Seasonal, Operational, and Plant Effects on Water Treatment Processes in Constructed Wetlands

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MONTANA STATE UNIVERSITY
Center for Biofilm Engineering

Applying knowledge to improve water quality
National Water Program
A Partnership of USDA CSREES & Land Grant Colleges and Universities

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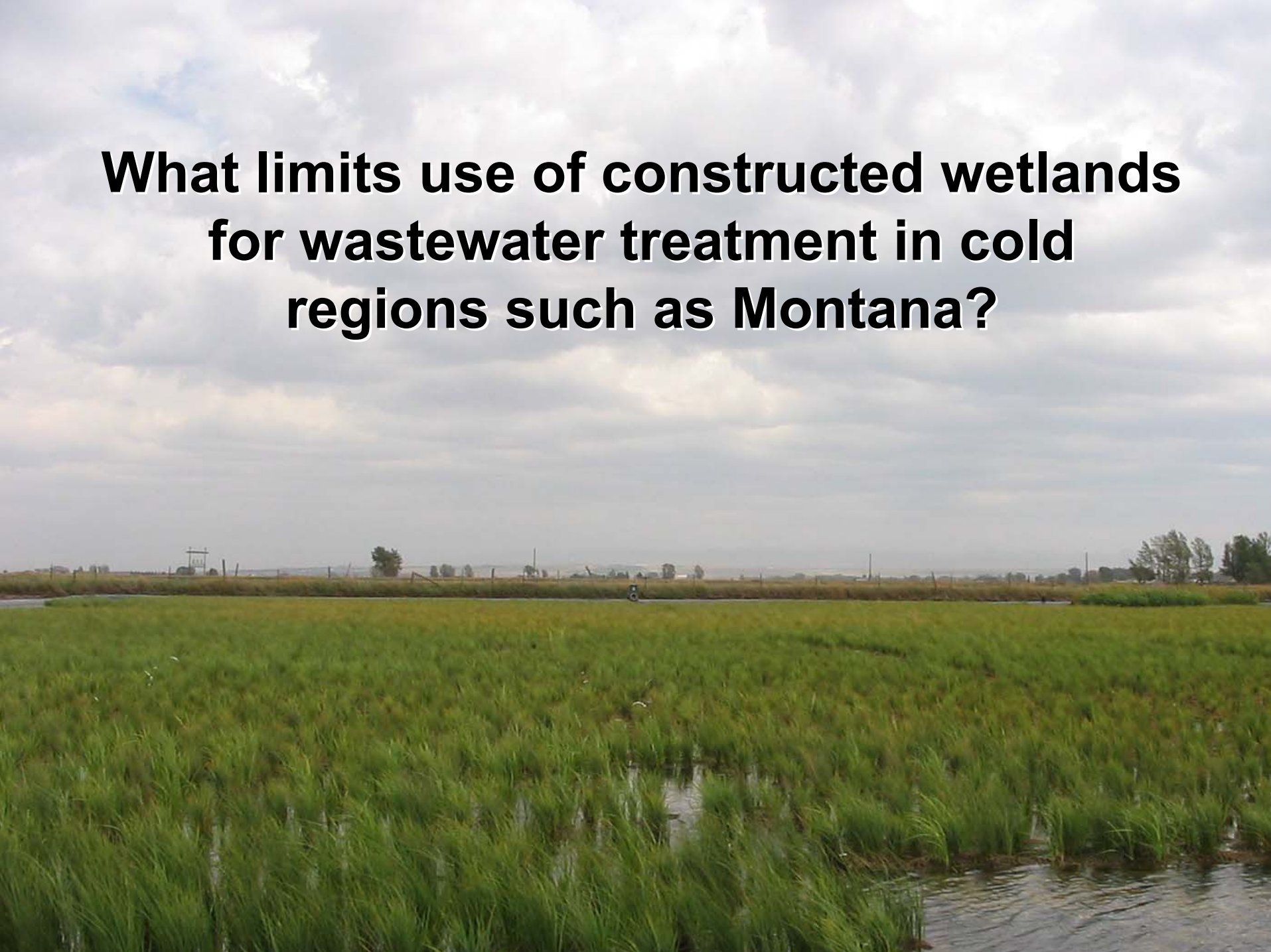
What limits use of constructed wetlands for wastewater treatment in cold regions such as Montana?



- **Technological challenges**

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- Regulatory barriers

Our focus:

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- optimizing hydraulic operations

Greenhouse-scale wetland microcosms

Horizontal flow cells
(continuous loading)

PVC columns
(batch loading)

Summer (above)
and
Winter (right)

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- 4 - 24°C
- natural day length
- growth and dormancy

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Artificial wastewaters

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- mineland
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Different plant species

- commonly used
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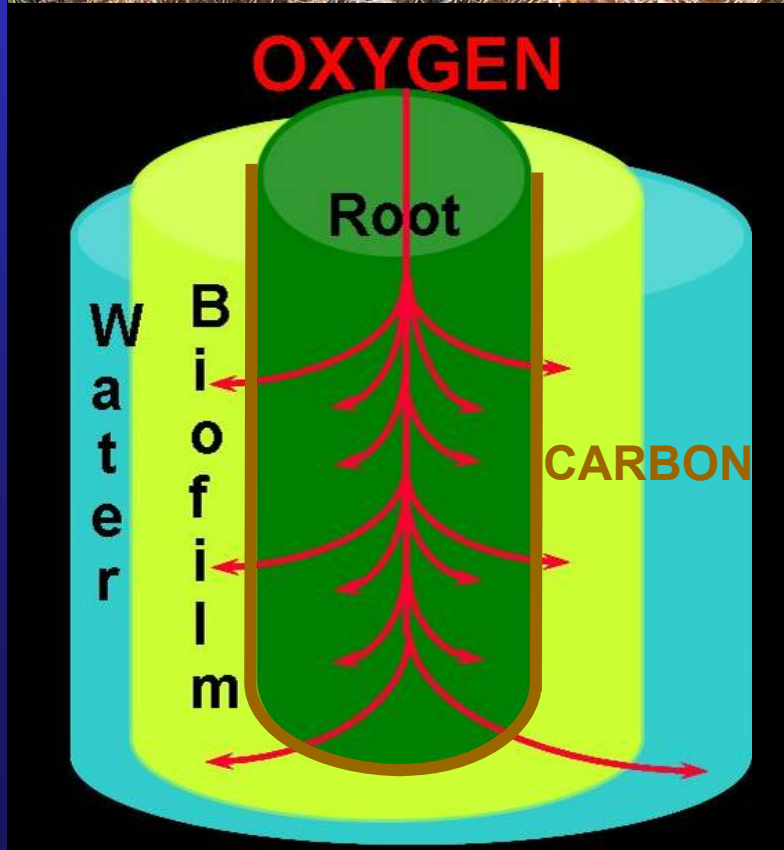
Hydraulic operation

