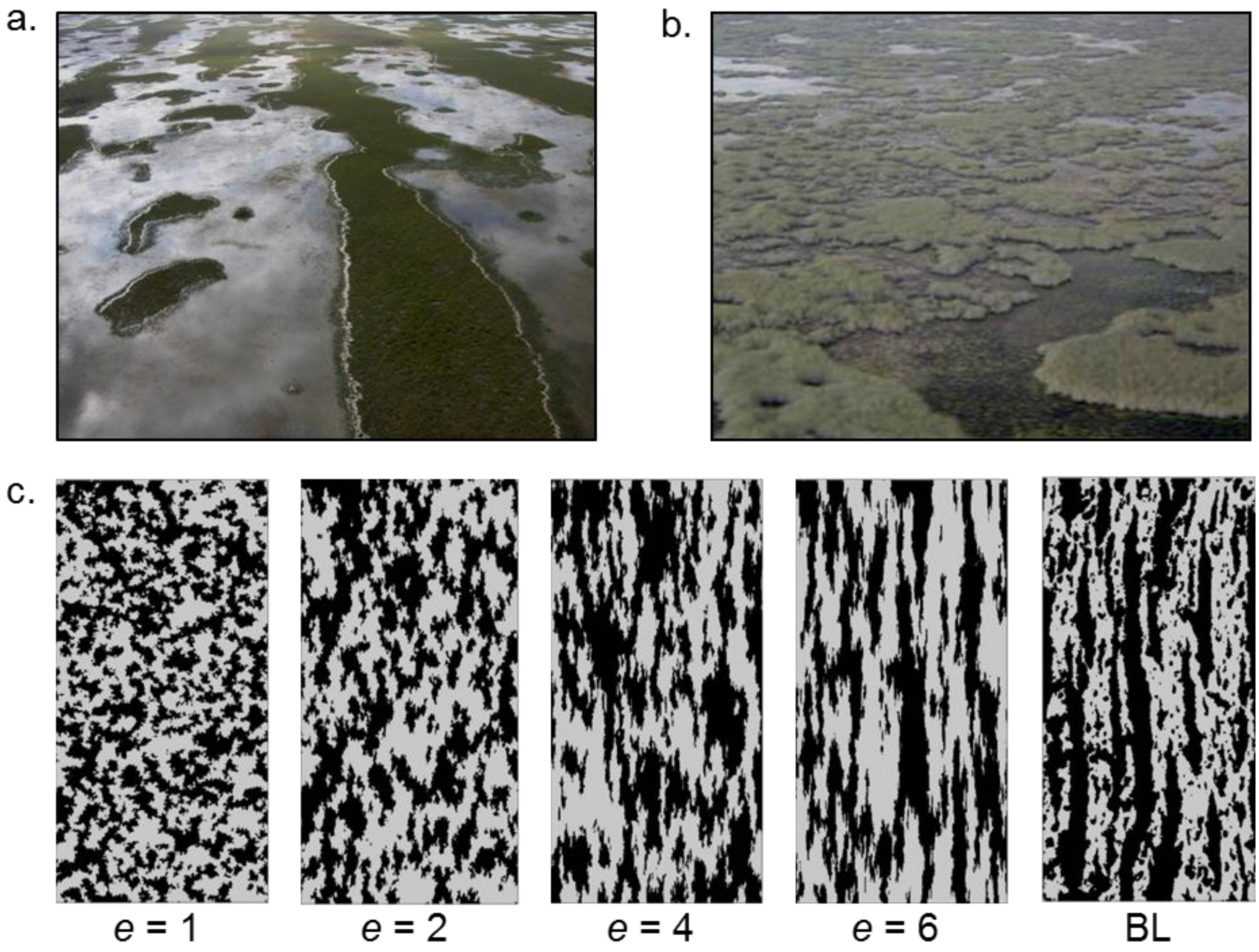
3. Effect of ridge orientation:



Perpendicular ridges yield deeper flooding at same flow



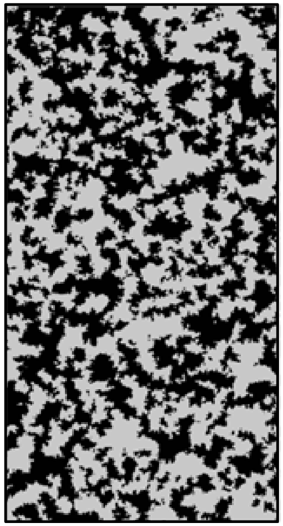
Hydrological Modeling: Simulated Domains

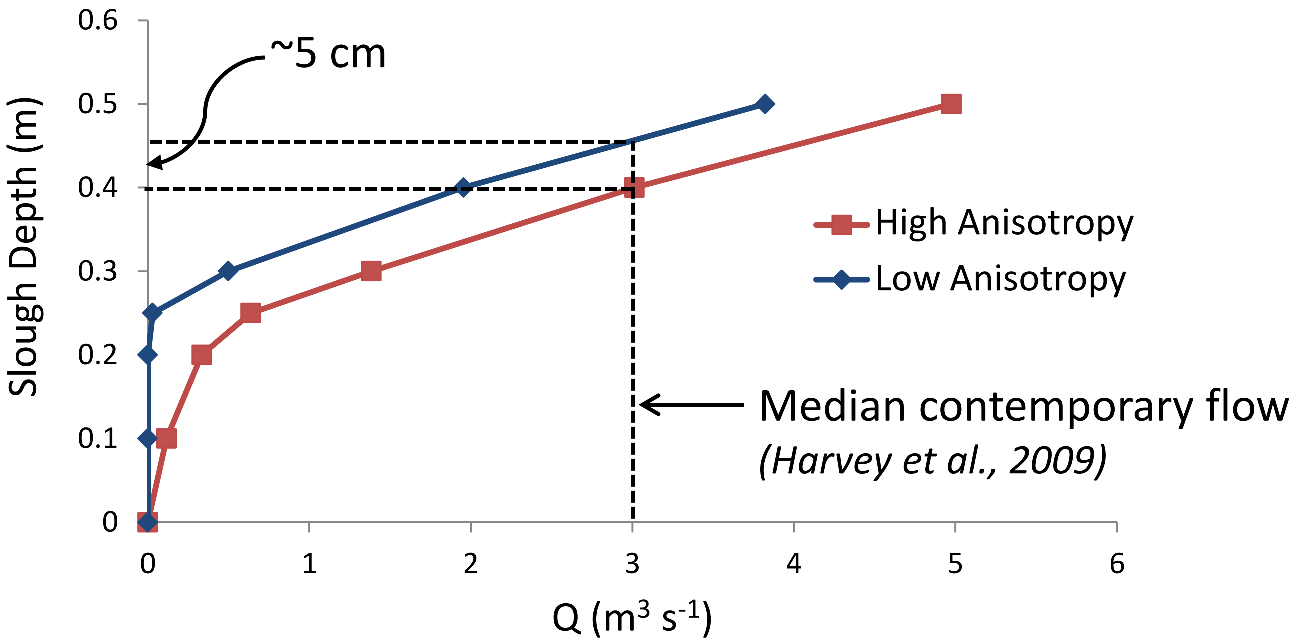


Effect of Patch Anisotropy on Flooding Depth

High Anisotropy

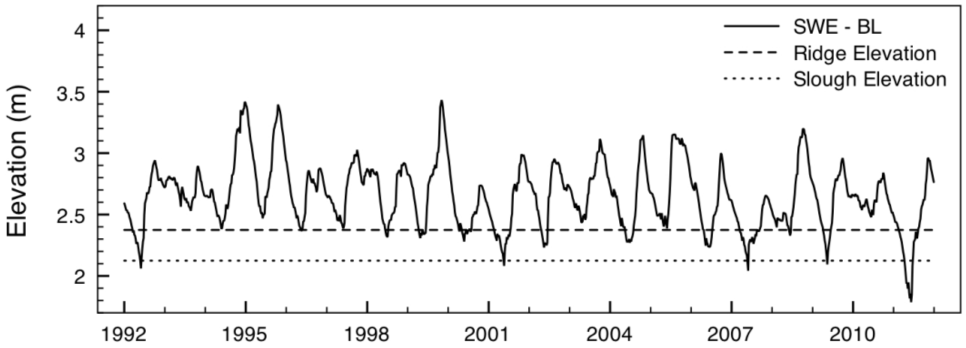
