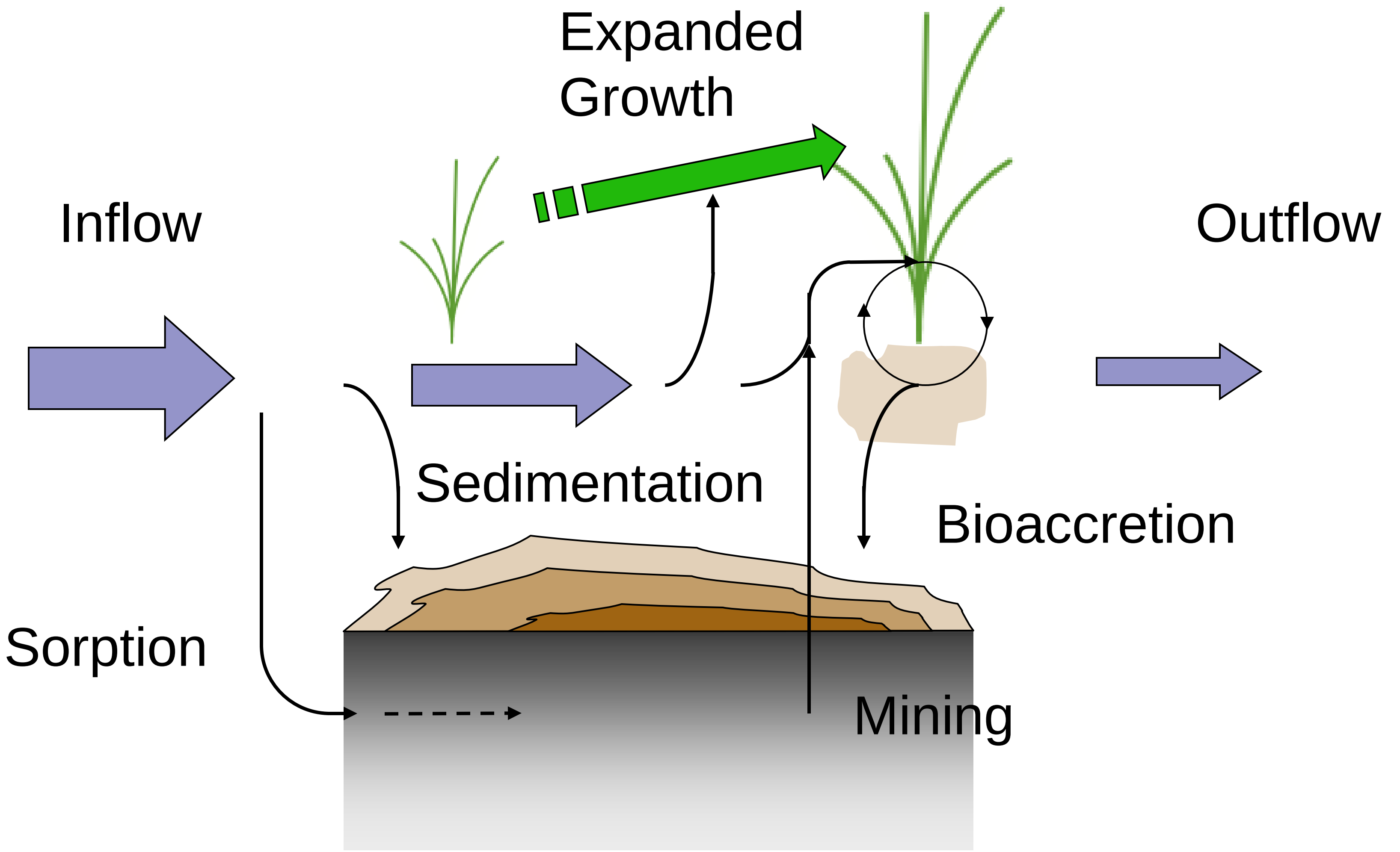
Longevity of Phosphorus Control Marshes

Focus on the Ecosystems

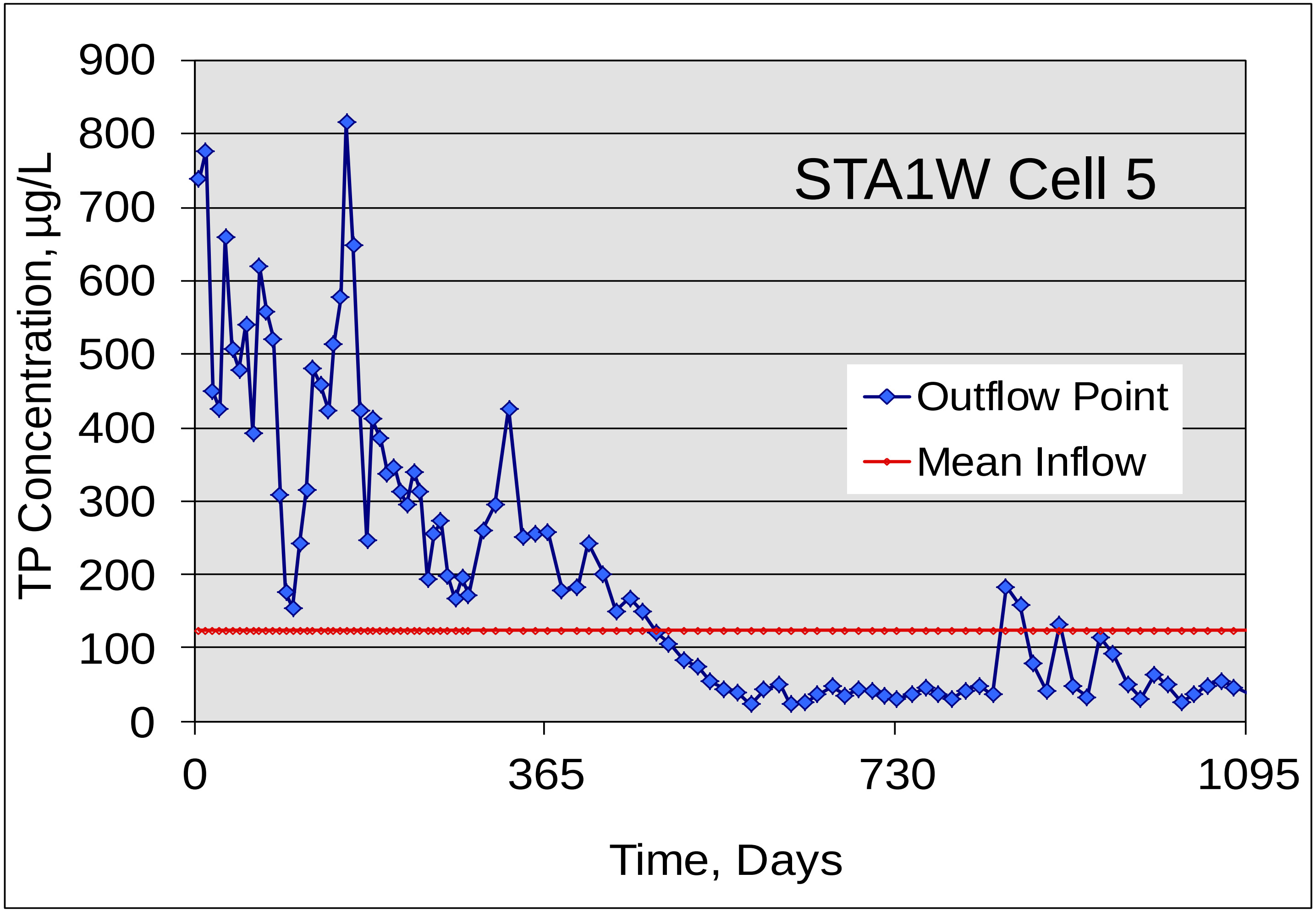
(Mechanical Parts Have a Life Expectancy Too)

- Processes
- Ecosystem responses
- Observed STA trajectories
- Options for control

Marsh Phosphorus Removal



Transient Phenomena:
Startup increments or decrements



P Removal: The Tweaks

Mechanism	Storage Location
• Growth Increase – Collapse back	• In Bigger Plants – Space limited – Short-lived – Small: 1 - 5 gP/m^2
• Sorption – Desorption – Redox release	• On Existing Soils – Binding site limited – Short-lived – Small: 1 - 3 gP/m^2

P Removal: The Mains

Mechanism	Storage Location
• Sedimentation – Incoming particulates – Mineral or algae – Resuspension	• In New Deposits – Increases each year – Solids fill-up limited – Inlet preferential
• Bioaccretion – Internally generated – Organic – Release	• In New Deposits – Increases each year – Solids fill-up limited – System-wide

Two Kinds of Accretion

The STAs are bioaccretion systems

ENRP: 10.5 mg/L TSS Inlet; 2.1 mg/L Outlet
237 $g/m^2 \cdot yr$ removed
TSS removed = 0.09 cm/yr accretion
Measured = 0.81 cm/yr accretion

Apopka is a sedimentation system

Apopka: 40 mg/L TSS Inlet; 4 mg/L Outlet
1050 $g/m^2 \cdot yr$ removed
TSS removed = 0.4 cm/yr accretion
If in cross ditches = 8.0 cm/yr accretion