- batch loading
- continuous flow
- varied residence time

Previous results with 3 plant species

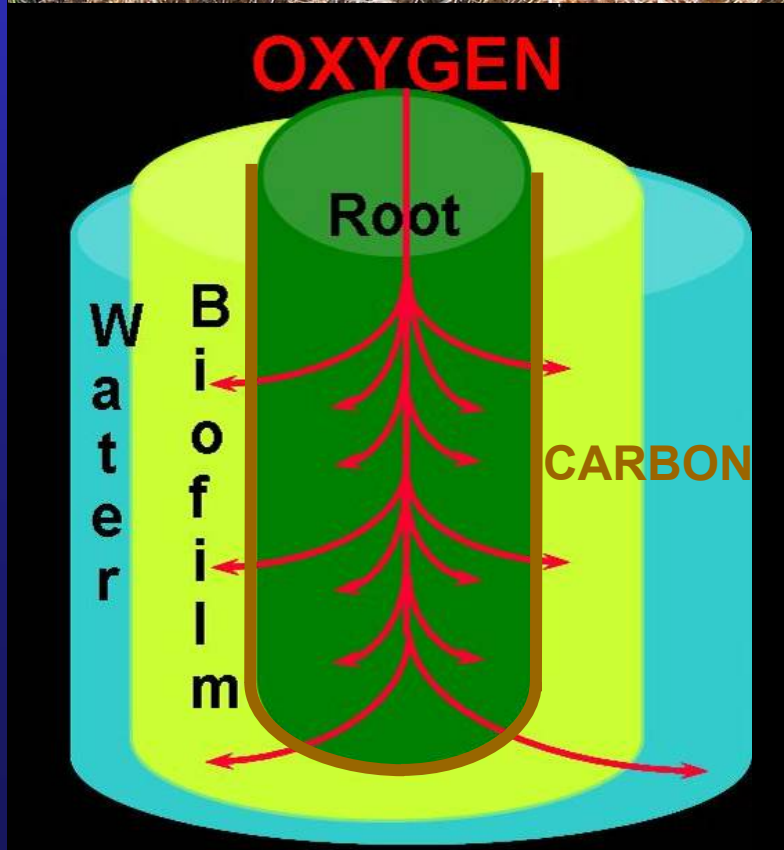
- Plants reduce the effects of cold temperatures on water treatment



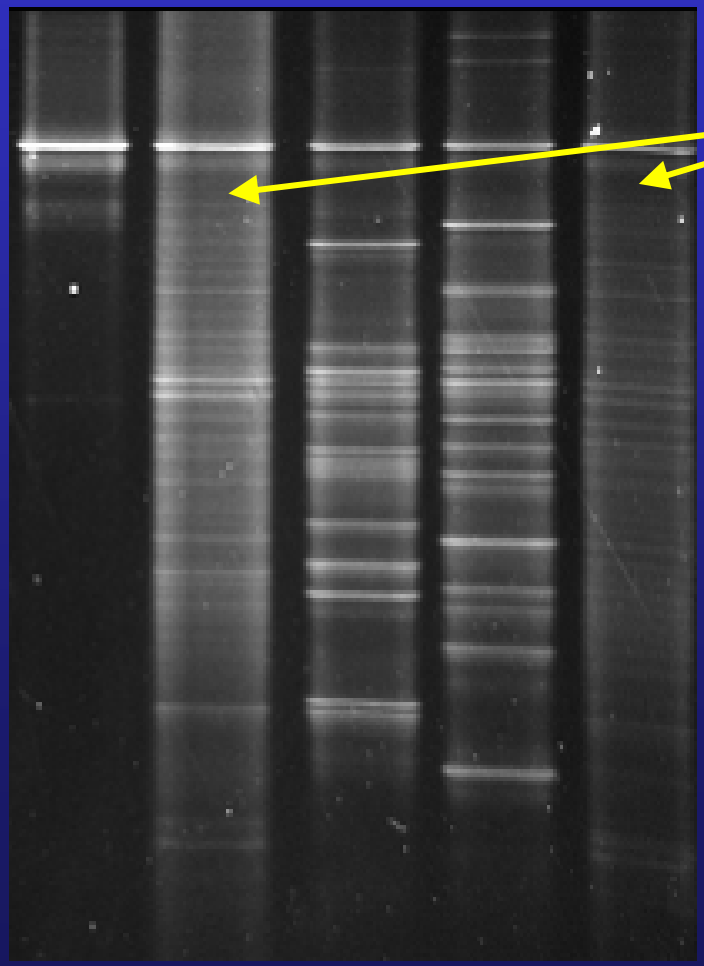
Previous results with 3 plant species

- Plants reduce the effects of cold temperatures on water treatment

- Major differences between species likely result from:
  - oxygen supply at root surface
  - carbon supply at root surface
  - root surface area
  - seasonal growth & physiology

