

# Innovative and Classic Applications of Handheld Photosynthesis Systems



Photo credit:

<http://www.wired.com/2010/02/quantum-photosynthesis/>

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- All attendees will be muted to reduce feedback/noise during the webinar
- Questions/comments can be typed into the chat box, using the GoToMeeting control panel on the right side of your screen and will be discussed at the end of the webinar.

Moderator:  
Brienne J. Meyer  
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Application Scientist



Also Joining Us from CID Bio-Science:  
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amelnychenko@cid-inc.com  
Application Scientist

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# Agenda

## PART I

- CO<sub>2</sub> gas exchange & photosynthesis
- Who measures photosynthesis?
- CI-340 photosynthesis system features
- Traditional vs. non-traditional uses

## PART II

- Current research

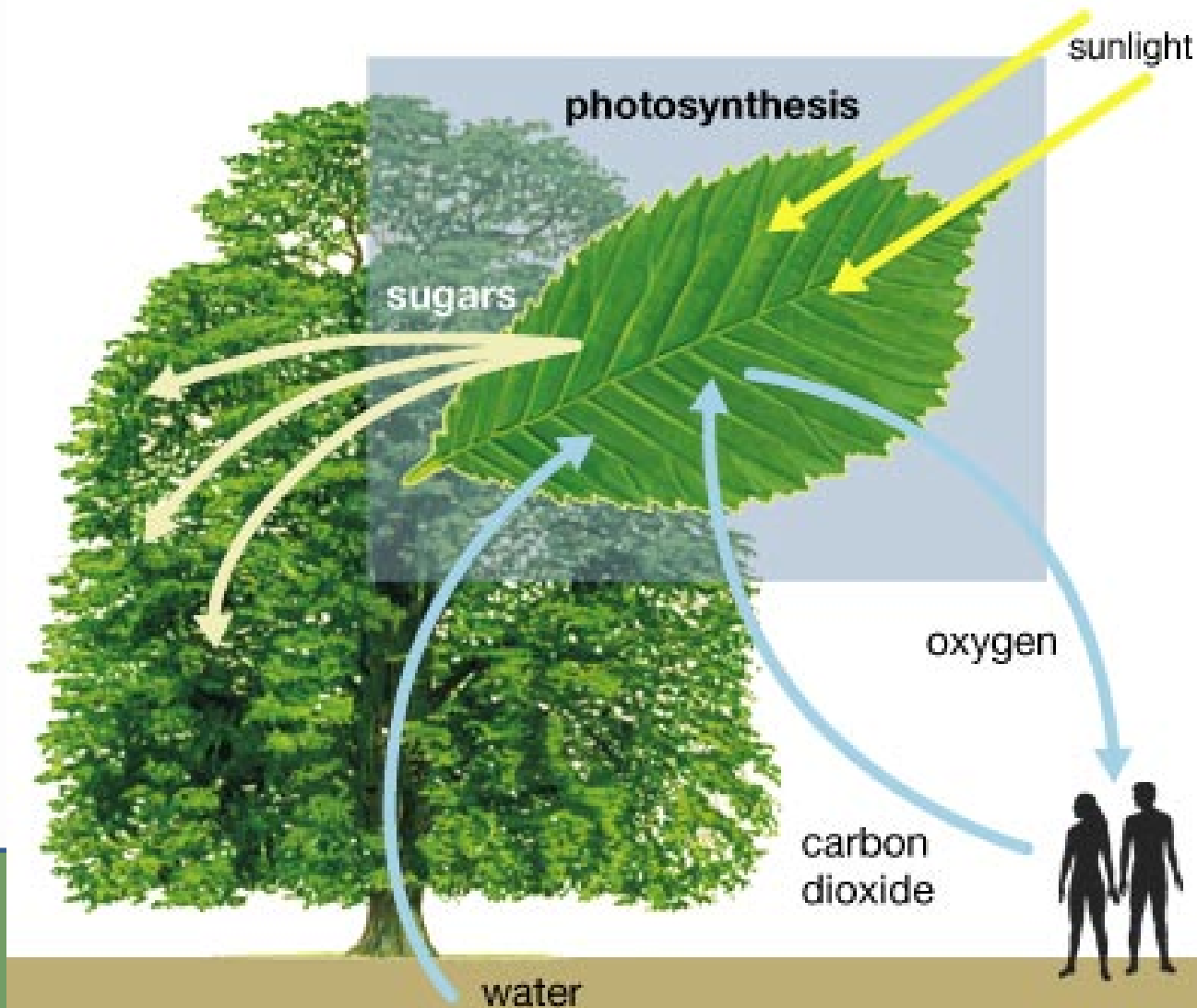
## PART III

- Travel grant opportunity
- Your questions

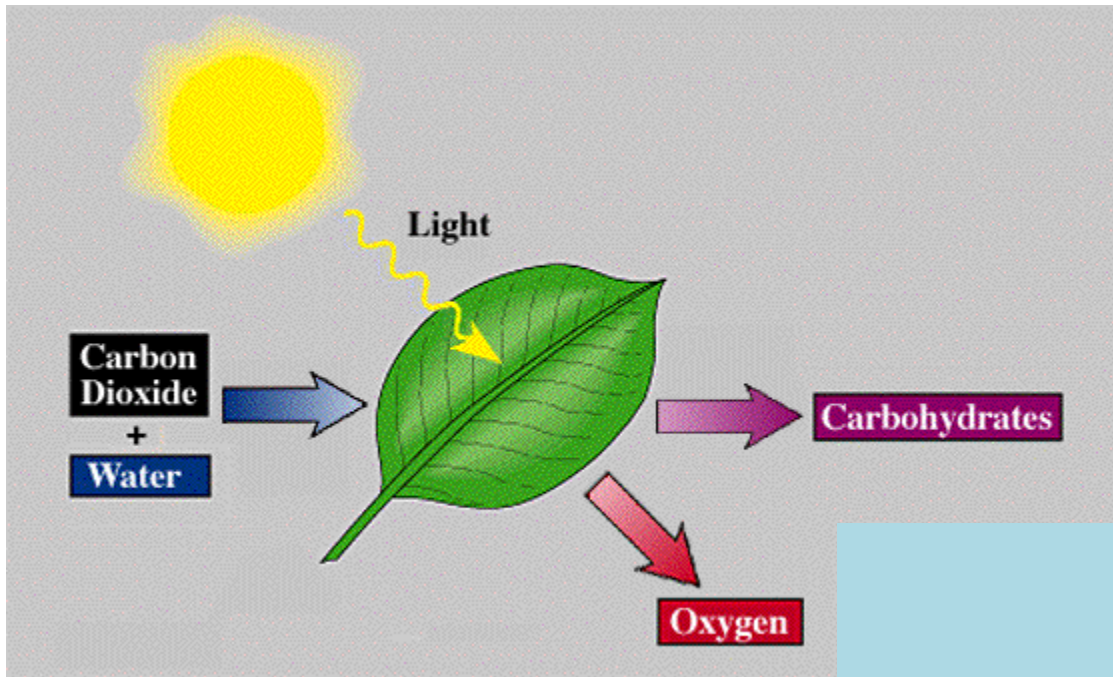




# PART I

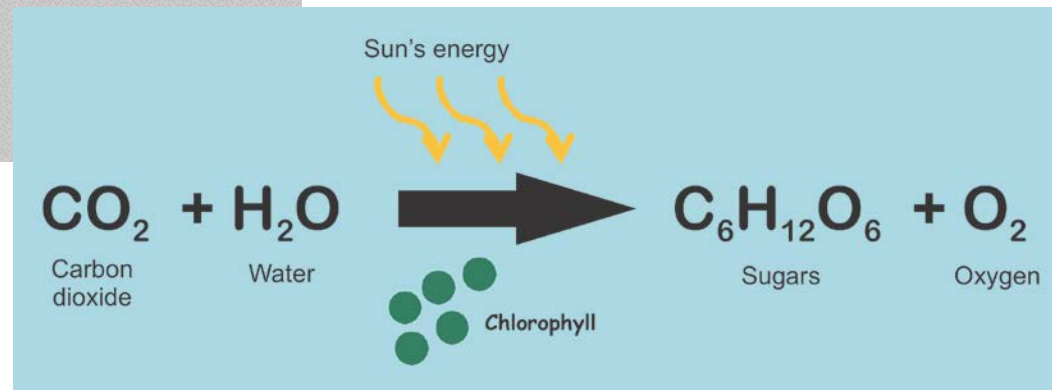


# Photosynthesis



Process of converting light energy into chemical energy

About 50% of the earth is covered in photosynthetic plant life



# Handheld Photosynthesis System Features

- Infrared CO<sub>2</sub> gas analyzer
- H<sub>2</sub>O/humidity analyzer
- PAR sensor
- Temperature sensors
  - Leaf temperature
  - Air temperature
  - Internal temperature
- Soil respiration chamber