Sustainability of Main Mechanisms

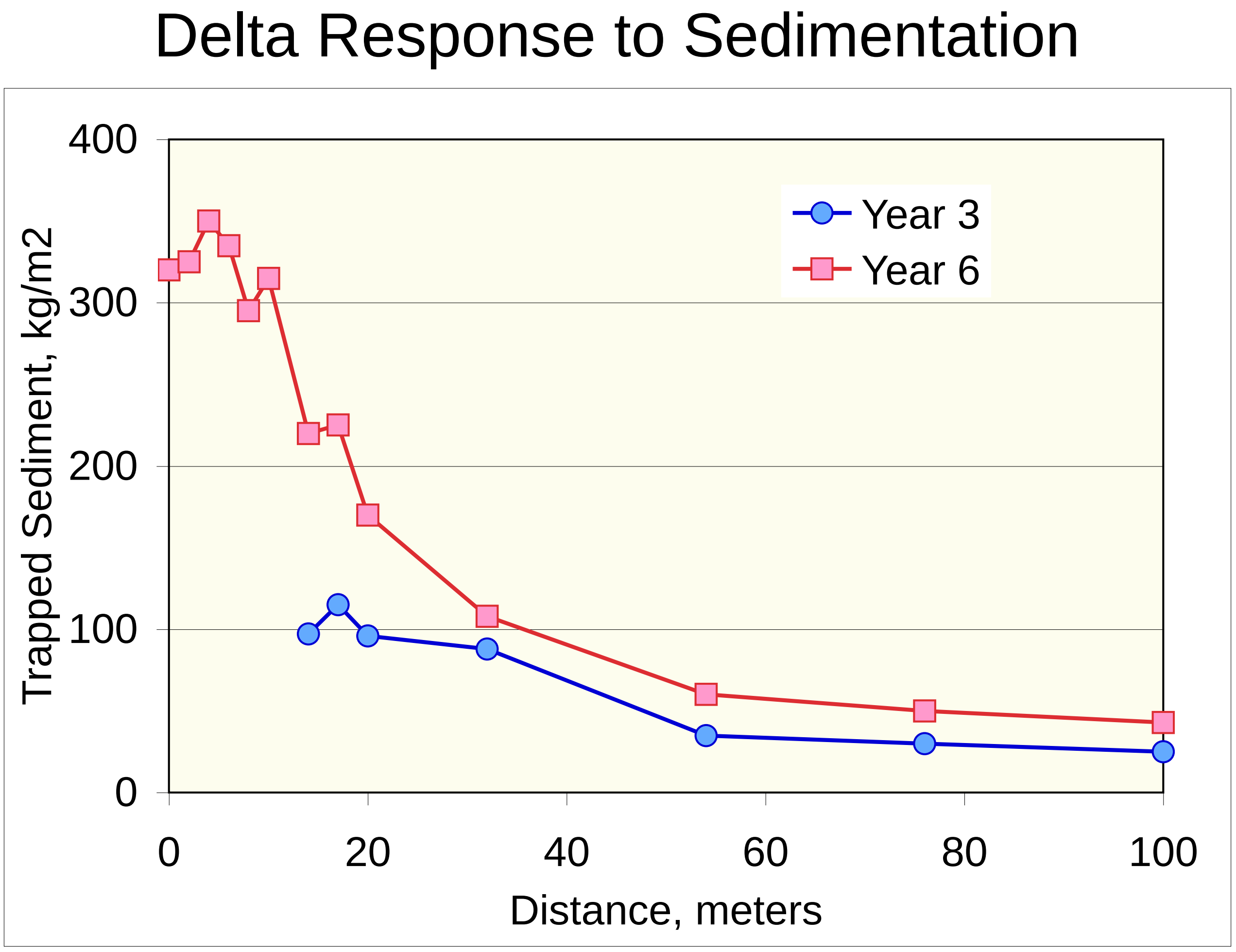
1. Sedimentation and bioaccretion are both inherently sustainable. Neither physics nor biogeochemistry wear out, nor do these mechanisms "saturate."