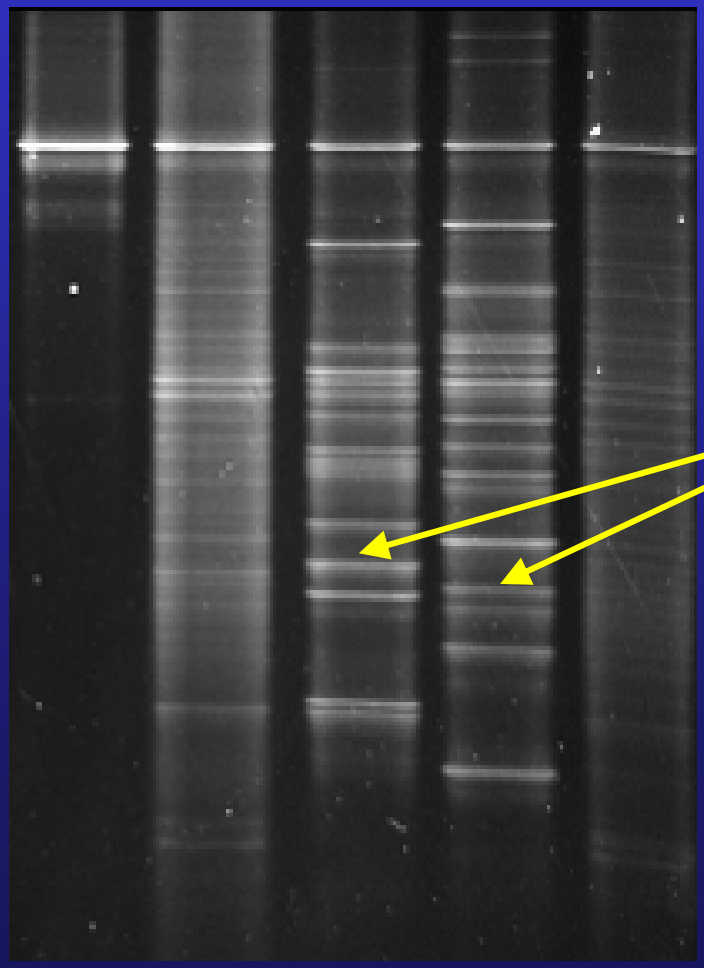


PCR analysis of microbial communities: sedge rhizosphere sample



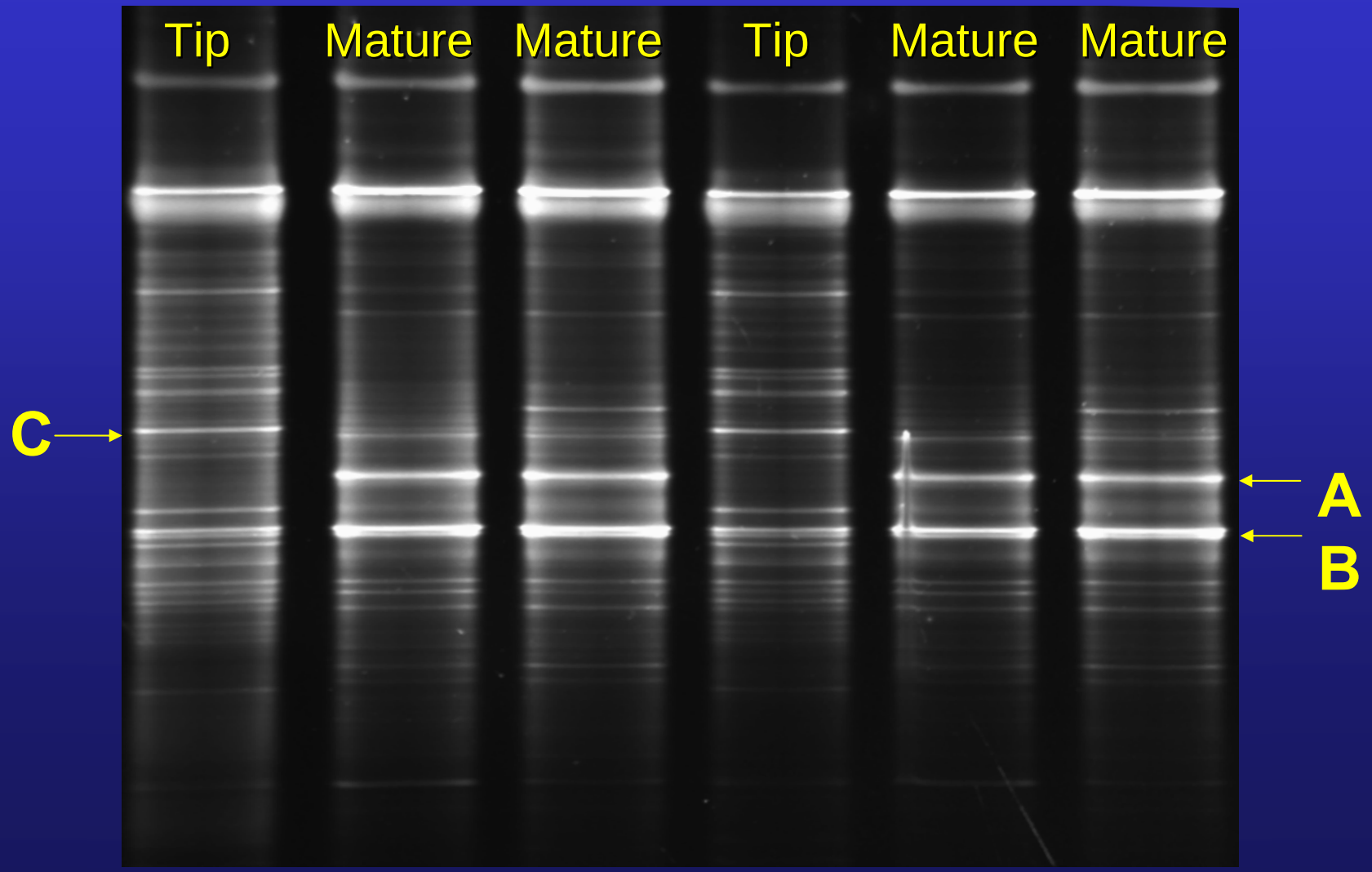
- **Lanes 1 and 4 amplified directly from DNA extract**
  - "too much information"