Low Anisotropy

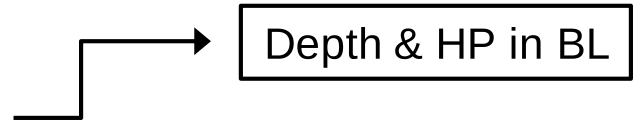




- Depth difference = *f*(flow)
- Will depth differences at **low flows** drive different flooding dynamics (hydroperiod)?

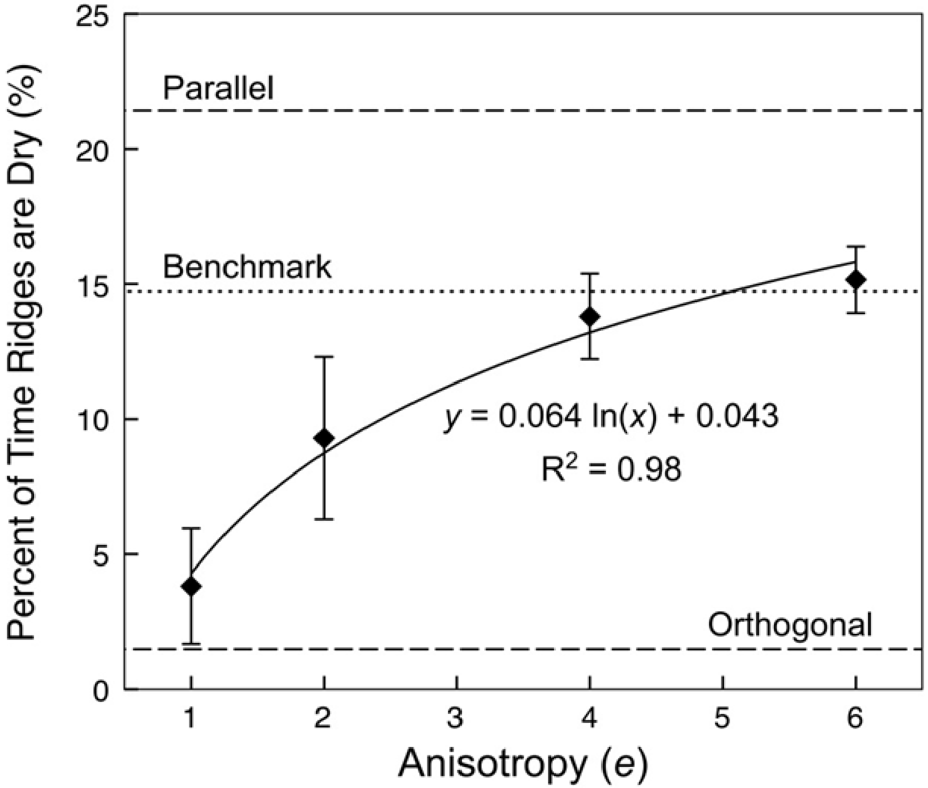
a. Measured Surface Water Elevation (SWE)

