Ecological Impacts of *Phragmites australis*

Invasion & Management Strategies

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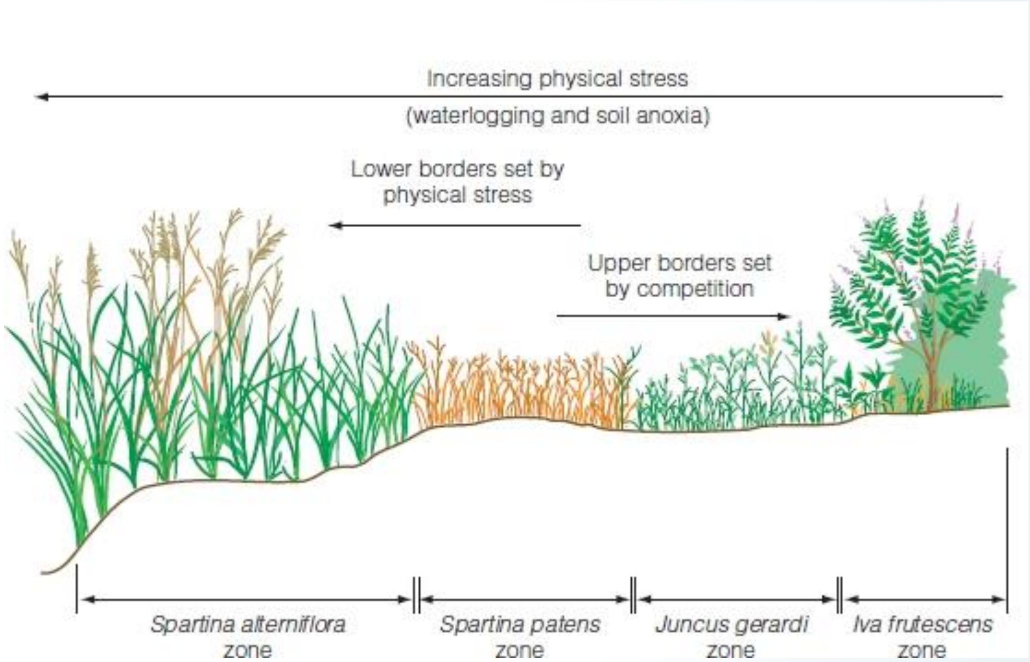
Overview

- Drivers of Invasion
- Habitat Alterations
- Faunal Impacts
- Biogeochemical Cycling
- North Carolina
- Management Impacts

Drivers of Invasion

- Marsh zonation and presence of neighboring plants
- We create a more favorable environment
  - Role of nutrient enrichment
  - Role of development, draining, and ditching
- Dispersal and expansion via sexual & asexual reproduction
- High salinity not a limiting factor



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Habitat Alterations

- *Phragmites* as a habitat "modifier"
  - Soil properties
  - Biomass accumulation
  - Decomposition rates
  - Flow dynamics
  - Influence of age of *Phragmites* stand
  - Captured sediment

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HABITAT ALTERATIONS

Soil Properties

Variables	Raw Data				
	Phragmites		Shortgrass		
	Mean	SD	Mean	SD	p
Aboveground biomass (g m²)	1,868	189.34	199.02	37.97	<0.0001
Salinity (‰)	6.05	1.61	8.22	1.48	0.0090
Depth to water table (cm)	4.14	3.43	−4.24	4.75	0.0006
Microtopographic relief (cm)	0.94	0.77	8.20	2.81	<0.0001
Redox potentials:					
High tide—10 cm	19.00	25.5	−152.9	84.00	<0.0001
High tide—5 cm	33.33	32.83	−166.9	100.46	<0.0001
High tide—5 cm (hummock)	—	—	−76.67	98.07	0.0066
Low tide—10 cm	26.68	52.846	−56.34	54.34	0.0047
Low tide—5 cm	57.43	57.51	−52.55	99.8	0.0096
Low tide—5 cm (hummock)	—	—	−37.06	101.55	0.0273

Windham and Lanthrop Jr. 1999.

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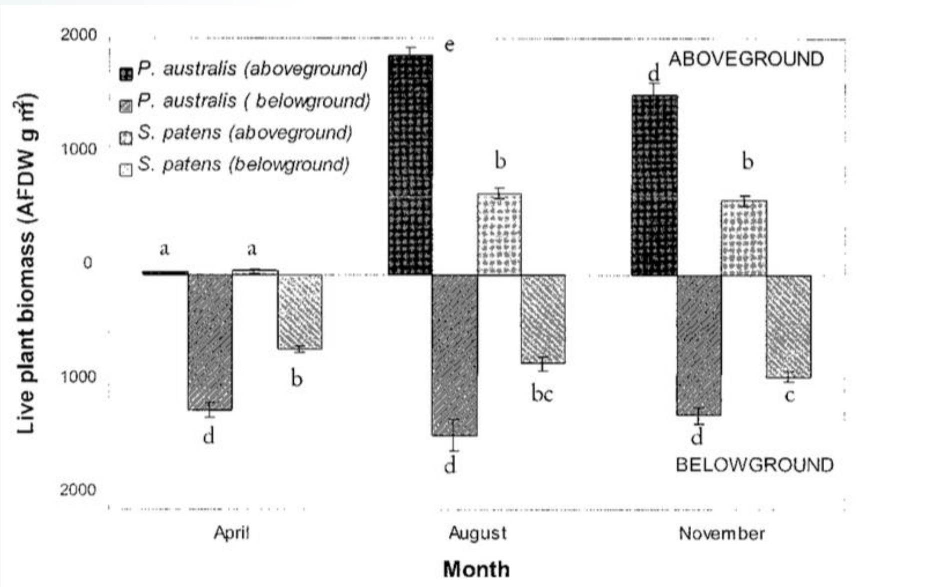
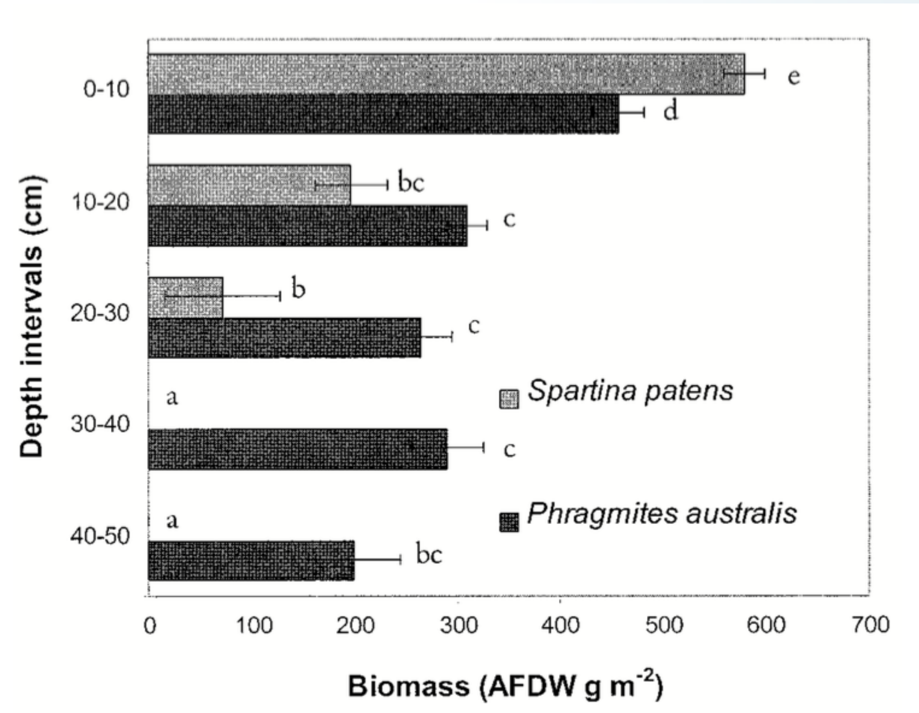
HABITAT
ALTERATIONS

