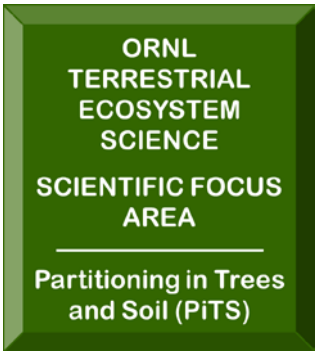
PiTS-1: Carbon Partitioning in Loblolly Pine after 13C Labeling and Shade Treatments



Summary:

This data set reports the results of the Partitioning in Trees and Soil (PiTS-1) field investigation that examined how carbon partitioning in a stand of loblolly pine trees varied with short-term changes in gross primary production (GPP) due to shading. These measurements were made over range of June 2010 through May 2011 with most samples and measurements collected from July to September 2010 near the 13CO2 labeling event. There are 19 comma-separated ASCII data files provided with this data set in the general data types listed below, along with a companion file, the published paper describing the PiTS-1 investigation and results (Warren et al., 2012).

Environmental and Site Characterization:

- Meteorological measurements included precipitation, relative humidity, photosynthetically active radiation (PAR), direct shortwave radiation, wind speed, and air temperature.
- Soil characterization of the site included bulk density, texture, and moisture measurements.

Tree Biophysical Measurements:

- Measurement included estimates of tree growth, root biomass and production, sap flow and leaf water potential, and foliage light response curves, A-Ci curves, foliar nitrogen, carbon, and leaf mass per area.

Tree 13C Partitioning

- Plant foliar, phloem and root tissue samples were collected from individual trees prior to the 13C labeling (31 August) and on five occasions after the labeling event (1, 2, 5, 9 and 21 September) and analyzed for 13C.

Soil 13C and CO2 Efflux

- Following the 13 C labeling, the appearance of 13C in surface soil CO2 efflux was measured along with vertical profiles of soil 13CO2 gas that were periodically collected (2, 4, 8 and 20 days post-label) at 5, 10, 20 and 30 cm depths.
- Soil CO2 efflux rate is reported as a measure of soil respiration.

Figure 1. The PiTS-1 experimental plots were established across two rows in a stand of loblolly pine trees, with four adjacent sample trees selected from each row. A trench was excavated in-between the two rows and instrumentation installed as shown.

Data Citation:

Cite this data set as follows:

Warren, J.M., C.M. Iversen, C.T. Garten, Jr, R.J. Norby, J. Childs, D. Brice, R.M. Evans, L. Gu, P. Thornton, and D.J. Weston. 2013. PiTS-1: Carbon Partitioning in Loblolly Pine after 13C Labeling and Shade Treatments. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. http://dx.doi.org/10.3334/CDIAC/ornlsfa.001

Acknowledgement of Sponsor for Terrestrial Ecosystem Science - Scientific Focus Area (TES SFA):

Research sponsored by the Terrestrial Ecosystem Science Program, Office of Biological and Environmental Research within the U.S. Department of Energy's Office of Science.

Partitioning in Trees and Soil (PiTS) Project Description

The Partitioning in Trees and Soil (PiTS) task was established with the objective of improving the carbon (C) partitioning routines in existing ecosystem models based on the concepts gathered from plant partitioning models and tested against field observations and manipulations. The approach we are pursuing, which was inspired in part by our research experience in the free-air CO2 enrichment (FACE) experiment, is to employ relatively short-term field manipulations to reveal specific responses that can lead to improvements in model representation of C partitioning processes. A key feature of this task is the close interaction between modelers and empiricists in the planning of the manipulations and the analysis of results.

Three research sites were selected for this task (PiTS-1, -2, -3) and projects are in various stages of completion.

PiTS-1: Carbon Partitioning in Loblolly Pine after 13C Labeling and Shade Treatments (this data set)

Fieldwork and data collection at PiTS-1 sites (shading in loblolly pine) has been completed and a manuscript describing results has been published (Warren et al. 2012).

The PiTS-1 trees were enclosed in a temporary plastic chamber and labeled with a pulse of 13C-enriched CO2. Subsequently, trees were enclosed in shade cloth to produce light shade (LS) and heavy shade (HS) treatments in order to alter GPP and the C balance of the canopy. The impacts of shading on photosynthesis, plant water potential, sap flow, basal area growth, root growth, and soil CO2 efflux rate were assessed for each tree over a 3-week period. The progression of the 13C label was concurrently tracked from the atmosphere through foliage, phloem, roots, and surface soil CO2 efflux.

PiTS-2: Belowground C Storage and Cycling in Sweetgum Following Long-term Elevated CO2 Exposure and Trunk Girdling

Fieldwork and data collection at PiTS-2 is ongoing with anticipated completion in 2013.

A second research site (PiTS-2 – sweetgum girdling) has been established that takes advantage of the residual 13C label in soils within previously CO2-enriched plots of the legacy ORNL FACE experiment. The 13C signal will be used to facilitate measurement and modeling of the impact that variation in belowground C partitioning has on decomposition of soil organic matter (SOM).

PiTS-3: Carbon Partitioning in Dogwood after 13C Labeling and Shade Treatments

Fieldwork and data collection at PiTS-3 has been completed. Laboratory analysis is ongoing with anticipated completion in 2013.

The final research site (PiTS-3 – dogwood shading) improves upon PiTS-1 by physically isolating the belowground system using trenches, and spatially isolating treatments by distance. We will subsequently manipulate GPP by shading and monitor changes in C flux through the system using seasonal 13C labeling events. Plant C uptake, water use, growth and respiration will be quantified. The fate of new C as plant biomass, litter, mycorrhizal transfer or respiratory release will be assessed and the results will be used in a modeling framework.

Data and Documentation Access:

Get Data

For public access to PiTS data please visit the ORNL TES-SFA Web Site: http://tes-sfa.ornl.gov/home

Description and Links to Supplemental Information

Published paper describing the PiTS-1 investigation and results (Warren et al., 2012).

Data Policy - Sharing, Access, and Use Recommendations: (Under development)

Related Data Sets: Watch for PiTS-2 and PiTS-3 data sets.

Table of Contents:

1. Data Set Overview:

This data set reports the results of the Partitioning in Trees and Soil (PiTS-1) field investigation that examined how carbon partitioning in a stand of loblolly pine trees varied with short-term changes in gross primary production (GPP) due to shading. These measurements were made from June 2010 through May 2011 with most samples and measurements collected from July to September 2010 near the 13CO2 labeling event.

2. Data Characteristics:

Spatial Coverage

The research was conducted on individual trees within a small existing stand of planted *Pinus taeda L.* (loblolly pine) on the University of Tennessee Forest Resources Research and Education Center in Oak Ridge, Tennessee (36°00′N, 84°11′W). Improved, 1-year-old seedlings from the TN Department of Agriculture's forestry nursery were planted at 2.5 × 3 m spacing in 2003 over a ~20 × 100 m area.

Site boundaries: Latitude and longitude given in decimal degrees.

