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

Paul Hook, Otto Stein, Anne Camper,
Cathy Zabinski, Mark Burr, Warren Jones,
Carrie Taylor, Jennifer Faulwetter, Rickey Schultz

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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

Our focus:

- cold region design and operation
- plant species effects and selection
- optimizing hydraulic operations
- root-zone microbial processes

Greenhouse-scale wetland microcosms

Horizontal flow cells
(continuous loading)

PVC columns
(batch loading)

Summer (above)
and
Winter (right)

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Four seasons

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

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Artificial wastewaters

- domestic
- mineland
- laboratory

Hydraulic operation

- batch loading
- continuous flow
- varied residence time

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Hydraulic operation

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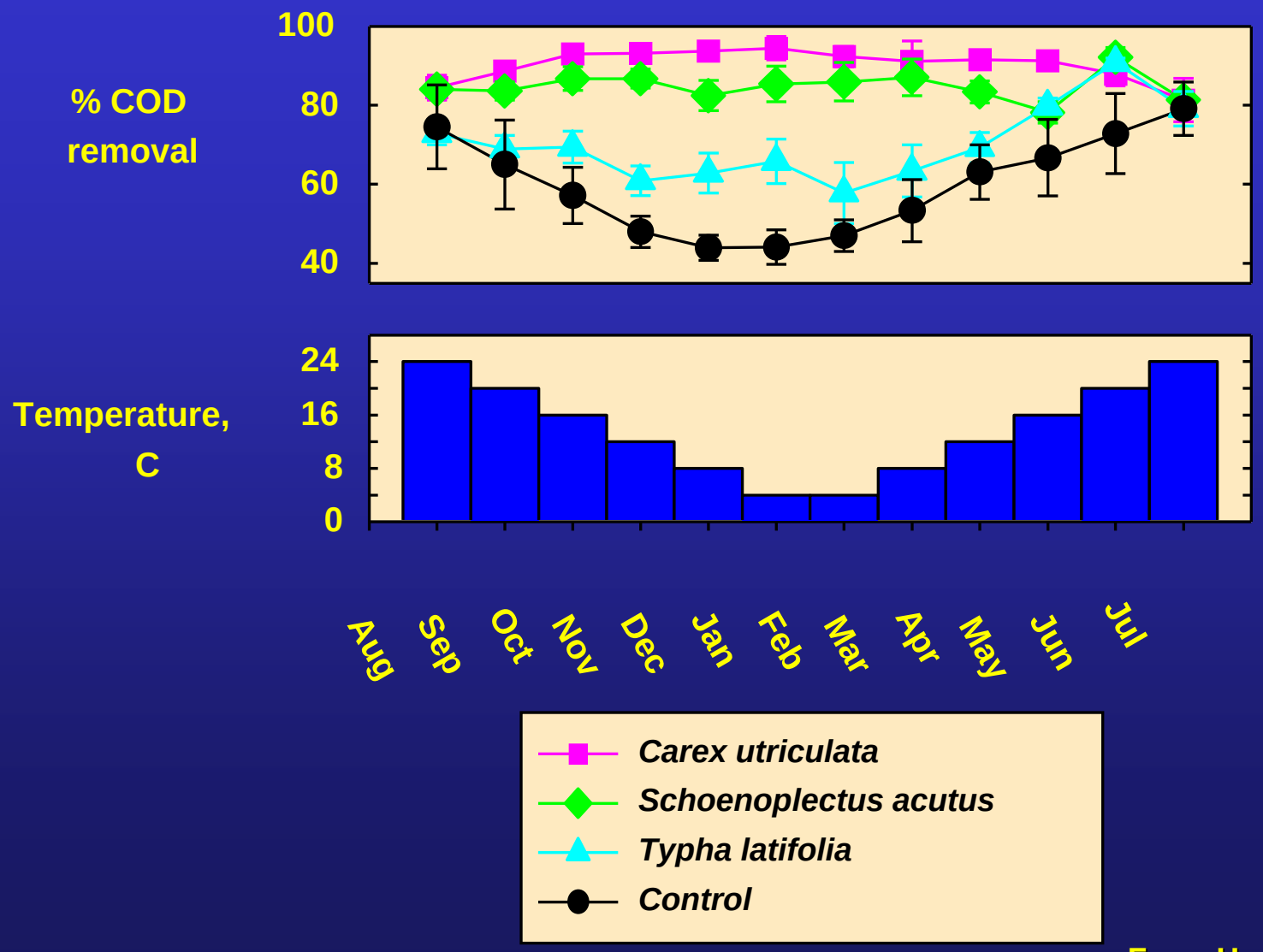
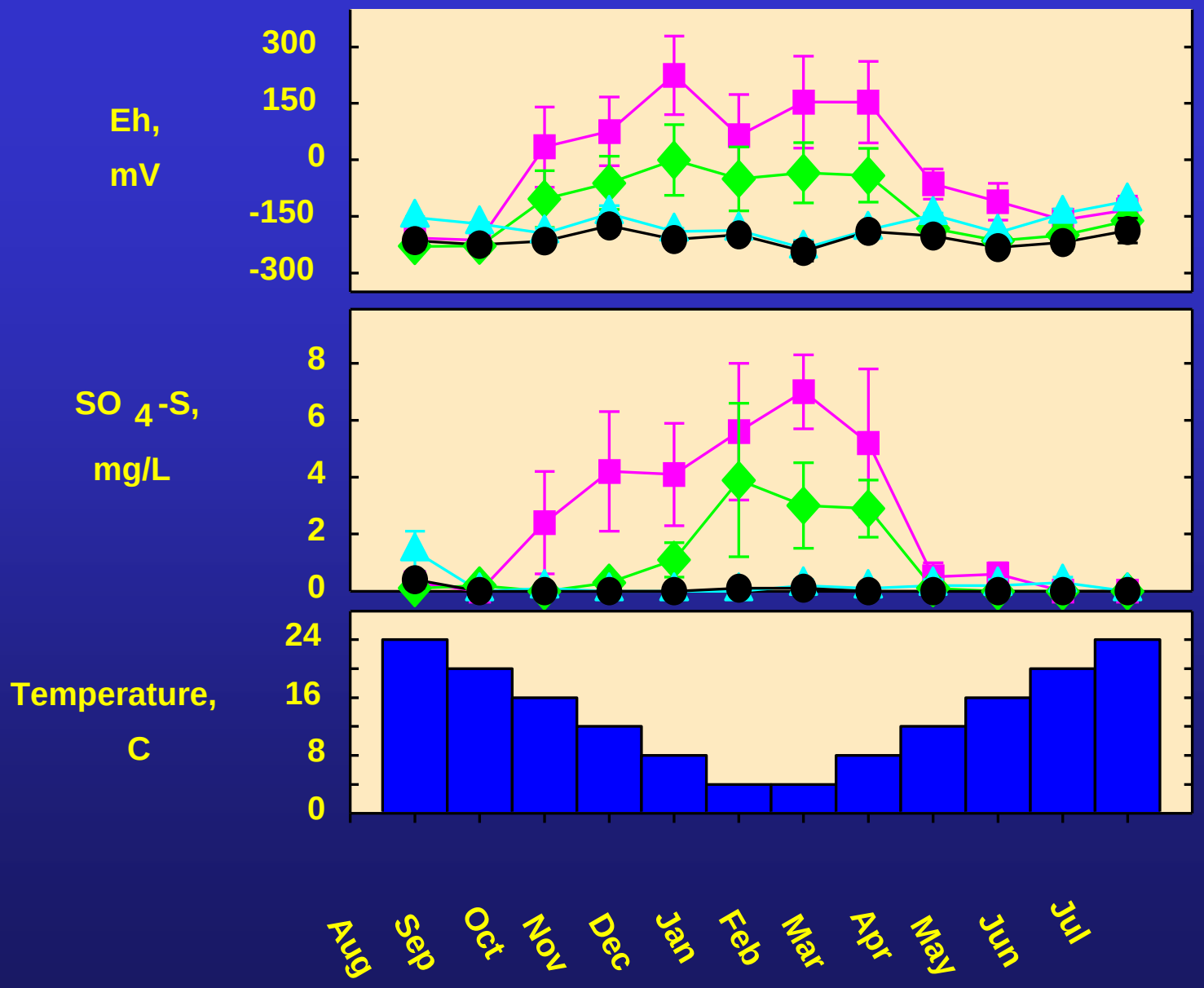
Different plant species

