Great Lakes PHRAGMITES COLLABORATIVE

WELCOME!

Effects of Elevated CO_2 and Nitrogen Pollution on *Phragmites australis*

Thomas J. Mozdzer, PhD - *Assistant Professor, Bryn Mawr College*

November 12, 2014

The webinar is listen only. You can listen by phone or through your computer's speakers.

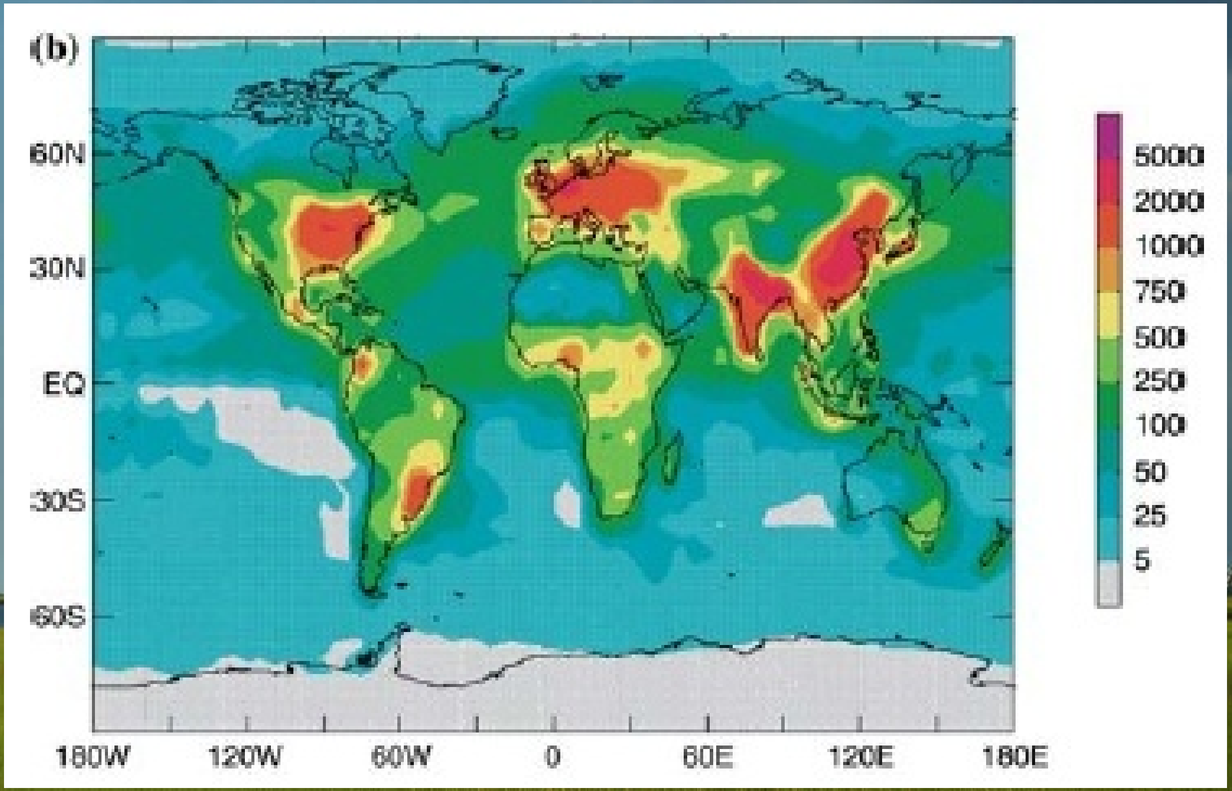
We will begin shortly!

Greetings from Bryn Mawr!

Phragmites in a changing world

Global Change Threats

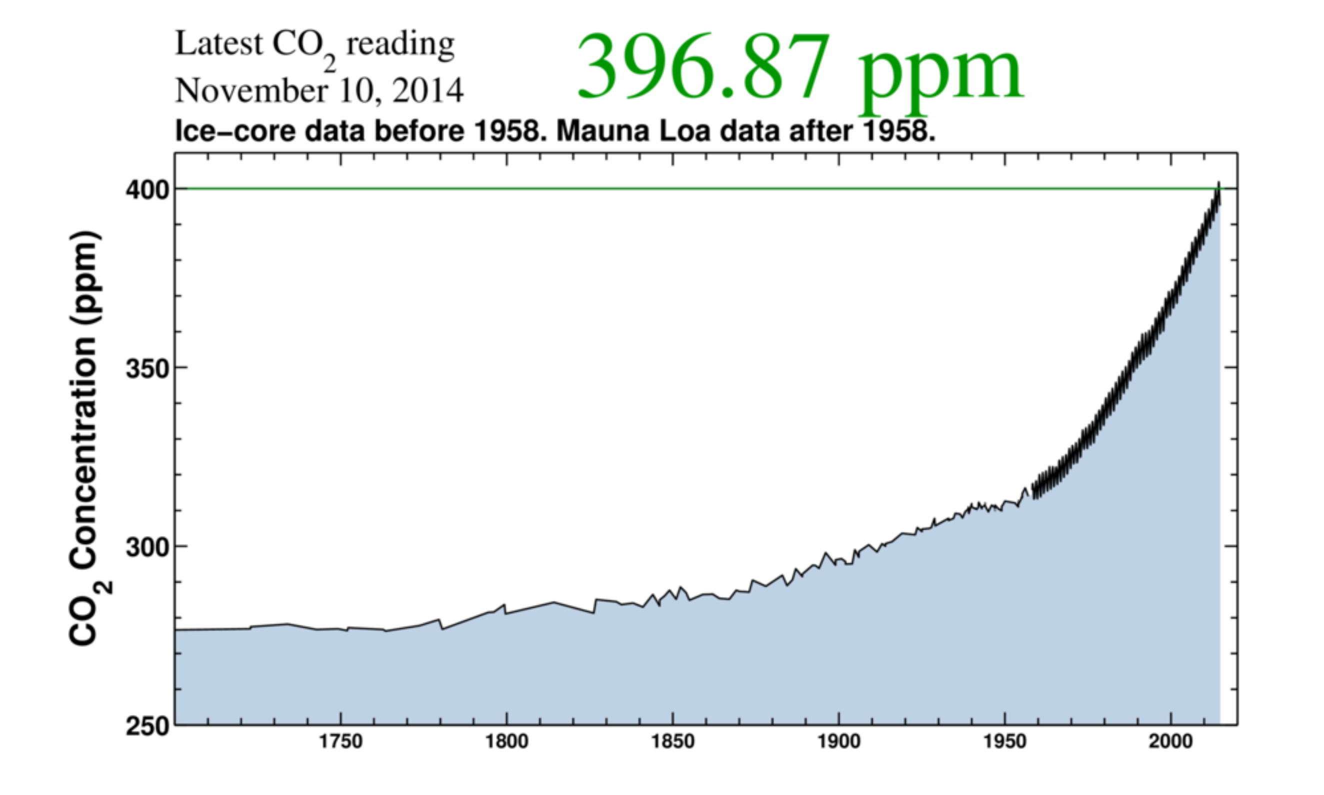
- N Eutrophication



Galloway et al 2004

Global Change Threats

- N Eutrophication
- Rising CO_2



Source: https://scripps.ucsd.edu/programs/keelingcurve/

Global Change Threats

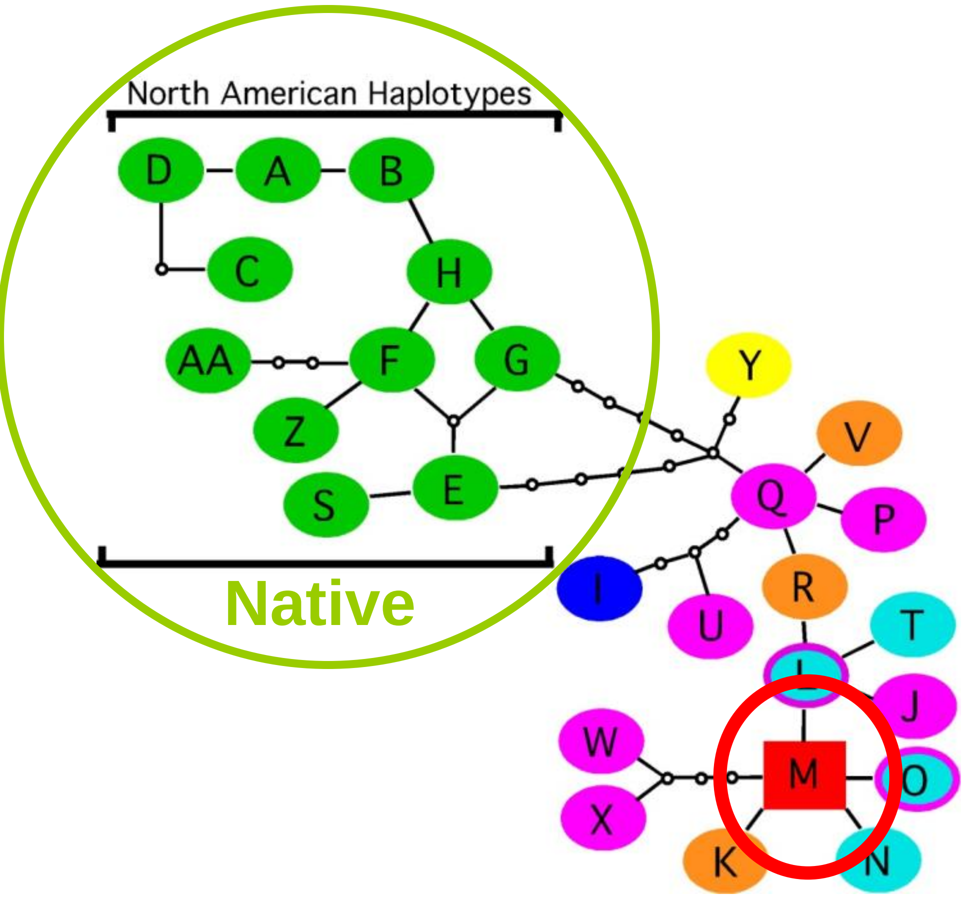
- N Eutrophication
- Rising CO_2
- Invasive species

What is driving the change in plant communities in wetlands?

Recent invasion of *Phragmites australis*

- Interdisciplinary investigations from ecophysiological and ecosystem perspective
- How are native & introduced *Phragmites* lineages affected by global change

Cryptic Invasion of *Phragmites*



Introduced - Eurasia

Non-native lineage of *Phragmites* has been introduced into North America

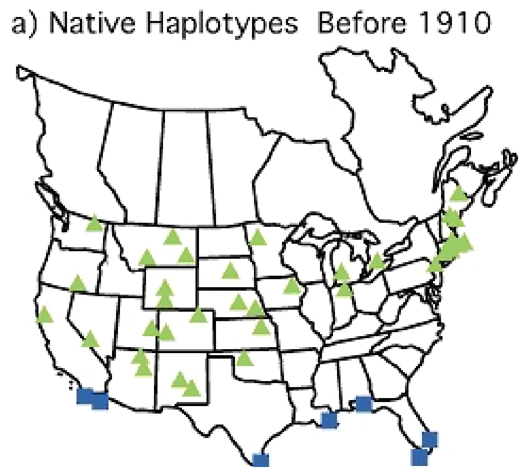
- 27+ types word wide
- 11 types native to North America