Biomass Allocation



Windham. 2001.



Windham. 2001.

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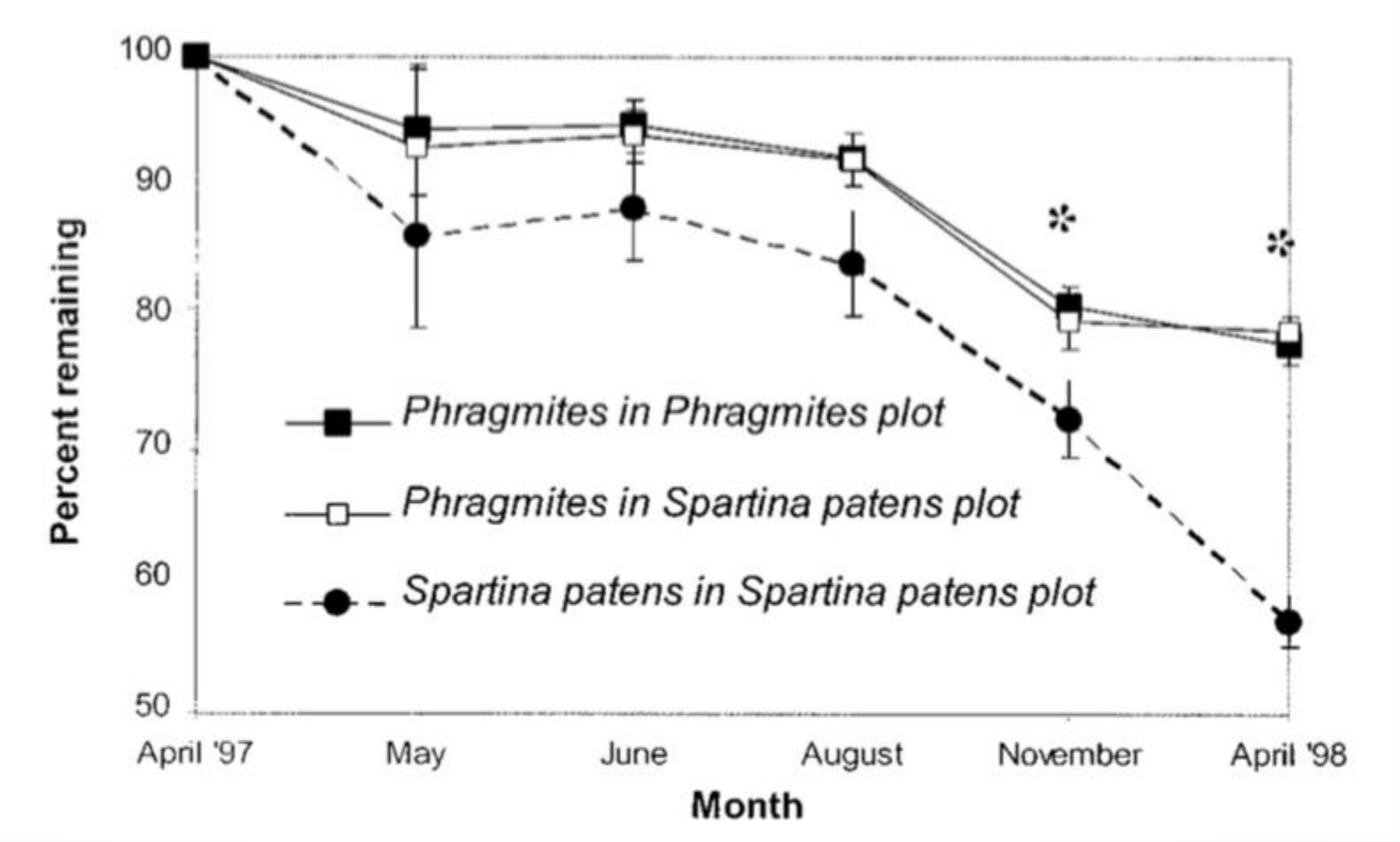
HABITAT
ALTERATIONS

Decomposition



Windham. 2001.