- commonly used
- not widely used

Previous results: simulated domestic wastewater



From Hook et al. 2003



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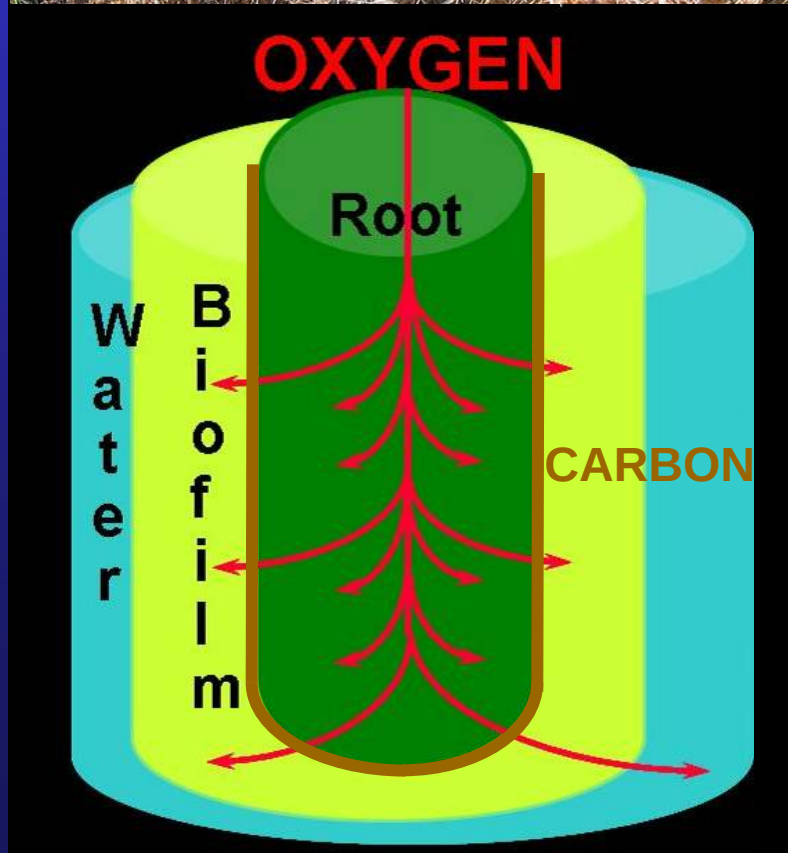
Conclusion

- **Plants strongly modify the effects of cold temperatures on water treatment processes**



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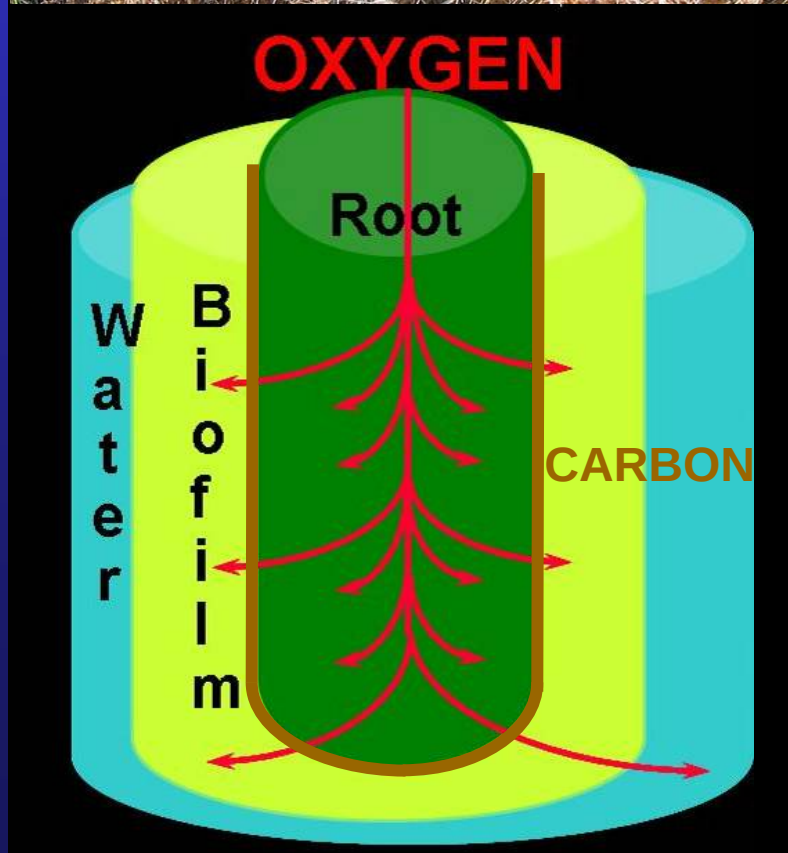
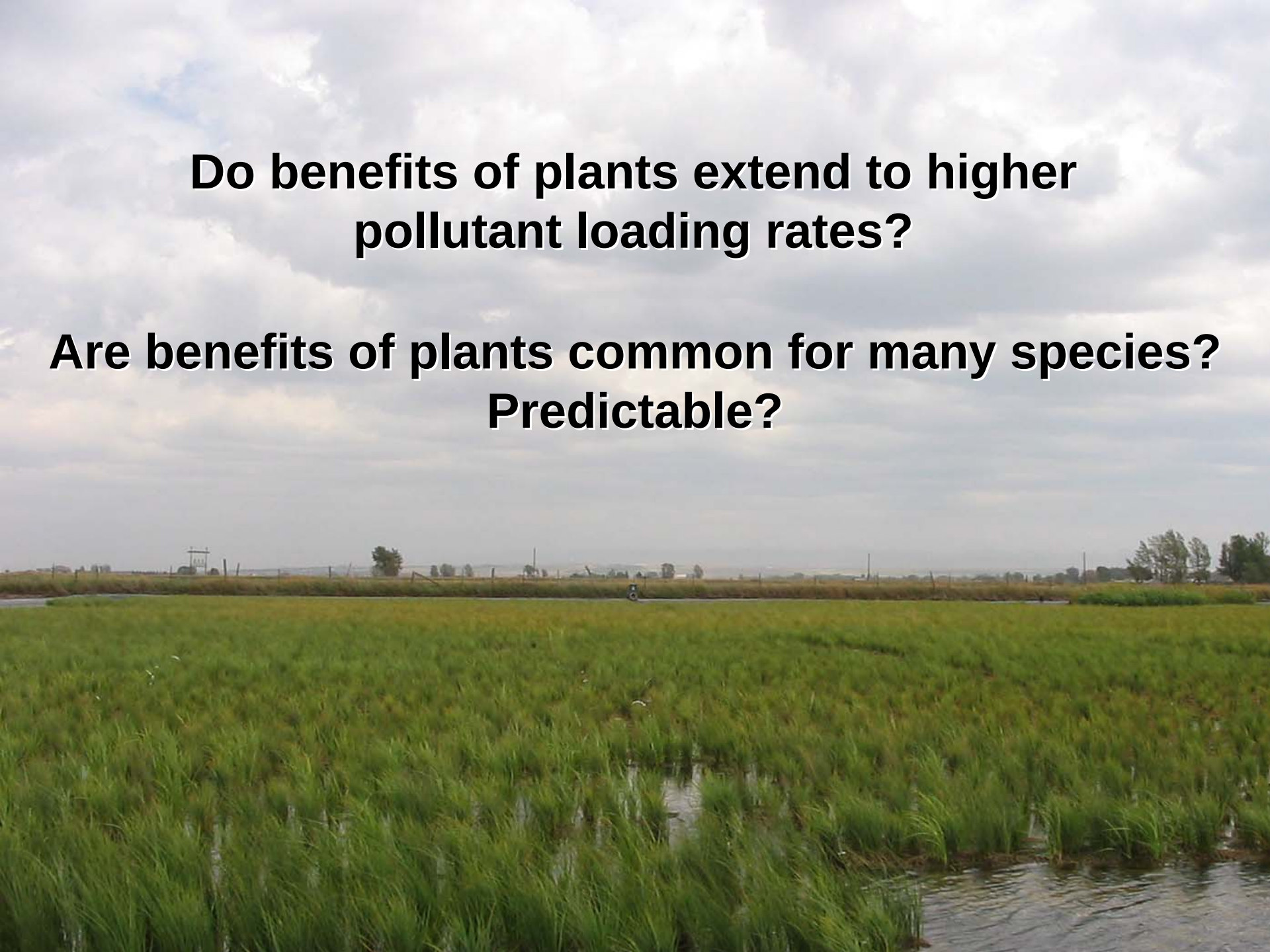
Interpretation

