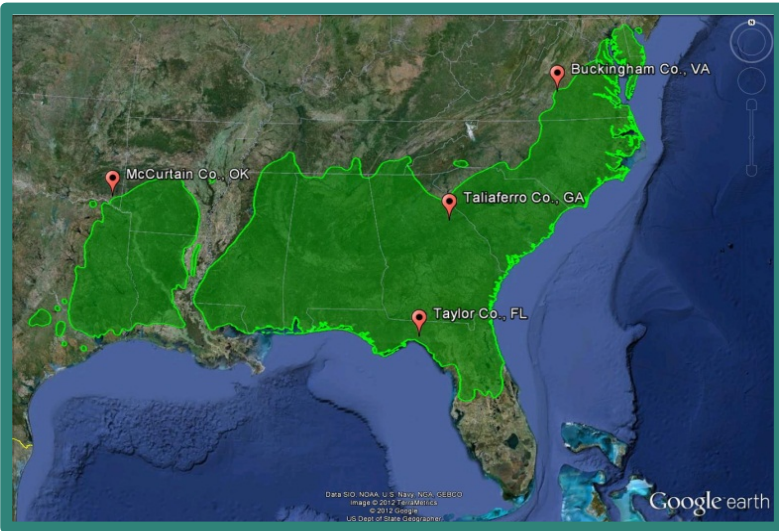




# Field Tour Guide

## PINEMAP 2013 Annual Meeting



April 25, 2013  
Tier III Site  
Taliaferro County, GA

# Field Tour Stations

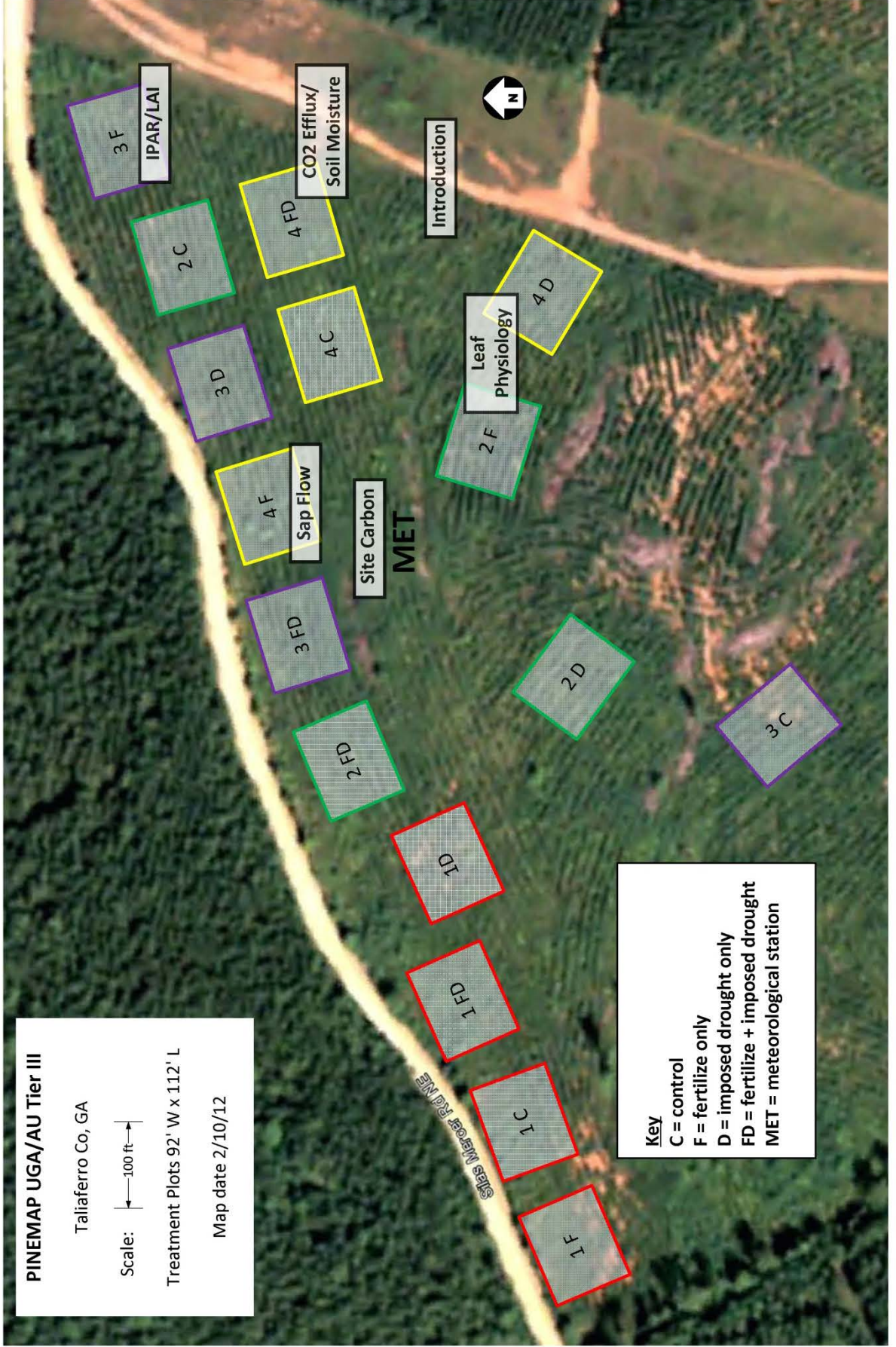
**Introduction** (15 minutes as a large group)

- **Tier III Experiment Overview**  
Madison Akers and Duncan Wilson

**Stations** (groups rotate among stations; 15 minutes/station)

- **Sap Flow: Infrastructure, Technology, & Data Handling**  
Asko Noormets and Mary Anne McGuire
- **Soil CO<sub>2</sub> Efflux and Soil Moisture**  
John Seiler and Dan Markewitz
- **Leaf Physiology**  
Lisa Samuelson and Tom Stokes
- **Intercepted Photosynthetic Active Radiation (IPAR) & Leaf Area Index (LAI)**  
Rod Will and Joe Clark
- **Site Carbon Pool Quantification**  
Andy Laviner and Geoff Lokuta

# Site Map/Station Locations



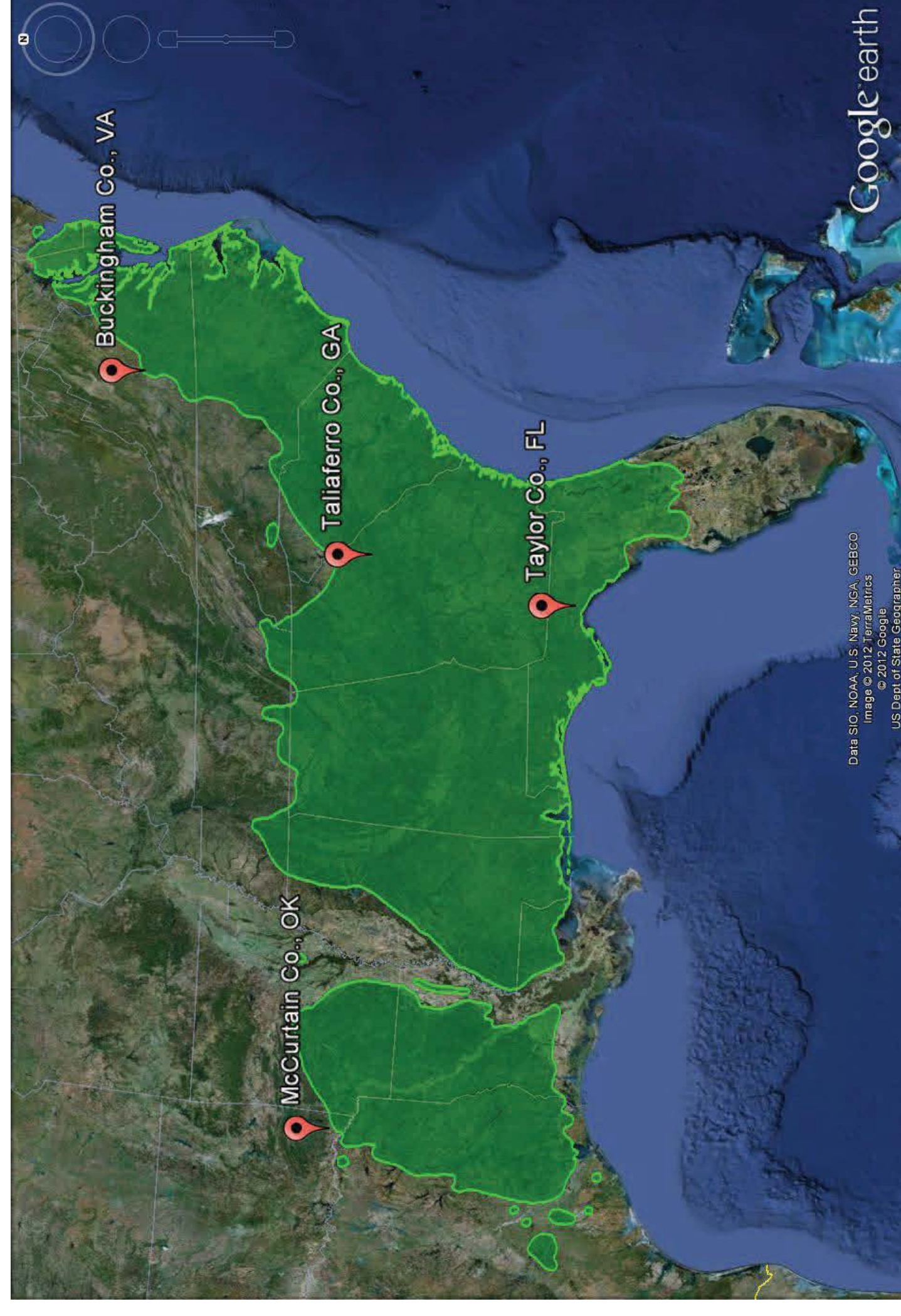
**PINEMAP UGA/AU Tier III**  
 Talliaferro Co, GA  
 Scale: 100 ft  
 Treatment Plots 92' W x 112' L  
 Map date 2/10/12

**Key**  
 C = control  
 F = fertilize only  
 D = imposed drought only  
 FD = fertilize + imposed drought  
 MET = meteorological station