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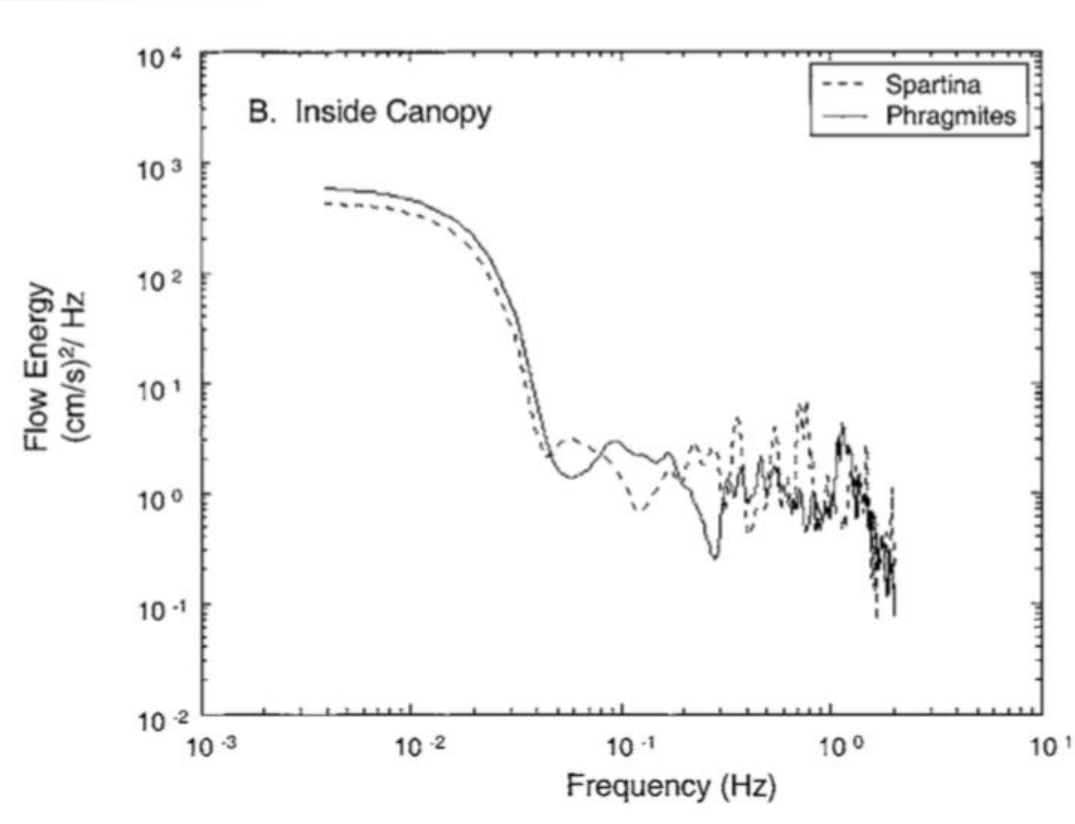
HABITAT ALTERATIONS

Flow Dynamics



Leonard, Wren, and Beavers. 2002.

- Flow speed attenuated in both marsh types
- Mean flow speed <5cm/s for both *Phragmites* and *Spartina*
- Comparable attenuation of flow energy

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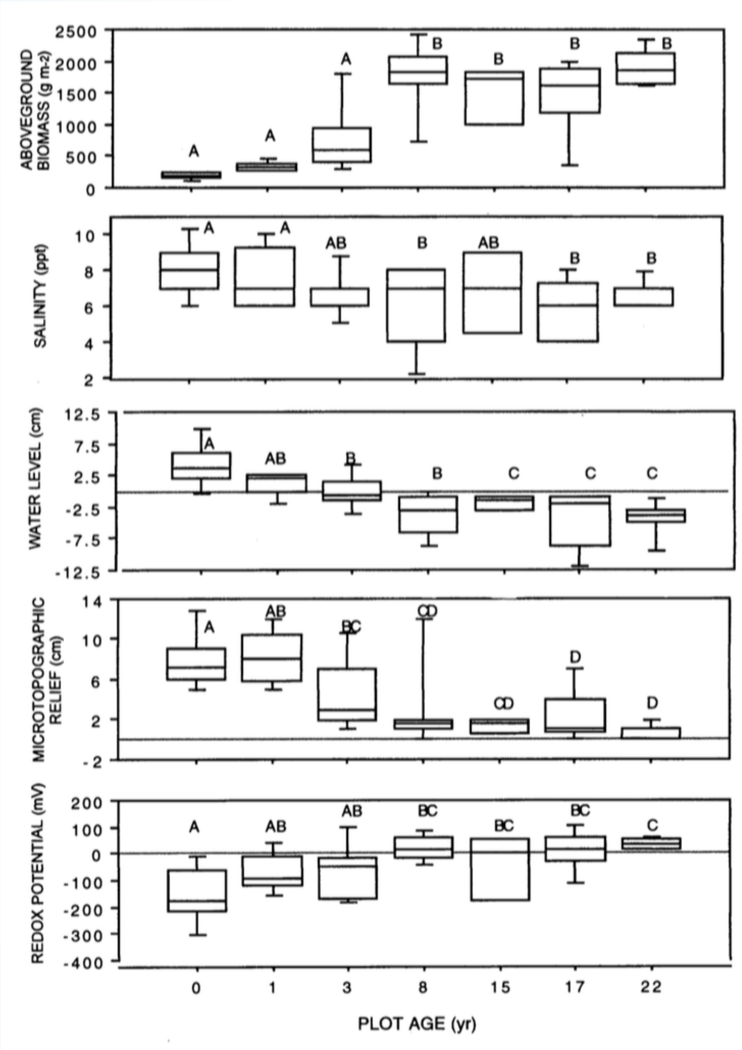
Age of Stand



Windham and Lanthrop Jr. 1999.