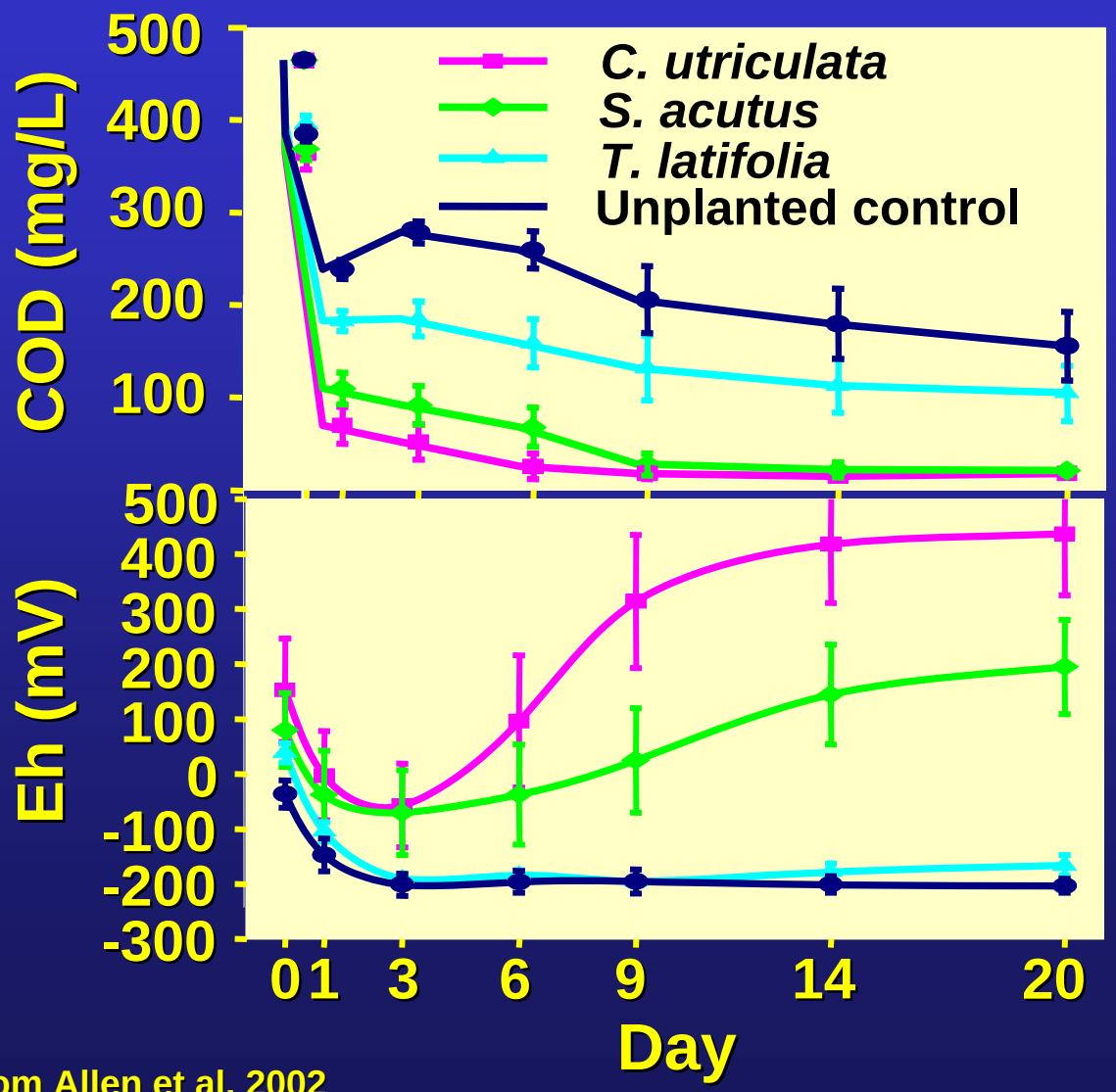
- **Major differences between species likely result from:**
  - oxygen supply at root surface
  - carbon supply at root surface
  - root surface area
  - seasonal growth & physiology



Do benefits of plants extend to higher pollutant loading rates?

Are benefits of plants common for many species? Predictable?