Wide selections of leaf chambers to operate as an *open* or a *closed* system





# Complete set of environmental control modules



- CO<sub>2</sub>/H<sub>2</sub>O concentration
- Light intensity
- Temperature
- Chlorophyll fluorescence

# Who wants to measure photosynthesis?

- Plant Scientists
  - Phenotyping
  - Carbon cycling dynamics
  - Maturity and aging
  - **Characterizing stress responses**
  - **Relationships between photosynthesis and water balance**
- Other scientists and researchers interested in non-traditional uses



# Non-traditional uses

- Measure anything that releases or absorbs  $\text{CO}_2$  and/or  $\text{H}_2\text{O}$
- Soil respiration
- Insect respiration
- Carbon credits
- Climate change



# PART II

## Peer-Reviewed Literature Summary:

- Publications: > 50
- Countries: > 16
- Complete list on web:

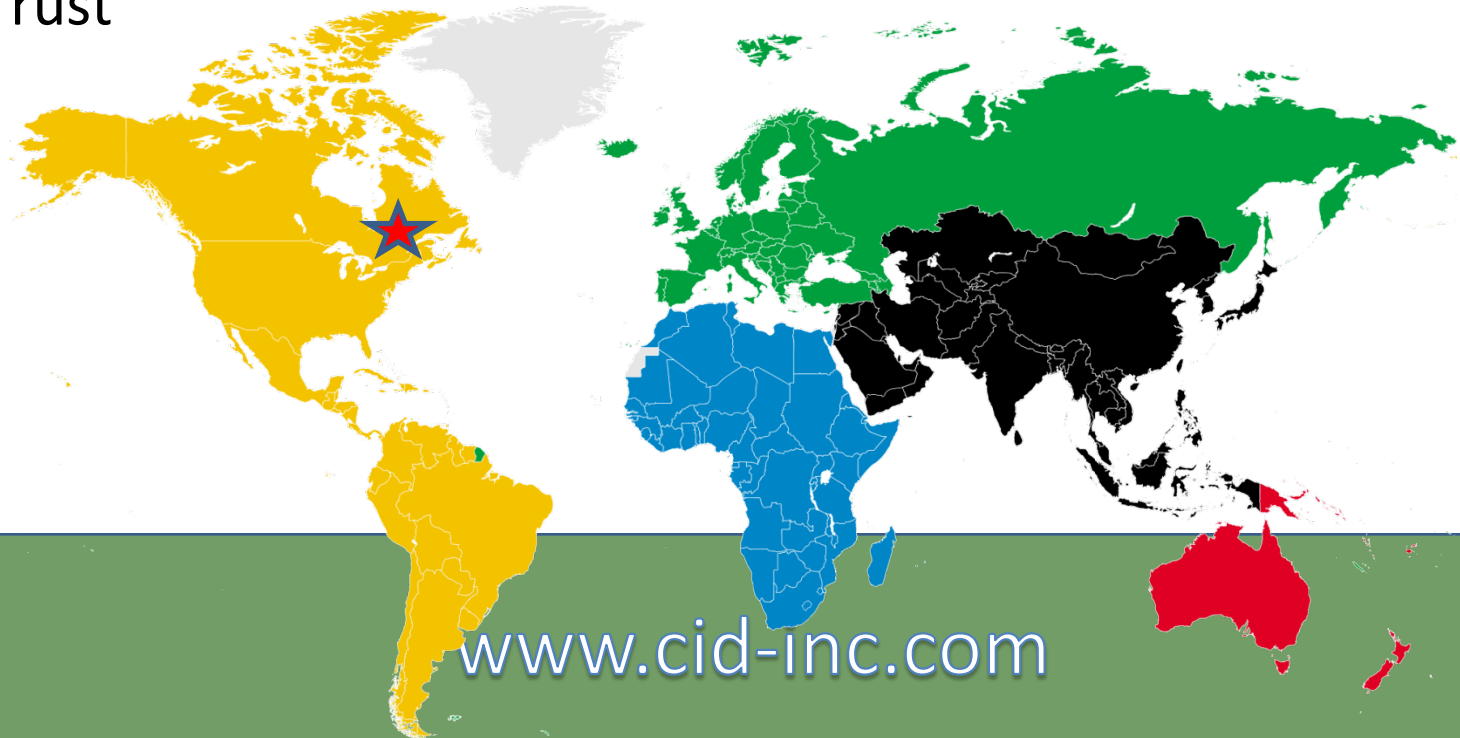
[www.cid-inc.com/ci-340-publishedresearch](http://www.cid-inc.com/ci-340-publishedresearch)

Country
People's Republic of China
Pakistan
India
USA
Spain



# Dr. Benoit Truax, ETFRT, Québec, Canada

- Eastern Townships Forest Research Trust
- **Julien Fortier**, Ph.D. Université du Québec à Montréal
- **Daniel Gagnon**, Ph.D. Regina University
- **France Lambert**, M.Sc. Eastern Townships Forest research Trust



# Dr. Benoit Truax, ETFRT, Québec, Canada

## Materials and Methods

- **Soil respiration** was measured (summer 2014) at three 14 year-old hybrid poplar plantation sites located in southern Québec, Canada (Brompton, La Patrie and Melbourne).
- The experimental design contains 27 plots (3 sites x 3 poplar genotype x 3 blocks/ sites).
- In each plot, **soil respiration** (including root respiration) was measured *in situ* using a CI-340 Ultra-Light Portable Photosynthesis System
- Three sampling time were also selected for the experiment (Late May, Late July and Late October).



photo credit: B.  
Truax /Eastern  
Townships Forest  
Research Trust



# Dr. Benoit Truax, ETFRT, Québec, Canada

## Materials and Methods Continued

- **Respiration** was measured by placing the CI-340 chamber on the soil surface for a 2 minute time period during which the  $\text{CO}_2$  production was measured in the chamber and expressed as  $\mu\text{mol CO}_2^{-1} \text{ m}^{-2} \text{ s}^{-1}$ .
- This procedure was repeated at 5 random sampling points in order to account for soil heterogeneity within plots.
- **Soil temperature** (measured in the CI-340 chamber) and **air temperatures** were recorded simultaneously during respiration measurements.
- Soil respiration rate, soil temperature and air temperature were averaged for each sampling time in each plot (mean of 5 sampling points).



photo credit: B.  
Truax /Eastern  
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Research Trust





photo credit: B. Truax / Eastern Townships Forest Research Trust



# Dr. Benoit Truax, ETFRT, Québec, Canada

## Results

- Significant **Time x Site** interactions for soil respiration, air and soil temperature.
- Across the 3 sites temperature conditions were rarely similar.
- A strong relationship was observed at each site between soil temperature and respiration rates ( $R^2$  ranging from 0.62 to 0.80, depending on the site).

Site	Brompton			La Patrie			Melbourne		
	Spr	Sum	Fall	Spr	Sum	Fall	Spr	Sum	Fall
Respiration rate	↓	↑	↓	↑	↑	↓	↓	↑	↓

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# Dr. Benoit Truax, ETFRT, Québec, Canada

- Measured soil respiration
  - hybrid poplar
  - red oak
  - bur oak
  - red ash
  - white pine
- Comparing silvicultural treatments arranged in a split plot:
  - black plastic mulch
  - control (weeds plots)