# Tier III Experiment Overview

PINEMAP 2013 Annual Meeting Field Tour  
Tier III site, Taliaferro County, GA



**Figure 1.** Locations of the four throughfall exclusion x fertilization (Tier III) sites.



**Figure 3.** Oklahoma Tier III site.



**Figure 2.** Virginia Tier III site.



**Figure 4.** Florida Tier III site.

**Treatments:** Fertilization and 30% throughfall exclusion

**Fertilization:** 224 kg/ha N, 28 kg/ha P, 56 kg/ha K, and micro-nutrient blend

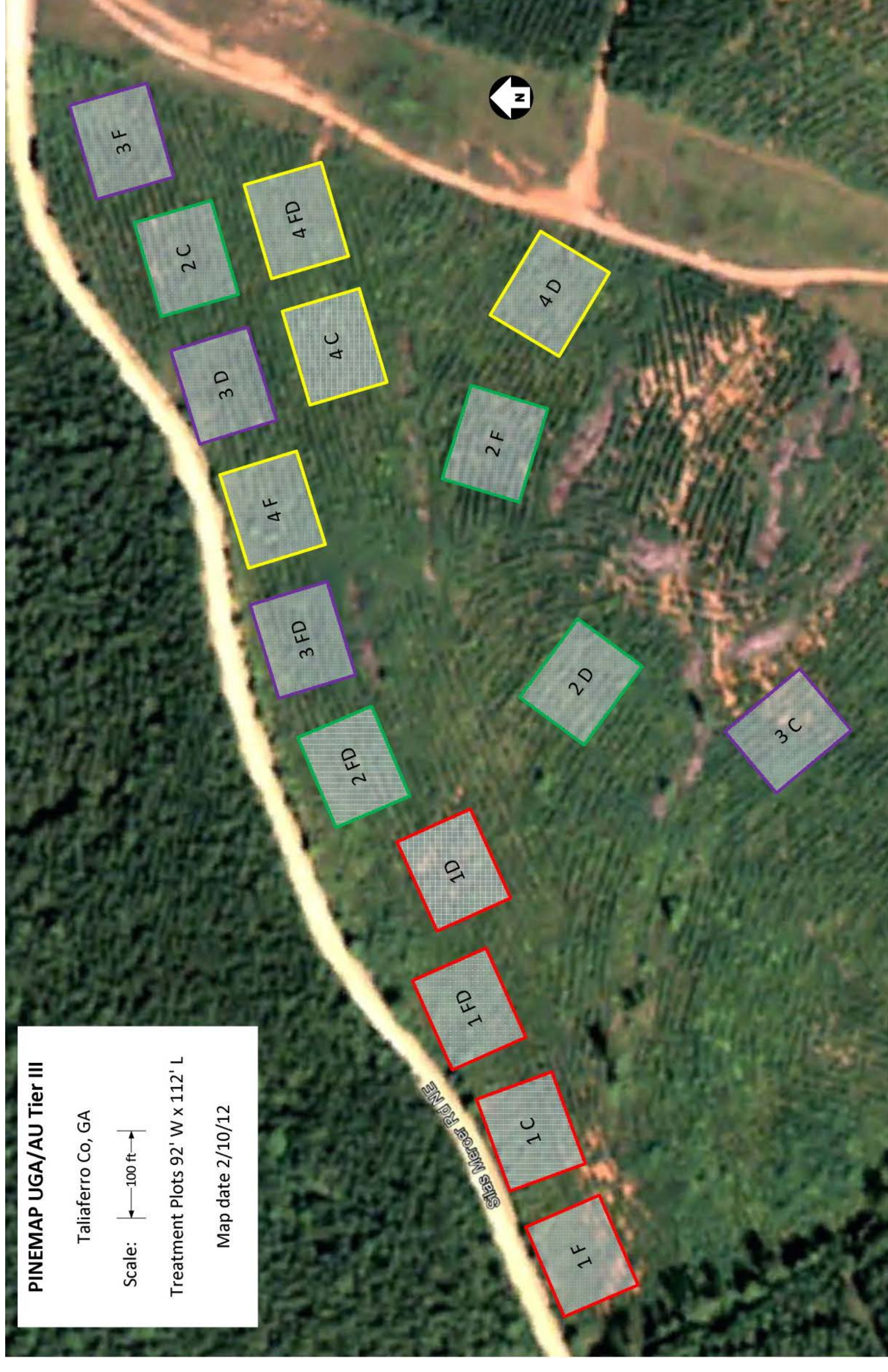
**Treatment plots:** 34.1 x 28.0 meters

**Measurement plots:** 21.3 x 14.0 meters

**Untreated buffer:** 6.1 meters

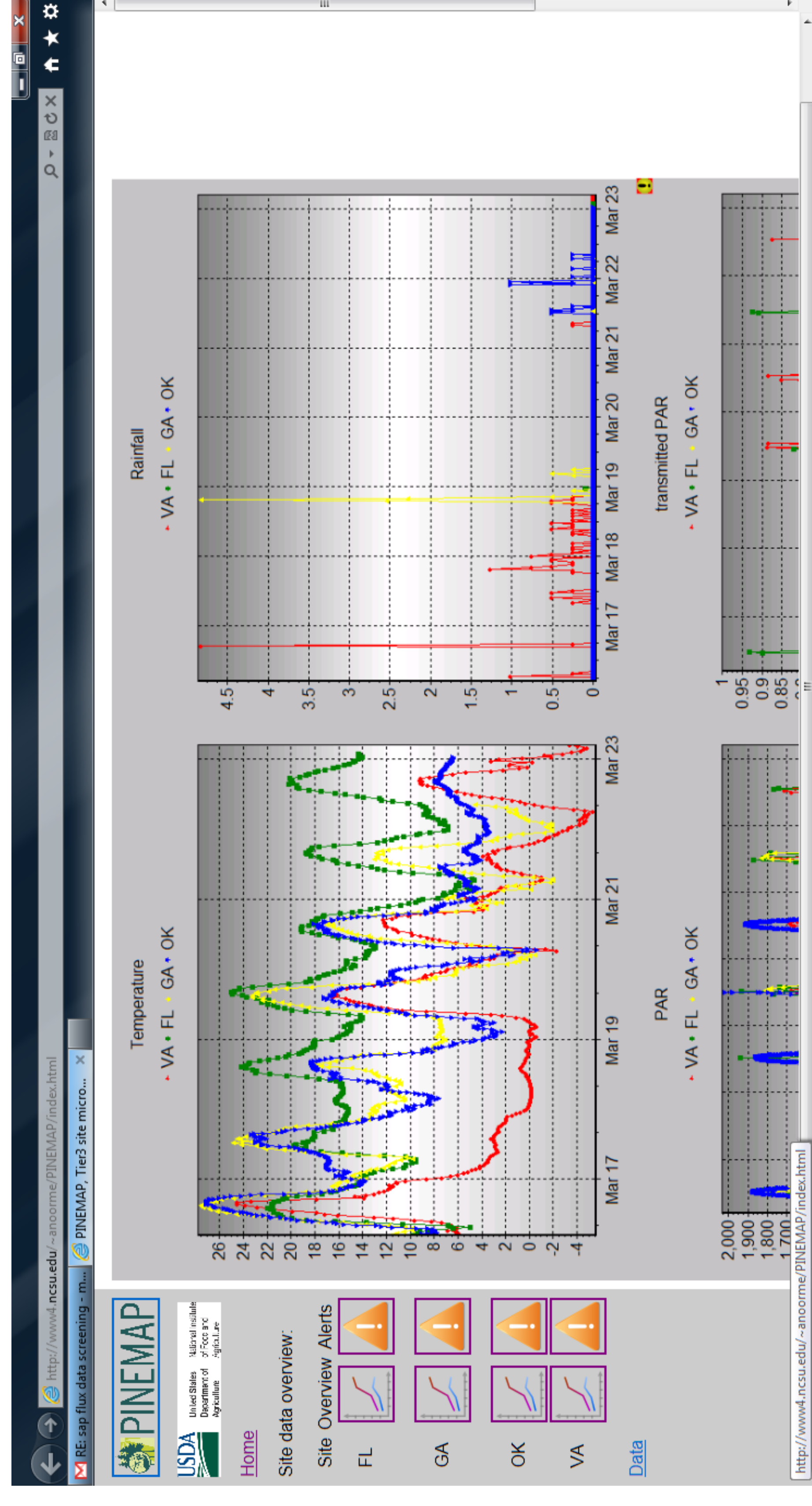
**Study Design:** Randomized complete block

**Species:** Loblolly pine



**Figure 5.** Plot locations for the PINEMAP Tier III site in Georgia. Numbers on plots represent block assignments.

C = control, F = fertilization only, D = throughfall exclusion only, FD = fertilization + throughfall exclusion



**Figure 6.** Tier III site weather data. Found at: <http://www4.ncsu.edu/~anoorme/PINEMAP/index.html>

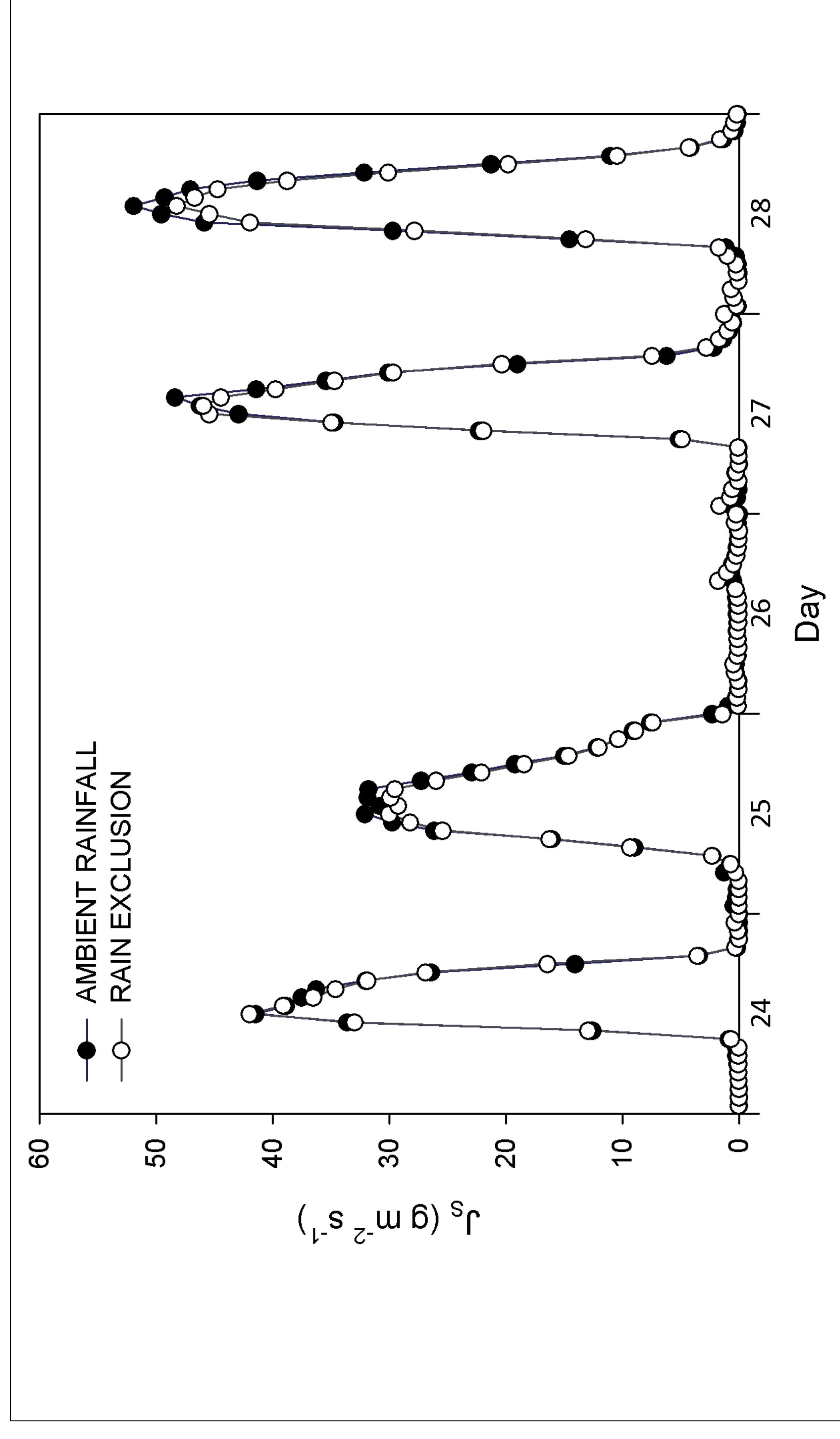
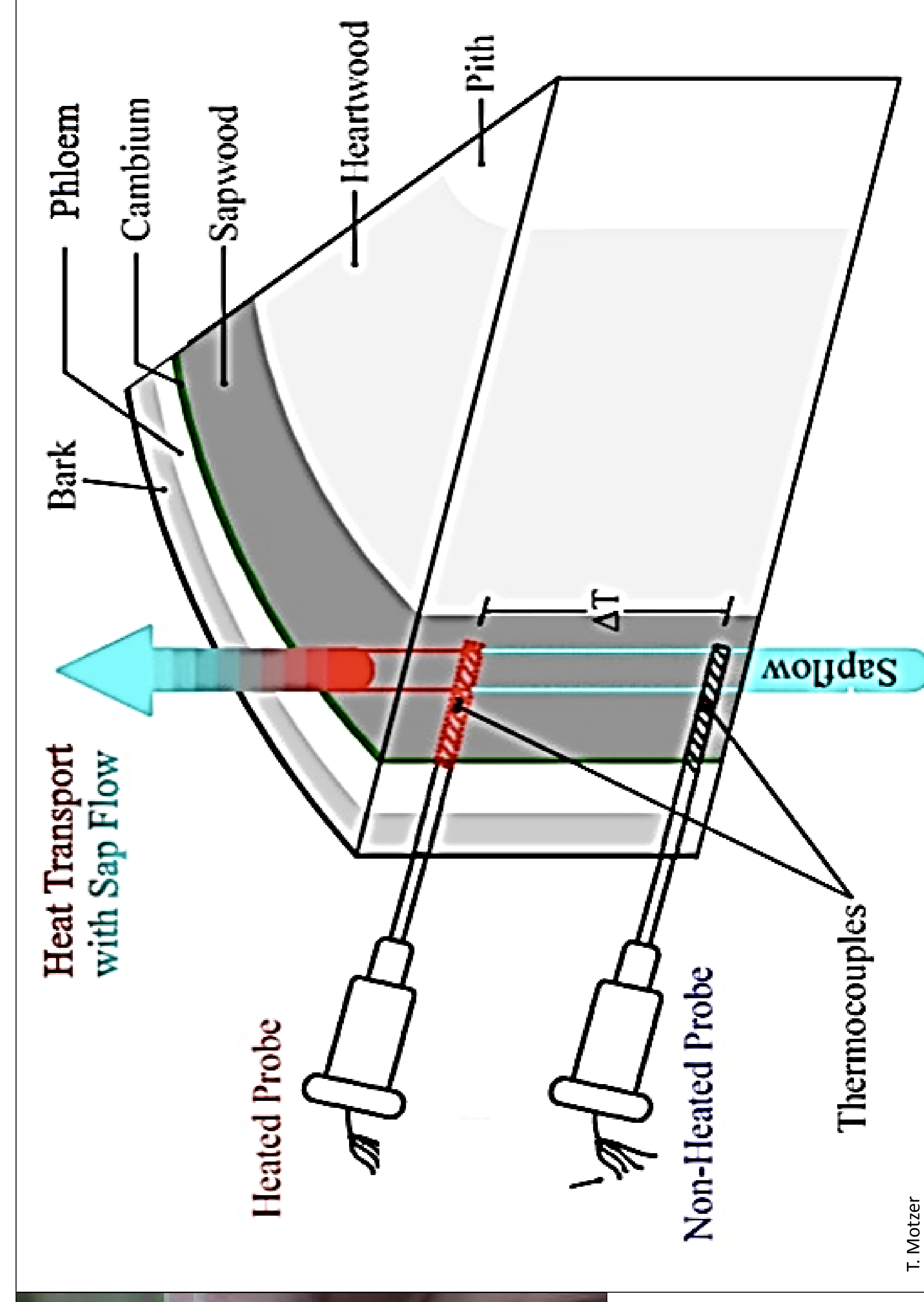


# Sap Flow Sensor Technology & Use of Data

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Tier III site, Taliaferro County, GA

