



A MICROBIAL APPROACH TO *PHRAGMITES* MANAGEMENT

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U.S. Geological Survey





Current management strategies



Chemical



Hydrologic



Mechanical



Fire

- Challenges

- Resource intensive
- Not species specific
- What happens after treatment?
- Adaptive management difficult

Emerging Research: Can new tools be integrated?



Conventional



Gene Silencing

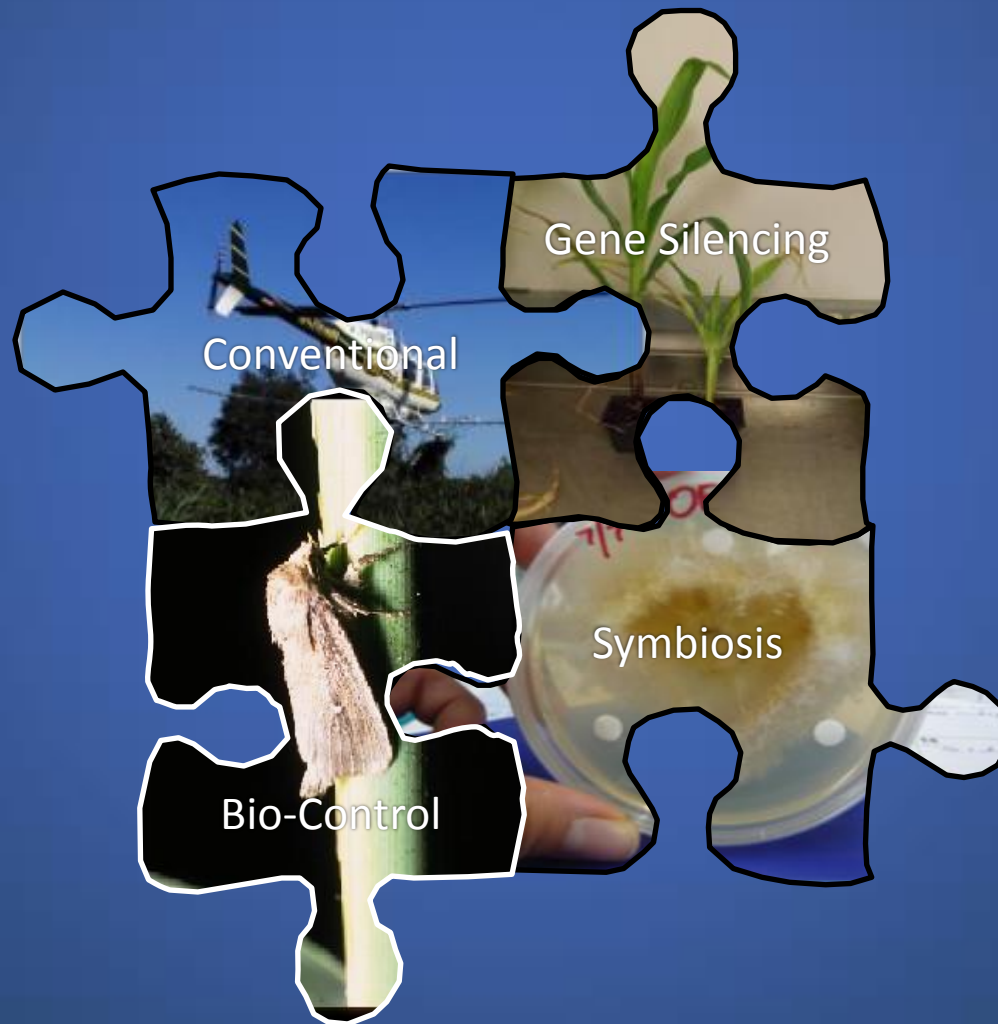


BioControl



Microbial Symbiosis

Emerging Research: Can new tools be integrated?



Using an Integrated Pest Management (IPM) approach

- Examination of pest and environmental conditions during phases of invasion or establishment