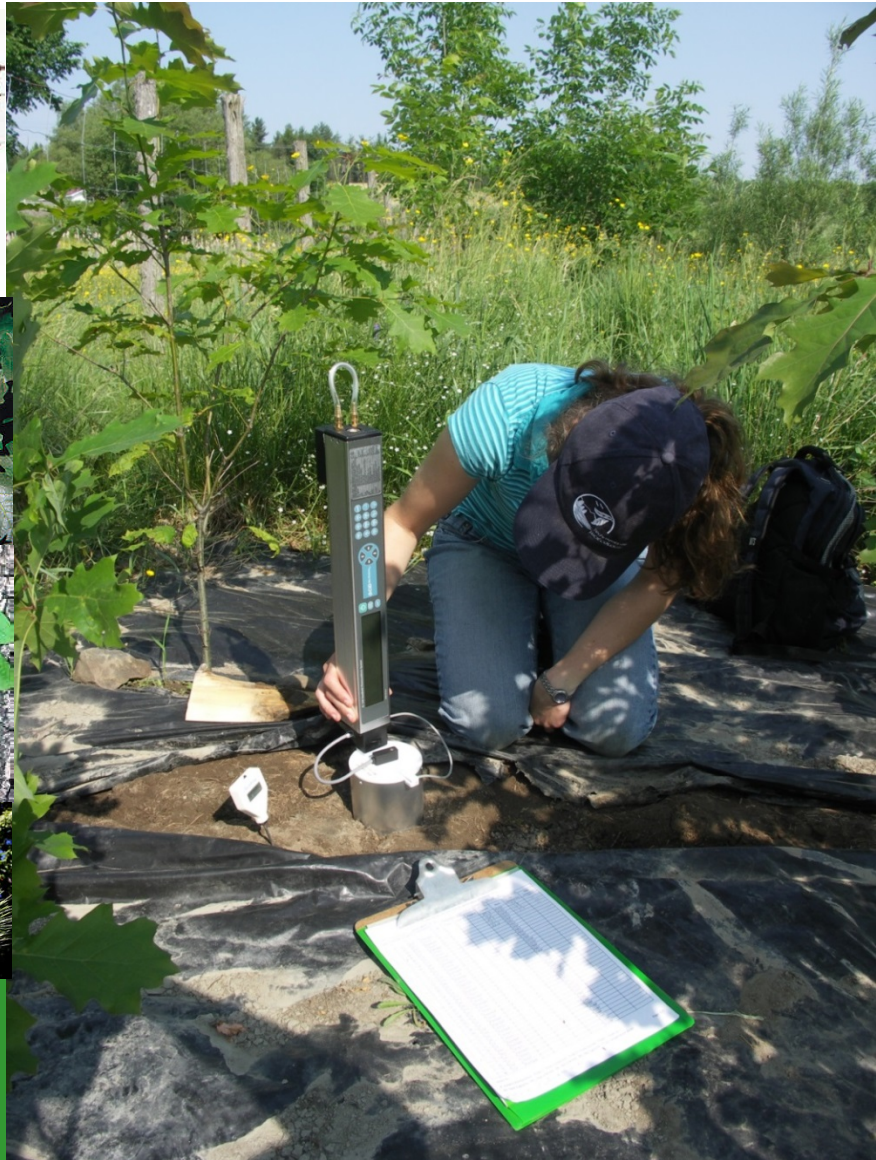


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# Dr. Benoit Truax, ETFRT, Québec, Canada

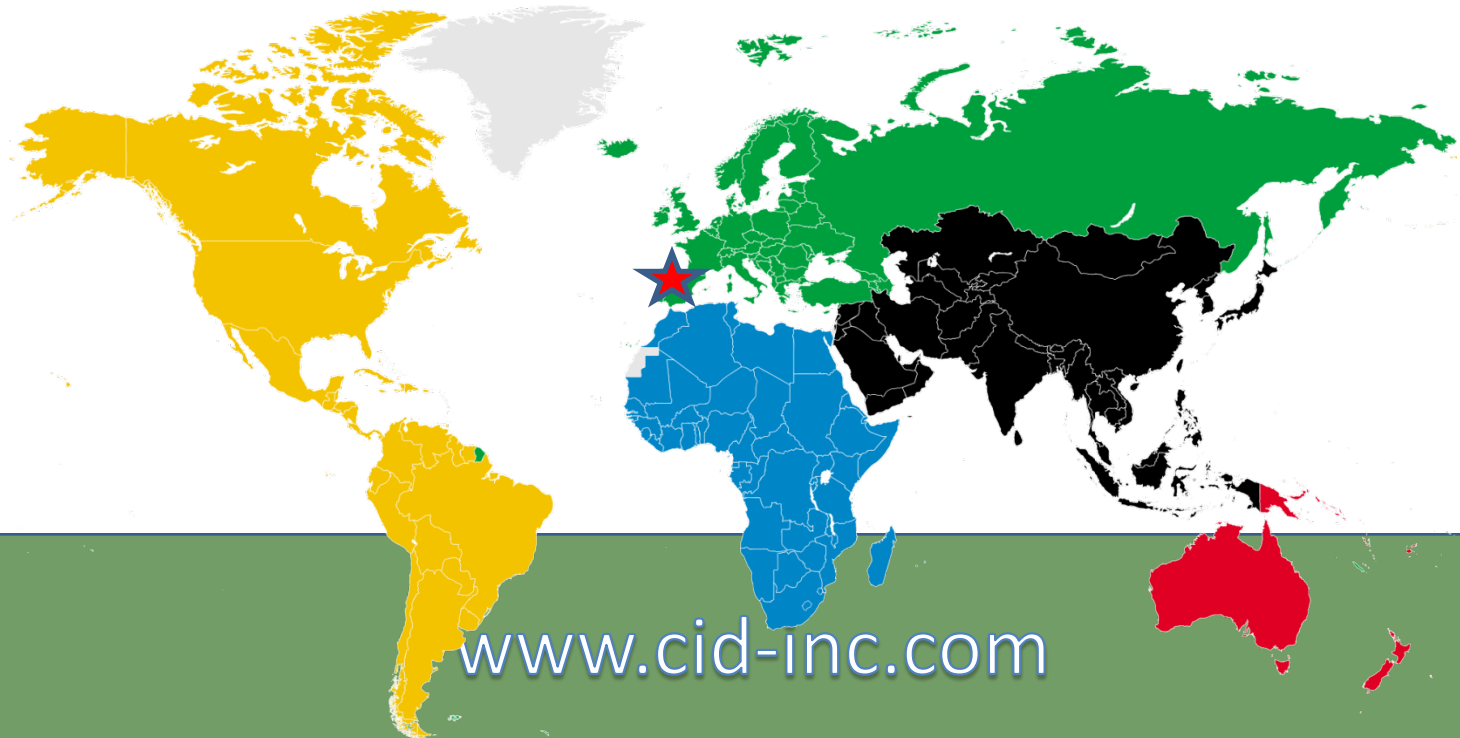
**Yield in 8 year-old hybrid poplar plantations on abandoned farmland along climatic and soil fertility gradients.** Benoit Truax, Daniel Gagnon, Julien Fortier, France Lambert.  
*Forest Ecology and Management*, volume 267 **2012**.



photo credit: B.  
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# Dr. Josep Peñuelas, CREAMF, Spain

- Center for Ecological Research and Forestry Applications (CREAF) and the National Research Council in Spain
- Many recent publications (3 in 2013)





# Dr. Josep Peñuelas, CREAM, Spain

## 1. Needle terpene concentrations and emissions of two coexisting subspecies of Scots pine attacked by the pine processionary moth (*Thaumetopoea pityocampa*).

Achotegui-Castells, A., Llusia, J., Hódar, J., Peñuelas, J. *Acta Physiologiae Plantarum*, volume 35 (10) **2013**.

## 2. Intensive measurements of gas, water, and energy exchange between vegetation and troposphere during the MONTES campaign in a vegetation gradient from short semi-desertic shrublands to tall wet temperate forests in the NW Mediterranean Basin.

Peñuelas, J., Guenther, A., Rapparina, F., Llusia, J., Filella, I., Seco, R., Estiarte, M., Mejia-Chang, M., Ogaya, R., Ibanex, J., Sardans, J., Castano, L., Turnipseed, A., Duhl, T., Harley, P., Vila, J., Estavillo, J., Menendez, S. *Atmospheric Environment*, volume 75 **2013**.