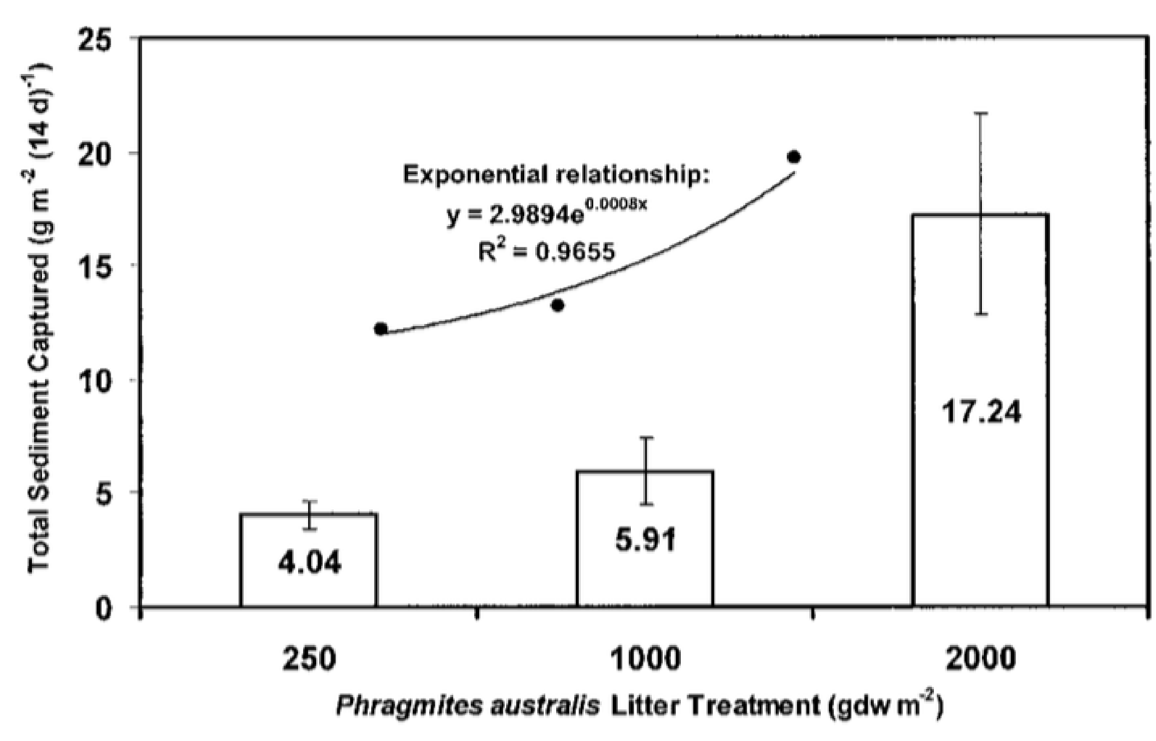
"Edaphic differences between the two communities developed over a relatively short period."

– Windham & Lanthrop Jr. 1999

- Aboveground biomass peaked by yr. 8
- Decrease in salinity stabilized by yr. 8
- Water level stabilized by yr. 15
- Micro-topographic relief stabilized by yr. 8
- Redox potential stabilized by yr. 8

HABITAT ALTERATIONS

Captured Sediment



Rooth, Stevenson, and Cornwell. 2003

"In terms of sediment accumulation, both deteriorating marsh types, coastal eroding and subsiding creek bank, appear to benefit from the presence of high densities of litter in P. australis."

-Rooth & Stevenson 2000

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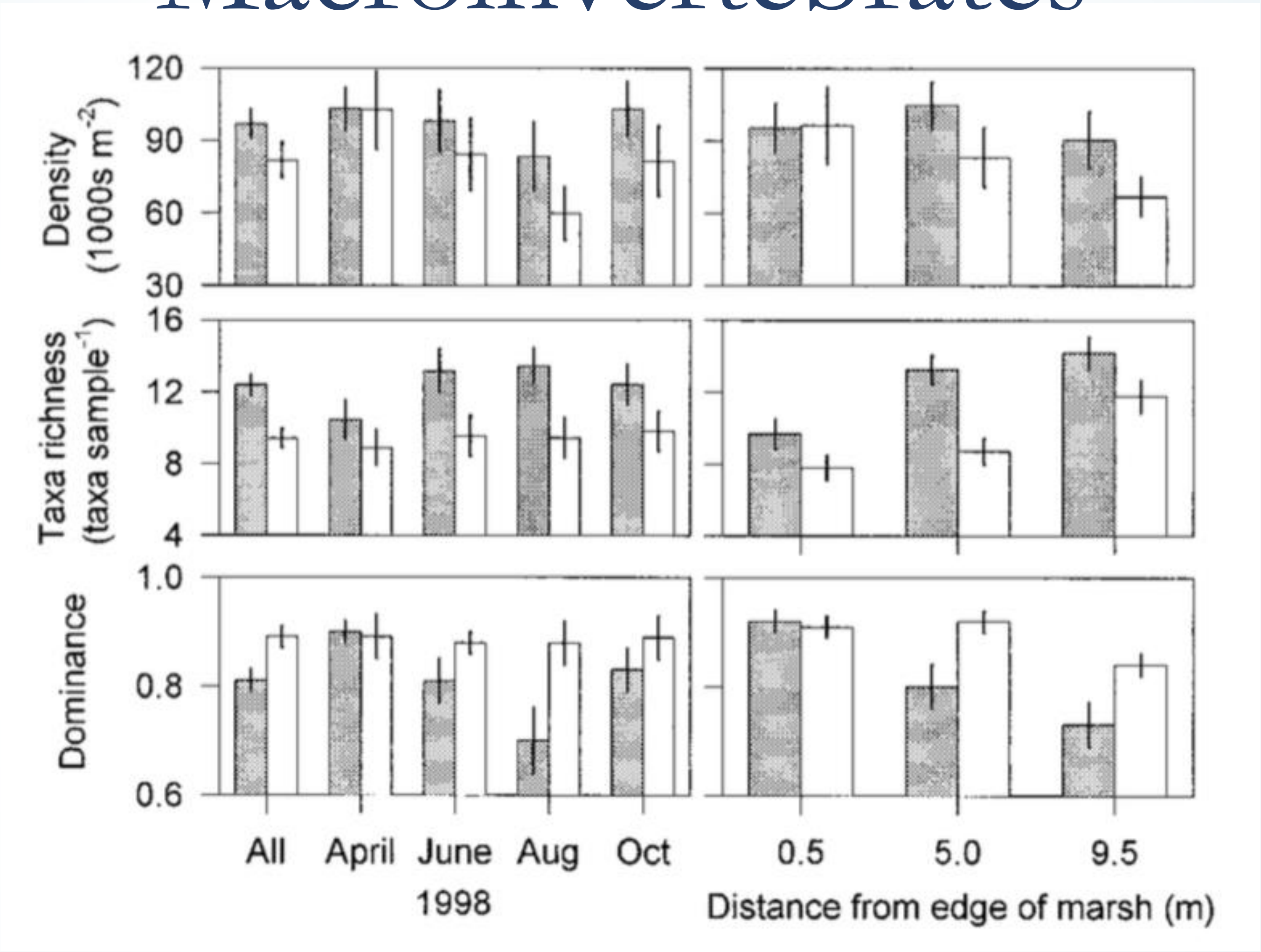
Faunal Impacts