Saltonstall 2002 PNAS

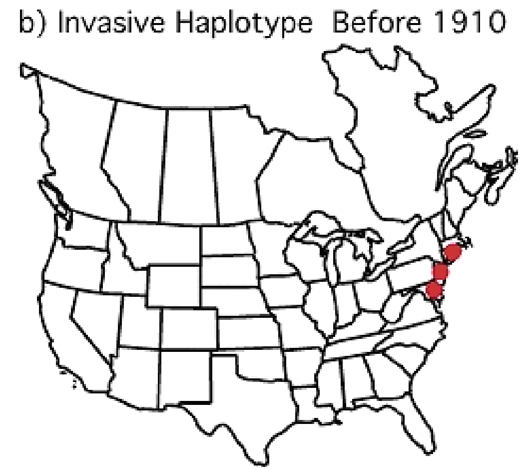
Cryptic Invasion of *Phragmites*

- Prior to 1910, very few introduced populations found in North America

Native



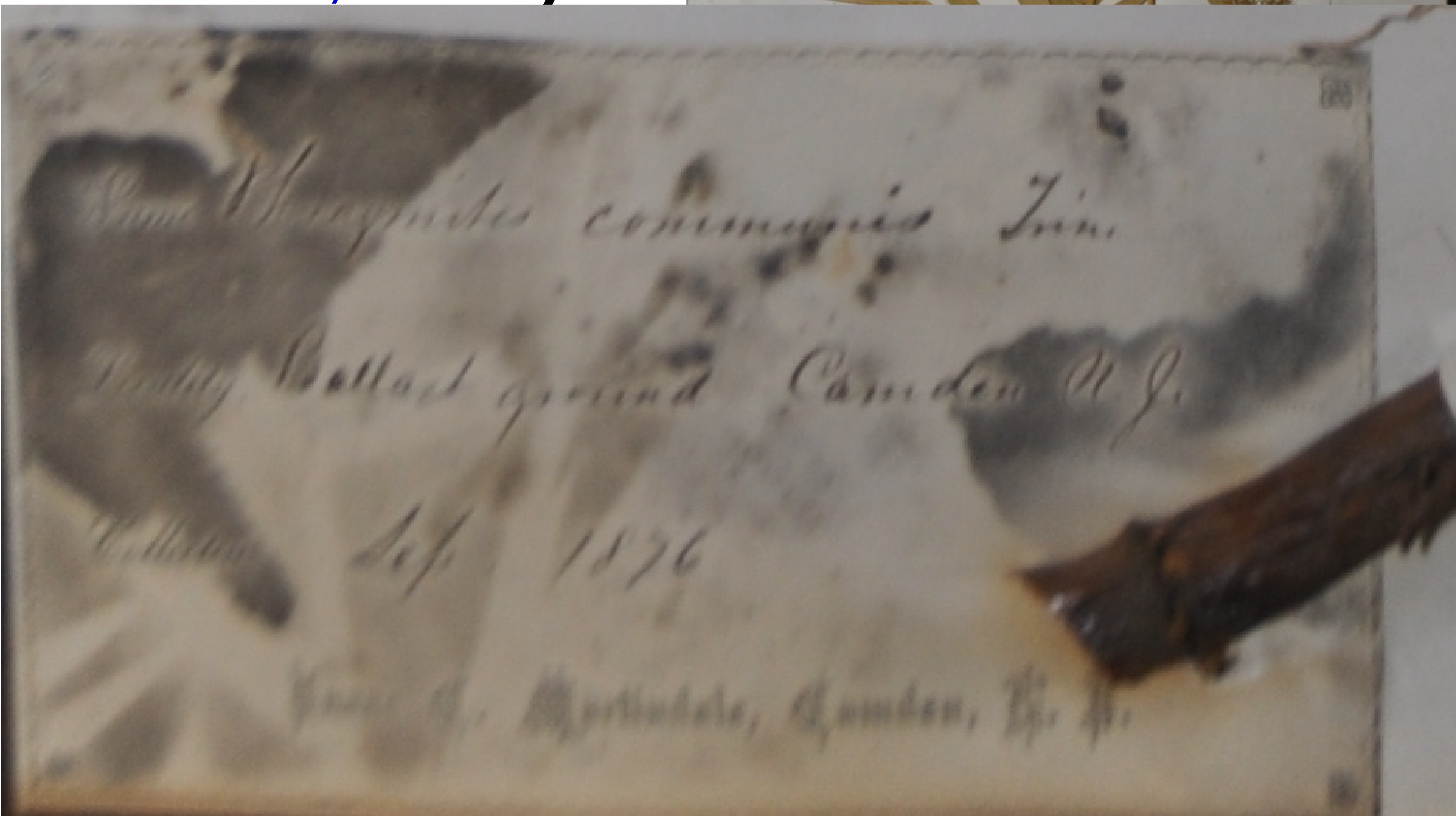
Introduced

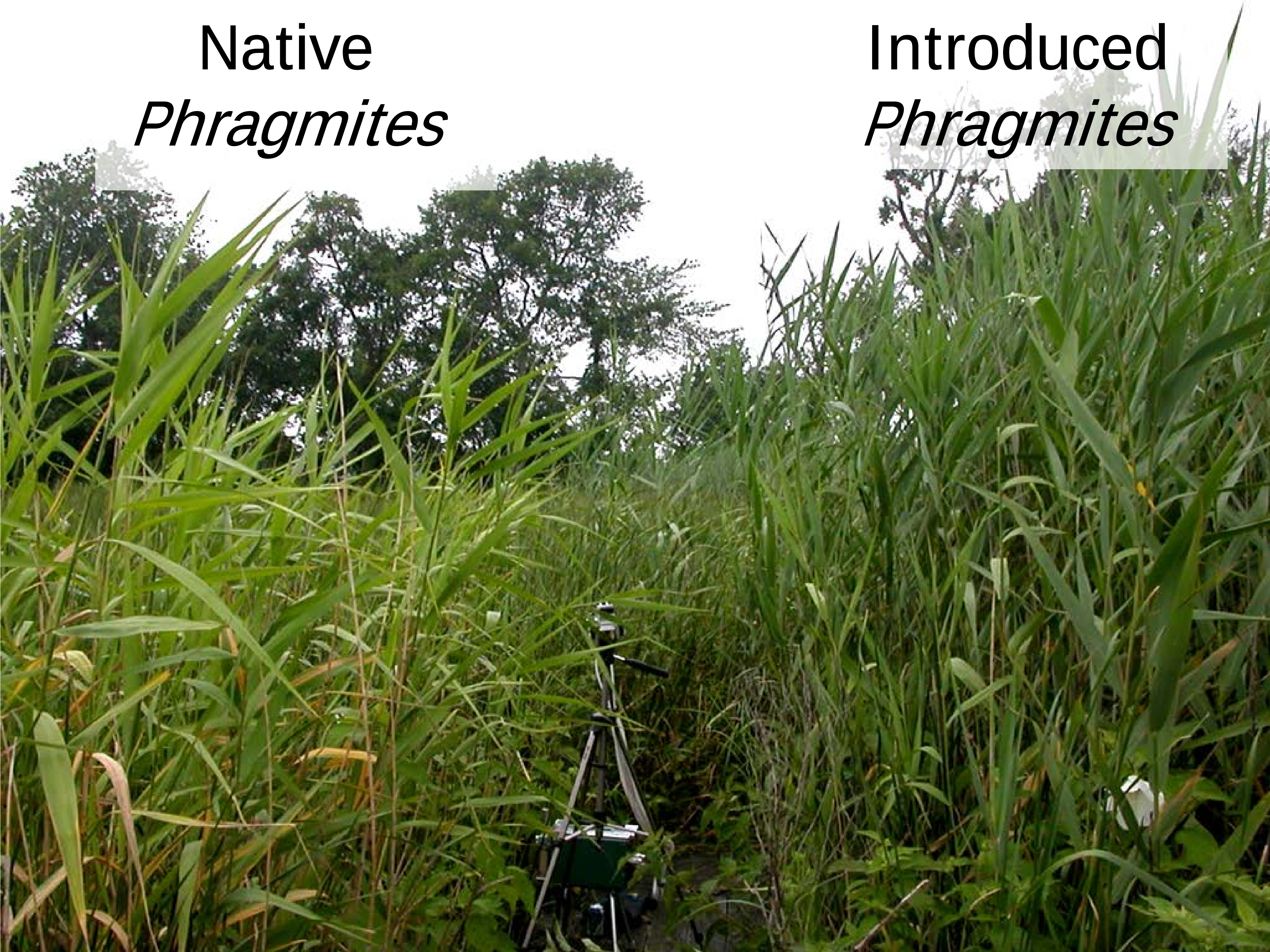


- After 1960, introduced lineage spreading rapidly south and west

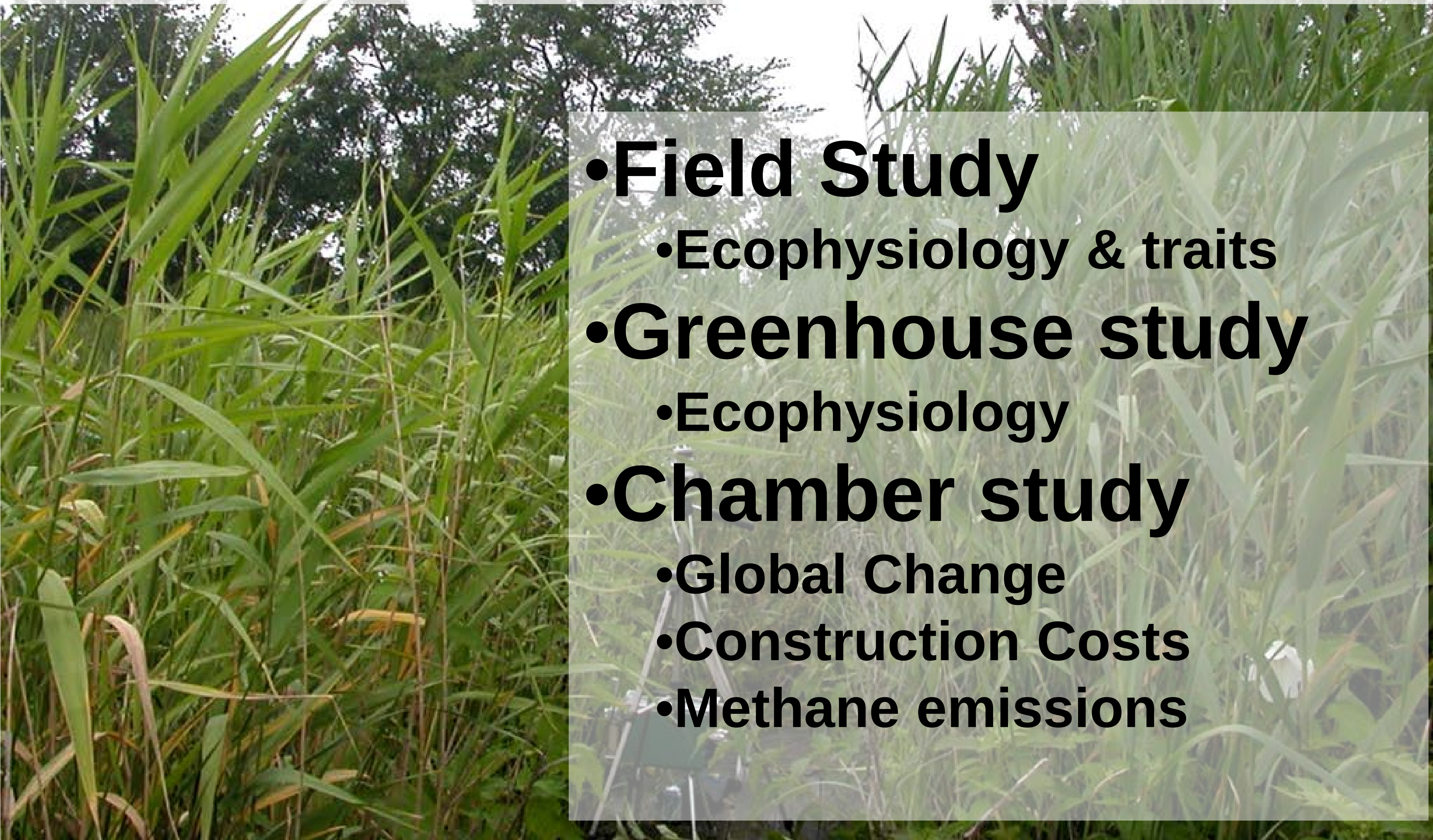
Saltonstall 2002 PNAS

Introduced *Phragmites* Camden, NJ 1876




Native *Phragmites*
Introduced *Phragmites*

What makes the introduced lineage so successful?

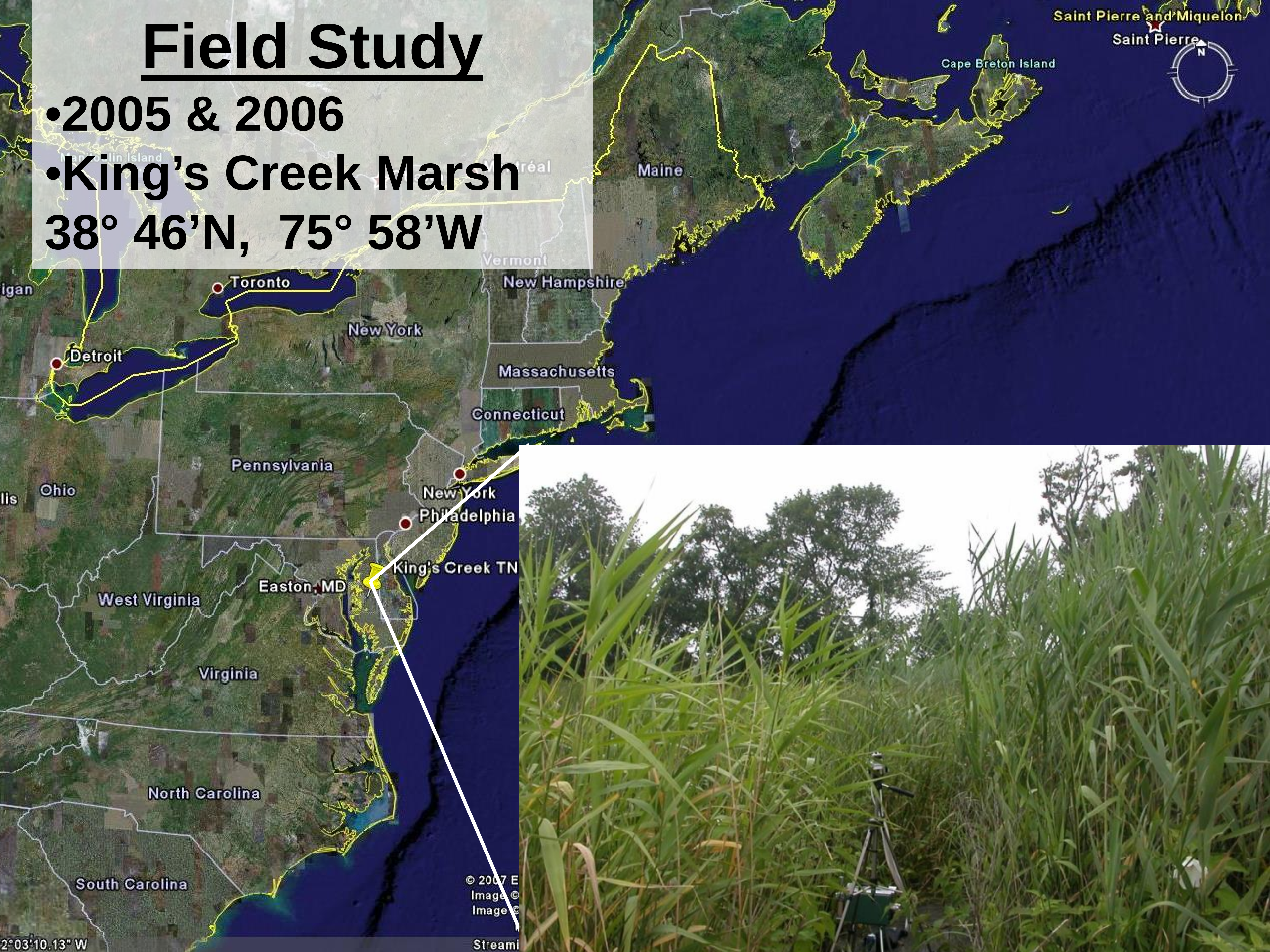


- **Field Study**
  - **Ecophysiology & traits**
- **Greenhouse study**
  - **Ecophysiology**
- **Chamber study**
  - **Global Change**
  - **Construction Costs**
  - **Methane emissions**

Field Study

- 2005 & 2006
- King's Creek Marsh

38° 46'N, 75° 58'W



Measured photosynthetic rates for two years

Journal of Ecology

Journal of Ecology 2010, **98**, 451–458 doi: 10.1111/j.1365-2745.2009.01625.x

Ecophysiological differences between genetic lineages facilitate the invasion of non-native *Phragmites australis* in North American Atlantic coast wetlands