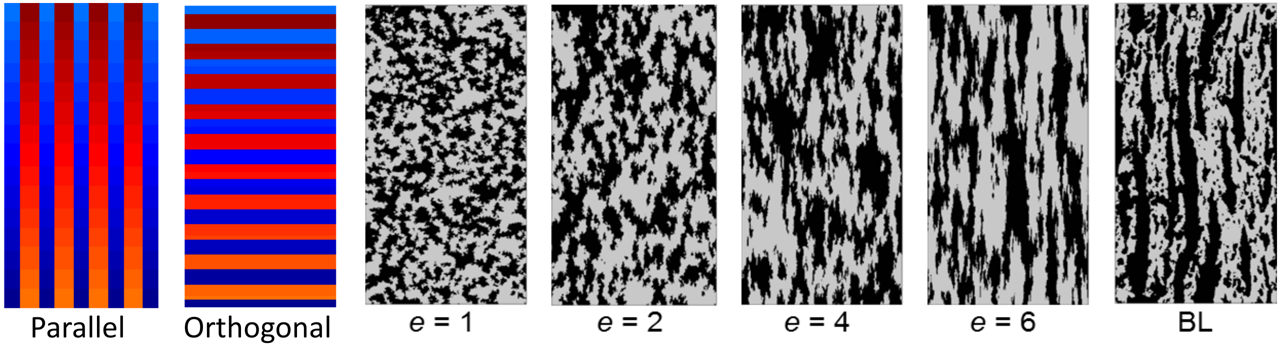




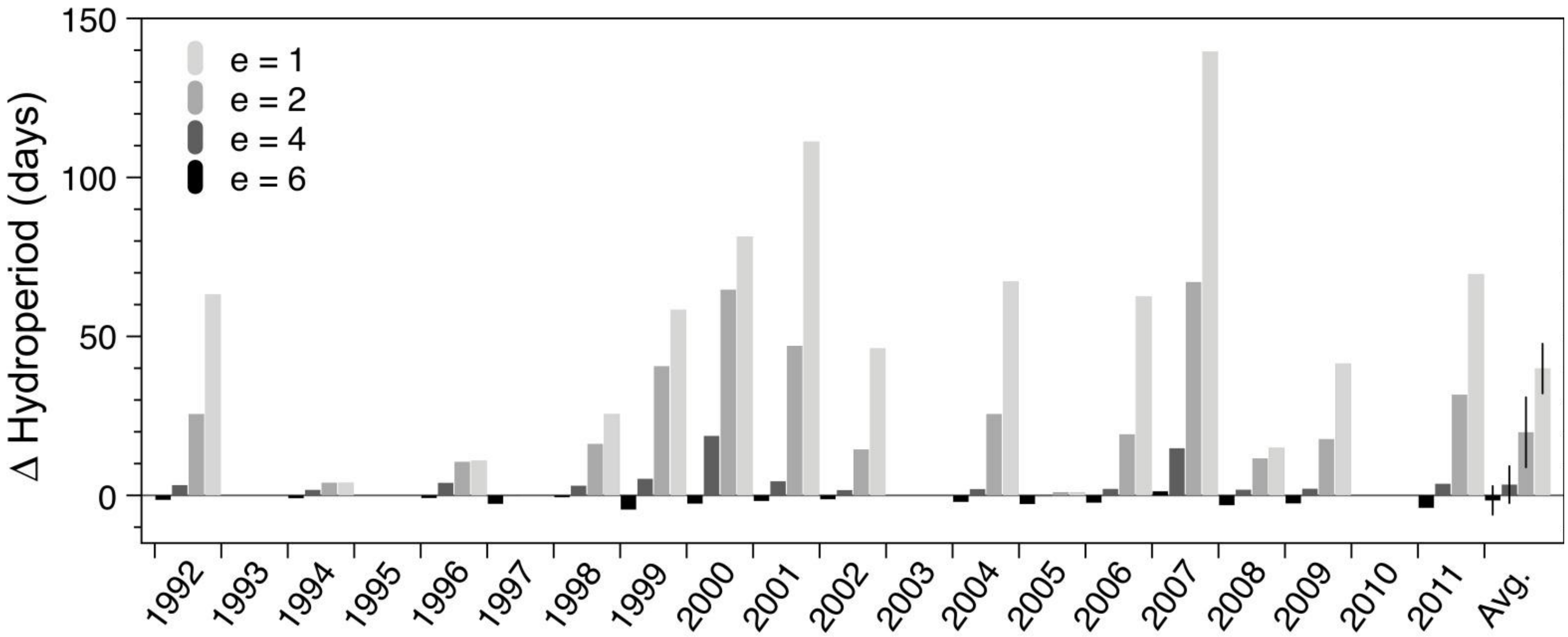
Effect of Patch Anisotropy on Hydroperiod

