Ecological Thresholds and How they Inform Potential Tradeoffs: A Thought Experiment

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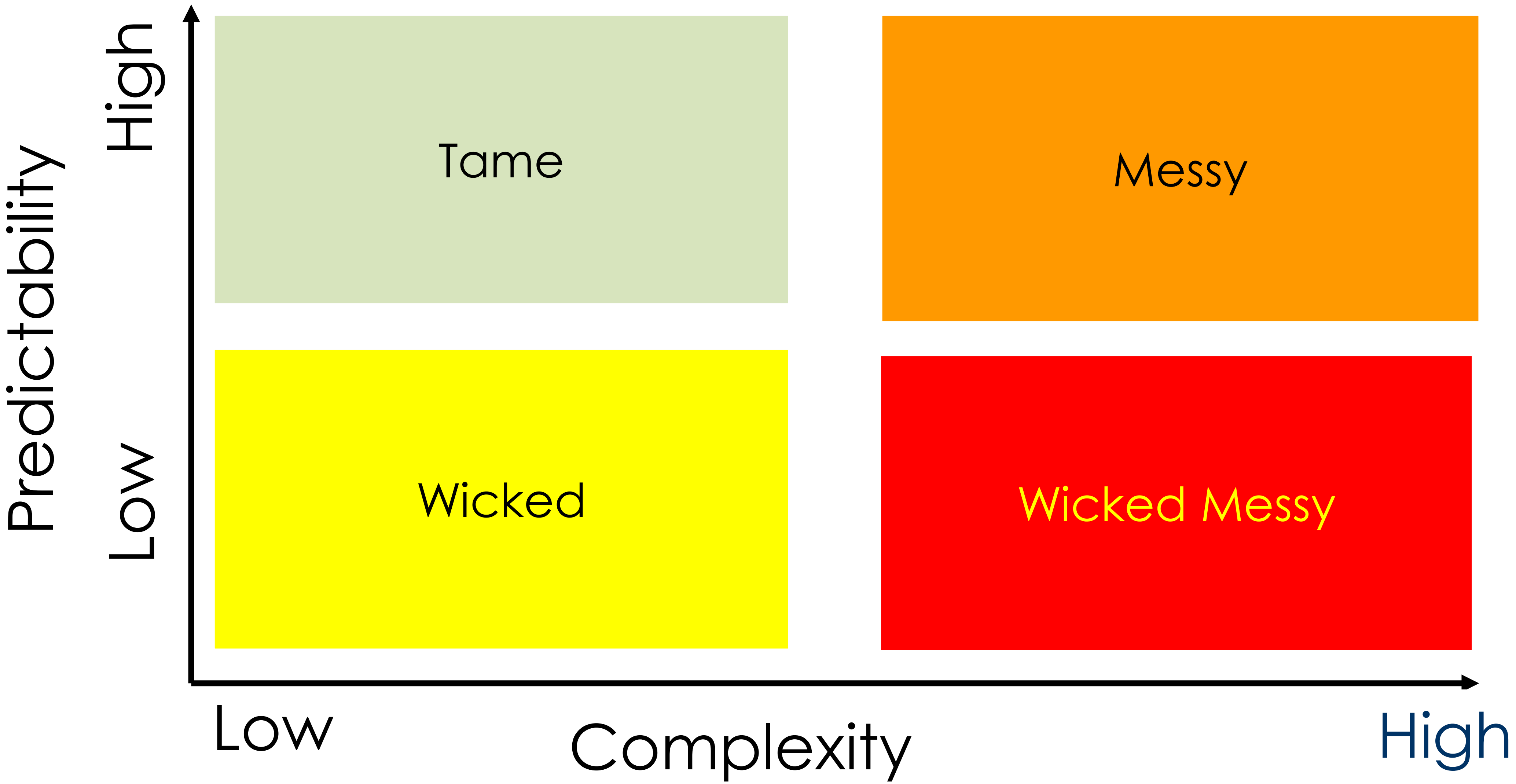
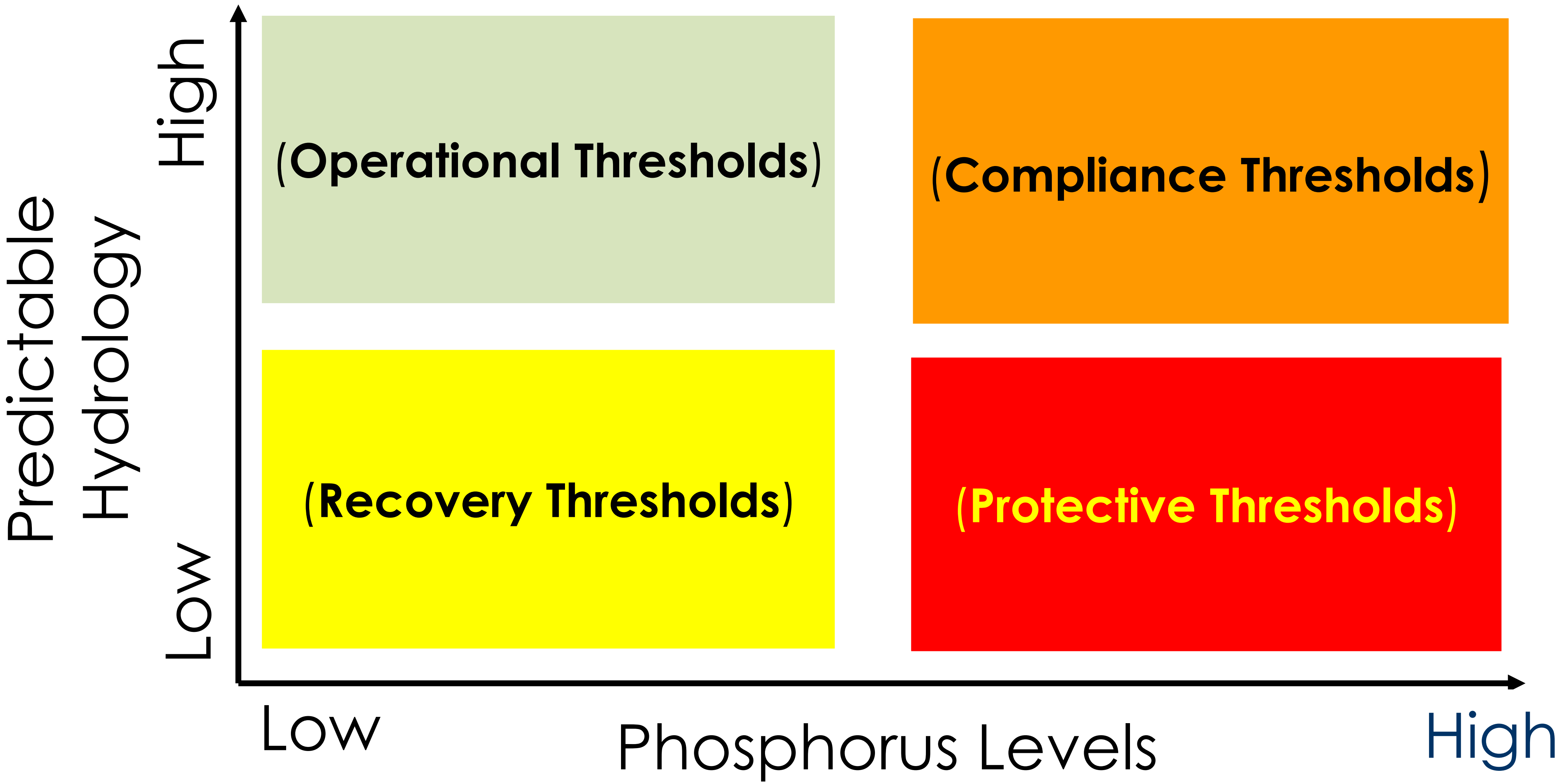
Greater Everglades Ecosystem Restoration (GEER) Conference, Coral Springs, FL, April 21-25, 2025

