Innovative *Phragmites*-Control Strategies

Dr. Kurt P. Kowalski (USGS – GLSC)
Dr. Russell J. Rodriguez (USGS –WFRC)
Dr. Edward M. Golenberg (WSU)

U.S. Department of the Interior
U.S. Geological Survey

Investigators

USGS Project Lead: Kurt P. Kowalski, 734/214-9308, kkowalski@usgs.gov
Lead Scientist: D. Carl Freeman, 313/577-2793, cfreeman@sun.science.wayne.edu

Investigators: D. Carl Freeman[1], Regina S. Redman[2,4], Russell J. Rodriguez[2,3,4], Edmond Van Hees[5], Edward M. Golenberg[1], Douglas A. Wilcox[6], and Kurt P. Kowalski[7]

[1]Dept. of Biological Sciences, Wayne State University, Detroit, MI 48202
[2]Dept. of Biology, University of Washington, Seattle, WA 98195
[3]USGS-Western Fisheries Research Center, Seattle, WA 98115
[4]College of Forest Resources, University of Washington, Seattle, WA 98195
[5]Dept. of Geology, Wayne State University, Detroit, MI 48202
[6]Dept. of Environmental Science and Biology, SUNY-Brockport, Brockport, NY 14420
[7]USGS-Great Lakes Science Center, Ann Arbor, MI 48105

USGS

Phragmites australis (Cav.) Trin. ex Steud (Common Reed)

- Fast growing clonal grass
  - Wide leaves (1-5 cm) and large inflorescence
- Grows up to 6m high, often in high densities
- In North America for over 3000 years
- Invasive and exotic haplotype M is causing most of the problems

USGS

Current Management Techniques

USGS

Innovative *Phragmites*-control strategies

Two-pronged approach:

- Determine role of microbial community in competitive advantage during invasions
- Apply gene silencing technology to modify plant characteristics

Partner driven:
U.S. Geological Survey
Wayne State University
University of Washington
SUNY – Brockport

Support:
GLRI
USFWS
Ducks Unlimited
TNC – Michigan
SEMCOG
New York Dept. Conservation
Healing Our Waters Coalition

USGS

Endophytes

Microscopic Fungi

Microscopic Fungi

Microscopic Fungi

BENEFITS

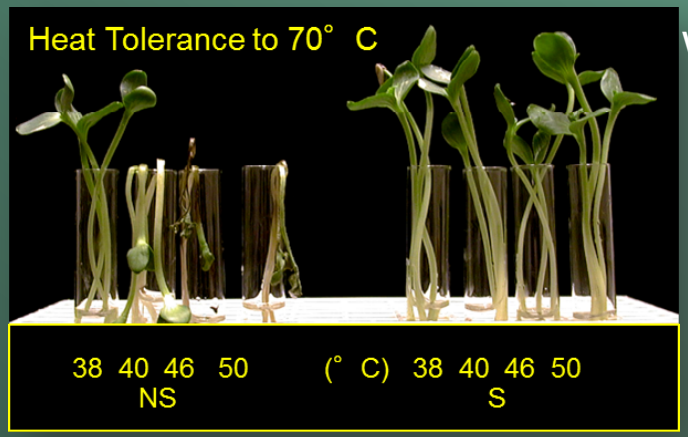
Tolerance
- Drought
- Temperature
- Salt

Accelerated Development of Seedlings

Increased Growth and Yield

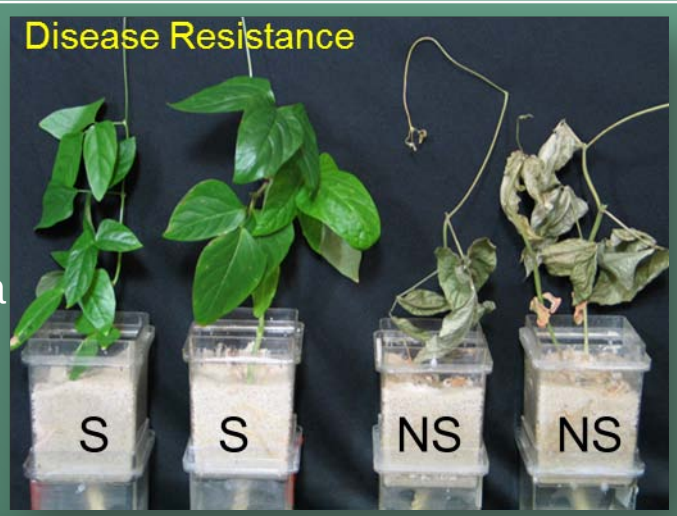
USGS

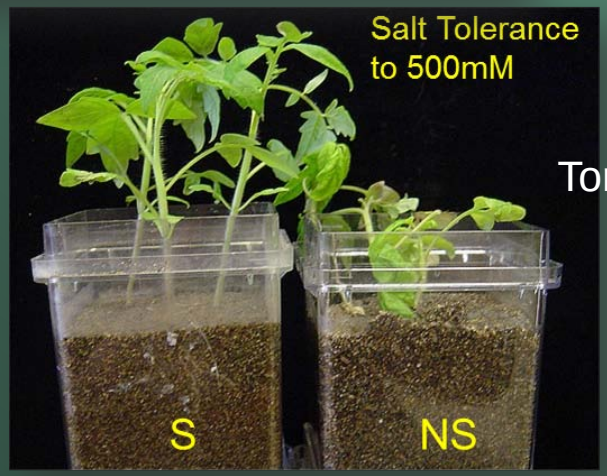
Stress Tolerance Conferred by Fungal Endophytes