- Physical and biological changes associated with *P. australis* invasion results in impacts to some marsh inhabitants
  - Macroinvertebrates
  - Fish
  - Birds

FAUNAL IMPACTS

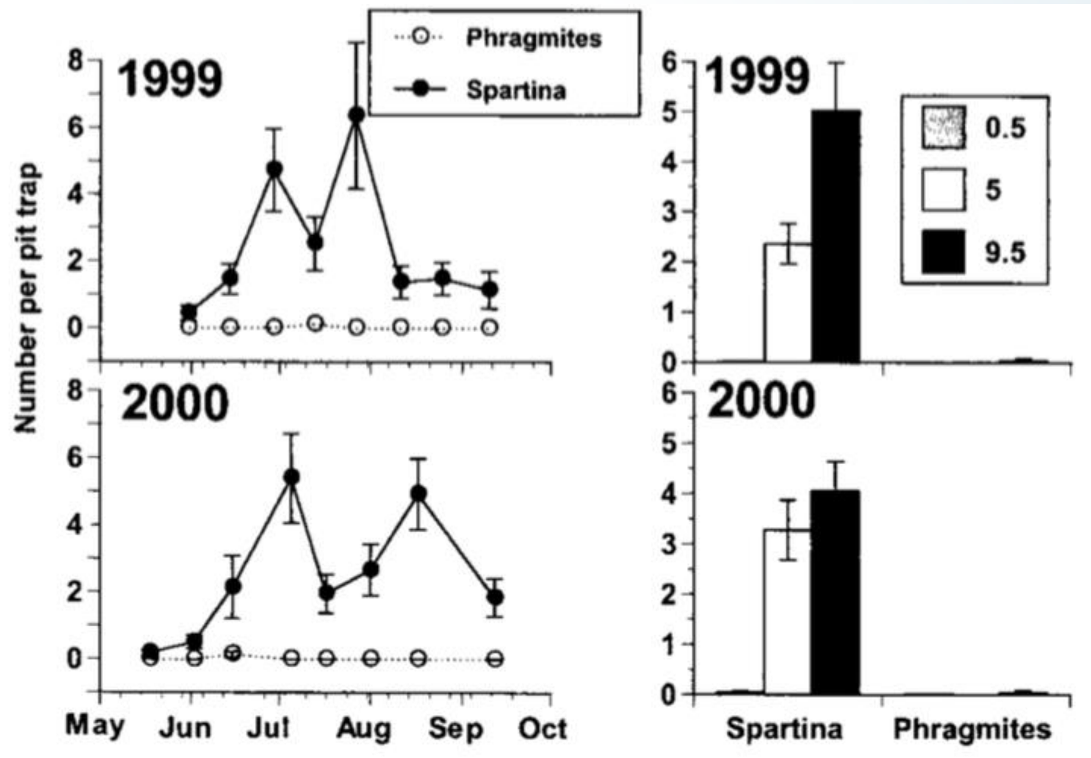
Macroinvertebrates



Angradi, Hagan, and Able. 2001.

Mummichog

- # of eggs per stem did not vary
- Egg density decreased over reproductive season in *Phragmites*
- Higher proportion of unfertilized eggs in *Phragmites*
- Fish use & *F. heteroclitus* abundance significantly higher in Spartina



Able and Hagan. 2003.

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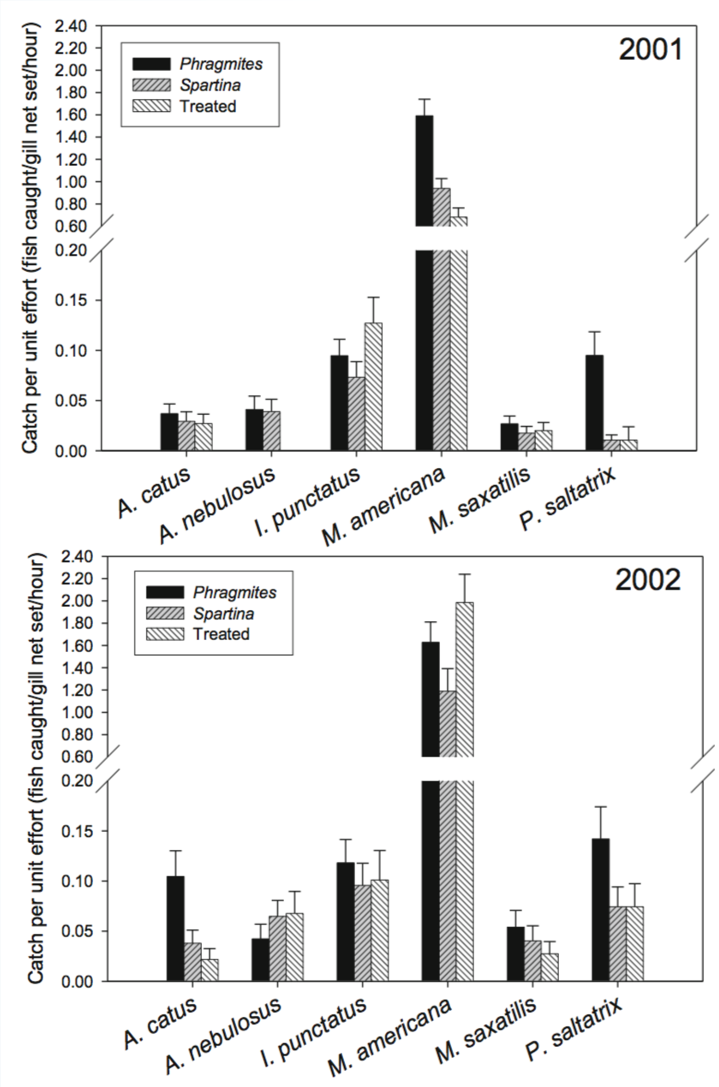
FAUNAL IMPACTS

Predatory Fish



Jones and Able. 2014.