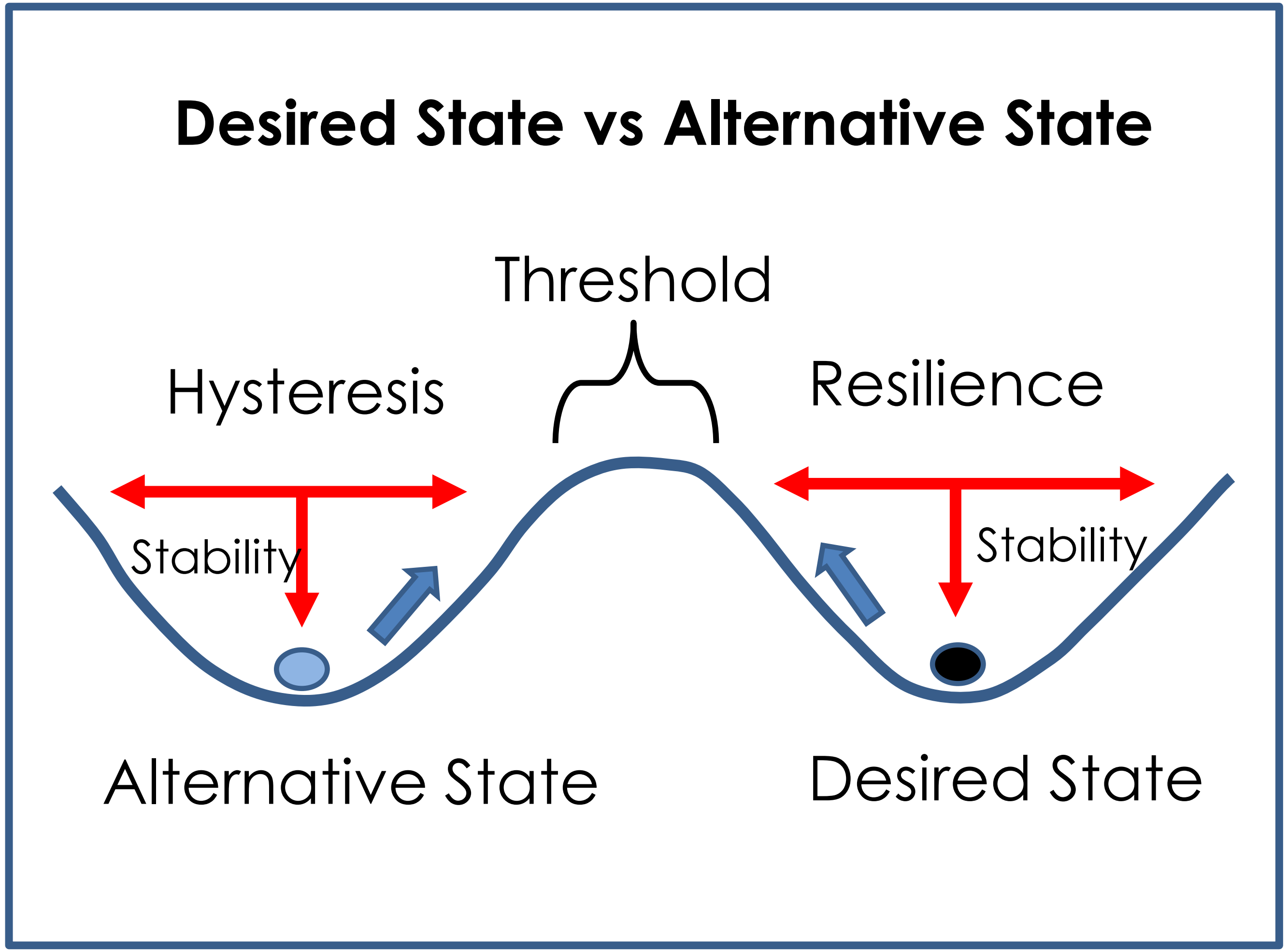
Thought #1: A Framework



Thought #2: Categorization



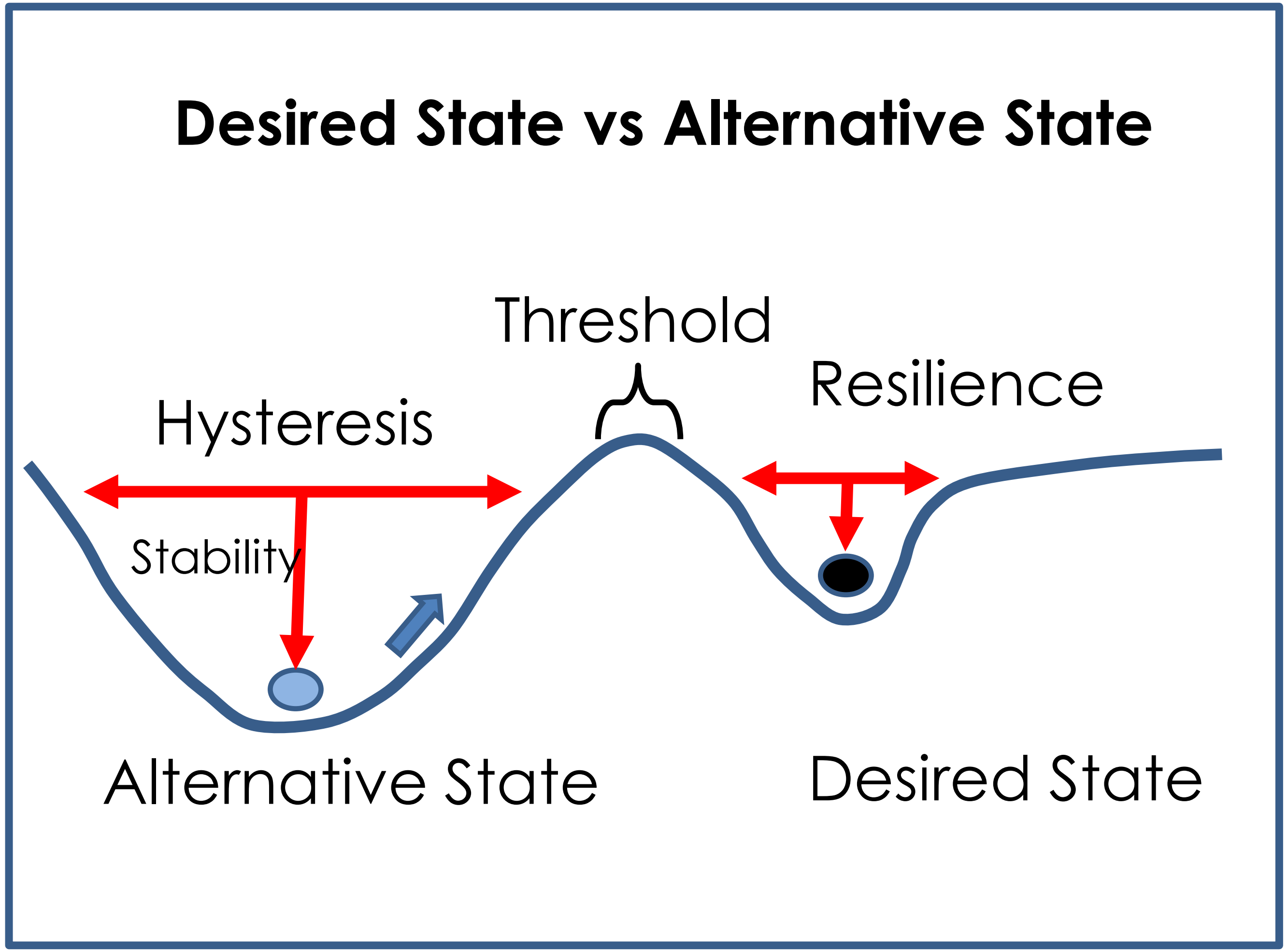
Thought #3: Stability & Resilience Threshold Diagrams



Both states are equally likely to exist

Threshold: A value or level above which there is an "ecological imbalance" and below which the Everglades can be preserved or restored.

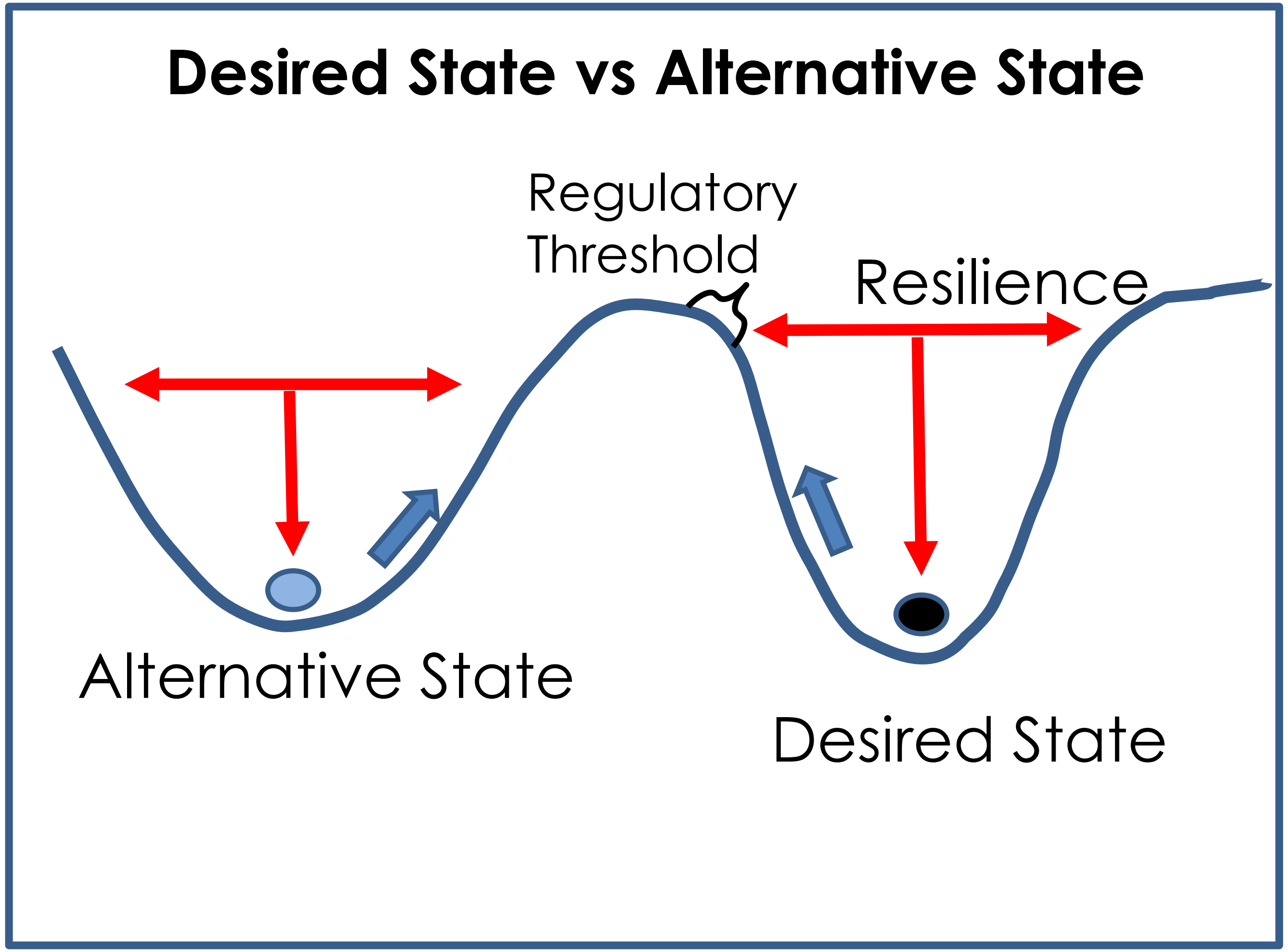
Thought #3: Stability & Resilience Threshold Diagrams



Large-scale disturbance favors the alternative state

Hysteresis: The value or level of a threshold capable of creating an alternative stable state is less than the value or level capable of returning to the initial/desired stable state.

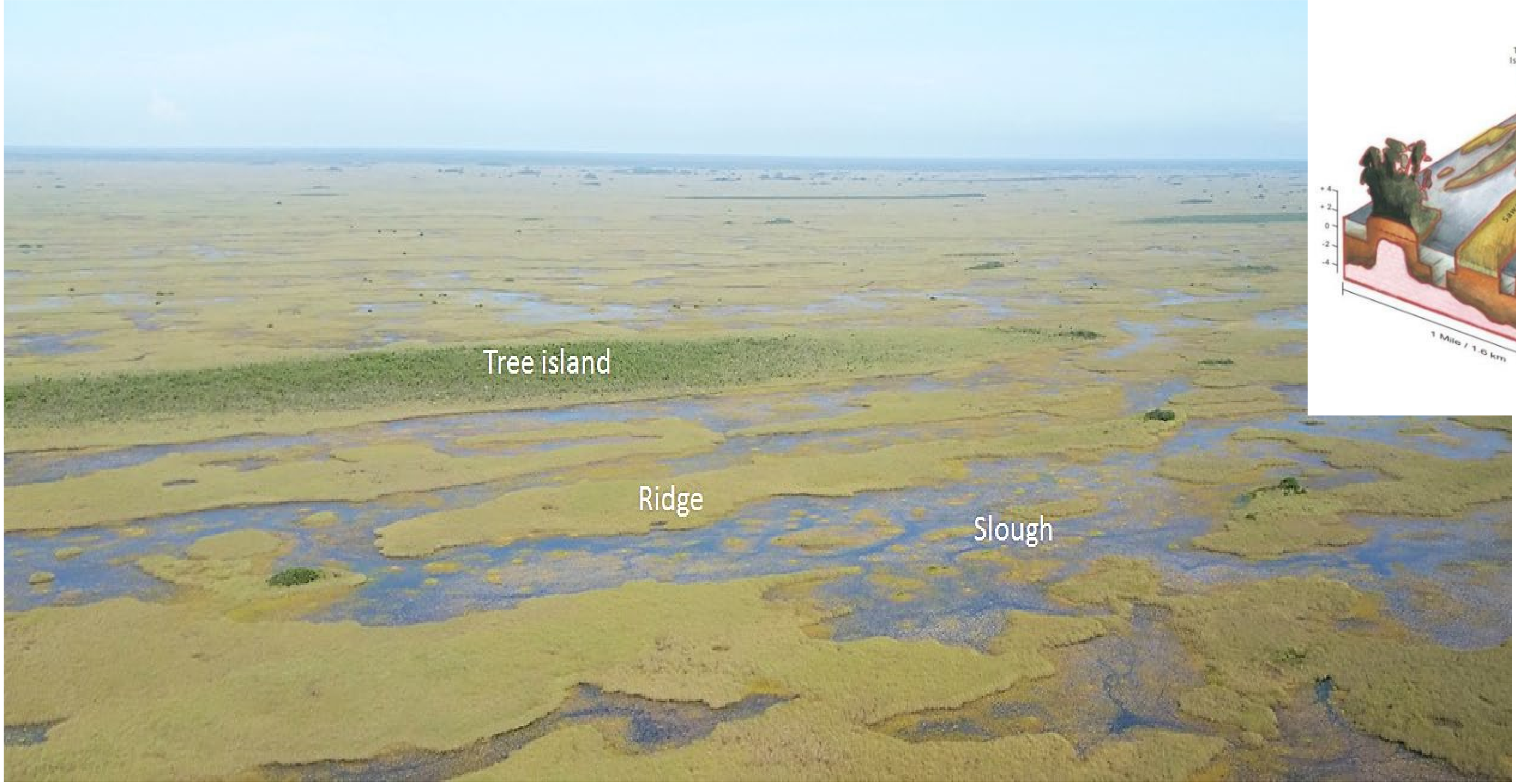
Thought #3: Stability & Resilience Threshold Diagrams

