

# **2013 DOE Bioenergy Technologies Office (BETO) Project Peer Review**

## **Saint Joseph's University Institute for Environmental Stewardship**

May 23, 2013

Technology Area Review: Feedstock Supply & Logistics

Principal Investigator: Clint J. Springer\* & Michael McCann

Organization: Saint Joseph's University

# Goal Statement

- Establishment of an Institute of Environmental Stewardship at Saint Joseph's University in Philadelphia, PA who's mission will have a three-fold commitment to sustainability education, research, and outreach

# Quad Chart Overview

## Timeline

- Project start date: 08/31/2010
- Project end date: 5/31/2013
- Percent complete as of 12/31/12:
  - Switch grass 90%
  - Green roof 100%
  - Outreach 95%

## Budget

- **Total project funding \$1,225,000**
  - **DOE share \$1,000,000:**  
Switchgrass \$450,000, Green roof \$450,000, Outreach \$100,000.
  - **SJU share \$225,000:**  
Switchgrass \$112,500, Green roof \$112,500
- **Funding received in FY09: \$0**
- **Funding for FY10-12: \$1000000**
  - DOE share \$1000000
  - SJU share \$250000
- **ARRA Funding: \$0**

## Barriers

- FT-B: Sustainable Production
  - Water & Nutrient Requirements
- FT-C: Crop Genetics
  - Physiology
- FT-G: Feedstock quality and monitoring
  - Tissue Chemistry

## Partners

- Clint Springer, P.I. for Switchgrass Research
- Michael McCann P.I. for Green roof and outreach

# SJU IES Overview

- **Objective 1:**

- design and install a green roof system of ca. 6000 sq. ft. on the roof of the Science Center for use in research, research training and educational outreach.

- **Objective 2:**

- examine the physiological, morphological, and reproductive responses of *Panicum virgatum* cultivars to projected changes in climate for the central portion of the United States.

- **Objective 3:**

- hold a series of programs and events to publically disseminate the results of both the switchgrass and the green roof projects.

# Green Roof on the SJU Science Center

- Design and engineer green roof system for the Science Center
  - 4 green roofing systems:
    - Gravel
    - Recycled foam
    - 2 different textiles
- Installation of the green roof system
- Use green roof performance data for basic research and research training
  - Experiments planned to investigate:
    - Direct performance comparisons of the 4 different systems
    - Chemical analysis of runoff water
    - Microbial community analysis
    - Plant species performance

# SJU IES Green Roof System



# Green Roof Progress

- Green roof installed Fall 2010
- All plant species planted; Data currently being analyzed for Years 1-2
- Data collection equipment installed and operational:
  - Lysimeters measuring water retention
  - Temperature sensors on roof deck, inside the green roof system, and air
  - Heat flux sensors measuring heat flux into and out of building
  - Weather station without wind speed
- Currently working on data management system with SJU IT Services

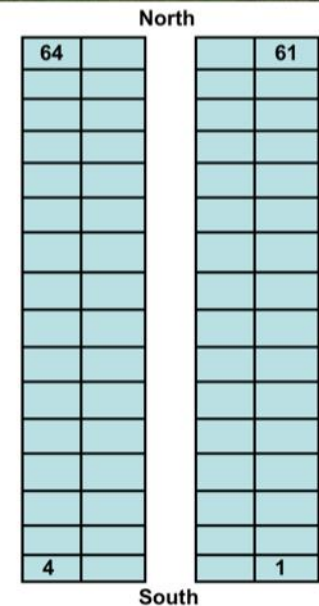
# Switchgrass responses to Climate Change

- Determine changes in the biomass of switchgrass in response to climate change
- Determine changes in the physiology of switchgrass in response to climate change
- Determine changes in the tissue biochemistry of switchgrass in response to climate change



# Switchgrass Approach

- Grow naturally occurring as well as Kanlow and Alamo varieties of switchgrass
- Expose plants to three different water regimes based on model estimates of precipitation for 2050 in the Central Plains
- Measure biomass, physiology, and tissue chemistry
- Complement field studies with controlled environment studies