PCR analysis of microbial communities: sedge rhizosphere sample

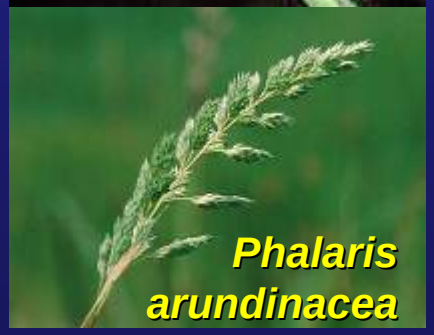


- **Lanes 2 and 3 use DNA cloning to highlight subsets of PCR products**
  - Profiles allow comparison among samples

Example: microbial communities differ between root tips and mature roots of *Carex utriculata*



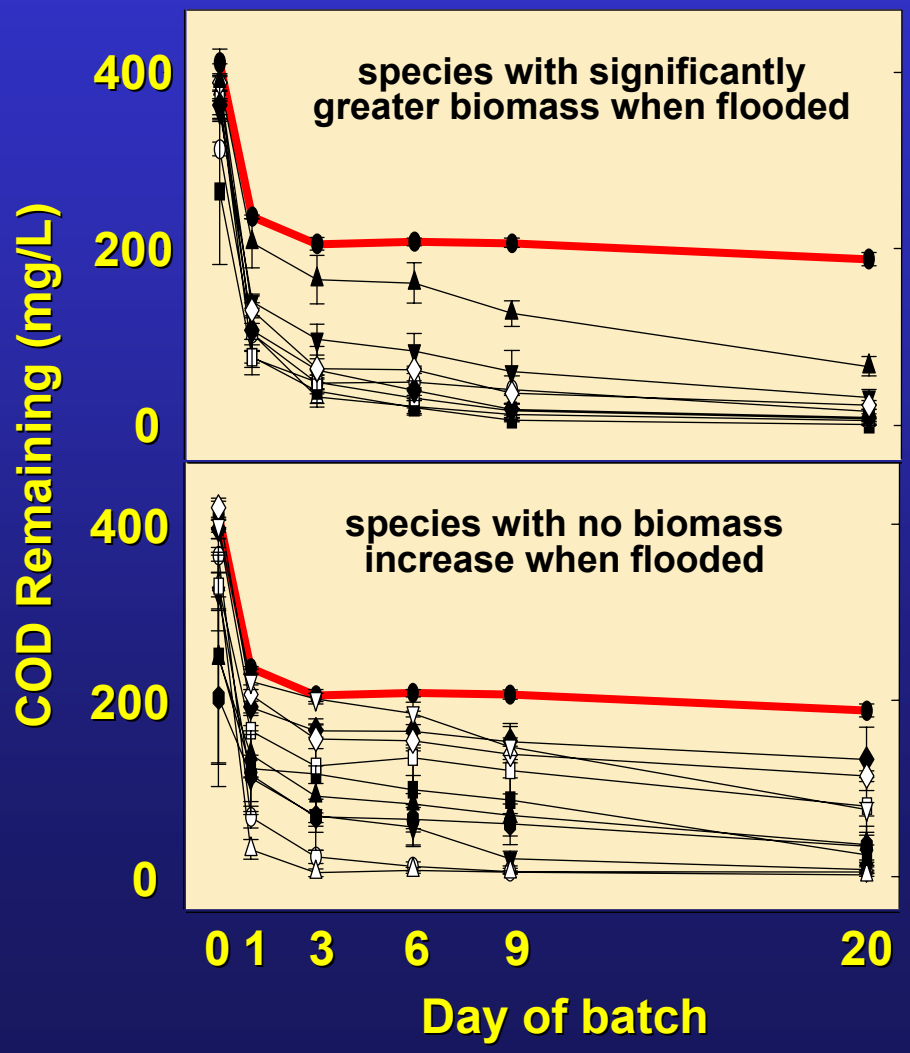
Investigation of diverse plant species



	Species
Obligate	*Typha latifolia*
	Carex utriculata
	Carex aquatilis
	Carex nebrascensis
	Carex bebbii
	Schoenoplectus acutus
Facultative Wetland	*Iris missouriensis*
	Calamagrostis canadensis
	Phalaris arundinacea
	Phragmites australis
	Carex praegracilis
	Juncus balticus
	Juncus torreyi
	Deschampsia cespitosa
Facultative	*Hordeum jubatum*
	Carex microptera
	Panicum virgatum
	Leymus cinereus
	Prunella vulgaris

Plants effects on wastewater treatment in winter (4˚C)