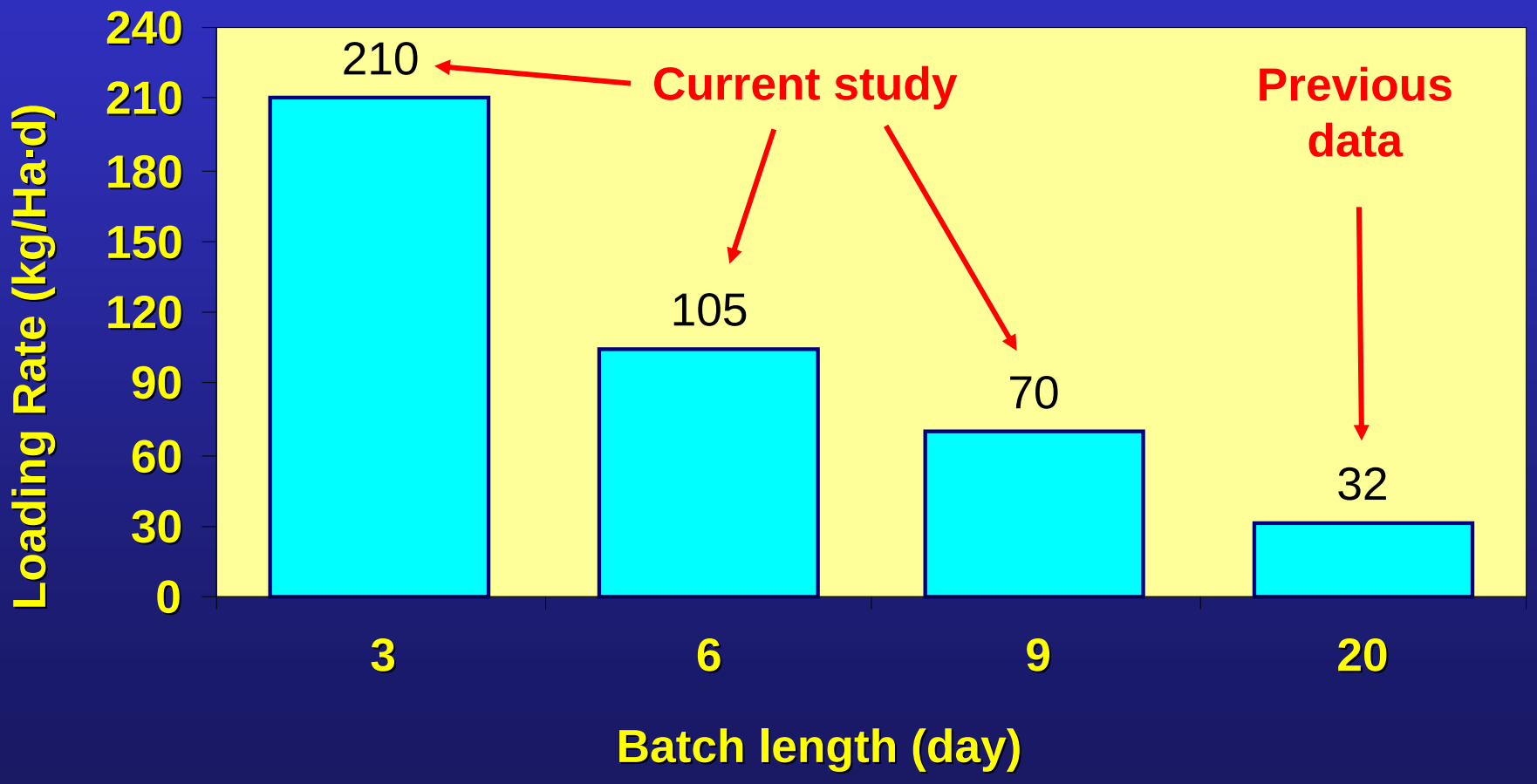


From Allen et al. 2002

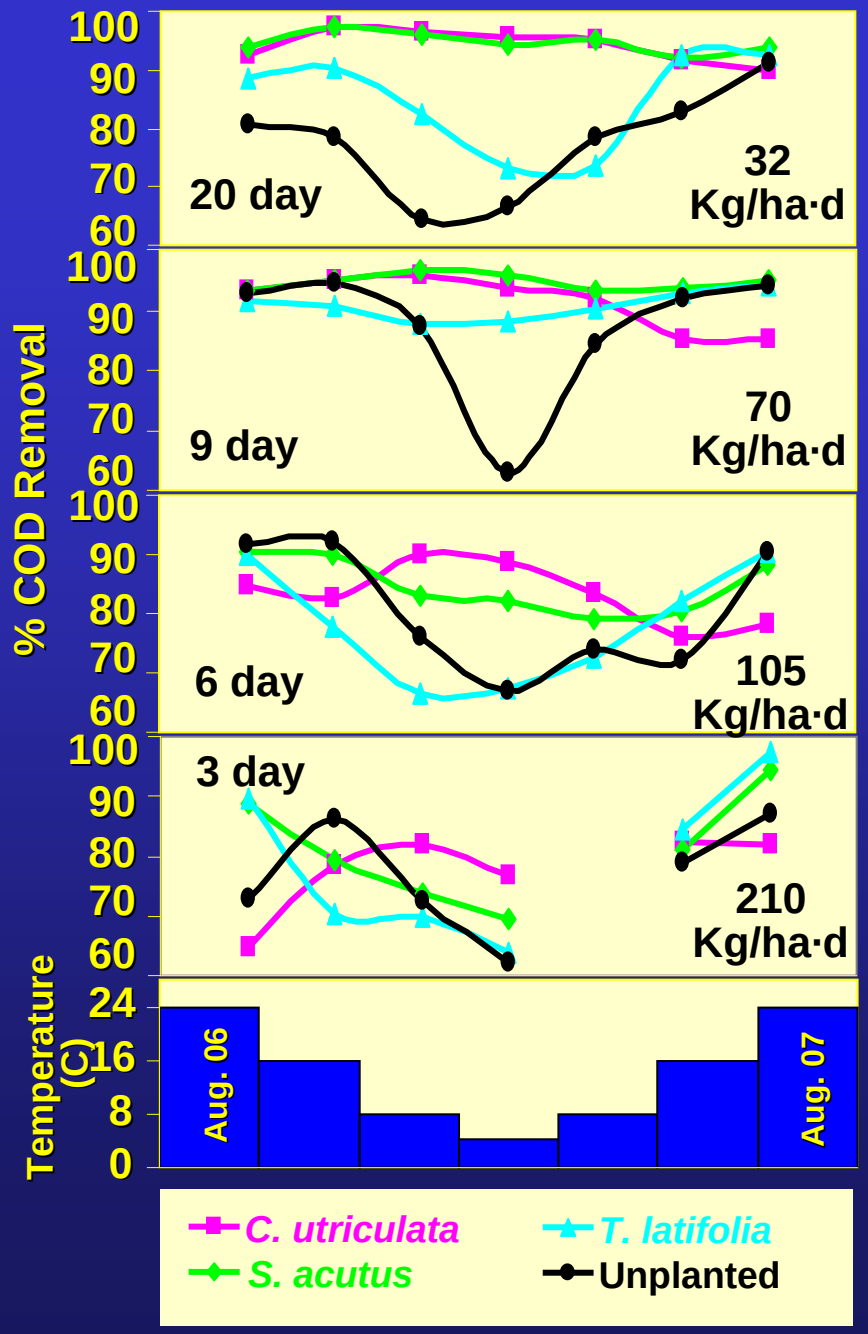
Original study

- Long residence times
- Low time-averaged loading rates

Test of 7-fold range of batch length and pollutant loading rate

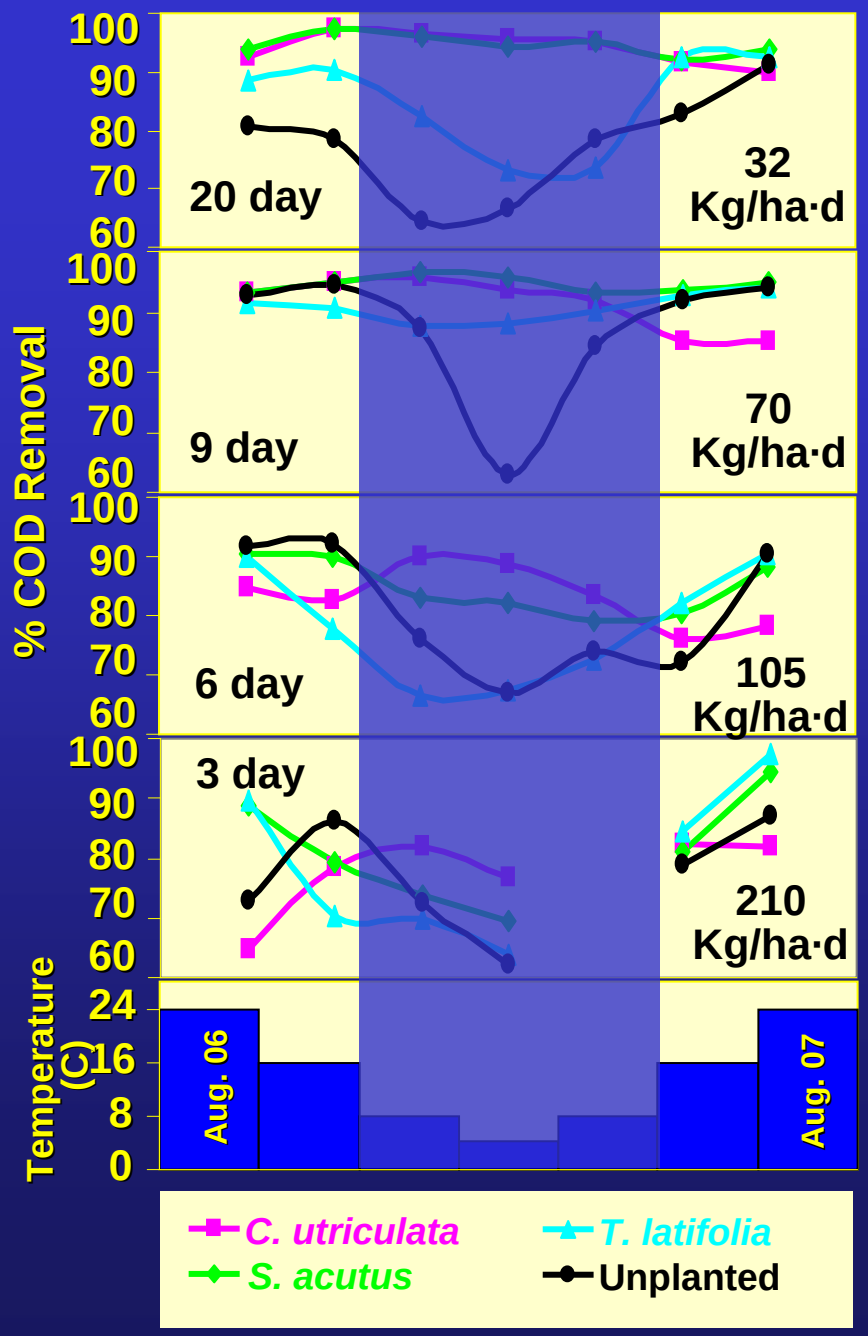


Interaction of COD loading rate, plants, and season



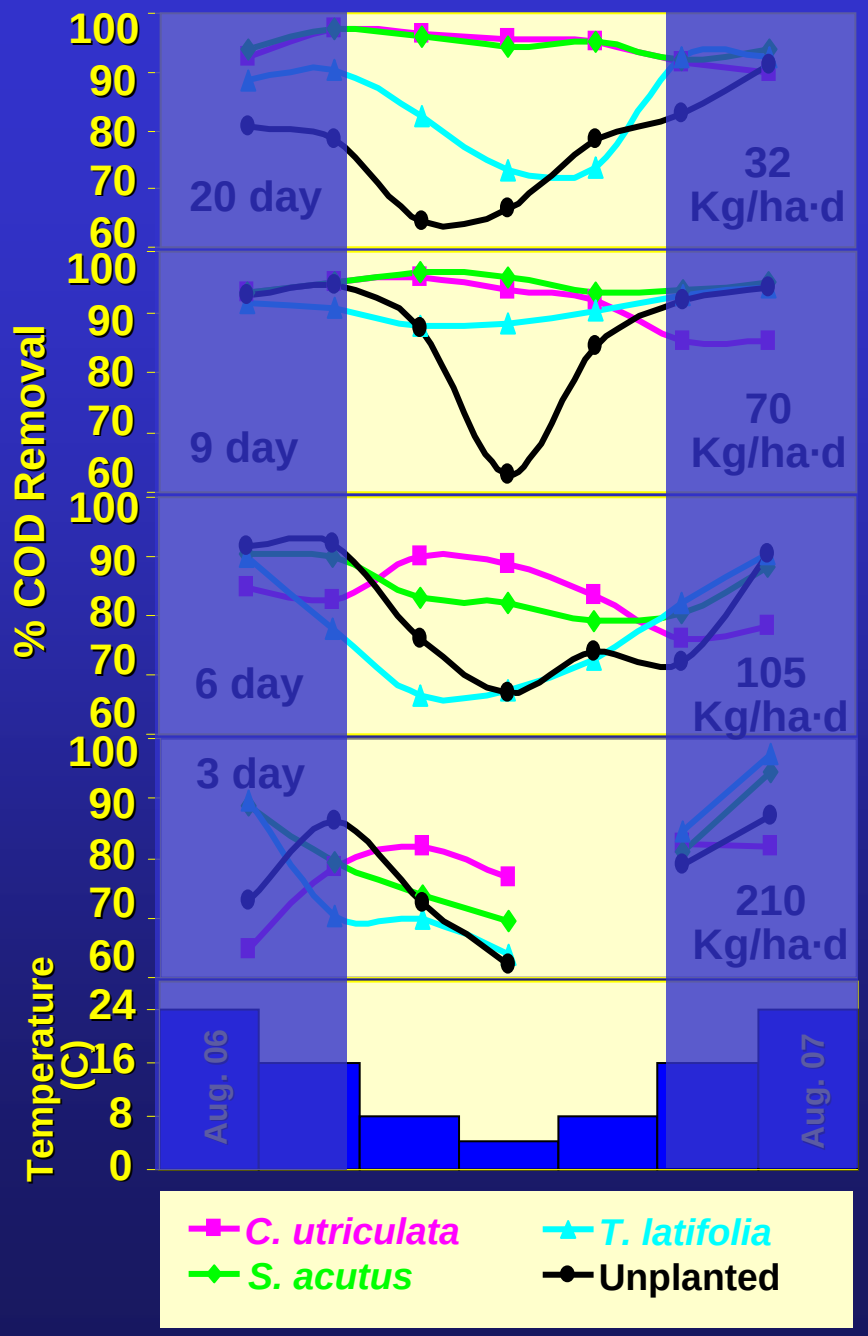
Summer

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



Winter

- Poor performance in unplanted controls at all loadings
- *Carex* and *Schoenoplectus* retain good performance at low & moderate COD loading



