Ecophysiology in an ombrotrophic spruce bog – *potential impacts with climate change*

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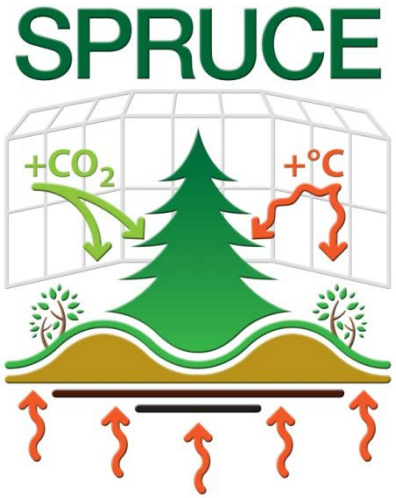
THE SPRUCE EXPERIMENT
at the Marcell Experimental Forest
http://www.mnspruce.ornl.gov/



***S**pruce and*
***P**eatland*
***R**esponses*
***U**nder*
***C**limatic and*
***E**nvironmental*
change

What is SPRUCE?

→ **An experiment to assess the response of northern peatland ecosystems to increases in temperature and exposures to elevated atmospheric CO_2 concentrations.**

→ A multi-year cooperative among scientists at ORNL and the USDA Forest Service Northern Research Station at the Marcell Experimental Forest in northern Minnesota

→ Sponsored by the Office of Biological and Environmental Research within the US Department of Energy's Office of Science

Outline

SPRUCE study overview

→ Ecosystem characteristics

→ Warming and CO_2 treatments

→ Main science questions - quantifying ecosystem responses

Plant water relations

→ Sphagnum, shrub tree water use

→ Sap flow

→ Water potential

Plant carbon physiology

→ Photosynthesis in response to light (light response curves)

→ Photosynthesis in response to CO_2 (A-C_i curves)

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SPRUCE Project Setting

***Picea mariana – Sphagnum spp.* forest in N. Minnesota**

→ This ecosystem is located at the southern extent of the spatially expansive boreal peatland forests

→ Considered vulnerable to climate change and is expected to generate important greenhouse gas feedbacks to the atmosphere under changing future climates.

Marcell Experimental Forest

Species in the S1 bog at Marcell

→ *Picea mariana* (black spruce) – dominant overstory

→ *Larix laricina* (larch) – sparse to dominant overstory

→ *Ledum groenlandicum* (Labrador tea) – co-dominant understory

→ *Chamaedaphne calyculata* (leatherleaf) – co-dominant understory

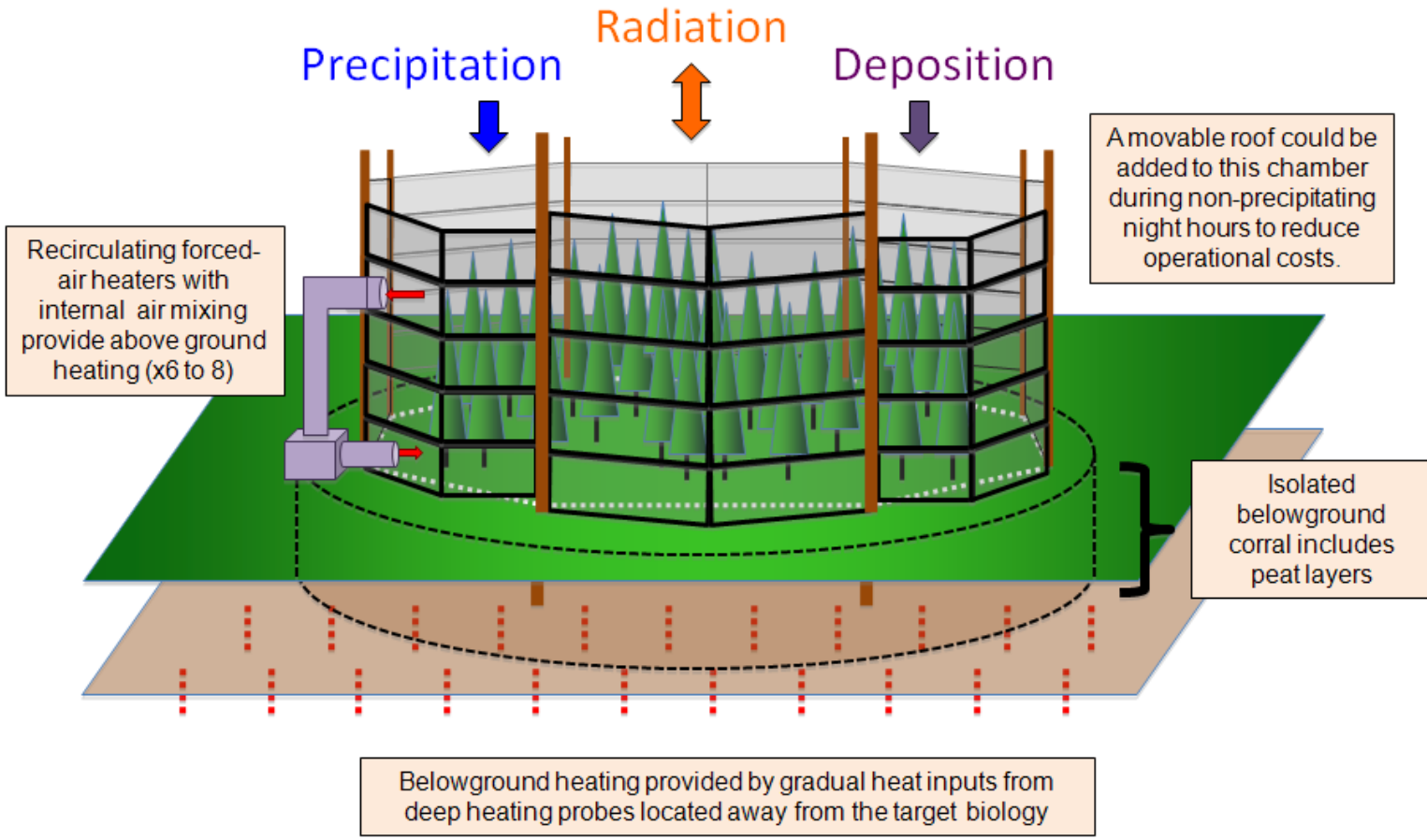
→ *Kalmia polifolia* (bog laurel) – sparse understory