2. Both produce new residuals, which pile up and eventually alter the hydraulics of the wetland.

3. The time scale for significant hydraulic alteration is on the order of 15 years.

4. Pile-up alteration may reduce, but not eliminate, the P removal function of the system.

Long-term Wetland Responses

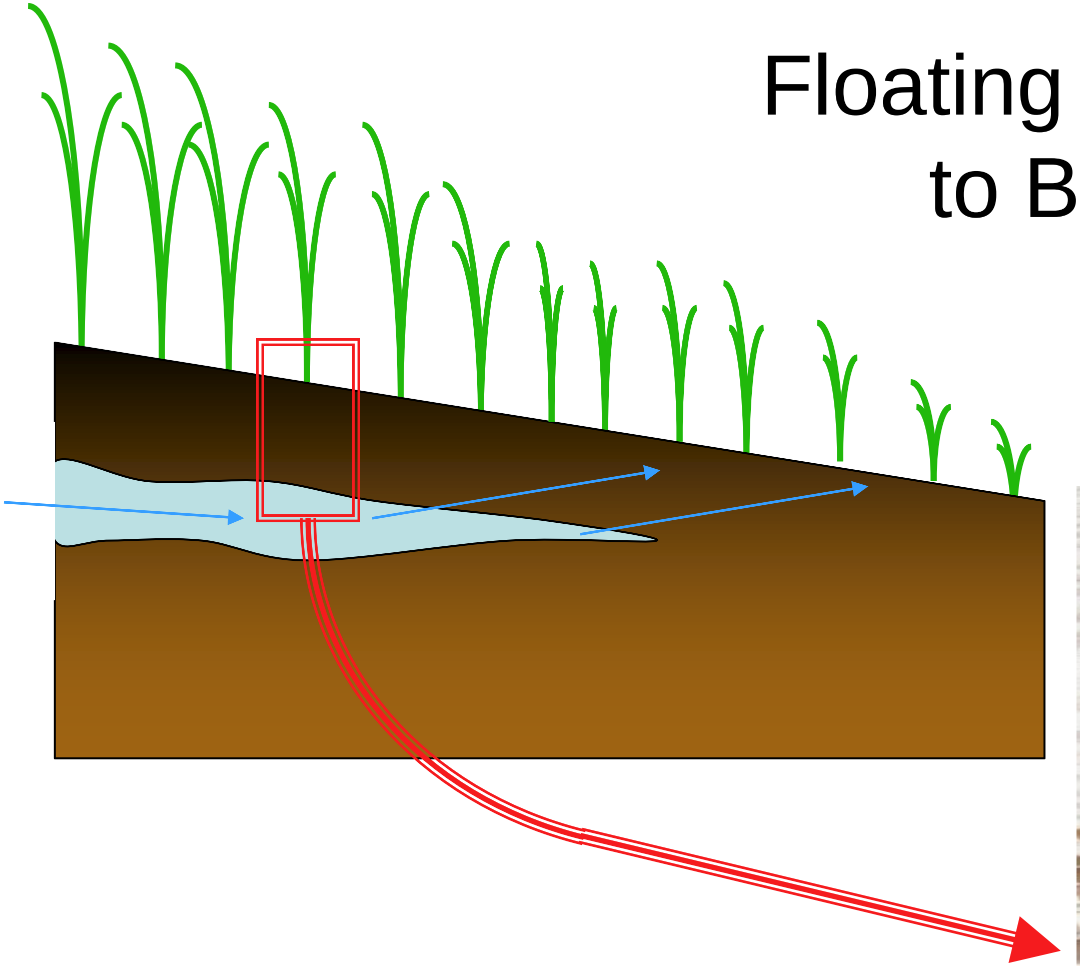


Braskerud, 2001

100 kg/m^2 ≈ 10 cm

Channelization Response to Bioaccretion

Floating Mat Response to Bioaccretion



Buoyant root/sediment mat lifts free; water underflows

“Tussock” Problems

Continuous mats are interwoven and physically stable. They move up and down, but not sideways.