Are benefits of plants common? Predictable?

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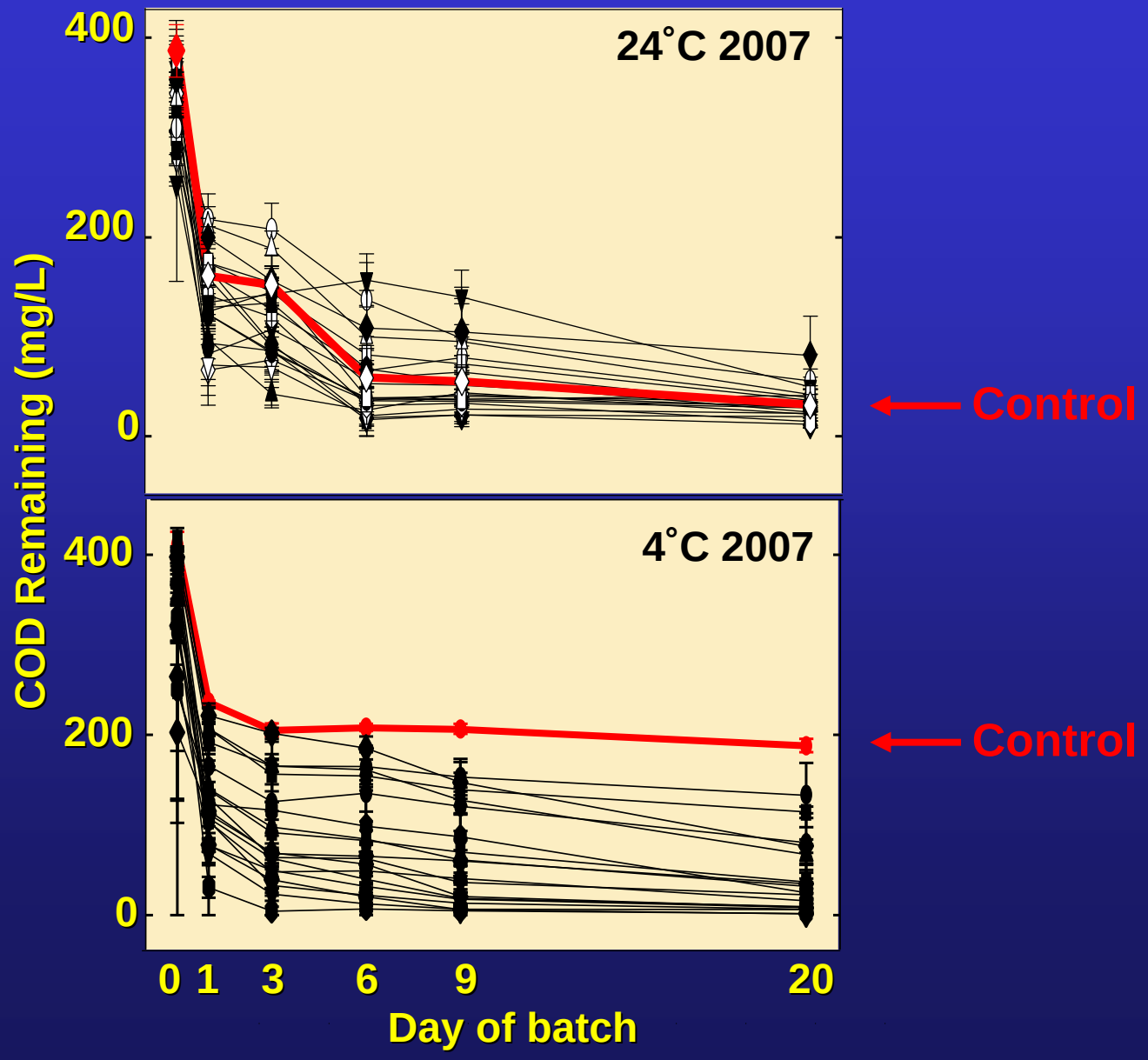
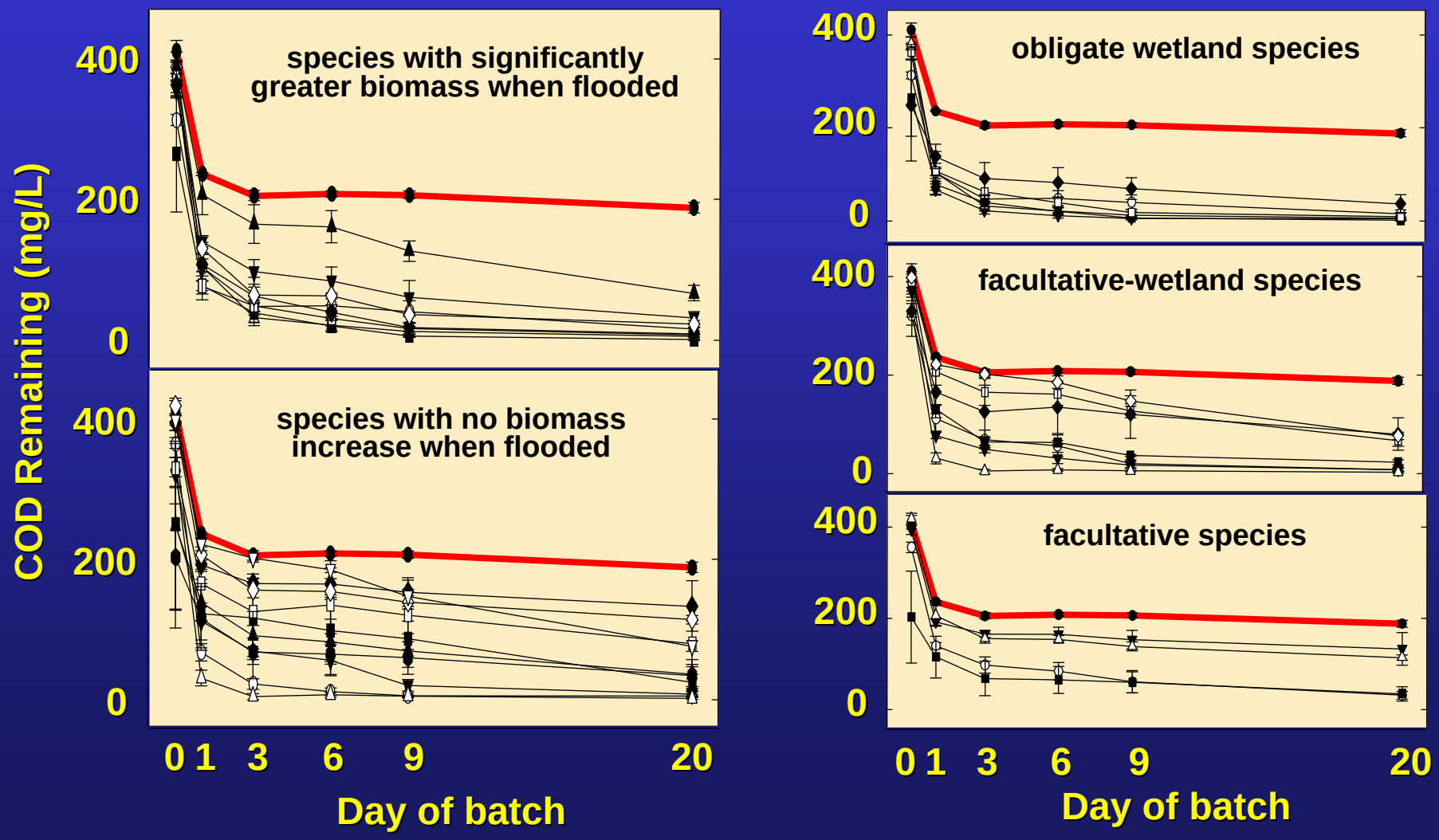
	Species
Obligate	*Typha latifolia*
	Carex utriculata
	Carex aquatilis
	Carex nebrascensis
	Carex bebbii
	Schoenoplectus acutus
Facultative Wetland	*Iris missouriensis*
	Calamagrostis canadensis
	Phalaris arundinacea
	Phragmites australis
	Carex praegracilis
	Juncus balticus
	Juncus torreyi
	Deschampsia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