→ *Vaccinium spp*. (blueberry, cranberry) – sparse understory

→ *Eriophorum spp.* (cottongrass), *Smilacina trifolia (Solomon's-seal)*

→ *Sphagnum spp.* – dominant groundcover

Treatments – Open-topped Heated Chamber



→ *12 m diameter internal study area.*

→ *8 m tall aboveground chamber.*

→ *Heating to 2 to 3 meter within peat.*

→ *Belowground environment enclosed in a subsurface corral*

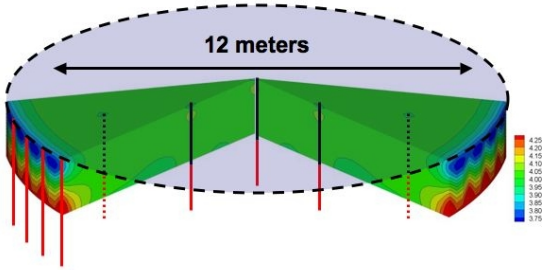
Study Design

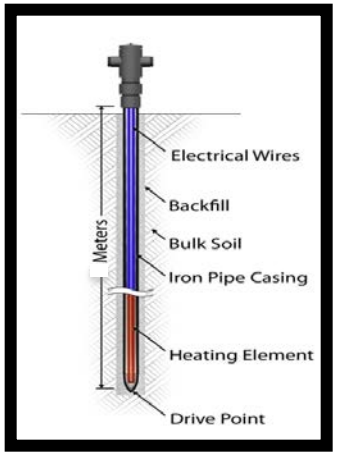
→ Replicated air and soil warming ambient to + 9 °C

→ Replicated CO_2 treatments up to 900 ppm

→ Wooden boardwalk access

→ 10 years of treatments





Main Science Questions

→ How vulnerable are peatlands to climate change?

→ How will species- specific ***physiological*** responses affect their competitive capacity?

→ Will full belowground warming release large amounts of greenhouse gases?

→ What are the critical temperature response functions for ecosystem processes?

→ How will ecosystem services (e.g., biogeochemical, hydrological, or societal) be affected by climatic change?

→ ***Overarching desire to establish strong and direct linkages between mechanisms and models***

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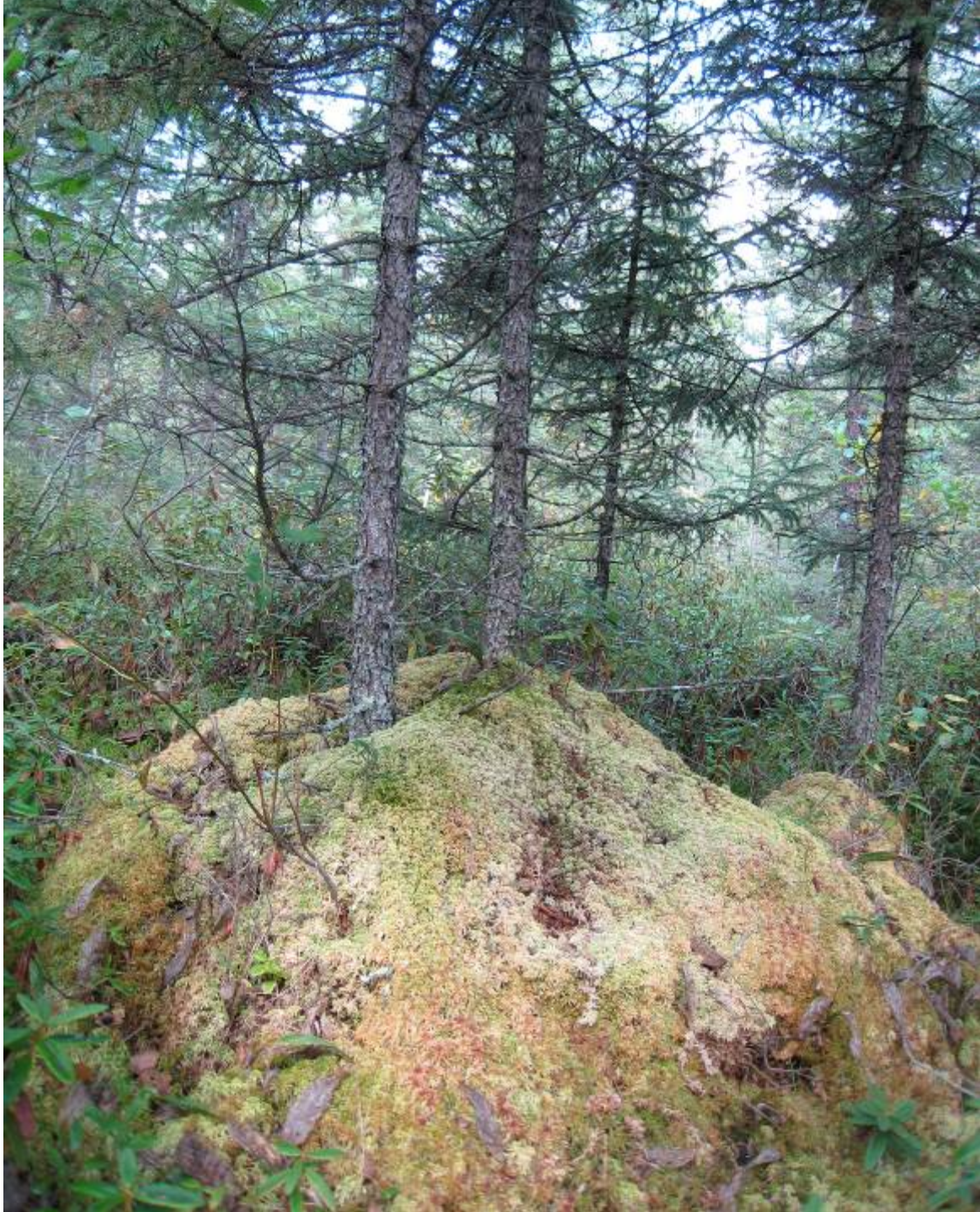
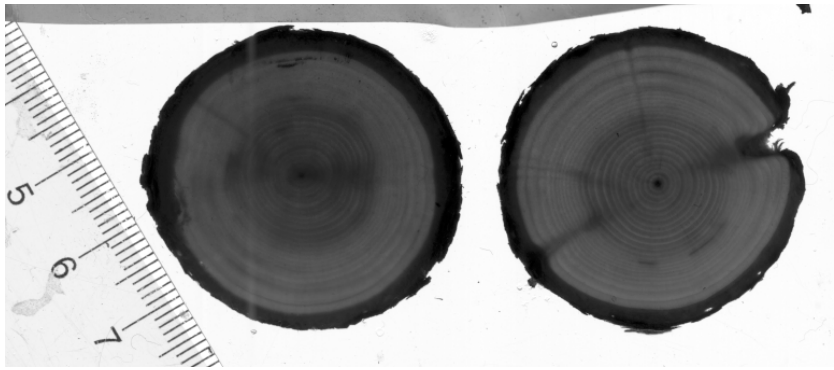
→ Water Use