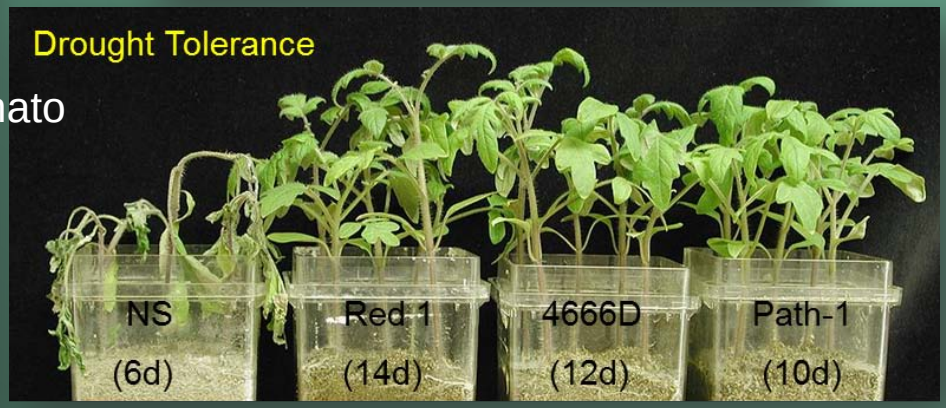
Watermelon

Cow Pea





Tomato



USGS

Redman et al. 2002, *Science*
Marquez et al. 2007, *Science*

Chemical Tolerance Conferred by Fungal Endophytes

Heavy Metal Tolerance

NS S

4000ppm Fe

TNT Tolerance

S NS

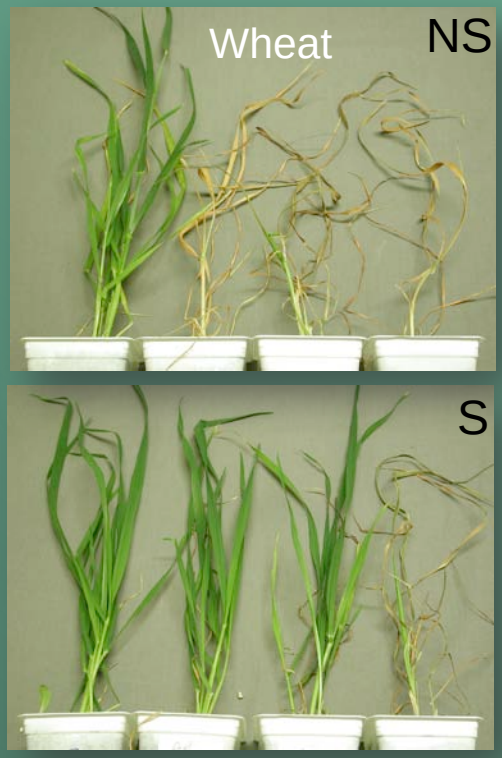
60μg/ml TNT

USGS

Drought Tolerance Observed in Monocots and Dicots

NS (6d) | Red 1 (14d) | 4666D (12d) | Path-1 (10d)