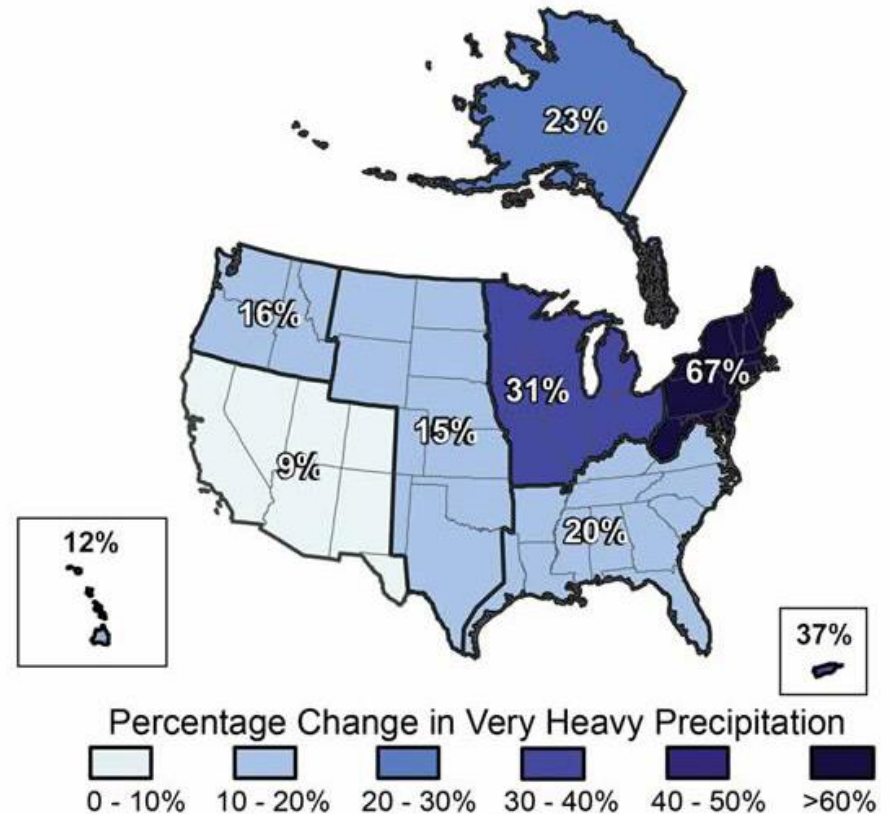
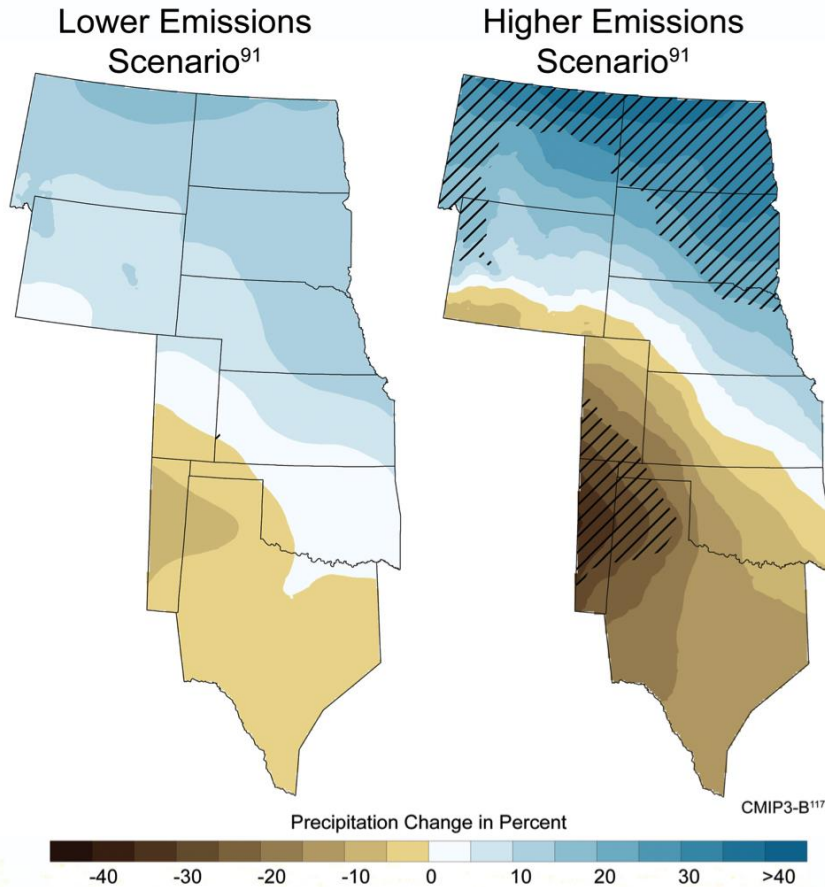