→ Carbon Uptake



Water relations- estimating sap wood area

Often use light penetration through wood core or disk



Diameter 6.4 cm

Sap wood radius 1.0 to 1.7 cm

Estimated SW Area

16 to 25 cm^2

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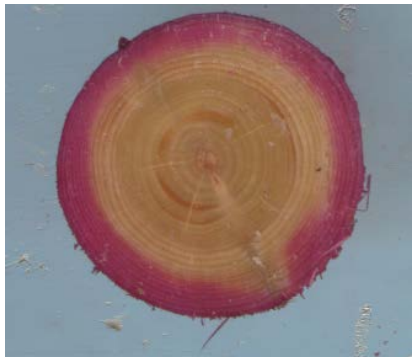
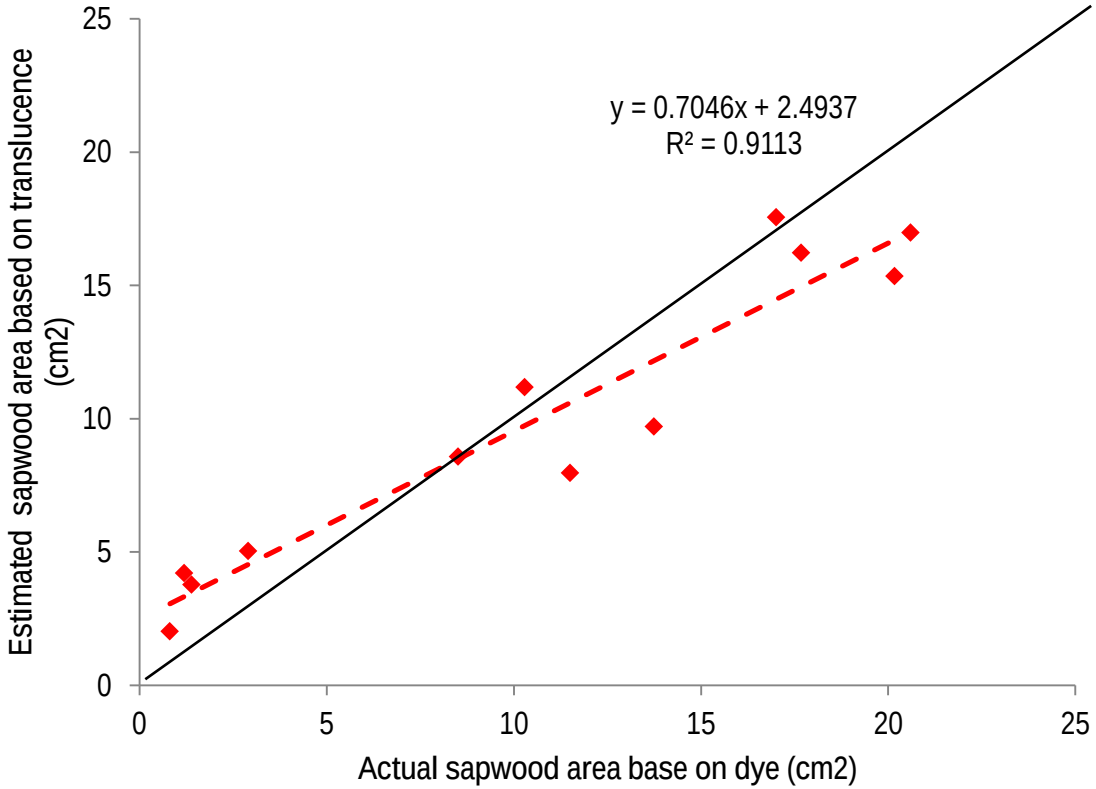
Sap flow - errors in estimating sap wood area

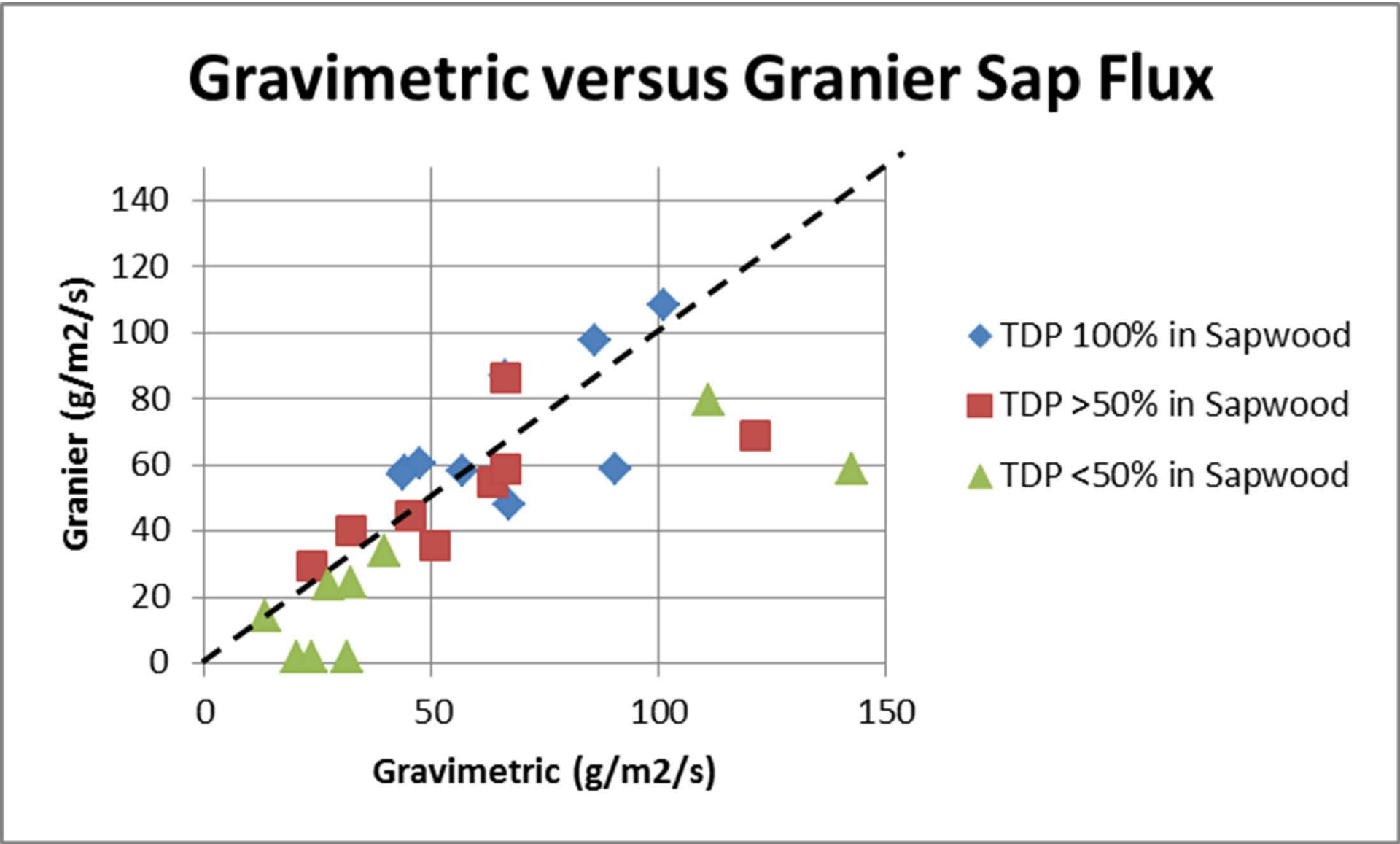
Variation in sap wood radius – differences from translucence