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Elevation (meters amsl)	Geodetic Datum
University of Tennessee Forest Resources Research and Education Center, Oak Ridge, TN	- 84.1833	- 84.1833	36.0000	36.0000	320	WGS84

Temporal Coverage

These measurements were made from June 2010 through May 2011 with most samples and measurements collected from July to September 2010 near the 13C labeling event.

Time period: The data set covers the period June 2010 through May 2011.

Data File Description

The data are provided in 19 comma separated (*.csv) ASCII files in these general data types.

Meteorological Data

- PiTS_1_met_data.csv

Soil Characterization

- PiTS_1_soil_temp.csv
- PiTS_1_soil_water.csv
- PiTS_1_soil_BD_texture.csv

Tree Biophysical Measurements

- PiTS_1_tree_size.csv
- PiTS_1_daily_growth.csv
- PiTS_1_annual_growth.csv
- PiTS_1_root_biomass.csv
- PiTS_1_root_production.csv
- PiTS_1_sap_flow.csv
- PiTS_1_A_Ci_curve.csv
- PiTS_1_light_response_curve.csv
- PiTS_1_foliar_LMA_N.csv
- PiTS_1_leaf_water_potential.csv

Tree 13C Partitioning

- PiTS_1_d13C_plant.csv
- PiTS_1_d13C_roots.csv
- PiTS_1_d13C_soil_efflux_roots.csv

Soil 13C and CO2 Efflux

- PiTS_1_d13C_soil_efflux.csv
- PiTS_1_soil_CO2_efflux.csv

Data Dictionary:

Meteorological Data

#1 File name: PiTS_1_met_data.csv

Column	Heading	Units/Format	Description
1	Year		sampling year
2	DOY	DDD	day of year, January 1, 2010 = DOY 1
3	Date	yyyy-mm-dd	date sampled
4	Time	hh:mm	time sampled
5	Dayfrac	DDD.DD	DOY fraction when sampled
6	Rain	mm	precipitation, 30 minute total, collected by onsite, open field MET station positioned 2 m off ground
7	Wind	m/s	wind speed 2 m off ground
8	Temp	deg C	air temperature 2 m off ground
9	RH	%	relative humidity 2 m off ground
10	PAR	umol/m2/s	photosynthetically active radiation (400-700 nm) 2 m off ground
11	Pyran	W/m2	total radiation 2 m off ground (approx. 0.4 um to 1.2 um)
12	HS_PAR	umol/m2/s	photosynthetically active radiation (400-700 nm), sensor above the canopy but beneath high shade cover
13	LS_PAR	umol/m2/s	photosynthetically active radiation (400-700 nm), sensor above the canopy but beneath low shade cover

Example Data Records:

```
Year,DOY,Date,Time,Dayfrac,Rain,Wind,Temp,RH,PAR,Pyran,HS_PAR,LS_PAR
2010,243,2010-08-31,15:00,243.625,0,0,0,0,0,0,1320.8,1465.3
2010,243,2010-08-31,15:30,243.6375,0,0.83602,31.258,33.676,1208.5,651.8,1225.4,1349.1
2010,243,2010-08-31,16:00,243.6666667,0,0.97699,32.018,37.143,1111.7,598.6,1062.8,1161.8
...
2010,270,2010-09-27,07:30,270.3,0,0.70031,15.36,91.701,23.621,11.021,5.593,19.25
2010,270,2010-09-27,08:00,270.33,0.1,0.81278,15.374,91.39,30.756,14.027,6.809,23.357
2010,270,2010-09-27,08:30,270.35,1.2,0.79652,15.568,90.642,68.893,32.608,7.0522,53.388
```

Soil Characterization

#2 File name: PiTS_1_soil_temp.csv

Column	Heading	Units/Format	Description
1	DOY	day of year	January 1, 2010 = DOY 1
2	Date	yyyy-mm-dd	date sampled
3	Temp_LS	deg C	average daily soil temperature (0-5 cm) adjacent to the light shade trees (n=4) associated with the soil CO2 efflux system

4	Temp_HS	deg C	average daily soil temperature (0-5 cm) adjacent to the heavy shade trees (n=4) associated with the soil CO2 efflux system
	Missing values are designated as -9999		

Example Data Records:

DOY,Date,Temp_LS,Temp_HS,
213,2010-08-01,25.05,25.45,
214,2010-08-02,25.6,25.95,
215,2010-08-03,26.23,26.56,
…
259,2010-09-16,19.85,20.49,
260,2010-09-17,20.8,21.38,
261,2010-09-18,18.04,18.56,

#3 File name: PiTS_1_soil_water.csv

Column	Heading	Units/Format	Description
1	DOY	day of year	January 1, 2010 = DOY 1
2	date	yyyy-mm-dd	date sampled
3	tree_id		number of tree (1-8) adjacent to soil moisture probe
4	treat		shade treatment (0 - light shade; 1 - heavy shade)
5	depth	cm	depth of soil moisture measurement (10 cm interval centered at reported depth) based on a multisensor probe spanning the vertical soil profile
6	VSM	percent	volumetric soil moisture content, %, (cm3/cm3)*100
	Missing values are designated as -9999		

Example Data Records:

DOY,date,tree_id,treat,depth,VSM,,,
244,2010-09-01,1,0,20,27.56,,,
245,2010-09-02,1,0,20,26.89,,,
246,2010-09-03,1,0,20,26.49,,,
…
267,2010-09-24,8,1,90,29.346,,,
268,2010-09-25,8,1,90,29.337,,,
269,2010-09-26,8,1,90,29.336,,,

#4 File name: PiTS_1_soil_BD_texture.csv

Column	Heading	Units/Format	Description
1	depth	cm	sampling depth horizontally into pit wall
2	pit_wall		the trench had two walls, A and B
3	rep		replicate soil sample from different location along the wall
4	BD	g/cm3	bulk density - intact 10 cm long core with roots and rocks
5	sand	percent	particle size analysis based on hydrometer method
6	silt	percent	particle size analysis based on hydrometer method
7	clay	percent	particle size analysis based on hydrometer method
	Soil cores collected date: 2011-06-03		
	Missing values are designated as -9999		

Example Data Records:

```
depth,pit_wall,rep,BD,sand,silt,clay
10,A,1,1.27,11.17,31.79,57.04
10,B,1,1.36,16.50,32.75,50.75
10,A,2,1.10,20.15,30.35,49.50
…
70,B,1,1.43,11.89,40.63,47.48
70,A,2,1.24,-9999,-9999,-9999
70,B,2,1.41,14.92,33.37,51.70
```

Tree Biophysical Measurements

#5 File name: PiTS_1_tree_size.csv

Column	Heading	Units/Format	Description
1	tree_id		Tree identifier
2	treatment		Shade-cloth treatment either light shade (0) or heavy shade (1)
3	height	m	Total tree height
4	dbh_bark	cm	Diameter measured at 1.3 meters (DBH) with bark intact.
5	dbh_shaved	cm	Diameter measured at 1.3 meters (DBH) after removal of bark prior to installation of automatic dendrometer bands.
	All measurements made on date: 2010-06		
	Light shade: trees 1, 2, 5, 6 Heavy shade: trees 3, 4, 7, 8		