- Ridges in most anisotropic landscapes are dry ~4x as frequently as those in isotropic landscapes
- Variance in hydroperiod likely driven by "quality" of connectivity: presence, location, and geometry of slough connectivity (e.g., DCI; Larsen et al., 2012)





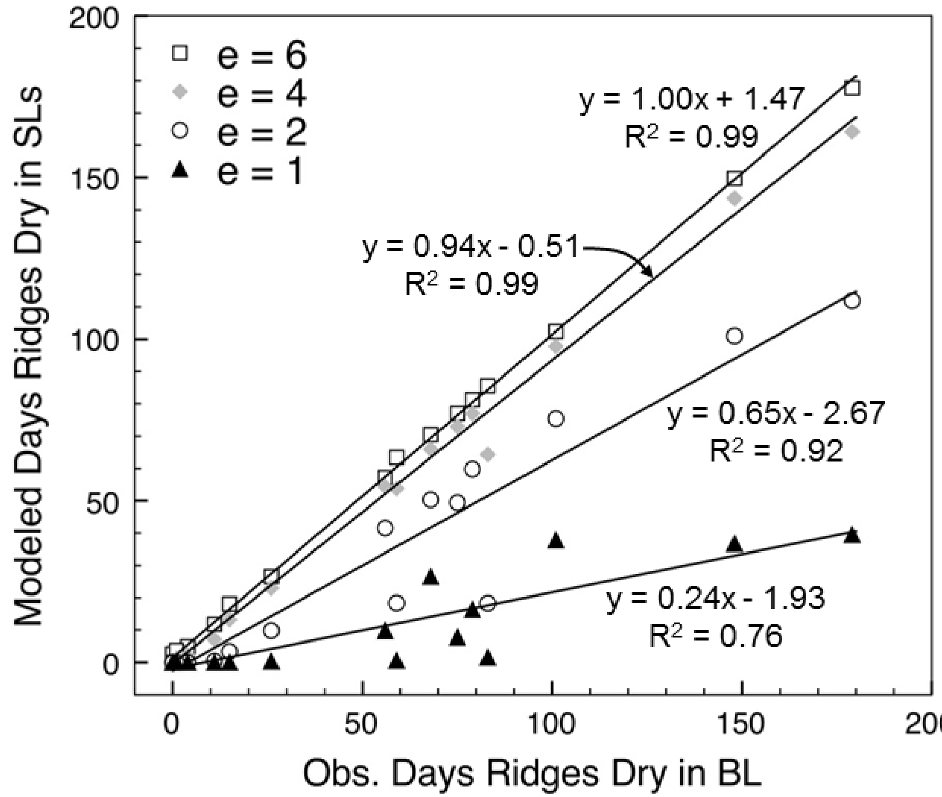
Effect of Patch Anisotropy on Hydroperiod

