LBA-ECO TG-07 Long-Term Soil Gas Flux and Root Mortality, Tapajos National Forest

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Revision date: September 11, 2012

Summary:

This data set reports measurements of trace gas fluxes of methane (CH4), nitric oxide (N2O), nitrous oxide (NO), carbon dioxide (CO2) from soils at a study site in the Tapajos National Forest (TNF), near the km 83 on the Santarem-Cuiaba Highway south of Santarem, Para, Brazil. Data for root mass and carbon content, soil nitrogen (N), nitrification, and moisture content are also provided. There are five comma-delimited data files with this data set.

The research was conducted to test the effects of root mortality on the soil-atmosphere trace-gas fluxes over the course of one year. Root mortality was induced by isolating blocks of land to 1 m depth using trenching and root exclusion screening. Gas fluxes were measured weekly for ten weeks following the trenching treatment and monthly for the remainder of the year.

Note: The related data set LBA-ECO TG-07 Soil Trace Gas Flux and Root Mortality, Tapajos National Forest contains the same flux data that were measured weekly for ten weeks following the trenching treatment. This data set also provides the monthly data for the remainder of the year.

Data Citation:

Cite this data set as follows:

Silver, W.L., A.W. Thompson, M.E. McGroddy, R.K. Varner, J.R. Robertson, J.D. Dias, H. Silva, P. Crill, and M. Keller. 2012. LBA-ECO TG-07 Long-Term Soil Gas Flux and Root Mortality, Tapajos National Forest. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. http://dx.doi.org/10.3334/ORNLDAAC/1116

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This data set was archived in September of 2012. Users who download the data between September 2012 and August 2017 must comply with the LBA Data and Publication Policy.

Data users should use the Investigator contact information in this document to communicate with the data provider. Alternatively, the LBA website [http://lba.inpa.gov.br/lba/] in Brazil will have current contact information.

Data users should use the Data Set Citation and other applicable references provided in this document to acknowledge use of the data.

Table of Contents:

1. Data Set Overview:

Project: LBA (Large-Scale Biosphere-Atmosphere Experiment in the Amazon)

Activity: LBA-ECO

LBA Science Component: Trace Gas and Aerosol Fluxes

Team ID: TG-07 (Keller / de Mello)

The investigators were Silver, Whendee L. and McGroddy, Megan E. You may contact Silver, Whendee L. (wsilver@berkeley.edu).

LBA Data Set Inventory ID: TG07_Root_Mortality_Longterm

This data set reports measurements of trace gas fluxes of methane (CH4), nitric oxide (N2O), nitrous oxide (NO), carbon dioxide (CO2) from soils at a study site in the Tapajos National Forest (TNF), near the km 83 on the Santarem-Cuiaba Highway south of Santarem, Para, Brazil. Data for root mass and carbon content, soil nitrogen (N), nitrification, and moisture content are also provided.

The research was conducted to test the effects of root mortality on the soil-atmosphere trace-gas fluxes over the course of one year. Root mortality was induced by isolating blocks of land to 1 m depth using trenching and root exclusion screening. Gas fluxes were measured weekly for ten weeks following the trenching treatment and monthly for the remainder of the year.

Related Data Set:

- LBA-ECO TG-07 Soil Trace Gas Flux and Root Mortality, Tapajos National Forest (data from the first ten weeks of the same experiment)

2. Data Characteristics:

Data are presented in five comma-delimited ASCII files:

File #1: TG07_trench_plot_gas_fluxes.csv

File #2: TG07_trench_plot_root_mass.csv

File #3: TG07_trench_plot_root_chemistry.csv

File #4: TG07_trench_plot_soil_N.csv

File #5: File name: TG07_trench_plot_soil_moisture.csv

File #1: TG07_trench_plot_gas_fluxes.csv

Column	Heading	Units/format	Description
1	Date	YYYYMMDD	Date (YYYYMMDD)
2	Day_year		Day of the year January 1=1 and December 31=365
3	Day_expt		Day since the start of the experiment
4	Soil_type		Soil texture class: Soil or Clay. See documentation for more detail on soils.
5	Treatment		Plot treatment: Control or Trench (indicating trenched to 1.5 meters depth)
6	Plot		Plot identification number: 1 - 5
7	Rep		Replicate within the plot: A or B
8	Flux_N2O	ng N/cm2/hr	Flux of nitric oxide reported in ng N per centimeter squared per hour (ng N per cm2/hr): positive values indicate a flux from the soil to the atmosphere and negative values indicate a flux from the atmosphere into the soil
9	Flux_CH4	mg CH4/m2/hr	Flux of methane reported in mg CH4 per meter squared per day (mg/m2/day): positive values indicate a flux from the soil to the atmosphere and negative values indicate a flux from the atmosphere into the soil
10	Time		Start of sampling time (hh:mm) for NO and CO2 in local time (GMT+3)
11	T_air	degrees C	Air temperature measured at 30 cm above the ground in degrees Centigrade
12	T_soil	degrees C	Soil temperature taken at 2 cm depth in degrees Centigrade
13	Flux_NO	ng N/cm2/h	Flux of nitrous oxide measured in nanograms of nitrogen in the form of NO per centimeter squared of soil surface per hour (ng N/cm2/hr). Positive values indicate a flux from the soil to the atmosphere.
14	Flux_CO2	umol CO2/m2/sec	Flux of carbon dioxide measured in micromoles of carbon dioxide per meter squared of soil surface per second (umol CO2/m2/s). Positive values indicate a flux from the soil to the atmosphere.

Example data records:

```
Date,Day_year,Day_expt,Soil_type,Treatment,Plot,Rep,Flux_N2O,Flux_CH4,Time,T_air,T_soil,Flux_NO,Flux_CO2
20000604,156,1,Clay,Control,1,A,31.39,2.8,12:41,26.7,25,0.7,3.43
20000604,156,1,Clay,Control,1,B,14.87,-0.49,12:46,26.9,25.2,1.21,6.18
...
20000604,156,1,Clay,Control,2,A,10.53,-0.43,10:27,26.5,24.7,8.42,3.85
20000604,156,1,Clay,Control,2,B,4.68,-0.78,10:33,26.4,25,10.44,3.28
20000604,156,1,Clay,Control,3,A,1.77,-9999,11:05,27.3,24.9,0.76,3.33
20000604,156,1,Clay,Control,3,B,14.5,-0.97,11:17,26.7,24.9,1.33,4.44
20000604,156,1,Clay,Control,4,A,16.33,-0.03,10:12,26.5,24.9,0.66,3.71
20000604,156,1,Clay,Control,4,B,37.06,-0.32,10:18,26.2,24.1,0.83,3.51
20000604,156,1,Clay,Control,5,A,16.59,-0.33,11:36,26.4,24.8,0.5,3.73
20000604,156,1,Clay,Control,5,B,7.55,-0.67,11:42,26.5,24.8,0.81,4.78
20000604,156,1,Clay,Trench,1,A,8.87,0.69,12:30,26.7,25,5.58,1.69
```

File #2: TG07_trench_plot_root_mass.csv

Column	Heading	Units/format	Description
1	Date	YYYYMMDD	Sampling date (YYYYMMDD)
2	Soil_type		Soil texture class: Soil or Clay. See documentation for more detail on soils.
3	Treatment		Plot treatment: Control or Trench (indicating trenched to 1.5 meters depth)
4	Plot		Plot identification number: 1 - 5
5	Rep		Replicate number: there were three replicate samples per plot per sample date
6	Mass_live_rts	g	Mass of live fine roots measured after oven drying at 60 degrees C reported in grams (g)
7	Mass_dead_rts	g	Mass of dead fine roots measured after oven drying at 60 degrees C reported in grams (g)
8	Mass_medium_rts	g	Mass of roots with diameters greater than 2 and less than or equal to 5 mm measured after oven drying at 60 degrees C reported in grams (g)
9	Mass_coarse_rts	g	Mass of roots with diameters greater than 5 mm measured after oven drying at 60 degrees C reported in grams (g)
10	Density_live_rts	g/m2	Density of live fine roots calculated by dividing the measured mass of live fine roots by the volume of the sampling cylinder, expressed as grams per meter squared (g/m2)
11	Density_dead_rts	g/m2	Density of dead fine roots calculated by dividing the measured mass of dead fine roots by the volume of the sampling cylinder, expressed as grams per meter squared (g/m2)
missing data are indicated by -9999			