Example Data Records:

```
tree_id,treatment,height,dbh_bark,dbh_shaved
tree_1,0,6.6,9.23,8.8
tree_2,0,7.2,9.87,9.4
tree_3,1,7,9.55,9
tree_4,1,7.8,10.31,9.8
tree_5,0,7.3,12.41,12
tree_6,0,6.1,8.82,8.4
tree_7,1,7.9,12.57,12.6
tree_8,1,7.6,10.19,9.9
```

#6 File name: PiTS_1_daily_growth.csv

Column	Heading	Units/Format	Description
1	DOY	day of year	January 1, 2010 = DOY 1
2	tree_1	mm	Minimum daily tree circumference measured with an automated band dendrometer.
3	tree_2	mm	Minimum daily tree circumference measured with an automated band dendrometer.
4	tree_3	mm	Minimum daily tree circumference measured with an automated band dendrometer.
5	tree_4	mm	Minimum daily tree circumference measured with an automated band dendrometer.
6	tree_5	mm	Minimum daily tree circumference measured with an automated band dendrometer.
7	tree_6	mm	Minimum daily tree circumference measured with an automated band dendrometer.
8	tree_7	mm	Minimum daily tree circumference measured with an automated band dendrometer.
9	tree_8	mm	Minimum daily tree circumference measured with an automated band dendrometer.
	Light shade: trees 1, 2, 5, 6 Heavy shade: trees 3, 4, 7, 8		

Example Data Records:

```
DOY,tree_1,tree_2,tree_3,tree_4,tree_5,tree_6,tree_7,tree_8
182,276.46,295.31,282.74,307.88,376.99,263.89,395.84,311.02
183,276.46,295.31,282.74,307.88,376.99,263.89,395.84,311.02
184,276.58,295.36,282.89,308.00,377.08,263.99,395.98,311.31
...
261,287.75,307.32,292.54,321.09,391.91,275.20,408.74,331.25
262,287.73,307.32,292.49,320.99,391.92,275.20,408.66,331.21
263,287.77,307.35,292.49,321.03,392.02,275.22,408.72,331.22
```

#7 File name: PiTS_1_annual_growth.csv

Column	Heading	Units/format	Description
1	mean_rad	mm/year	Mean annual radial growth increment measured on cores from 5 trees adjacent to the 8 experimental trees cored at 1 m.
2	se	mm/year	Standard error
3	n		Number of cores
4	year	yyyy	Growth year
	Cores were collected on date: 2011-03-22		

Example Data Records:

```
mean_rad,se,n,year
2.73,0.48,5,2004
5.80,0.81,5,2005
4.72,0.54,5,2006
4.57,0.58,5,2007
8.46,0.29,5,2008
13.72,0.55,5,2009
13.07,0.54,5,2010
```

#8 File name: PiTS_1_root_biomass.csv

Column	Heading	Units/Format	Description
1	Core		soil core number (R1, R2, R3)
2	Type		root species - grass, cedar or loblolly pine
3	Start_depth	cm	starting depth of core
4	End_depth	cm	end depth of core
5	Depth	cm	depth range
6	Root_biomass	g	total biomass in sample
7	Length	cm	total root scanned length
8	Diameter	mm	mean root diameter
9	Volume	cm3	root volume
10	Density	mg/cm3	root density
11	RML	mg/cm	root mass per length
12	Root_biomass_SA	g/m2	root biomass per soil surface area sampled

Example Data Records:

```
Core,Type,Start_depth,End_depth,Depth,Root_biomass,Length,Diameter,Volume,Density,RML,Root_biomass_SA
R1,cedar,0,5,0-5,0.003,83.483,0.311,0.063,47.619,0.036,1.480
R1,cedar,5,15,5-15,0.024,558.723,0.286,0.359,66.852,0.043,11.841
R1,cedar,15,30,15-30,0.007,215.608,0.282,0.135,51.852,0.032,3.454
...
R3,pine,5,15,5-15,0.255,537.830,0.520,1.142,223.292,0.474,125.812
R3,pine,15,30,15-30,0.141,360.555,0.468,0.619,227.787,0.391,69.567
R3,pine,30,45,30-45,0.352,252.411,0.567,0.638,551.724,1.395,173.670
```

#9 File name: PiTS_1_root_production.csv

Column	Heading	Units/Format	Description
1	Days_since_shade	day	number of days before or after the shade treatments were imposed (day 0)
2	DOY	day of year	January 1, 2010 = DOY 1
3	tree_1	relative change	root-standing crop (relative change from pre-treatment)
4	tree_2	relative change	root-standing crop (relative change from pre-treatment)
5	tree_3	relative change	root-standing crop (relative change from pre-treatment)
6	tree_4	relative change	root-standing crop (relative change from pre-treatment)
7	tree_5	relative change	root-standing crop (relative change from pre-treatment)
8	tree_6	relative change	root-standing crop (relative change from pre-treatment)
9	tree_7	relative change	root-standing crop (relative change from pre-treatment)
10	tree_8	relative change	root-standing crop (relative change from pre-treatment)
	Light shade: trees 1, 2, 5, 6 Heavy shade: trees 3, 4, 7, 8		
	Based on minirhizotron tubes at 5 cm depth adjacent to each tree		

Example Data Records:

```
Days_since_shade,DOY,tree_1,tree_2,tree_3,tree_4,tree_5,tree_6,tree_7,tree_8,,,,,
-1,243,1.000,1.000,1.000,1.000,1.000,1.000,1.000,1.000,,,,,
0,244,1.000,1.000,1.000,1.000,0.948,1.000,0.773,0.983,,,,,
1,245,1.000,1.014,1.000,1.007,0.948,1.049,0.589,0.987,,,,,
2,246,1.000,1.014,0.991,1.044,0.957,1.076,0.589,0.990,,,,,
...
13,257,0.976,0.993,0.825,0.908,1.040,0.941,0.854,1.003,,,,,
16,260,0.997,0.993,0.890,0.887,0.979,0.850,0.854,0.989,,,,,
19,263,1.002,0.956,0.872,0.887,0.989,0.850,0.854,0.983,,,,,
```

#10 File name: PiTS_1_sap_flow.csv

Column	Heading	Units/Format	Description
1	DOY	day of year	January 1, 2010 = DOY 1
2	Date	measurement date	
3	tree_1	liters/day	total sap flow per tree per day
4	tree_2	liters/day	total sap flow per tree per day
5	tree_5	liters/day	total sap flow per tree per day
6	tree_6	liters/day	total sap flow per tree per day
7	tree_3	liters/day	total sap flow per tree per day
8	tree_4	liters/day	total sap flow per tree per day
9	tree_7	liters/day	total sap flow per tree per day
10	tree_8	liters/day	total sap flow per tree per day
	Missing values are designated as -9999		
	Based on three thermal dissipation probes per tree (TDP 30mm (n=2) and TDP 50mm (n=1))		