Sap flow - errors in probe placement

Our spruce trees must be > 5cm for use of 1cm TDP sensors



Kleaf – black spruce

Leaf specific conductivity

→ P-V curves

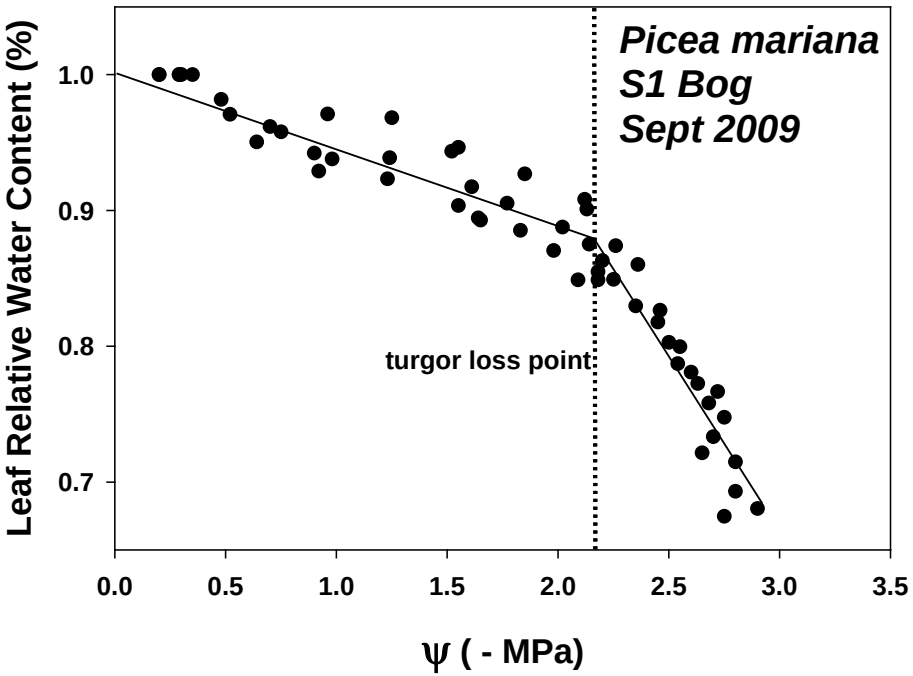
→ estimate capacitance

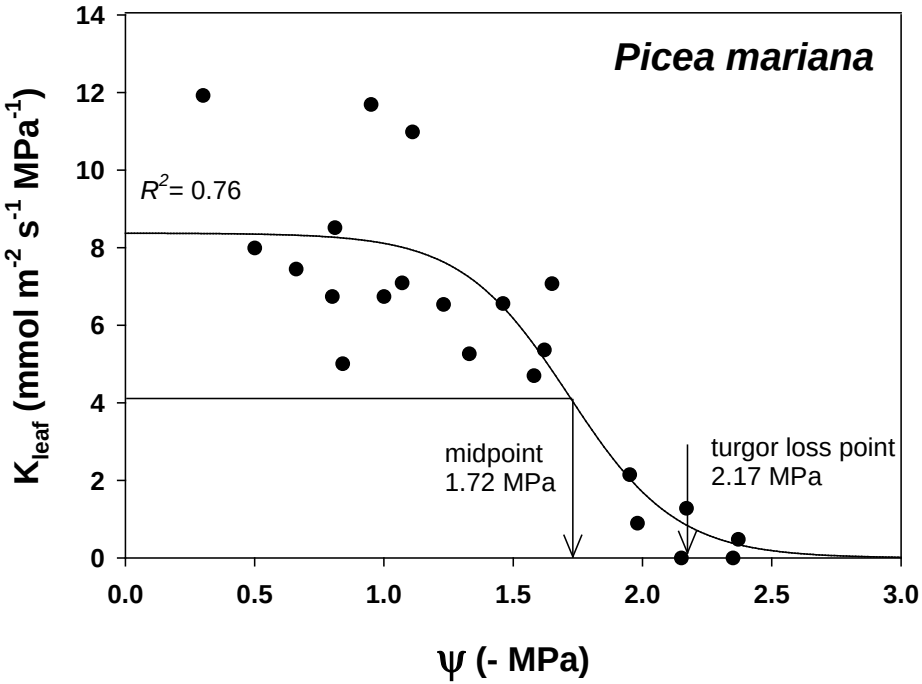
→ estimate turgor loss point