Days Without Water

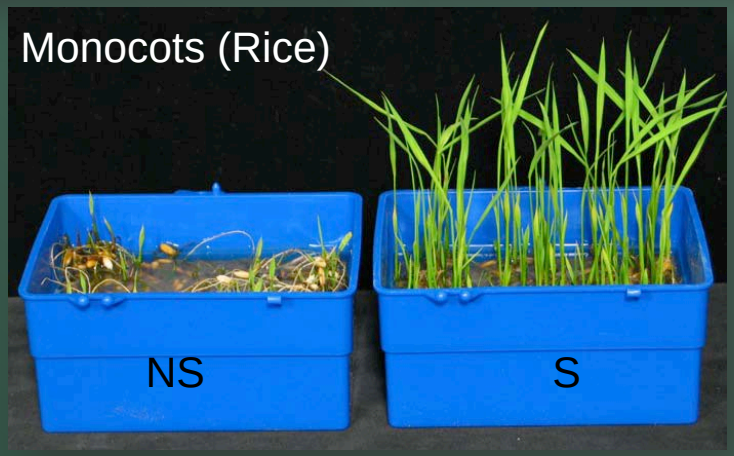


0 12 15 18

Days w/o Water

USGS

Endophytes Regulate Plant Growth and Development: Nutritional Stress Tolerance



USGS

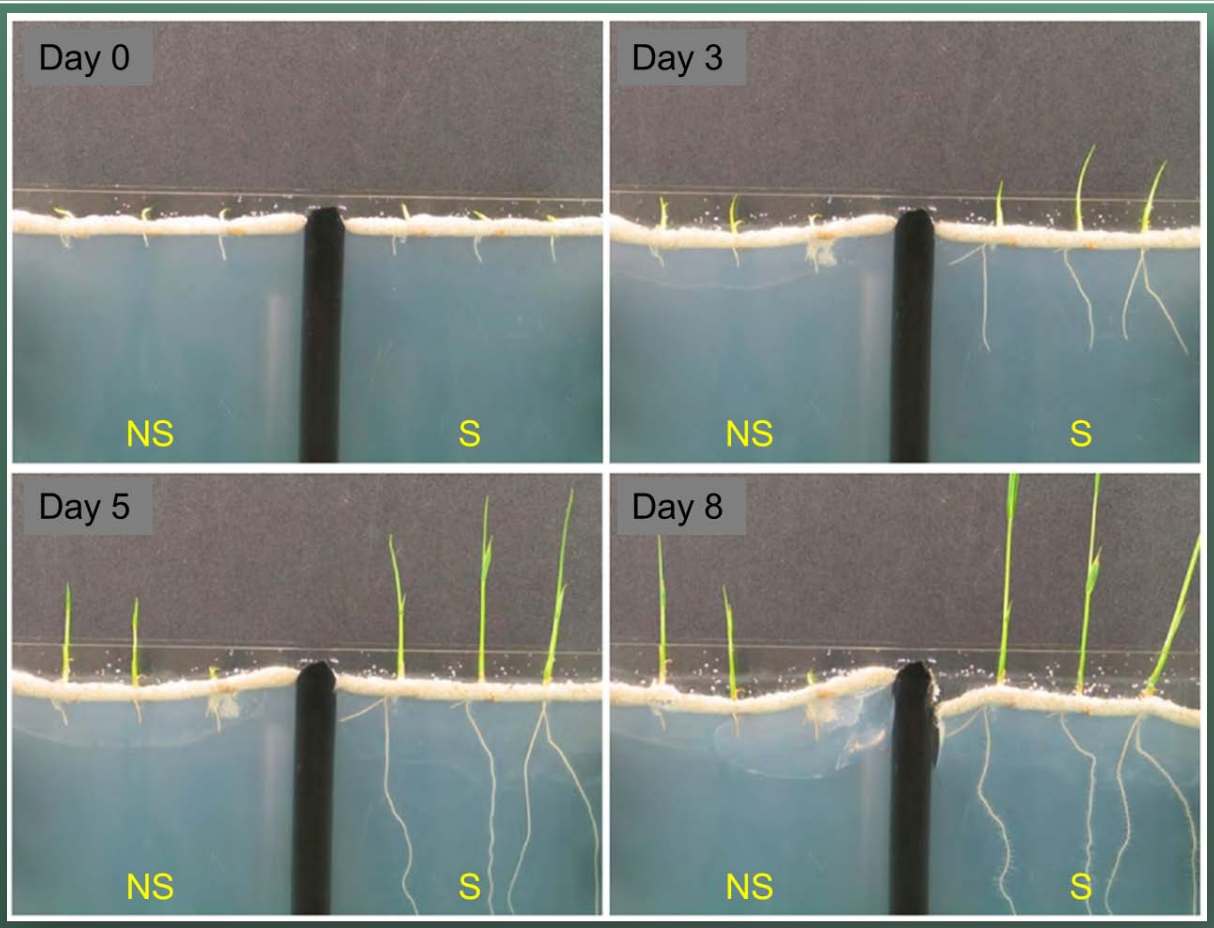
Influence of Endophytes on Seedling Development