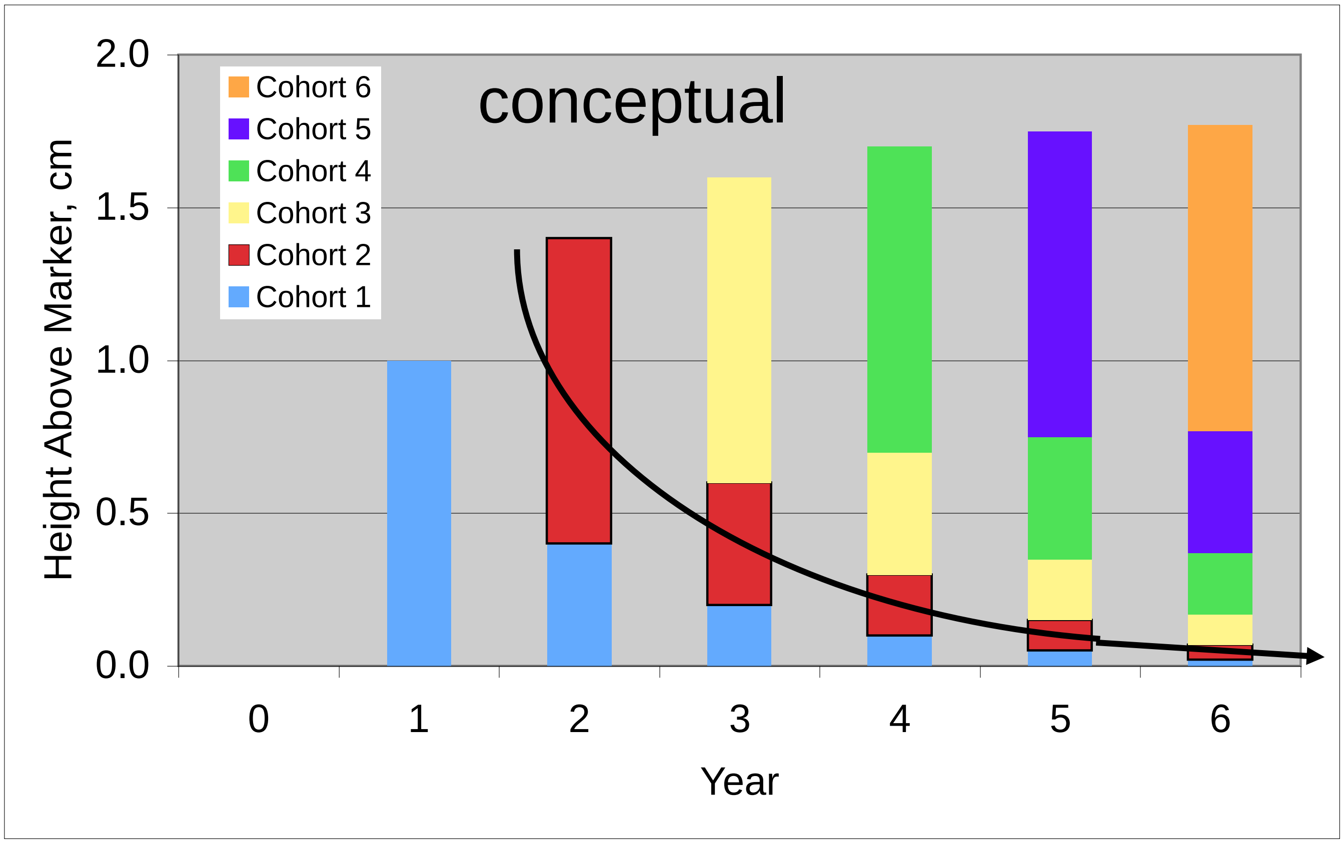
Patchy mats give rise to islands of floating vegetation. These can move, and create problems.

Measuring Accretion

- Horizon markers
- Water surface elevation change
- Ground elevation - surveying
- Stable isotope changes along soil cores
- Radioisotope deposition profiles
  - Cesium 137
  - Lead 210