Relation to flooding tolerance



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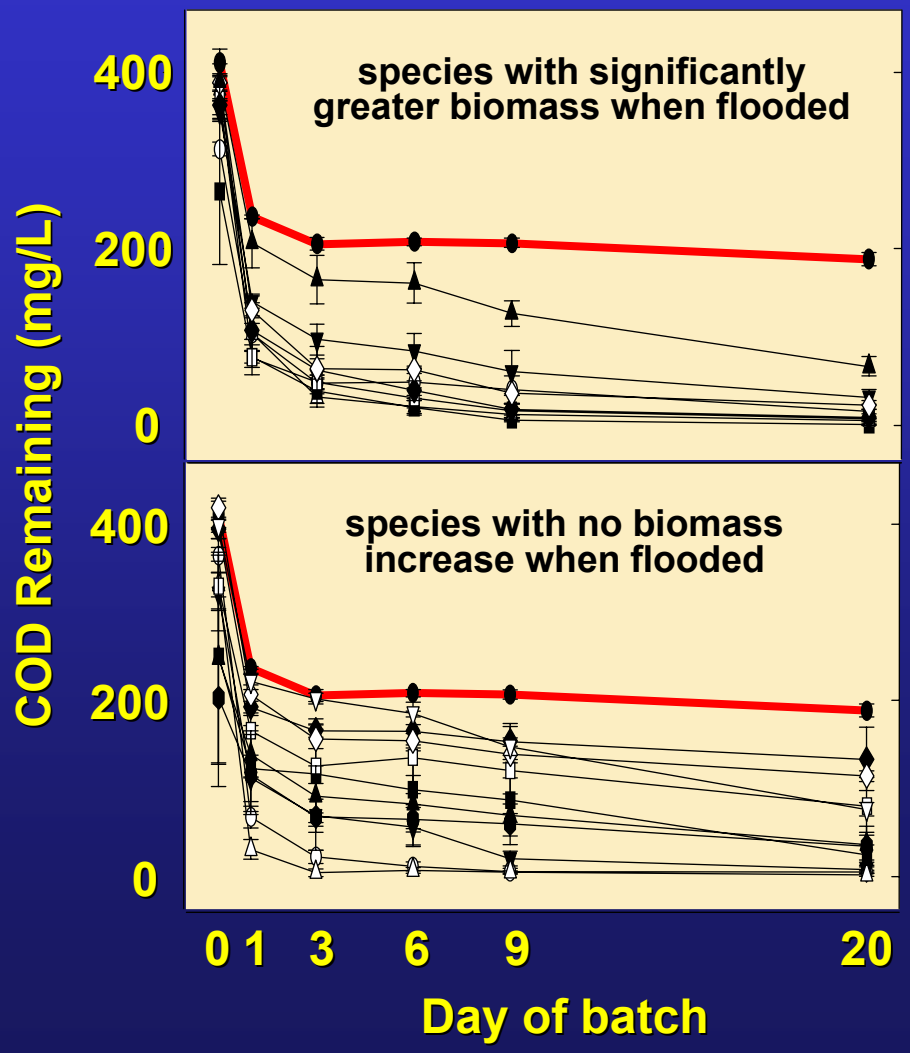
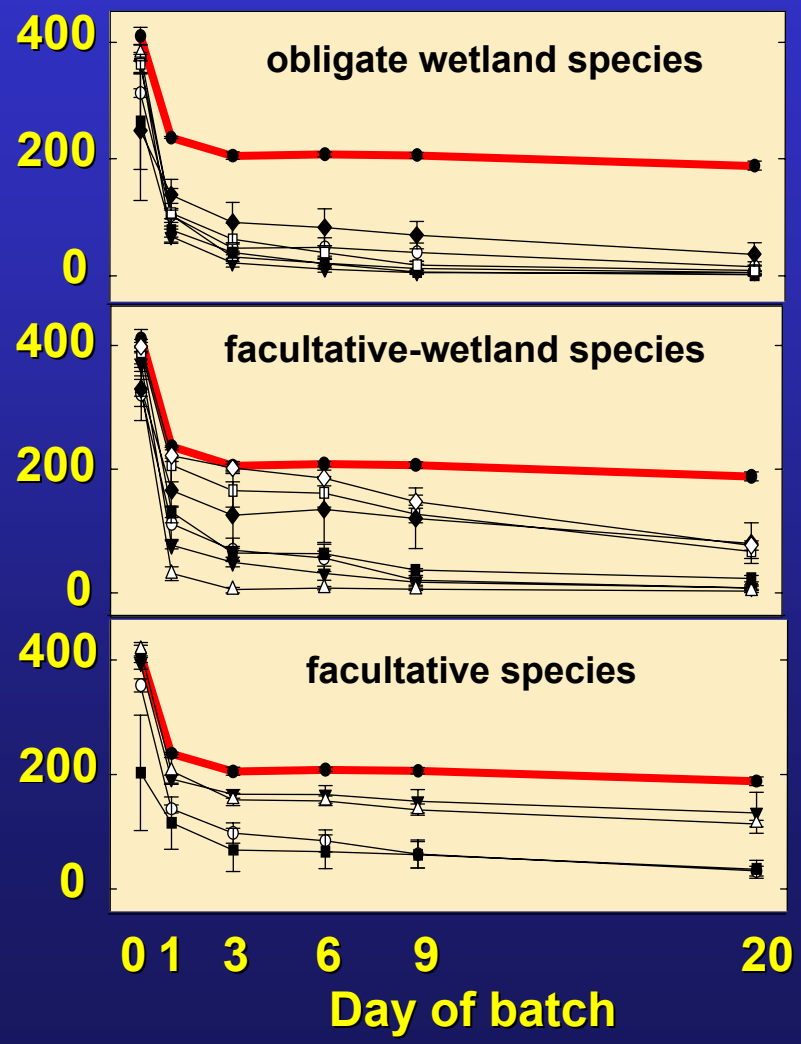
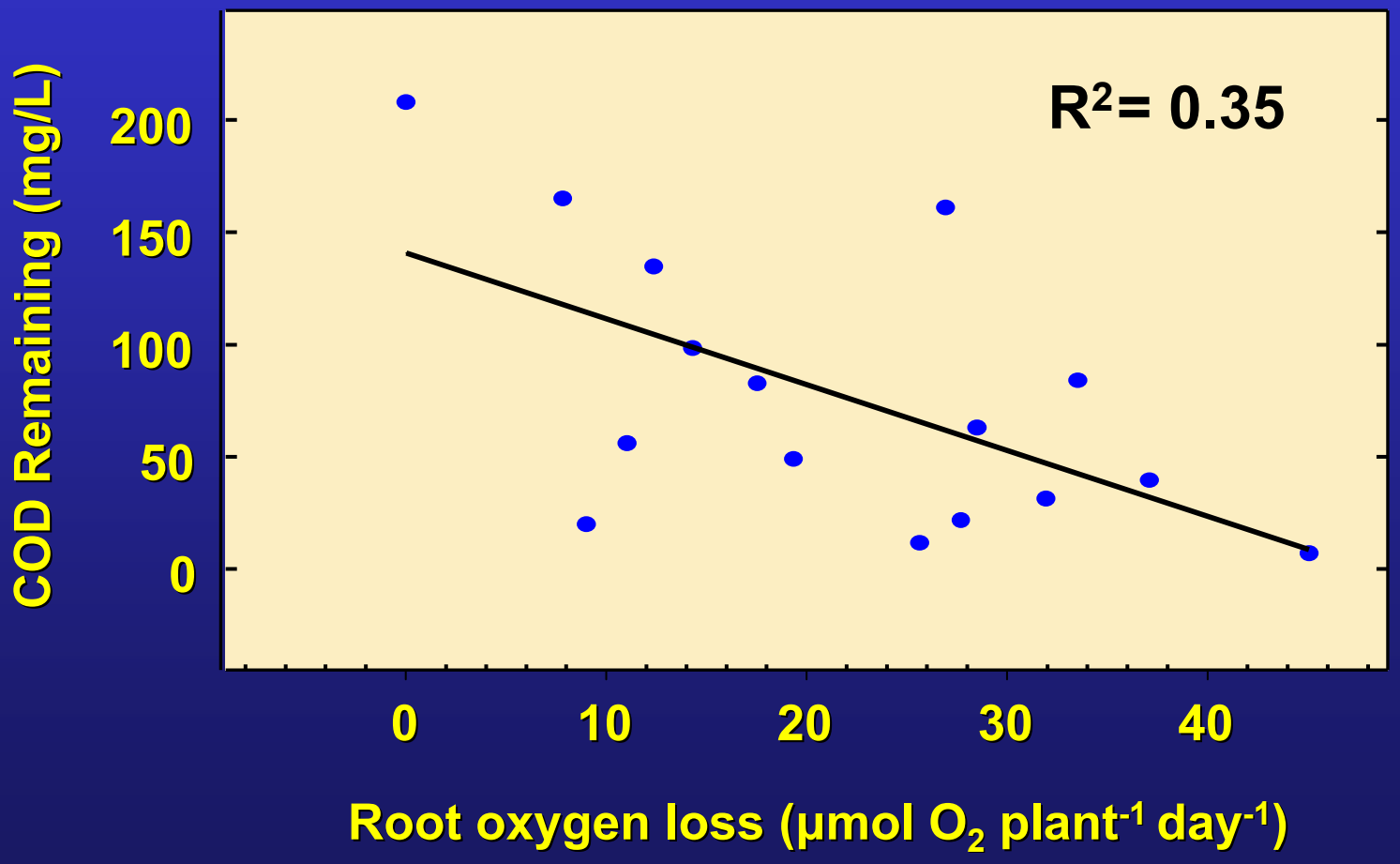