Thomas J. Mozdzer*† and Joseph C. Zieman

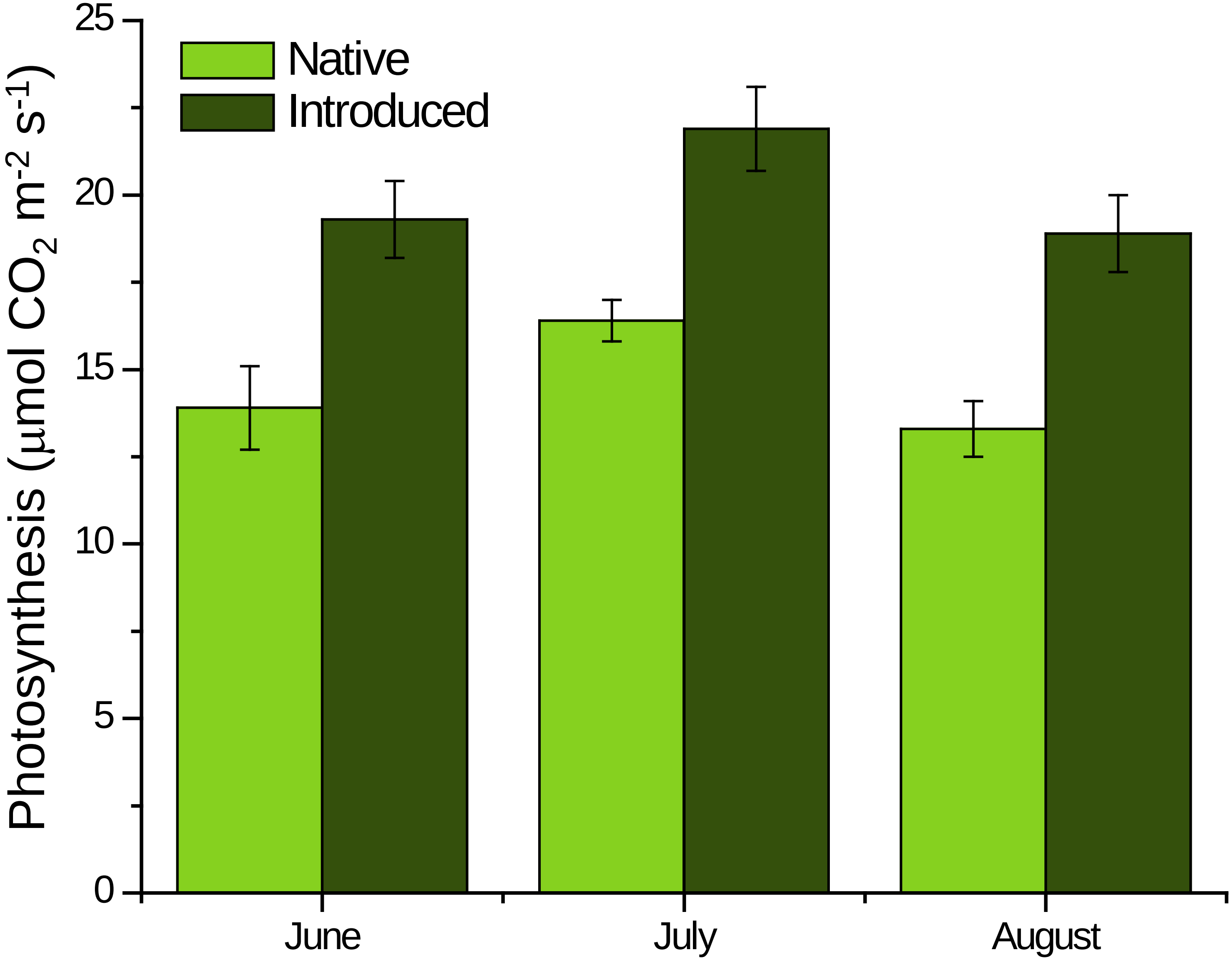
Department of Environmental Sciences, University of Virginia, 291 McCormick Rd, PO Box 400123, Charlottesville, VA 22904, USA

Summary

1. Over the last century, native *Phragmites australis* lineages have been almost completely replaced along the North American Atlantic coast by an aggressive lineage originating from Eurasia. Understanding the mechanisms that facilitate biological invasions is critical to better understand what makes an invasive species successful.

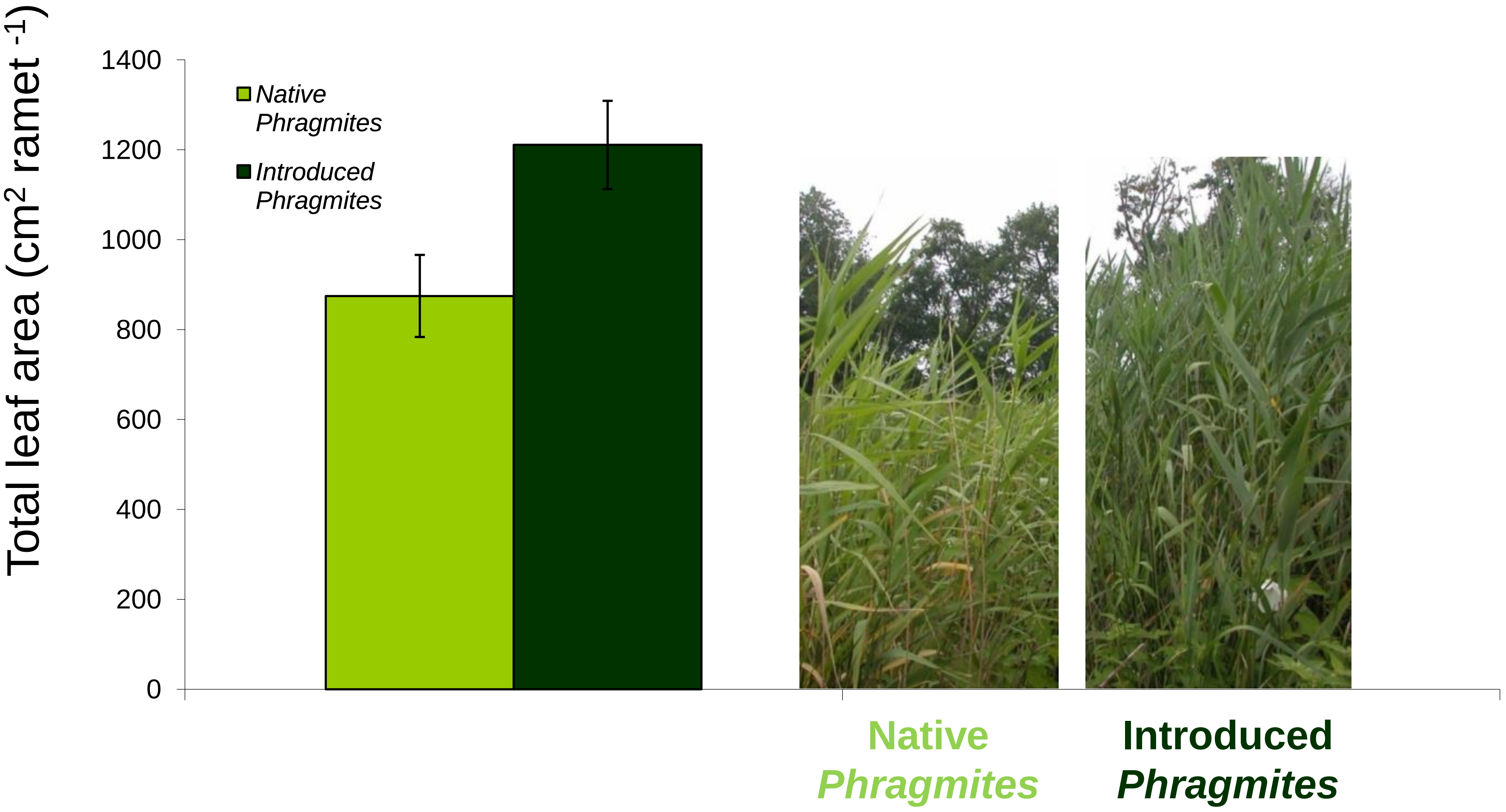
2. Our objective was to determine what makes the introduced lineage so successful in the study area by specifically investigating if morphological and ecophysiological differences exist between native and introduced genetic lineages of *P. australis*. We hypothesized *a priori* that due to phenotypic differences and differences in plant nitrogen (N) content between lineages, the introduced lineage would have a greater photosynthetic potential.

Introduced has 30-44% greater PS rate



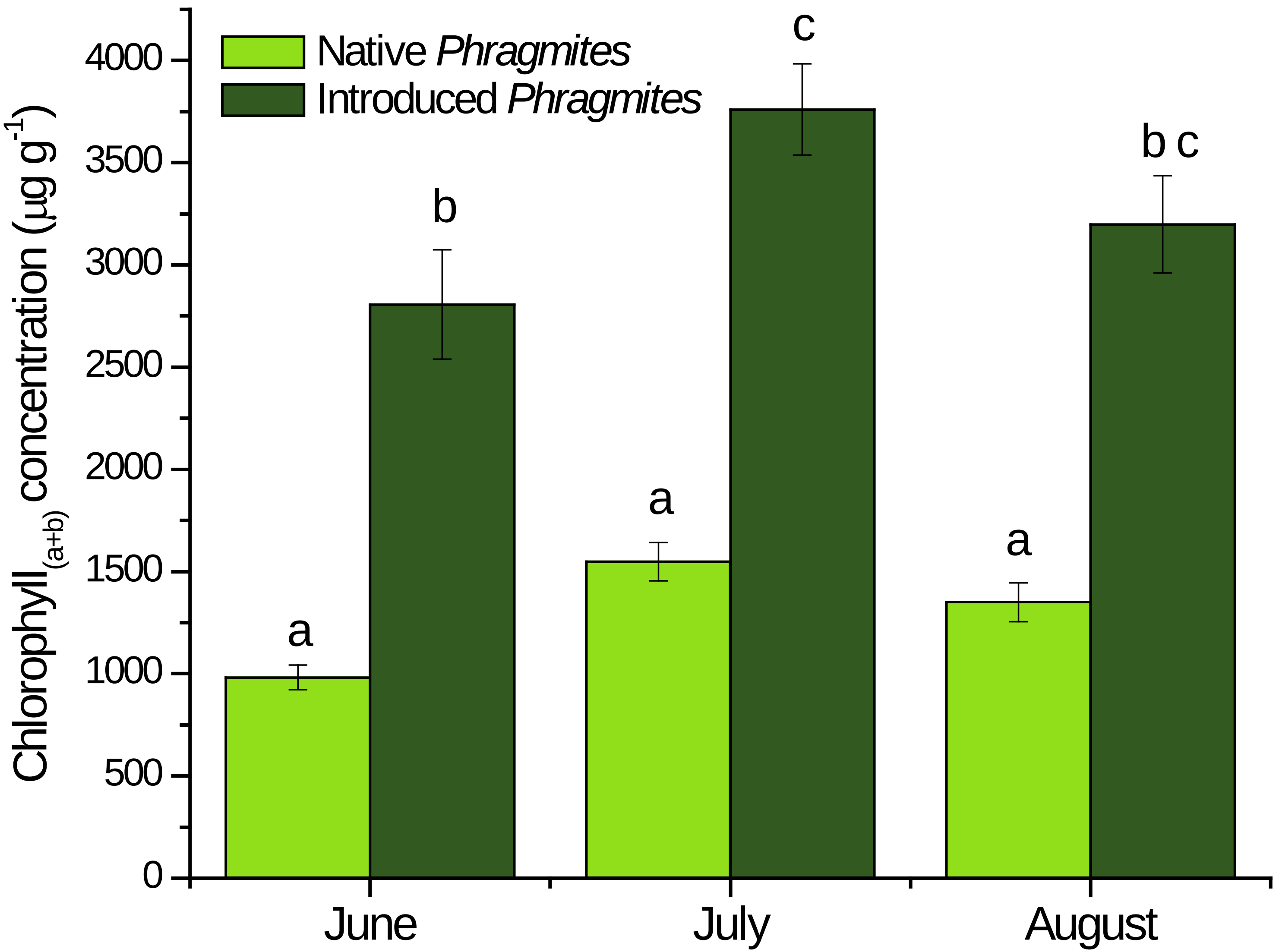
Mozdzer & Zieman 2010 *Journal of Ecology*

Introduced has 50% greater canopy



Mozdzer & Zieman 2010 *Journal of Ecology*

Introduced has 2× chlorophyll concentration



Mozdzer & Zieman 2010 *Journal of Ecology*

AoB PLANTS
The open-access journal for plant sciences

Invited Review

SPECIAL ISSUE: *Phragmites australis* in North America and Europe

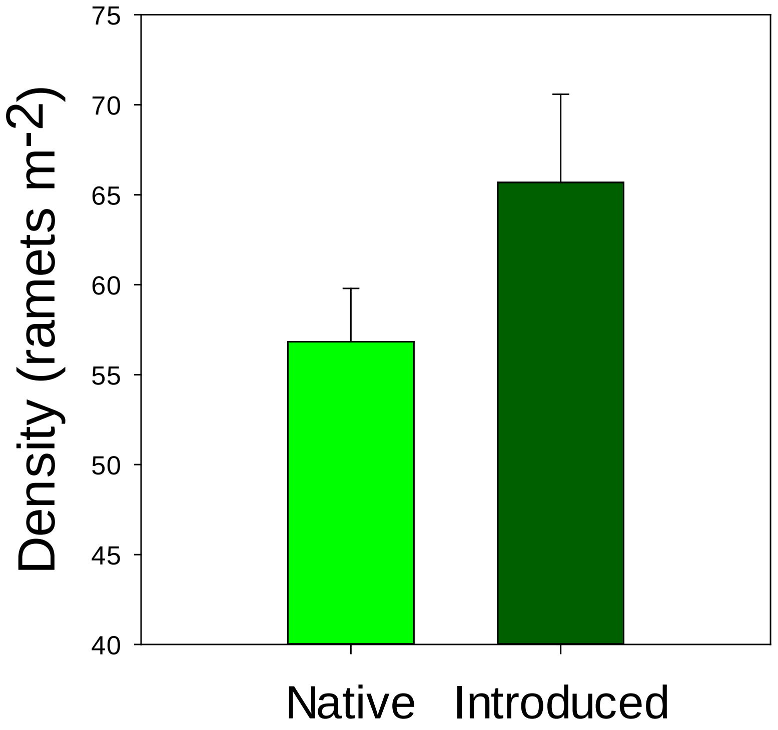
Physiological ecology and functional traits of North American native and Eurasian introduced *Phragmites australis* lineages

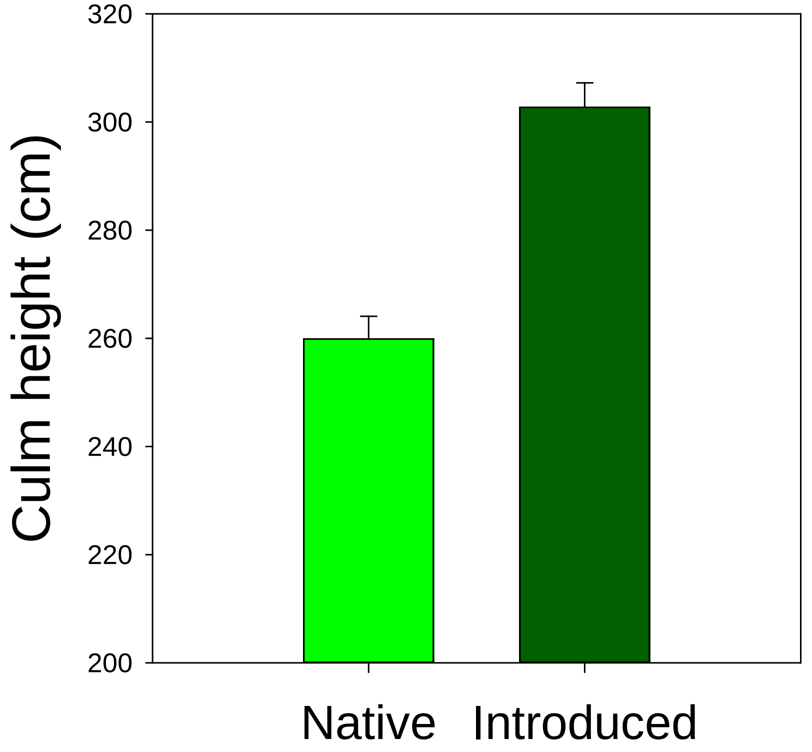
Thomas J. Mozdzer[1]*, Jacques Brisson[2] and Eric L. G. Hazelton[3,4]