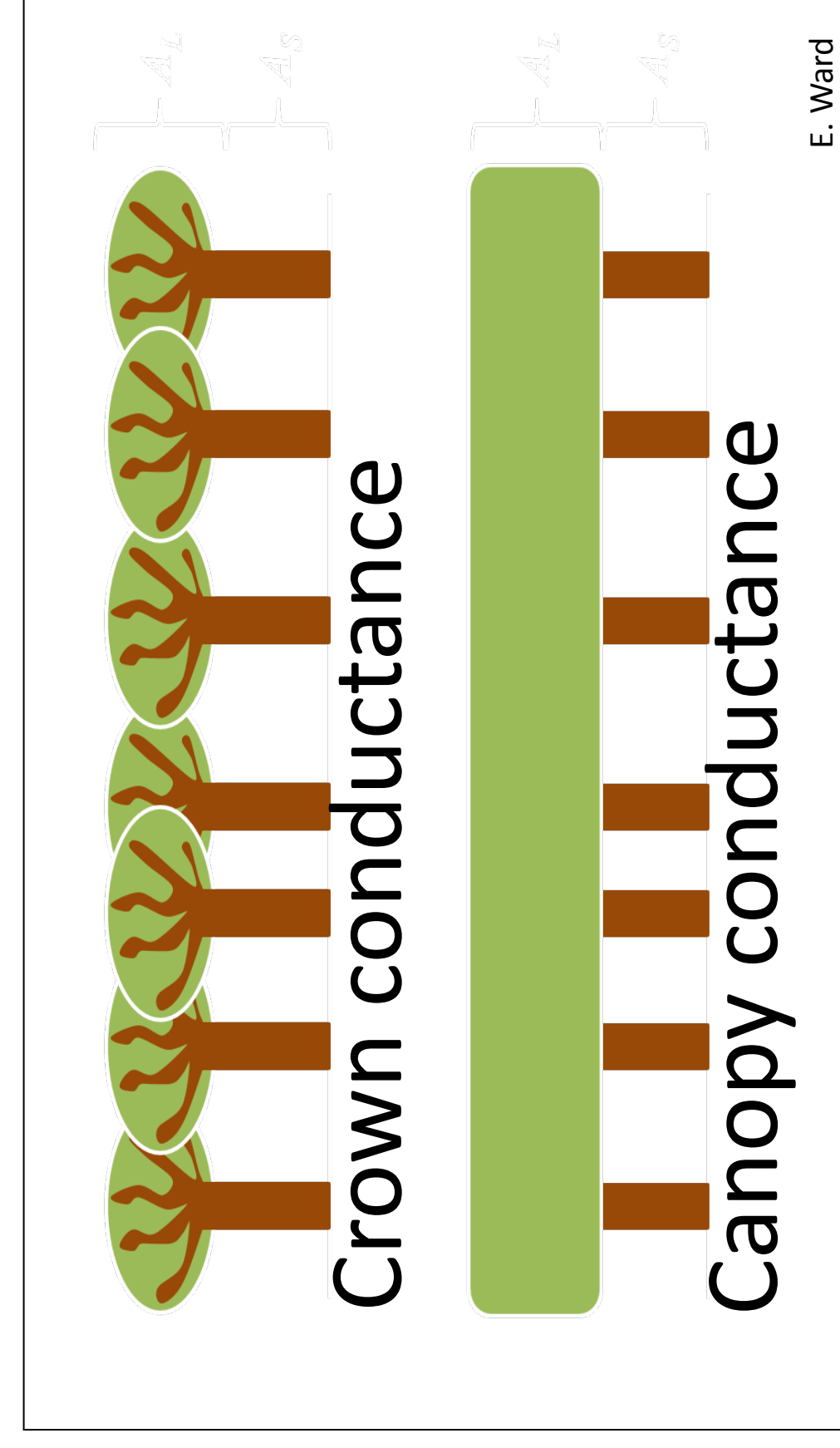


**Figure 1.** Schematic of Thermal Dissipation Probe sensor technology

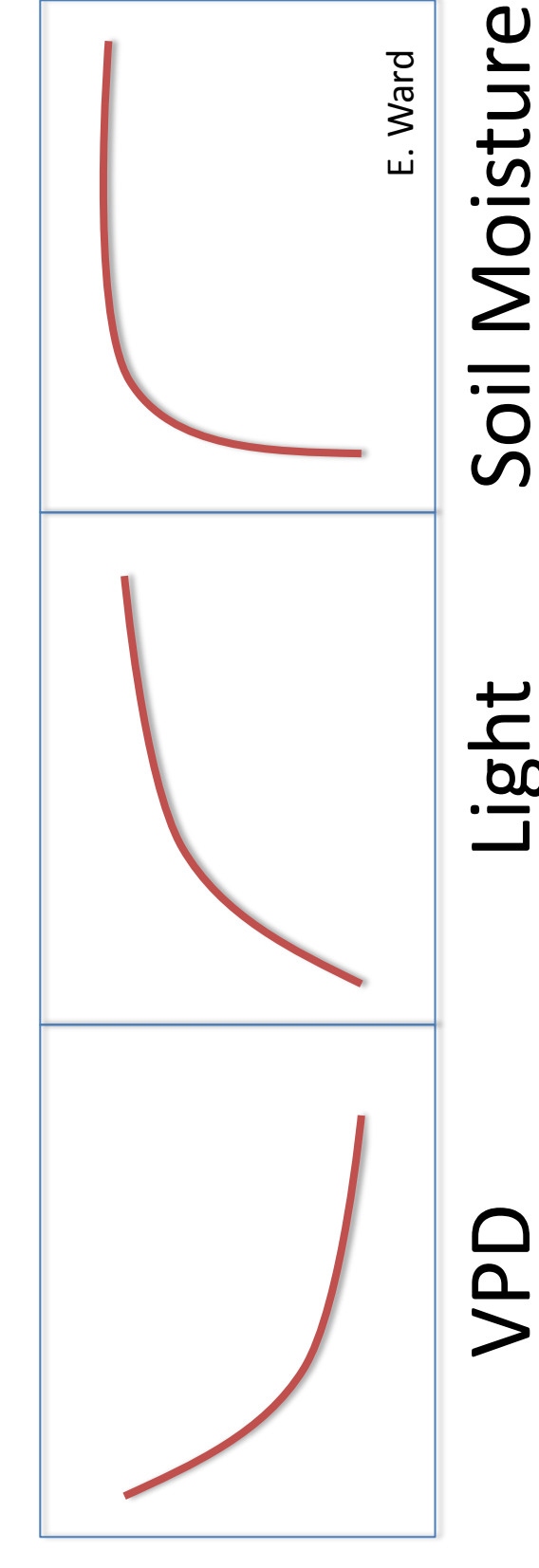


**Figure 2.** Diurnal sap flux at Washington, GA PINEMAP site, February 24-28, 2013.

$$E_T \approx \frac{c_p \rho_a}{\gamma \lambda} D g_C$$



Responses of conductance to VPD and soil moisture will be analyzed



**Figure 3.** Stomatal conductance, crown conductance, and canopy conductance.

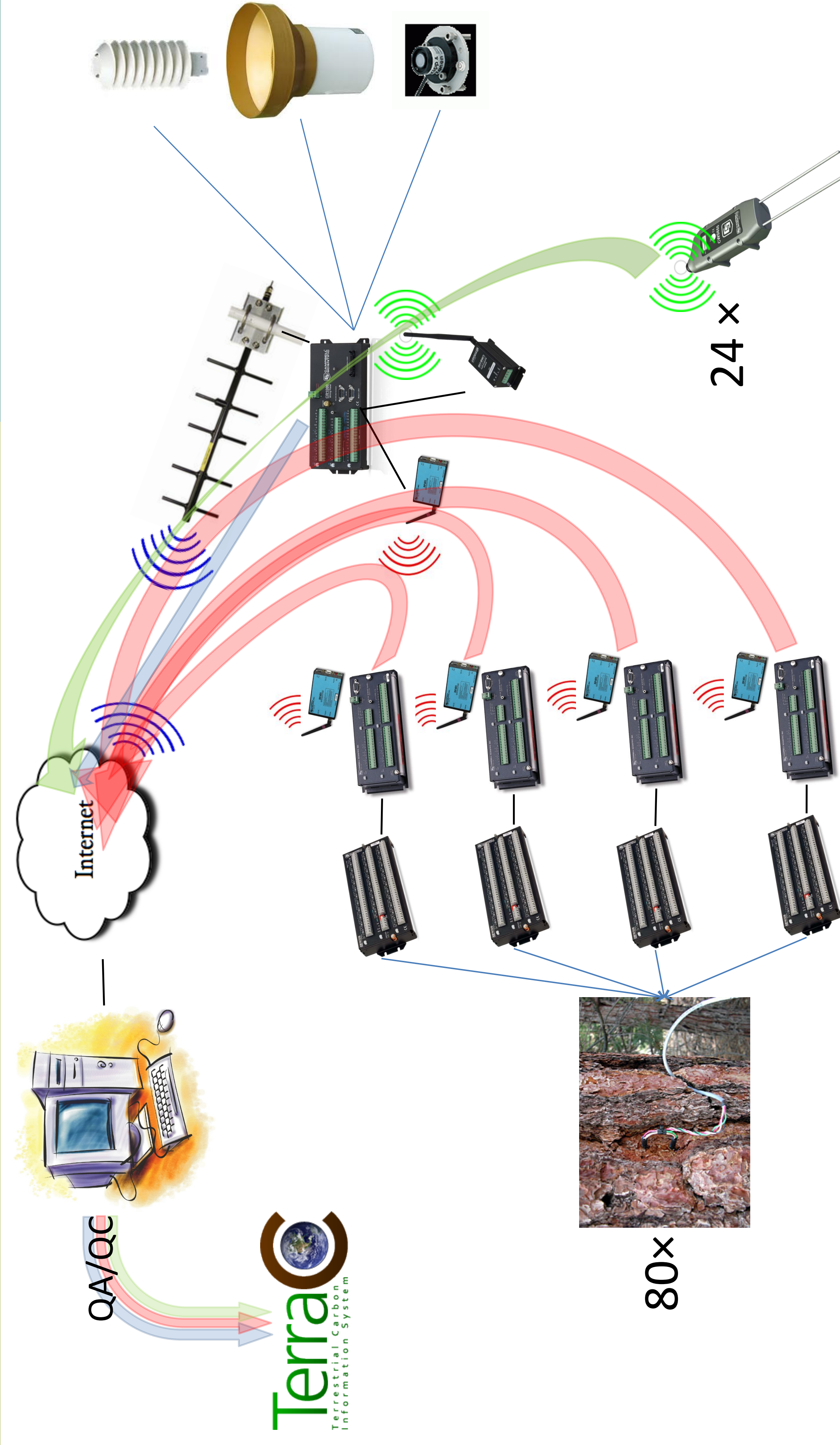
### 3-PG: Physiological Principles in Predicting Growth

- Model uses physiological process data, statistical growth and yield models, and weather and site conditions to simulate the growth of forest stands (Landsberg and Waring, 1997)
- Field data will be used to parameterize the conductance functions of the model for all treatment combinations
- Measurements of actual tree water use will be compared with model outputs

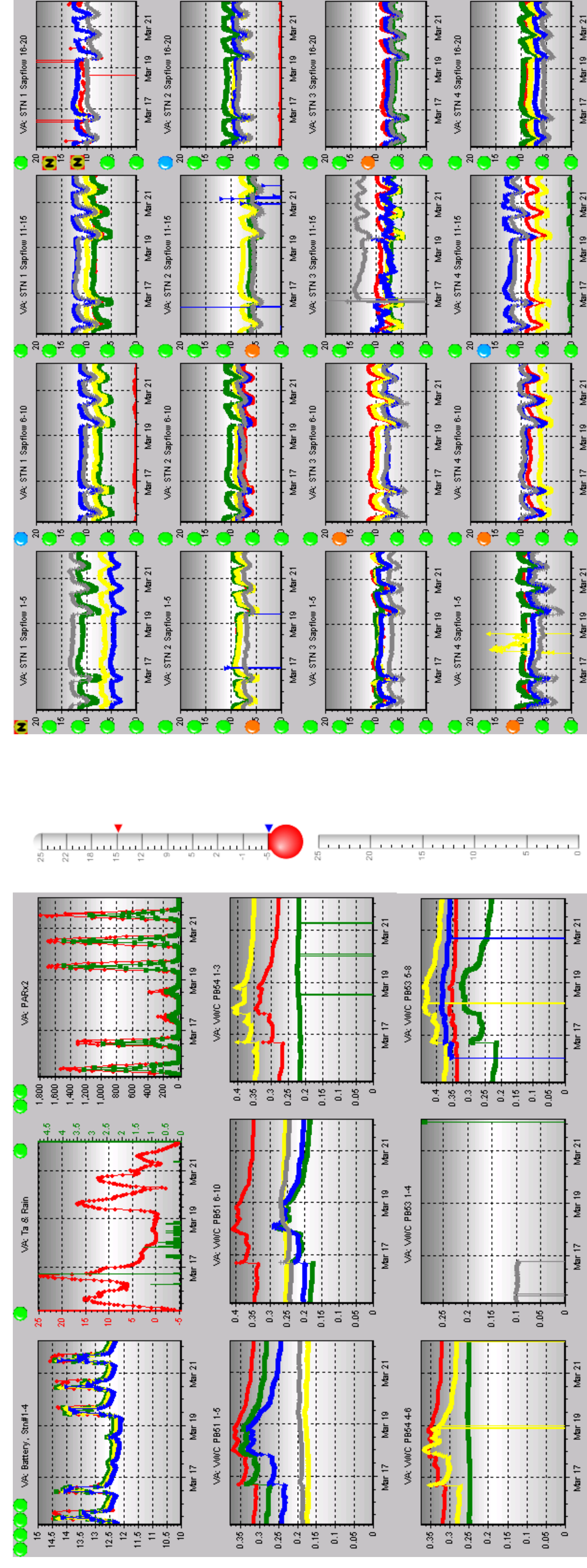


# Sap Flow: Infrastructure and Data Handling

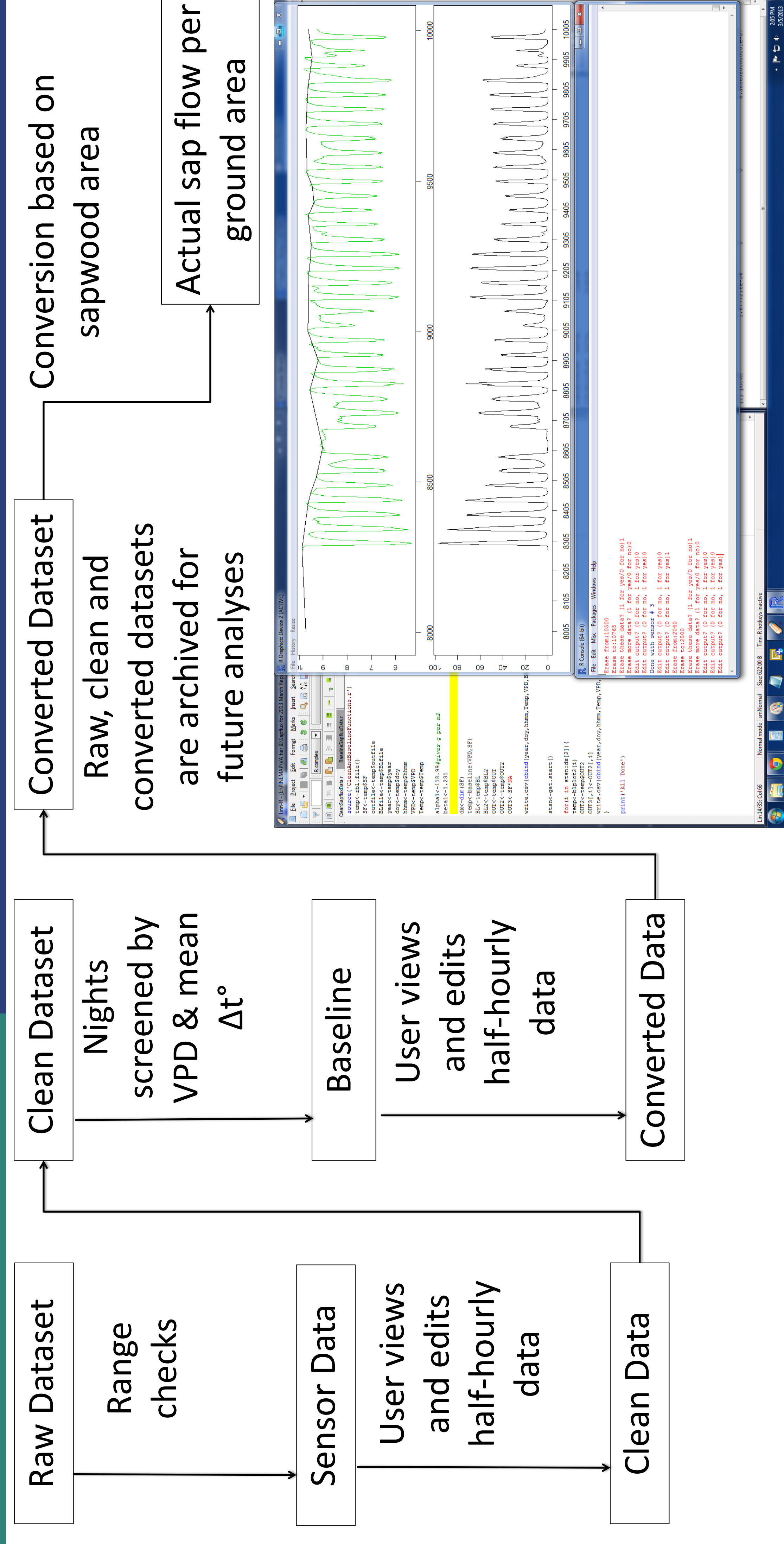
PINEMAP 2013 Annual Meeting Field Tour  
Tier III site, Taliaferro County, GA