Rice

USGS

Influence of Endophytes on Seedling Development

Rice



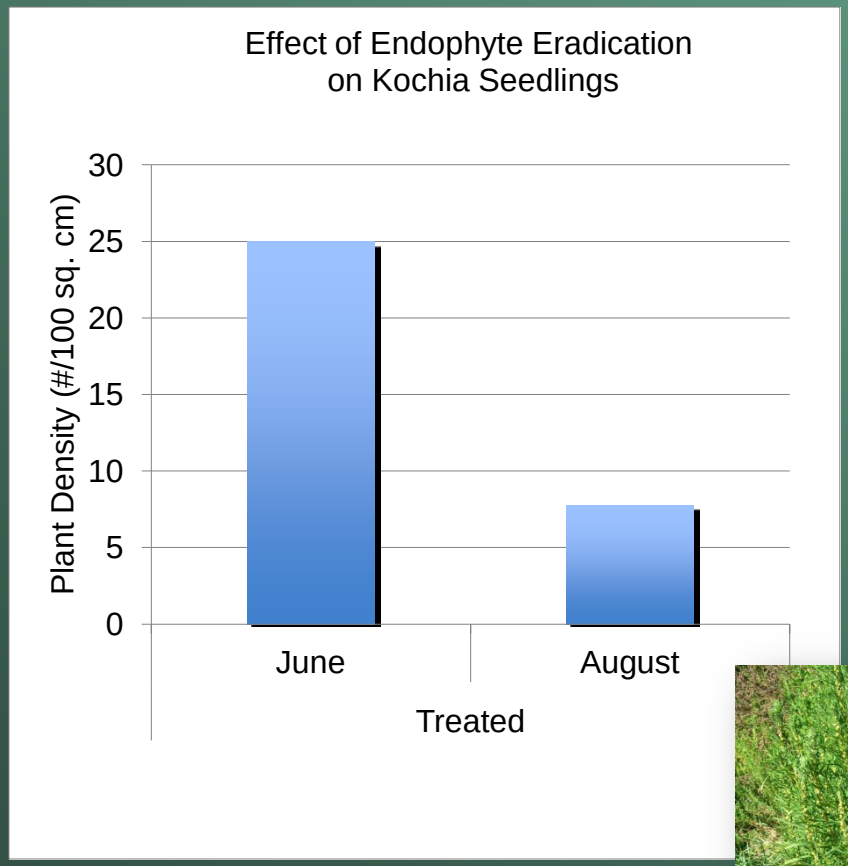
USGS

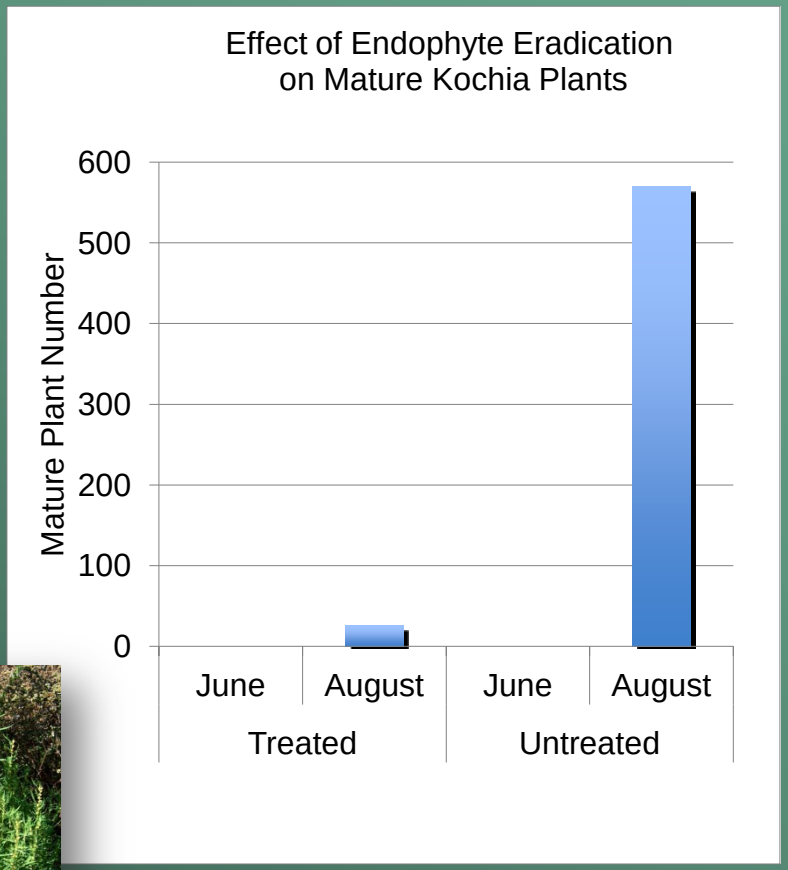
Invasive Plants Analyzed for Fungal Endophytes

Invasive Plant	Genus-Species	Location	Role of Endophytes
Phragmites	*P. australis*	Great Lakes, WA	?
Spartina	*Spartina anglica*	WA	Salt tolerance
Halogeten	*H. glomeratus*	UT	Drought tolerance
Kochia	*Kochia scoparia*	WA	?
Diffuse knapweed	*Centaurea diffusa*	WA	?
Russian thistle	*Salsola kali*	UT, WA	?
Cheat grass	*Bromus tectorum*	UT, WA	?
Bulbous blue grass	*Poa bulbosa*	WA	?

USGS

Preliminary Studies with Kochia Reveal the Importance of Endophytes for this Invasive Plant





USGS

Next Steps for Endophyte Research

2011

- Test endophyte-eradication strategy on several invasive plants including *Phragmites*
- Test the effectiveness of different chemicals for eradicating endophytes
- Optimize chemical spray strategy for long-term management

2012 and beyond (no current funding)

- Expand strategy to include other invasive plants
- Demonstrate the utility of this strategy in different areas
- Identify potential non-target impacts

USGS

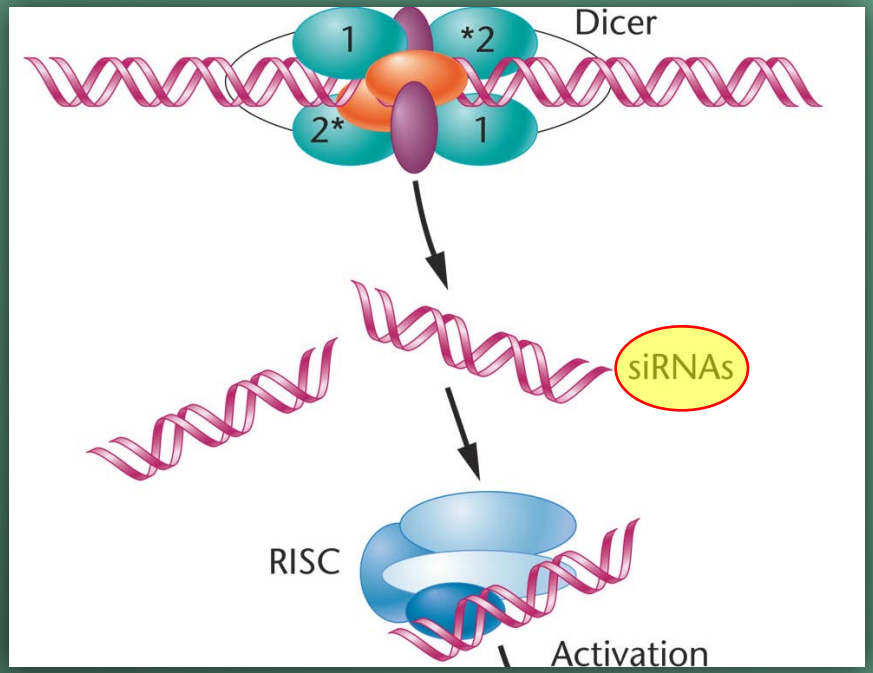
Gene Silencing

USGS

Gene Silencing

Gene Silencing by RNA Interference (RNAi)