Most plants enhanced COD removal during winter



Association of winter (4°C) COD removal with easy to determine species traits



Implications

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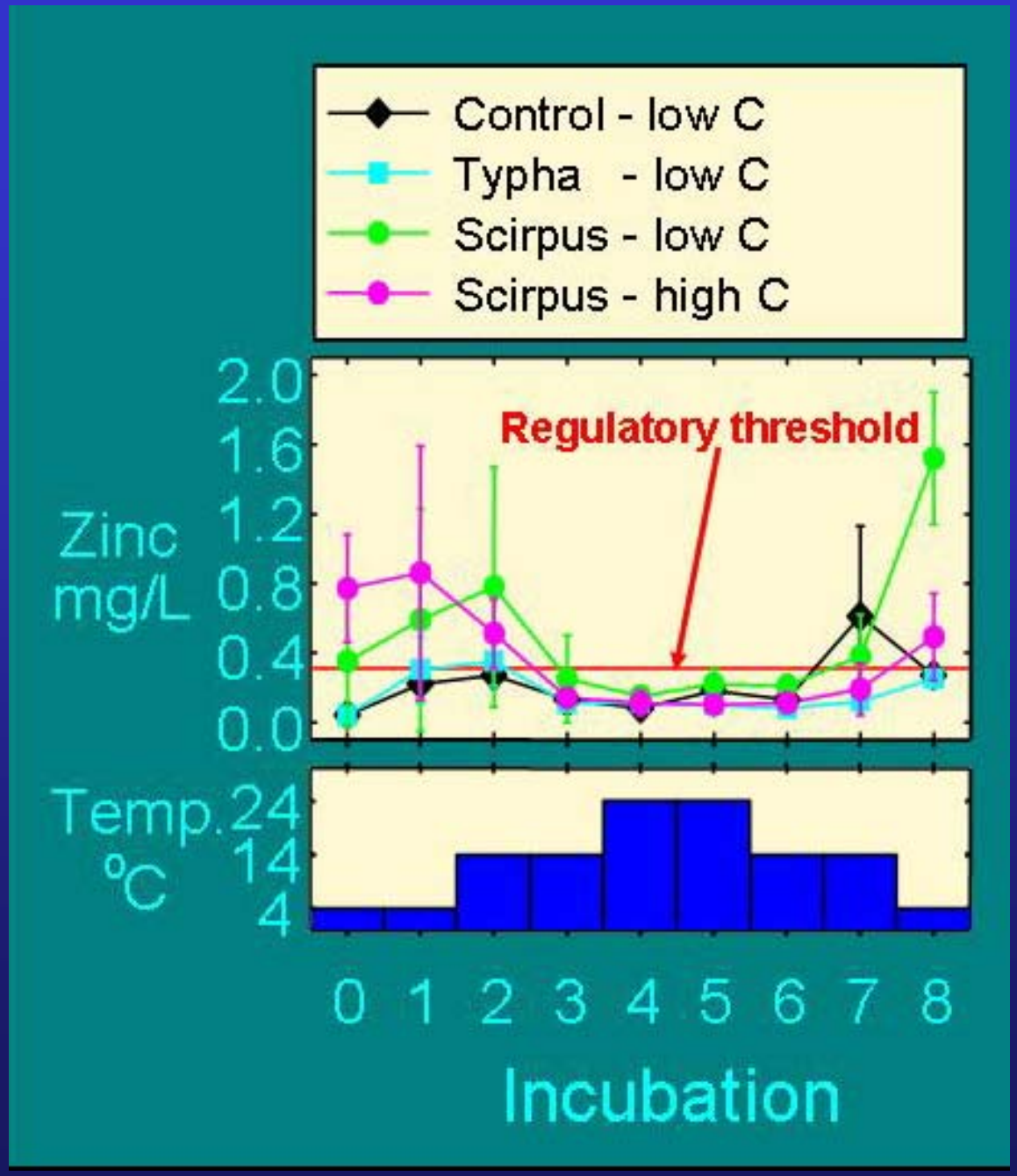
- Plants can offset effects elevated COD loading on constructed wetland performance
- Regionally appropriate native plant species can enhance performance, especially in winter
- Plant traits can help guide plant selection but cannot fully predict wastewater treatment during winter
- Results corroborate field studies indicating that constructed wetlands are feasible year-round in cold regions