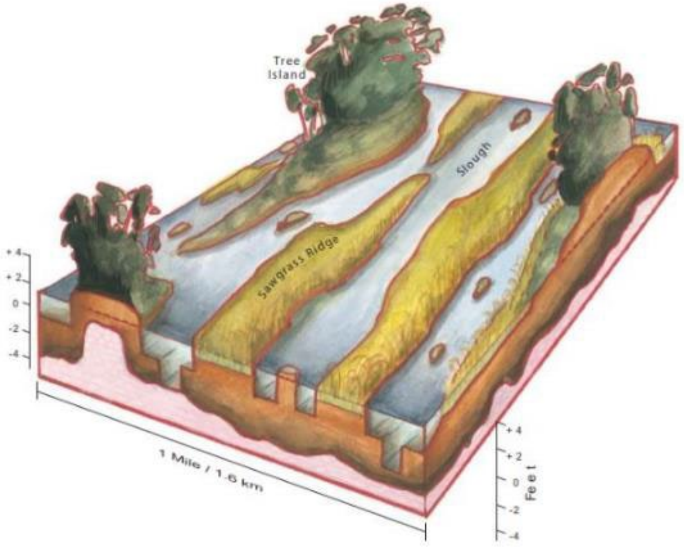


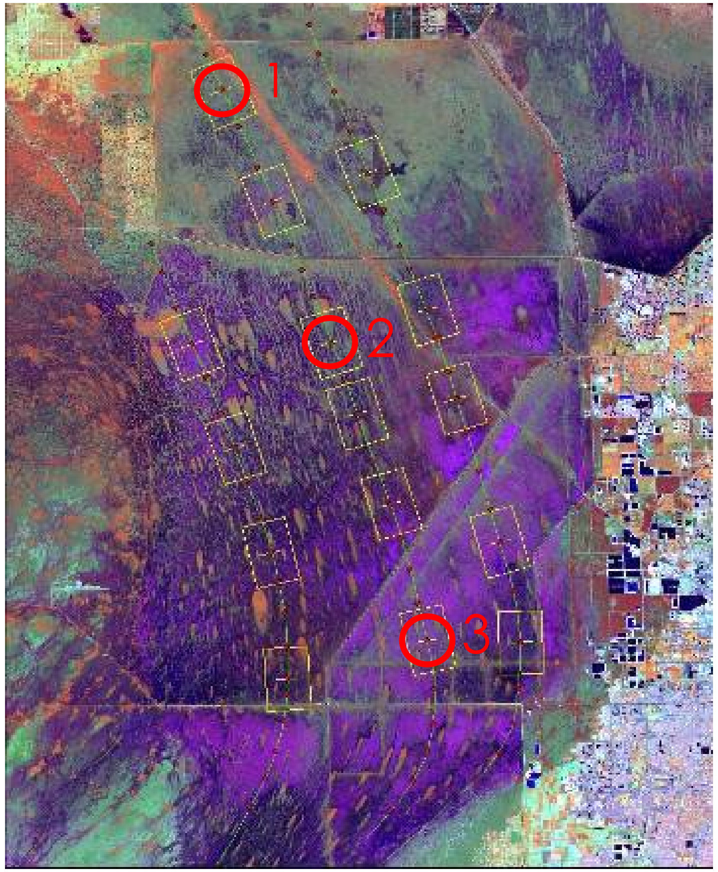
Conservation measures favors the desired state

Resilience: The amount of disturbance that the Everglades can withstand without changing self-organized processes and structures.

1. Ridge-Slough-Tree Island Restoration: An Operational Threshold

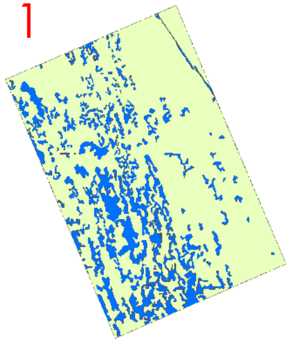




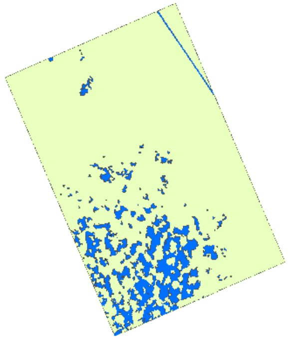


	1940	2004

1



N1 1940



N1 2004

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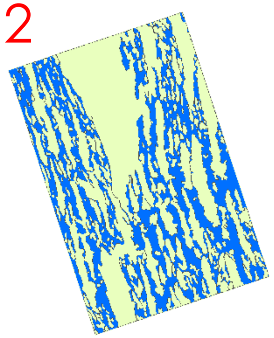
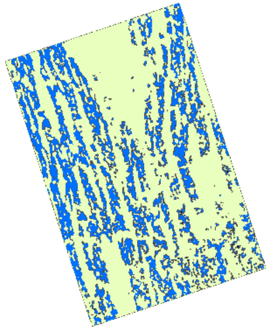
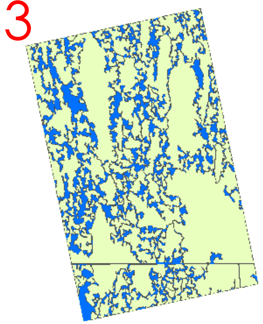


N3 1940

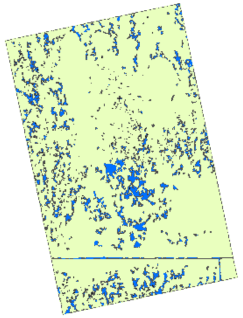


N3 2004

3



N6 1940



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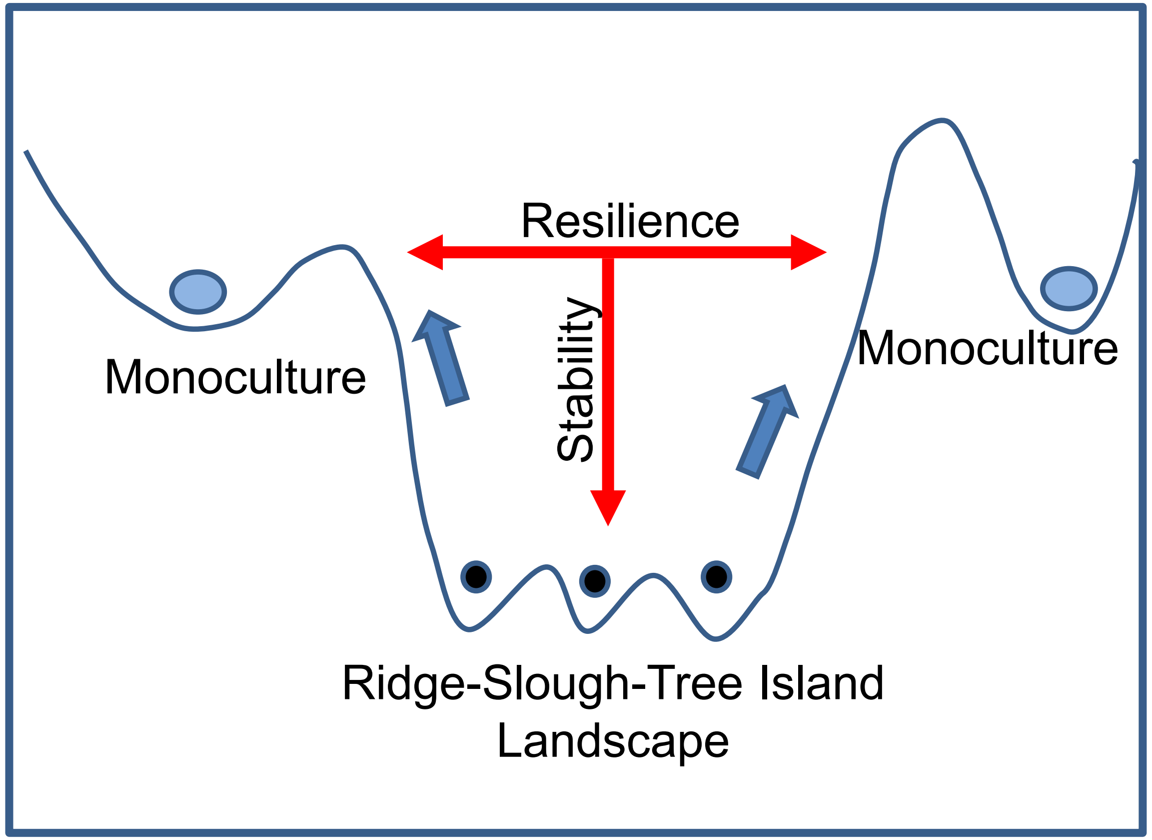
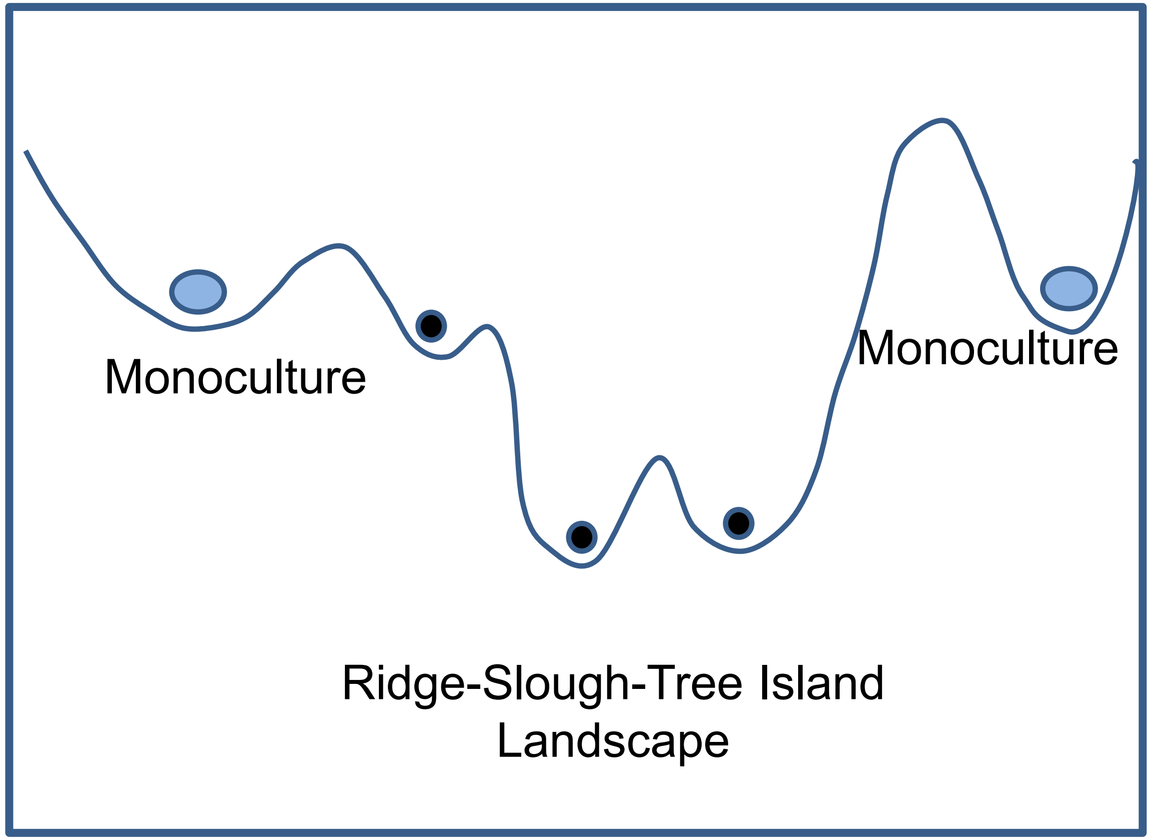
The Ridge-Slough-Tree Island Pattern



Thresholds to maintain a ridge-slough pattern:

Water TP < 10 µg/l
Soil TP < 500 mg/kg
Hydroperiods 8-11 months
Sheetflow 1-3 cm/sec
Depth Range 0.25-1.5 meters