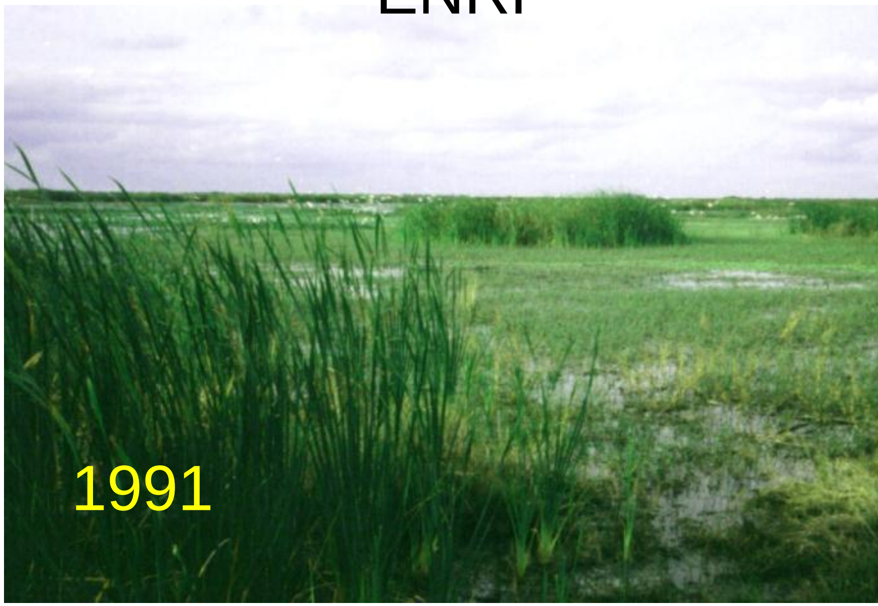
Horizon Marker Interpretation

Cohort Compaction & Decomposition Occurs
The Collapsing, Churning Layer Cake



Rybcyzk et al, 2002

ENRP

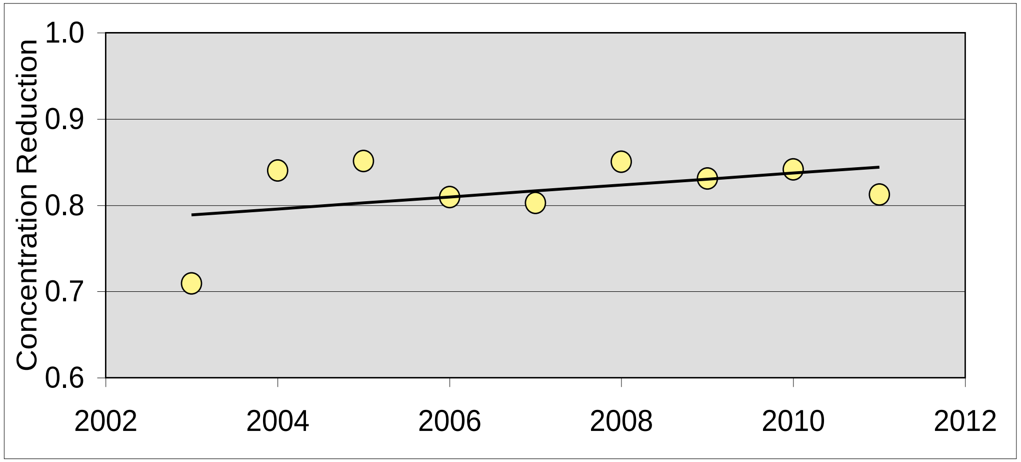


The Stormwater Treatment Areas

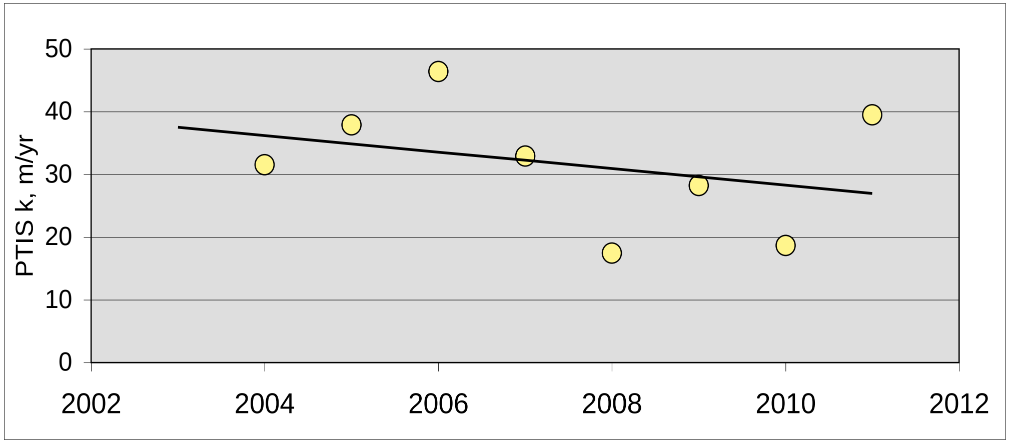
Some STAs still look the same

Other STA cells have been intentionally altered

Getting Better or Getting Worse?
Example: STA2 Cell 3 Track Records



Concentration reductions have slightly improved



Removal rate coefficients have decreased

Performance Trends for the STAs

1 = Improvement   -1 = Worsened

	Flow Path	Years	Rate Coefficient	Concentration Reduction	P Load Removed
STA1W	East	9	-1	1	-1
	West	7	1	1	1
	North	11	1	1	1
STA2	1	9	-1	1	1
	2	9	-1	1	-1
	3	9	-1	1	-1
STA34	East	6	-1	-1	-1
	Central	6	-1	-1	-1
STA5	North	9	1	1	1
	Center	9	-1	-1	-1
STA6	3	11	1	1	1
	5	11	1	1	1
Total			-2	6	0

Accretion in the STAs 2012 SFER

	Cell	Accumulation cm	Rate cm/yr	C.V.
STA1W	1A	19	1.2	0.38
	2A	16	1.0	0.10
	3	13	0.9	0.33
	5A	10	1.0	0.42
	5B	13	1.2	0.54
	Northern	12	1.2	0.46
	ENRP	16	1.0	0.40
STA2	1	9	1.0	0.26
	2	10.5	1.0	0.26
	3	12.5	1.2	0.33
STA34	1A	8	1.4	0.57
	2A	12	2.0	0.55
	1B	12	2.0	0.42
	2B	8	1.5	0.31
Mean		12.2	1.26	0.38