Example Data Records:

DOY,Date,tree_1,tree_2,tree_5,tree_6,tree_3,tree_4,tree_7,tree_8,
184,2010-07-03,14.54,14.63,26.59,17.31,14.56,21.77,38.05,13.76,
185,2010-07-04,14.72,14.83,26.41,17.40,14.91,20.78,39.14,14.02,
186,2010-07-05,14.65,14.47,25.72,17.07,14.79,19.85,38.41,14.01,
…
267,2010-09-24,8.98,8.93,20.94,10.32,8.98,9.63,17.84,9.65,
268,2010-09-25,5.63,5.38,14.34,7.64,4.58,4.77,12.80,6.00,
269,2010-09-26,1.34,1.09,4.82,2.65,0.47,0.35,5.15,2.03,

#11 File name: PiTS_1_A_Ci_curve.csv

Column	Heading	Units/Format	Description
1	tree_ID		tree identification
2	Foliar_year		year of foliar emergence
3	Flush_no		number of flush used - 1 is the first flush
4	canopy_pos		top or middle of canopy
5	Photo	umol CO2/m2/s	CO2 uptake at specified Ci level
6	Cond	mol H2O/m2/s	conductance at specified Ci level
7	Ci	umol CO2/mol air	intercellular CO2 concentration
8	Trmmol	mmol H2O/m2/s	H2O release at specified Ci level
9	VpdL	kPa	vapor pressure deficit at specified Ci level
10	Tair	deg C	air temperature

11	Tleaf	deg C	leaf temperature
12	CO2R	umol CO2/m2/s	reference CO2 level
13	RH_S	%	relative humidity
14	PARi	umol photons/m2/s	photosynthetically active radiation
15	C	% mass	leaf carbon content
16	N	% mass	leaf nitrogen content
17	SLA	m2/kg	specific leaf area
	All measurements made on date: 2010-08-31		
	Sampled from upper or mid canopy foliage prior to shading		
	Missing values are designated as -9999		

Example Data Records:

tree_ID,Foliar_year,Flush_no,canopy_pos,Photo,Cond,Ci,Trmmol,VpdL,Tair,Tleaf,
CO2R,RH_S,PARi,C,N,SLA
5,2010,1,top,9.050741438,0.076878203,198.28674,2.06406769,2.552350844,36.6961441,35.36105347,
406.8372498,54.96984863,1499.781738,46.53,1.27,5.557461407
5,2010,1,top,6.643149266,0.083246172,160.5500619,2.209872433,2.52413089,36.7681694,35.45096207,
303.401062,55.55166626,1499.965332,46.53,1.27,5.557461407
5,2010,1,top,3.302380064,0.080281643,127.5070047,2.073429397,2.454916063,36.73907852,35.32184219,
202.8565369,56.21880722,1501.213013,46.53,1.27,5.557461407
…
2,2010,1,mid,13.89025748,0.039707917,350.7232753,1.410839424,3.350707969,38.62241364,37.17487717,
956.5892334,47.51955795,1500.314087,43.62,1.34,5.985748219
2,2010,1,mid,17.76872066,0.037310244,388.7621809,1.327040325,3.354729588,38.44096756,37.05246353,
1207.625488,47.34244919,1500.469727,43.62,1.34,5.985748219
2,2010,1,mid,25.29724433,0.039956413,523.3515986,1.39566643,3.297758036,38.12347412,36.78147888,
1612.316772,47.50207138,1499.242676,43.62,1.34,5.985748219

#12 File name: PiTS_1_light_response_curve.csv

Column	Heading	Units/Format	Description
1	PAR	(umol photons/m2/s)	photosynthetically active radiation from LI6400
2	tree_5	(umol CO2/m2/s)	CO2 uptake at specified PAR level
3	tree_2	(umol CO2/m2/s)	CO2 uptake at specified PAR level
4	tree_3	(umol CO2/m2/s)	CO2 uptake at specified PAR level
5	tree_8	(umol CO2/m2/s)	CO2 uptake at specified PAR level
6	tree_4	(umol CO2/m2/s)	CO2 uptake at specified PAR level

	All measurements made on date: 2010-09-02
	Sampled from upper canopy 1-year-old foliage prior to shading
	Positive CO2 uptake values indicate that foliage is accumulating carbon via photosynthesis. Negative CO2 values indicate that the foliage is losing carbon via respiration.

Example Data Records:

```
PAR,tree_5,tree_2,tree_3,tree_8,tree_4,
1500,3.66,6.45,3.62,6.06,7.90,
1001,4.87,7.84,5.60,5.80,7.63,
500,4.60,6.84,4.86,4.69,5.89,
200,3.45,4.32,3.05,3.05,3.37,
150,3.14,3.59,2.55,2.45,2.65,
75,1.78,1.56,0.97,1.14,1.12,
39,0.85,0.01,0.04,0.51,0.24,
0,-1.16,-1.69,-1.24,-1.00,-1.50,
```

#13 File name: PiTS_1_foliar_SLA_N.csv

Column	Heading	Units/Format	Description
1	PAR	(umol photons/m2/s)	photosynthetically active radiation from LI6400
2	tree_5	(umol CO2/m2/s)	CO2 uptake at specified PAR level
3	tree_2	(umol CO2/m2/s)	CO2 uptake at specified PAR level
4	tree_3	(umol CO2/m2/s)	CO2 uptake at specified PAR level
5	tree_8	(umol CO2/m2/s)	CO2 uptake at specified PAR level
6	tree_4	(umol CO2/m2/s)	CO2 uptake at specified PAR level
	All measurements made on date: 2010-09-02		
	Sampled from upper canopy 1-year-old foliage prior to shading		
	Positive CO2 uptake values indicate that foliage is accumulating carbon via photosynthesis. Negative CO2 values indicate that the foliage is losing carbon via respiration.		

Example Data Records:

```
Date,tree_id,canopy_pos,foliar_year,flush_no,no_needles,length,dry_wt,proj_length,C,N,proj_area,LMA,SLA,
LRC,ACI,Cuvette
2010-08-31,1,mid,2009,1,20,2,101.3,42.59,45.42,0.84,4.22,24.00473934,4.165844028,0,0,-9999
2010-08-31,1,mid,2010,1,6,4,49.7,24.8,45.23,1.12,2.75,18.07272727,5.533199195,0,0,-9999
2010-08-31,1,upper,2010,1,5,4,48.9,20.66,44.95,1.48,2.19,22.32876712,4.478527607,0,0,-9999
...
2010-09-21,8,upper,2010,1,7,4,66.3,29.2,45.41,1.27,3.83,17.31070496,5.776772247,0,0,-9999
2010-09-30,2,upper,2010,2,6,4,54.4,25.3,44.84,1.55,2.43,22.38683128,4.466911765,0,0,-9999
2010-09-30,4,upper,2010,1,6,4,54,25.04,44.72,1.49,3.04,17.76315789,5.62962963,0,0,-9999
```