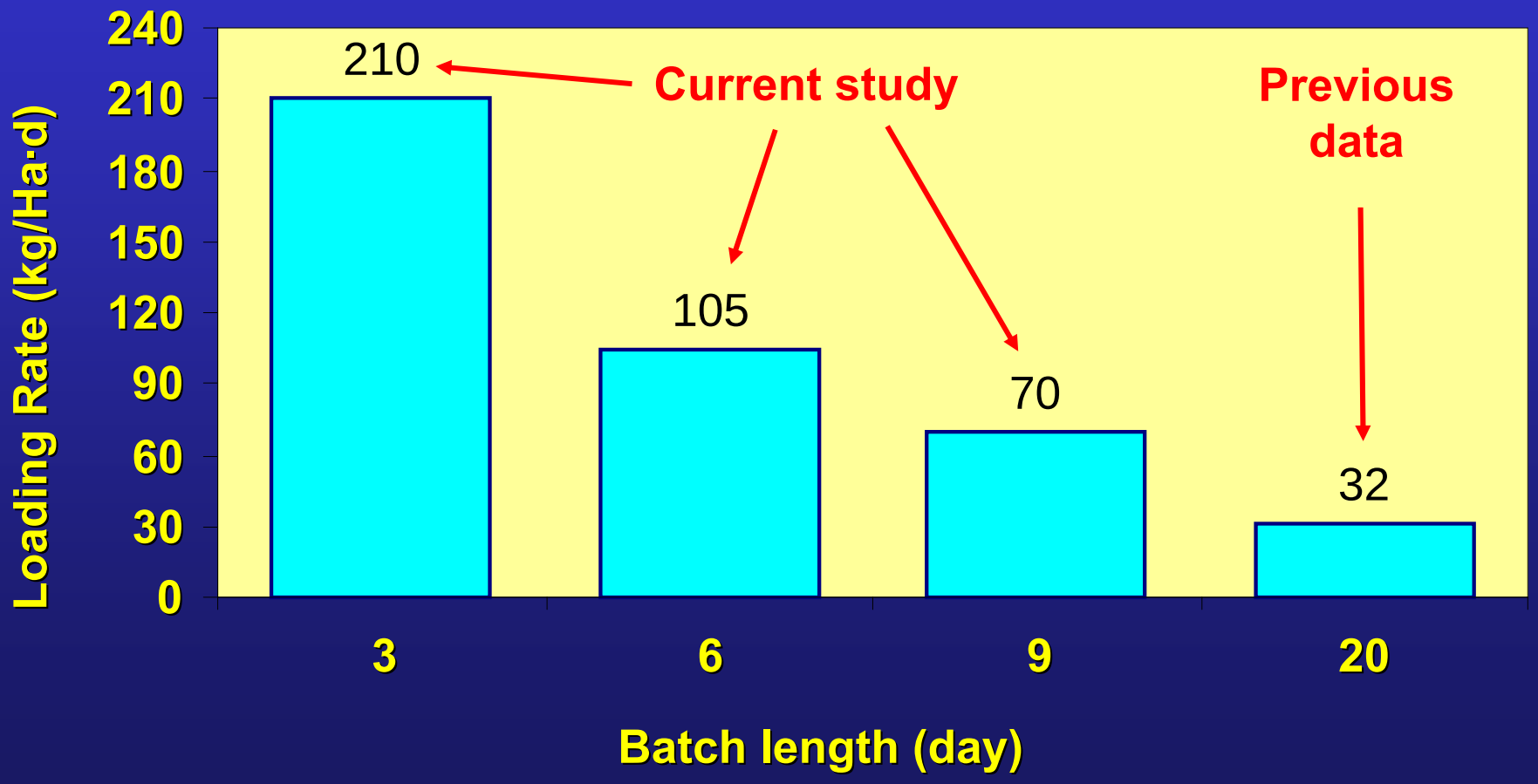
Relation to wetland indicator status



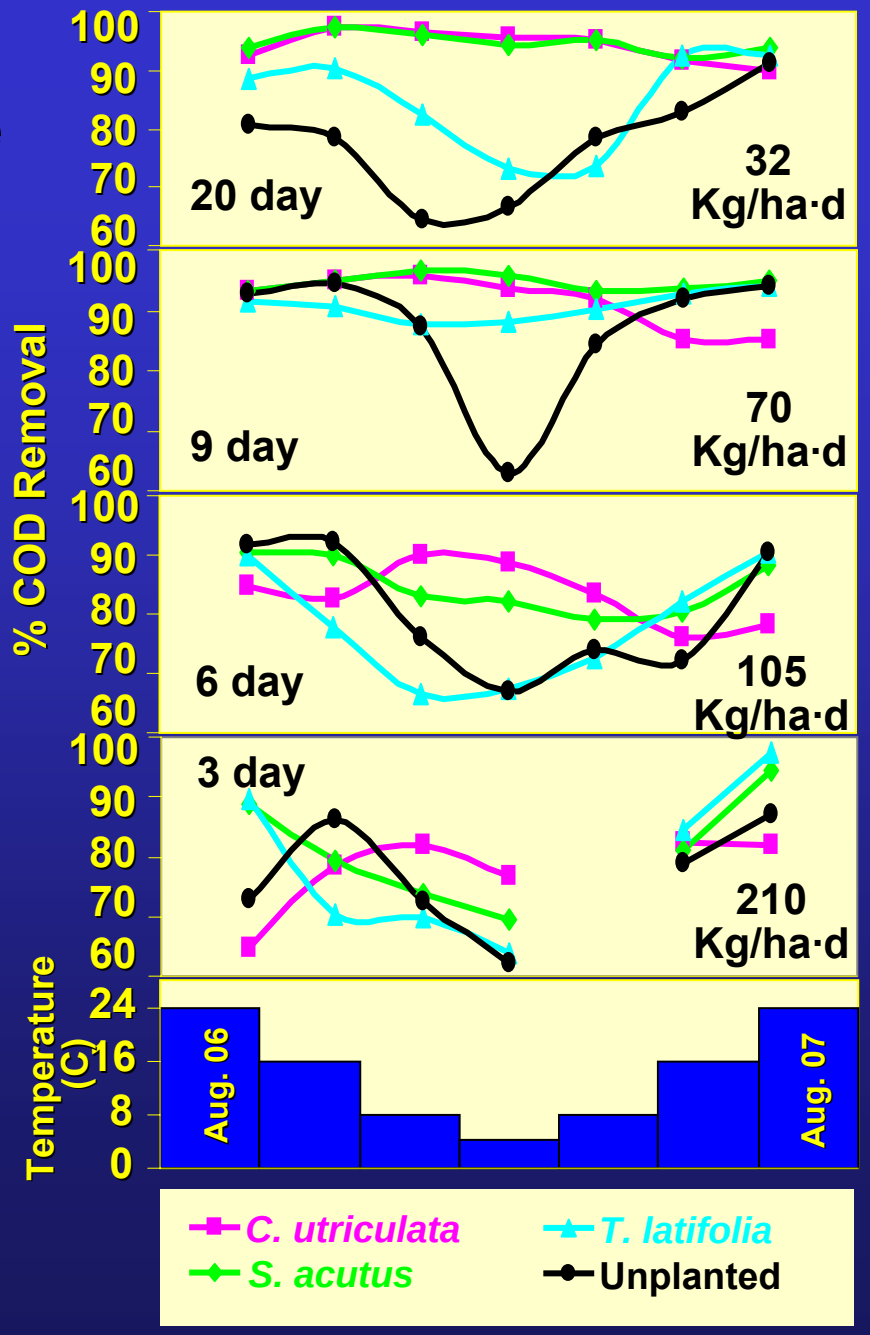
Relationship of 6-day COD removal to *in vitro* root oxygen loss at 4˚C