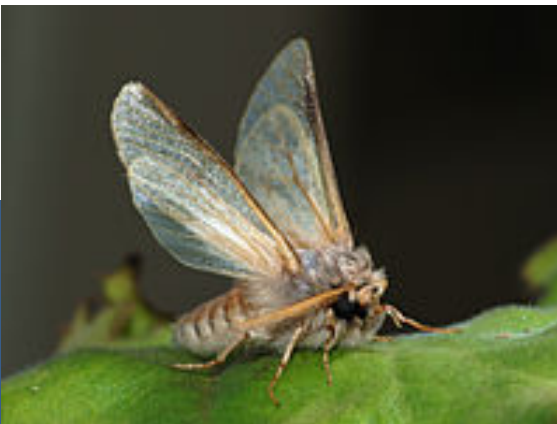


Photo credit:

<http://en.wikipedia.org/wiki/Moth>

Photo credit:

<http://www.geog.cam.ac.uk/research/projects/mediterraneanecosystem>



# Dr. Josep Peñuelas, CREAM, Spain

## 3. Physiological and antioxidant responses of *Quercus ilex* to drought in two different seasons.

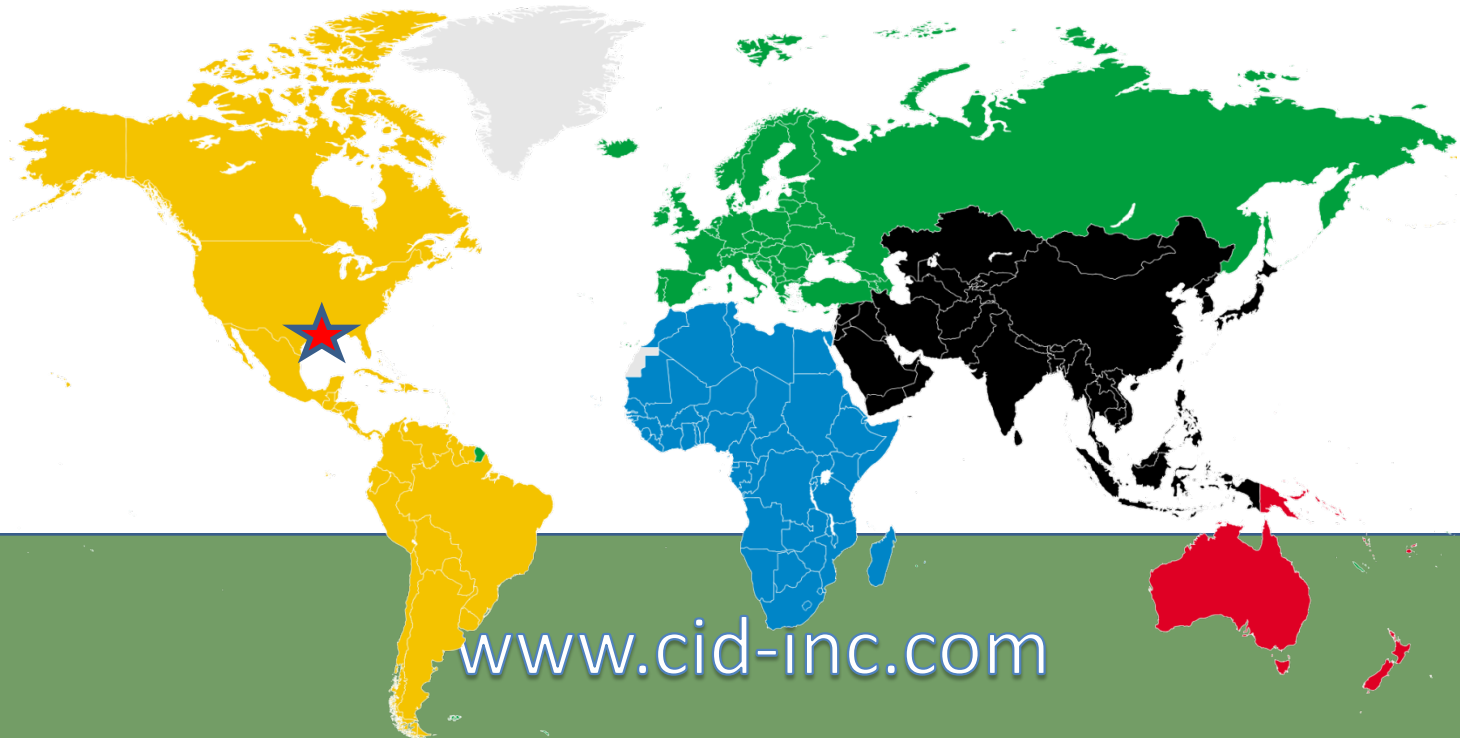
Nogues, I., Llusia, J., Ogaya, R., Munne-Bosch, S., Sardans, J., Peñuelas, J., Loreto, F. *Plant Biosystems*, 2013.



Photo credits: [http://en.wikipedia.org/wiki/Quercus\\_ilex](http://en.wikipedia.org/wiki/Quercus_ilex)

# Dr. Joseph Kloepper, Auburn University, Alabama

- Department of Entomology & Plant Pathology
- Drought evaluation with photosynthesis system





# Dr. Joseph Kloepper, Auburn University, Alabama

Drought conditions were induced to corn plants at V8 stage of growth and photosynthesis was measured in the upper most developed leaf of the plant. We used photosynthesis rate, transpiration and stomatal conductance parameters to compare plants under drought conditions and plants under normal watering conditions



**Photo credit: Dr. Kloepper,  
Auburn University**





Photo credit: Dr. Kloepper, Auburn University, Alabama

# Dr. Joseph Kloepper, Auburn University, Alabama

## Results

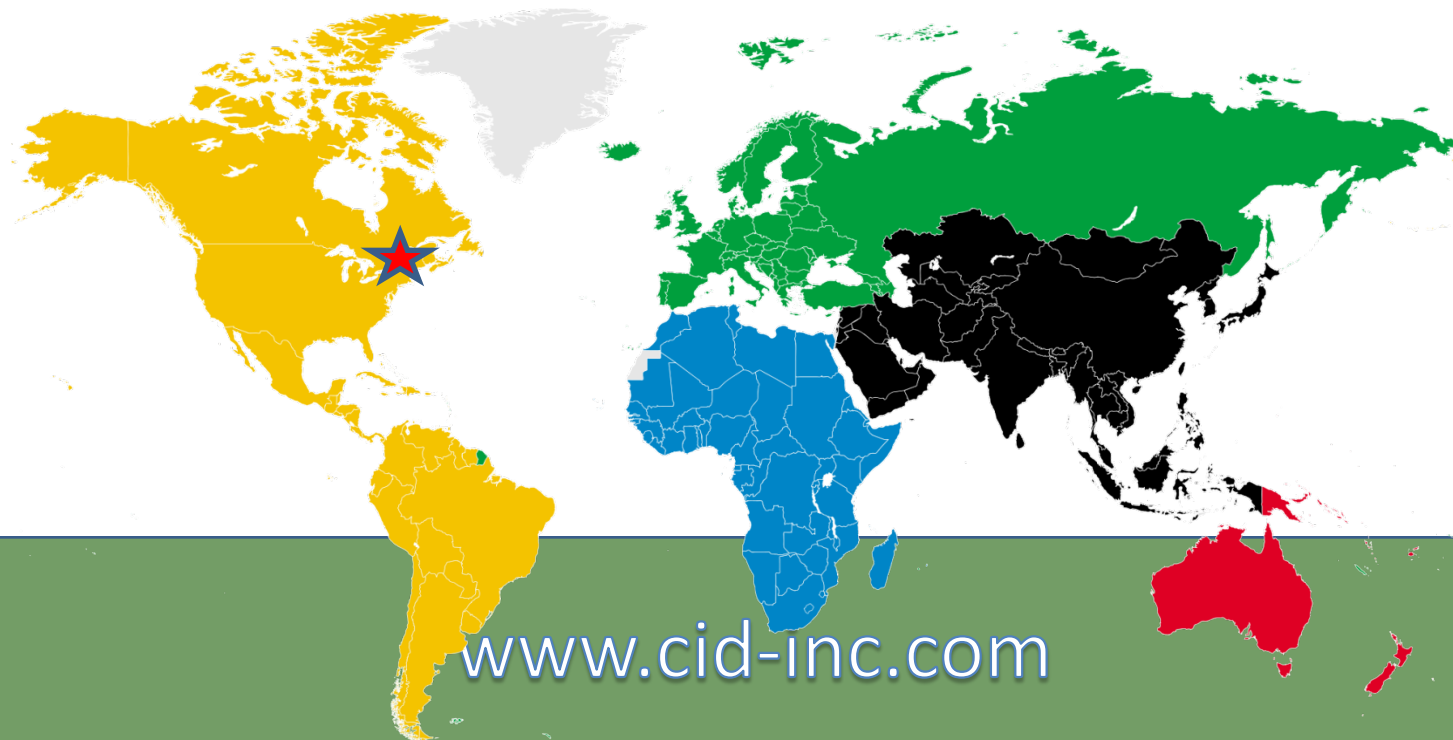
- Corn plants evaluated at V10 stage of growth after one week of drought

Treatments	Pn	E	C
	$\mu\text{mol}/\text{m}^2/\text{s}$	$\text{mmol}/\text{m}^2/\text{s}$	$\text{mmol}/\text{m}^2/\text{s}$
Control normal watering	16.41 a	1.58 a	973.0 a
Control drought (7 days)	0.64 b	0.24 c	24.94 c



# Michaël Belluau, Université de Sherbrooke

- Dr. Bill Shipley, Department of Biology, Québec
- The leaf economics spectrum and the prediction of photosynthetic light-response curves. Giancarlo Marino, Marouane Aqil and Bill Shipley. *Functional Ecology*, issue 24, **2010**.