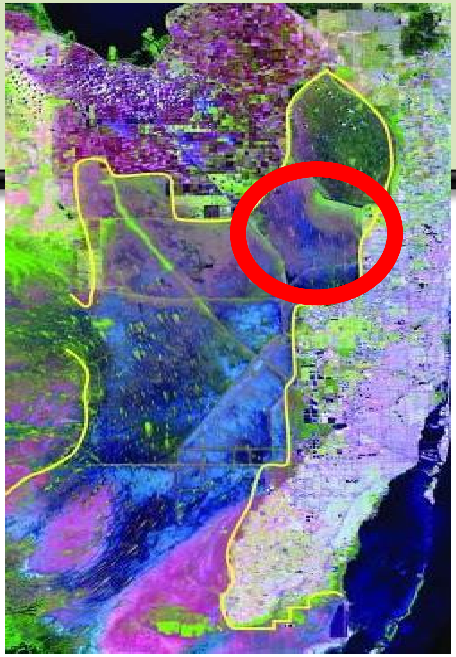
The Ridge-Slough-Tree Island Pattern



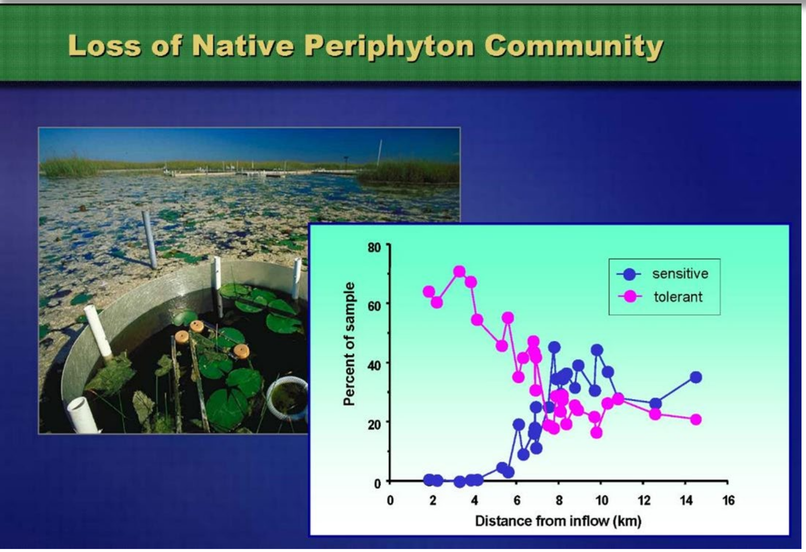
Tradeoffs:

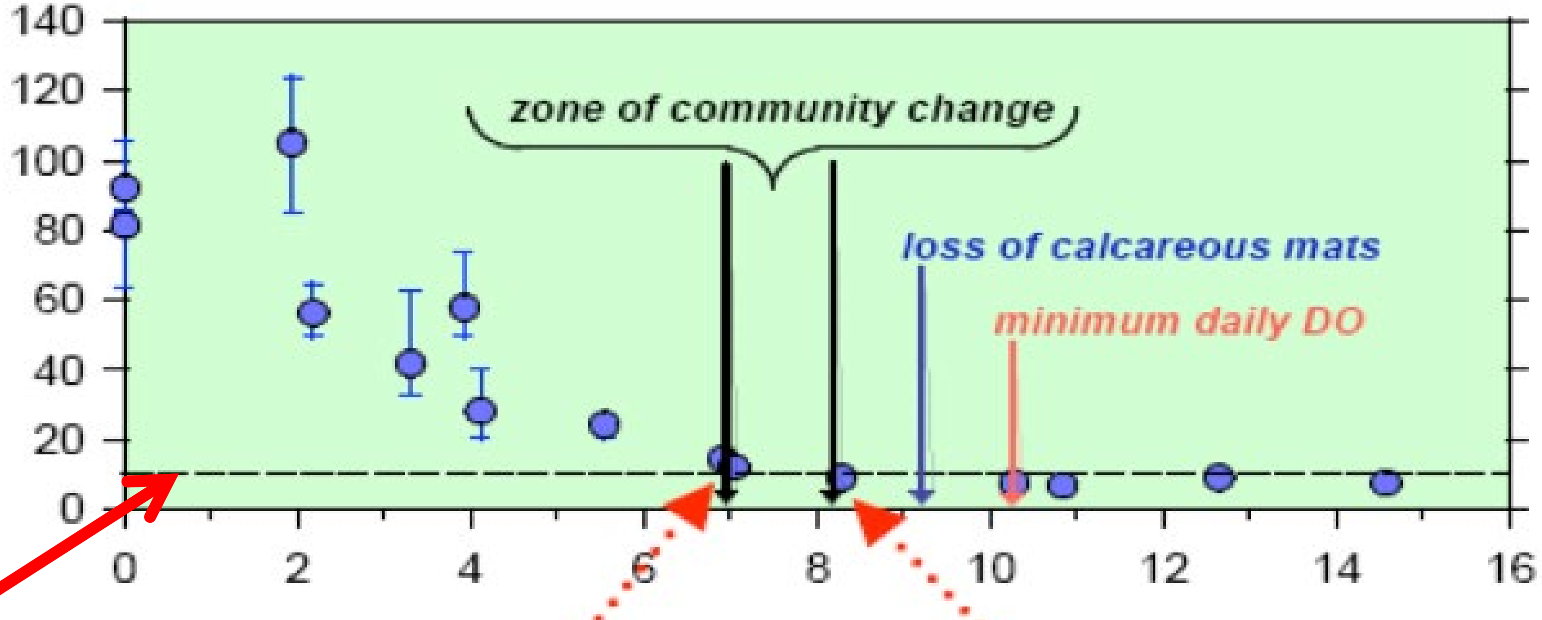
1) A shift to a monoculture of dense willow, or sawgrass, or cattail.
2) An unbalanced landscape pattern

2. Invasive Cattail: A Compliance Threshold

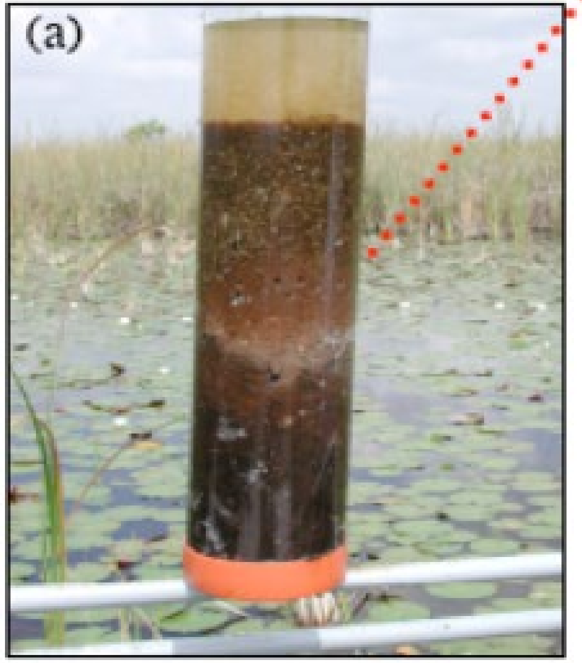


Oligotrophy: Phosphorus created a cattail "invasion."

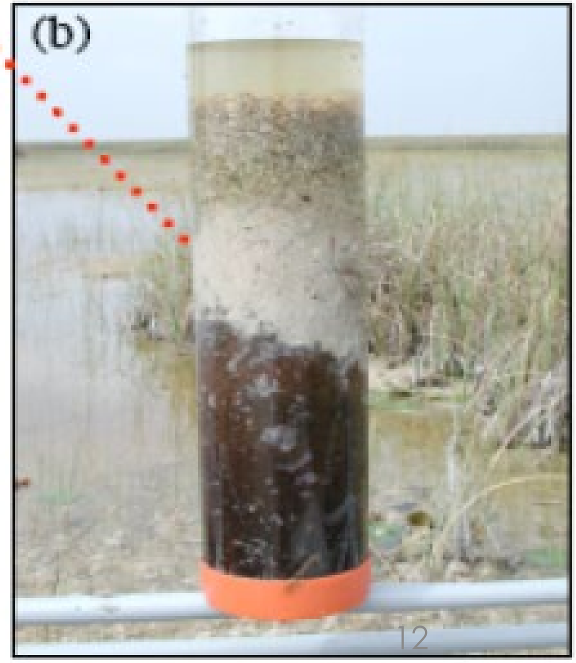




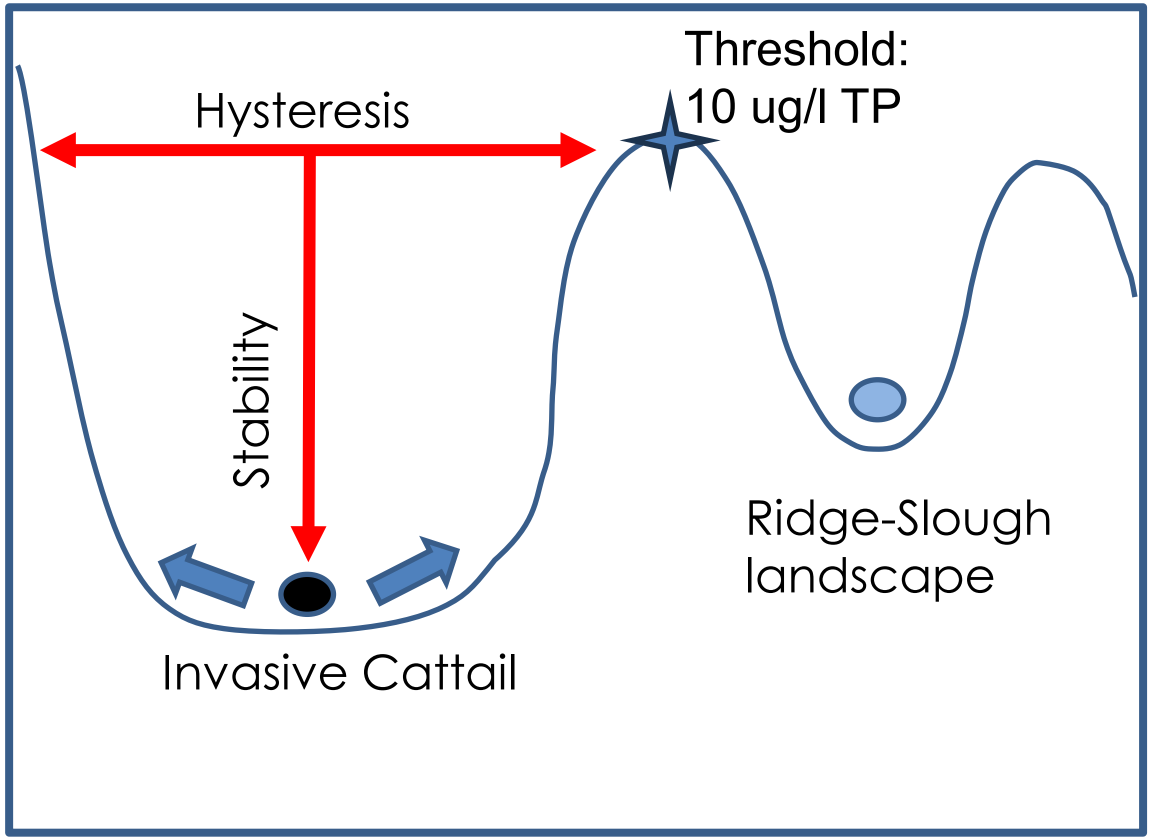
Phosphorus Threshold



"Ecological Imbalance" occurs in the Everglades at TP >10 µg/L.