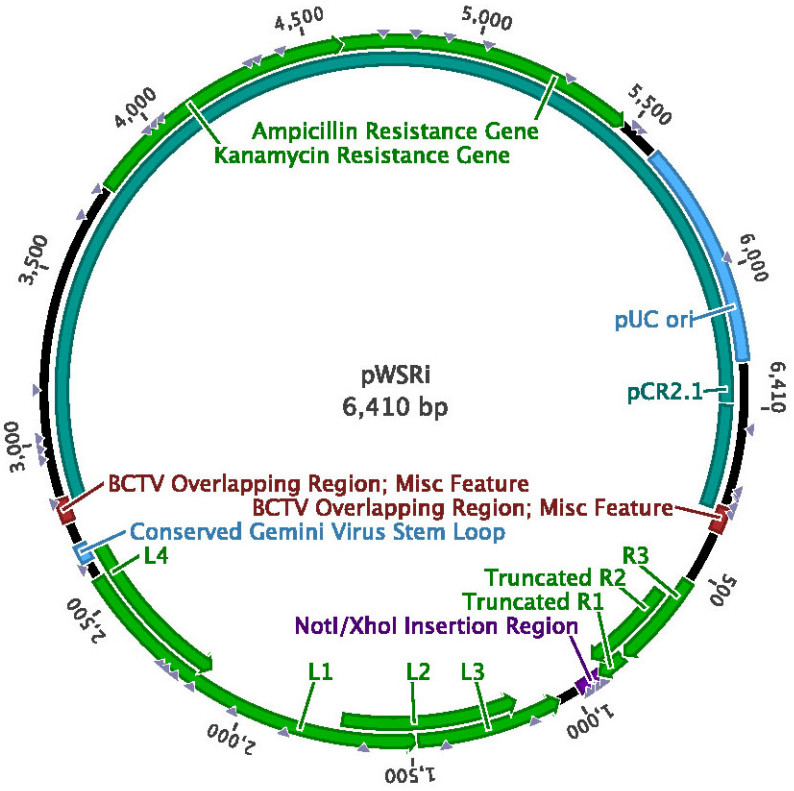
- Gene silencing mechanisms are used by plants and animals in normal anti-viral and developmental processes
- Double stranded RNA triggers the production of short interfering RNAs (siRNAs)
- siRNAs can repress gene expression in many ways



USGS

Plant Gene Silencing Vector Developed at WSU

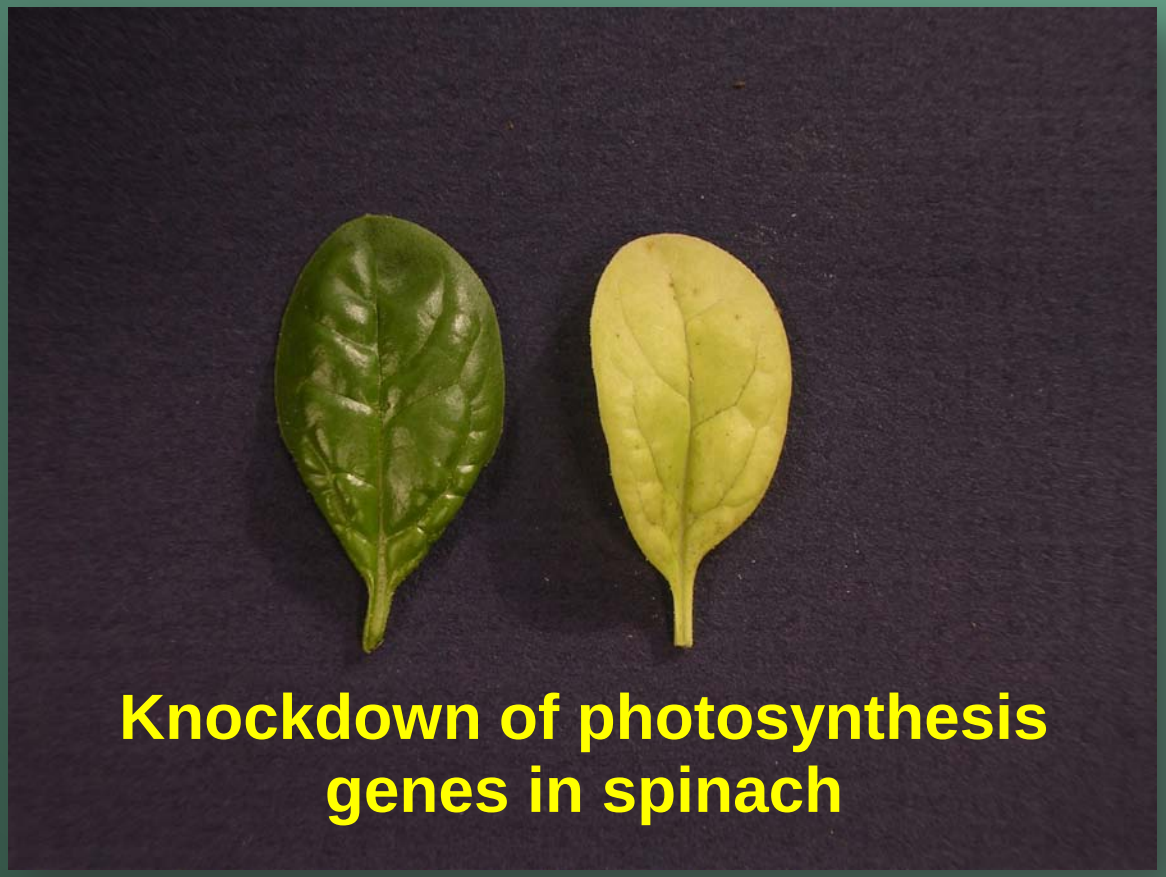
- **pWSRi: plasmid Wayne State RNA interference**
- **Targeted gene attached to vector**
- **Vector introduced to plant cells -> siRNAs**
- **Result: Progressive yet transient silence**
  - ***Not incorporated into genome***