Effect of batch length and pollutant loading rate

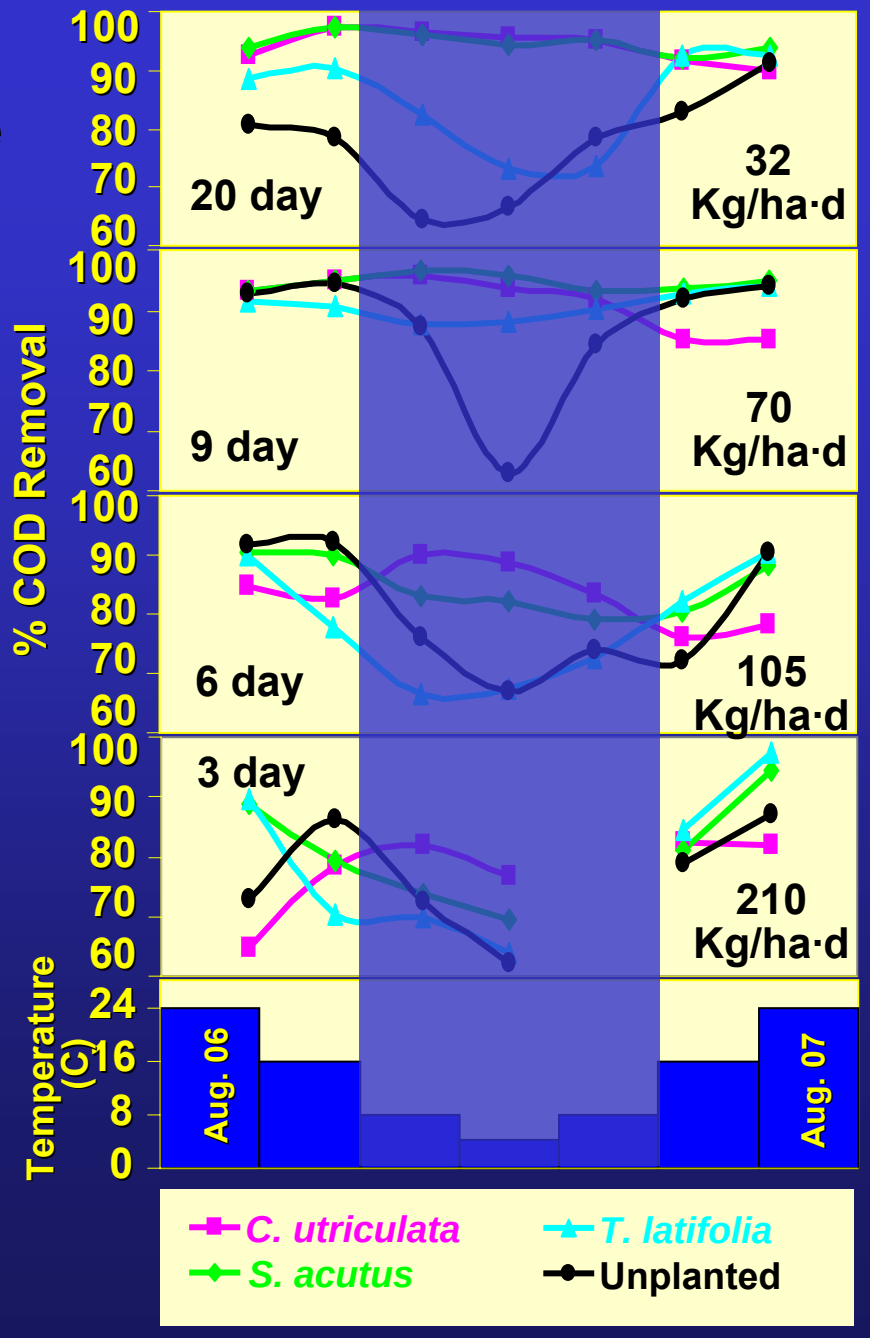


Plants strongly modify effects of loading on seasonal performance



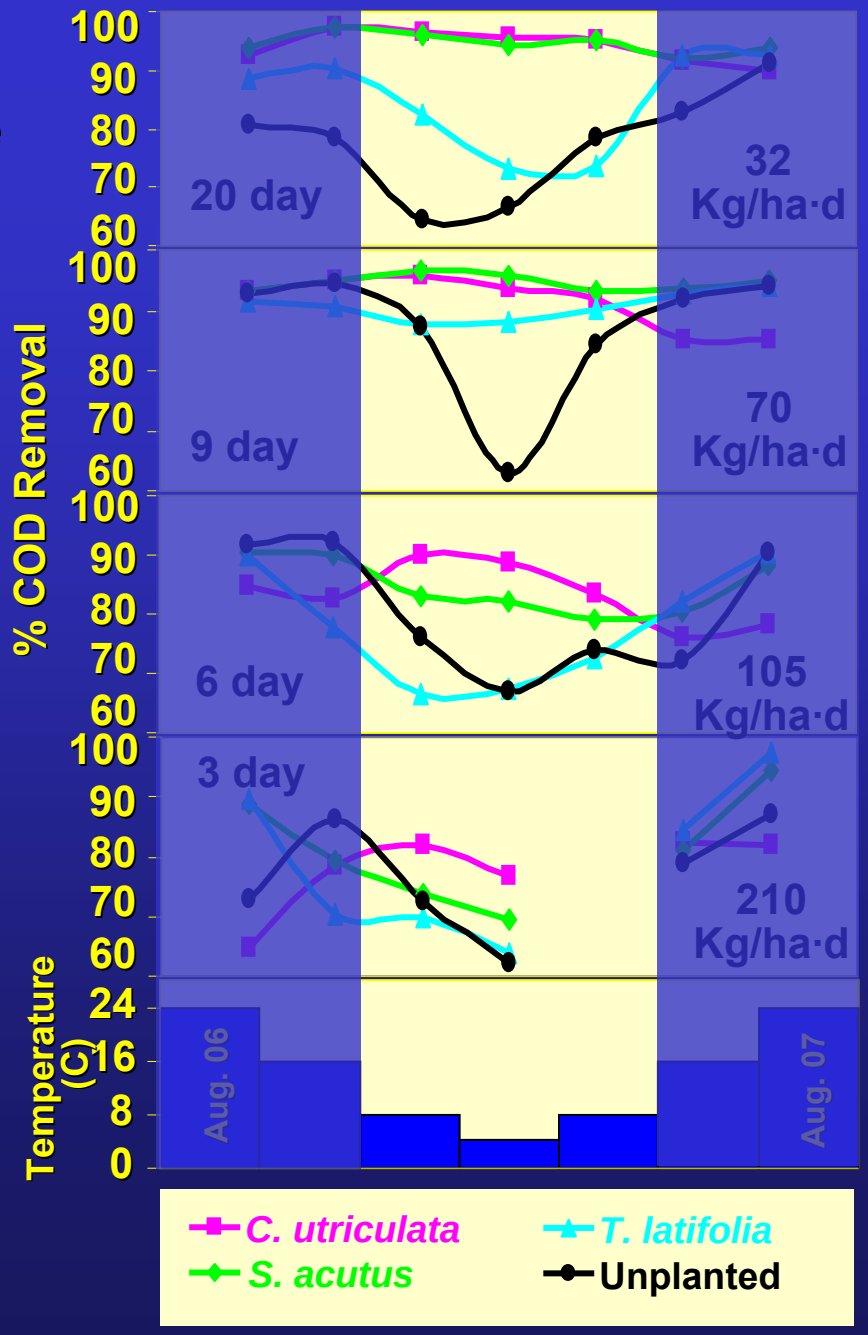
Plants strongly modify effects of loading on seasonal performance

- **Summer**
  - Good performance at all loading rates
  - Little difference due to plants



Plants strongly modify effects of loading on seasonal performance

- **Winter**
  - Poor performance in unplanted controls at all loadings
  - With *Carex* and *Schoenoplectus* reduced performance seen only at high loading rates
  - *Typha* had an intermediate response to loading



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- Plants can offset effects of cold temperatures on constructed wetland performance
- Plants can offset effects elevated COD loading on constructed wetland performance
- Regionally appropriate native plant species can enhance performance, especially in winter
- Results corroborate field studies indicating that constructed wetlands are feasible in cold regions

Impacts and Goals

- ✓ Science and technology

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