→ timed-rehydration technique

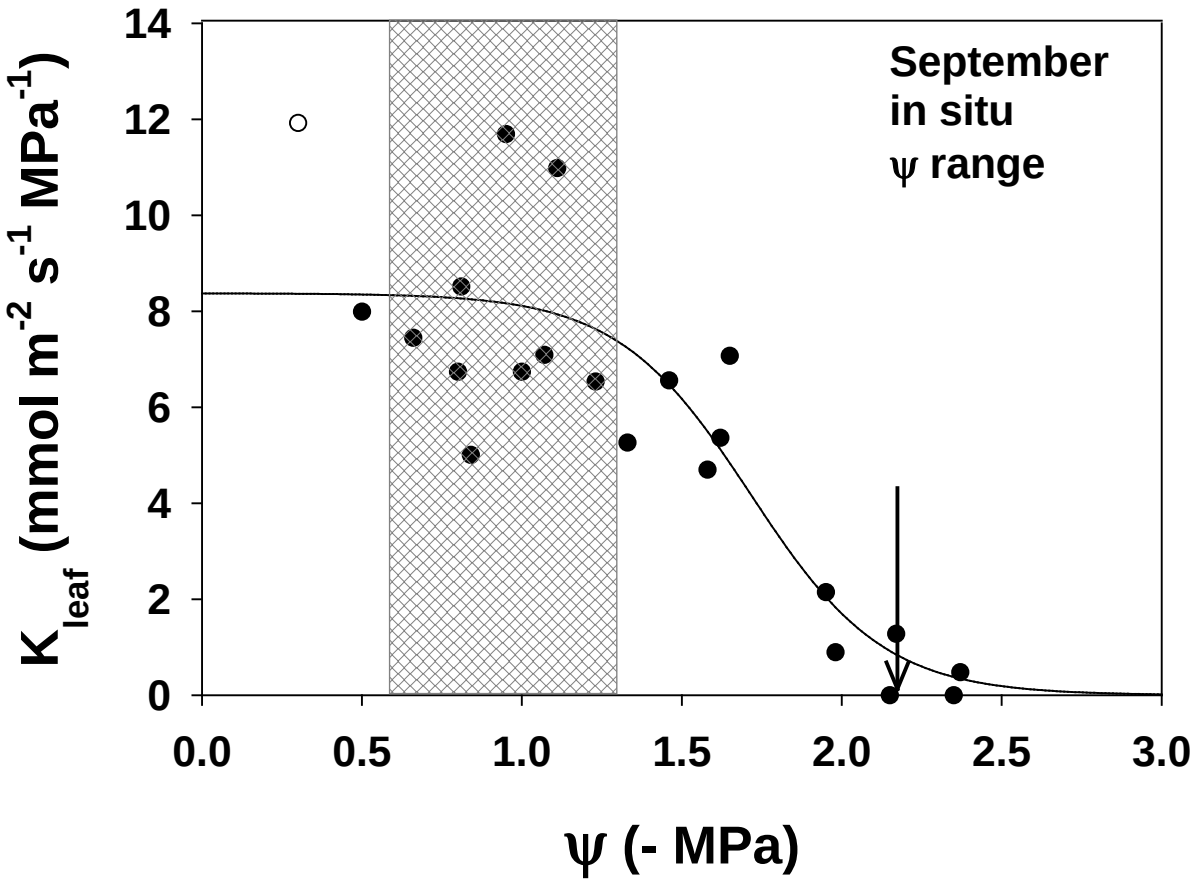
Relation to in situ ψ

→ how close to the turgor loss point does spruce operate?





Kleaf – black spruce – September PV curve



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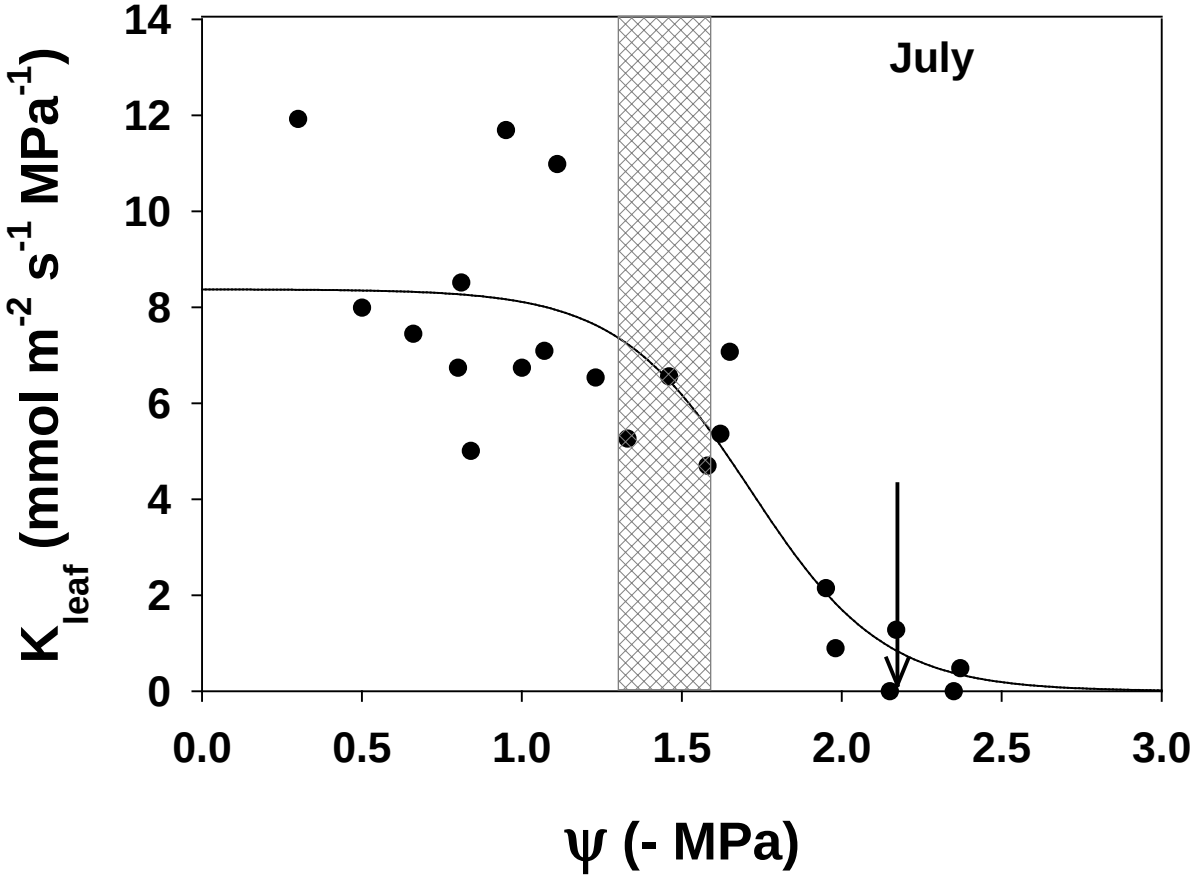