Golenberg et al. 2009. Plant Methods 5,9

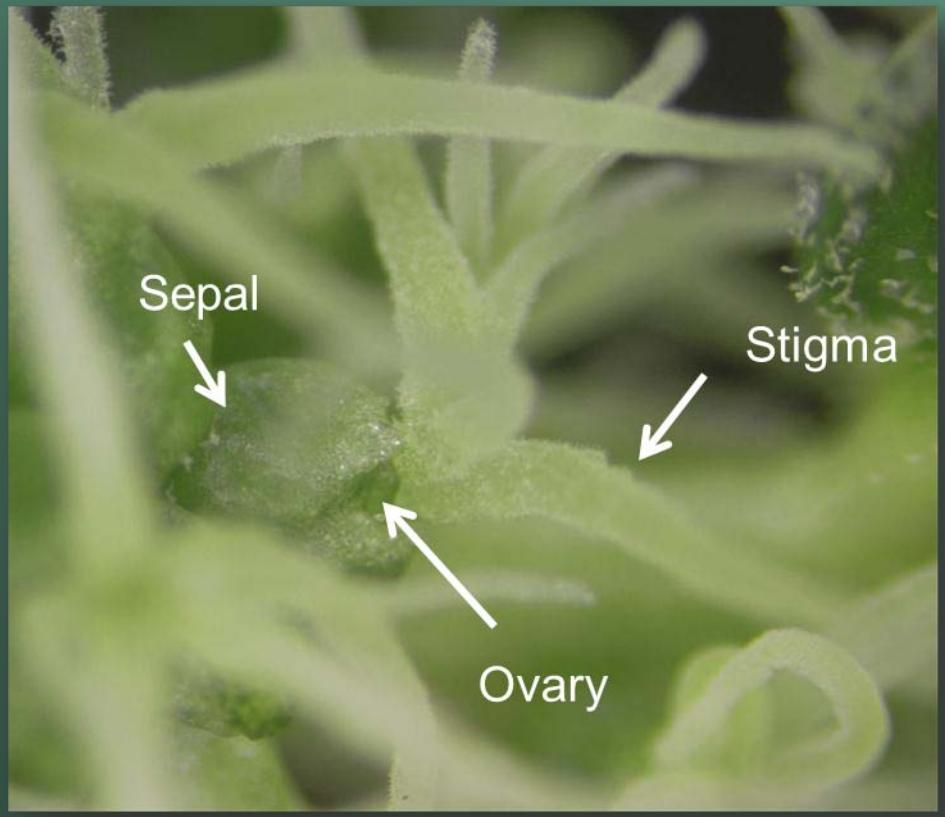
USGS

Gene Silencing Can Reduce Productivity



USGS

Gene Silencing Can Disrupt Flower Development

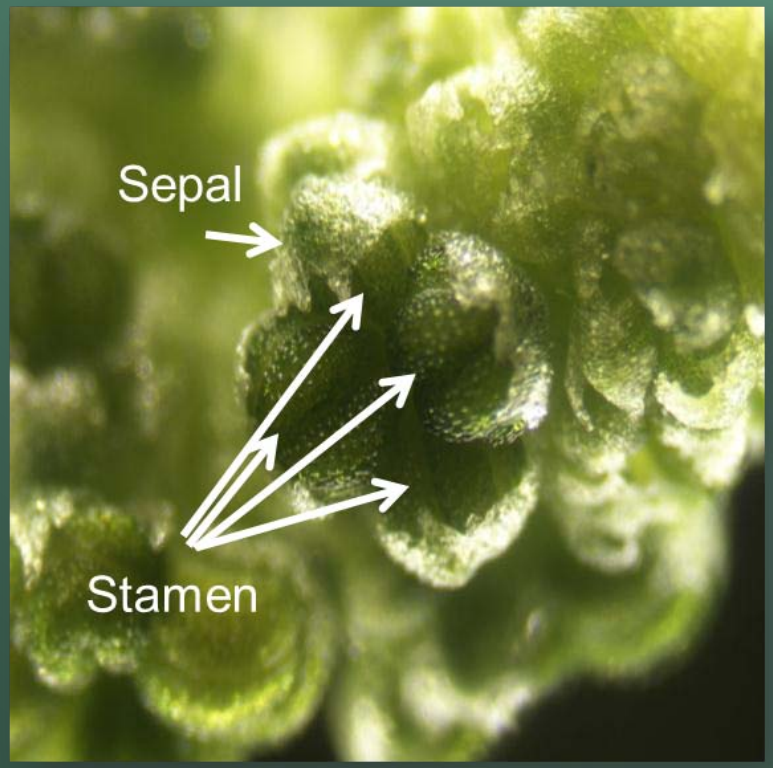


Wildtype Female Flower

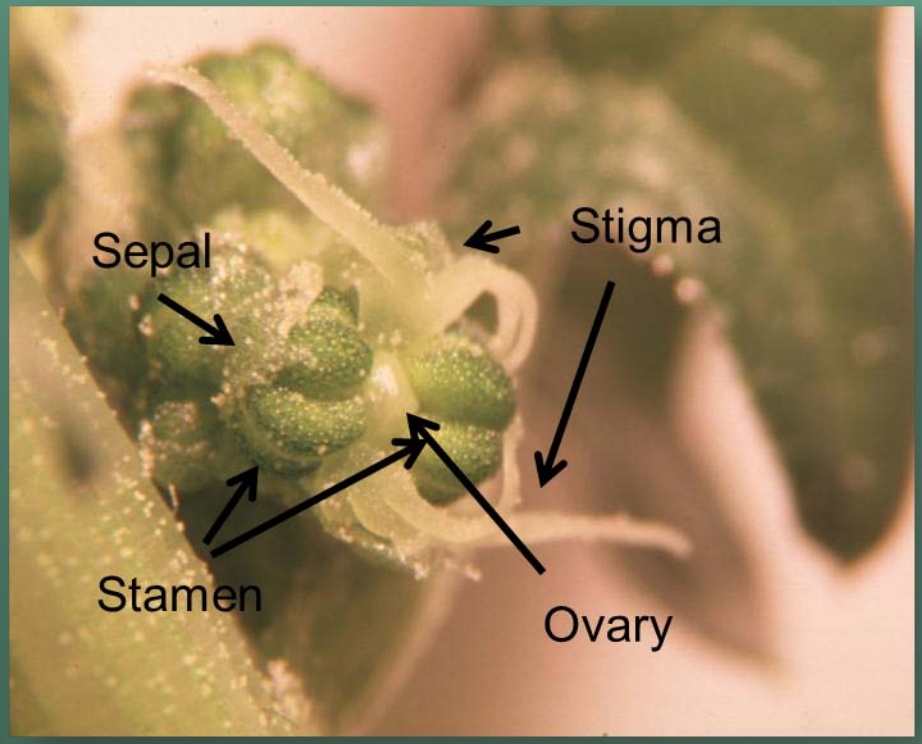
SpAG Silenced Female Flower

USGS

Gene Silencing Can Alter Organ Identity