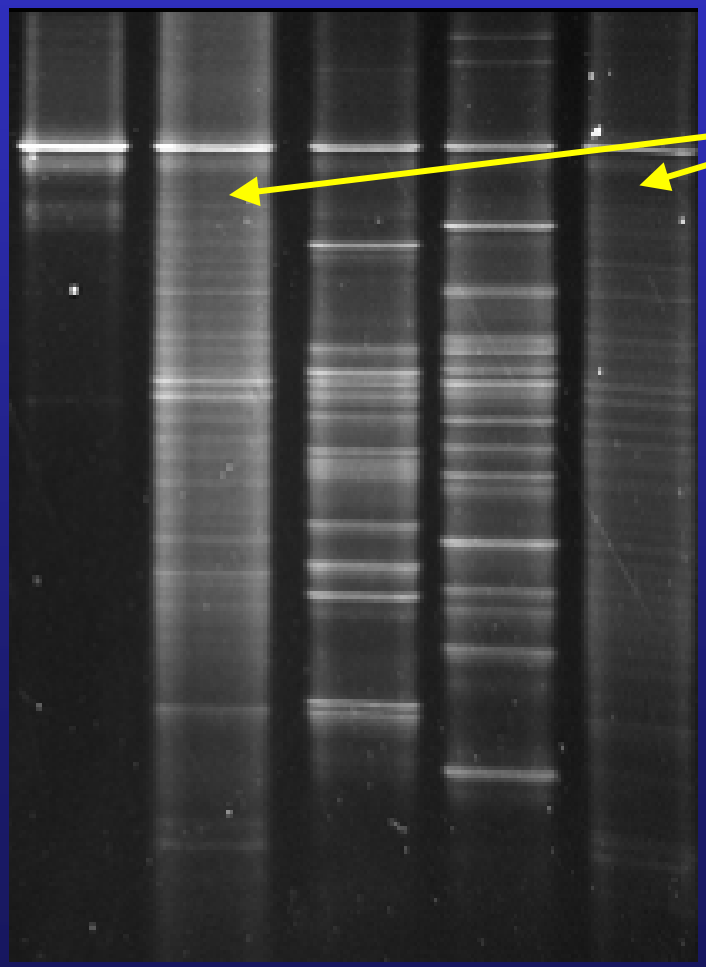
Future goals:

- Scale up experiments to field-scale constructed wetlands
- Achieve regulatory and professional acceptance in northern Rocky Mountain region
- Build operational systems with municipal and private partners

Simulated mineland runoff



PCR analysis of microbial communities: sedge rhizosphere sample



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

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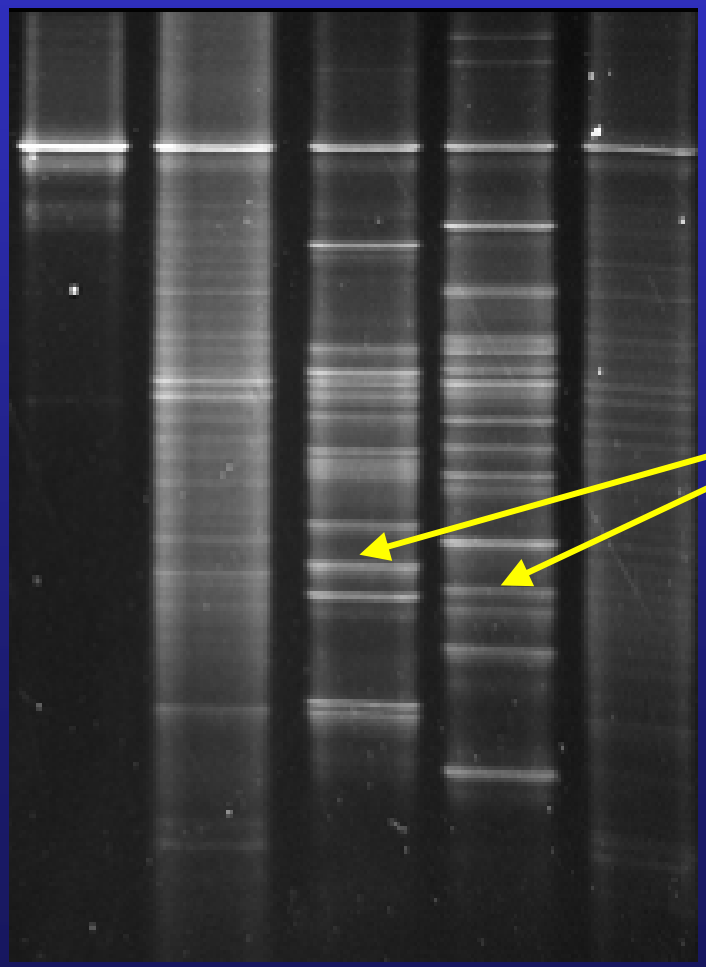
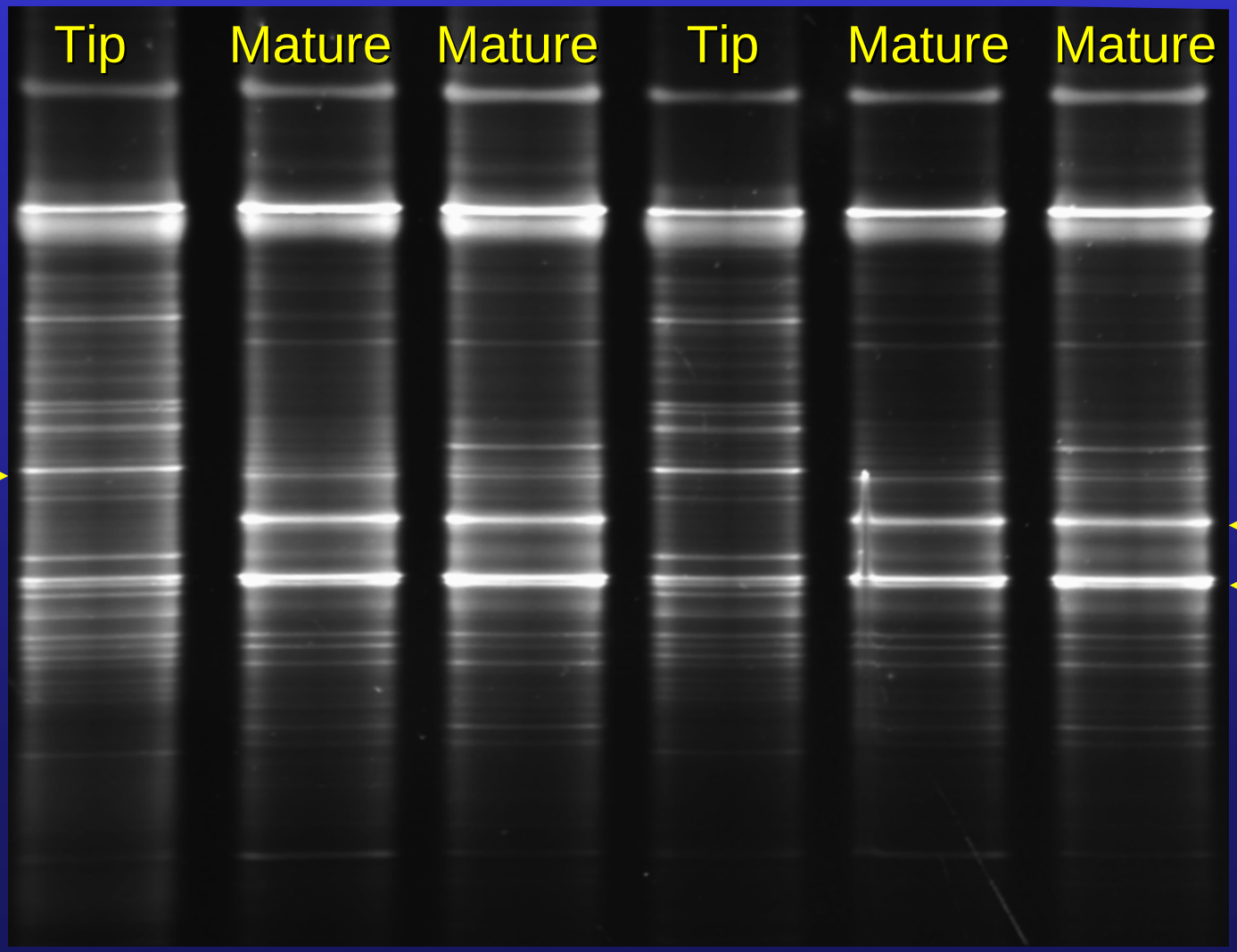
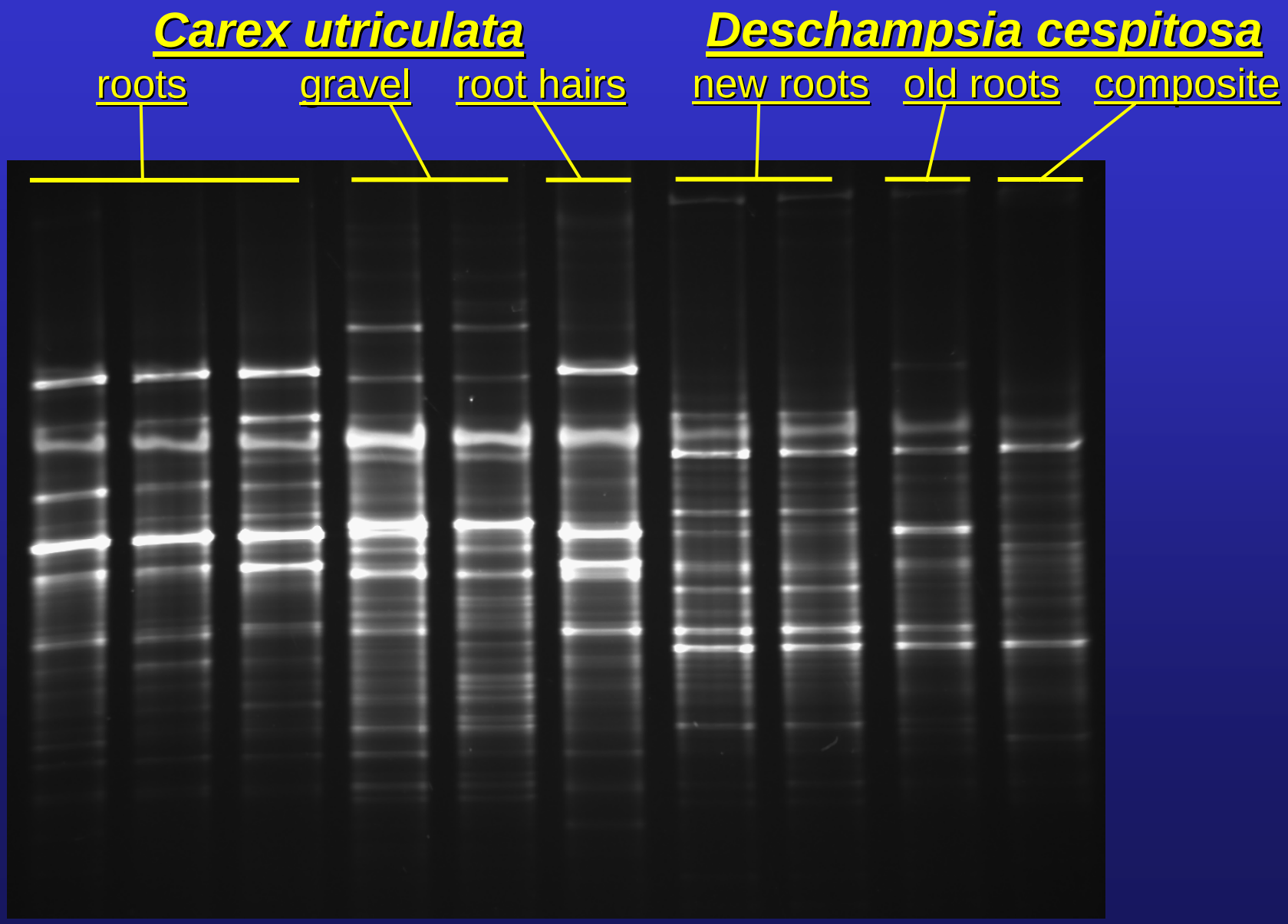