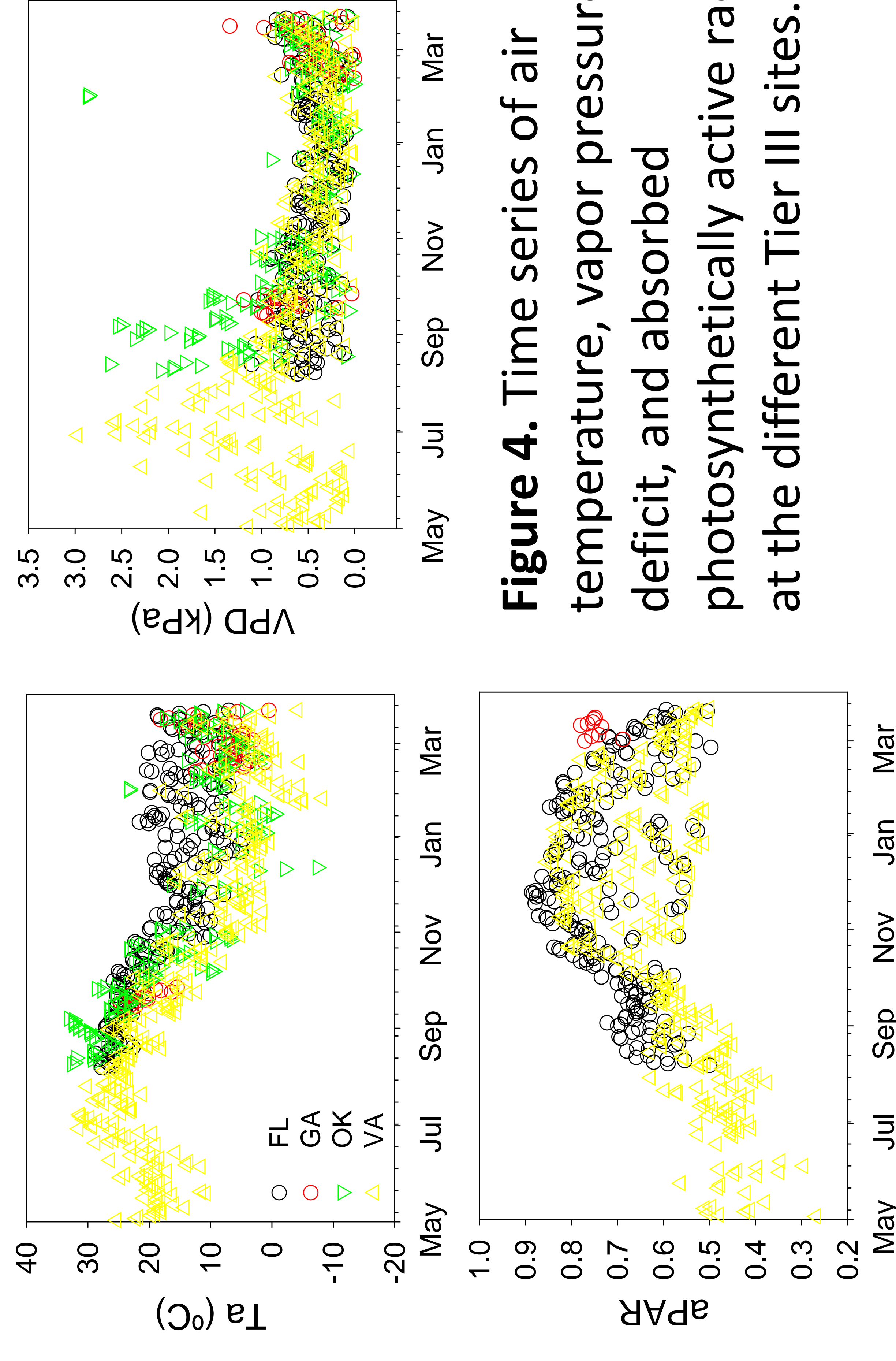
**Figure 1.** Sensor infrastructure at Tier III sites. All sensors are linked through phone and radio communication to the central monitoring system and downloaded daily. Reports and alarms of sensor malfunction are posted on the web and e-mailed to site personnel.



**Figure 2.** A set of sample reports (VA Tier III site). Key parameters are graphed for the past week. Alarm 'lights' indicate the condition and error type of each sap flow probe.



**Figure 3.** Flow diagram of key steps in sap flow data processing, and a screen capture of the R software (written by E. Ward, NCSU) used to baseline the data.



**Figure 4.** Time series of air temperature, vapor pressure deficit, and absorbed photosynthetically active radiation at the different Tier III sites.

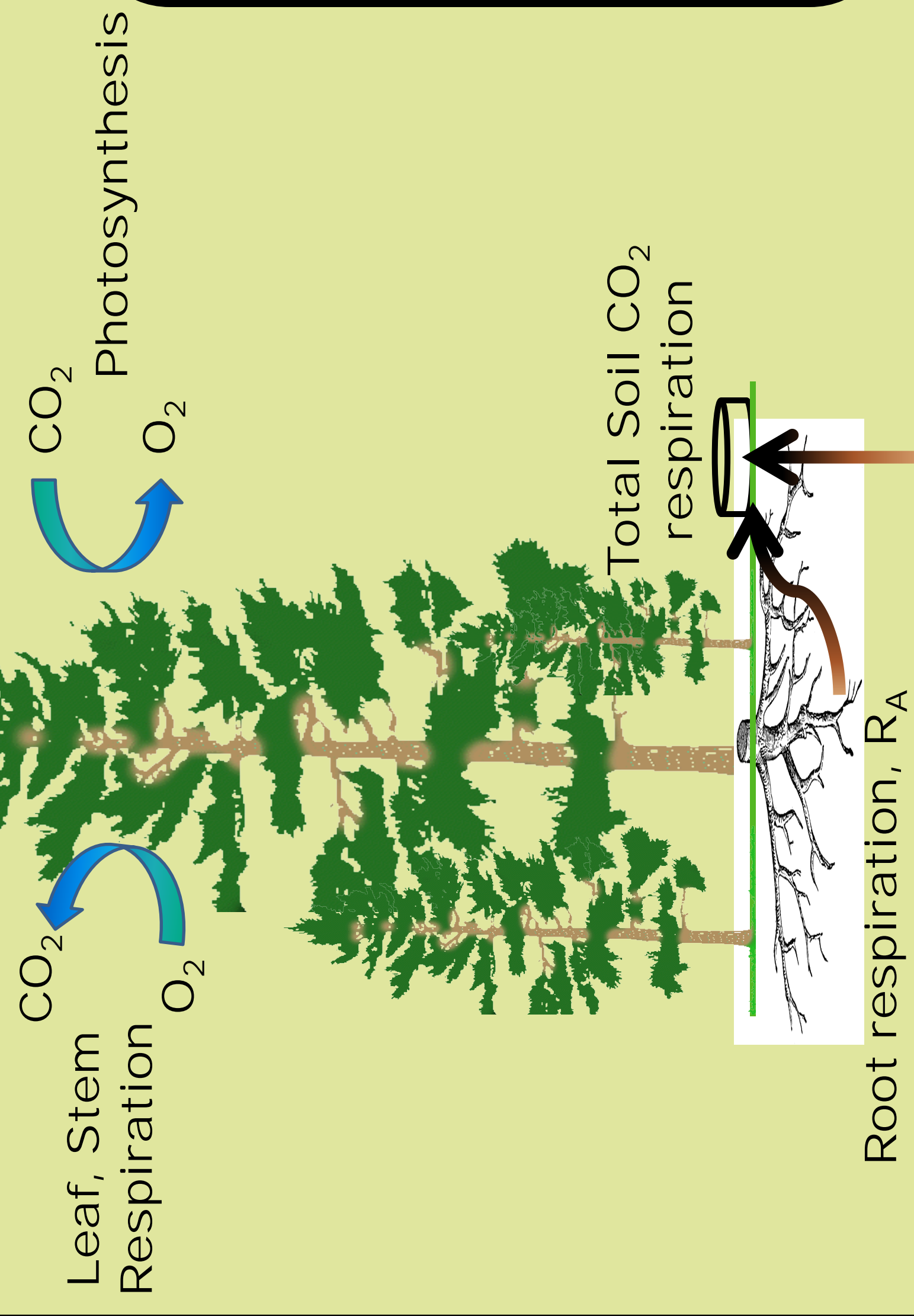


# Soil CO<sub>2</sub> Efflux and Carbon Cycling

PINEMAP 2013 Annual Meeting Field Tour

Tier III site, Taliaferro County, GA

## Basic Carbon Cycle



- To estimate Net Ecosystem Productivity (NEP), silviculture and ecophysiology team researchers require a separate estimate of **heterotrophic soil respiration (R<sub>H</sub>)**.
- Deep root isolation cores** result in root respiration falling to zero as root carbohydrates are depleted. A measure of soil CO<sub>2</sub> respiration above these cores is used to estimate **R<sub>H</sub>**.
- NEP is used by the modeling team to produce estimates of carbon sequestration.

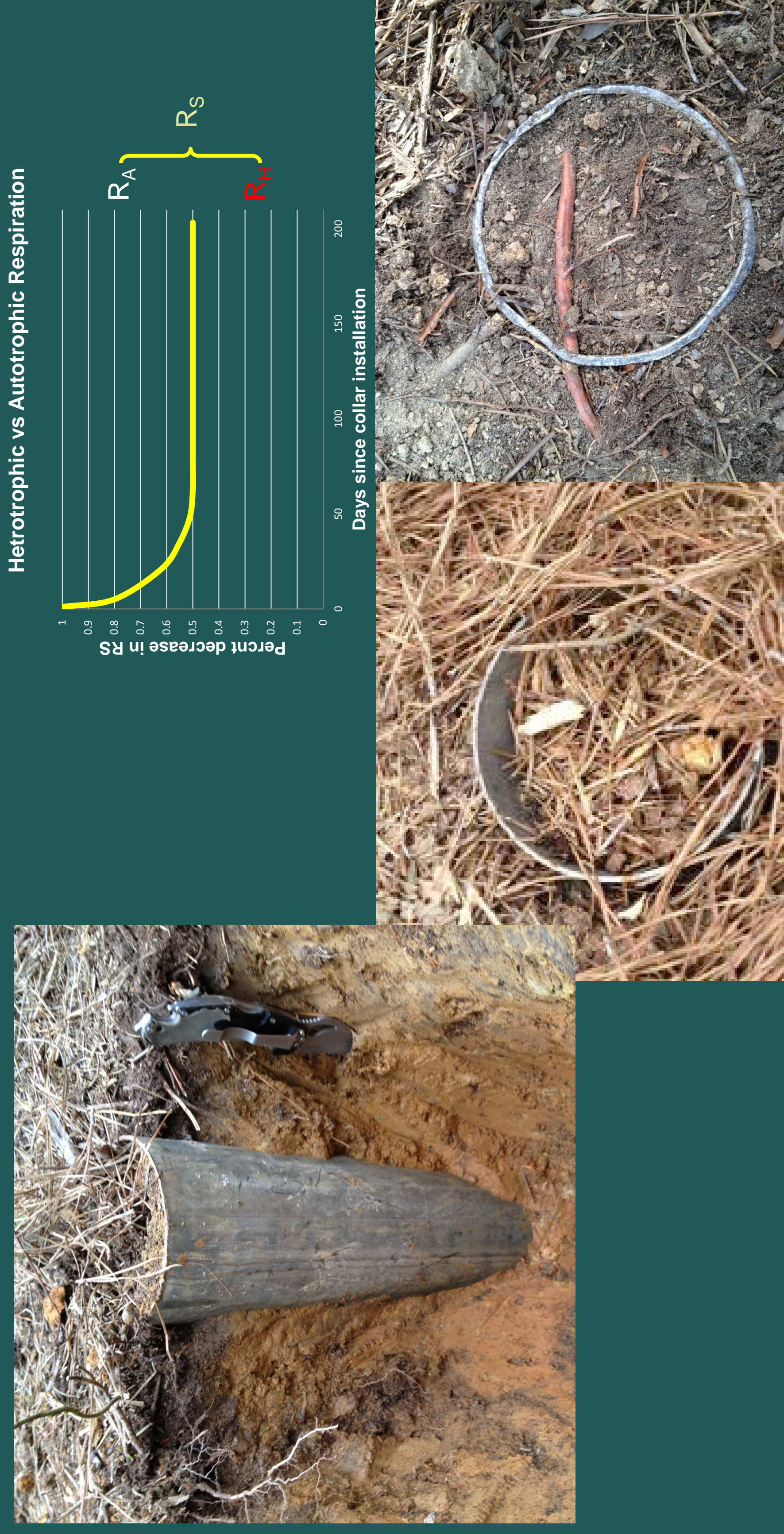
**Figure 1.** Terrestrial carbon cycle showing key CO<sub>2</sub> flux rates being measured by the PINEMAP silviculture and ecophysiology team. These numbers are being used by the modeling team to prepare estimates of carbon sequestration.



Soil CO<sub>2</sub> efflux or soil respiration (R<sub>S</sub>) is the second largest flux in the C cycle.

**Figure 3.** Soil CO<sub>2</sub> efflux is measured with a chamber sealed over the soil surface and an infrared gas analyzer. Measurements are taken over root isolation cores (R<sub>H</sub> estimate) and adjacent to cores (R<sub>H</sub> plus R<sub>A</sub>)

## Root Isolation Cores



**Figure 2.** Installation of root isolation cores. Over time, respiration of roots in the chamber falls to zero and CO<sub>2</sub> emissions at this point are from soil heterotrophic organisms only (R<sub>H</sub>).



**Figure 4.** Soil moisture and temperature are measured at each sampling point. These measures are used to standardize soil CO<sub>2</sub> efflux rates.