- No significant difference in fish size
- Little consistency in fish abundance
- White perch was most dominant species

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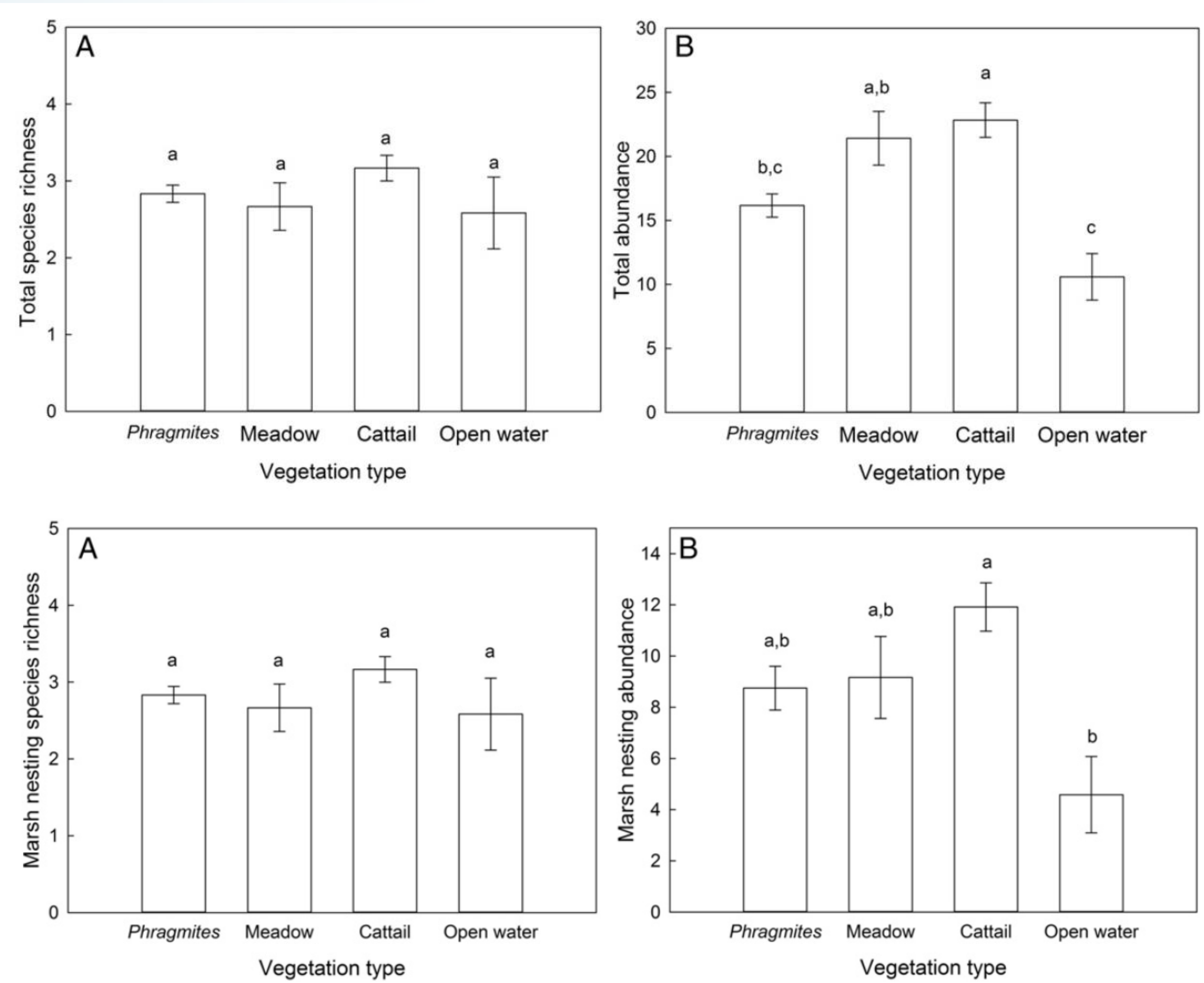
FAUNAL IMPACTS

Bird Assemblage



Robichaud and Rooney. 2017.

- *Phragmites* had lower total abundance than meadow marsh, significantly lower than cattail
- No strong vegetation influence on marsh-nesting bird species richness or abundance

Biogeochemical Cycling

- Invasion of *Phragmites australis* can alter natural biogeochemical processes
  - Methane emissions
  - Nitrous oxide

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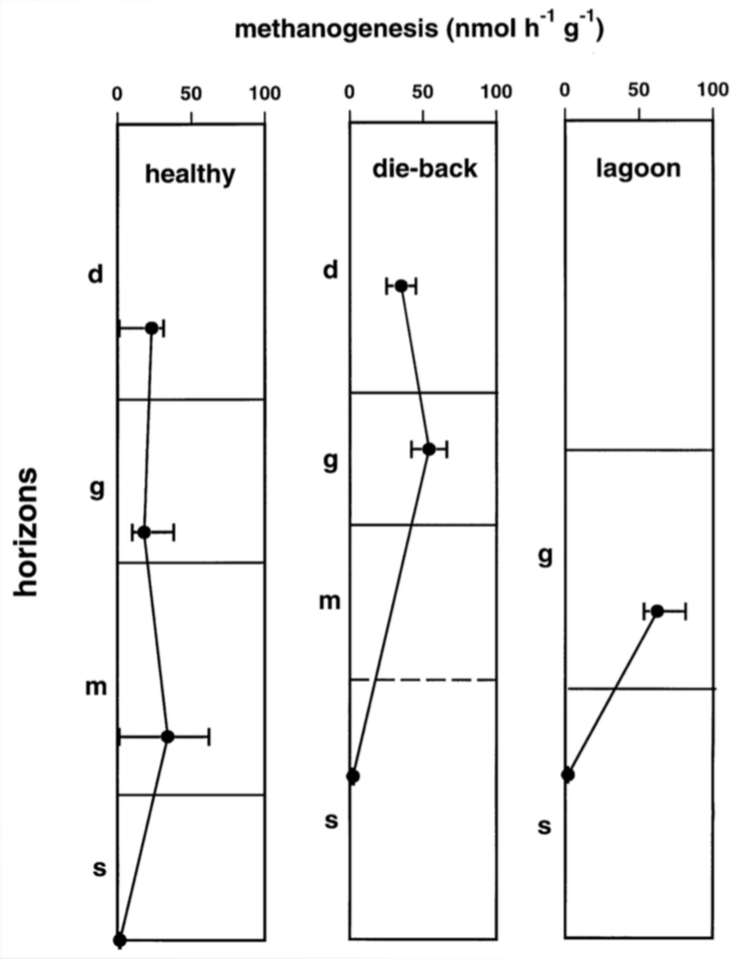
Methane Production in Die-back Communities



Sorrell et al. 1997.