- **Lanes 2 and 3 use DNA cloning to highlight subsets of PCR products**
  - Profiles allow comparison among samples

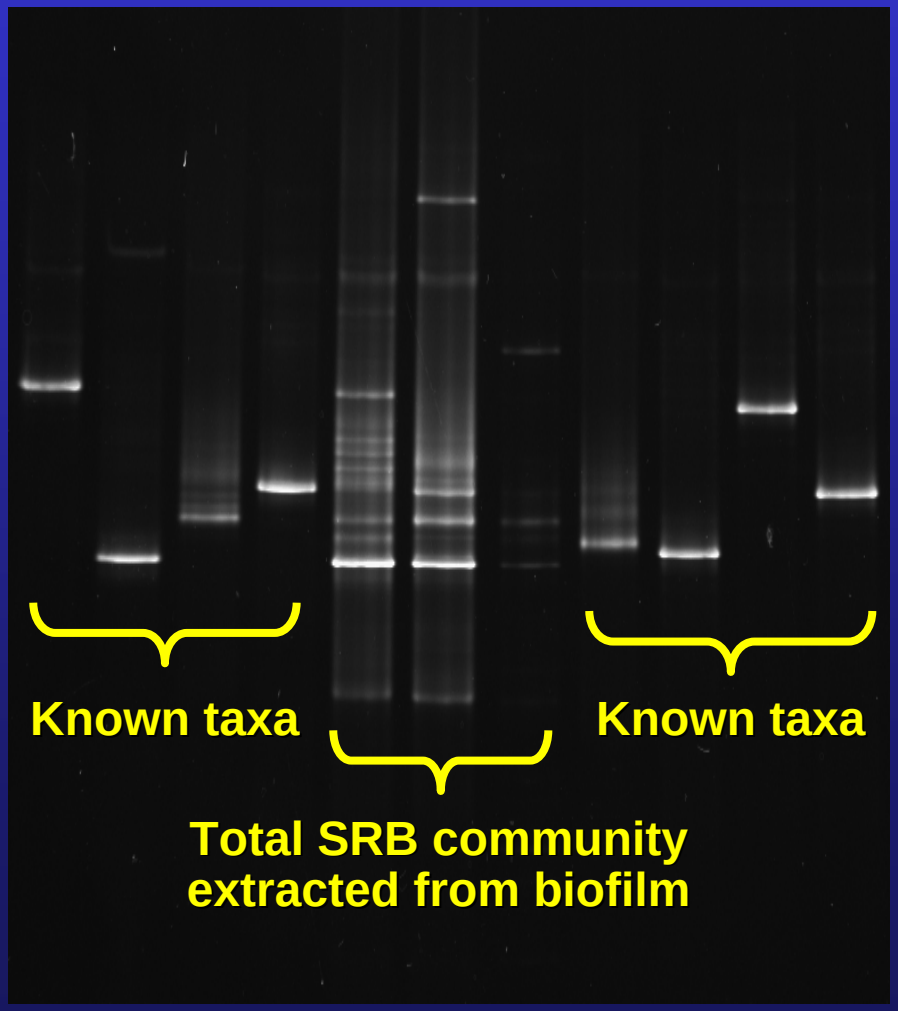
Microbial communities differ between root tips and mature roots of *Carex utriculata*



Substrate and species differences



Functional groups such as sulfate reducing bacteria can be evaluated



Ongoing microbiological research

- Identify specific microorganisms by DNA sequencing
- Analyze RNA to identify active portion of the microbial community
- Correlate wastewater treatment rates with microbial populations and activity
- Compare:
  - Planted vs. unplanted columns
  - Rhizosphere and gravel of different plant species
  - Same plant species in winter and summer