Microbial Approach

Microscopic Fungi



Microscopic
Fungi



Microscopic Fungi



BENEFITS

Tolerance

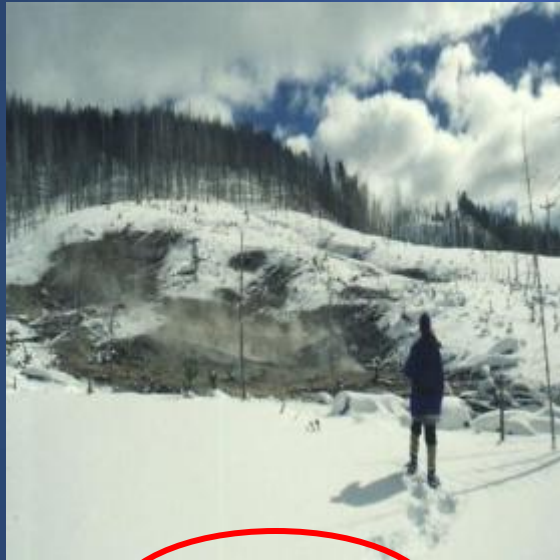
- Drought
- Temperature
- Salt

Accelerated
Development
of Seedlings

Increased Growth
and Yield

Adaptation to Stress in Specific Habitats

Geothermal Soils



Temperature

-

-

Coastal Beach



-

Salt

-

Subtropical Agriculture



-

-

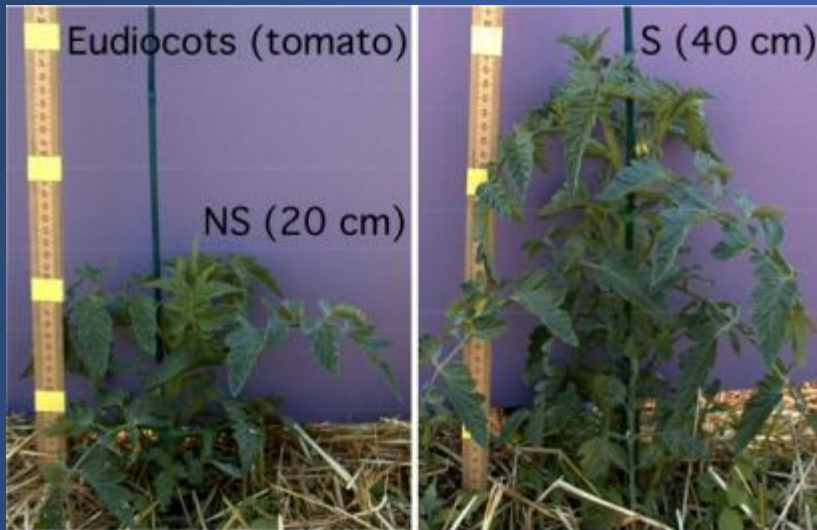
Disease



Habitat-Adapted Symbiosis

Rodriguez et al., 2008, ISME-Nature

Fungal Endophytes Regulate Plant Growth and Development



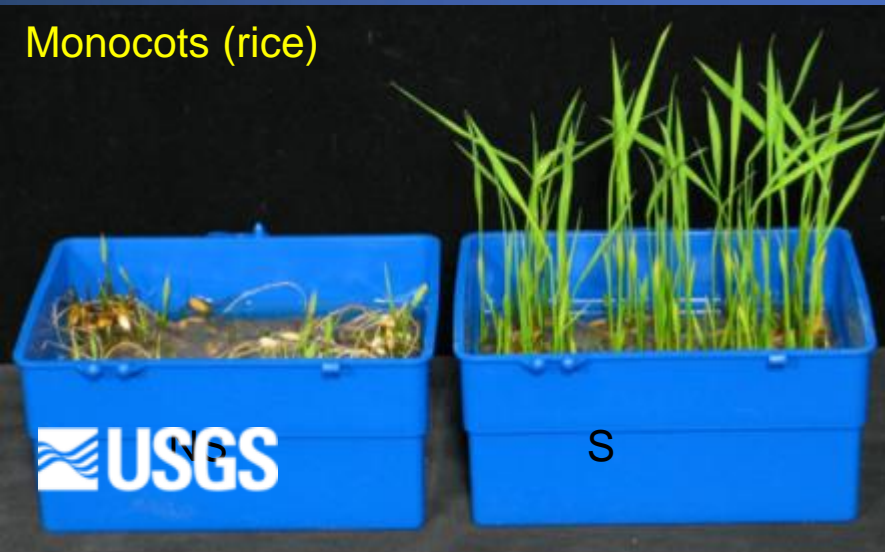
Native Species (switchgrass)