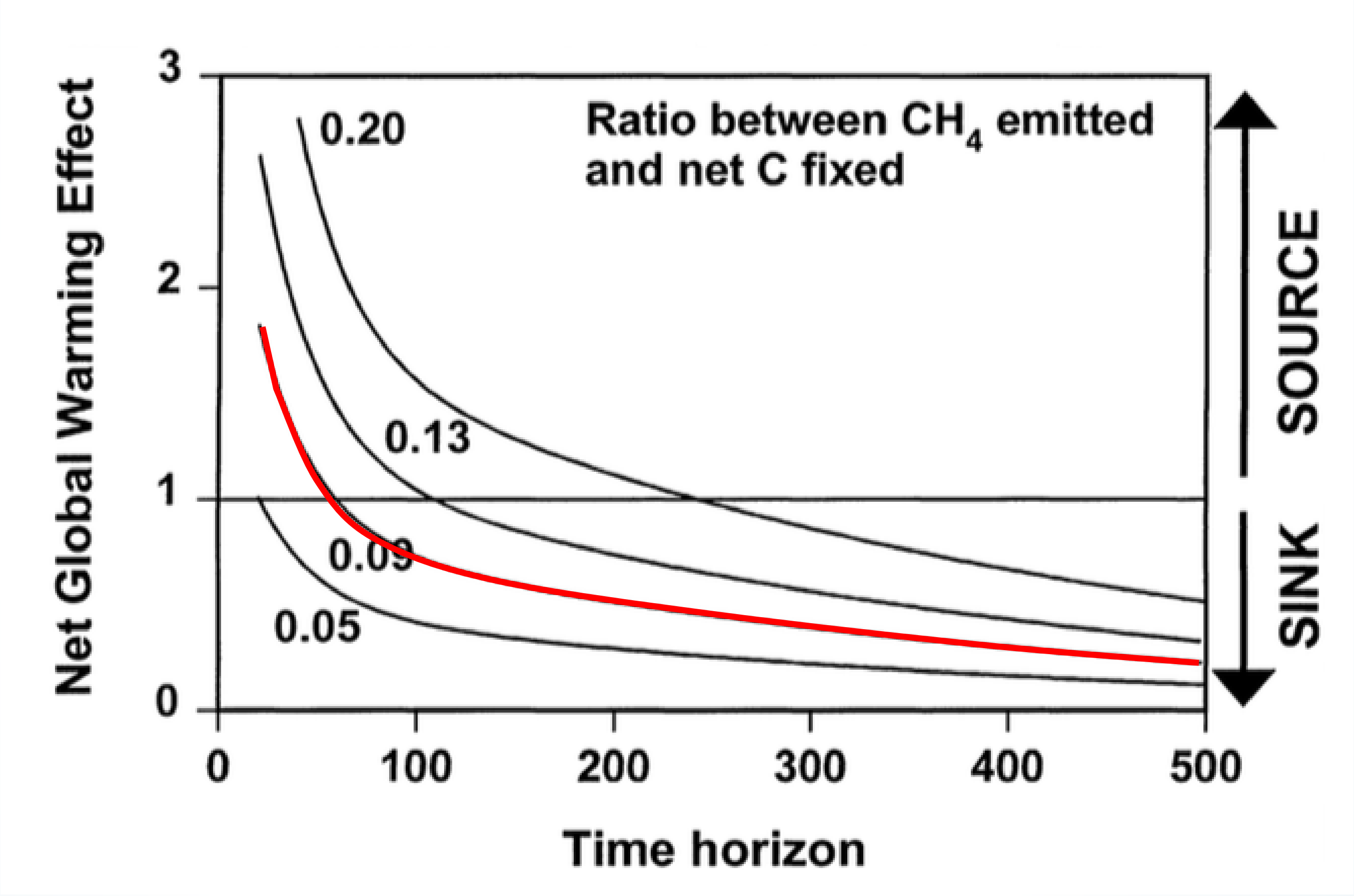
"…become more intense methane producers as they senesce and die"

- Sorrell et al. 1997

Site	Gross CH_4 Production
Healthy	1-7 mmolCH_4/m^2day
Die-Back	10-25 mmolCH_4/m^2day
Lagoon	45-53 mmolCH_4/m^2day

BIOGEOCHEMICAL CYCLING

Sink or Source?



Brix, Sorrell, and Lorenzen. 2001.

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North Carolina Specific

- Is invasion an ecological disaster?
- "Neutral" effect of *Phragmites* density on:
  - Shoreline change rates, carbon sequestration, plant diversity, community structure
  - Why?
- Management Framework:
  - Identify the ecosystem services to protect
  - Identify the type of environment
    - Protected, human-impacted?
  - Determine the density dependent impacts of *Phragmites* on these services

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Management Impacts

- Glyphosate & Imazapyr
  - Ecological Risk Assessments
  - Faunal & Microbial Impacts
  - Restoration
- Non-herbicidal management

MANAGEMENT IMPACTS

Glyphosate: Ecological Risk Assessment

Risk Characterization		
Organism	**Terrestrial Appl.**	**Aq. Appl.**
T. Mammals	max. 0.005	0.02
T. Birds	max. 0.00005	0.002
T. Invertebrates	0.3; 2.4	*N/A*
T. Plants	2-769	*N/A*
T. Microorganisms	*N/A*	*N/A*
Fish	*N/A*	0.0009; 0.03
A. Amphibians	*N/A*	0.06; 0.2
A. Invertebrates	*N/A*	0.1; 0.4
A. Plants	*N/A*	0.4-2; 1.6-8

"The toxicity of the original Roundup and similar formulations containing POEA surfactants is far greater than the toxicity of technical grade glyphosate, Rodeo, or other formulations that do not contain surfactants."