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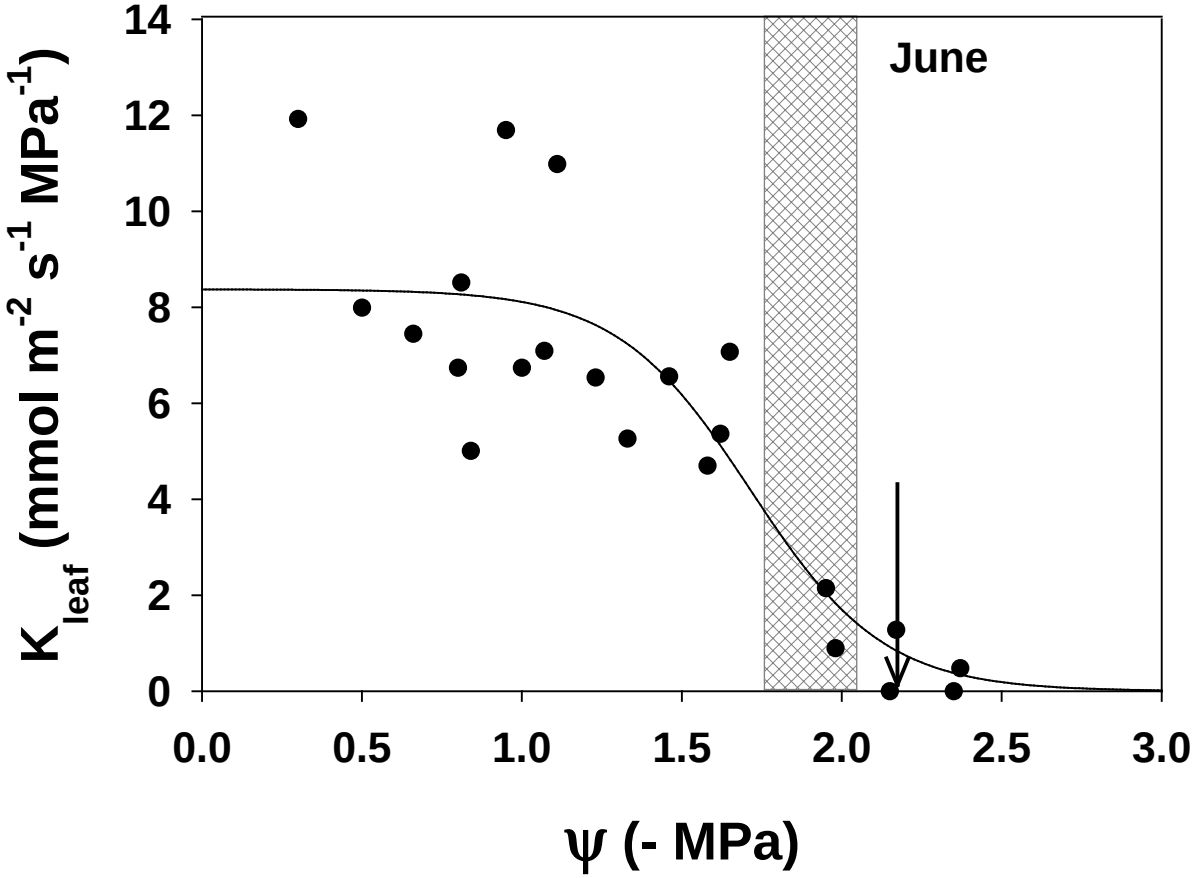
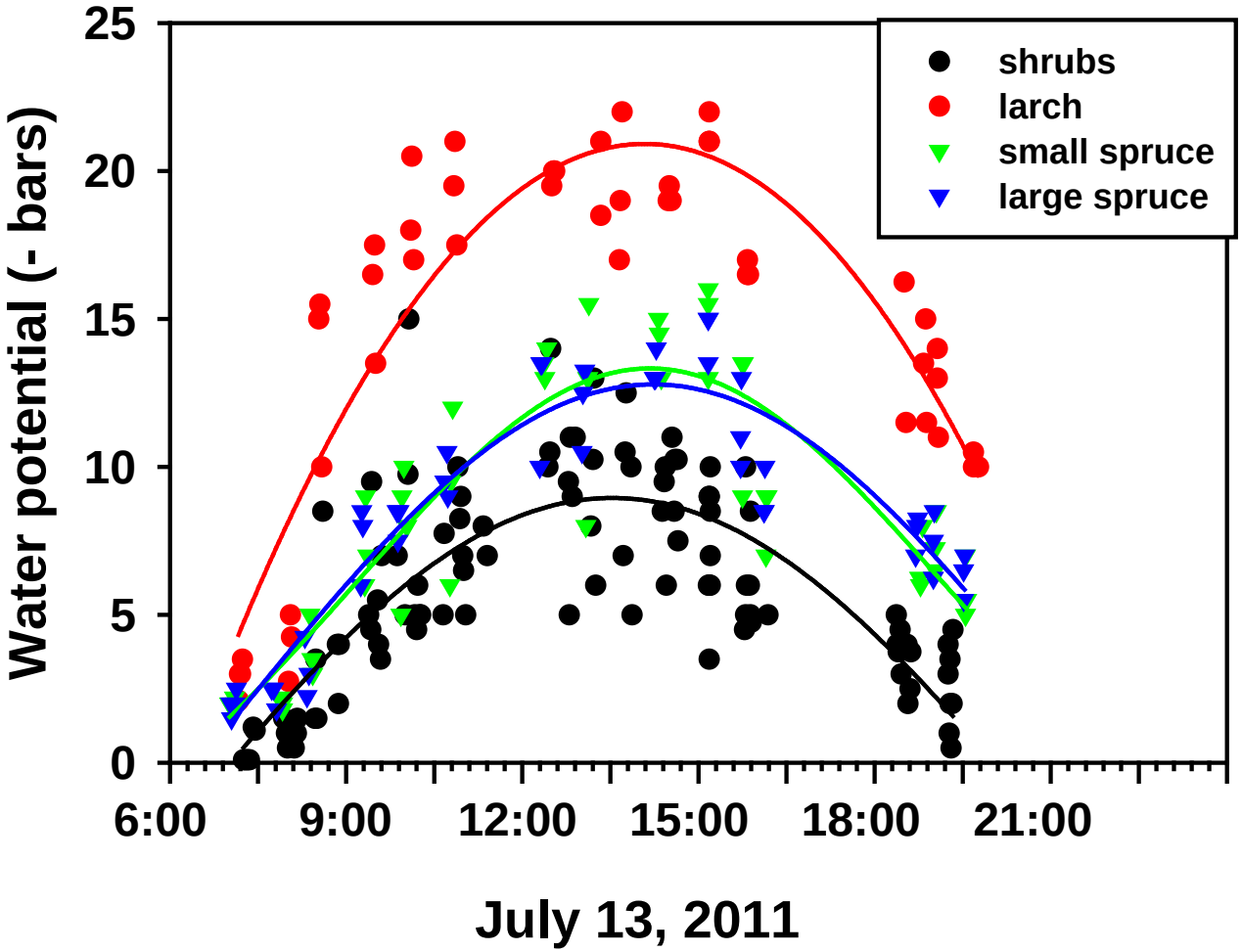