Invasive Cattail: A Compliance Threshold

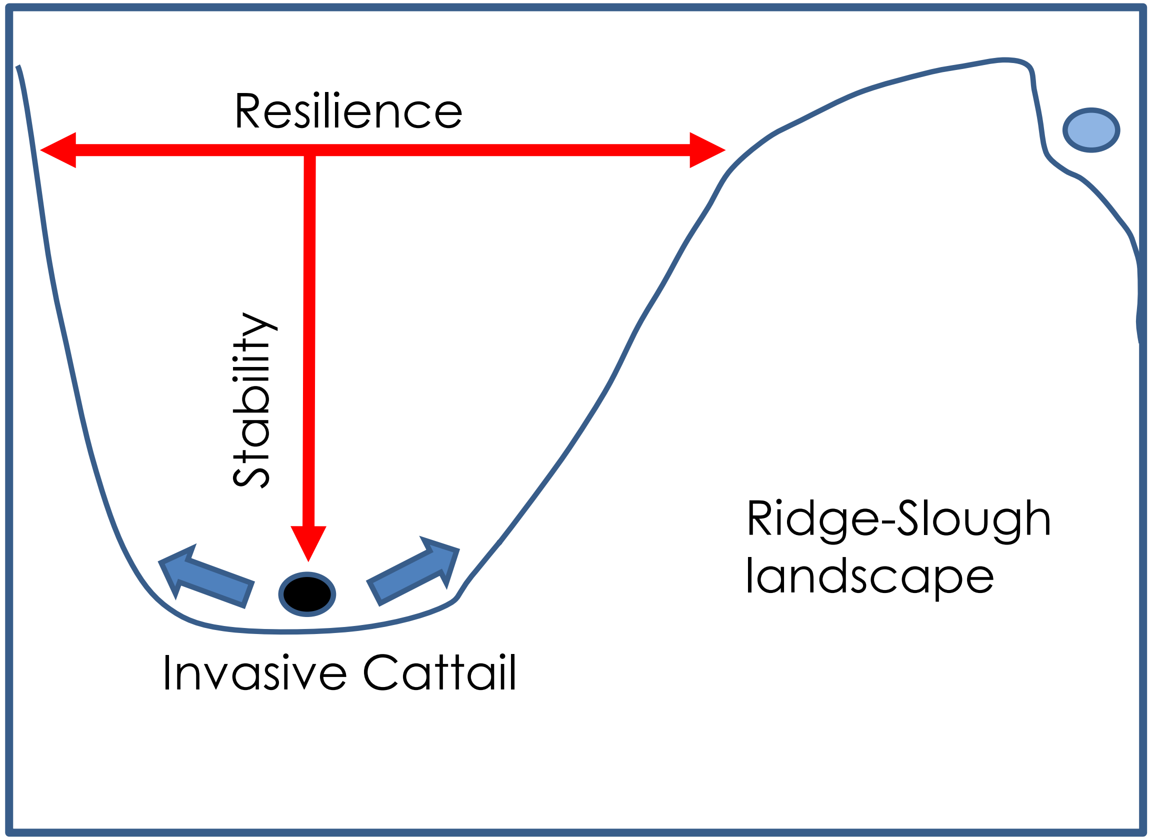


Threshold: The stability and hysteresis is very high for invasive cattail, therefore: The Everglades Forever Act established a TP Rule for flows into the Everglades not to exceed an Annual TP Flow-Weighted Mean of 10 ug/L

Tradeoff:

1) Water treatment facilities to prevent cattail expansion
2) Active Marsh Improvement (AMI) to created an alternative state

Invasive Cattail: A Compliance Threshold



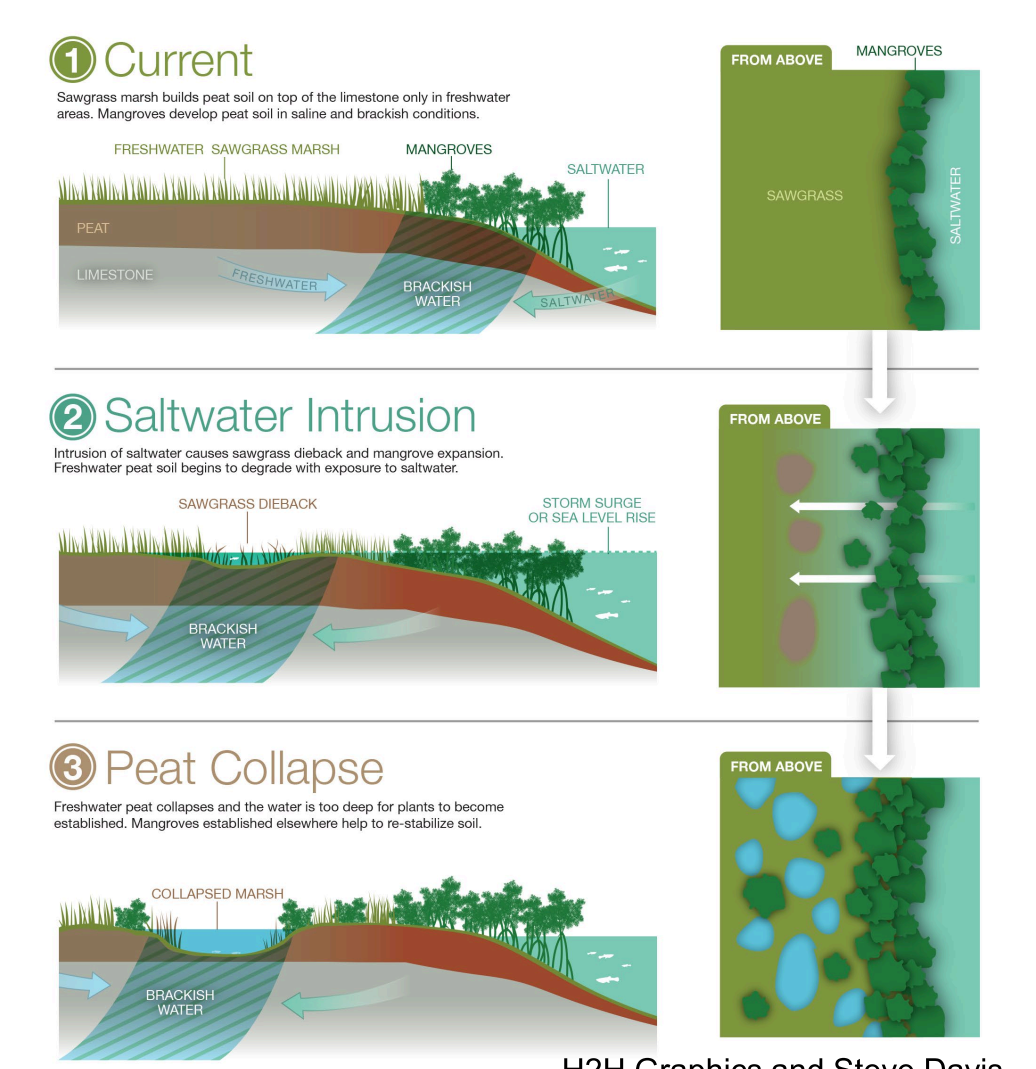
The stability and hysteresis is very high for invasive cattail, therefore:
The Everglades Forever Act established a TP Rule for flows into the Everglades not to exceed an Annual TP Flow-Weighted Mean of 10 ug/L

Tradeoff:

1) Water treatment facilities to prevent cattail expansion
2) Active Marsh Improvement (AMI) to created an alternative state

Unless the alternative state is permanent.

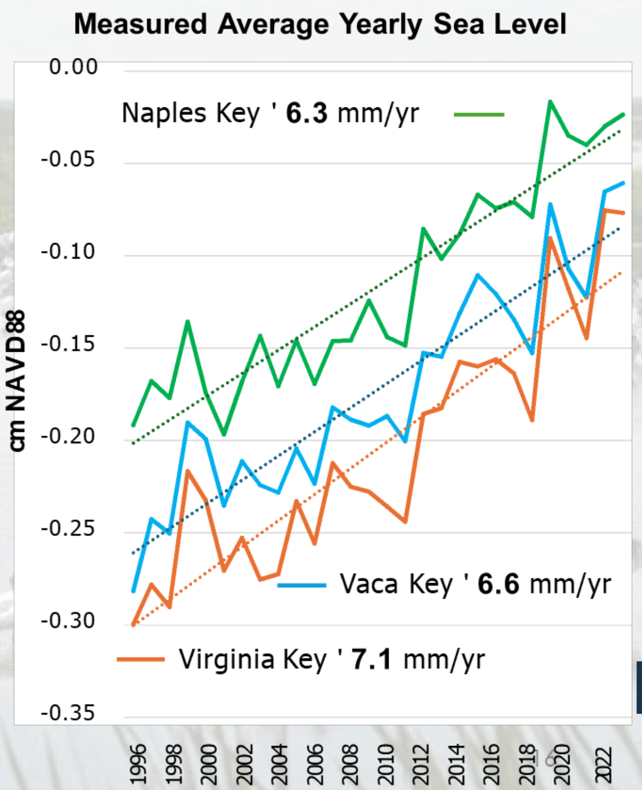
3. Adaptive Foundational Resilience (AFR): A Protective Threshold



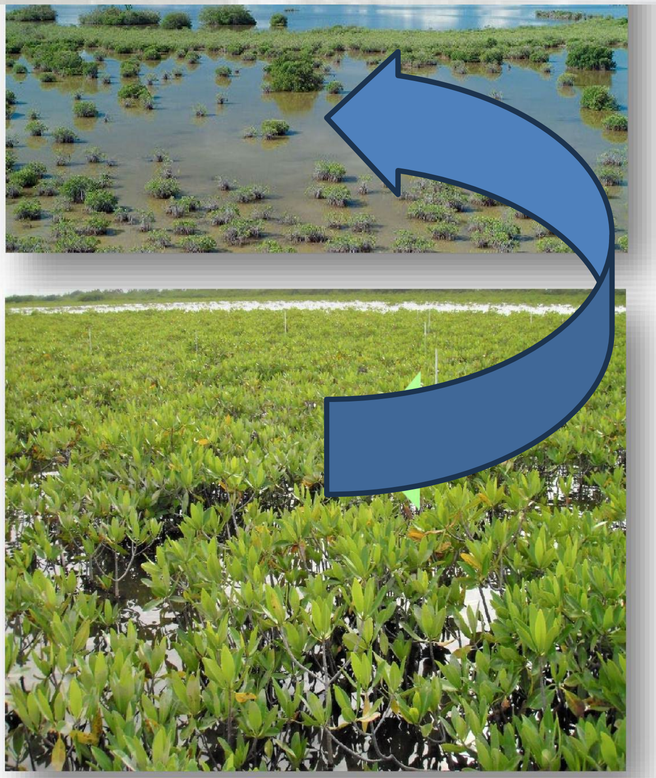
H2H Graphics and Steve Davis

Saltwater intrusion alters biogeochemical cycles and stresses vegetation, when combined can lead to peat collapse