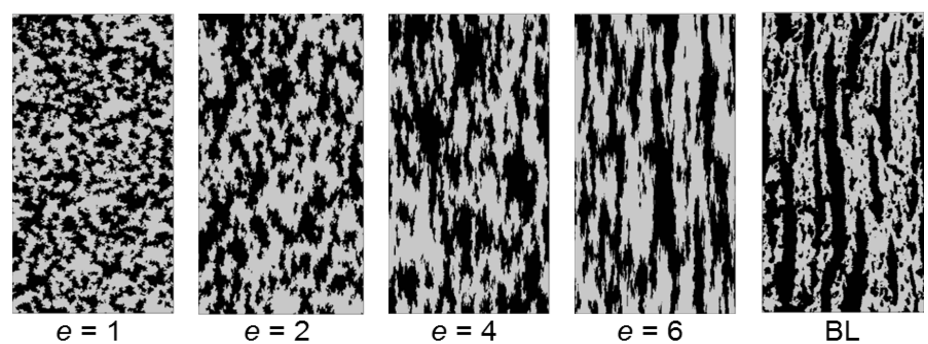


- Δ HP ranged from 0 to 140 days in any particular year
- For *e* = 1, average ΔHP = 40 days yr^{-1} → increase of 74% over BL
- For *e* = 2, average ΔHP = 20 days yr^{-1} → increase of 37% over BL

Effect of Patch Anisotropy on Hydroperiod

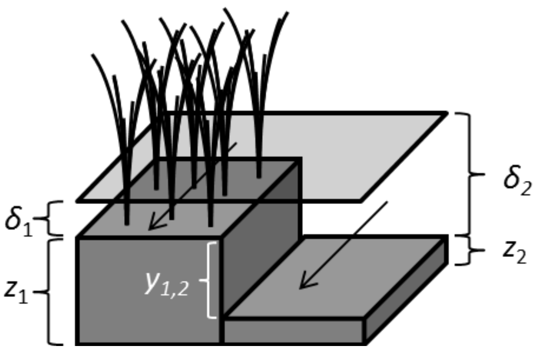
- Differences in hydroperiod driven by hydrologic variability
- Dry events vs. wet events as drivers of landscape formation
  (e.g., *Bernhardt and Willard,* 2009)