Example data records:

```
Date,Soil_type,Treatment,Plot,Rep,Mass_live_rts,Mass_dead_rts,Mass_medium_rts,Mass_coarse_rts,
Density_live_rts,Density_dead_rts
20000604,Clay,Control,1,1,0.1022,0.6077,0.0789,
0,36.15,214.96
20000604,Clay,Control,1,2,0.1486,
0.3664,0.0304,
0,52.56,129.61 20000604,Clay,Control,1,3,0.068,0.5625,0.238,
0,24.05,198.97
20000604,Clay,Control,2,1,0.021,0.2027,0.3003,
0.1141,7.43,71.7
20000604,Clay,Control,2,2,0.0332,0.8438,0.1206,1.1709,
11.74,298.48
20000604,Clay,Control,2,3,0.0431,0.198,0.3487,0.6135,
15.25,70.04
...
20000604,Clay,Control,3,1,0.2198,0.606,0.5935,0.3141,
77.75,214.36
 20000604,Clay,Control,3,2,0.0439,0.3007,0.2199,0,
15.53,106.37
20000604,Clay,Control,3,3,0.1105,0.2515,0,0,
39.09,88.96
20000604,Clay,Control,4,1,0.069,0.4609,0.3594,0,
24.41,163.04
```

File #3: TG07_trench_plot_root_chemistry.csv

Column	Heading	Units/format	Description
1	Date	YYYYMMDD	Sampling date (YYYYMMDD)
2	Soil		Soil texture class: Soil or Clay. See documentation for more detail on soils.
3	Treatment		Plot treatment: Control (none included in this data file) or Trench (indicating trenched to 1.5 meters depth).
4	Plot		Plot identification number: 1 - 5
5	Rt_mass_remaining	%	Root mass remaining calculated as the mean oven-dry weight of fine roots (live and dead) divided by the mean oven-dry weight of the fine roots (live and dead) in the plot at the onset of the experiment and expressed as percentage
6	Ash	%	Percent of root mass composed of inorganic compounds determined by ashing samples at 550 degrees C

7	Non_polar_C	%	Concentration as carbon of compounds extractable in non-polar solutions as percent of total root carbon
8	Water_sol_C	%	Concentration of carbon, in the form of compounds extractable in water as percent of total root carbon
9	Acid_sol_C	%	Concentration of carbon in the form of compounds extractable in acid solutions as percent of total root carbon
10	Tannins	%	Concentration of carbon in the form of tannins as percent of total root carbon
11	Lignin	%	Concentration of carbon in the form of lignin as percent of total root carbon. Lignin content calculated as the difference between total root carbon content and the sum of the three extractable carbon fractions
12	Carbon	%	Total root carbon content measured by combustion expressed as percent of total mass
13	Nitrogen	%	Total root nitrogen content measured by combustion expressed as percent of total mass
14	C_to_N	gC/gN	Carbon to nitrogen ratio of root tissue calculated on mass basis
15	Lignin_to_N		Lignin to nitrogen ratio of root tissue calculated on a mass basis
missing data are indicated by -9999			