With No Protective Threshold in Place, Mangroves Will Transition to Open Marsh

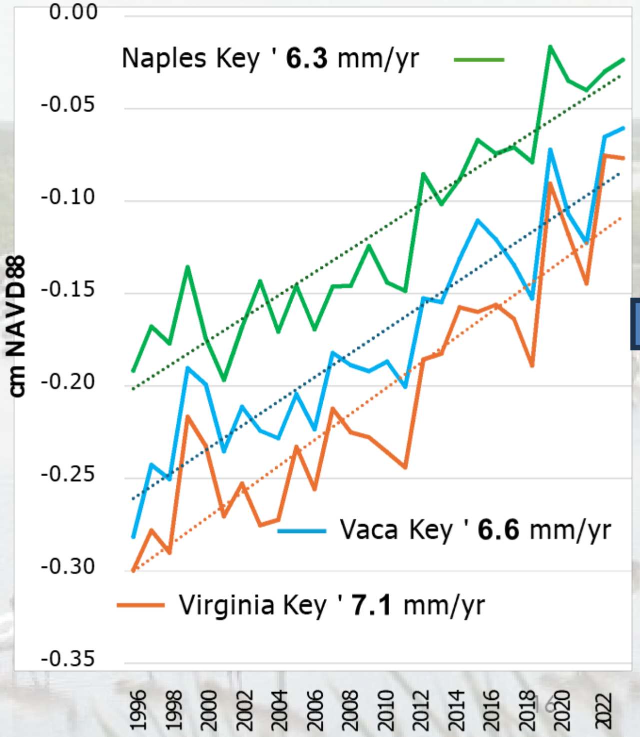


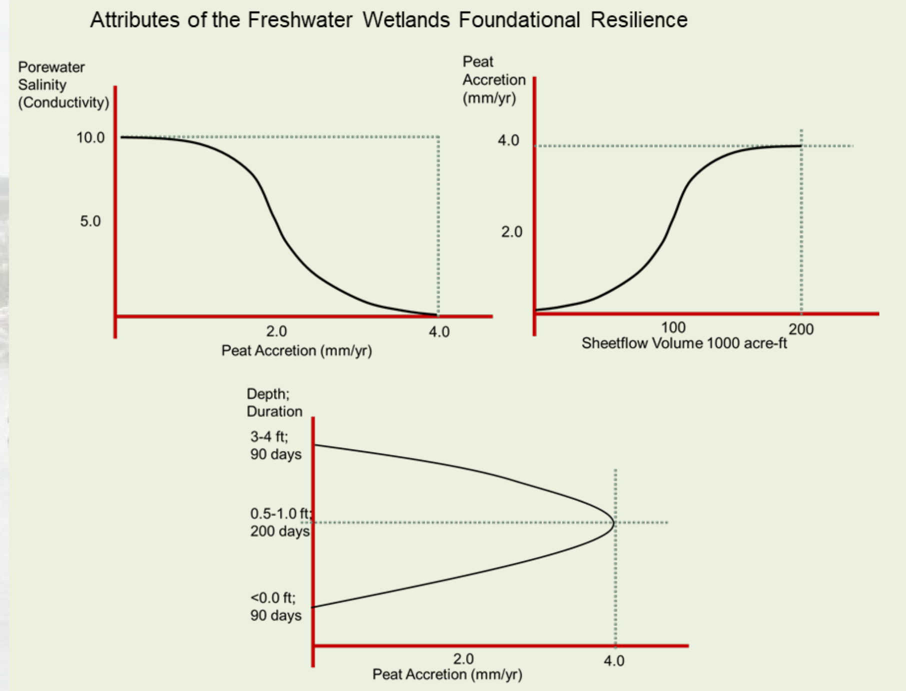
Mangrove Transition to Open Marsh



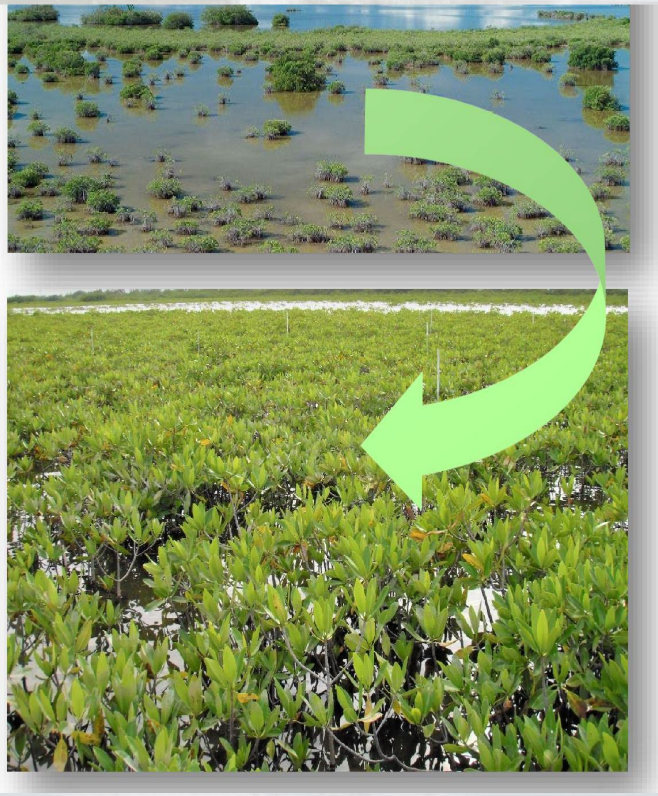
With A Protective Threshold in Place, Marsh & Open Water Will Transition to Mangroves

Measured Average Yearly Sea Level



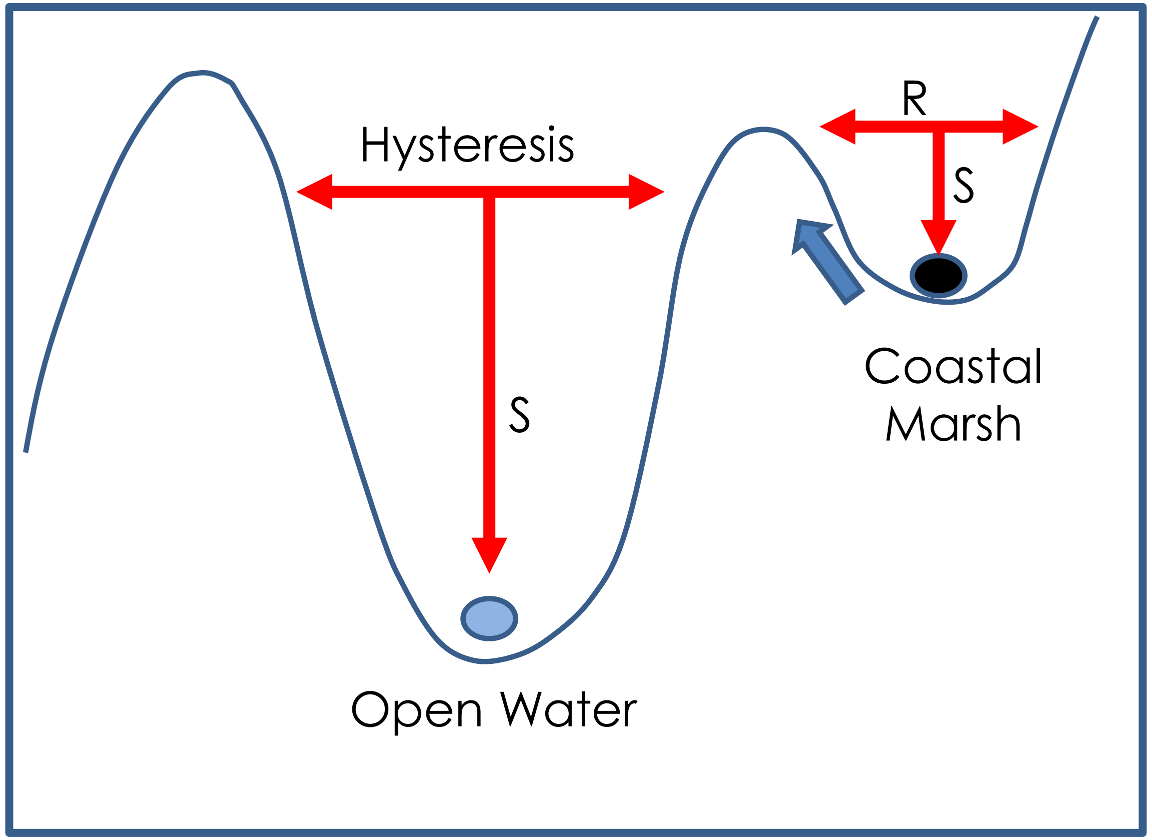


Mangrove Transgression and Marsh Transition



Adaptive Foundational Resilience (AFR) is the ability of the foundational vegetation (marsh and mangrove) to <u>adapt</u> to sea level rise by building elevation (peat accretion) as a function of water depth, salinity and flow.

Adaptive Foundational Resilence: A Protective Threshold



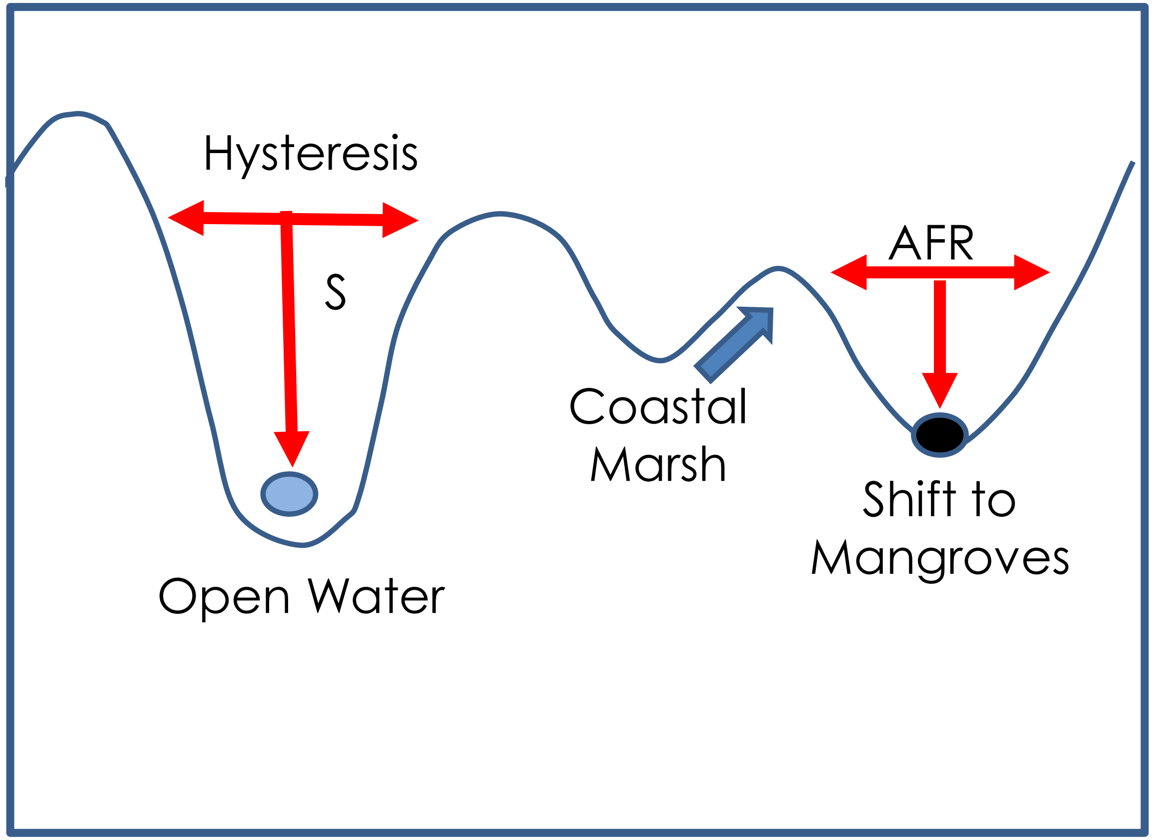
Threshold: Coastal marsh elevations will collapse if:

1. Water depths are too deep (>1.0m) for long periods of time (10-12 months).
2. Saltwater intrusion increases production of hydrogen sulfide, which is toxic to plants.

Tradeoffs:

1) A permanent shift to open water because elevation loss can be irreversible.

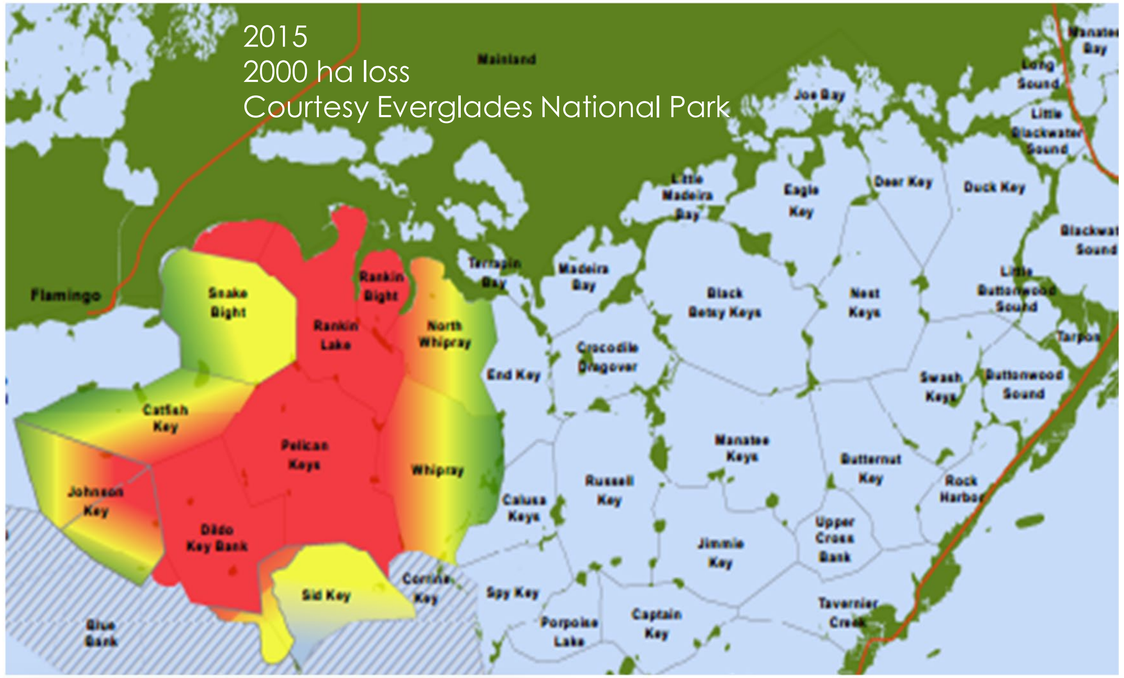
Adaptive Foundational Resilence: A Protective Threshold