# Soil Moisture Measurement and Modeling

PINEMAP 2013 Annual Meeting Field Tour

Tier III site, Taliaferro County, GA

## Soil Plant Atmosphere Continuum

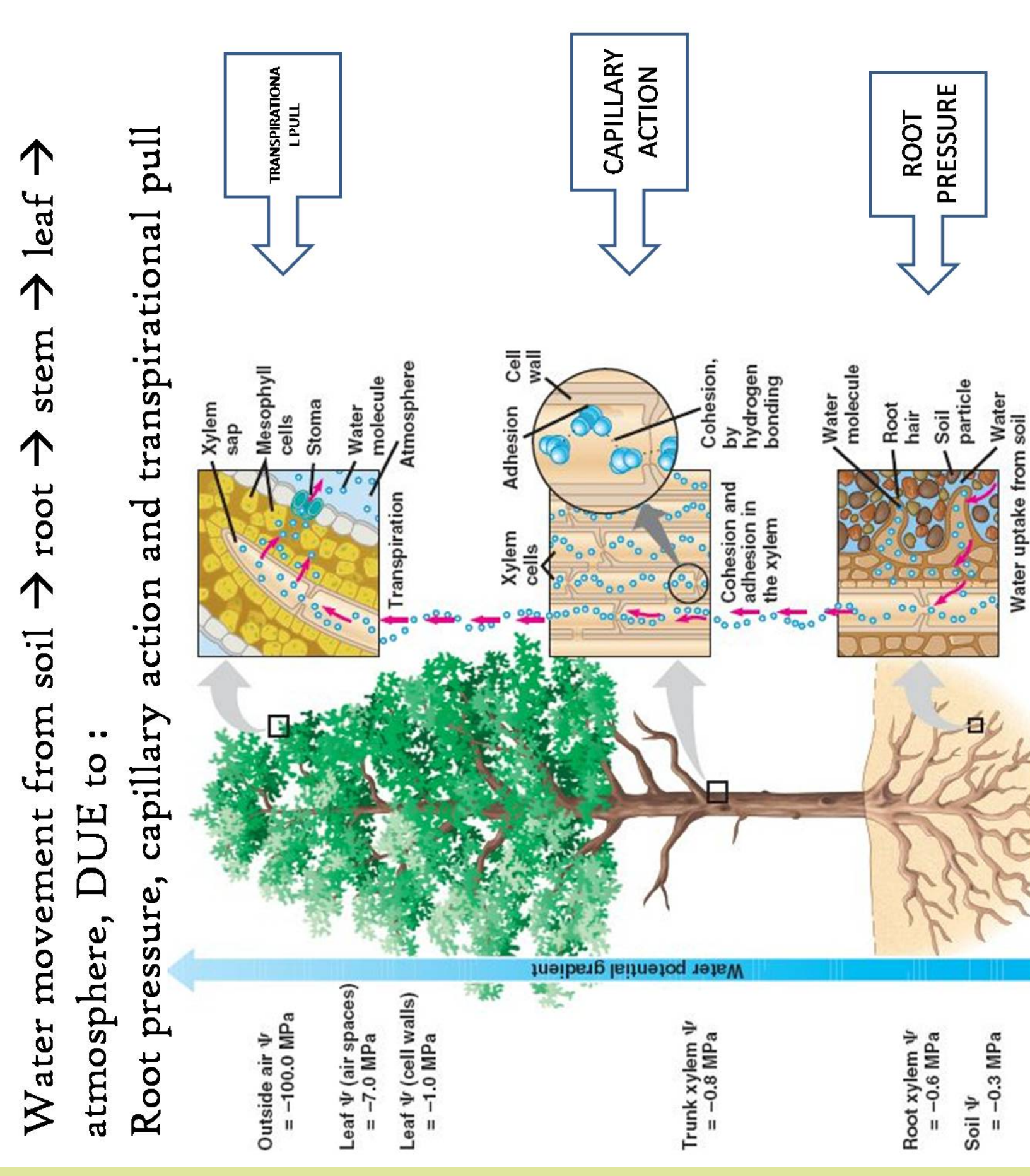


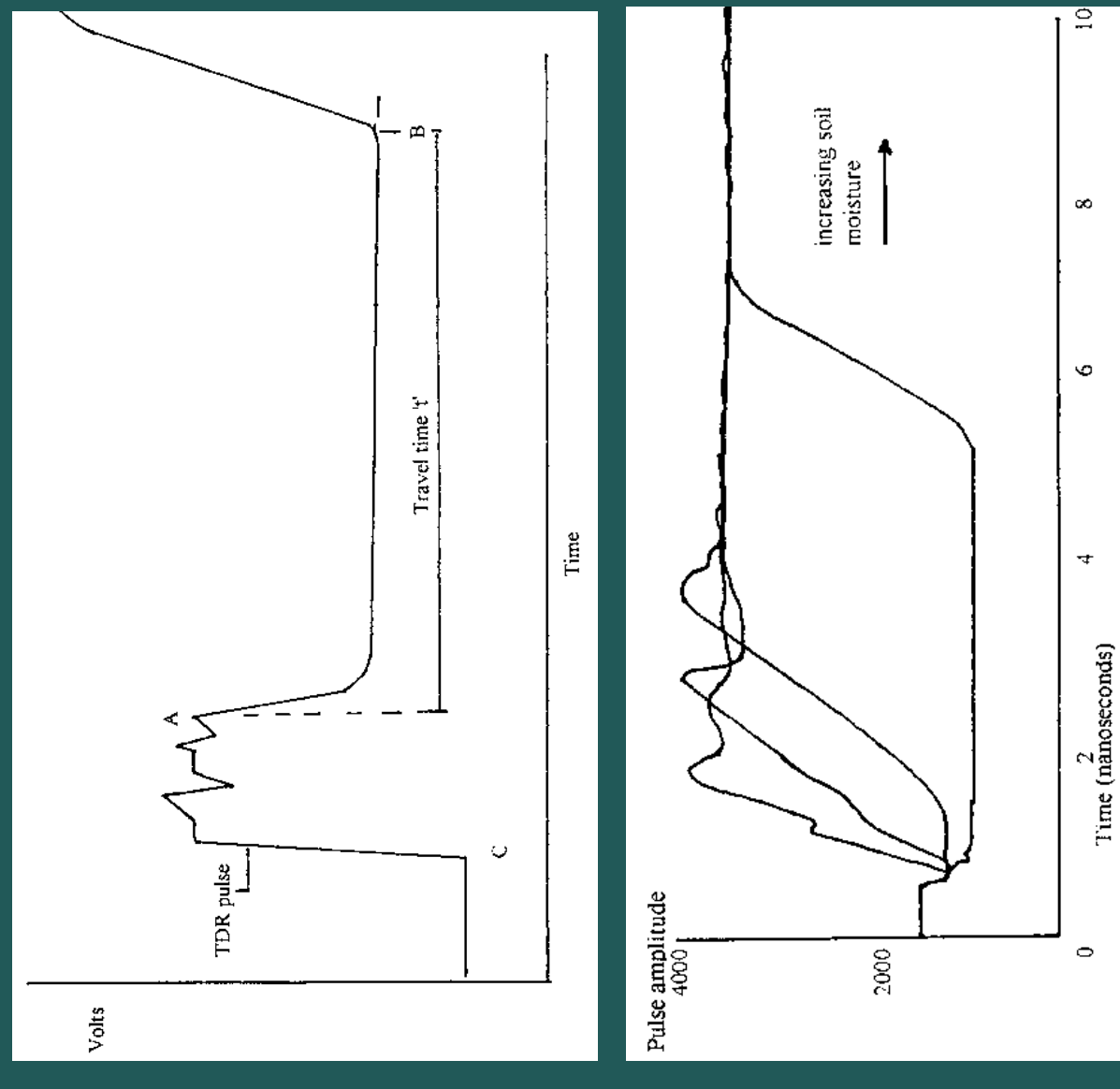
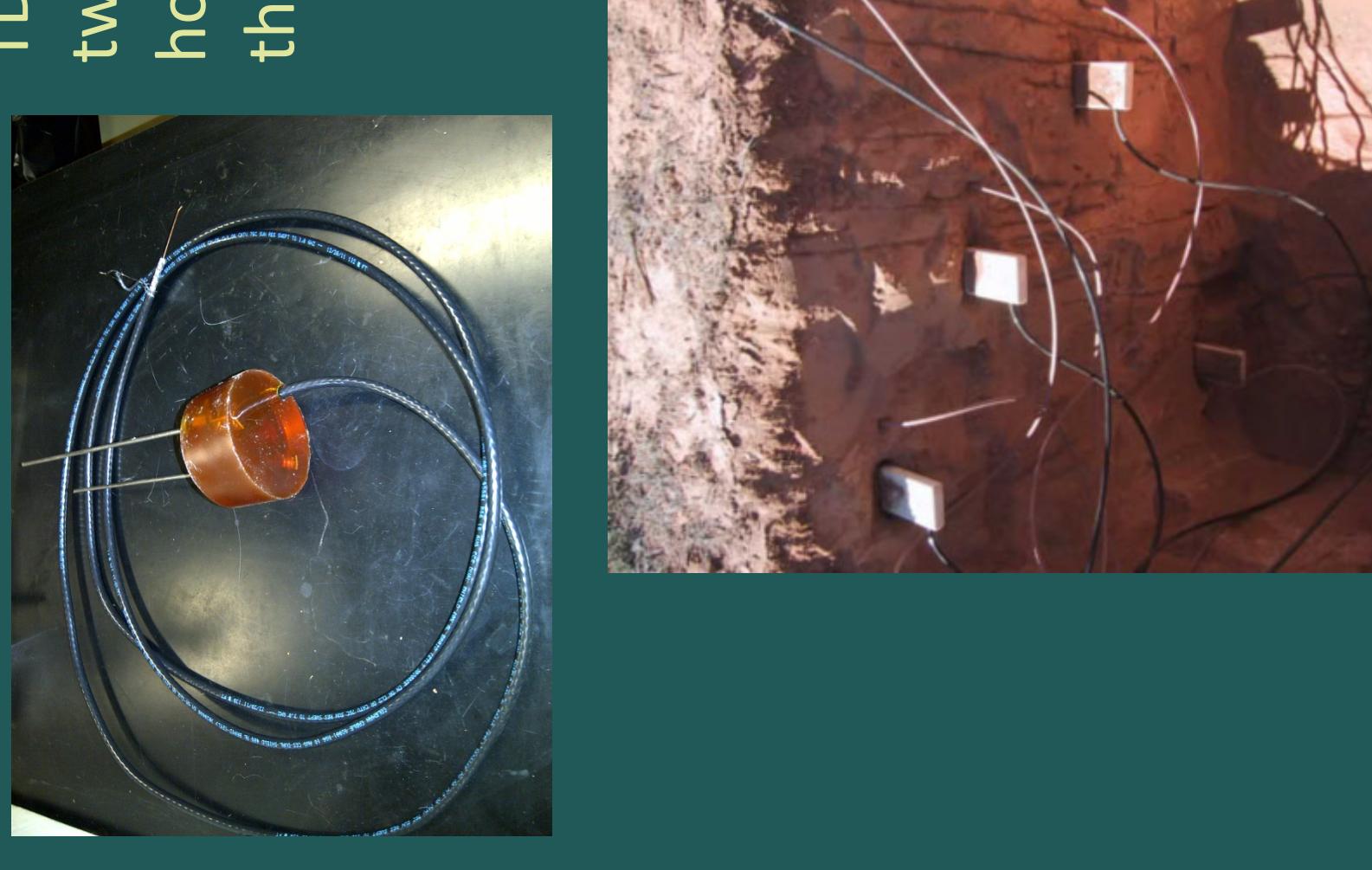
Figure modified from Pearson Education Inc 2008

**Figure 1. Soil Plant Atmosphere Continuum model** showing key pressure potentials driving water use through plants. Potential are being measured by team members at the soil, plant, and atmosphere level. These estimates will be used to quantify plant water use from different depths in the soil profile.

- To estimate changes in water use under throughfall exclusion, team members are measuring water use at the tree and soil level.
- Time Domain Reflectometry (TDR)** probes are being placed throughout the soil profile to quantify **volumetric soil moisture content** ( $\theta$ ,  $\text{cm}^3 \text{cm}^{-3}$ )
- Soil moisture contents are combined with **hydraulic conductivities (K)** and plant water uptake to estimate water flow through the soil profile

## TDR probes and wave forms

TDR probes, which may be as simple as two parallel rods, may be installed horizontally in pit faces or vertically at the bottom of auger holes.



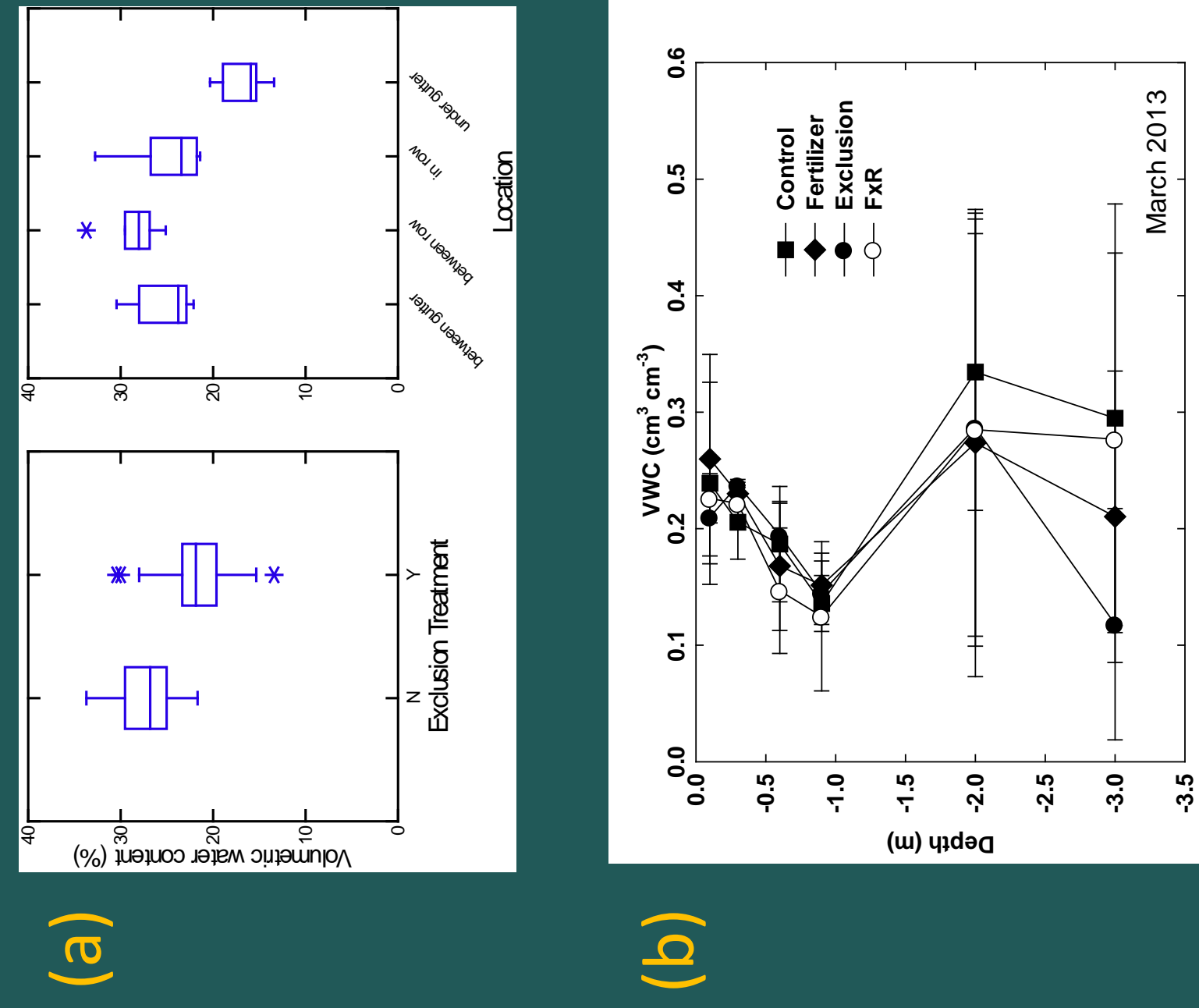
Wave forms of the reflected energy are used to estimate travel time, which is a function of soil moisture content.

**Figure 2.** TDR works by transmitting a pulse of energy down a cable (note that the two rods and the insulating soil material are acting like a cable). When that pulse reaches the end of the cable, virtually all the energy is reflected back to the instrument.