[1] Biology Department, Bryn Mawr College, Bryn Mawr, PA 19010, USA
[2] Département de sciences biologiques, Institut de recherche en biologie végétale, University of Montreal, 4101 East, Sherbrooke Street, Montreal, QC, Canada H1X 2B2
[3] Ecology Center and Department of Watershed Science, Utah State University, Logan, UT 84322, USA
[4] Smithsonian Environmental Research Center, PO Box 28, 647 Contees Wharf Road, Edgewater, MD 21037, USA



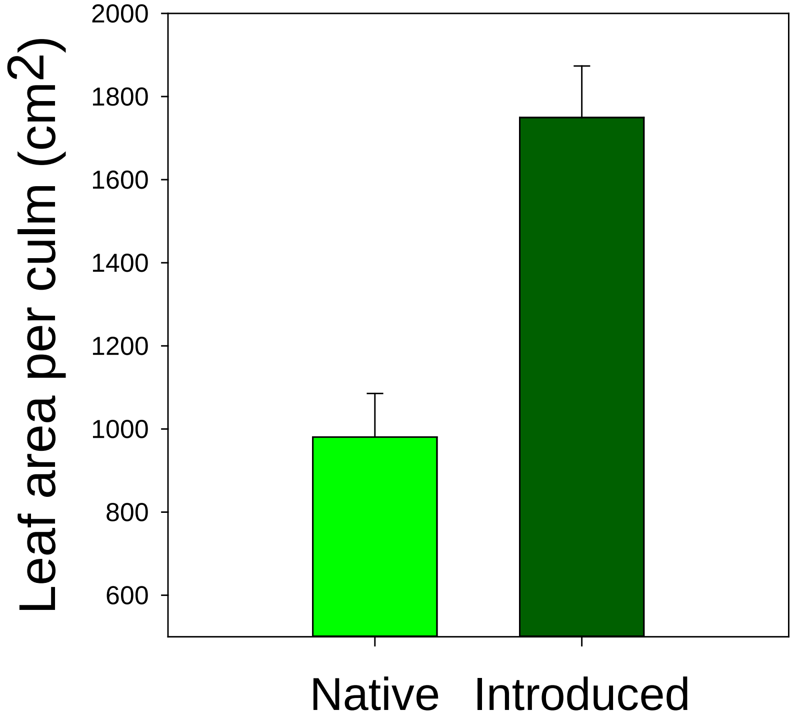
Introduced has greater Density & is Taller

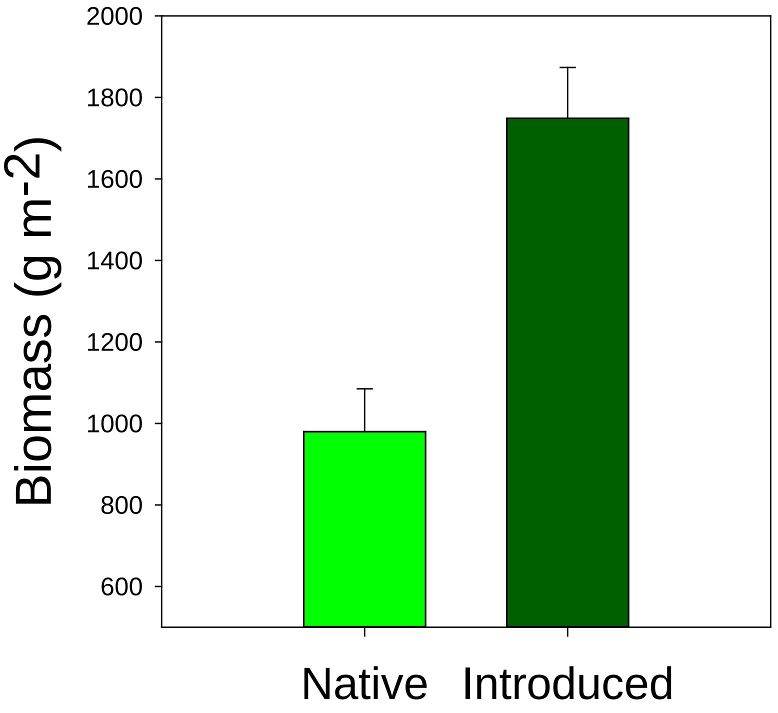




Mozdzer *et al* 2013 AoB Plants

Introduced has greater Leaf Area & Biomass

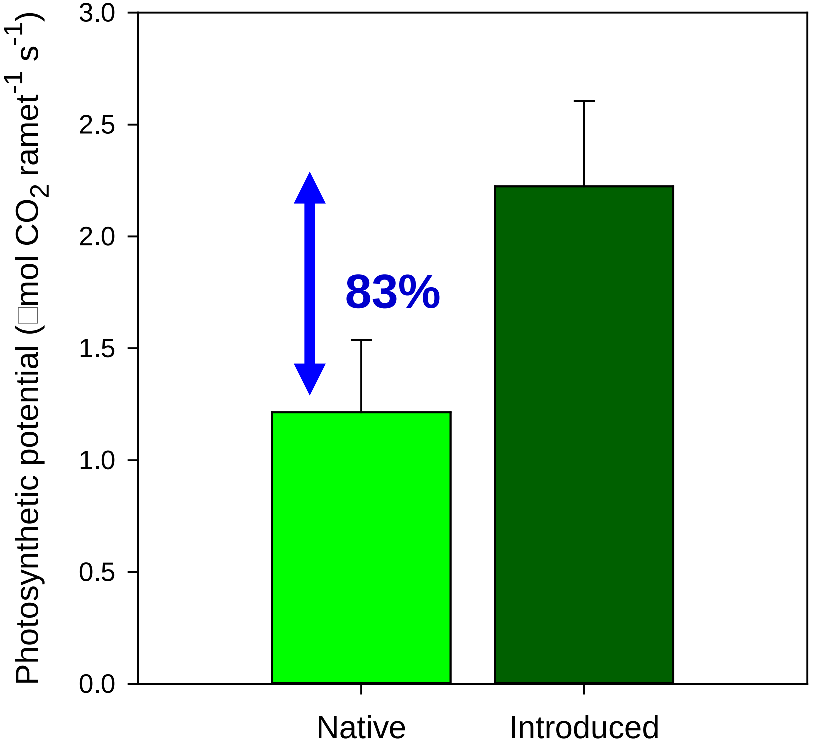




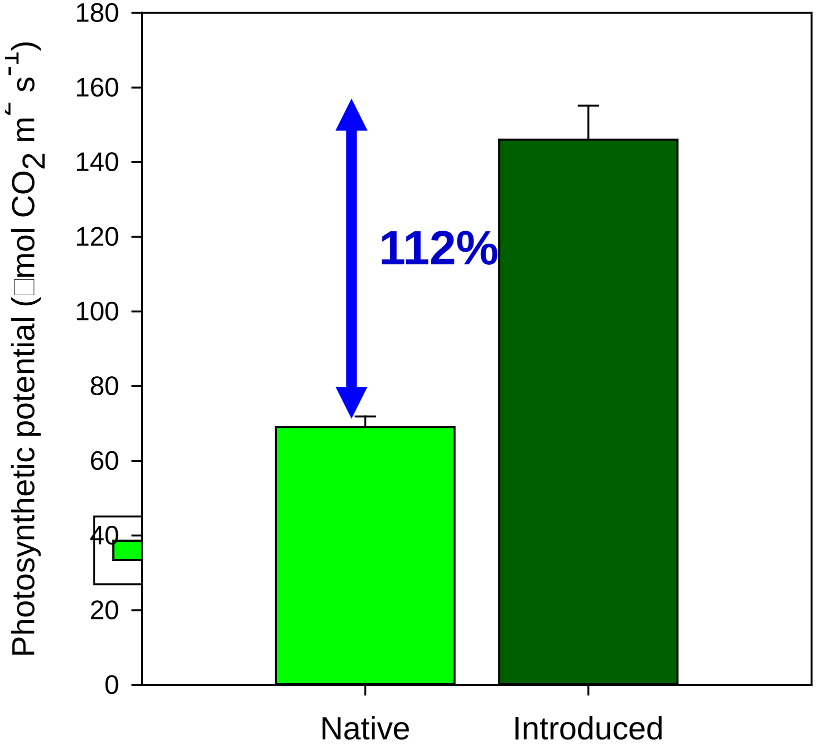
Mozdzer et al 2013 AoB Plants

Scaling Results Up

Per Plant



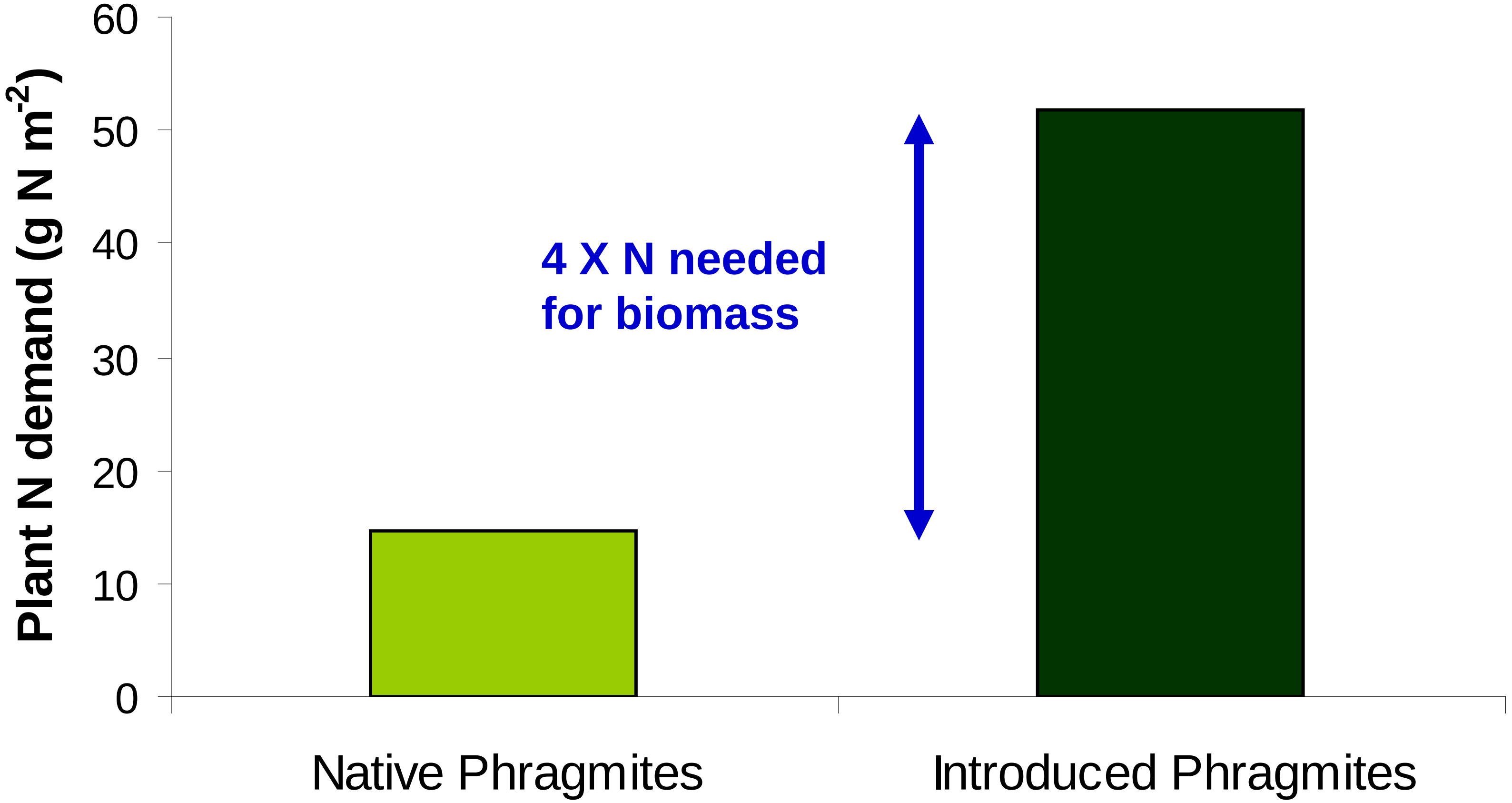
Per m^2 marsh



- Introduced has 83% greater PS rate per plant
- Introduced has 112% greater rate per m^2

Mozdzer *et al* 2013 AoB Plants

Introduced demands 4 × more N



Plant N Content	2.3%	2.8%

Mozdzer & Zieman 2010 *Journal of Ecology*

Estuaries and Coasts (2010) 33:784–797
DOI 10.1007/s12237-009-9254-9

Nitrogen Uptake by Native and Invasive Temperate Coastal Macrophytes: Importance of Dissolved Organic Nitrogen

Thomas J. Mozdzer · Joseph C. Zieman · Karen J. McGlathery

Received: 3 July 2009 / Revised: 27 November 2009 / Accepted: 4 December 2009 / Published online: 19 February 2010

Abstract We investigated if the success of the invasive common reed *Phragmites australis* could be attributed to a competitive ability to use dissolved organic nitrogen (DON) when compared to the dominant macrophyte *Spartina alterniflora* in tidal wetlands. Short-term nutrient uptake experiments were performed in the laboratory on two genetic lineages of *Phragmites* (native and introduced to North America) and *S. alterniflora*. Our results provide the first evidence for direct assimilation of DON by

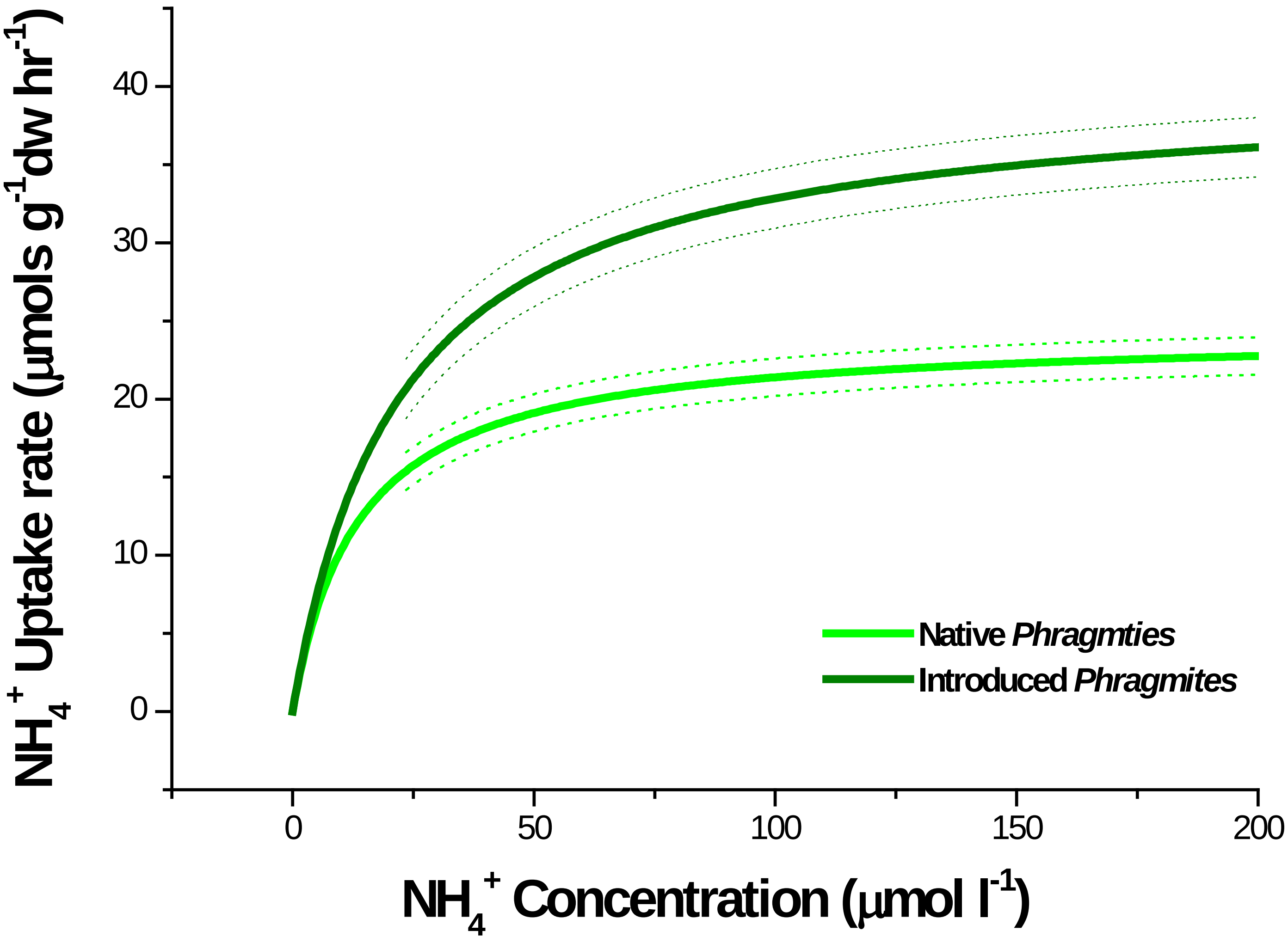
Keywords *Phragmites* · *Spartina* · Amino acids · Urea · DON · N uptake