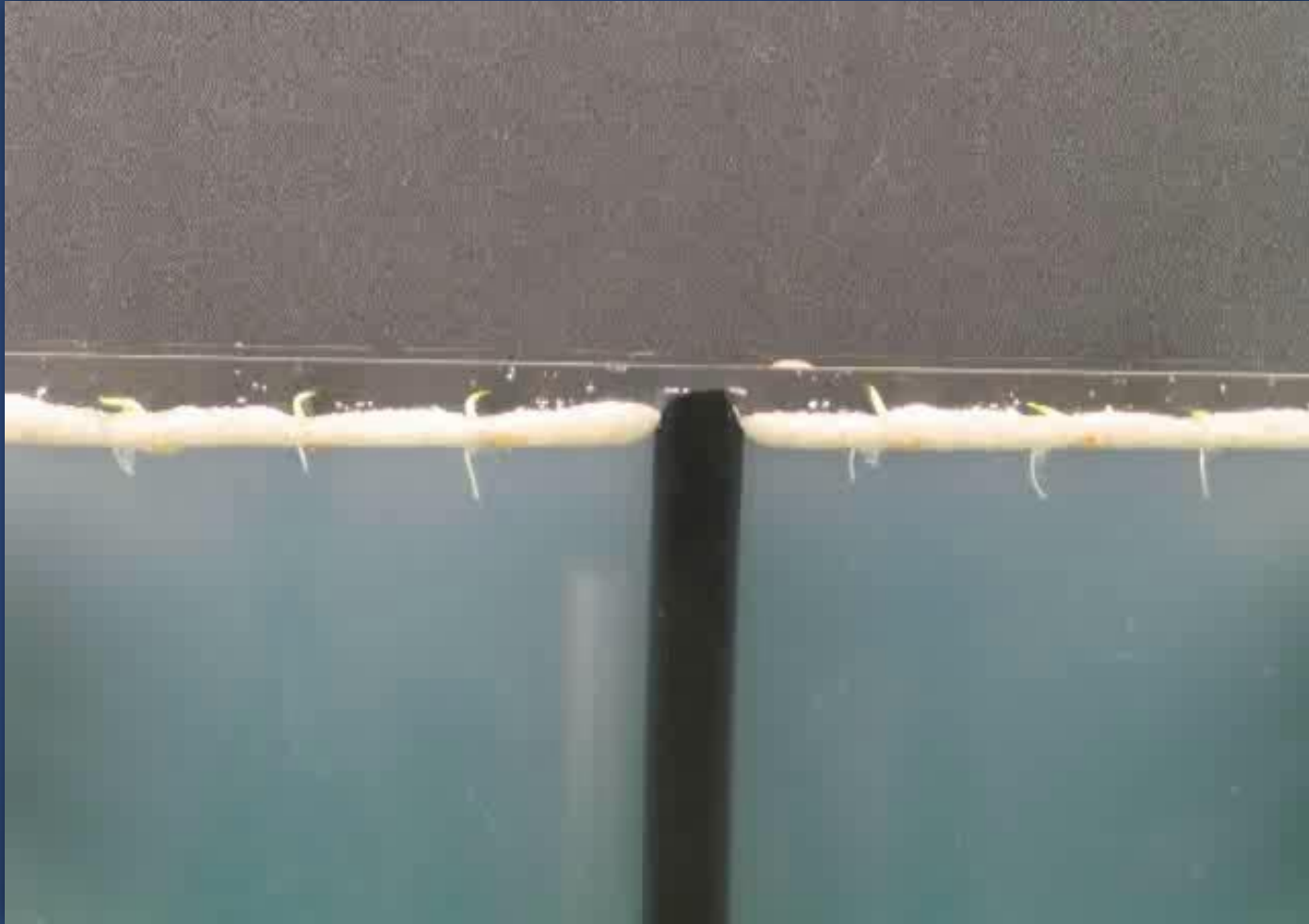
NS

S

Monocots (rice)



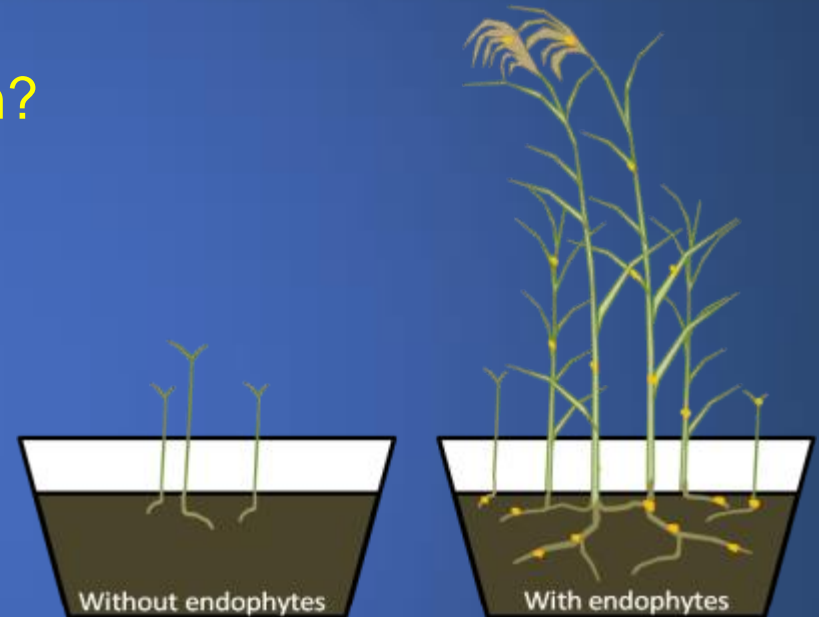
Time Lapse Video: Impacts of Endophytes on Rice Growth



Symbiosis and Invasion

Does symbiosis influence invasion?

Can we disrupt symbiotic relationships to impact invasive properties of *Phragmites*?