## Soil Moisture Measurements Spatially and Temporally



PhD student Jill Qi collecting the TDR data



**Figure 3.** Soil moisture will be collected spatially both horizontally under excluders (a) and vertically throughout the profile (b) as well as over time (c).

## Modeling Soil Water Uptake and Drainage

Soil water content ( $\theta$ ) is determined for each soil layer using water depth (D) and layer thickness ( $\Delta z$ ).

$$E1: \theta(z) = \frac{D_w(z)}{\Delta z}$$

Water flux between soil layers is determined using Darcy's law for one-dimensional (vertical), unsaturated flow where  $q_z$  is the vertical water flux ( $\text{m s}^{-1}$ ),  $K(\theta)$  is the unsaturated hydraulic conductivity ( $\text{m s}^{-1}$ ),  $\Delta H$  is the difference in total hydraulic head between two adjoining layers (m) and  $\Delta z$  is the downward-directed, vertical distance between the midpoints of the layers (m).

$$E2: q_z = K(\theta) \frac{\Delta H}{\Delta z}$$

The matric head of the soil water is determined by the van Genuchten equation relating water content to matric head where  $\Theta = (\theta - \theta_r) / (\theta_s - \theta_r)$  with s and r being saturated and residual water content.

$$E3: h_m = \frac{1}{\alpha} \left[ \Theta - \frac{1}{m} - 1 \right]^{-1/n}$$

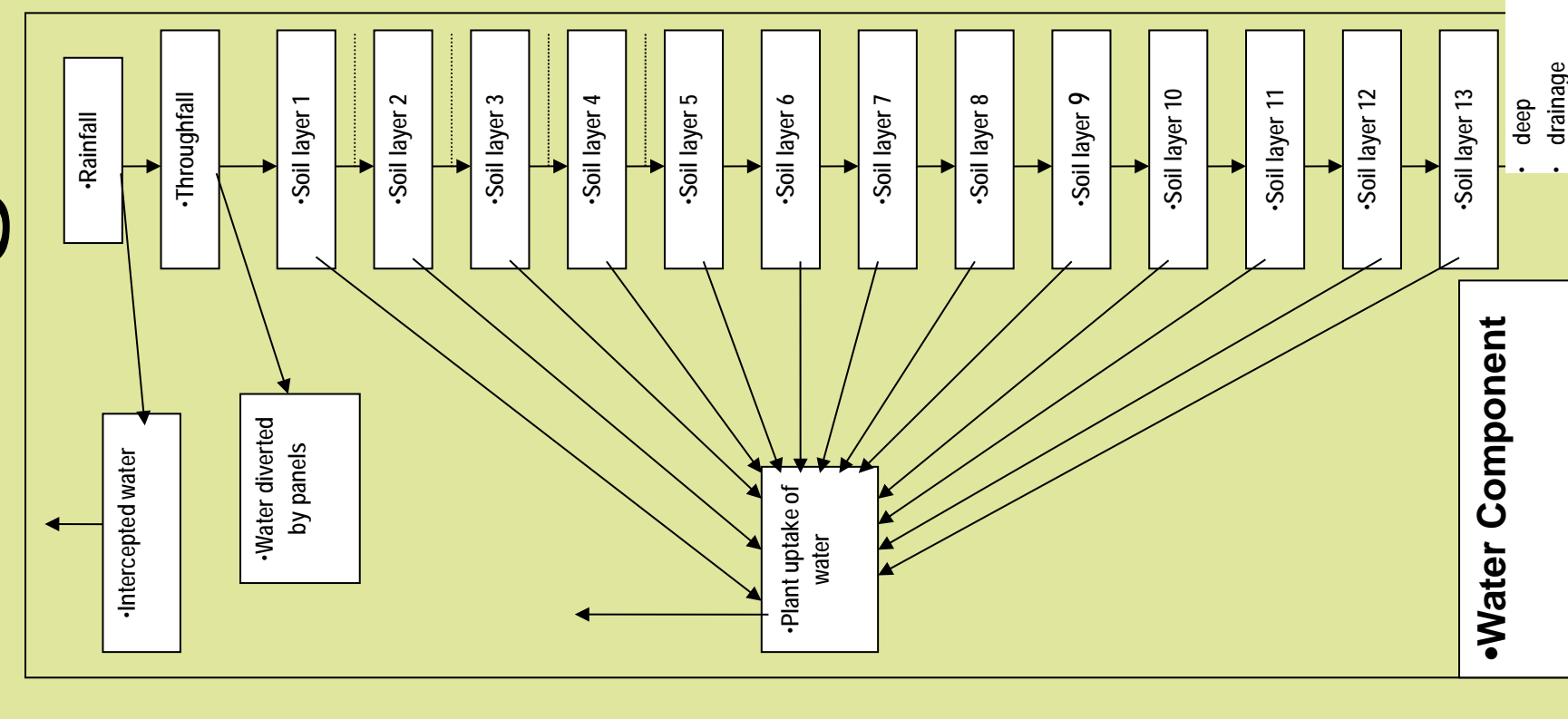
Unsaturated hydraulic conductivity,  $K(\theta)$ , is calculated from saturated hydraulic conductivity,  $K_s$ , according to the equation of Mualem (see (5)).

$$E4: K(\theta) = K_s \Theta^{1/2} \left[ 1 - \left( 1 - \Theta^{1/(n-1)} \right)^m \right]^2$$

Changes in soil water storage are modeled using the Richards' (mass balance) equation that accounts for inflows and outflows in each layer. Root uptake is the main mechanism for water loss (see (E6) and (H)).

$$E5: \frac{\partial q_z(z)}{\partial z} + U(z) = \frac{\partial \theta(z)}{\partial t}$$

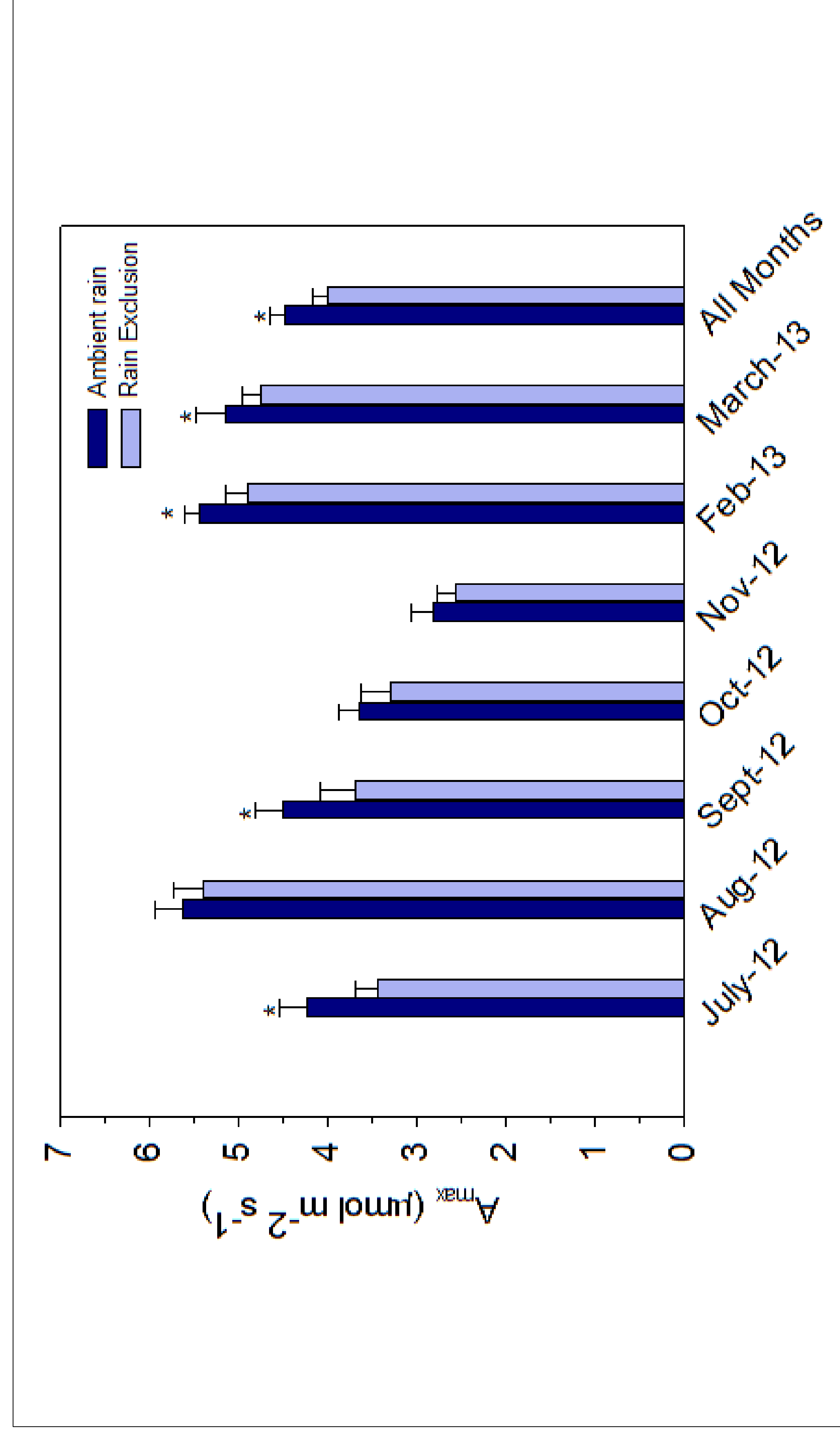
**Figure 4.** The flow of soil water from one layer to another and the uptake of soil water from different soil layers by plants is not measured directly but is modeled. The modeling requires measurement of other soil attributes (saturated hydraulic conductivity, soil moisture characteristic curves) and requires an estimation of plant water uptake. The model is constrained by the ability to represent the observed time series of soil moisture contents measured with TDR.