Introduction

Intertidal marshes of the North American Atlantic coast are dominated by the halophytic smooth cordgrass, *Spartina alterniflora* (Mitsch and Gosselink 1993). Over the past


Saint Pierre and Miquelon
Saint Pierre
Cape Breton Island
Manitoulin Island
Ottawa
Montréal
Maine
Vermont
New Hampshire
Toronto
New York
Detroit
Massachusetts
Connecticut
Pennsylvania
Ohio
New York
Philadelphia
King's Creek TNC site
Easton, MD
West Virginia
Virginia
North Carolina
South Carolina
http://www.personal-drones.net/wp-content/uploads/2013/10/University_of_Virginia_Rotunda_20061.jpeg
© 2007 Europa Technologies
Image © 2007 TerraMetrics
Image © 2007 DigitalGlobe
Image NASA
©2007 Google™
Streaming 100%
Eye alt 1380.44 mi

Introduced better under higher [N]



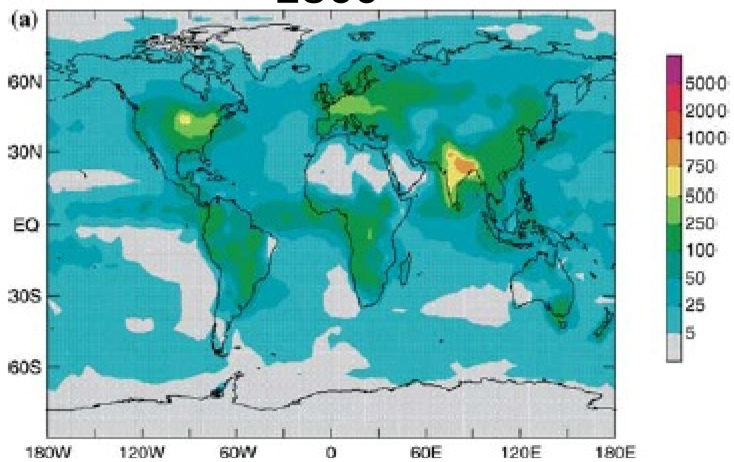
Mozdzer et al. 2010 *Estuaries & Coasts*

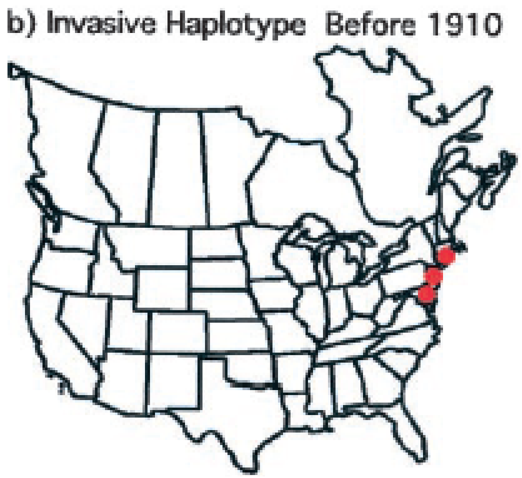
Native		Introduced
-	Canopy	+
-	Chlorophyll	+
-	A_{max}	+
+	$N_{affinity}$	-
-	N_{uptake}	+
-	N demand	+

Effects of Global Change

Atmospheric N deposition

1860

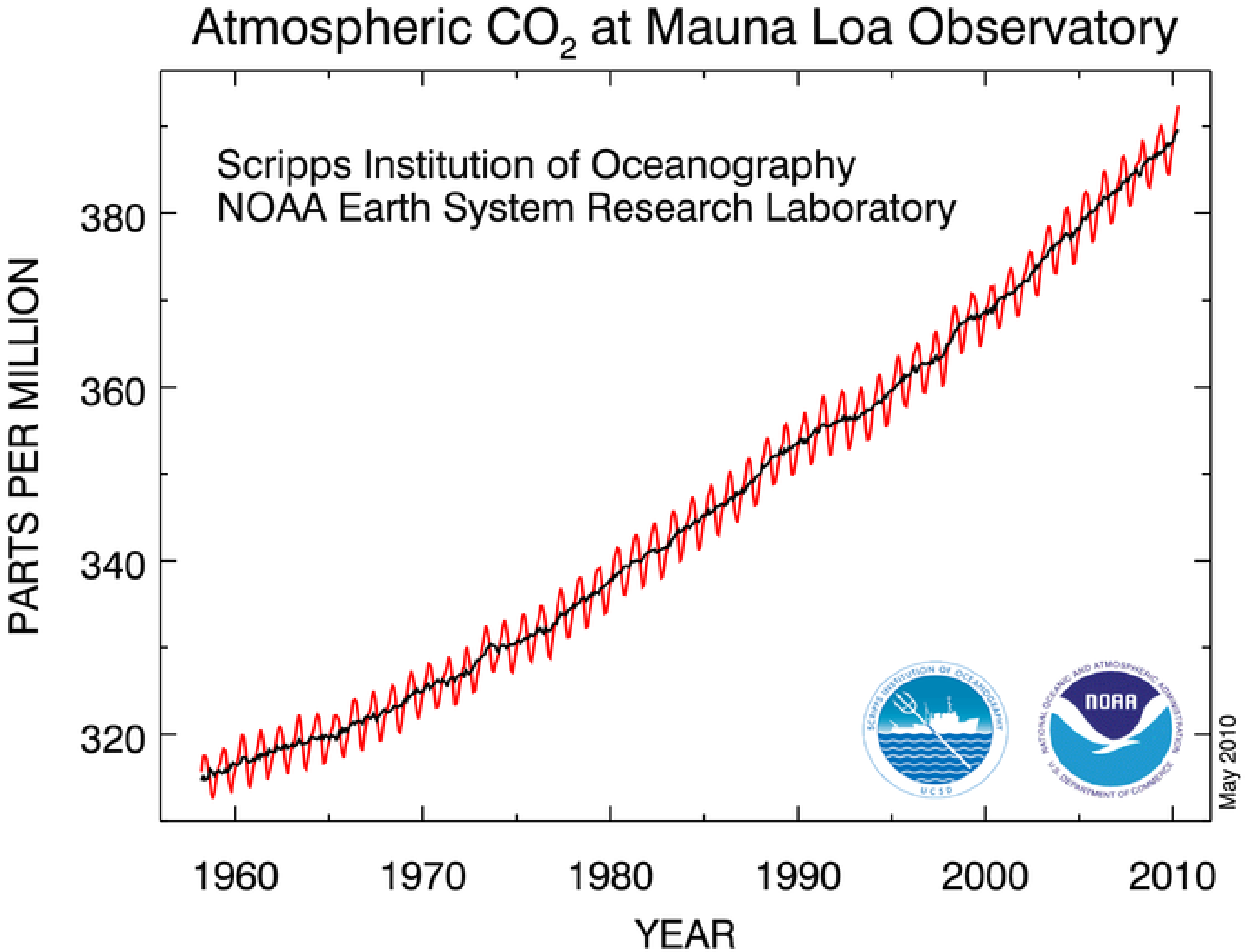




Galloway et al 2004

Saltonstall 2002

CO_2 concentrations are increasing



http://www.esrl.noaa.gov/gmd/ccgg/trends/

How may *Phragmites* respond in the coming century to changes in CO_2 and N pollution?

Chamber Study

- 2009
- SERC
- 38° 53’N, 76° 33’W

Chamber Experiment

- Native & Introduced *Phragmites*
- 2 N levels
  - Ambient & Eutrophied
- 2 CO_2 levels
  - Ambient Elevated

OPEN ACCESS Freely available online

PLOS | ONE

Jack-and-Master Trait Responses to Elevated CO_2 and N: A Comparison of Native and Introduced *Phragmites australis*

Thomas J. Mozdzer*¤, J. Patrick Megonigal

Smithsonian Environmental Research Center, Edgewater, Maryland, United States of America

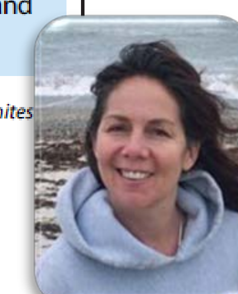
Abstract

Global change is predicted to promote plant invasions world-wide, reducing biodiversity and ecosystem function. Phenotypic plasticity may influence the ability of introduced plant species to invade and dominate extant communities. However, interpreting differences in plasticity can be confounded by phylogenetic differences in morphology and physiology. Here we present a novel case investigating the role of fitness trait values and phenotypic plasticity to global change factors between conspecific lineages of *Phragmites australis*. We hypothesized that due to observed differences in the competitive success of North American-native and Eurasian-introduced *P. australis* genotypes, Eurasian-introduced *P. australis* would exhibit greater fitness in response to global change factors. Plasticity and plant performance to ambient and predicted levels of carbon dioxide and nitrogen pollution were investigated to understand how invasion pressure may change in North America under a realistic global change scenario. We found that the introduced Eurasian genotype expressed greater mean trait values in nearly every ecophysiological trait measured – aboveground and belowground – to elevated CO_2 and nitrogen, outperforming the native North American conspecific by a factor of two to three under every global change scenario. This response is consistent with "jack and master" phenotypic plasticity. We suggest that differences in plant nitrogen productivity, specific leaf area, belowground biomass allocation, and inherently higher relative growth rate are the plant traits that may enhance invasion of Eurasian *Phragmites* in North America. Given the high degree of genotypic variability within this species, and our limited number of genotypes, our results must be interpreted cautiously. Our study is the first to demonstrate the potential importance of jack-and-master phenotypic plasticity in plant invasions when facing imminent global change conditions. We suggest that jack-and-master invasive genotypes and/or species similar to introduced *P. australis* will have an increased ecological fitness, facilitating their invasion in both stressful and resource rich environments.

Citation: Mozdzer TJ, Megonigal JP (2012) Jack-and-Master Trait Responses to Elevated CO_2 and N: A Comparison of Native and Introduced *Phragmites australis*. PLoS ONE 7(10): e42794. doi:10.1371/journal.pone.0042794

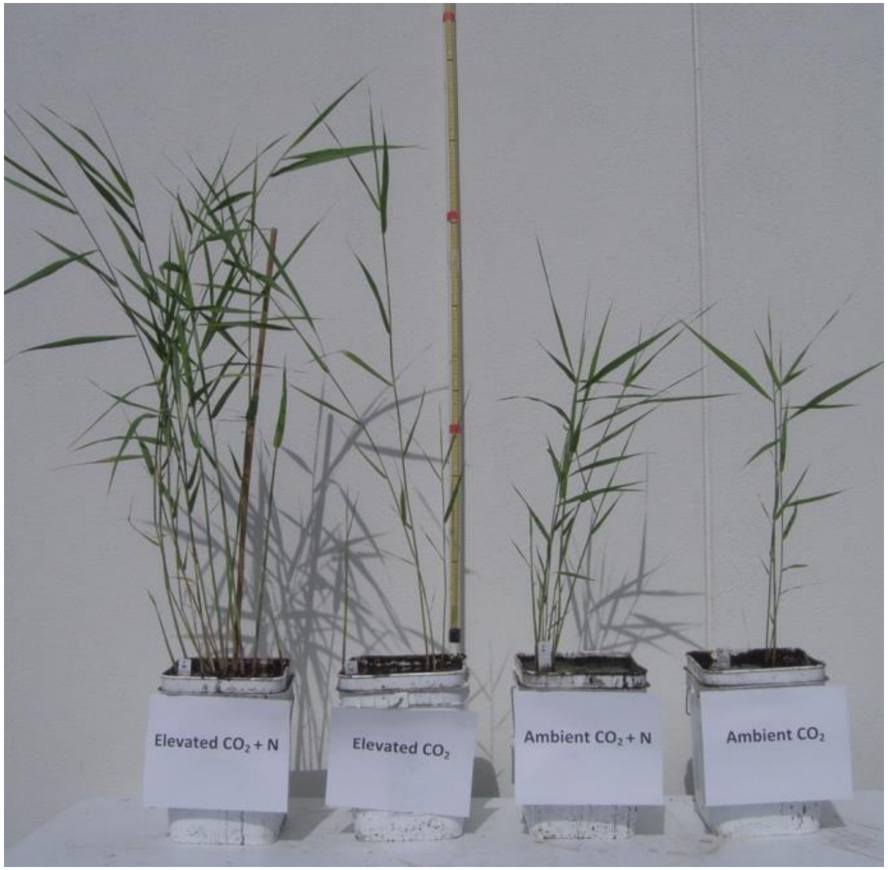
Editor: Jacqueline Mohan, University of Georgia, United States of America

Thanks to Laura Meyerson for providing plants!