**Objective: Express drought tolerance of forbs with a functional trait approach.**



Photo credit: M. Belluau,  
University of Sherbrooke



# Michaël Belluau, Université de Sherbrooke

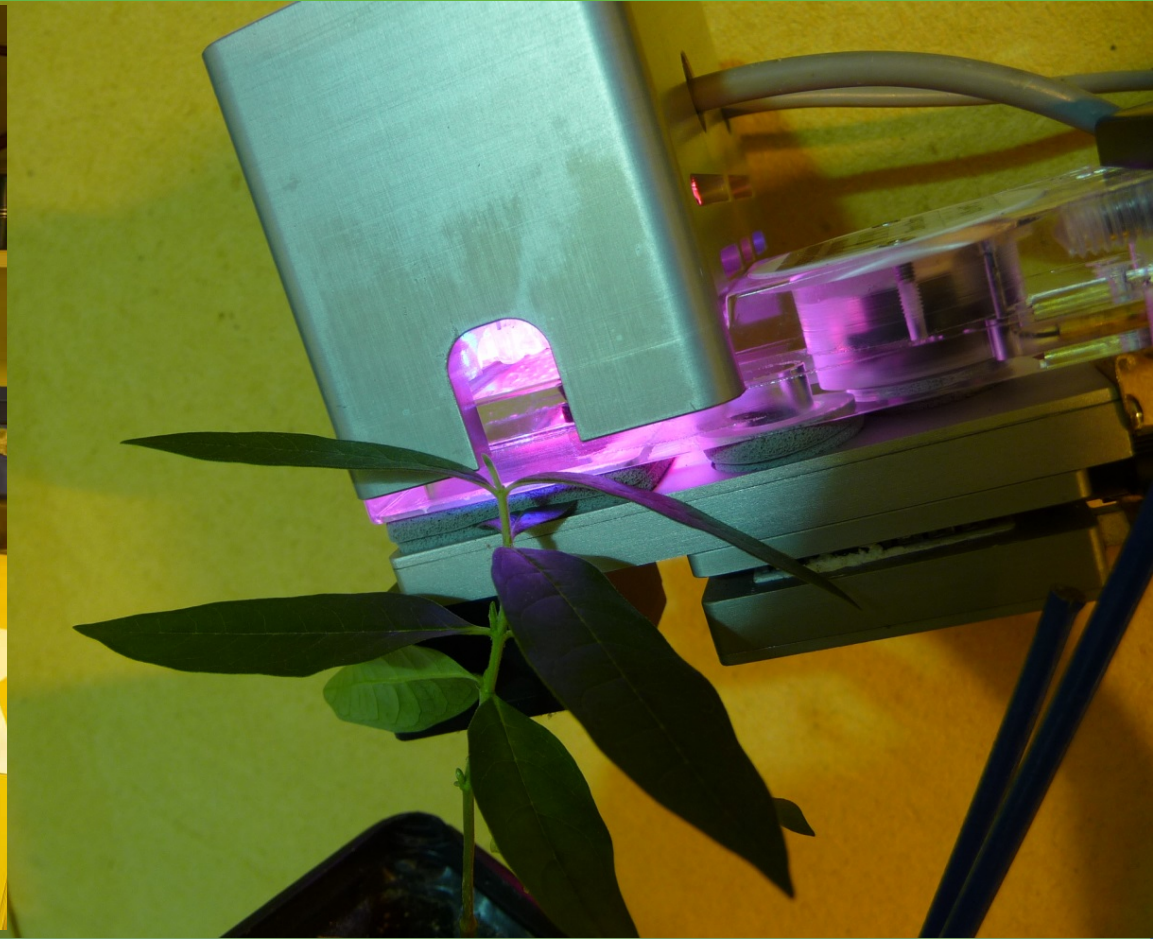
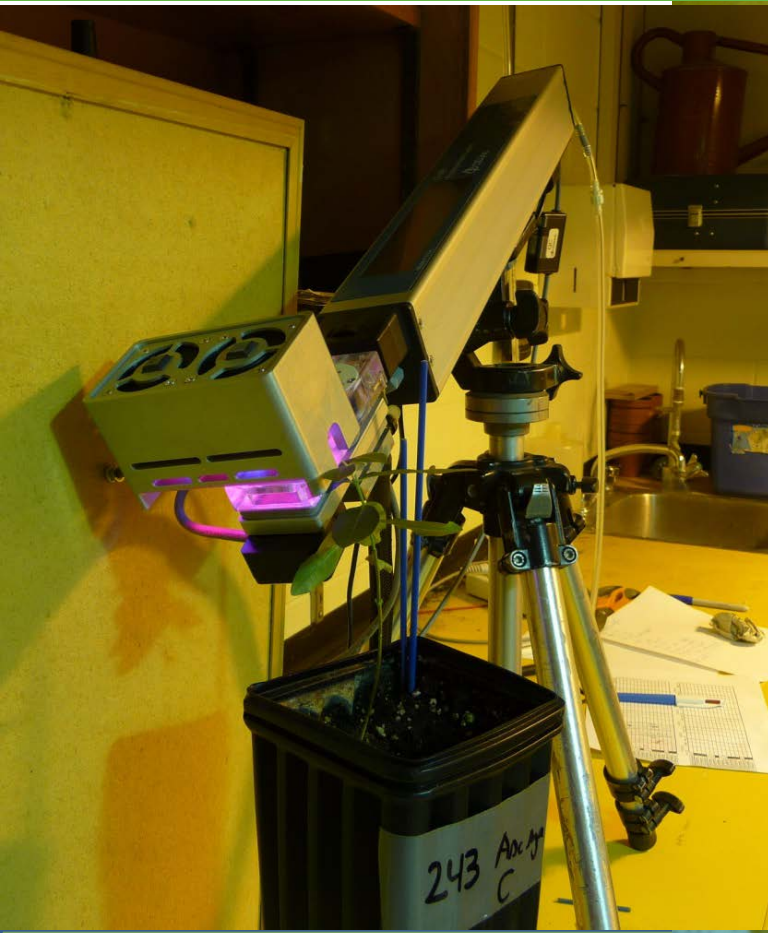


Photo credits: M. Belluau,  
University of Sherbrooke

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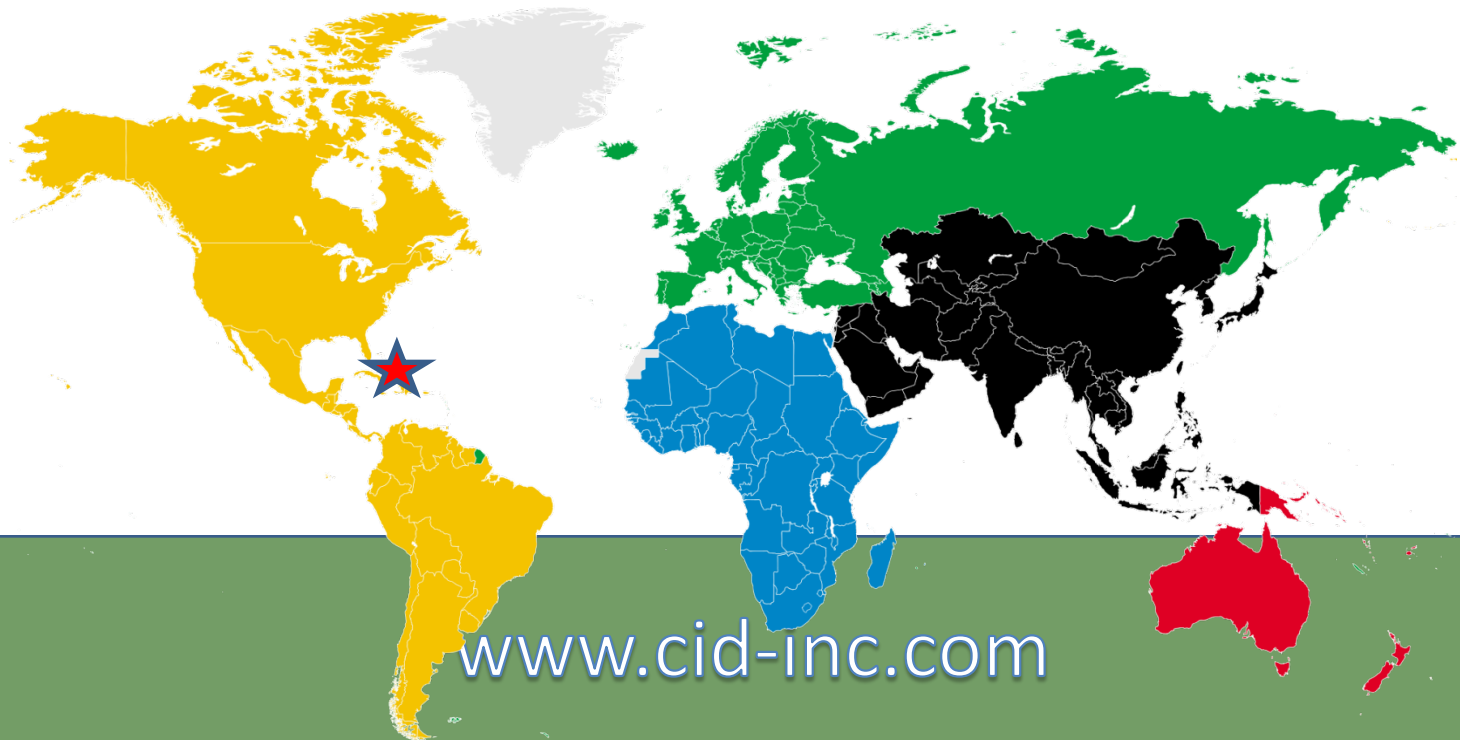
# Michaël Belluau, Université de Sherbrooke