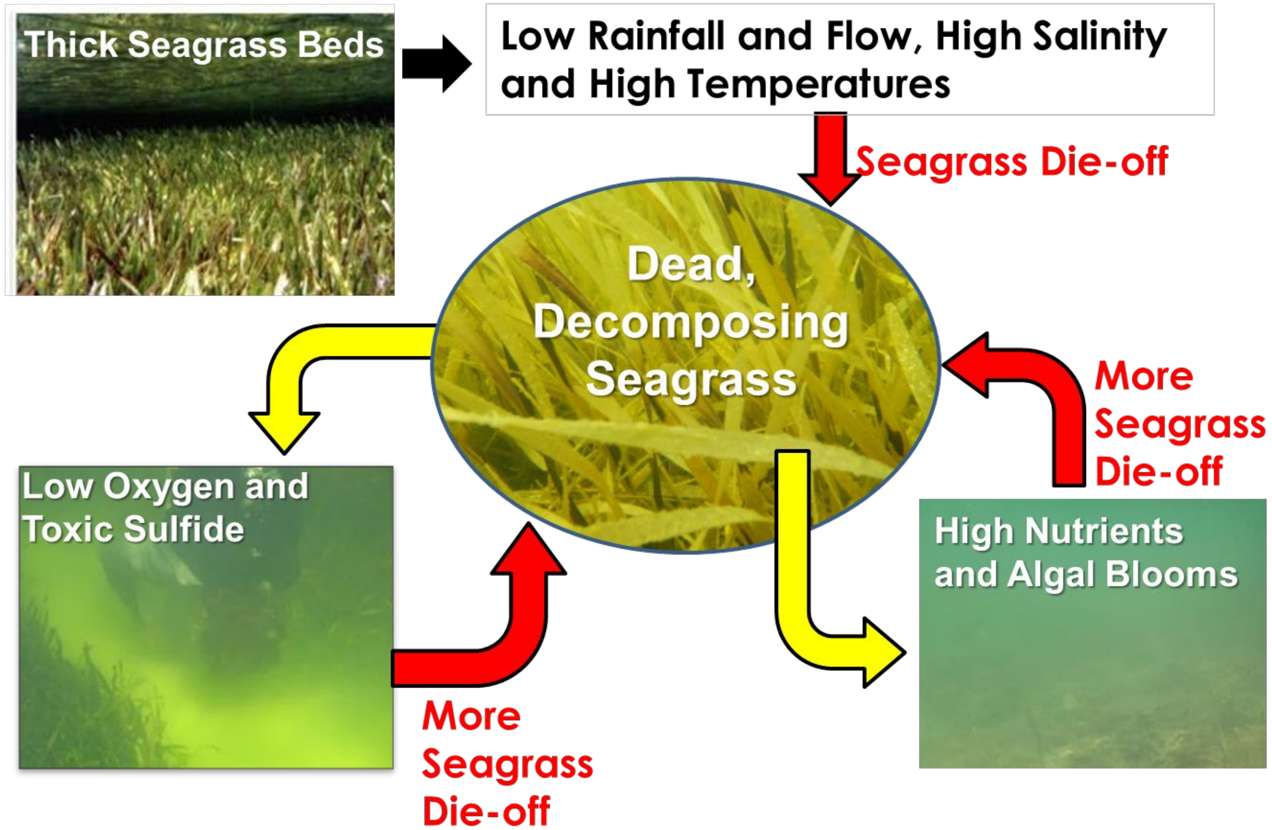


Tradeoffs….or:

1) A shift to a more resilient red mangroves ecosystem.

4. Healthy Seagrass: A Recovery Threshold

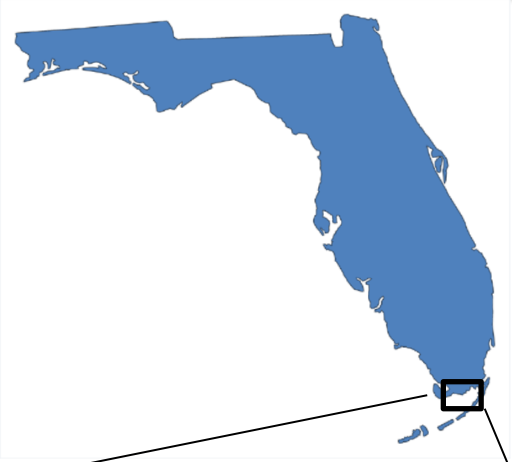


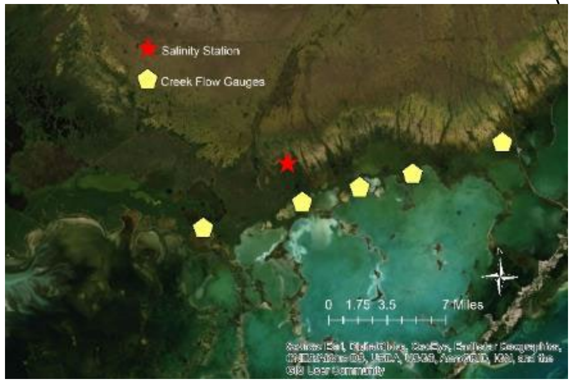



Turtle Grass (Thalassia)

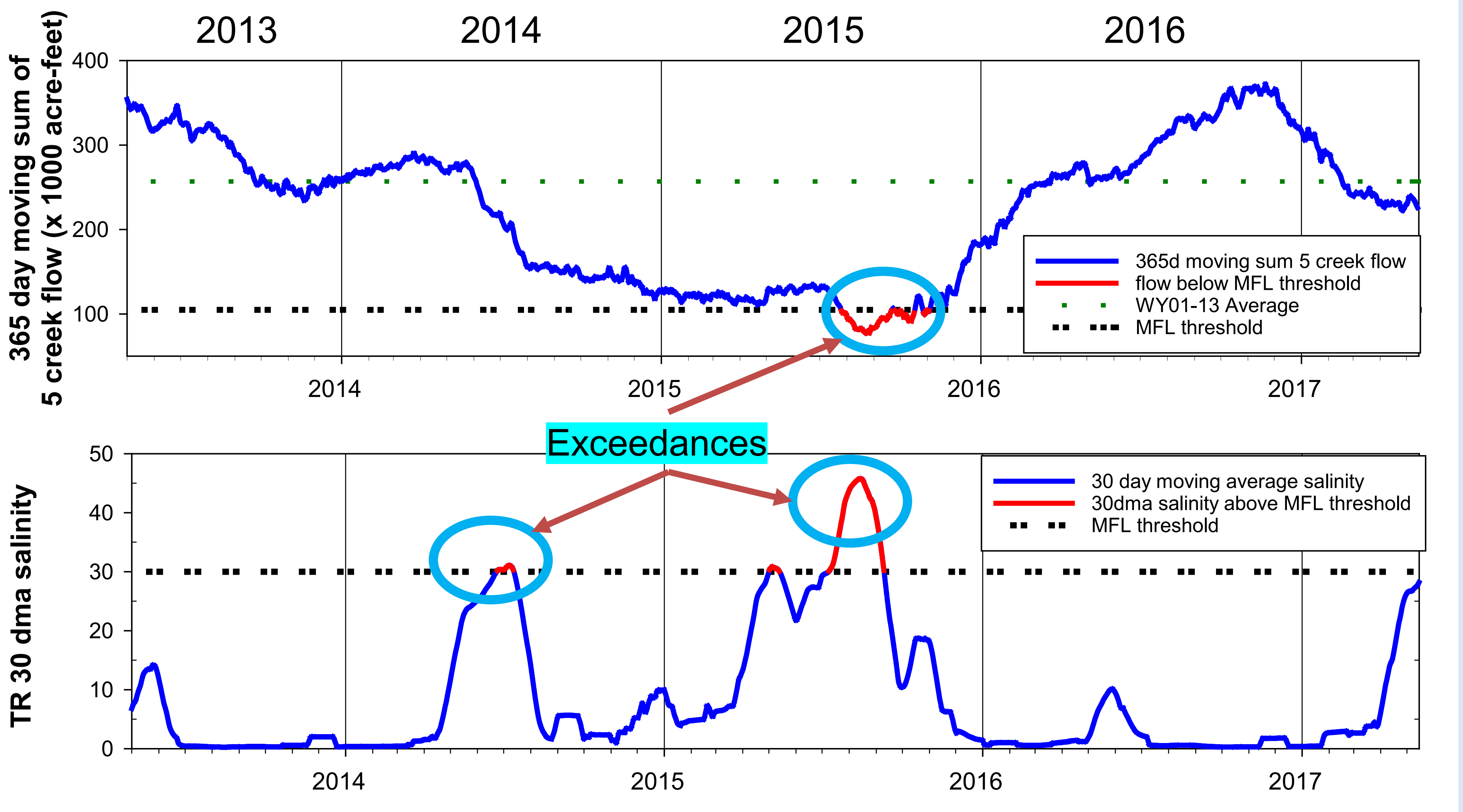

Shoal Grass (Halodule)

The MFL (Minimum Flows & Levels) Thresholds for Florida Bay "Calls for Recovery"



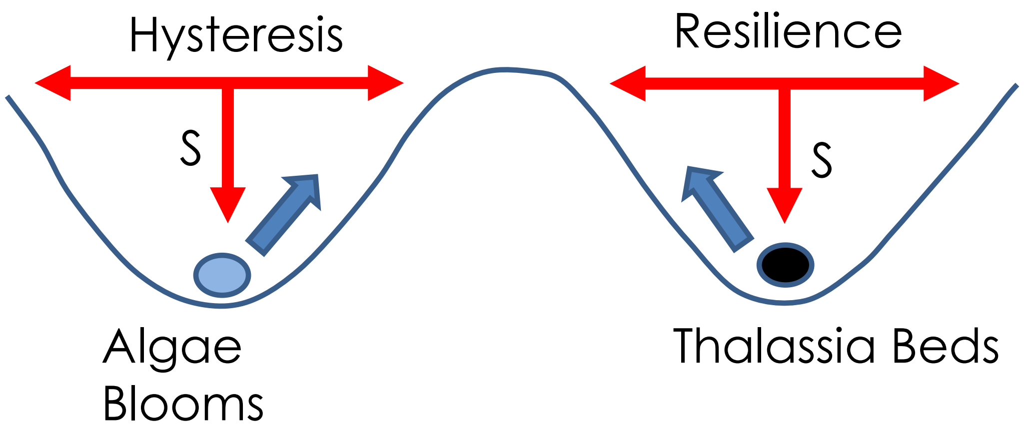


A Call for RECOVERY: Exceedance in back-to-back years twice during the previous 10 years OR Exceedances in 3 years consecutively during the previous 10 years