# Switchgrass Progress & Plans

- *Switchgrass established in the mesocosms during summer 2010*
- *All major instrumentation purchased*
- *Summer 2011: Field data collection completed*
- *Fall 2011: Controlled chamber studies began*
- *2012: Continued controlled chamber studies; Began tissue chemistry analysis*

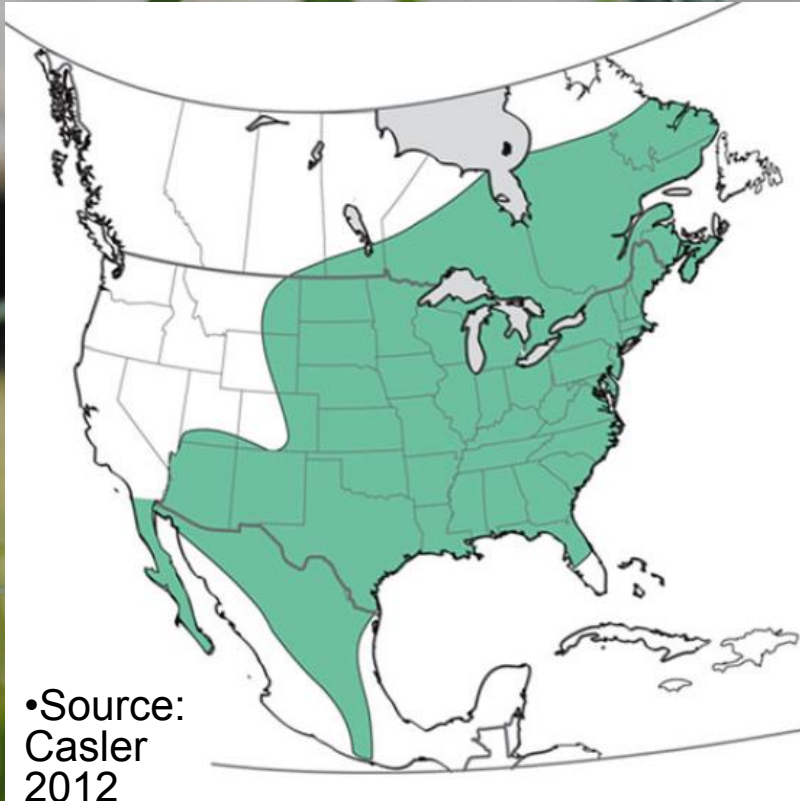
# Climate change in the Great Plains

- No change in precipitation **amount**
- Change in precipitation **intensity**



•Sources: Solomon et al. 2007, Karl et al. 2009

# Switchgrass (*Panicum virgatum* L.)



# Switchgrass Diversity



- Upland
- Tetraploid - Octoploid



- Lowland
- Tetraploid

# Genome size v Local Adaptation

- Are phenotypic traits expressed due to genome size or local adaptation, and do these affect the response of *P. virgatum* to precipitation variability?
- Difficult to separate effects of genome size from site-specific adaptations

# Objectives

1. Identify differences in physiology and productivity of *P. virgatum* individuals collected from natural populations located across a latitudinal gradient
2. Investigate the response of *P. virgatum* to precipitation variability with respect to **population of origin**
3. Examine the relationship between **genome size** and plant traits, as well as phenotypic responses to precipitation variability.