#14 File name: PiTS_1_leaf_water_potential.csv

Column	Heading	Units/Format	Description
1	date	yyyy-mm-dd	sampling date
2	time	hh:mm	time of morning sampling
3	tree_id	deg C	tree id of foliage sampled - tree id > 8 are outside treatment area
4	WP	bars	water potential of pine needles
5	Shade		degree of shade (0 is full sun, 1 light shade, 2 medium-light shade, 3 medium-heavy shade, 4 heavy shade)
6	notes		comments concerning specific sample
	Missing values are designated as -9999		

Example Data Records:

```
Day ,time,tree_id,WP,Shade ,notes
2010-08-27,06:14,9,-4.7,0,
2010-08-27,06:56,9,-6.8,0,
2010-08-27,06:48,10,-5.6,0,
...
2010-09-21,06:41,8,-5.1,4,
2010-09-21,06:49,8,-5.8,4,
2010-09-21,06:57,8,-5.3,4,
```

Tree 13C Partitioning

#15 File name: PiTS_1_d13C_plant.csv

Column	Heading	Units/Format	Description
1	Tissue		tissue type - foliage, phloem, or root tissue
2	Date	yyyy-mm-dd	collection date
3	mean_LS	per mil	delta 13C value of sample tissue - mean of 4 light shade (LS) samples
4	max_LS	per mil	delta 13C value of sample tissue - maximum of 4 light shade (LS) samples
5	se_LS	per mil	delta 13C value of sample tissue - standard error of 4 light shade (LS) samples
6	mean_HS	per mil	delta 13C value of sample tissue - mean of 4 heavy shade (HS) samples
7	max_HS	per mil	delta 13C value of sample tissue - maximum of 4 heavy shade (HS) samples
8	se_HS	per mil	delta 13C value of sample tissue - standard error of 4 heavy shade (HS) samples
9	mean_out	per mil	delta 13C value of sample tissue - mean of 2-3 samples from trees outside shade treatments

10	max_out	per mil	delta 13C value of sample tissue - maximum of 2-3 samples from trees outside shade treatments
11	se_out	per mil	delta 13C value of sample tissue - standard error of 2-3 samples from trees outside shade treatments
	Missing values are designated as -9999		

Example Data Records:

```
Tissue,Date,mean_LS,max_LS,se_LS,mean_HS,max_HS,se_HS,mean_out,max_out,se_out
foliage,2010-08-31,-27.98,-24.20,0.36,-27.98,-24.20,0.36,-9999,-9999,-9999
foliage,2010-09-01,28.00,55.70,10.62,24.33,34.90,5.05,-9999,-9999,-9999
foliage,2010-09-02,-4.80,4.73,2.53,-9.47,-6.93,0.85,-9999,-9999,-9999
...
root,2010-09-05,-25.76,-20.78,1.80,-25.98,-21.07,1.74,-9999,-9999,-9999
root,2010-09-09,-27.70,-26.88,0.38,-23.89,-21.41,1.33,-9999,-9999,-9999
root,2010-09-20,-15.24,18.55,11.26,-25.81,-22.70,1.50,-9999,-9999,-9999
```

#16 File name: PiTS_1_d13C_roots.csv

Column	Heading	Units/Format	Description
1	Date	yyyy-mm-dd	sample collection date
2	Type		Tissue type: new = roots grown during the study period 2010-09-01 to 2010-09-20; tip = terminal 2-4 cm of root tip grown after 2010-09-20; old = basal portion of roots grown after 2010-09-20
3	Rep		Replicate sample identification number for light shade (LS) and heavy shade (HS) root window samples. Note: 2 composite samples per window on 2010-09-21, 1 composite sample per window on 2011-05-20.
4	LS	per mil	delta 13C value of sample tissue
5	HS	per mil	delta 13C value of sample tissue
	Missing values are designated as -9999		

Example Data Records:

```
Date,Type,Rep,LS,HS,,,,,
2010-09-21,new,1,-27.56086031,58.6901892,,,,,,
2010-09-21,new,2,1.649437356,33.39097982,,,,,,
2010-09-21,new,3,-1.559043025,-29.05043512,,,,,,
...
2011-05-20,old,2,-27.6784549,-27.39564314,,,,,,
```

```
2011-05-20,old,3,-27.9734549,-19.75447043,,,,,,
2011-05-20,old,4,-27.3278393,-24.22403834,,,,,,
```

#17 File name: PiTS_1_d13C_soil_efflux_roots.csv

Column	Heading	Units/Format	Description
1	tree_id		tree adjacent to soil core
2	bulk_density	g/cm3	mean bulk density of soil core
3	depth	cm	depth of soil core taken beneath each 13CO2 efflux flask adjacent to each tree
4	root_biomass	mg/g	root biomass per gram of soil
5	soil_mass	g	total mass of soil
6	root_biomass_SA	mg/m2	root biomass per soil surface area sampled

Example Data Records:

```
tree_id,bulk_density,depth,root_biomass,soil_mass,root_biomass_SA,,,,,,
tree_2,1.12,18,0.997,202187,201639,,,,,,
tree_3,1.10,18,2.064,198687,410084,,,,,,
tree_5,1.00,18,2.023,180427,365016,,,,,,
tree_6,1.12,18,0.413,201041,83049,,,,,,
tree_7,0.97,18,2.205,174770,385437,,,,,,
tree_8,1.05,18,2.379,189401,450641,,,,,,
```

Soil 13C and CO2 Efflux

#18 File name: PiTS_1_d13C_soil_efflux.csv

Column	Heading	Units/Format	Description
1	Days_since_label		number of days since label was introduced on 2010-09-01 (day 0)
2	tree_id		tree adjacent to soil surface CO2 collection flask
3	day_night		daytime (day) or nighttime (night) sampling period
4	d13C	per mil	chamber d13C label from soil surface CO2 efflux measured in situ with Picarro 12C/13C isotope analyzer
5	CO2	ppmv	carbon dioxide concentration within collection flask
	Missing values are designated as -9999		

Example Data Records:

```
Days_since_label,tree_id,time,d13C,CO2,,,,,,,
1,tree_2,day,-21.48,3989.4,,,,,,,
2,tree_2,day,3.08,3663.5,,,,,,,
3,tree_2,day,35.42,4612.7,,,,,,,
…
13,tree_8,night,-7.22,3502.1,,,,,,,
14,tree_8,night,-8.39,2667.7,,,,,,,
15,tree_8,night,-12.27,7060.4,,,,,,,
```