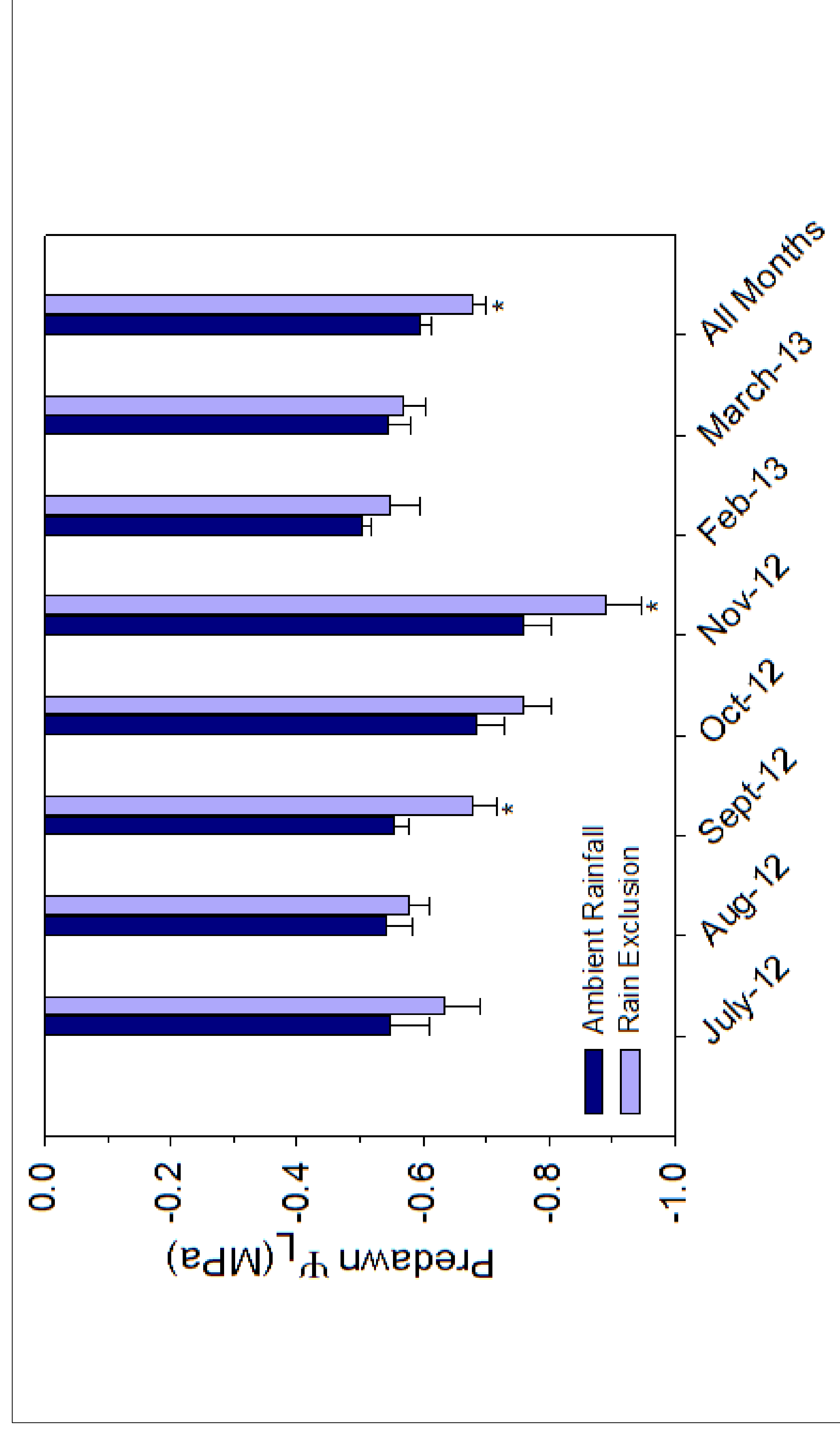


# Leaf Physiology

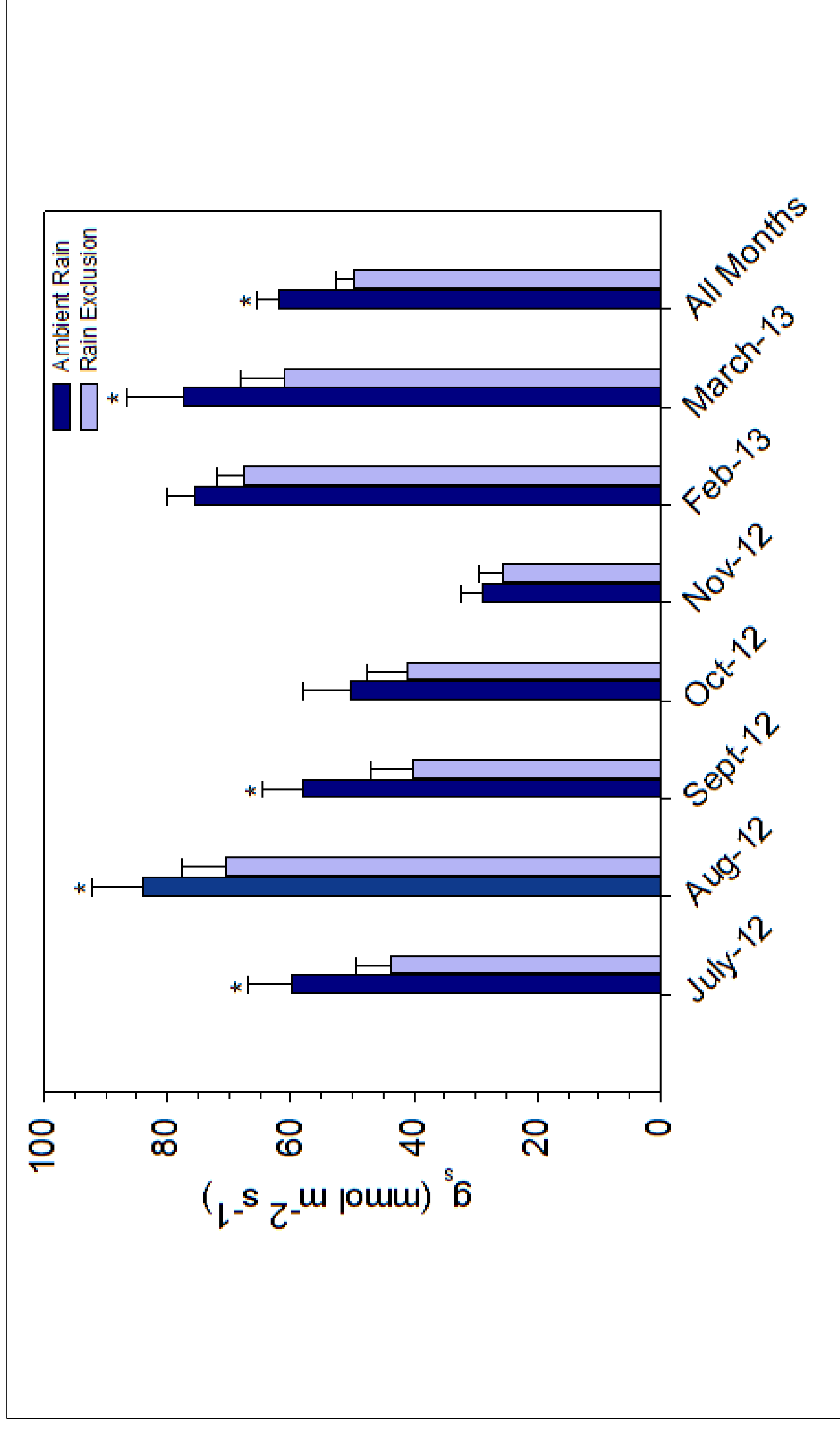
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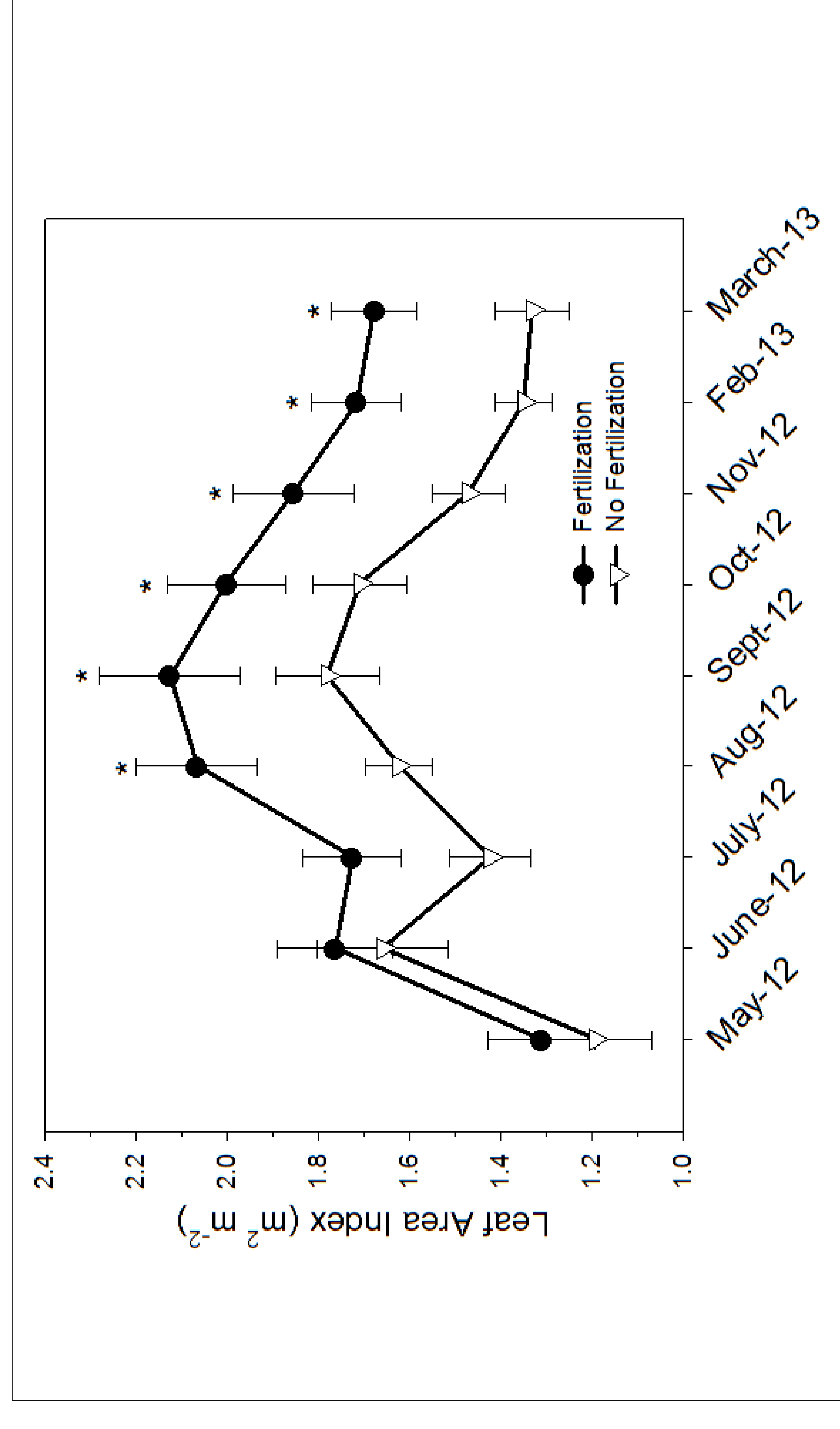
**Figure 1.** Light-saturated net photosynthesis ( $A_{max}$ ) response to rainfall treatments. Asterisks indicate a significant difference.



**Figure 3.** Predawn leaf water potential ( $\psi_L$ ) response to rainfall treatments. Asterisks indicate a significant difference.



**Figure 2.** Stomatal conductance ( $g_s$ ) in response to rainfall treatments. Asterisks indicate a significant difference.



**Figure 4.** Response of leaf area index to fertilization treatments. Asterisks indicate a significant difference.



# Intercepted Photosynthetic Active Radiation (IPAR) & Leaf Area Index (LAI)

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Tier III site, Taliaferro County, GA

**IPAR** = Intercepted Photosynthetic Active Radiation =  

$$\frac{\text{PAR Above Canopy} - \text{PAR Below Canopy}}{\text{PAR Above Canopy}}$$
 Measured with ceptometer

**LAI** = Leaf Area Index =  

$$\frac{\text{Area of leaves}}{\text{Ground area}}$$
 Measured with LAI-2000

With assumptions about foliage orientation, foliage quantity can be calculated by comparing attenuation at different angles.

IPAR and LAI are highly correlated, but can differ depending on foliage display within the canopy, i.e., higher clumping of foliage decreases IPAR/LAI.

Litter traps allow direct measure of LAI but can't be used to measure seasonal changes and estimates are delayed until current foliage abscises.