Interactions with microbes may impact:

BIOMASS PRODUCTION
TOLERANCE TO STRESS
STEM DENSITY
RHIZOME GROWTH
SEED OUTPUT
GROWTH RATE

Collaborative Approach

BIG RESEARCH QUESTION:

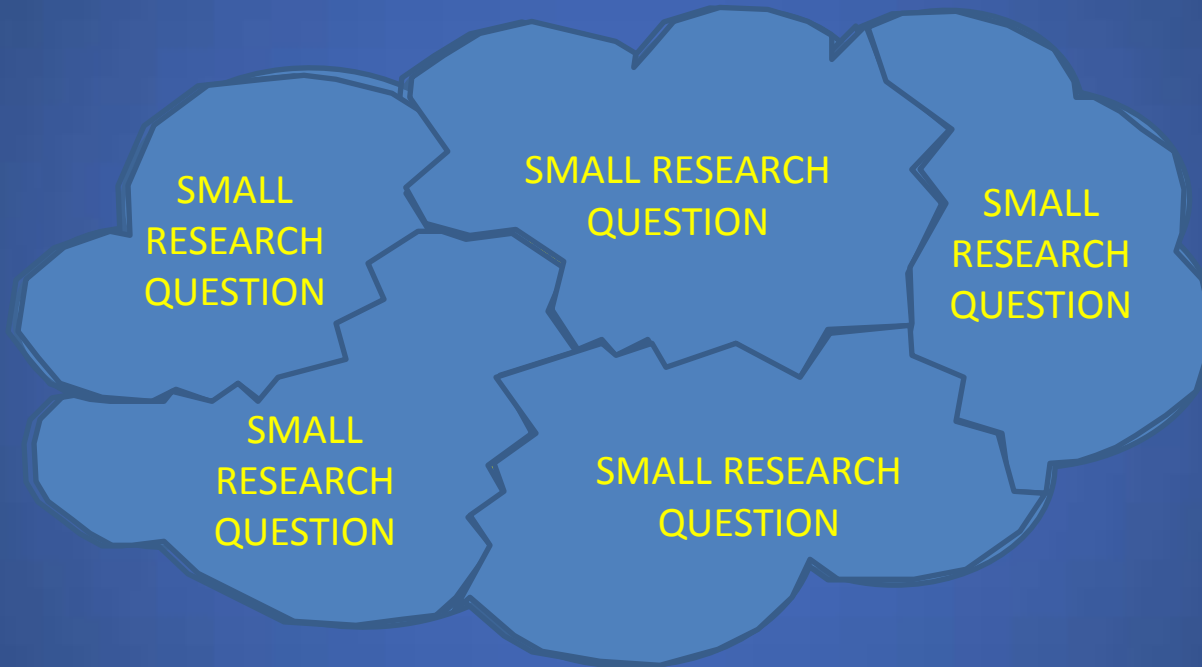
Can *Phragmites* management
be improved by utilizing
existing microbial
relationships?

Collaborative Approach

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Collaborative Approach



Expert

Expert

Expert

Expert

Expert

Collaborative Approach



Collaborative Approach

BIG RESEARCH QUESTION:

Can *Phragmites* management be improved by utilizing existing microbial relationships?

SMALL
RESEARCH
QUESTION

Expert

Expert

Expert

Expert



Collaborative Approach

BIG RESEARCH QUESTION:

Can *Phragmites* management
be improved by utilizing
existing microbial
relationships?

Expert

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Expert

Collaborative for Microbial Symbiosis and *Phragmites* Management

Purpose

Support and facilitate research focused on furthering the science of *Phragmites* and symbiosis

Strategy

Engage leading microbial scientists to develop a research agenda toward a common goal

- *Bring experts together to have a larger collective impact*



Collaborative for Microbial Symbiosis and *Phragmites* Management

What do we know about *Phragmites* and symbiosis?

What gaps exist in our understanding?

Create Science Agenda

Craft individual research projects addressing gaps

All members contribute to goal of microbe based *Phragmites* control

The Collaborative

- International Membership
- ~10 Researchers
 - Microbial ecologists
- Active since April 2013

Advancing the Science

Goal:

Microbe-based
Phragmites
management
approaches

Advancing the Science

Identify
microbes
influential to
Phragmites

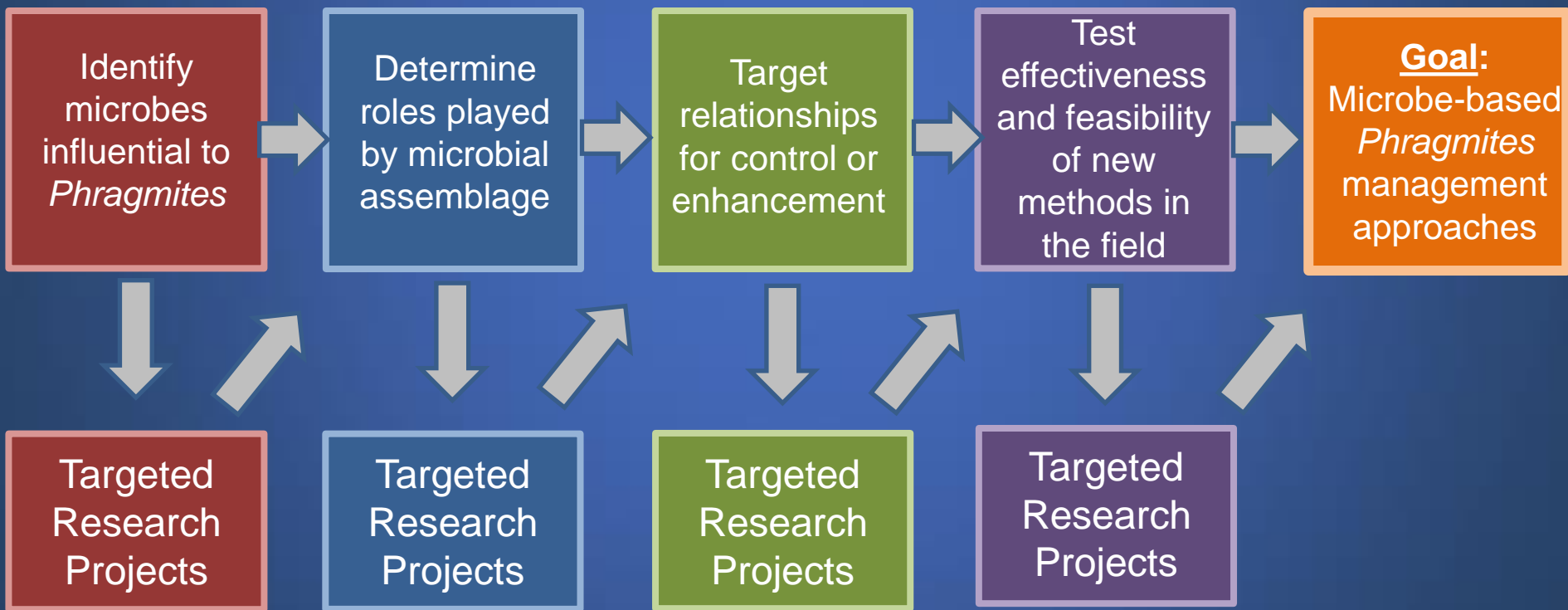
Determine
roles played
by microbial
assemblage

Target
relationships
for control or
enhancement

Test
effectiveness
and feasibility
of new
methods in
the field

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Which endophytes
associate with
Phragmites?

Fungal

Bacterial

What about
Pathogens?

Do they vary in
space?

... by growth
stage?

Native Species
and Microbes

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How do endophytes affect
competitive abilities?

Phragmites

Native
Species

Plant developmental
pathways

Nitrogen fixing
bacteria

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Endophyte
Sensitivity to
Inhibitors

Fungicides?

Other
Substances?

Can we eliminate
some microbes?

Can we inoculate with
beneficial microbes?