Wildtype Male Flower



SpPI Silenced Male Flower

USGS

Gene Silencing and Habitat Restoration

Invasive species achieve dominance by outcompeting native species through increased:

- productivity

- seed and sexual reproductive output

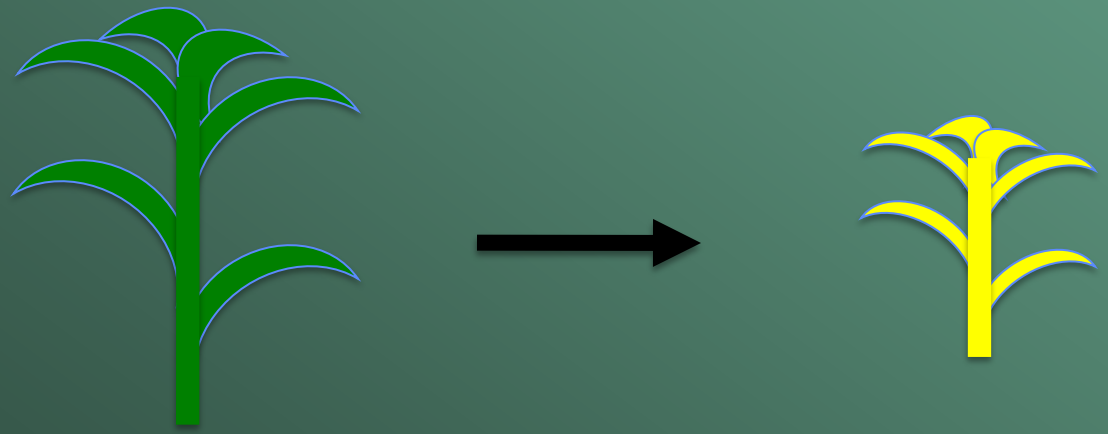
- vegetative reproduction

USGS

Gene Silencing and Habitat Restoration

Reduce competitiveness by:

- Reducing photosynthetic output by silencing photosynthesis machinery

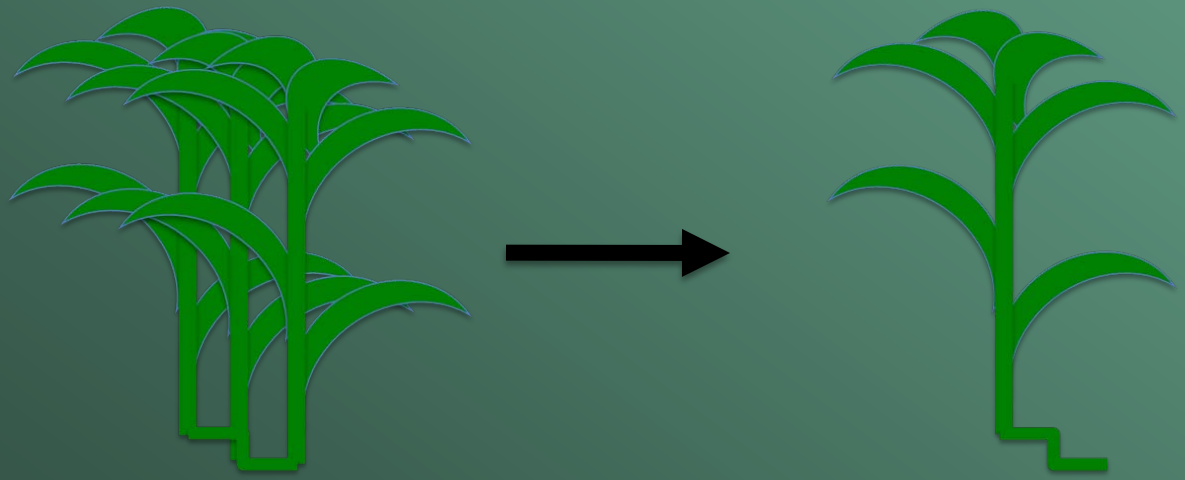


USGS

Gene Silencing and Habitat Restoration

Reduce competitiveness by:

- Reducing biomass by suppressing vegetative reproduction

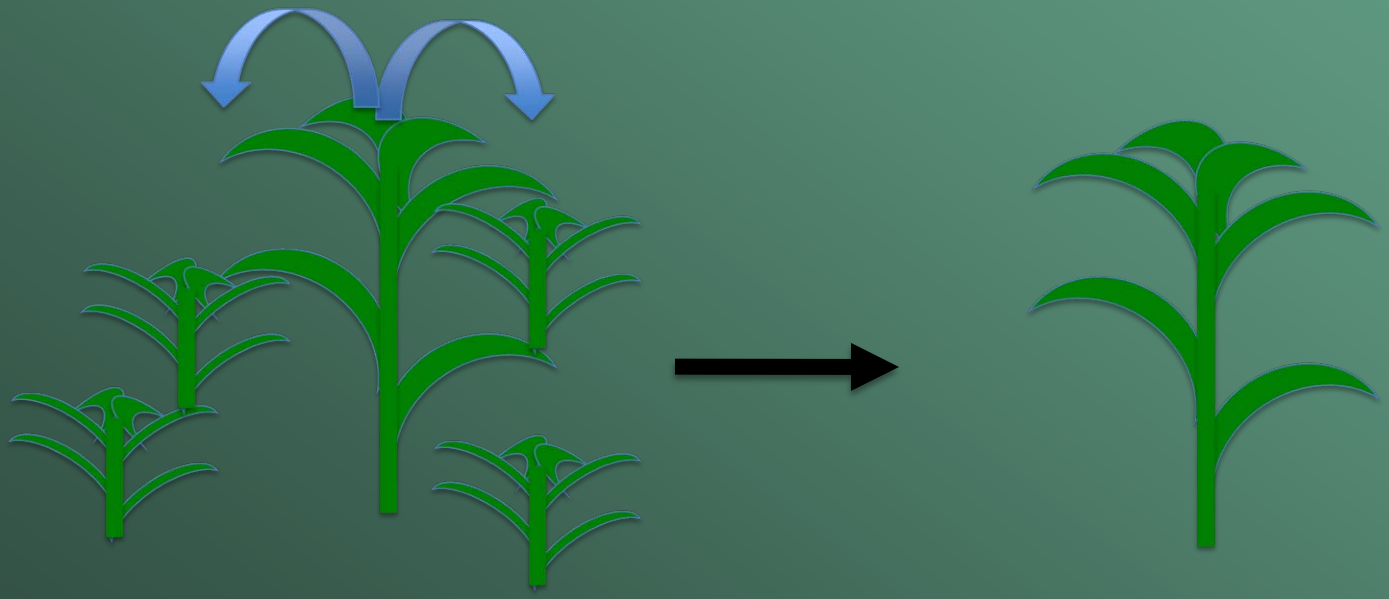


USGS

Gene Silencing and Habitat Restoration

Reduce competitiveness by:

- Reducing flower production and seed set



USGS

Next Steps for Gene Silencing Research

2011

- Identify additional floral or root developmental genes in *Phragmites*
- Test the ability of *pWSRi* to replicate in *Phragmites* leaf disks
- Test RNAi knockdown function of *pWSRi:PharbcS* constructs *in planta*

2012 and beyond (no current funding)

- Test and engineer RNAi knockdown effects for species specificity
- Conduct controlled competition experiments between RNAi treated *Phragmites* and native plants (e.g., *Typha*)
- Develop application technologies for field trials

USGS

Innovative *Phragmites*-control strategies

USGS

WAYNE STATE UNIVERSITY

Great Lakes RESTORATION


USGS