Data and graphs courtesy of Joe Clark and Lisa Samuelson, Auburn University

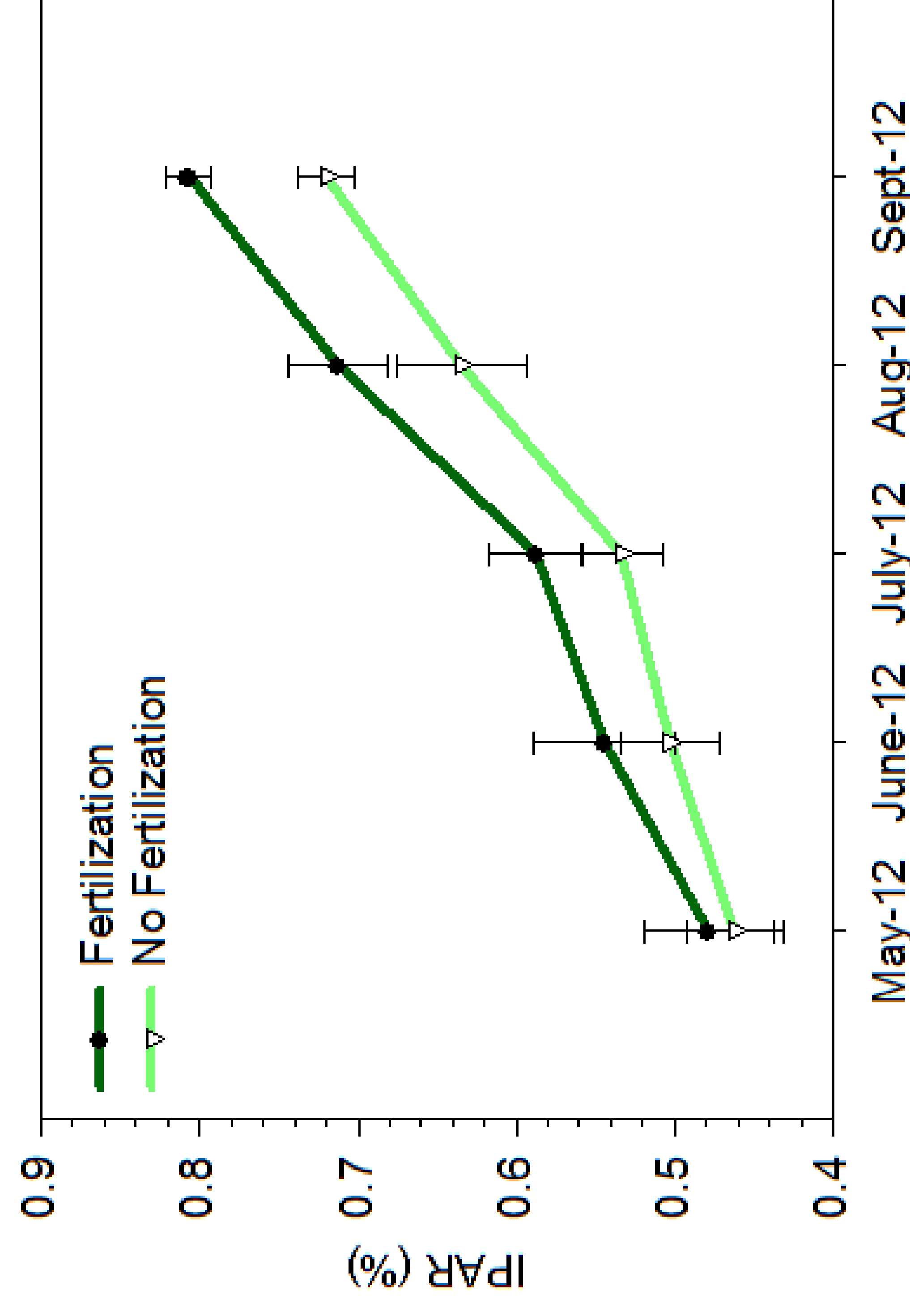


Figure 1. Fertilization increases IPAR

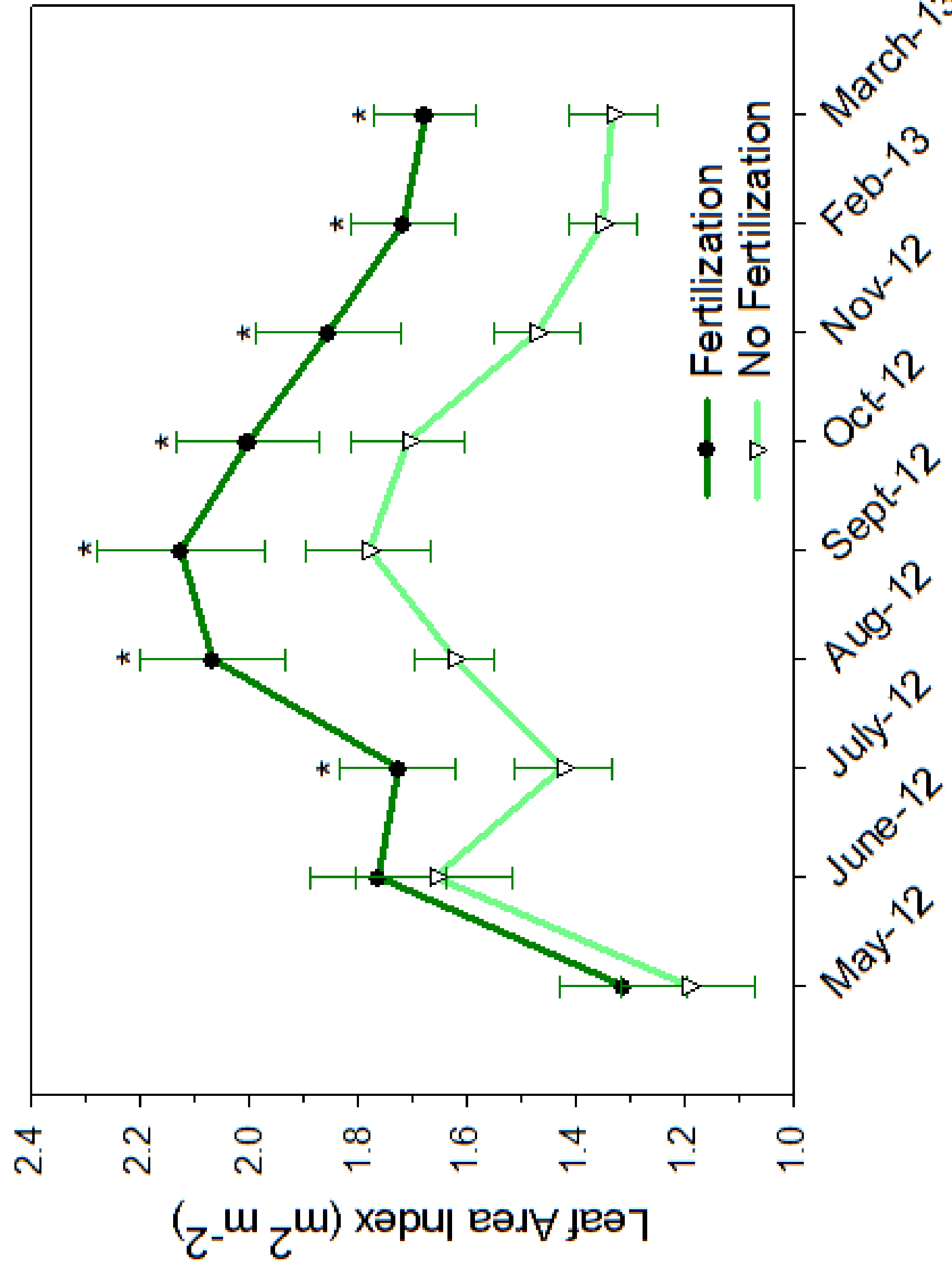


Figure 3. Fertilization increases LAI

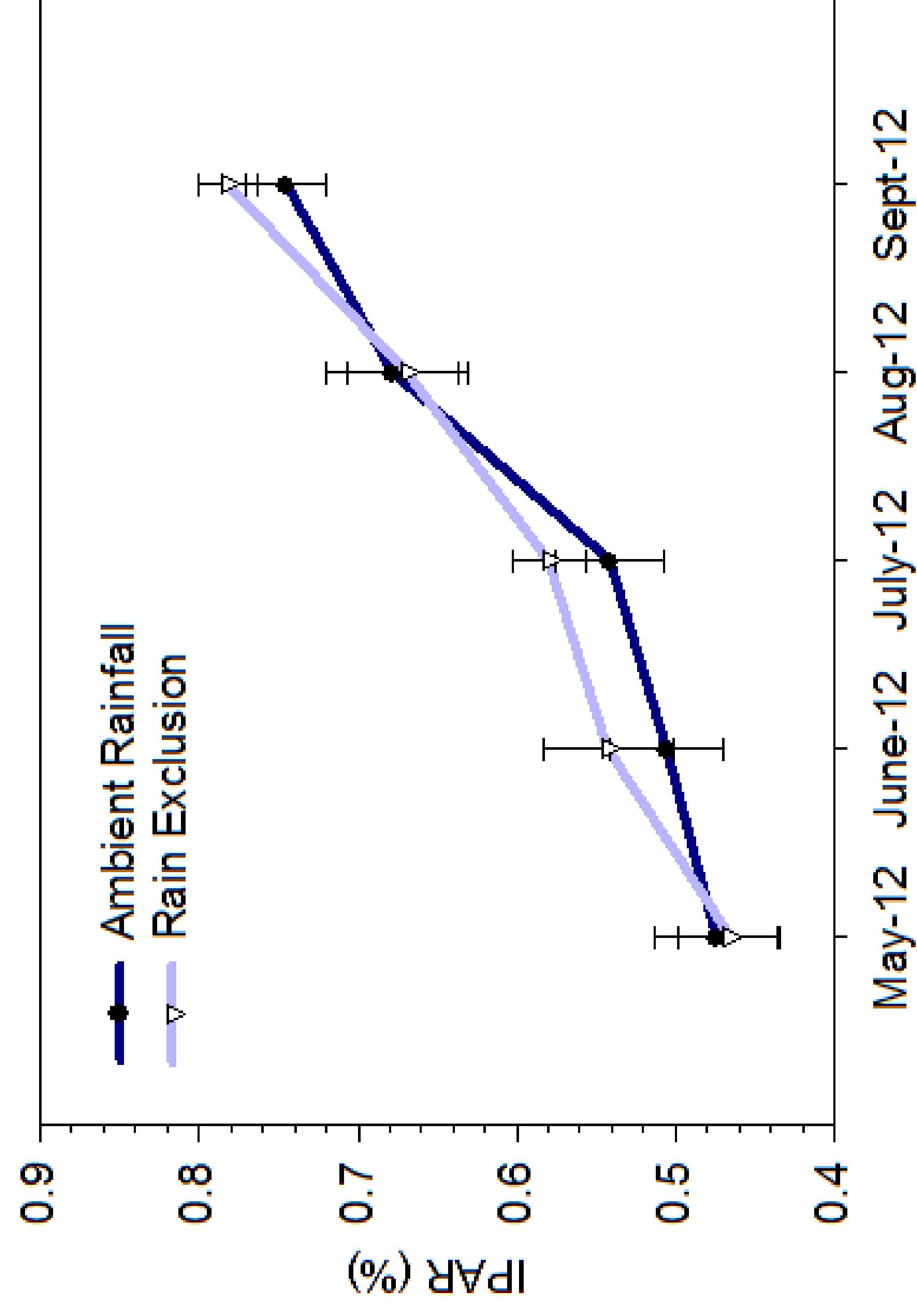


Figure 2. No effect of rainfall exclusion on IPAR

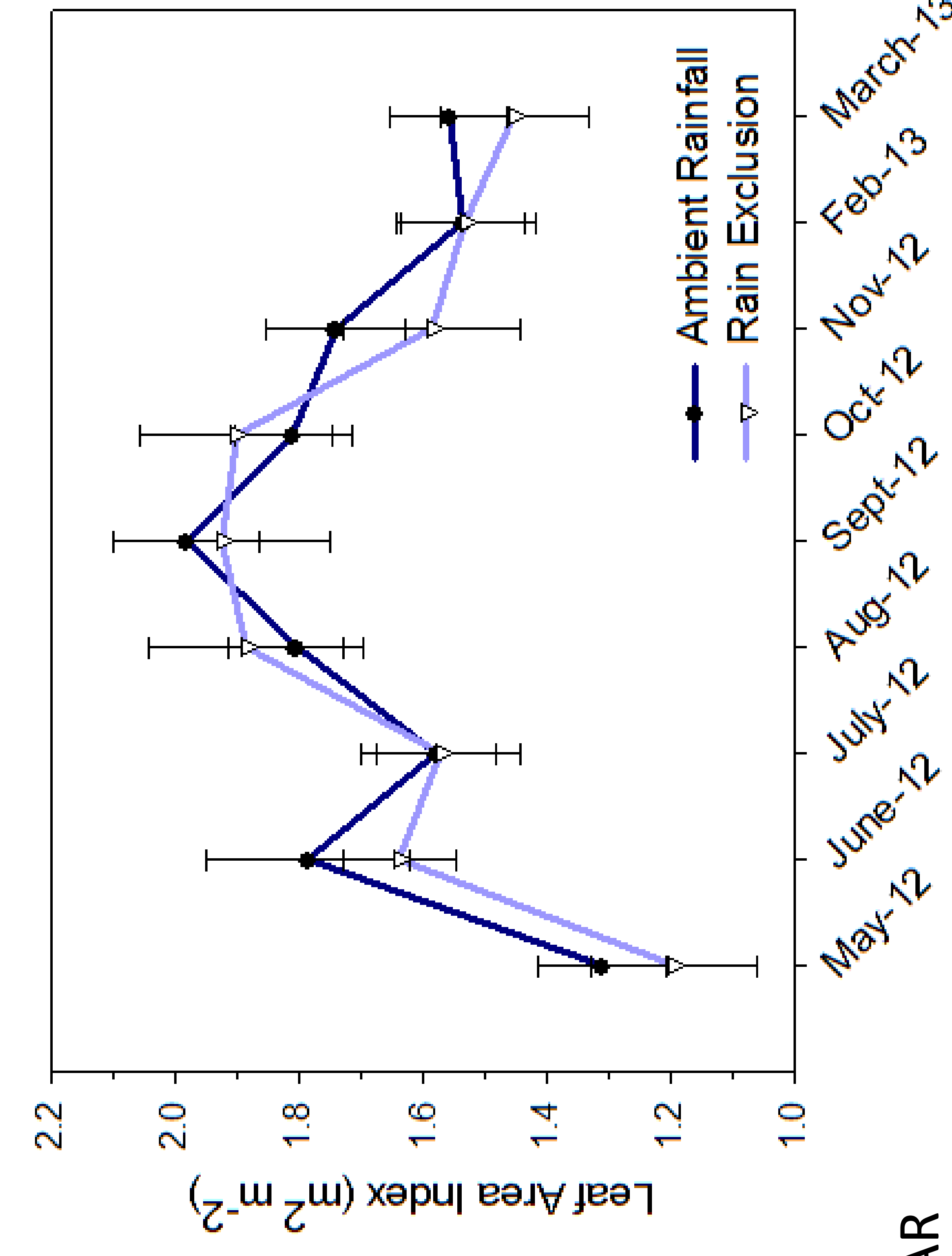


Figure 4. No effect of rainfall exclusion on LAI



Field data from a Tier II site

Crew: LOKUTA, MILLIGAN Date(s): 10-25-12

Site: SANDERSON PINES GPS: \_\_\_\_\_  
 Name: \_\_\_\_\_ Plot: REP2 MIX HW Corner: \_\_\_\_\_ N, \_\_\_\_\_ W  
 Plot dimensions (m):  
 With Bed (WB) 72 Across Bed (AB) 54 Add borders?    How many?     
 New dimensions: Y X  
 WB    AB   

Sample Points	Group 1		Group 2		Bed	Tree	Bed	Tree
	Y	X	Y	X				
	Ran#	WB	AB	Ran#	WB	AB	G1	G2
	1	63	6	5	53	0	36	115
	2	31	14	6	18	7	0	45
	3	29	32	7	15	51	18	71
	4	47	41	8	20	47	0	60
							G2	G2
							145	190
							30	120
							60	108
							63	75

Shrubs (Species, Group, Hgt, DBH, Basal diameter): Record on Back of Sheet -NONE

Ocular estimates (%)

	Non-wdy	Wdy	Planted	Litter	BS/Rock		Non-wdy	Wdy	Planted	Litter	BS/Rock
GP1-1	0	80	0	95	0	GP2-1	5	0	0	98	0
GP1-2	0	0	0	100	0	GP2-2	0	0	0	100	0
GP1-3	0	0	0	100	0	GP2-3	0	0	0	100	0
GP1-4	0	0	0	100	0	GP2-4	0	0	0	100	0

Sample Check: Understory Plants: Did you collect the following? Just check the spot

	Forb	Woody	Palms		Forb	Woody	Palms
GP1-1	X	✓	X	GP2-1	✓	X	X
GP1-2	X	X	X	GP2-2	X	X	X
GP1-3	X	X	X	GP2-3	X	X	X
GP1-4	X	X	X	GP2-4	X	X	X

Notes: CLEAN STAND

Coarse Woody Debris (Record Extra on back of sheet)

Point	Type	Lgth	DiaL	DiaS	Decomp	Point	Type	Lgth	DiaL	DiaS	Decomp
2	PINE	29	3.2	2.9	3						
2	PINE	37	3.3	2.8	2						
4	PINE	52	3.3	2.7	2						

Notes: 3 PIECES TOTAL

Field Mass of Soils (0.01 kg) Device used: SOIL BUCKET AUGER - 3" O.D.

	0-10cm	10-20cm	20-50cm	50-100cm		0-10cm	10-20cm	20-50cm	50-100cm
GP1-whole	1853	3298	12502	22084	GP2-whole	2103	2768	12020	20780
GP1-sub	1853	3298	2245	3154	GP2-sub	2103	2768	2091	3249

Notes: \_\_\_\_\_

**PINEMAP 2013 Annual Meeting Field Tour- Site Carbon Pool Quantification Station**

Biomass and Nutrient data from a Tier II site control plot

**Working Spreadsheet for Forest Floor and Understorey**

order#	Site	Plot	Group	Collection Date	Material (litter, duff, herb, woody)	area sampled (m2)	Sample ID	OD mass +bag (g)	Bag wt (g)	Net Mass(g)	crucible #	crucible wt w/lid (g)	crucible wt+ sample (g)	Loss on ignition (g sample)	% N	% C	Carbon (kg/ha)	Nitrogen (kg/ha)
1	IMP106	con	1	7/30/2012	litter	0.49	T2-1	1062	126	876				0.5037263	49.02973	8765.315	90.05393	
2	IMP106	con	2	7/30/2012	litter	0.49	T2-2	1055	126	929				0.6595656	47.71093	9045.602	125.0483	
3	IMP106	con	1	7/30/2012	duff	0.49	T2-3	930	63	867	52a	27.38	28.61	0.682926829	31.68225	5605.819	127.8992	
4	IMP106	con	2	7/30/2012	duff	0.49	T2-4	1174	63	1111	69a	27.12	28.31	0.739495798	37.59902	8525.002	194.3884	
5	IMP106	con	1	7/30/2012	herb	1	T2-5	66	63	3						15		
6	IMP106	con	2	7/30/2012	herb	1	T2-6	65	63	2						10		
7	IMP106	con	1	7/30/2012	woody	1	T2-7	0	0	0						0		
8	IMP106	con	2	7/30/2012	woody	1	T2-8	221	63	158						790		

**Working Spreadsheet for Bulk Soil**

site	plot	group	depth	Sample ID	total mass + ziploc bag (g)	ziploc bag mass (g)	sub mass wet WC (g)	sub mass dry WC (g)	Db total mass + bag (g)	Db bag weight (g)	DB rock mass (g)	initial volume (mL)	DB rock volume (mL)	Bulk rock mass (g)	sample moisture content (g/g)	wet soil mass extracted (g)	Total dry soil mass sampled (g)	%N	%C	Nitrogen content (kg/ha)	Carbon content (kg/ha)
IMP106	control	1	0-10	1	2536.6	1.15	36.46	31.2	146.3	14.1	14.1	3.6	20	21	0.1685897	2535.45	2093	0.047573	1.128123	671.4509	15922.31
IMP106	control	1	10-20	2	3375.2	1.15	37.83	32.39	152	13.6	13.6	2.6	20	21	0.1679531	3374.05	2663	0.024619	0.671185	366.9301	10003.46
IMP106	control	1	20-50	3	3478.1	1.15	38.16	30.99	146	14.1	1.1	1.1	20	21	0.231365	14500	11096	0.020971	0.496575	903.1598	21385.63
IMP106	control	1	50-100	4	3401.4	1.15	36.04	26.92	145.2	13.8	0	0	20	20	0.3387816	22000	14397	0.00958	0.179929	683.3041	12833.17
IMP106	control	2	0-10	5	1156.4	1.15	30.85	25.86	137.1	13.6	0.1	0.1	20	20	0.1929621	1155.25	920	0.062349	1.574632	835.2456	21094.16
IMP106	control	2	10-20	6	4201.8	1.15	33.31	27.52	136.7	13.7	0.2	0.2	20	20	0.2103924	4200.65	3182	0.018663	0.579104	248.7996	7720.096
IMP106	control	2	20-50	7	3954.4	1.15	34.81	27.67	140.8	13.5	7.7	7.7	20	24	0.2580412	14500	10696	0.019036	0.458026	775.141	18650.52
IMP106	control	2	50-100	8	3455.5	1.15	30.11	22.26	118.8	13.8	0	0	20	20	0.3526505	22000	14164	0.009579	0.223913	545.9258	12761.63

**Lateral Roots Sorted from Bulk Soil**

site	plot	group	depth	sample ID	root mass (g)		
					V fine	Fine	Coarse
IMP106	control	1	0-10	1	0.39	0.712	2.025
IMP106	control	1	10-20	2	0.151	0.465	1.953
IMP106	control	1	20-50	3	0.049	0	1.252
IMP106	control	1	50-100	4	0.081	0	0
IMP106	control	2	0-10	5	0.572	0.9	1.372
IMP106	control	2	10-20	6	0.359	0.517	6.029
IMP106	control	2	20-50	7	0.029	0	3.6
IMP106	control	2	50-100	8	0.04	0.02	0.12