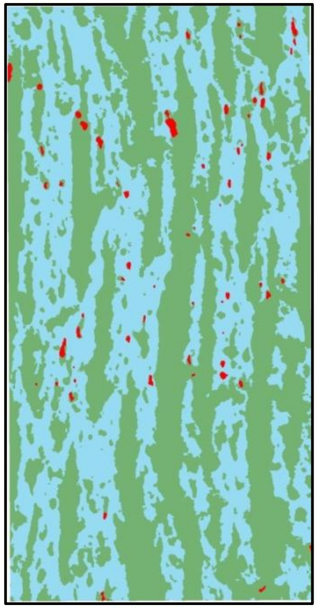


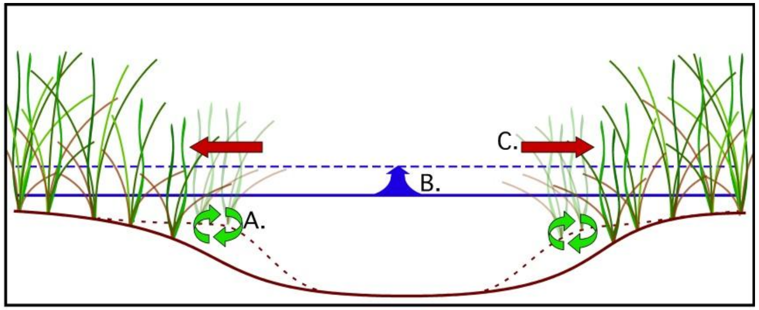


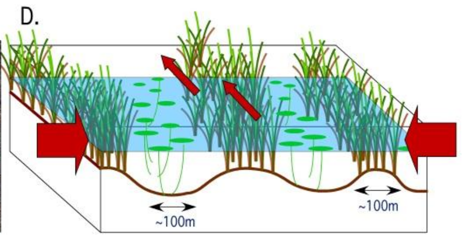
The SOC Hypothesis: Take-home Message

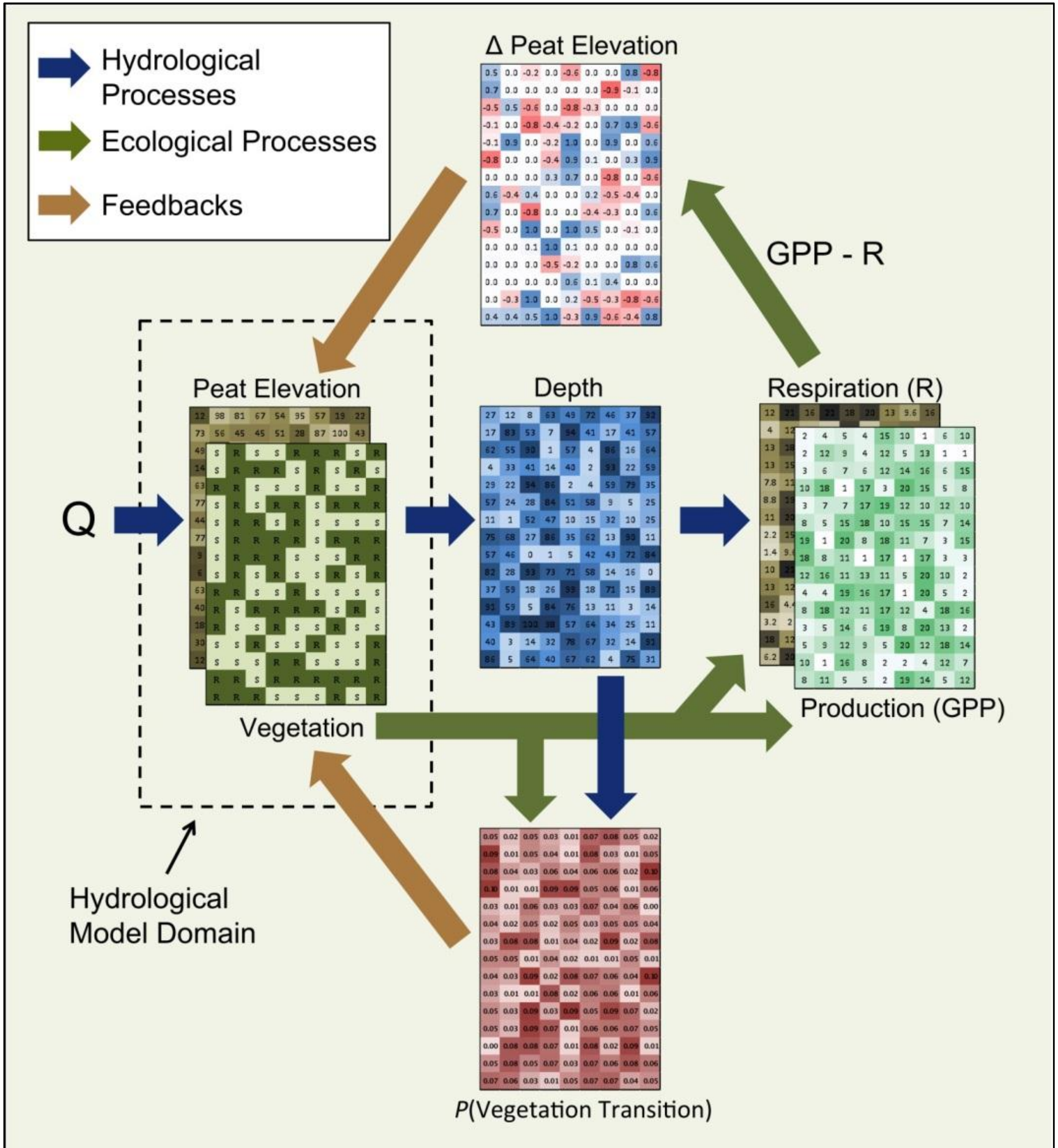
- Landscape geometry affects hydroperiod
    - Strong, anisotropic distal negative feedback → pattern geometry
- The SOC may be *sufficient* to explain the linear ridge-slough pattern emergence without sediment or nutrient redistribution










Hydrological Processes
Ecological Processes
Feedbacks
Δ Peat Elevation
GPP - R
Peat Elevation
Depth
Respiration (R)
Q
Vegetation
Production (GPP)
Hydrological Model Domain
P(Vegetation Transition)