- Konza Prairie  
•(Kansas)

- Tallgrass prairie preserve  
•(Oklahoma)

- USDA Landholdings  
•(Texas)



- Ambient

- 6 day interval  
•21 mm

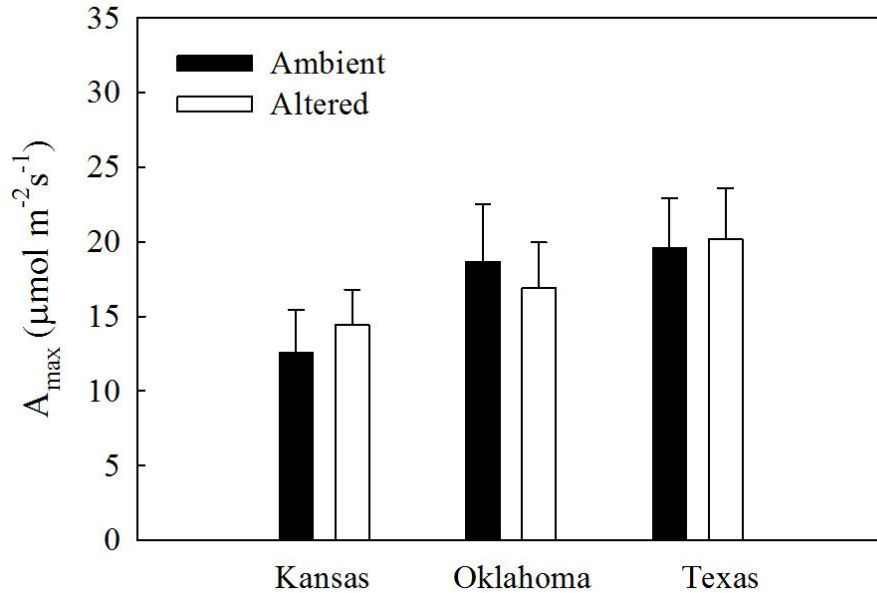
- Altered

- 12 day interval  
•42 mm

- Total: 642.25 mm

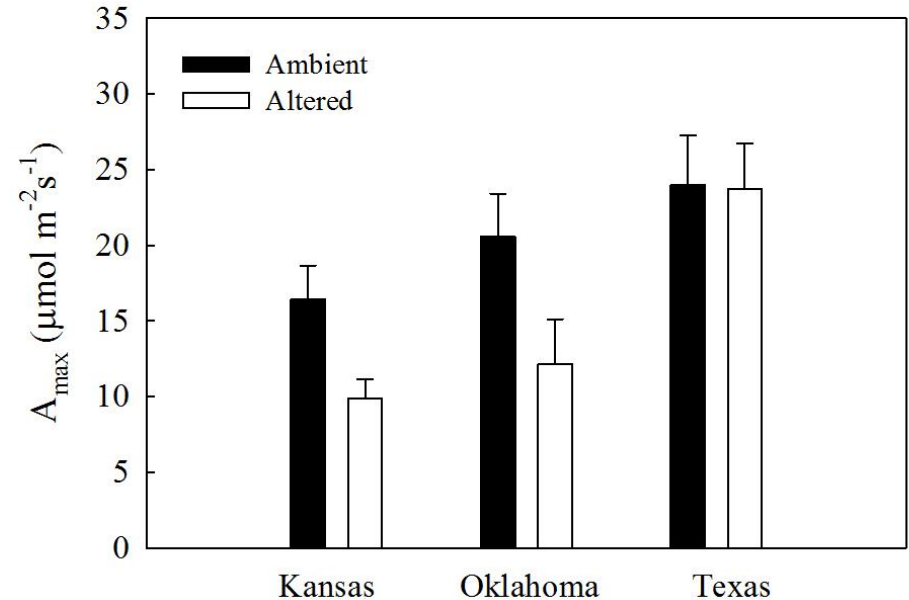


# Gas exchange differed between populations and treatments in September

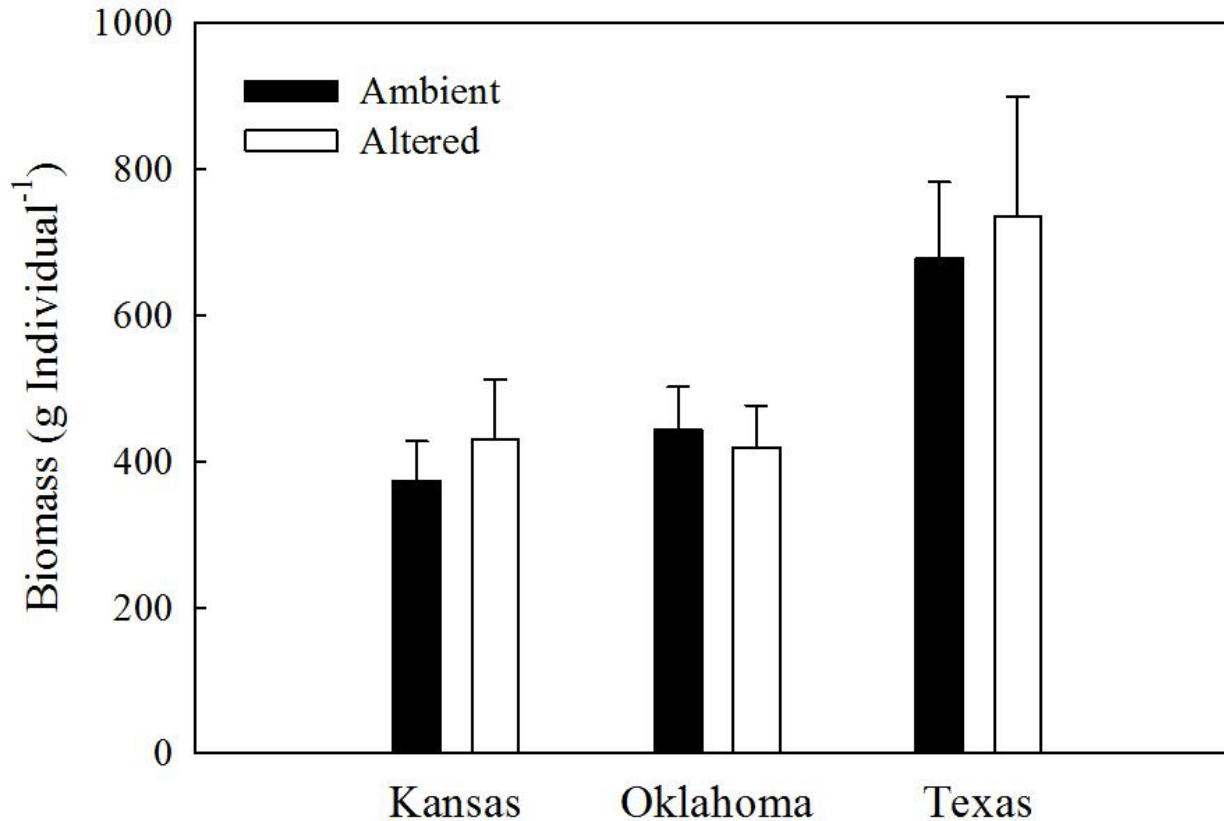