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Scaling up

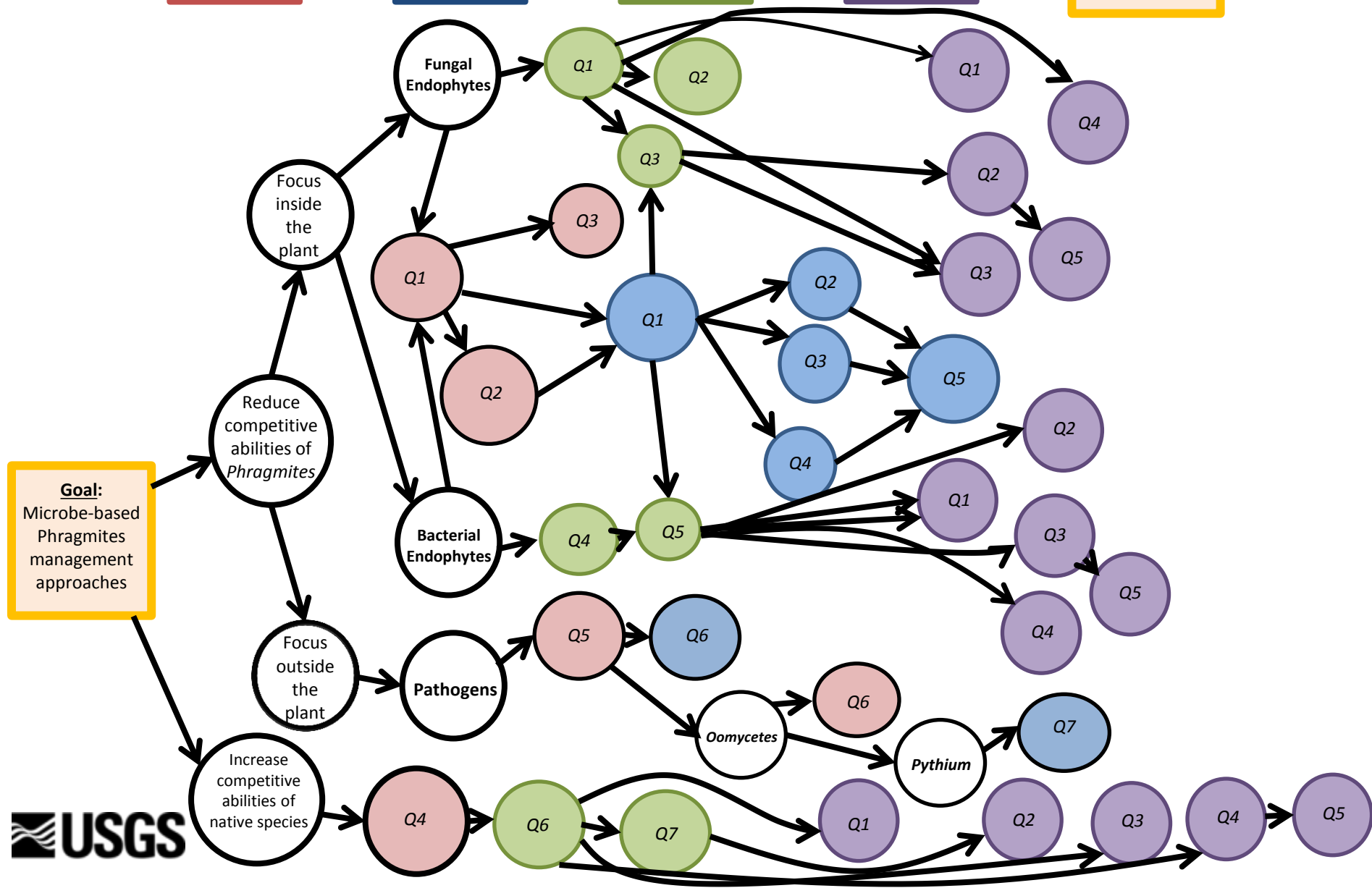
Non-target species
effects

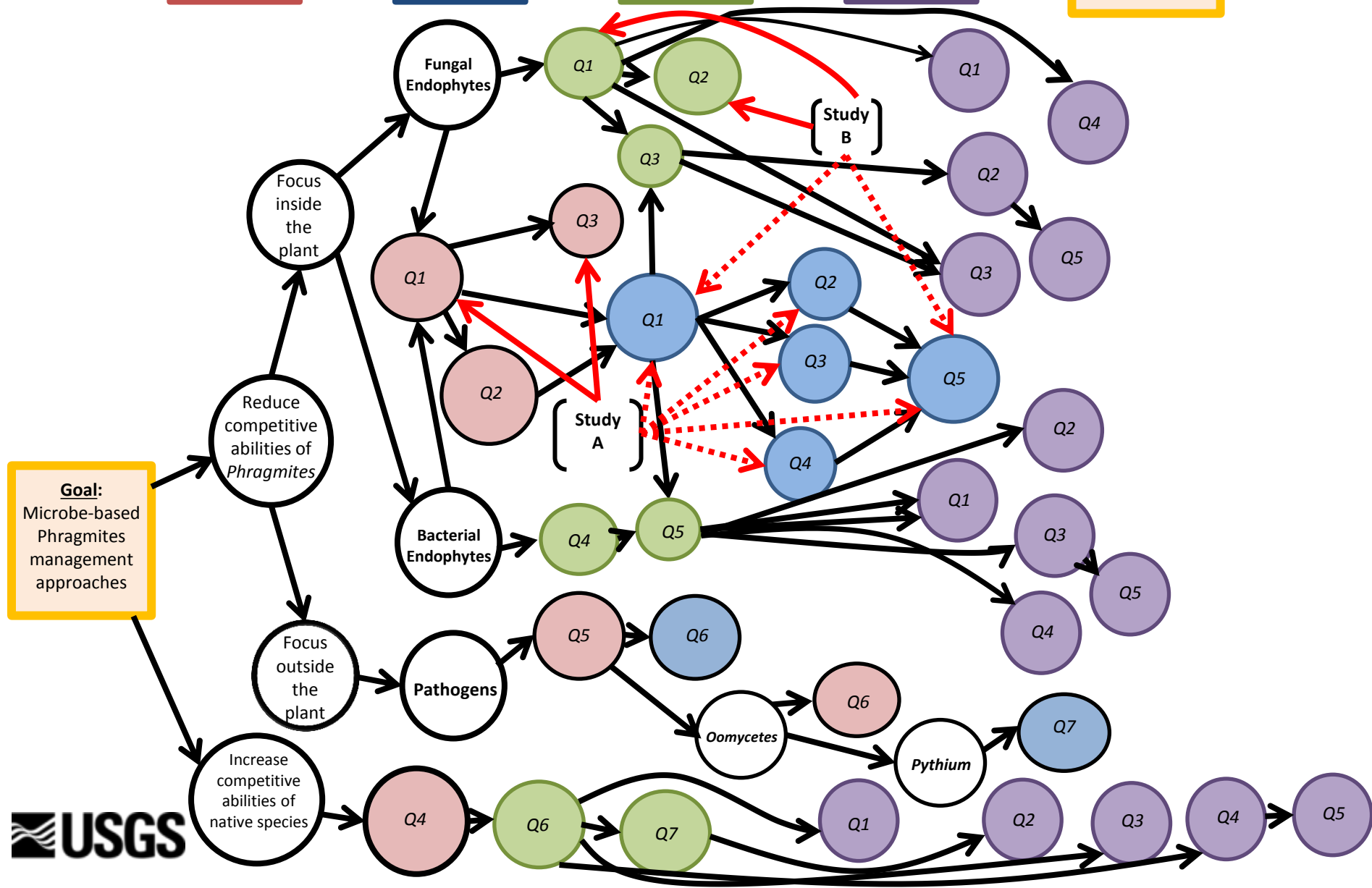
Negative ecosystem or
environmental impacts

Regulatory
Considerations

Who are the
appropriate
entities?