#19 File name: PiTS_1_soil_CO2_efflux.csv

Column	Heading	Units/Format	Description
1	Label		Characterizes the sample as before (prelabel) or after (postlabel) 13C labeling and shade treatments. Label date was 9/1/2010
2	DOY		January 1, 2010 = DOY 1
3	date	yyyy-mm-dd	date sampled
4	tree_1	umol/m2/s	Daily average soil surface carbon exchange rate (respiration) for tree_id
5	tree_2	umol/m2/s	Daily average soil surface carbon exchange rate (respiration) for tree_id
6	tree_3	umol/m2/s	Daily average soil surface carbon exchange rate (respiration) for tree_id
7	tree_4	umol/m2/s	Daily average soil surface carbon exchange rate (respiration) for tree_id
8	tree_5	umol/m2/s	Daily average soil surface carbon exchange rate (respiration) for tree_id
9	tree_6	umol/m2/s	Daily average soil surface carbon exchange rate (respiration) for tree_id
10	tree_7	umol/m2/s	Daily average soil surface carbon exchange rate (respiration) for tree_id
11	tree_8	umol/m2/s	Daily average soil surface carbon exchange rate (respiration) for tree_id
	Missing values are designated as -9999		

Example Data Records:

```
Label,DOY,date,tree_1,tree_2,tree_3,tree_4,tree_5,tree_6,tree_7,tree_8,
prelabel,228,2010-08-16,2.35,2.11,3.83,3.91,2.64,2.25,3.46,4.56,
prelabel,229,2010-08-17,2.50,1.41,4.66,5.02,1.11,1.88,3.55,4.42,
prelabel,230,2010-08-18,3.34,2.16,4.33,4.48,1.61,2.21,3.45,4.76,
…
postlabel,259,2010-09-16,2.89,2.17,2.54,3.07,2.64,2.08,1.82,3.62,
postlabel,260,2010-09-17,1.59,0.88,1.62,1.47,1.09,1.51,0.67,2.71,
postlabel,261,2010-09-18,3.00,2.22,2.84,3.06,1.35,1.63,0.80,4.05,
```

Companion File Descriptions

The published paper describing the PiTS-1 results (Warren et al., 2012) is provided courtesy of the author.

3. Data Application and Derivation:

Our objective was to inform model processes by describing relationships between C partitioning and accessible environmental or physiological measurements, with a special emphasis on short-term C flux through a forest ecosystem. MORE???

4. Quality Assessment:

These data are considered at **Quality Level 1**. Level 1 indicates an internally consistent data product that has been subjected to quality checks and data management procedures. Established calibration procedures were followed. MORE?

The Picarro measures the δ13CO2 in ambient air at a precision of 0.1‰. The Picarro factory calibration for [CO2] was checked against a range of CO2 standards (100–5000 ppm) (Scotty gas calibration standards from Sigma-Aldrich, St Louis, MO, USA). Measured CO2 concentrations were within 6% of expected values. The Picarro factory calibration was the default configuration for δ13CO2 and measurements at the top of the pine canopy were in agreement with expected values of δ13CO2 in ambient air (~ −8‰). Analyses indicated that δ13CO2 was not dependent on CO2 concentration at values ≥300 ppm. Measured concentrations of 12CO2 during the labeling experiment were ~450 ppm in the atmosphere, and ranged from 1200 to 19,000 ppm, on average, in soil CO2 efflux. Concentrations of 13CO2 were ~5 ppm in the atmosphere and ranged from 15 to 215 ppm, on average, in soil CO2 efflux.

5. Data Acquisition Materials and Methods:

Site Description:
The research was conducted on individual trees within a small existing stand of planted *Pinus taeda* L. (loblolly pine) on the University of Tennessee Forest Resources Research and Education Center in Oak Ridge, Tennessee (36°00′N, 84°11′W). Improved, 1-year-old seedlings from the TN Department of Agriculture's forestry nursery were planted at 2.5 × 3 m spacing in 2003 over a ~20 × 100 m area. In August 2010, mean tree height was 7.2 +/- 0.2 m and mean diameter (dbh) was 10.4 +/- 0.5 cm. The soil was classified as clayey, mixed, thermic Ochreptic, and was an Armuchee silt loam with a 5–12% slope. The site was previously cultivated, then in the 1940s became dominated by invasive *Pueraria* sp. (kudzu) until mowing and herbicide control began in the 1980s. Non-pine vegetation including grasses and small shrubs were removed by clipping and herbicide prior to study initiation.

Experimental Plot Preparation:
Plots were established across two rows in the interior of the stand, with four adjacent sample trees selected from each row. In April 2010, a trench was excavated in-between the two rows of four trees (oriented east–west) using a small track machine with a 2.13 m wide bucket. Study trees 1–4 were on the south side of the trench, trees 5–8 were on the north side of the trench. During excavation the edge of the bucket cleanly cut most roots, although some large roots (> 1 cm diameter) were manually clipped to avoid potential damage to the trees or the trench wall. The resulting trench was ~ 1 m deep × 15 m long, with trench edges ~40 cm from the base of the study trees. Walls were lined with white landscaping fabric to minimize moisture loss, light penetration and heating of the pit face. A sump pump was installed to prevent buildup of water in the trench.

Six 10 m aluminum poles with wire cable attached across the pole tops were installed surrounding the eight study trees. This rectangular frame was used to support the temporary plastic labeling chamber and the shade cloth treatments.

Figure 2. Experimental plot photographs: (a) trench excavated in-between the two rows of four trees, (b) completed installation of minirhizotron tubes, rhizotron windows, installed sap flow sensors, and static gas exchange chambers.

13C Labeling of Trees:
A 13C label was applied to the study trees by enclosing all eight trees in a large translucent plastic chamber (~510 m3) on the morning of 1 September 2010. The trench and soil surrounding each tree was covered with tarps to minimize direct diffusion of 13CO2 into the soil system. The trees were labeled by adding 53 l of 99 atom % 13CO2 (Cambridge Isotope Laboratories, Inc., Andover, MA, USA) to the enclosure over a 45-min period beginning at 08:31 h (EDT). The 13CO2 was fed to two fans at a flow rate of ~0.66 l min−1, and the fans were used to mix the 13CO2 tracer within the enclosure during the labeling event. Based on the volume of the enclosure, we calculated an expected maximum 13CO2

concentration of 21 atom %. Tree canopy temperature was monitored during the labeling event using a thermal imaging camera. The plastic enclosure was removed after 2 h at which point canopy temperature exceeded ~35 °C and the inside walls of the enclosure were covered in condensation. The [CO2] and δ13CO2 were monitored at six positions in the canopy (two upper, two middle, and two lower) and at a location immediately outside of the enclosure during the exposure period using a Picarro G1101-i Isotopic CO2 Analyzer (Picarro Inc., Sunnyvale, CA, USA). Each sampling position was measured for 10 min, but measurements from only the last 3 min of each data record were used for analysis (i.e., when the Picarro had reached steady state with respect to measurement of both CO2 concentration and δ13CO2). Per mil values from the Picarro (i.e., δ13CO2) were converted to atom % 13CO2.

The Picarro measures the δ13CO2 in ambient air at a precision of 0.1‰. The Picarro factory calibration for [CO2] was checked against a range of CO2 standards (100–5000 ppm) (Scotty gas calibration standards from Sigma-Aldrich, St Louis, MO, USA). Measured CO2 concentrations were within 6% of expected values. The Picarro factory calibration was the default configuration for δ13CO2 and measurements at the top of the pine canopy were in agreement with expected values of δ13CO2 in ambient air (~ −8‰). Analyses indicated that δ13CO2 was not dependent on CO2 concentration at values ≥300 ppm. Measured concentrations of 12CO2 during the labeling experiment were ~450 ppm in the atmosphere, and ranged from 1200 to 19,000 ppm, on average, in soil CO2 efflux. Concentrations of 13CO2 were ~5 ppm in the atmosphere and ranged from 15 to 215 ppm, on average, in soil CO2 efflux.