**Photo credits:  
M. Belluau,  
University of  
Sherbrooke**

# Setu Monroe, University of the West Indies

- Setu Monroe-student, primary researcher
- Dr. Kurt McLaren: Department of Life Sciences, University of the West Indies, Jamaica



# Setu Monroe, University of the West Indies

## Regeneration Ecology of a Moist Forest Over Limestone; Cockpit Country, Jamaica.

### Objectives:

- Collect and assess data on forest dynamics
- Assess major trends and relationships between forest dynamics and environmental variables
- Assign tree species to guilds based on plant ecophysiology and dynamics data



Photo credit: [www.wildlifeextra.com](http://www.wildlifeextra.com)



Photo credit:  
[http://en.wikipedia.org/  
wiki/Cockpit\\_Country](http://en.wikipedia.org/wiki/Cockpit_Country)



# Setu Monroe, University of the West Indies

## Challenges of the Project:

- Limestone karst topography with loose surface rocks
- Average slope incline of  $> 45\%$
- Requires backpack hikes up to 4 hours to reach sites
- Daily convectional rainfall
- Suitable power source for equipment

# Setu Monroe, University of the West Indies



CI-340 fixed to a tripod, showing the rough terrain and steep incline.

Photo credit: S. Monroe, U.  
of West Indies

[www.cid-inc.com](http://www.cid-inc.com)



# Setu Monroe, University of the West Indies



**CI-340 performing “Warming Up” procedure, prior to measurements**



**CI-340 with light module attached**



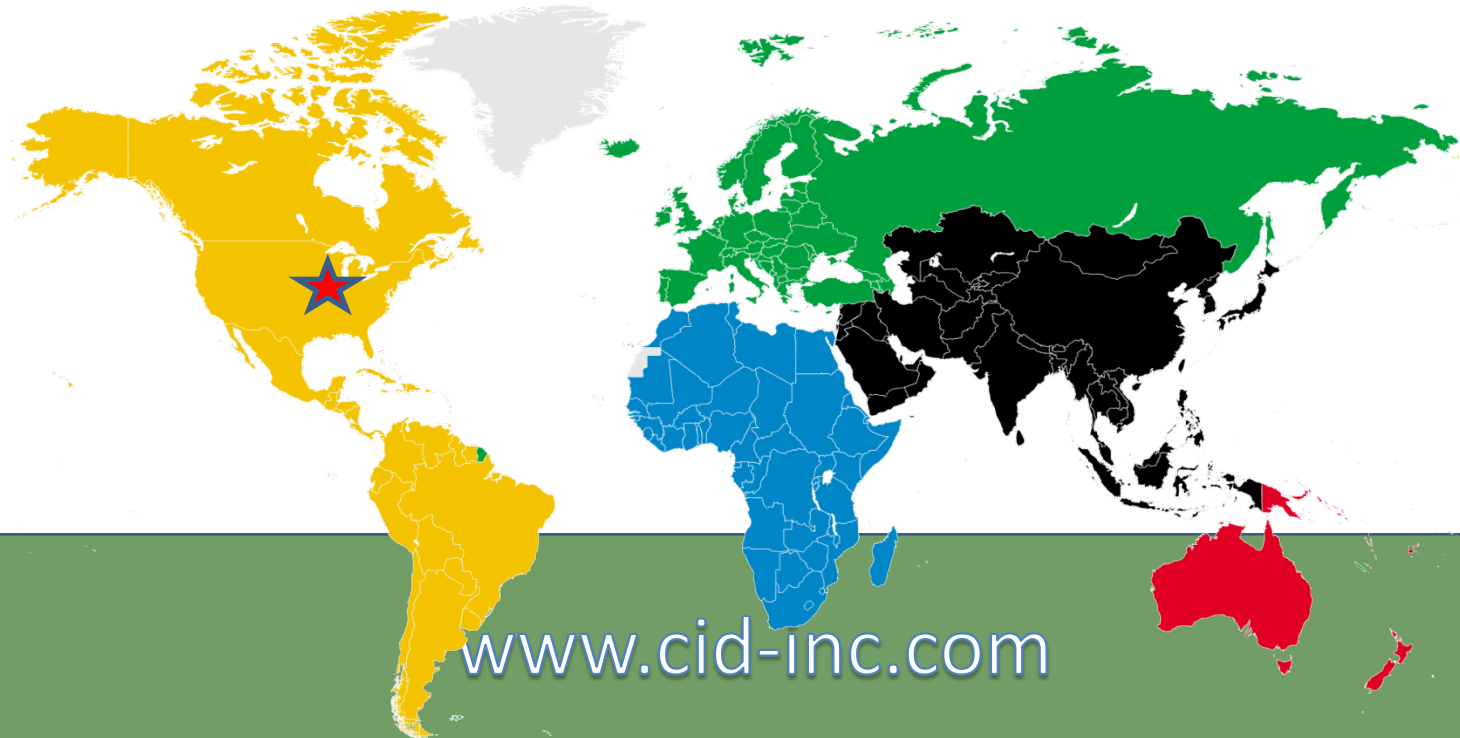
# Setu Monroe, University of the West Indies



**CI-340 with light module attached, showing a modified setup for in situ constant CO<sub>2</sub> supply which is varied to reflect forest floor CO<sub>2</sub> changes throughout the day**

# Scott Bradfield, Southern Illinois University

- Scott Bradfield-student, primary researcher
- Dr. Stephen Ebbs: Department of Plant Biology, Southern Illinois University Carbondale



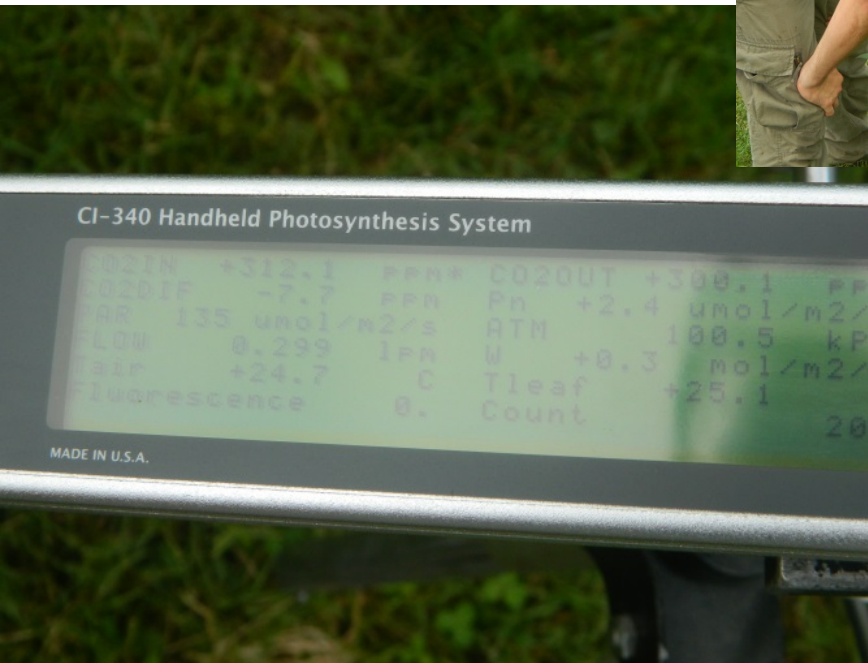
# Scott Bradfield, Southern Illinois University