How much
will it cost?





Endophytic Fungi and their Effects on Invasiveness

Dr. Keith Clay, Indiana University

- Which fungal endophytes does *Phragmites* associate with?
- What roles do they play?
- Culture and ID endophytes from field samples
 - Endophyte distribution
- Assay of endophyte effects
 - Individually inoculate *Phragmites* with each type of endophyte



Keith Clay

Exploring Nitrogen-Fixing Potential in *Phragmites*

Dr. James White, Rutgers University

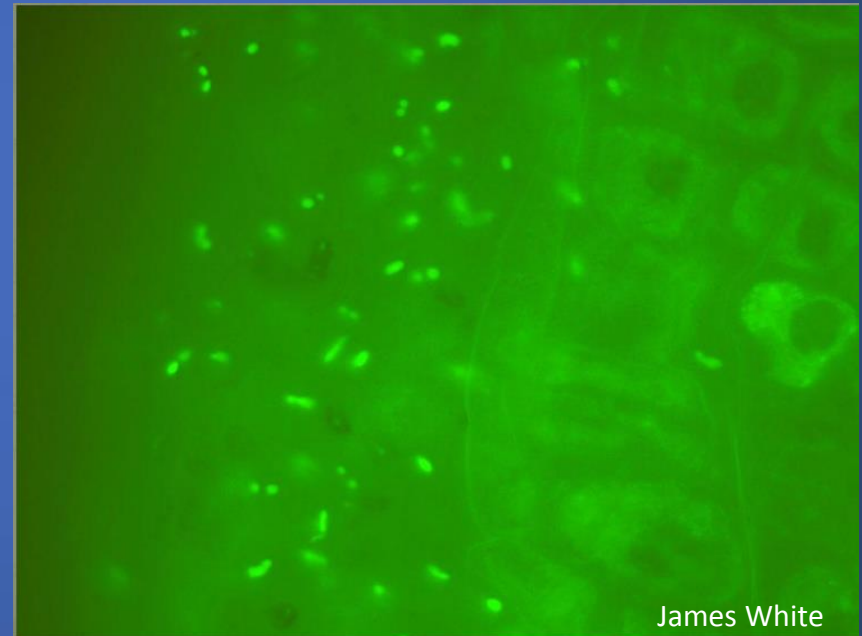
- *Phragmites* is common in nutrient rich areas
- How does it also invade low nutrient areas?
- N-fixation ability?
 - Bacterial endophytes



Exploring Nitrogen-Fixing Potential in *Phragmites*

Dr. James White, Rutgers University

1. Survey bacterial endophytes
 - a. Seeds and meristem
2. Identify sites of N fixation
 - a. $^{15}\text{N}_2$ assimilation
3. Location of bacteria in tissues
4. Can we curtail the ability of *Phragmites* to grow in low N environments?



James White

Layers of bacteria around meristematic tissue

Symbiotic Mechanism for *Phragmites* Invasions?

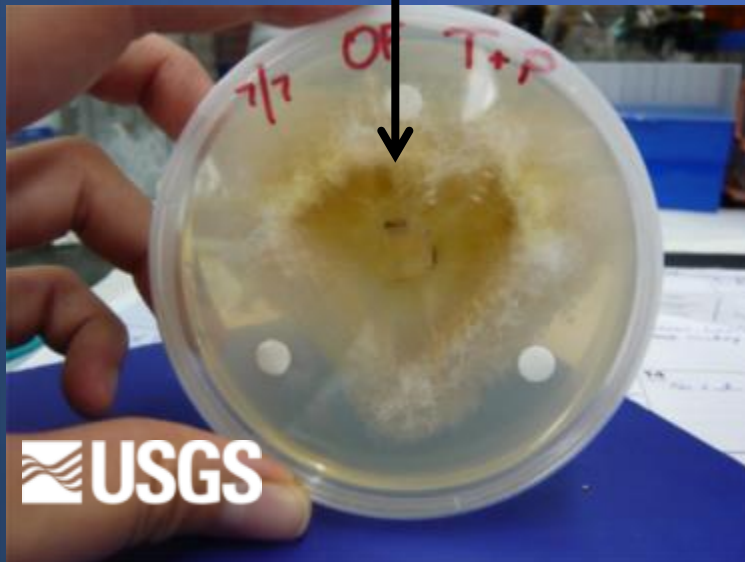
Fisher and Rodriguez 2013

Isolated fungal endophytes from 8 populations in Michigan.

All plants had fungal endophytes.

Endophytes showed sensitivity to fungicides.

Sensitivity to fungicides varied by isolate and type of fungicide



Fisher, M.S. and R.J. Rodriguez. 2013. Fungal endophytes of invasive *Phragmites australis* populations vary in species composition and fungicide susceptibility. *Symbiosis* 61:55-62.