Water potential

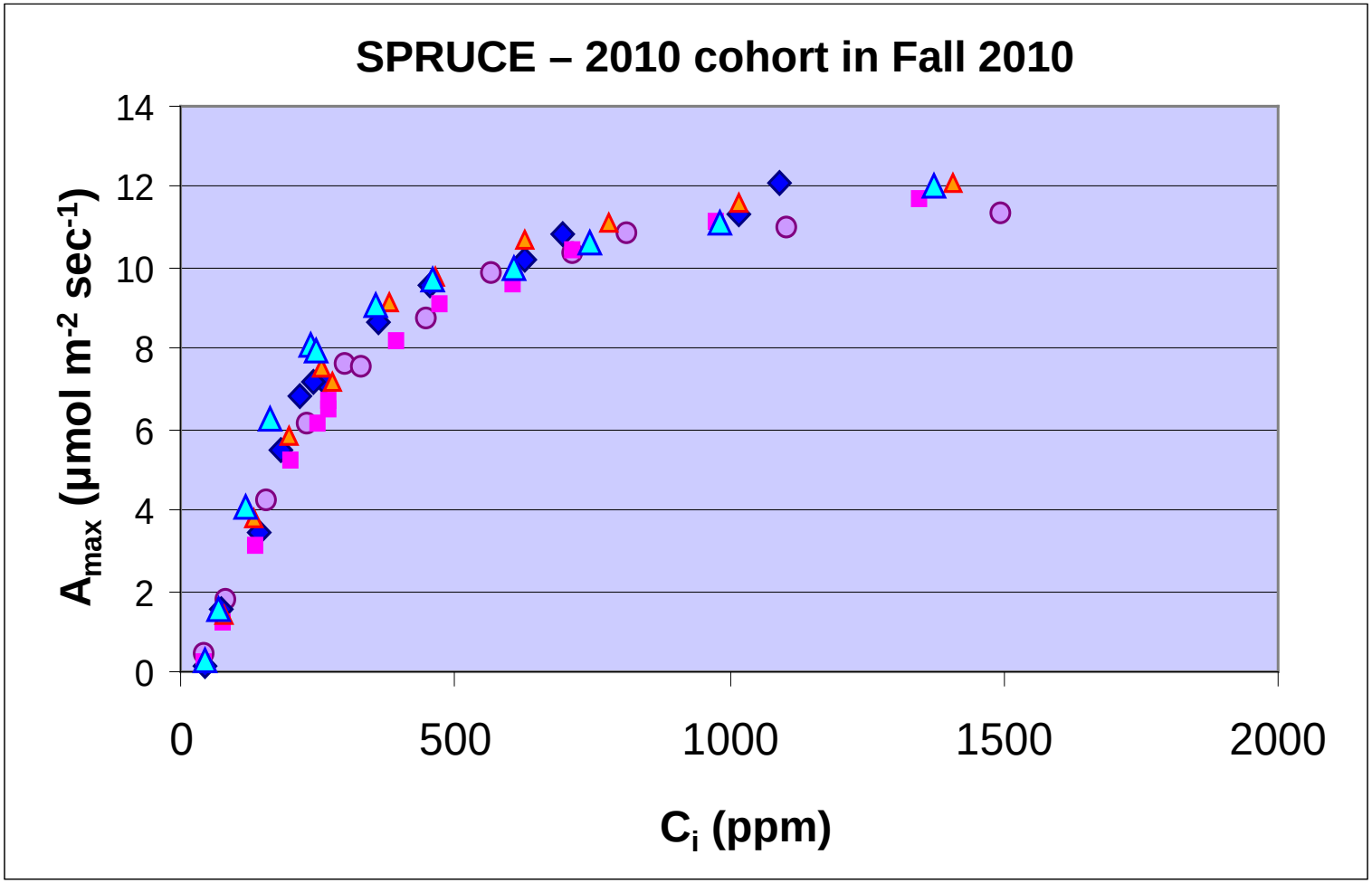


Carbon Physiology - A-Ci Curves

Measurements in situ and on detached foliage

Spruce - multiple cohorts, upper mid and lower branches

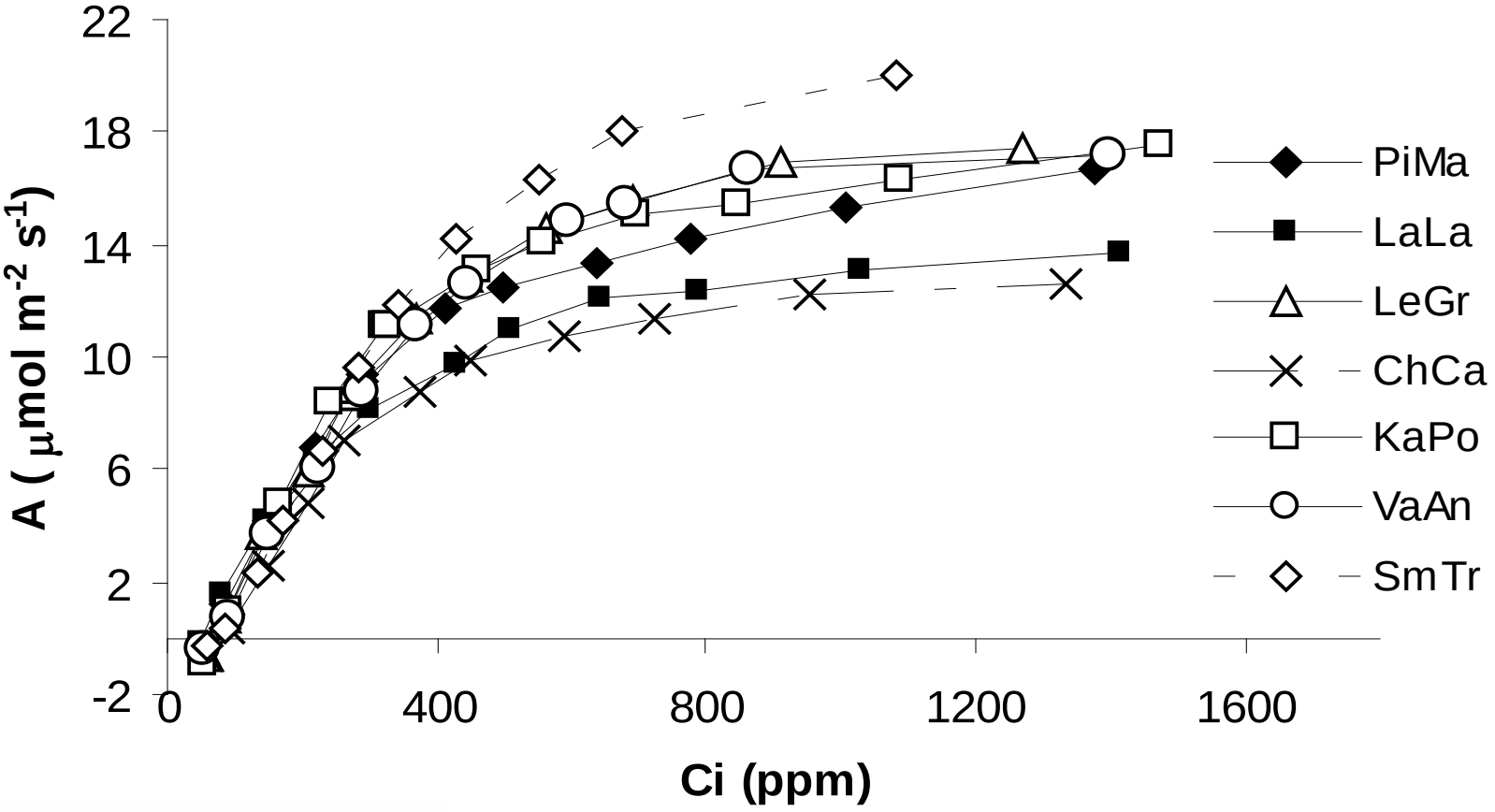
Carbon Physiology - A-Ci Curves



Carbon Physiology - A-Ci Curves

Initial slope A-Ci similar among species

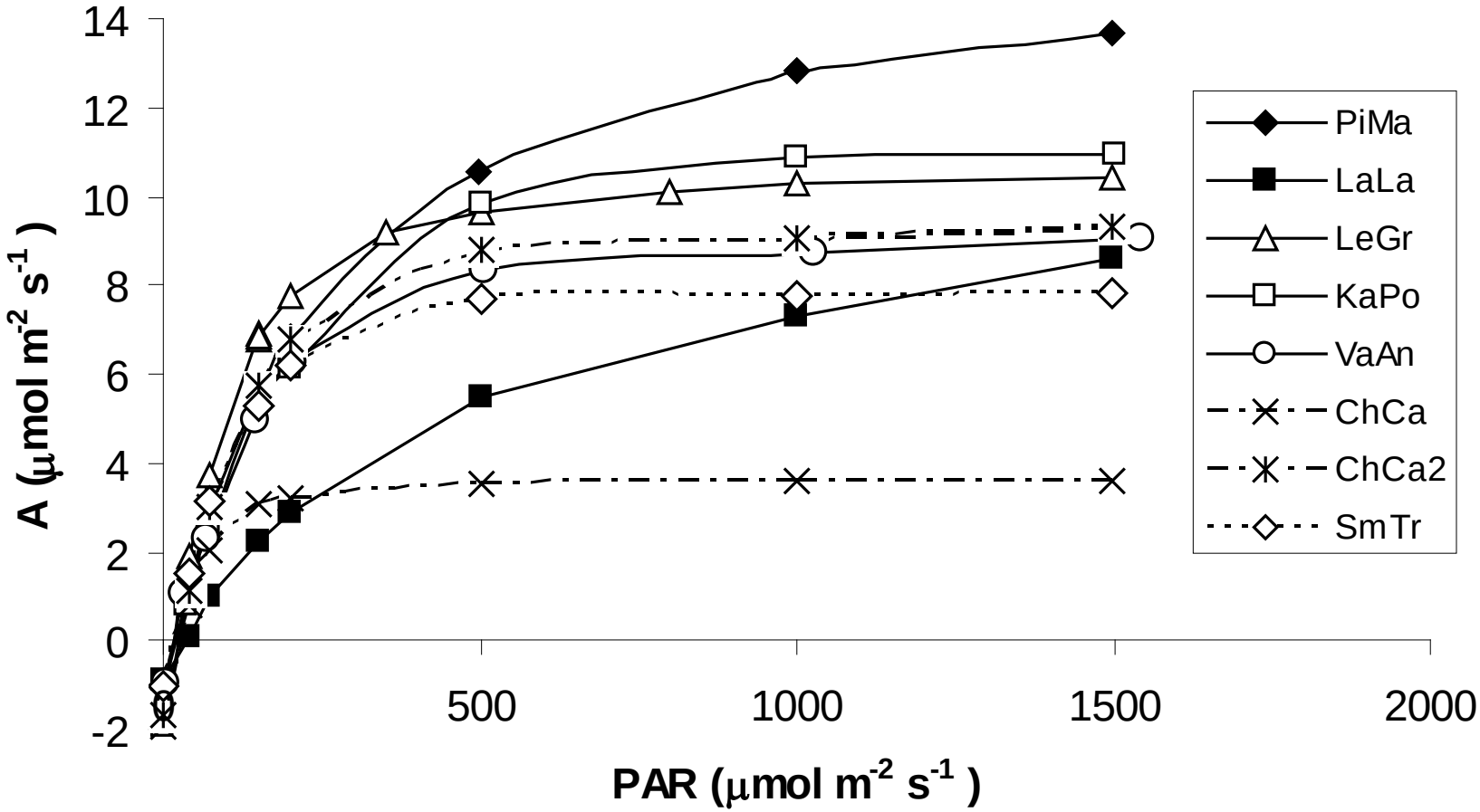
CO_2 saturation lower for trees and one shrub - *Chamaedaphne*



Carbon Physiology - Light Response Curves

Trees – light saturated > 1500 μmol m^{-2} sec^{-1}

Shrubs – light saturated by 500 μmol m^{-2} sec^{-1}



Projections

We expect heating to increase water use and reduce water table depth

We expect +CO_2 will to increase C uptake, greater WUE

→ change resource availability – water, nutrients

→ change net C uptake – increase Rs

→ differential species response

→ shift species composition

→ potential hydraulic adjustment of spruce