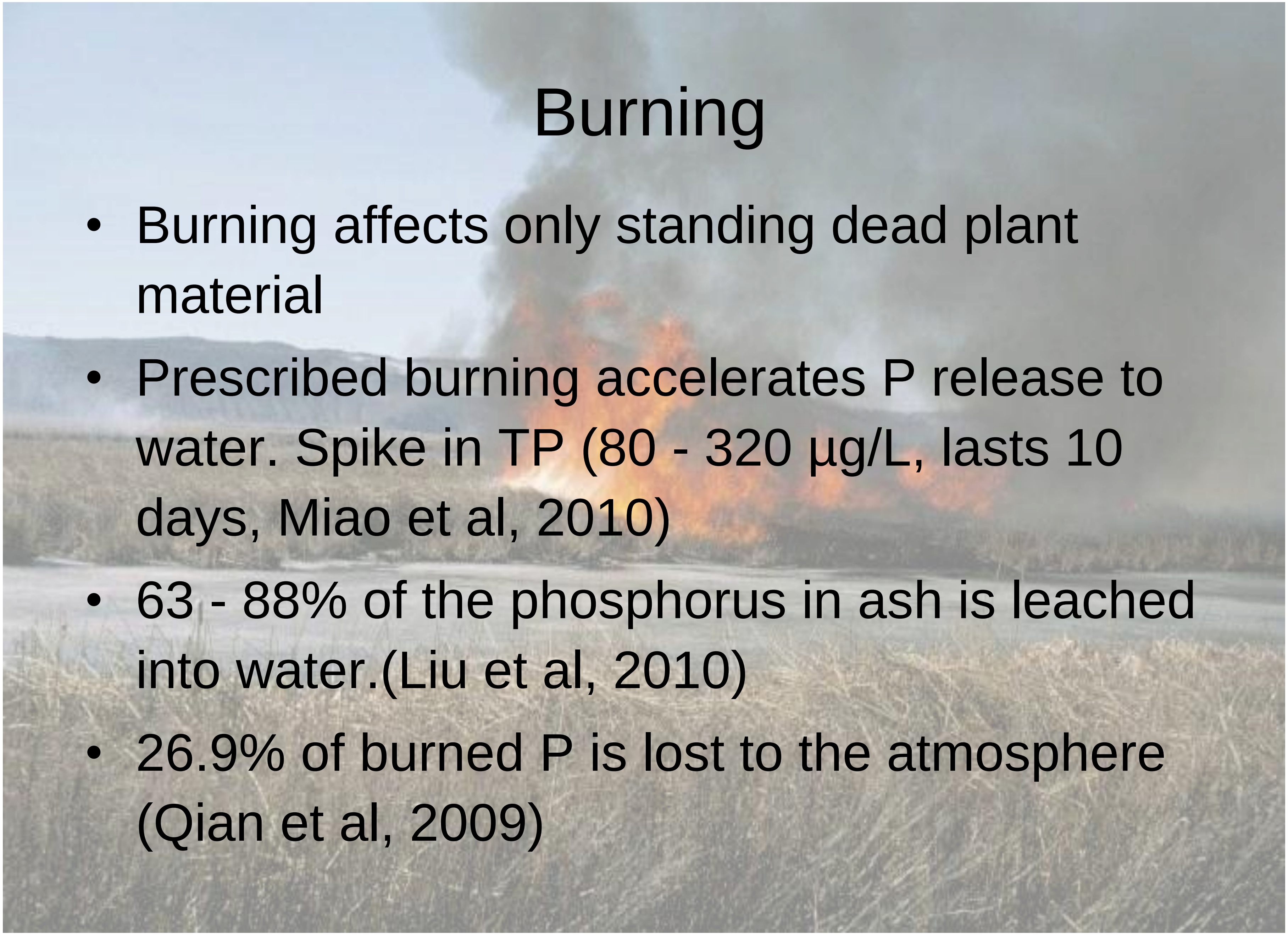
Aid for the Aging Wetland

Tweaks

- Vegetation removal (restore grow-in potential)
  - Harvest
  - Drawdown followed by burning
- Soil amendments (restore sorption capacity)
- Drawdown/consolidation (thickness reduction)