Field Research Summer 2013

Goals:

- Establish proof of concept
 - Endophyte Elimination Strategy
 - Not substituting fungicide for herbicide
 - How does *Phragmites* compete without endophytes?



Field Research Summer 2013

- Identified *Phragmites*-dominant sites
- Treated 1 X 1 m plots with fungal inhibitor
 - Broad spectrum, systemic fungicide
 - Divalent Mn solution (anti-microbial)
- Treatments either pre- or post- emergence



Field Research Summer 2013

- Data Collection
 - Stem density
 - Plant height
 - Above and belowground biomass
 - Species inventory
 - Floristic Quality Index



Field Research Summer 2013

Summary of preliminary results

- No significant differences between treatments in any parameters
 - Height
 - Cover
 - Biomass
- Why?
 - Were endophytes affected by treatments?



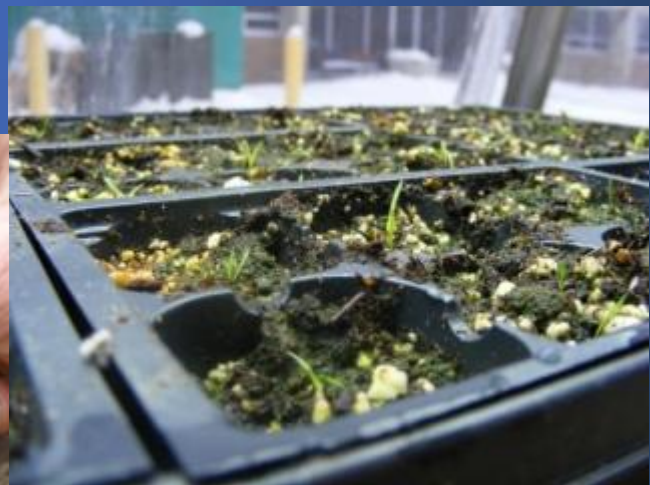
Follow-up Studies in Greenhouse

Research Questions

1. Fungicide translocation
2. Does plant growth stage matter?
3. Does soil type matter?
4. What is the impact on *Phragmites* success?



Growing *Phragmites* from Seed



Growing *Phragmites* from Seed



Expected Outcomes

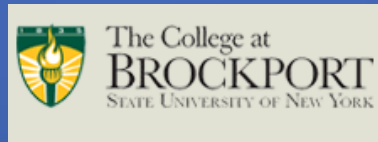
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Alternate Application
Promote beneficial microbes in desirable species

Emerging Research: Can new tools be integrated?



Conventional



Gene Silencing



BioControl



Microbial Symbiosis

Managing large stands of *Phragmites*



Alter Competitive Outcomes

Using Multiple Tools

GENE SILENCING
MICROBIAL INHIBITOR

BENEFICIAL
ENDOPHYTES

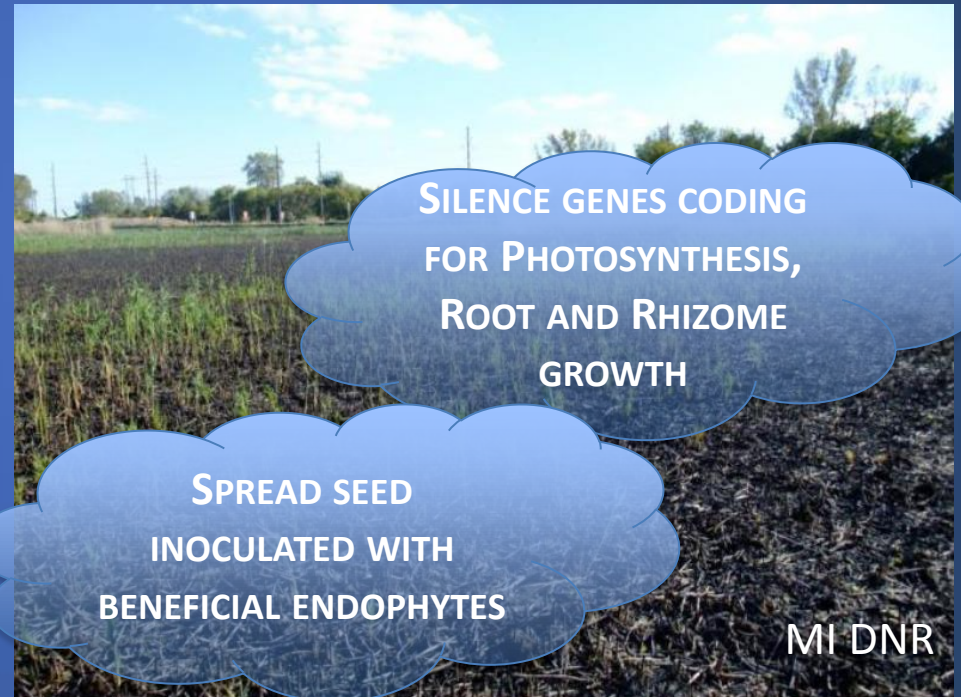


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**GENE SILENCING
MICROBIAL INHIBITOR**

**BENEFICIAL
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Thank you