## Research

- Determine the effects of foliar applied nanoparticles on photosynthetic efficiency of crop plants
  - Used the CI-340 to take biweekly measurements
    - Data collected from CI-340: Pn, E, C, and Leaf Temp. (Net Photosynthesis, Transpiration, Stomatal Conductance, and Leaf Temperature)
    - Derived radiation use efficiency and water use efficiency from data collected with the CI-340



Photo credits: S. Bradfield,  
Southern Illinois University

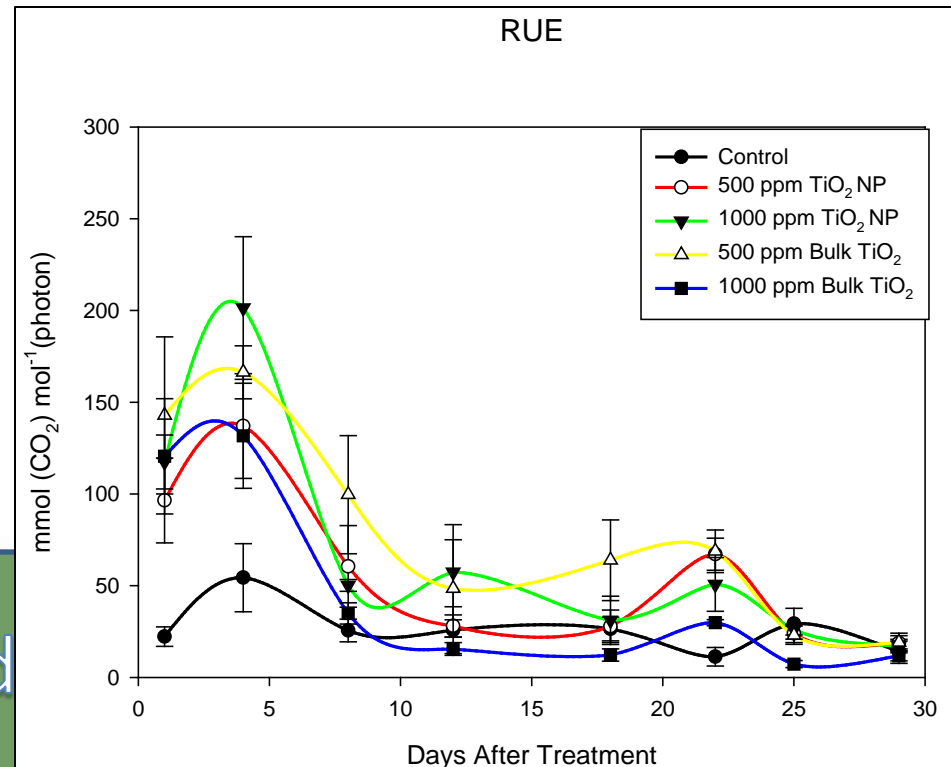


# Scott Bradfield, Southern Illinois University

## Results

- Large increase in RUE between 2 and 8 DAT
- After 8 DAT the plants begin to acclimate and have an RUE closer to normal