Mains

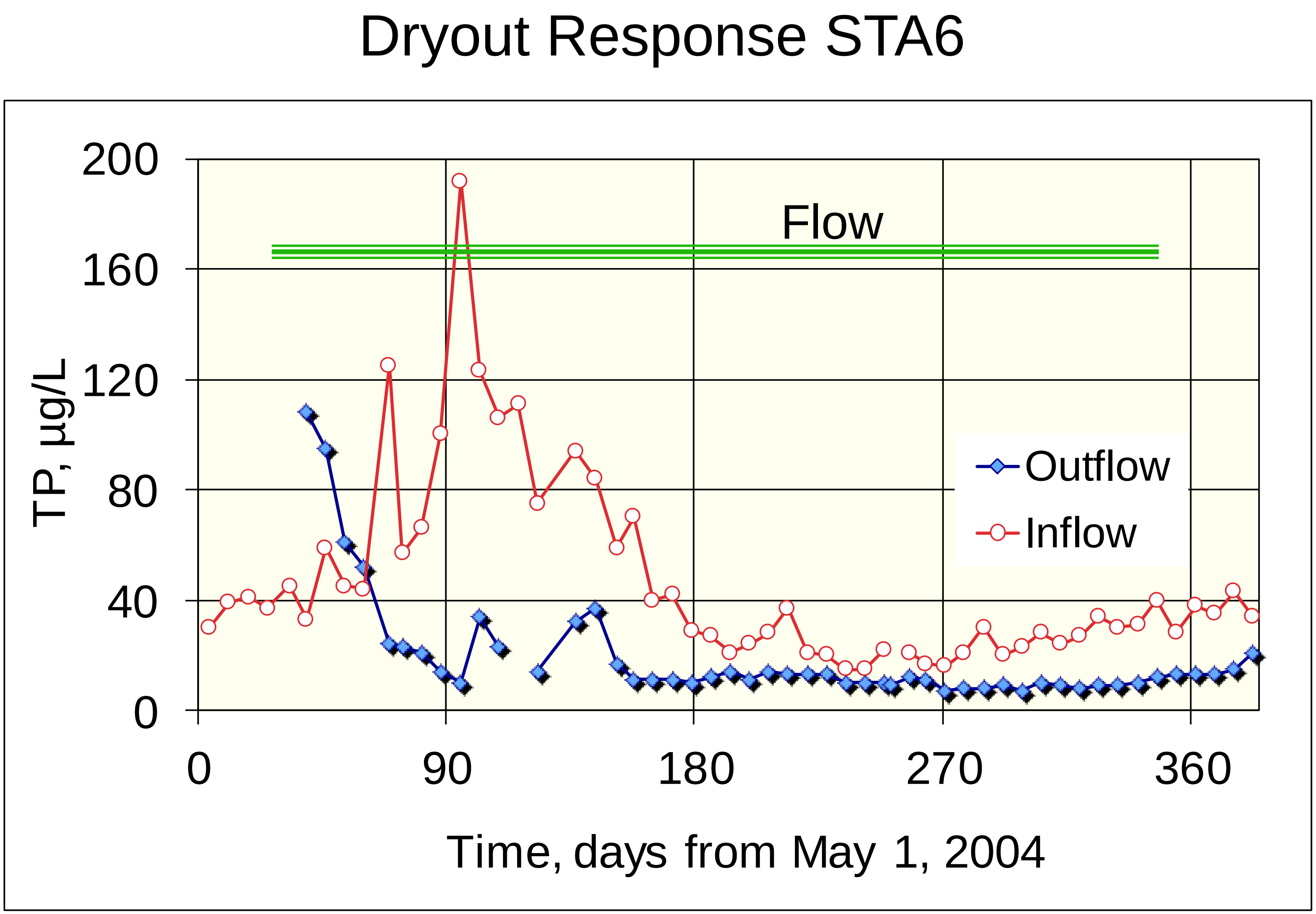
- Additional solid storage in the system
  (higher berms; adjustable structures)
  (sedimentation basins)
- Mechanical removal of sediments
  (suction dredging or clamshell or backhoe)



Burning

- Burning affects only standing dead plant material
- Prescribed burning accelerates P release to water. Spike in TP (80 - 320 µg/L, lasts 10 days, Miao et al, 2010)
- 63 - 88% of the phosphorus in ash is leached into water.(Liu et al, 2010)
- 26.9% of burned P is lost to the atmosphere (Qian et al, 2009)

Dryout Causes Temporary P Release



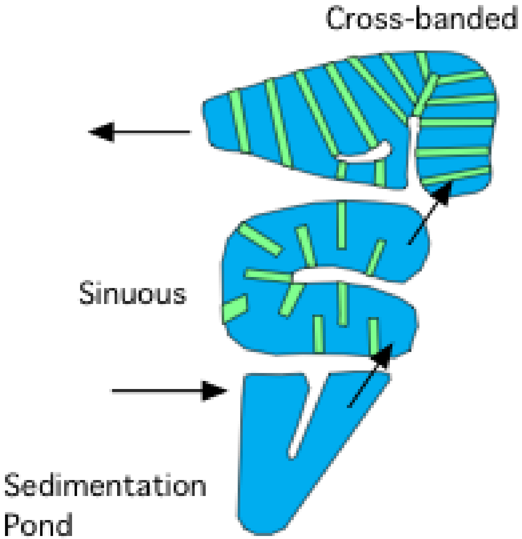
Raise Water Level

- Requires excess freeboard
- Water level not controlled by structures in large vegetated cells
  - Depth is vegetation-controlled
- Deeper water changes vegetation
  - Emergents may be replaced by SAV

Dig out the Acumulation

- Disruptive
  - Cell off-line
  - Vegetation needs restarting
- Expensive
  - Removal costs
  - Disposal costs
- Effective
- Demonstrated (OEW)

Sedimentation Basins



Brawley, CA

Sed Basin
164 kg/ha•yr TSS
1.6 cm/yr

PP Removal
12.6 gP/m^2•yr
89%

Wetlands
9 kg/ha•yr TSS
0.09 cm/yr

Closure

- Temporary mechanisms soon cease (a year or two in semi-tropics; longer in cold climates)
- Biogeochemistry does not wear out
- Wetlands eventually fill up with new solids (sedimentation or bioaccretion)
- Response is floating mats or channelization
- The best fix is accommodation (water level adjustment or sedimentation basin)