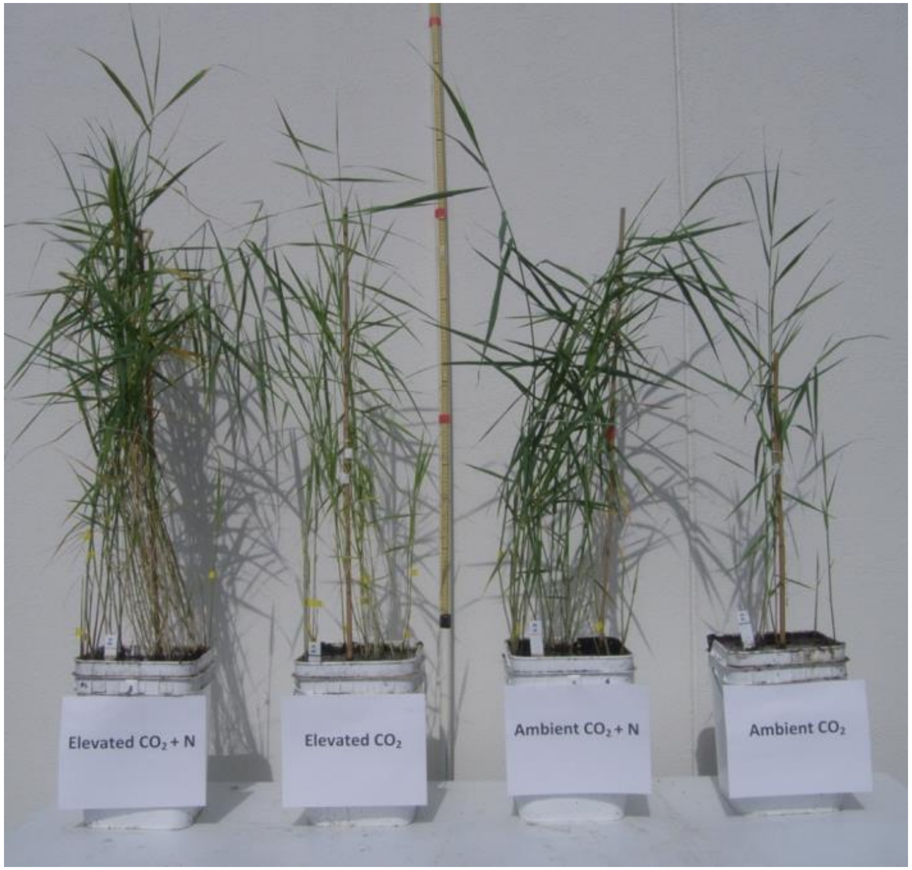
Effects of CO_2 & N on *Phragmites*

Native



eCO_2 +N **eCO_2 no N** **aCO_2 + N** **aCO_2 no N**

Introduced



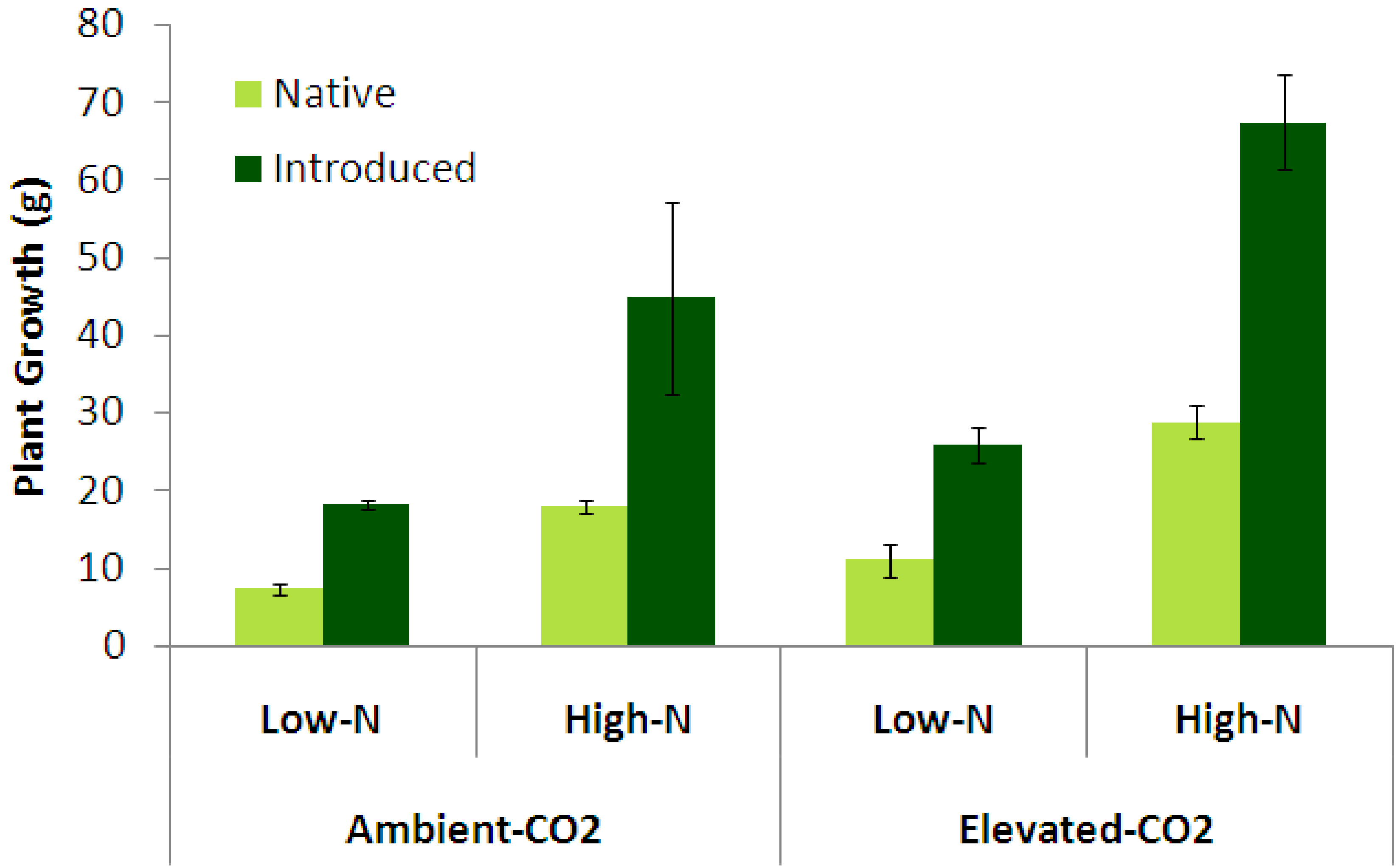
eCO_2 +N **eCO_2 no N** **aCO_2 + N** **aCO_2 no N**