Example data records:

```
Date,Soil,Treatment,Plot,Rt_mass_remaining,Ash,Non_polar_C,Water_sol_C,Acid_sol_C,Tannins,Lignin,
Carbon,Nitrogen,C_to_N,Lignin_to_N
20000604,Clay,Trench,1,1,6.59,3.94,6.19,50.4,1.41,39.46,
50.32,1.55,32.46,25.46
20000604,Clay,Trench,2,1,7.84,2.05,5.34,52.08,0.69,40.53,
49.72,1.27,39.15,31.91
20000604,Clay,Trench,3,1,6.93,7.67,5.88,45.92,1.14,40.54,
52.28,1.5,34.85,27.03
...
20000604,Sand,Trench,4,1,7.67,5.97,11.59,43.23,1.55,39.21,
50.77,1.37,37.06,28.62
20000604,Sand,Trench,5,1,4.65,3.95,6.02,52.26,0.74,37.77,
52.51,1.47,35.72,25.69
20000630,Clay,Trench,1,0.704,7.11,2.17,6.56,53.6,0.96,37.67,
50.17,1.27,39.5,29.66
...
20010714,Sand,Trench,3,0.312,6.28,3.75,5.06,49.26,0.47,41.93,
52.1,1.52,34.28,27.59
20010714,Sand,Trench,4,0.779,7.05,2.85,5.79,35.74,0.64,55.62,
48.95,1.34,36.53,41.51
20010714,Sand,Trench,5,0.652,8.05,4.16,6.38,43.94,0.72,45.52,
53.97,1.72,31.38,26.47
```

File #4: TG07_trench_plot_soil_N.csv

Column	Heading	Units/format	Description
1	Date	YYYYMMDD	Sampling date (YYYYMMDD)
2	Soil_type		Soil texture class: Soil or Clay. See documentation for more detail on soils.
3	Treatment		Plot treatment: Control or Trench (indicating trenched to 1.5 meters depth)
4	Plot		Plot identification number: 1 - 5
5	Rep		Replicate number: there were three replicate samples per plot per sample date
6	Soil_moisture	%	Soil moisture reported in percent by weight
7	Soil_NH4_initial	ug/gdw	Initial concentration of NH4-N extracted from the soil with 2M KCl reported in micrograms of N in the form of NH4 per gram dry weight of soil (ug N/gdw)
8	Soil_NO3_initial	ug/gdw	Initial concentration of NO3-N extracted from the soil with 2M KCl reported in micrograms of N in the form of NO3 per gram dry weight of soil (ug N/gdw)
9	Soil_NH4_final	ug/gdw	Final concentration of NH4-N extracted from the soil with 2M KCl reported in micrograms of N in the form of NH4 per gram dry weight of soil (ug N/gdw)
10	Soil_NO3_final	ug/gdw	Final concentration of NO3-N extracted from the soil with 2M KCl reported in micrograms of N in the form of NO3 per gram dry weight of soil (ug N/gdw)
11	Net_mineralization	ug/gdw/day	Calculated rate of net mineralization of N reported in micrograms of N per gram dry weight of soil per day (ug/gdw/day)

12	Net_nitrification	ug/gdw/day	Calculated rate of net nitrification reported in micrograms of N per gram dry weight of soil per day (ug/gdw/day)
missing data are indicated by -9999			

Example data records:

```
Date,Soil_type,Treatment,Plot,Rep,Soil_moisture,Soil_NH4_initial,Soil_NO3_initial,Soil_NH4_final,
Soil_NO3_final,Net_mineralization,Net_nitrification
20000604,Clay,Control,1,1,27.35,0.56,10.95,7.63,
28.81,1.01,2.55
20000604,Clay,Control,1,1,27.35,0.56,10.95,7.63,
28.81,1.01,2.55
20000604,Clay,Control,1,2,31.77,27.18,29.68,2.44,
36.64,-3.53,0.99
...
20000706,Sand,Trench,5,1,13.95,1.94,7.74,0.98,
22.3,-0.14,2.08
20000706,Sand,Trench,5,2,15.5,2.02,6.85,0.69,
34.78,-0.19,3.99
20000706,Sand,Trench,5,3,15.16,1.63,20.77,0.63,
27.04,-0.14,0.9
...
20010714,Sand,Trench,5,1,11.35,2.86,26.65,-9999,
-9999,-9999,-9999
20010714,Sand,Trench,5,2,11.28,1.77,16.61,-9999,
-9999,-9999,-9999
20010714,Sand,Trench,5,3,13.51,1.58,14.3,-9999,
-9999,-9999,-9999
```