- SERA, 2011

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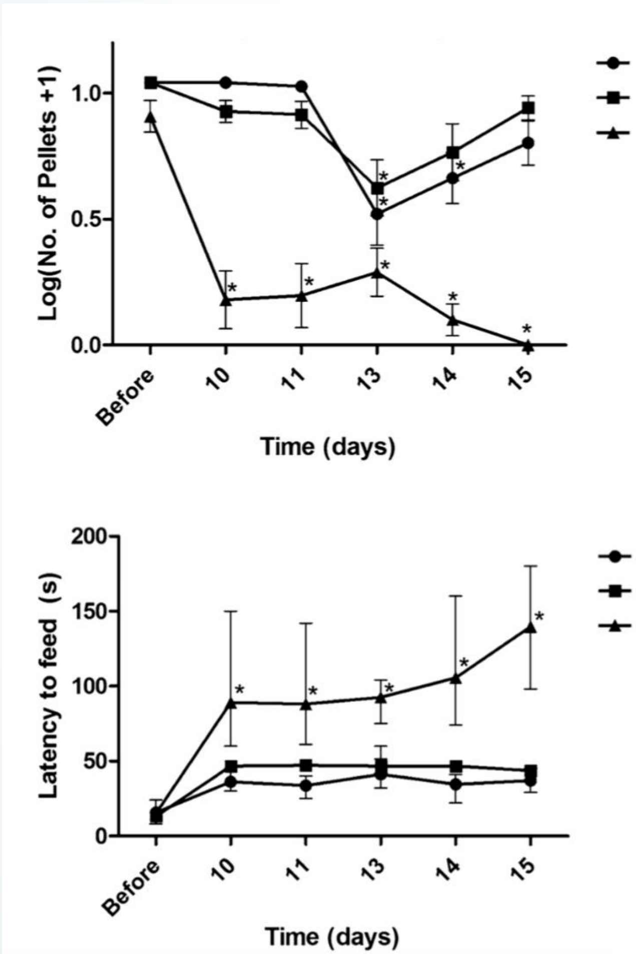
MANAGEMENT IMPACTS

Glyphosate Impacts

Faunal



Giaquinto et al. 2017.

Microbial

- 2000 & 2006 study found minimal impacts to microbial communities
    - Soil respiration
    - Community structure
- 2016 study on aquatic habitats found no impact from herbicide treatments

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MANAGEMENT IMPACTS

Imazapyr: Ecological Risk Assessment

- Non-target species damage
- Non-toxic to terrestrial mammals and birds
- Species specific impacts to terrestrial microorganisms
- Acute toxicity "practically non-toxic" to fish and aquatic invertebrates

Risk Characterization		
Organism	**Terrestrial Appl.**	**Aq. Appl.**
T. Mammals	0.02-0.9	0.009
T. Birds	1.4	0.002
T. Invertebrates	0.04-0.6	*N/A*
T. Plants	3-194	*N/A*
Fish	0.01-0.03	0.01-0.04
A. Invertebrates	0.006-0.01	0.004-0.01
Algae	0.005-0.03	0.01-0.04
A. Macrophytes	0.003-87	12-123

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MANAGEMENT IMPACTS

Imazapyr Impacts

Variable	Taxon	*f* Value	*p* Value	*p* Value, imazapyr treatment
Abundance	Total	1.04	0.45	0.64
	Caecidotea	1.86	0.21	0.89
	Crangonyx	0.72	0.60	0.58
	Dipteran	1.78	0.23	0.39
	Chironomid	1.33	0.34	0.44
	Polypedilum	1.46	0.30	0.84
	Chironomus	1.15	0.40	0.26
	Ablabesmyia	1.33	0.36	0.32
	Procladius	2.73	0.13	0.14
Taxa richness	Total	0.95	0.48	0.39
	Dipteran	0.59	0.68	0.63
	Chironomid	0.82	0.55	0.48

Fowlkes et al. 2003.

- No significant impacts to macroinvertebrates
- Toxicity low to birds and mammals
- Added surfactants may influence mammals
- Wetlands tend to be slower to recover after treatment with imazapyr

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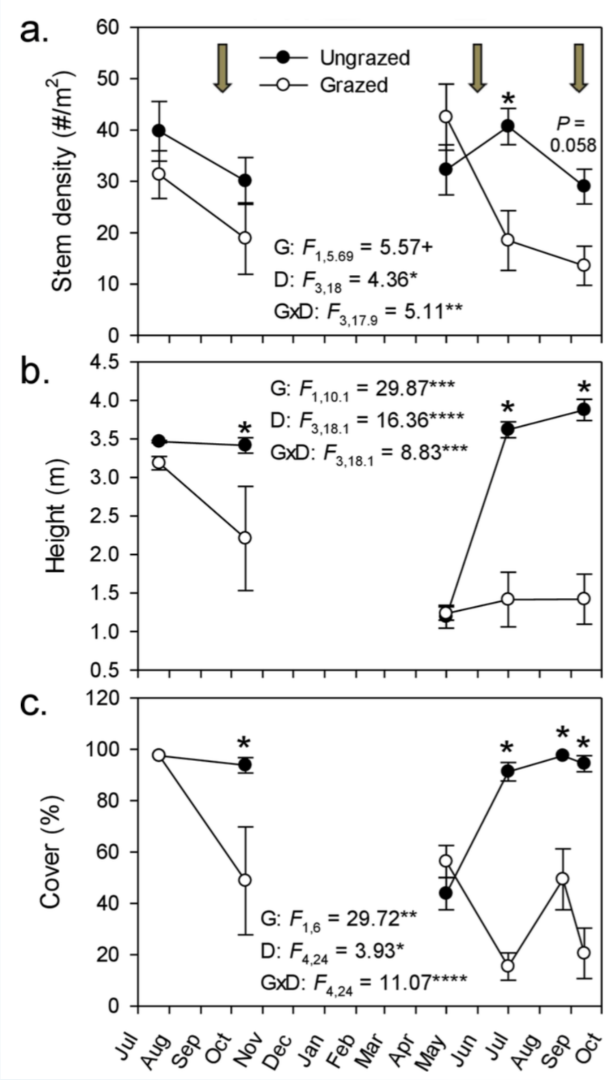
Non-Herbicidal Impacts



Silliman et al. 2014.

- Reed cutting
- Burning
- Grazing
- 40 years of management review

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Summary

- Invasion is driven by anthropogenic forces
- Habitat is significantly altered
- Faunal impacts depends on species in question
- Increases in methane production, and potentially nitrous oxide
- Management should be based on which ecosystem services are to be protected
- Do the benefits of treating with herbicides outweigh the costs? Should other methods be pursued?

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Questions?

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