Figure 3. Experimental plot photographs 13C treatment: (a) completed enclosure, (b) interior of enclosure showing traps placed to prevent infiltration of 13C directly into soil, (c) interior of enclosure showing edge of wall and tarps, (d) release of 13C into enclosure and with Picarro instrument in tent.

Shade Treatments:

After the labeling event, the greenhouse film was removed and replaced with black knitted shade cloth for the duration of the study. Two levels of shading were applied to the trees in order to reduce GPP and thereby manipulate C flux and partitioning within trees. A 30% shade cloth (light shade; LS) treatment was applied to the top and north, east and south sides of one group of four trees (T1, 2, 5, 6) as the control, and a 90% shade cloth (heavy shade; HS) treatment was applied to the top and north, west and south sides of the adjacent group of four trees (T3, 4, 7, 8). Actual daily PAR within the two treatments at the upper canopy surface averaged 11% (HS) or 68% (LS) of ambient.

Figure 4. Completed shade treatment: (a) installed heavy shade cloth, (b) close up of heavy shade cloth.

Sampling and Measurement Methods:

Meteorological Data

- PiTS_1_met_data.csv

Standard environmental monitoring included precipitation, relative humidity, photosynthetically active radiation (PAR), direct shortwave radiation, wind speed and air temperature at ~2 m height at a fully exposed location adjacent to the stand (~15 m from the study trees). Data were collected automatically every 30 min and stored on a logger (model CR10X, Campbell Scientific, Logan, UT, USA). Photosynthetically active radiation was also monitored just above the canopy for each of the two shade treatments.

Soil Characterization

- PiTS_1_soil_temp.csv
- PiTS_1_soil_water.csv

Soil moisture was also measured vertically within the soil profile at each tree using multi-sensor frequency domain capacitance probes (EnviroSCAN, Sentek Pty Ltd., Adelaide, Australia). Sensors were deployed at 10, 20, 30, 40, 60, 80 cm depth for Trees 1–4 and 20, 30, 40, 50, 60, 100 cm depth for Trees 5–8 and automated measurements were collected every 30 min.

- PiTS_1_soil_BD_texture.csv

Soil bulk density was also measured vertically within the soil profile at each tree, using a standard 5 cm diameter split soil core sampler lined with brass rings. Soil texture (% sand, silt and clay) was measured vertically within the soil profile by the hydrometer method.

Tree Biophysical Measurements

- PiTS_1_tree_size.csv
- PiTS_1_daily_growth.csv
- PiTS_1_annual_growth.csv

Basal area growth was assessed for each tree every 30 min using automated band dendrometers (DR 26, EMS, Brno, Czech Republic), which recorded stem circumference at 1.3 m height every 30 min. Daily stem growth was calculated as the change in daily minimum cross-sectional area, which generally occurred shortly after sunset.

- PiTS_1_root_biomass.csv

Root standing crop beneath each of the soil gas exchange chambers was estimated following removal of shade treatments for the 0–5, 5–15 and 15–30 cm depth increments. A 5 cm diameter by 30 cm deep soil core was taken from the center of each soil gas exchange chamber. Roots were separated from the soil using a hydropneumatic elutriator with a 530 μm filter (Gillison Variety Fabrications, Benzonia, MI, USA), and subsequently sorted into pine and non-pine roots (primarily fibrous grass roots), and living and dead roots. Roots were oven-dried at 70 °C and weighed, and the biomass of living roots was used as a covariate in analyses of soil CO2 efflux.

- PiTS_1_root_production.csv

Root growth was assessed using minirhizotron tubes installed laterally into the pit face within the trench. Cellulose acetate butyrate minirhizotron tubes (5 cm diameter by 91 cm length) were installed in May 2010, at 5 and 30 cm depths (i.e., two tubes per tree), positioned 50 cm horizontally from the base of each tree These depths were chosen based upon initial measurements of P. taeda root standing crop distribution estimated from 45 cm deep soil cores collected in February 2010. Minirhizotron images (38 frames per tube, beginning ~5 cm into the soil profile from the pit face) were collected daily beginning on 27 August, and every 3 days from 11 September to 20 September 2010. Root length production and mortality were averaged over each tube, which was considered a statistical replicate. Roots were observed in only two of the eight deeper (30 cm depth) tubes; therefore, these analyses focus on the dynamics of the shallow root population (5 cm depth). Adjacent to the minirhizotron tubes, we installed rhizotron windows (50 cm × 50 cm) consisting of acetate (1.3 mm thickness) attached to a wooden frame. The windows were secured against the trench face (0–50 cm depth) at the base of each tree using long bolts. Sieved soil (2 mm) was packed into the windows from above to fill gaps such that acetate was stretched taut in its frame. The windows allowed access to newly formed root tissue for 13C analysis.

- PiTS_1_sap_flow.csv

Sap flow was monitored in each tree using thermal dissipation sensors (Dynamax Inc., Houston, TX, USA) installed at depths of 1.5 cm (E and W aspect) and 2.5 cm (SE aspect) at 0.75 m height. Sensors were insulated to reduce thermal errors. Data were sampled every 30 min and stored on a logger. Standard techniques were used to assess relative differences in sap flux density between treatments (Granier 1985, Warren et al. 2011). Sap flux density was scaled to whole-tree flux using radial patterns of sap flow and sapwood depth. Sapwood depth was based on bark thickness and assumed to extend to the center of the tree.

- PiTS_1_A_Ci_curve.csv
- PiTS_1_light_response_curve.csv
- PiTS_1_foliar_LMA_N.csv

Light response curves, A–Ci curves (assimilation versus internal sub-stomatal CO2 concentration) and Amax at 1500 μmol m−2 s−1 PAR were obtained for foliage in the upper and mid canopy of several trees prior to shade treatment using an infrared gas analyzer (model 6400, LI-COR Biosciences, Lincoln, NE USA). Following treatments, there were periodic measurements of assimilation at maximum treatment PAR conditions (i.e., 150–200 and 1000–1100 μmol m−2 s−1 for HS or LS treatments, respectively). Relative daily photosynthesis within each treatment was estimated based on diel patterns of PAR within each treatment. Foliage was collected for assessment of nitrogen (N) and carbon (C) concentration using an elemental analyzer (Costeck Analytical Technologies, Inc., Valencia, CA, USA). Leaf mass per area (LMA) or specific leaf area (SLA) were assessed based on fresh leaf area and dry leaf mass.

- PiTS_1_leaf_water_potential.csv

Predawn leaf water potentials were obtained for the eight study trees and several additional trees in the surrounding plantation periodically during the study using a pressure chamber (PMS Instruments, Corvallis, OR, USA).