- $$RUE = \frac{Pn}{PAR} * 1,000$$

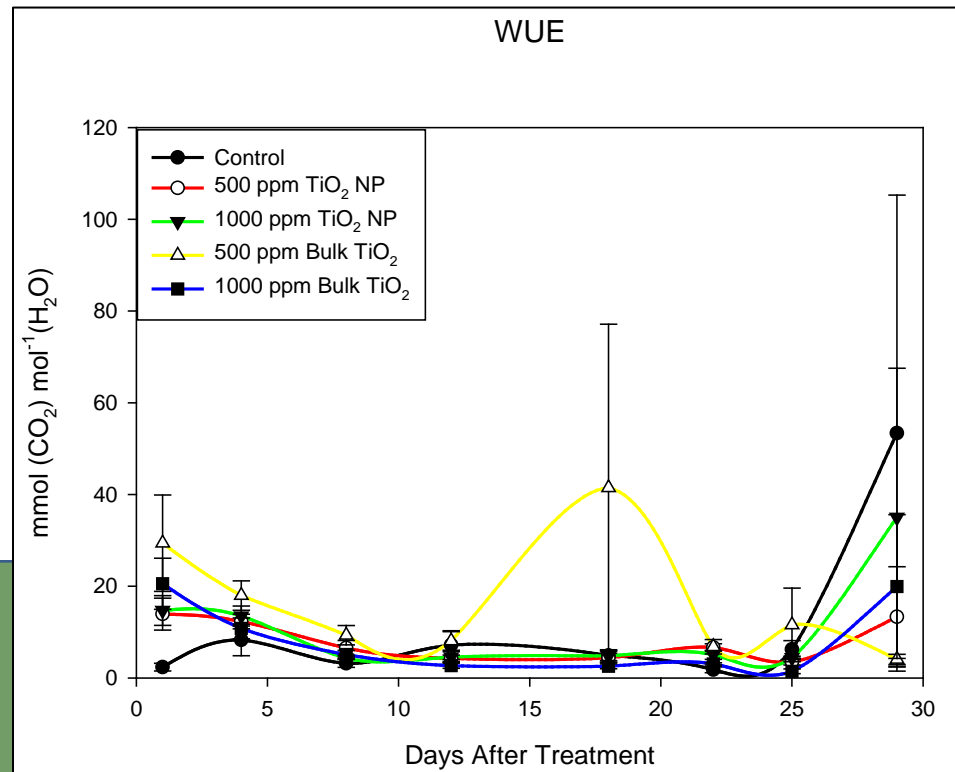


# Scott Bradfield, Southern Illinois University

## Results

- Initial increase in WUE but returned to the same rate as the control by 4 DAT

- $$WUE = \frac{Pn}{E}$$

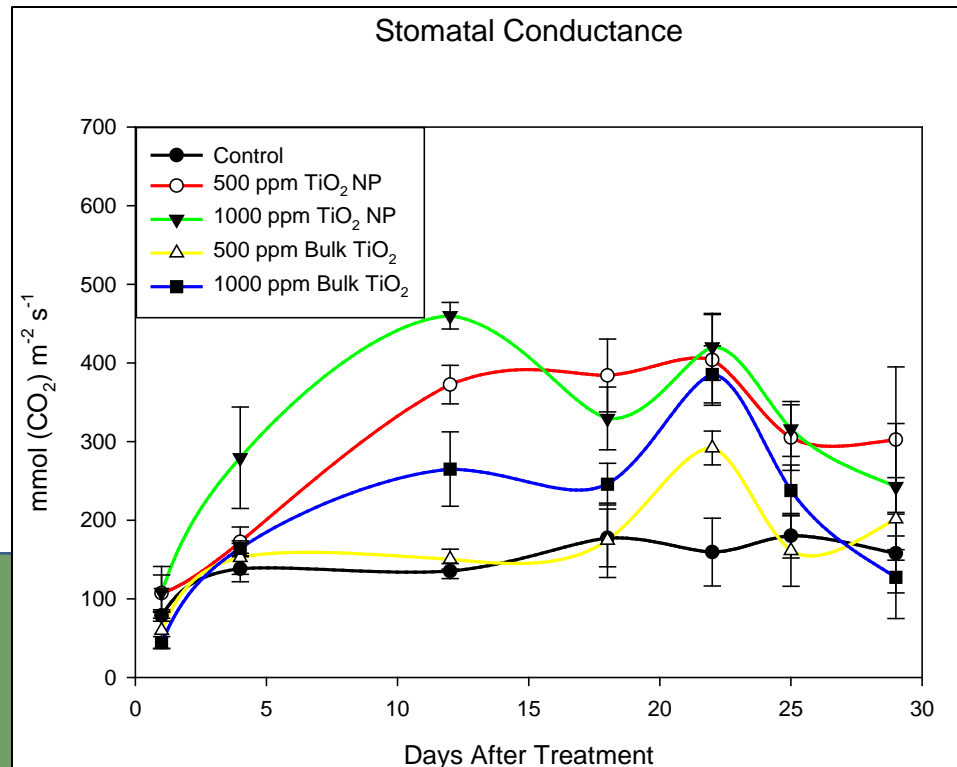




# Scott Bradfield, Southern Illinois University

## Results

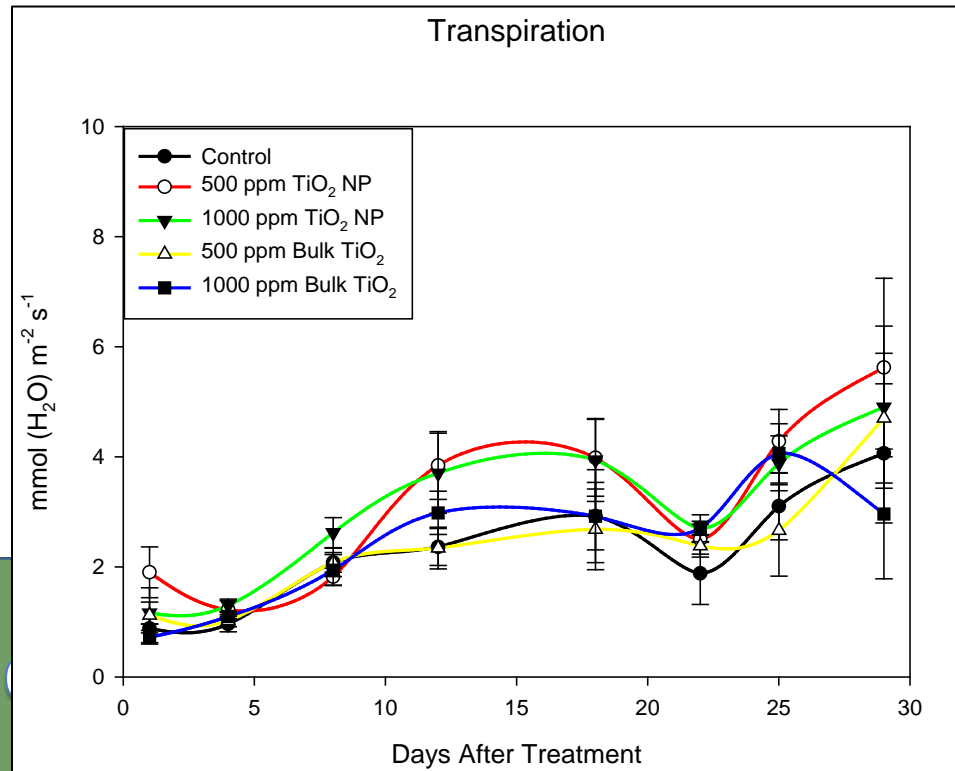
- Sustained increase in stomatal conductance after 4 DAT with all treatments except 500 ppm Bulk  $\text{TiO}_2$



# Scott Bradfield, Southern Illinois University

## Results

- Increase in transpiration from  $\text{TiO}_2$  ENPs after 12 DAT
- Bulk  $\text{TiO}_2$  did not have an effect on transpiration



# Scott Bradfield, Southern Illinois University

## Conclusion

- $\text{TiO}_2$  ENPs transiently enhance photosynthetic efficiency in *Z. mays*
  - There is an initial increase in RUE and WUE but the *Z. mays* acclimated to the stimulus and returned to normal rates
- Increase stomatal conductance but not evapotranspiration rates (higher gas exchange without increased water loss)



# Simone Whitecloud, Dartmouth University

- Ph.D. Student, Ecology and Evolutionary Biology:  
Dartmouth University, New Hampshire
- Studying low-lying plants at elevation
- Innovative custom leaf chamber

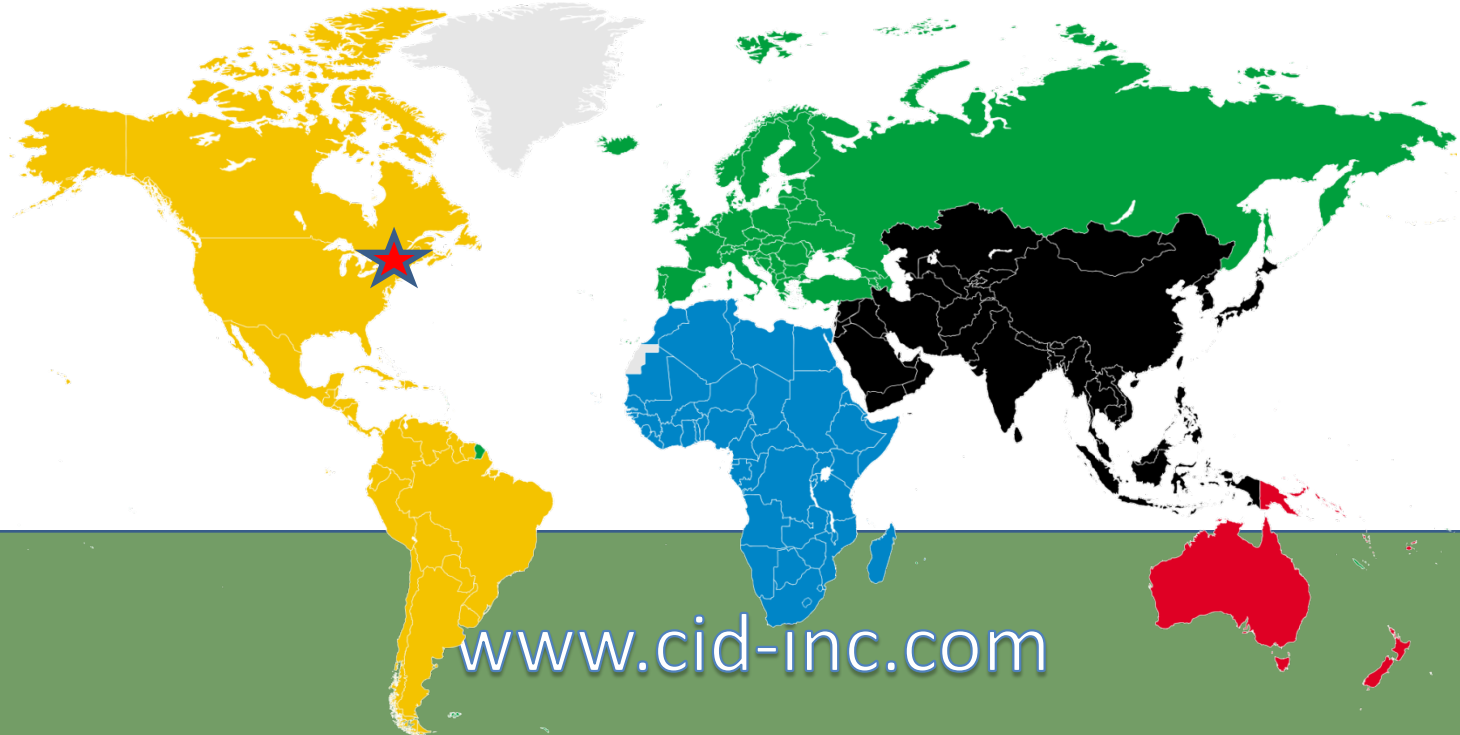




Photo credit: S. Whitecloud, Dartmouth





Photo credit: S. Whitecloud, Dartmouth



# PART III: Travel Grant Sign Up

- Winners of the grant will receive a 30-day extended evaluation of a CI-340 Handheld Photosynthesis System and a \$250 travel grant to present their findings at a conference of their choice.

## Guidelines:


- Submit a written proposal (1 page) outlining your idea for an experiment involving the use of the CI-340 Handheld Photosynthesis System. Proposals should highlight how collecting net photosynthesis data enhances your research. Priority will be given to innovative ideas and concepts. Any of the standard CI-340 leaf chambers and/or the soil respiration chamber are available for the project.

# Travel Grant Guidelines

- Projects proposals are due **May 1, 2014**. The top three proposals will be chosen by a panel made up of CID Bio-Science staff. Winners will be notified **May 15, 2014**. CI-340 evaluation units will be shipped to winners with the date depending on the specific project proposal.
- Winners will have the opportunity of an extended **30-day evaluation** of a CI-340 Handheld Photosynthesis System. The evaluation period is intended to allow winners to carry out the proposed project. At the end of the evaluation period, winners should submit a summary paper or poster and receipts for travel/registration to a plant science conference to claim the **\$250 travel grant**.
- Winners of travel grant may also have the opportunity to present their findings at upcoming conference workshops with CID Application Scientists (TBA).
- Submit your project proposal and information at: <http://www.cid-inc.com/340travelgrant>

[www.cid-inc.com](http://www.cid-inc.com)

# Thank you



**Your questions,  
please!**



**Travel Grant**

[www.cid-inc.com](http://www.cid-inc.com)