Differential belowground response

Native

Introduced

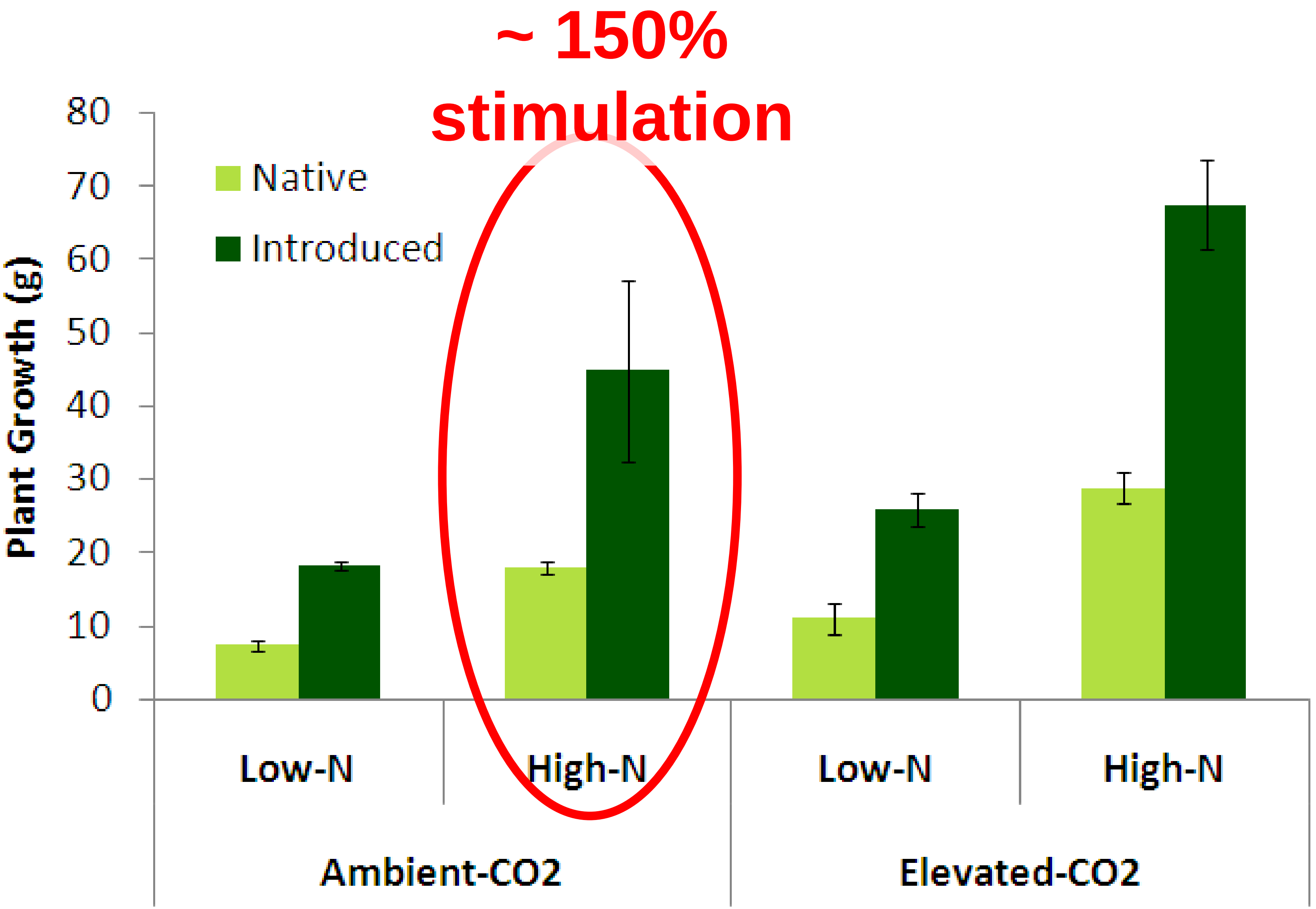
Effects of Predicted Global Change



Type $p<0.0001$

Mozdzer & Megonigal. 2012 *PLoS ONE*

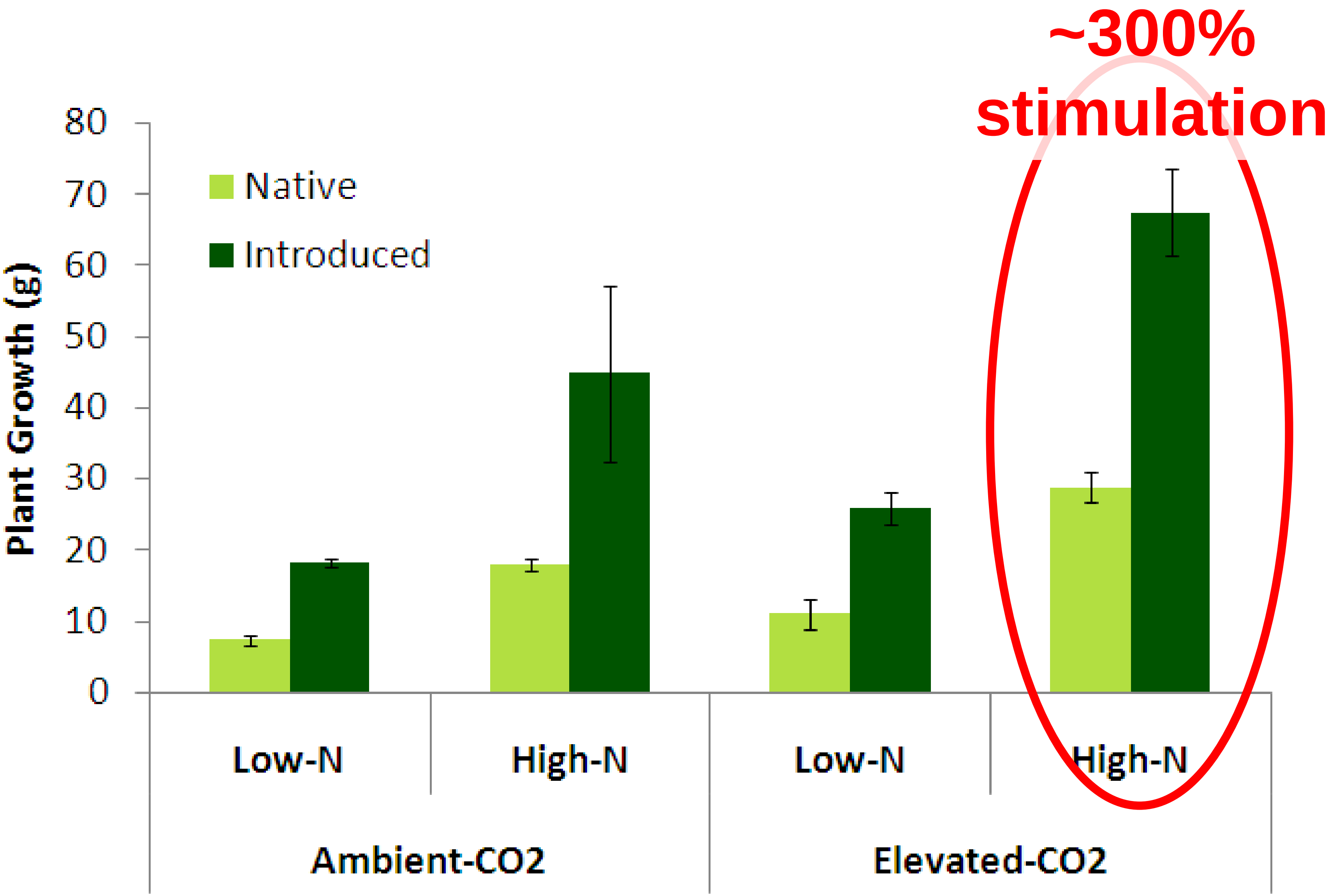
Introduced greater response to N



N $p<0.001$; Type×N $p= 0.0239$

Mozdzer & Megonigal. 2012 *PLoS ONE*

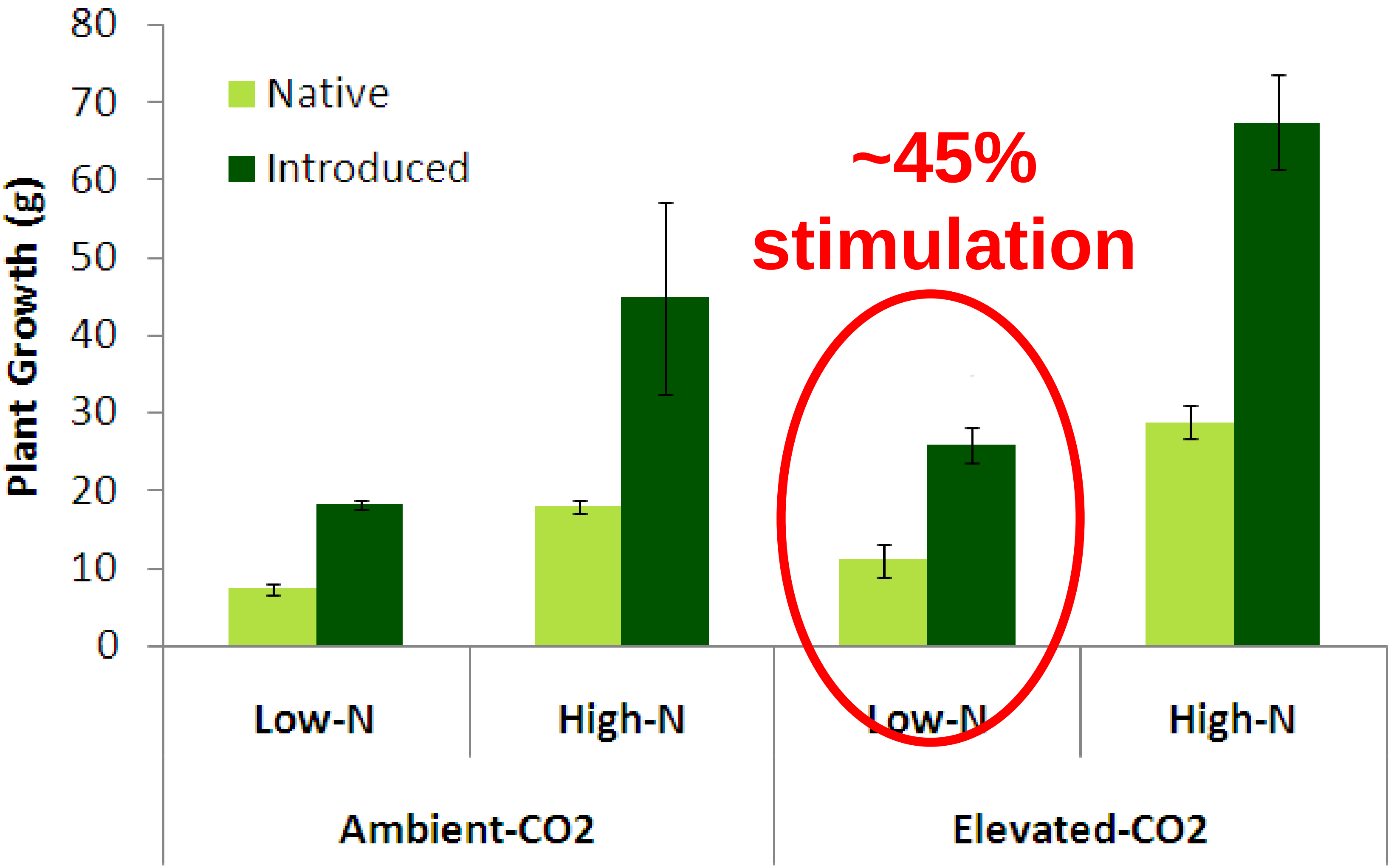
Introduced 3X response to CO_2+N



CO_2×N p=0.0476; Type×CO_2×N p= 0.0239

Mozdzer & Megonigal. 2012 *PLoS ONE*

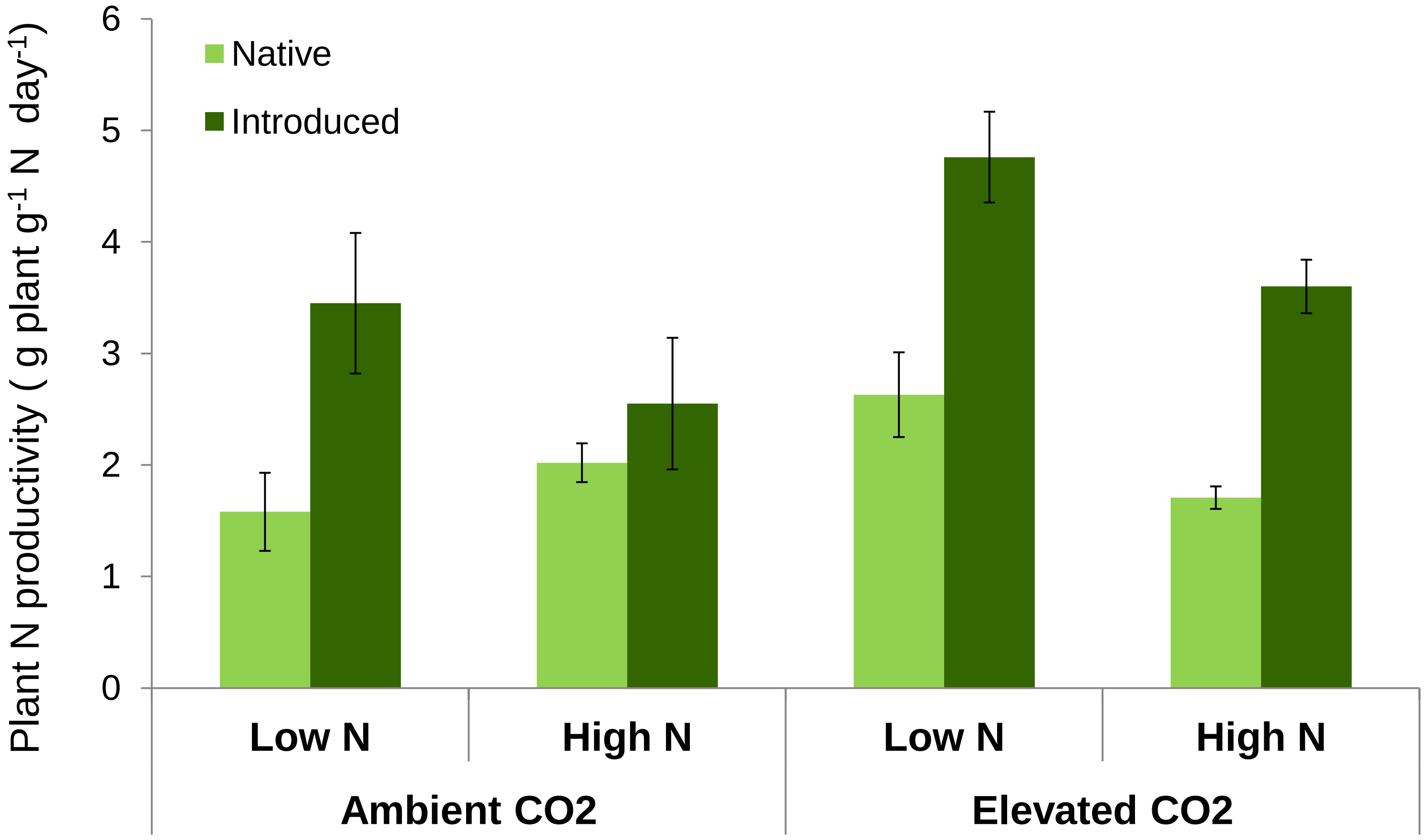
CO_2 response muted if N not available



CO_2 $p=0.0004$

Mozdzer & Megonigal. 2012 *PLoS One*

Introduced has greater NP – better at ↓ N



Mozdzer & Megonigal. 2012 *PLoS One*

G $p<0.0001$, CO_2 $p<0.0001$, N $p=0.142$, G×N $p=0.032$

Construction costs

- Energy needed to synthesize biomass
    - g glucose per g tissue
    - Estimated from [C], [N] and [ash]
        - High cost: lignin, protein
        - Low cost: starch
    - Pioneered by Penning De Vries 1974
        - See http://www.science.poorter.eu/HS33_index.html for more info
- Associated with longevity & payback time
- Usually measured in leaves

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Research Article

SPECIAL ISSUE: *Phragmites australis* in North America and Europe

Belowground advantages in construction cost facilitate a cryptic plant invasion

Joshua S. Caplan[1,2], Christine N. Wheaton[1] and Thomas J. Mozdzer[1,2*]

[1] Department of Biology, Bryn Mawr College, Bryn Mawr, PA, USA
[2] Smithsonian Environmental Research Center, Edgewater, MD, USA

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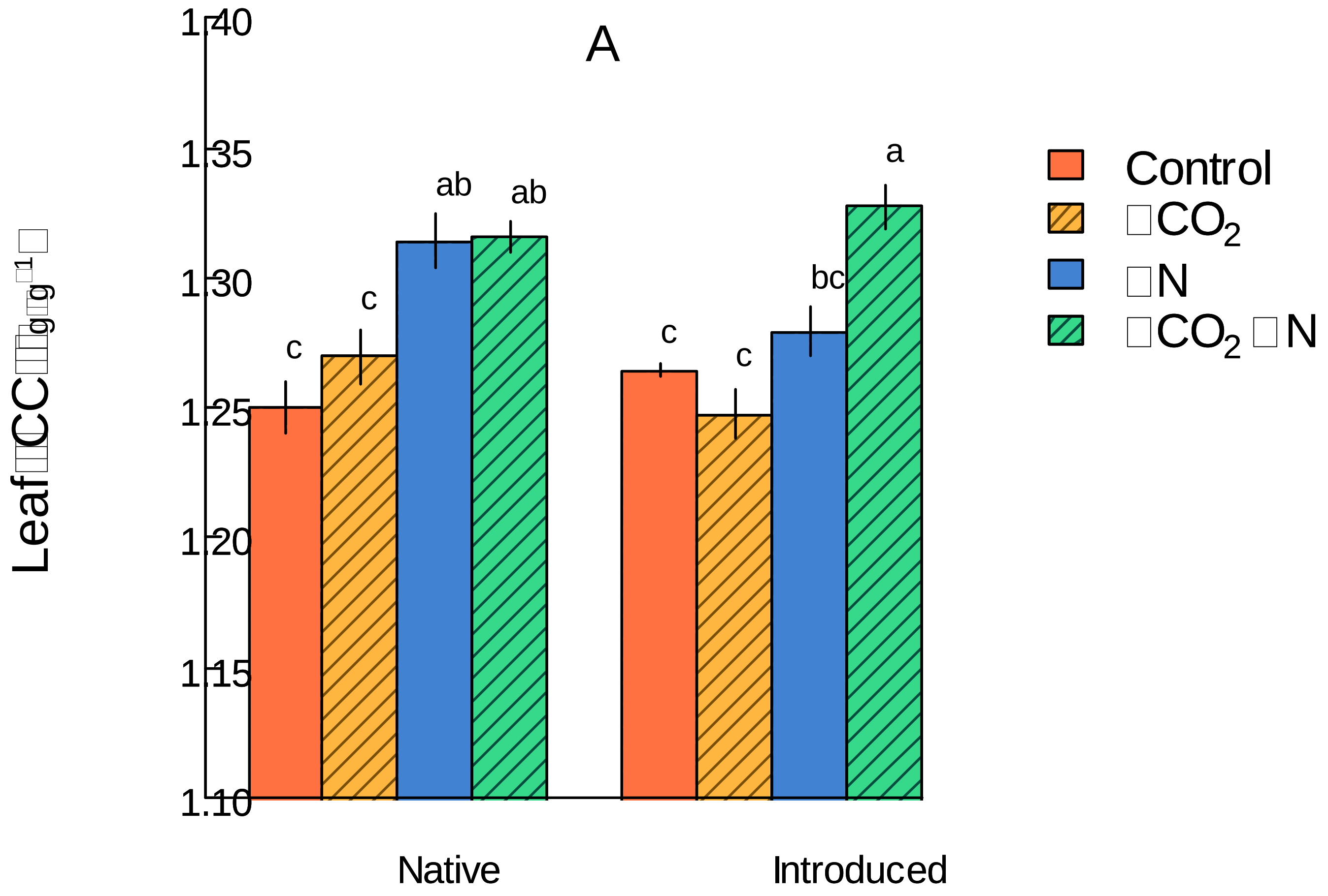
Associate Editor: Dennis F. Whigham

Citation: Caplan JS, Wheaton CN, Mozdzer TJ. 2014. Belowground advantages in construction cost facilitate a cryptic plant invasion. *AoB PLANTS* **6**: plu020; doi:10.1093/aobpla/plu020

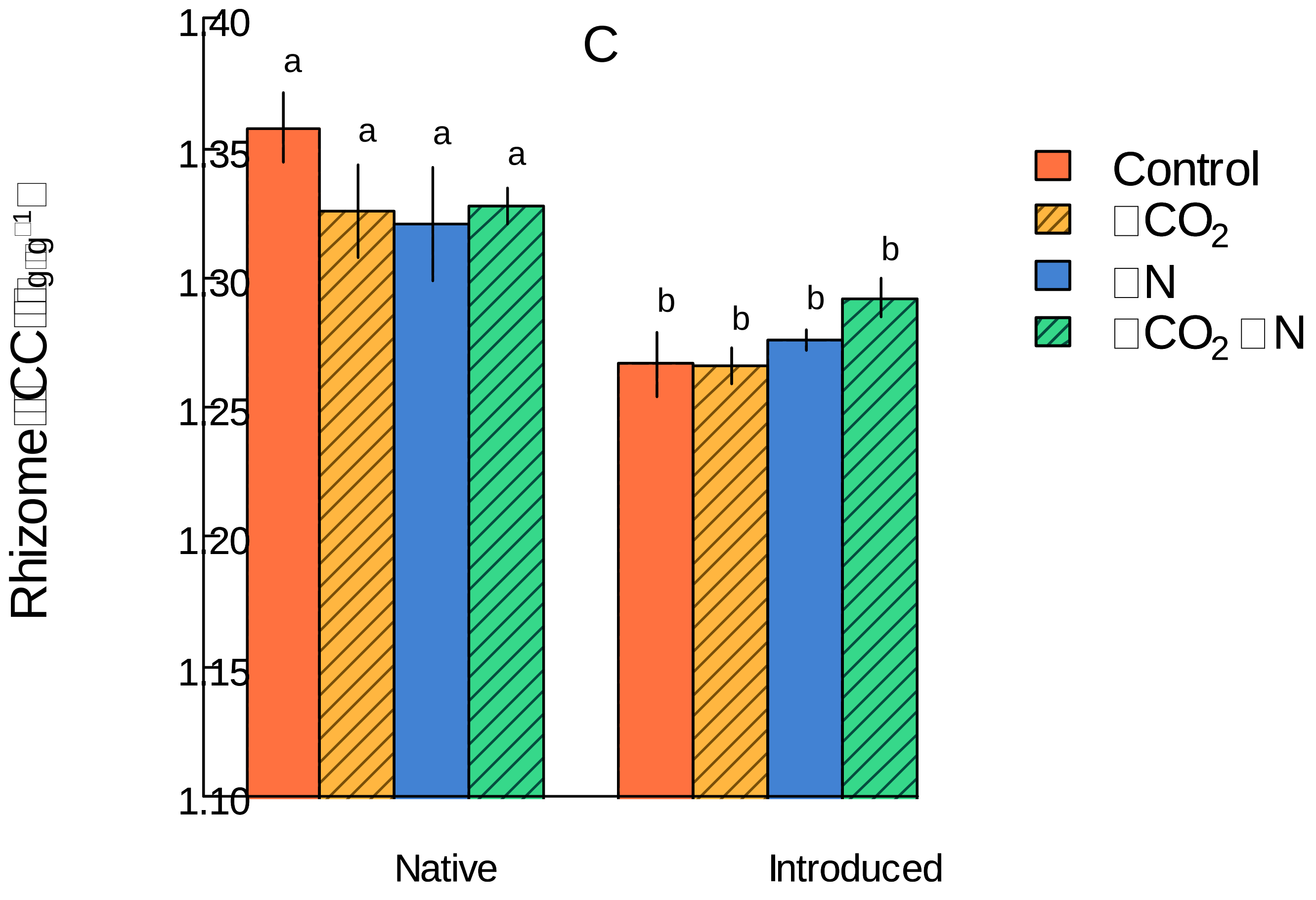
Leaf Construction Costs Do NOT among differ among lineages