Seagrass Die-off: A Recovery Threshold

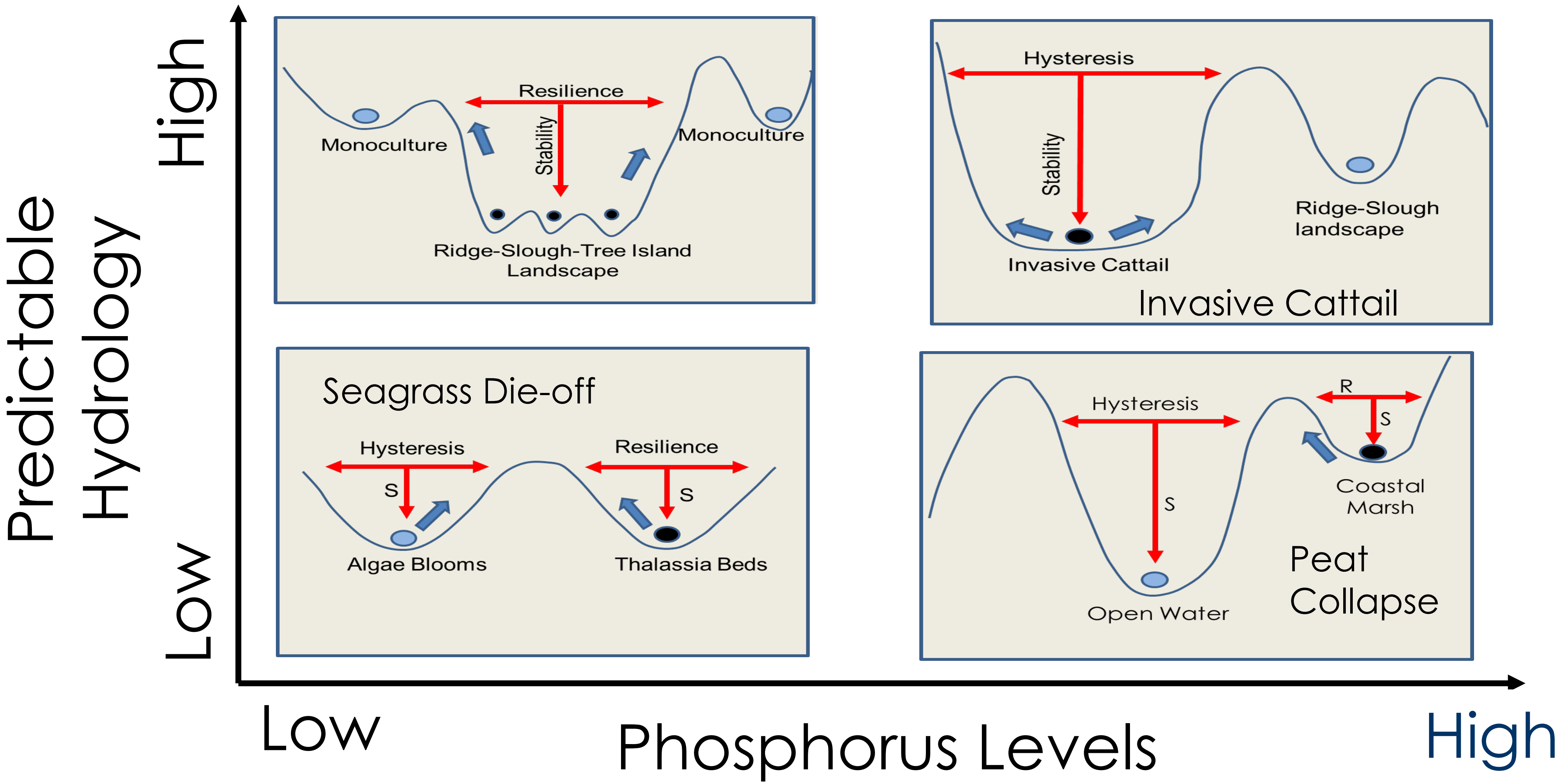
Algae bloom hysteresis =
Seagrass bed resilience.



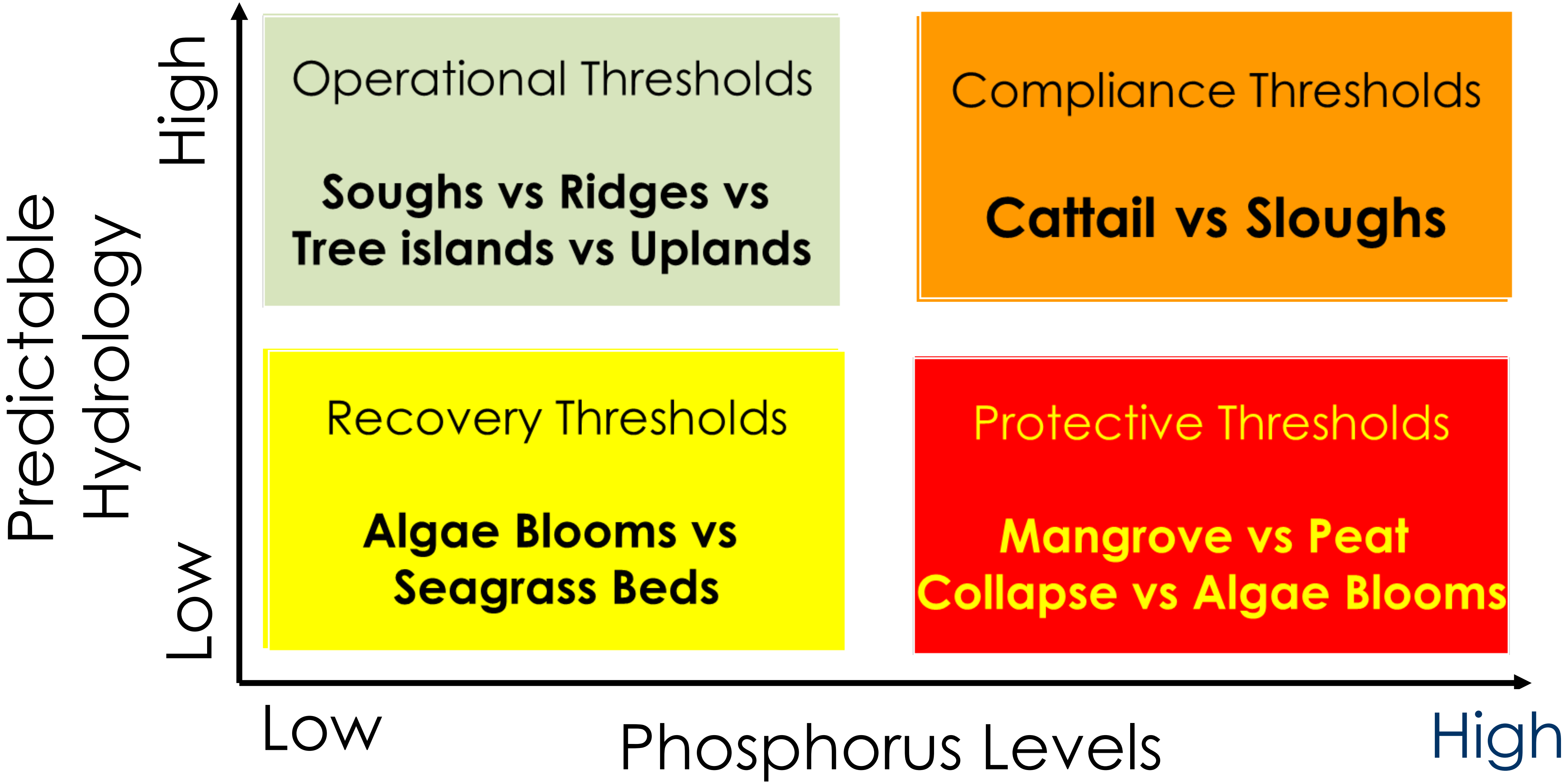
Thresholds:
Fl Bay Seagrass has a high level of resilience when:
FW inflows are high, Water TP <19 µg/l, Hydrologic residence time is short, Turbidity is low and Salinity is low

Tradeoffs:
A violation of the MFL will result in a state change to a pelagic ecosystem.

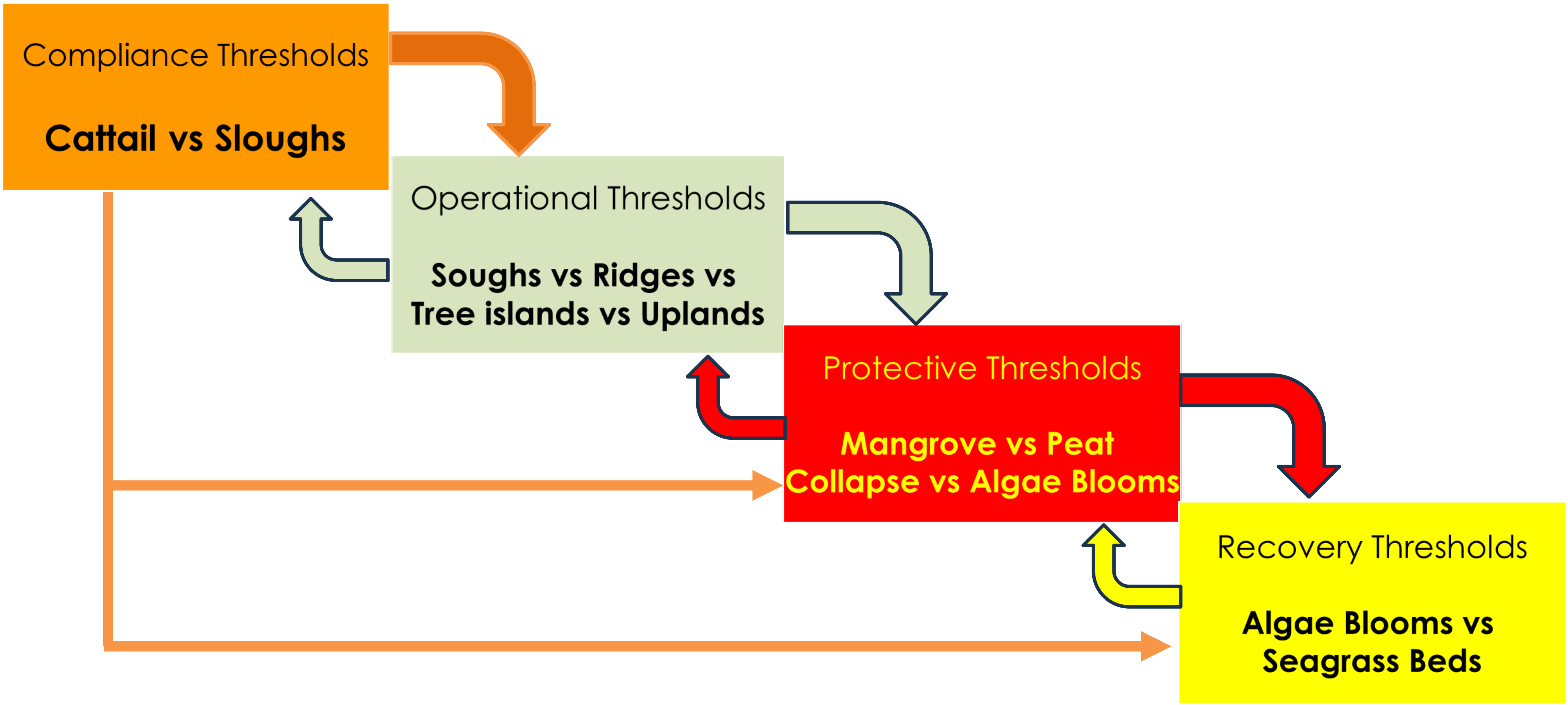
Thought #4: Tradeoffs within Thresholds Types



Thought #4: Tradeoffs within Thresholds



Thought #5: Ecological Thresholds Inform Potential Tradeoffs at the System and Landscape Level



Key Take-aways:

1) Thresholds are dynamic and influenced by both hydrology and water quality. For example, a Compliance Threshold can be negated or enhanced by a Hydrology Threshold.

2) Tradeoffs are the functional integration of Stability, Resilience, and Hysteresis. As such, Tradeoff Thresholds should include time domains, and quantifications for cumulative impacts and recovery, like the Recovery Threshold for seagrass beds in Florida Bay.

Questions?

The Peat Collapse Crew,
except for Joe Stachelek and Steve Davis

Ecological Thresholds: Associated Definitions

Threshold: A value or level above which there is an "ecological imbalance" and below which the Everglades can be preserved or restored.

Stability: The Everglades possesses ecological stability if it is capable of returning to its "dynamic equilibrium" state after a perturbation or does not experience unexpected large changes in its characteristics across time.

Resilience: The amount of disturbance that the Everglades can withstand without changing self-organized processes and structures.

Adaptive Foundational Resilience: The amount of disturbance needed for an ecosystem to shift to an alternative "stable" state but retain restoration functionality.

Hysteresis: The value or level of a threshold capable of creating an alternative stable state is less than the value or level capable of returning to the initial stable state.