- **July**
- Population: NS
- Treatment: NS
- P x T: NS

- **September**
- Population:  $p < 0.05$
- Treatment:  $p < 0.05$
- P x T: NS



# Aboveground biomass differed between populations

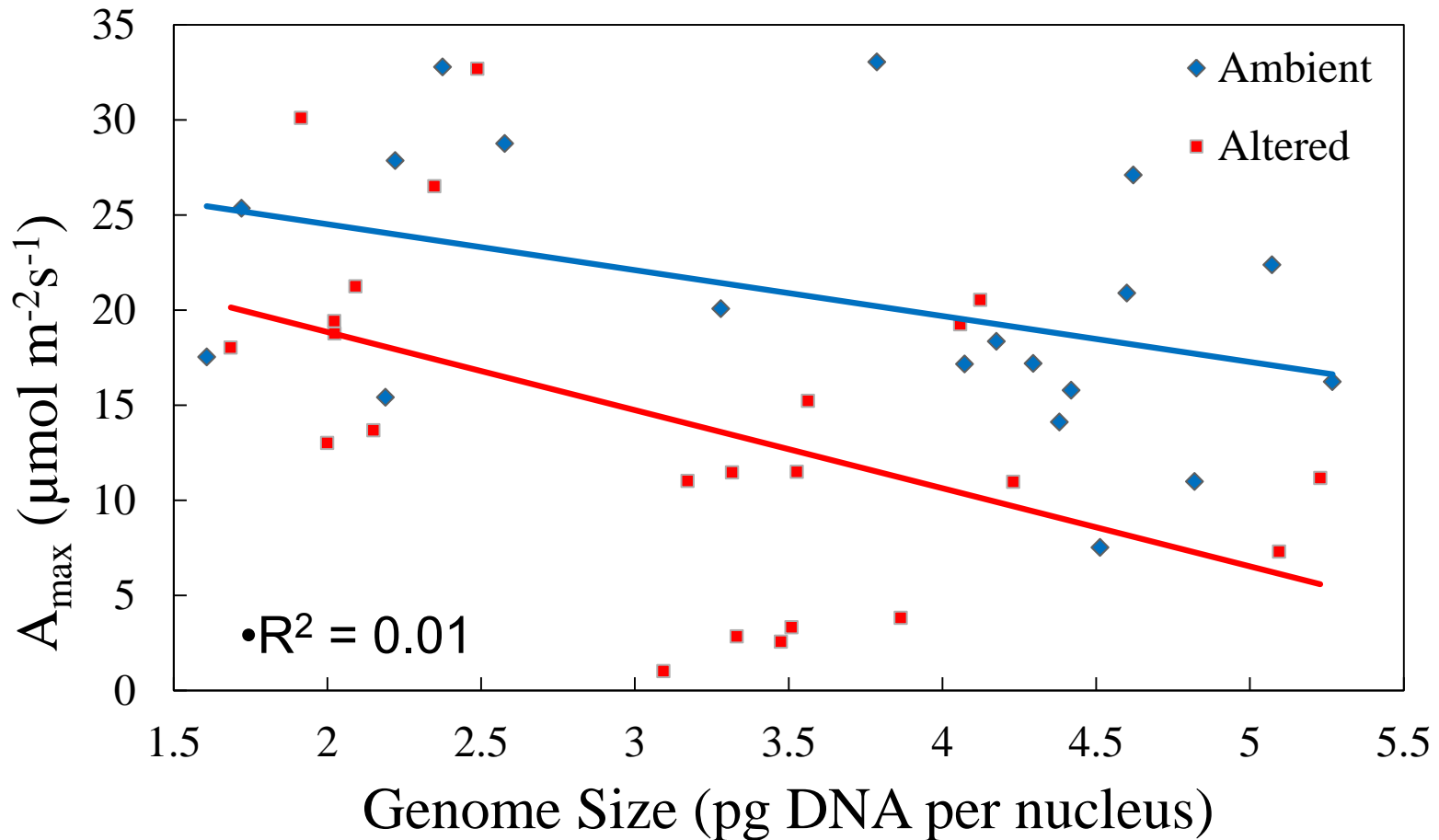


- Population:  $p < 0.05$
- Treatment: NS
- P x T: NS

# Genome Size - Objectives

1. Identify differences in physiology and productivity of *P. virgatum* individuals collected from natural populations located across a latitudinal gradient
2. Investigate the response of *P. virgatum* to precipitation variability with respect to **location of origin**
3. Examine the relationship between **genome size** and plant traits, as well as phenotypic responses to precipitation variability.