Tree 13C Partitioning

- PiTS_1_d13C_plant.csv

Plant foliar, phloem and root tissue samples were collected from individual trees prior to the labeling event (31 August) and five occasions after the labeling event (1, 2, 5, 9 and 21 September) to track the changes in δ13C over time. Foliar samples were collected throughout the canopy using a vertical lift. First and second flush needles from the current (2010) growing season and older needles were sampled. Needles were dried at 70 °C and ground to a fine powder for analysis.

Phloem tissue disks were collected from the east and west aspects of the lower bole 20 cm from the ground using a 10.5 mm diameter punch (cork borer). At each date, phloem sampling locations were progressively shifted over and down the bole 2–3 cm to avoid sampling wounded tissue. Phloem tissue

was easily peeled and separated from the suberized outer bark layers, frozen with liquid N2 and kept at −80 °C until extraction. For extraction, each phloem sample was cut into four quarters and 1/2 the sample retained for future analysis. Samples were pooled by tree by date. The tissue was then quickly rinsed twice with distilled water and incubated for 24 h at 4 °C in scintillation vials containing 2 ml distilled water (Gessler et al. 2004). After the incubation, the extracted phloem tissue was removed and dried. The supernatant was centrifuged, and 200 µl was added to a glass fiber filter in a tin cup and dried at 80 °C for 13C isotopic analysis. We assumed the supernatant was primarily composed of extracted sieve tube sap, although cutting and the freeze/thaw process could allow for minor contamination (dilution) by other soluble cellular constituents from adjacent damaged cells. If so, the reported 13C phloem concentrations would slightly underestimate the actual 13C concentrations in phloem sieve tube sap.

- PiTS_1_d13C_roots.csv
- PiTS_1_d13C_soil_efflux_roots.csv

Roots were collected from 5 cm diameter by 30 cm deep soil cores taken 20 cm horizontally from the base of each tree, separated by depth increment (0–5, 5–15 and 15–30 cm) and kept at −20 °C until processing. Thawed soil was passed through a 2 mm mesh sieve, and P. taeda roots (<2 mm) were removed with tweezers, quickly rinsed in distilled water, lyophilized and ground to a fine powder. Only the 0–5 cm depth increment was processed due to the fact that the minirhizotron observations did not observe root growth in deeper soil during the experimental manipulation.

To further assess fate and longevity of the 13C signal, new root tips growing against the face of the rhizotron windows were collected on 21 September 2010 and again in early May 2011. In addition, newly emerging buds, 2009 and 2010 foliage, and branch wood were sampled from each tree in early May 2011.

Root tissue was dried at 70 °C and ground for analysis. Ground or extracted tissue samples were analyzed for 13C using an Integra CN isotope ratio mass spectrometer (SerCon Ltd, Crewe, UK). Glucose (δ13C = −10.2‰) was used as the working standard for isotope analysis and was calibrated against reference material from the National Institute of Standards and Technology (NIST 8542, sucrose). The isotopic signature of C in plant tissues (leaves or roots) was expressed as δ13C (‰) (δ13C = [RSAMPLE/RSTANDARD − 1] ×1000), where R is the 13C/12C ratio and the standard is carbonate from Pee Dee Belemnite.

Soil 13C and CO2 Efflux

- PiTS_1_d13C_soil_efflux.csv

Following the labeling event, the appearance of 13C in soil CO2 efflux was monitored hourly using static chambers (volume = 5 l, surface area = 214 cm2) made from white, translucent, high-density polyethylene. Each chamber contained a small vent (6 mm diameter) on the side to equalize interior and exterior atmospheric pressure. The top of the chamber contained a second hole that was connected to 6

mm diameter Tygon plastic tubing. The tubing was led to a Picarro G1101-I isotopic CO2 analyzer for analysis of δ13CO2 in the chamber.

Chambers were placed near the base (within 1 m) of three trees in the control treatment (Trees 2, 5, 6) and the HS treatment (Trees 3, 7, 8). The analyzer sampled the gas in each chamber for 7–10 min, which included transit time for gas to reach the analyzer, several minutes for stabilization of transient responses and a final 3-min period of useable data. With a flow rate of 26 ml min−1, each sampling event replaced ≤6% of the existing (soil) CO2 in the chamber with new atmospheric CO2 via the vent. Due to a strong concentration gradient from the interior to the exterior of the chamber and the small diameter of the vent, we assumed negligible diffusional influence of atmospheric CO2 on the isotopic signature inside the chamber during periods when the chamber was not being sampled. Data were categorized as day or night (defined by sunrise and sunset). Atmospheric δ13CO2 (near the ground) was also measured each hour at the site of the analyzer.

Vertical profiles of soil 13CO2 gas were periodically collected (2, 4, 8 and 20 days post-label) at 5, 10, 20 and 30 cm depths. Stainless-steel tubes (2 mm diameter, 15 cm long) were inserted in the pit wall and 5–10 ml gas samples were extracted with a syringe inserted through a rubber stopper at the end of the tube and stored in evacuated vials. Additional samples were collected from soil beneath unlabeled trees. The samples were analyzed for [CO2] and 13C content at the University of California Davis Stable Isotope Facility using a PreCon-GasBench system interfaced to a Delta V Plus isotope ratio mass spectrometer (ThermoScientific, Bremen, DE, USA).

- PiTS_1_soil_CO2_efflux.csv

Soil CO2 efflux rate (CER) as a measure of soil respiration was monitored ~0.5 m from each tree and 0.5 m from the trench, using automated gas exchange chambers (Li-8100, LI-COR Inc., Lincoln, NE, USA) that sampled every 20 min. The gas exchange system included integral soil moisture and temperature measurements (0–5 cm depth) at each location. Measurements taken during rain events or when soil was flooded were removed from the data set.

6. References:

Gessler, A., H. Rennenberg, and C. Keitel. 2004. Stable isotope composition of organic compounds transported in the phloem of European beech—evaluation of different methods of phloem sap collection and assessment of gradients in carbon isotope composition during leaf-to-stem transport. Plant Biol. 6:721–729.

Granier, A. 1985. Une nouvelle méthode pour la mesure du flux de sève brute dans le tronc des arbres. Ann. Sci. For. 42:193–200.

Warren, J.M., C.M. Iversen, C.T. Garten, Jr, R.J. Norby, J. Childs, D. Brice, R.M. Evans, L. Gu, P. Thornton, and D.J. Weston. Timing and magnitude of C partitioning through a young loblolly pine (Pinus taeda L.) stand using 13C labeling and shade treatments Tree Physiol (2012) 32(6): 799-813.

Warren, J.M., R.J. Norby, and S.D. Wullschleger. 2011. Elevated CO2 enhances premature leaf senescence during extreme climatic events in a temperate forest. Tree Physiol. 31:117–130.

7. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Carbon Dioxide Information Analysis Center (CDIAC)

Data Archive Center:

Contact for Data Center Access Information:

E-mail: http://cdiacservices.ornl.gov/feedback.cfm