Lineage: p=0.20; **N: p<0.001**

Caplan *et al* 2014 AoB Plants

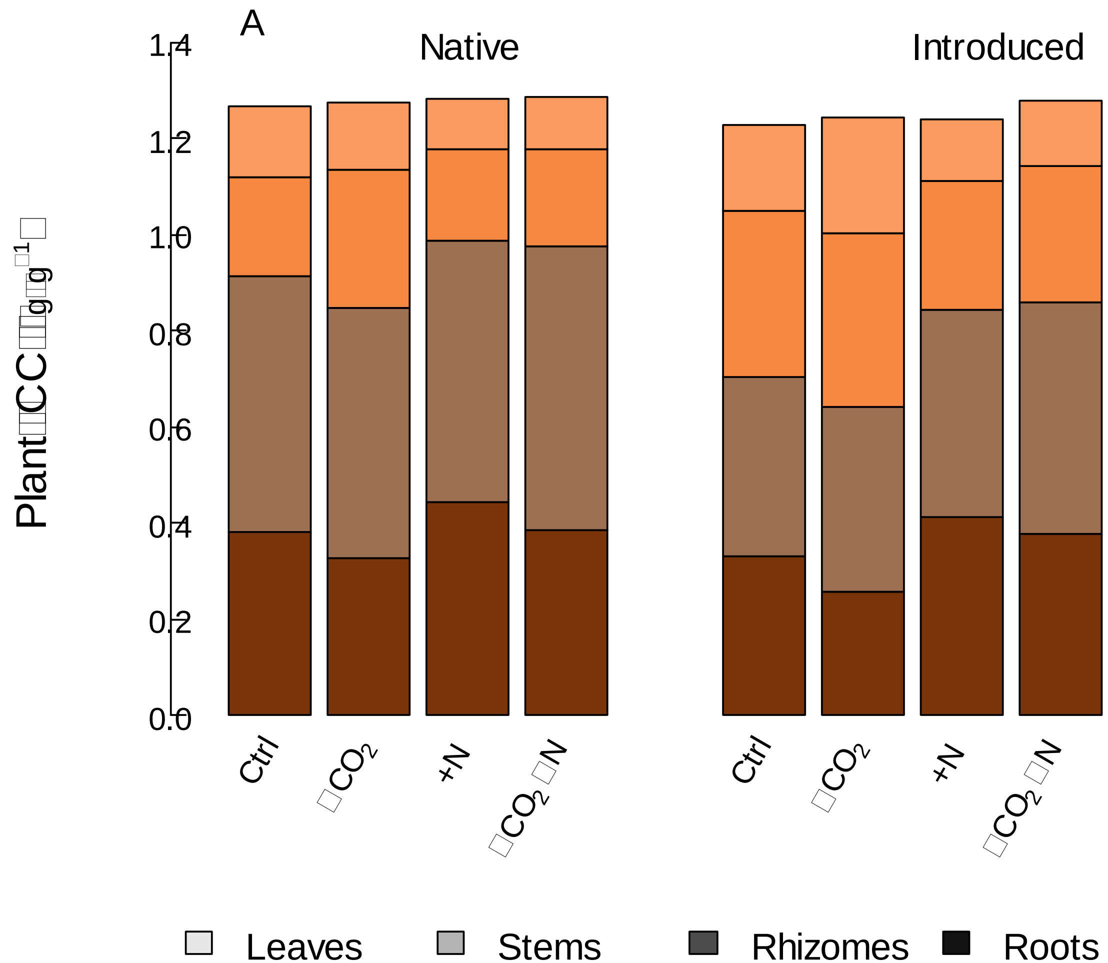
Construction Costs Differ in Rhizomes



Lineage: **p<0.001**

Caplan *et al* 2014 AoB Plants

Lower CC facilitate introduced *Phragmites* invasion



Caplan *et al* 2014 AoB Plants

What are the consequences of introduced *Phragmites* invasion on trace gas emissions?

- C-source or C-sink?

Wetlands
DOI 10.1007/s13157-013-0417-x

ARTICLE

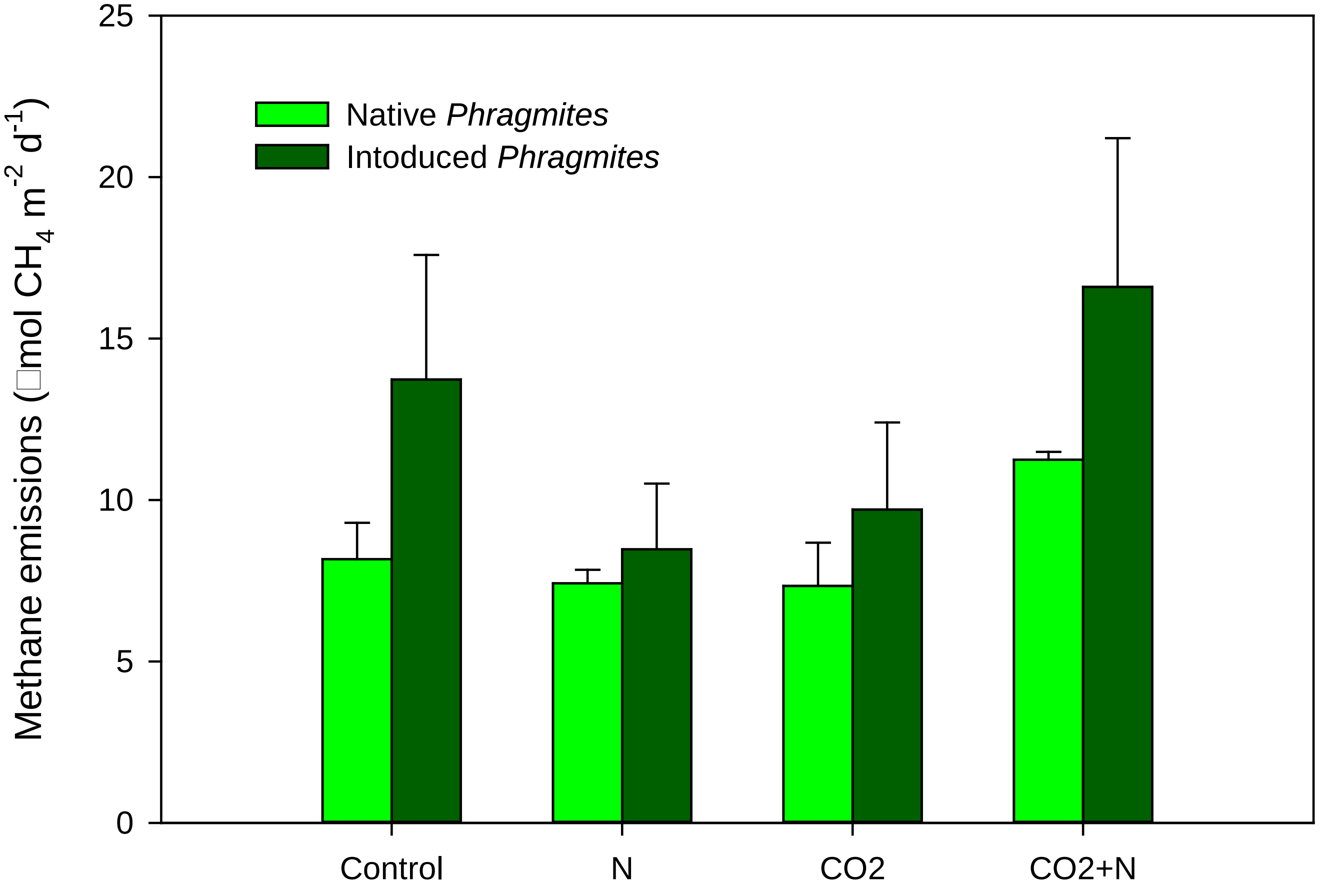
Increased Methane Emissions by an Introduced *Phragmites australis* Lineage under Global Change

Thomas J. Mozdzer • J. Patrick Megonigal

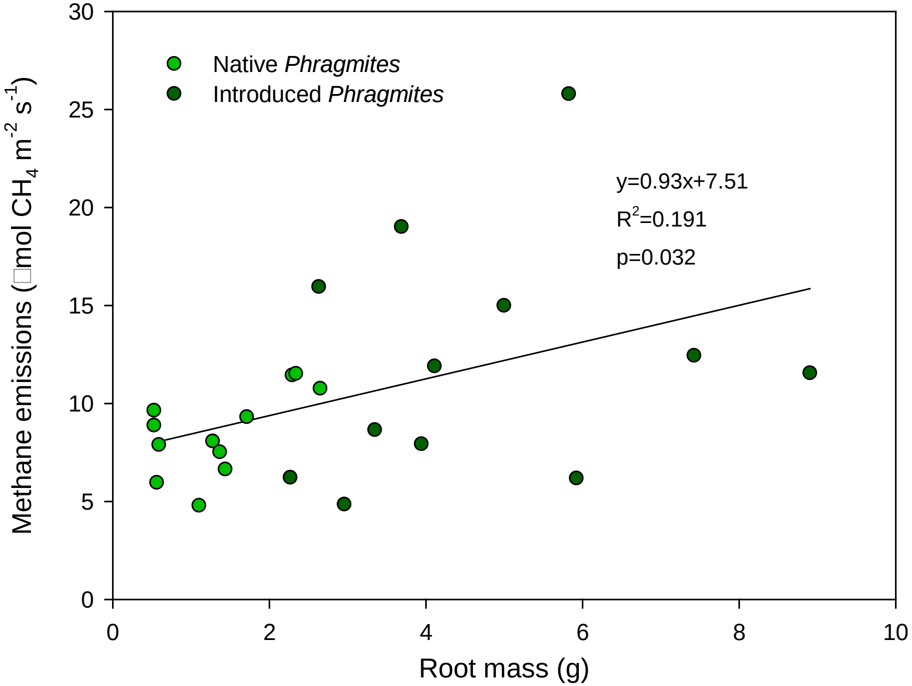
Received: 25 June 2012 / Accepted: 21 March 2013

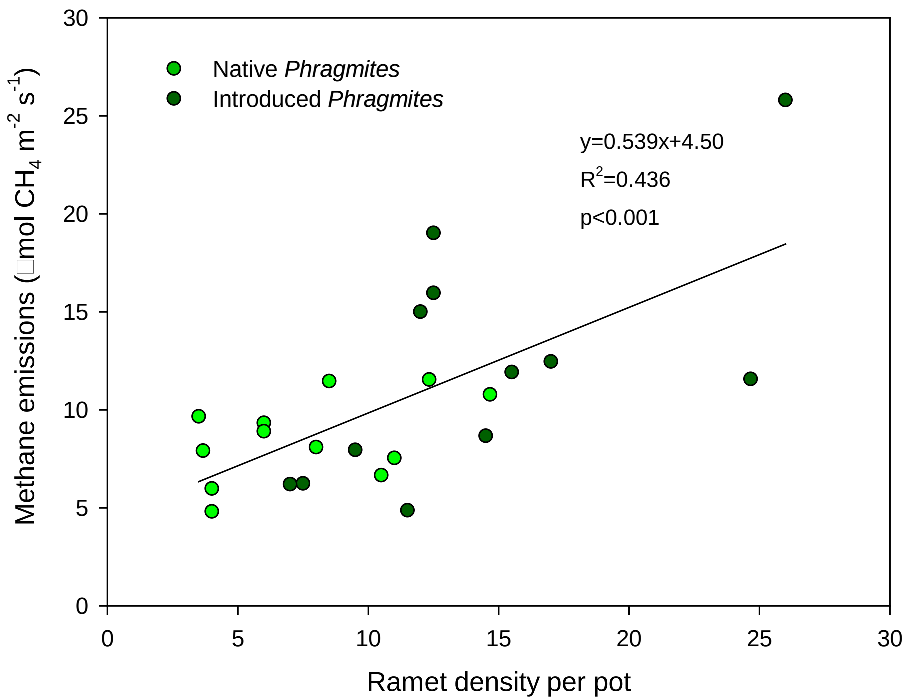
Thanks to student intern David Gonzalez!

Introduced has greater methane emissions, which also increase with global change



Mozdzer & Megonigal. 2013 Wetlands





Differences in root mass and plant density are correlated with increased methane emissions

Mozdzer & Megonigal. 2013 Wetlands

Summary of Global Change on *Phragmites lineages*

- Both lineages will likely increase productivity in response to both CO_2 and N
  - However, the introduced is more vigorous & has a greater response to both global change factors
  - N is driver for *Phragmites* invasion
- Expansion of introduced is likely due to:
  - greater N uptake rates, greater photosynthetic rates, RGRs, and all are influenced by ↑ N availability

Summary of Global Change on *Phragmites lineages*

- Lower rhizome construction costs facilitate expansion of the introduced lineage when compared to native lineage due to the already high returns aboveground
- Species shift to introduced *Phragmites* and enhanced productivity with global change may ***increase methane emissions***

Summary of Global Change on *Phragmites lineages*

- Management options:
  - We can’t do anything about CO_2
  - Limiting N availability can limit current and future invasions

Current Research

- How will global change (↑ CO_2 & N) affect *Phragmites* invasion *in situ*:
  - Elevated CO_2 ×N study to investigate global change effects on ecophysiology, biogeochemistry, surface elevation, and invasion processes


Smithsonian Global Change Research Wetland
CO_2 × N × RSLS experiment
World's longest running elevated CO_2 experiment
CO_2 × N × Invasive Species experiment
CO_2 × N experiment
Photo: Chuck Gallegos, aerial support by LightHawk

Smithsonian Global Change Research Wetland

Photo: Chuck Gallegos, aerial support by LightHawk


Smithsonian Global Change Research Wetland
CO_2 × N × Invasive Species experiment
CO_2 × N experiment
Photo: Chuck Gallegos, aerial support by LightHawk

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- **People:** J. Adam Langley, J. Pat Megonigal, Jay Zieman, Karen McGlathery, Peter Muller, Isaiah Seal, David Gonzalez, Lillian Aoki, Shannon Hagerty, Kate Shepard, Andrew Peresta, Gary Peresta, Jim Duhls, Nick Mudd, Anh Dohn, John Snyder, Rachel Hager, Joshua Caplan, Kim Holzer, Luke Cole, and many others…

References & Further Reading

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Q & A

Thomas J. Mozdzer, PhD

Assistant Professor
Department of Biology
Bryn Mawr College

610-526-5098
tmozdzer@brynmawr.edu

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THANK YOU!

Great Lakes Phragmites Collaborative: www.greatlakesphragmites.net

email: phragmites@glc.org

Twitter: GLPhragCollaborative (@GLPhrag)

Facebook: Great Lakes Phragmites Collaborative