# Genome size does not influence plant traits or responses to water



• Genome Size: **NS**      Treatment:  **$p < 0.05$**       T x GS: **NS**

• O'Keefe et al. 2013

# Genome size does not influence plant traits or responses to water

	Treatment	Genome Size	T x GS	r <sup>2</sup>
<b>A<sub>max</sub></b>	p<0.05	NS	NS	0
<b>g<sub>s</sub></b>	p<0.05	NS	NS	0
<b>E</b>	p<0.05	p<0.05	NS	0
<b>%N</b>	NS	NS	NS	0
<b>Total Biomass</b>	NS	p<0.05	NS	0

# Take home points

- Physiology did not respond to water until late in the growing season, so biomass was not affected
- Physiology differed between populations, but responses to the water did not differ among populations
- Genome size was not associated with trait differences within populations, nor did it determine individual responses to water



# Public Outreach

- Held three symposia related to stormwater management
  - First focused on homeowners/residential issues
    - November 2011
  - Second focused on commercial/professional issues
    - April 2012
  - Third focused on stormwater management in the context of historical preservation
    - March 2013
- Partnered with community, professional, and corporate groups
  - Lower Merion Conservancy
  - Pennsylvania Horticultural Society
  - Montgomery County (PA) Conservation District

# Scholarly Productivity

## PEER-REVIEWED PUBLICATIONS

- Hartman, J.C., R.A. Orozco, C.J. Springer, and J.B. Nippert. 2011. Potential ecological impacts of switchgrass (*Panicum virgatum* L.) biofuel cultivation in the Central Great Plains, USA. *Biomass and Bioenergy* 35: 3415-3421.
- Hartman, J.C., J.B. Nippert, J.B., and C.J. Springer. 2012. Ecotypic responses of switchgrass to altered precipitation. *Functional Plant Biology* 39: 126-136
- O'Keefe, K., N.J. Tomeo, J.B. Nippert, and C.J. Springer. 2013. Population origin and genome size do not impact *Panicum virgatum* (switchgrass) responses to variable precipitation. *Ecosphere*
- Tomeo, N.J., K. O'Keefe, J.B. Nippert, and C.J. Springer. *In preparation*. Functional mycorrhizal community associated with switchgrass is unresponsive to simulated future precipitation variability. Planned for submission to *PLOS One* in mid to late February.
- Springer, C.J., K. O'Keefe, and S. Davis. *In Review*. Cellulosic Biofuels and Their Ecological Consequences. Invited book chapter set for publication in Summer2013.

## PRESENTATIONS AT SCIENTIFIC MEETINGS

- Tomeo, N.J., K. O'Keefe, J.B. Nippert, and C.J. Springer. 2012. A mycorrhizal community is unresponsive to simulated future precipitation variability. Annual Meeting of the American Society of Plant Biologists, Austin, TX USA.
- O'Keefe, K., J.B. Nippert, and C.J. Springer. 2012. Genome size as an indicator of plastic responses to drought stress in *Panicum virgatum* L. (switchgrass) exposed to variable precipitation timing. Annual Meeting of the American Society of Plant Biologists, Austin, TX USA.
- O'Keefe, K., J.B. Nippert, and C.J. Springer. 2012. Influences of local adaptation and genome size on *Panicum virgatum* (switchgrass) responses to variable precipitation timing. Annual Meeting of the Ecological Society of America, Portland, OR USA.
- O'Keefe, K., J.B. Nippert, and C.J. Springer. 2011. Phenotypic responses of switchgrass (*Panicum virgatum*) to simulated climate change. Grasslands in a Global Context Symposium, Manhattan, KS, USA.