File #5: File name: TG07_trench_plot_soil_moisture.csv

Column	Heading	Units/format	Description
1	Date		Sampling date (YYYYMMDD)
2	Soil_type		Soil texture class: Soil or Clay. See documentation for more detail on soils.
3	Treatment		Plot treatment: Control or Trench (indicating trenched to 1.5 meters depth)
4	Plot		Plot identification number: 1 - 5
5	Soil_moisture	%	Gravimetric soil moisture calculated after drying the soil sample at 110 degrees C, expressed as percent (%)
6	WFPS	%	Water filled pore space (WFPS) is expressed as percent of total estimated pore space assumed to be filled with water rather than air. Calculated from soil moisture and soil texture measurements
missing data are indicated by -9999			

Example data records:

```
Date,Soil_type,Treatment,Plot,Soil_moisture,WFPS
20000531,Clay,Control,1,43.53,0.72
20000531,Clay,Control,2,40.99,0.67
20000531,Clay,Control,3,35.53,0.58
...
20010620,Clay,Control,5,36.41,0.6
20010620,Clay,Trench,1,40.08,0.66
20010620,Clay,Trench,2,35.44,0.58
...
20010714,Sand,Trench,3,9.96,0.27
20010714,Sand,Trench,4,10.81,0.3
20010714,Sand,Trench,5,13.71,0.37
```

Site boundaries: (All latitude and longitude given in decimal degrees)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Geodetic Datum
Para Western Km 83 not logged tower site (Para Western (Santarem))	-54.9707	-54.9707	-3.017	-3.017	World Geodetic System, 1984 (WGS-84)

Time period:

- The data set covers the period 2000/05/31 to 2001/07/14.
- Temporal Resolution: weekly to monthly for trace gases and every 2 months for root biomass and necromass

Platform/Sensor/Parameters measured include:

- FIELD INVESTIGATION / SOIL MOISTURE/WATER CONTENT / WEIGHING BALANCE
- FIELD INVESTIGATION / WEIGHING BALANCE/ BIOMASS
- FIELD INVESTIGATION / AUTOANALYZER/ NITROGEN
- FIELD INVESTIGATION / IR CO2 ANALYZER / SOIL GAS/AIR
- LABORATORY / GC-FID (GAS CHROMATOGRAPH/FLAME IONIZATION DETECTOR)/ NITROUS OXIDE

3. Data Application and Derivation:

From these measurements estimates of the decomposition rate of roots as well as the contribution of roots to soil-atmosphere gas exchange can be made.

4. Quality Assessment:

NO standards were run in the field at the beginning and end of 8 enclosure flux samples or approximately every hour. NO standard response calculated using a linear fit of the two standards encompassing the measurement period was compared to the frequent (generally hourly) standardization. A given hourly standard run varied by as much as 60% from the standard response calculated from the linear fit. On two dates of eight tested, at least 50% of the standards fall outside of the predicted standard response by at least 20% based on the starting and ending standards. On two other dates at least 10% of the standard runs fall outside of this +/-20% window. For additional QA, please see flux measurement section below.

5. Data Acquisition Materials and Methods:

Site Description

The region receives approximately 2000 mm of precipitation per year and has an annual mean temperature of 25 C (Silver et al., 2000). Vegetation at the site is evergreen, mature tropical forest with a total biomass of about 372 Mg ha-1 (Keller et al., 2001). Experimental plots were located on contrasting soils, a clay textured Oxisol (80% clay, 18% sand, 2% silt) and a sand textured Ultisol (60% sand, 38% clay, 2% silt) (Silver et al., 2000).

Experimental Design

The experiment was a randomized complete block design (Varner et al., 2003). For each soil type, 5 pairs of 2.5 x 2.5 m plots were located so that there were no trees greater than 10 cm diameter at breast height (DBH; 1.3 m) on the plots. One plot in each pair was randomly selected for trenching. In the trenched plots, trenches were dug to 1-m depth and were lined with a fine stainless steel mesh (<0.5 mm) to prevent the penetration of roots while allowing the movement of water and gases. All vegetation was clipped from the trenched plots at the time of trenching and every two weeks thereafter to prevent colonization of the plot by live roots. The trenching operations were completed in the period from Julian day 147 through 156 in 2000 (May 27 through June 4).

Trace Gas Flux Measurements

For all plots, measurements were made in an interior square region, 2 x 2 m that was surrounded by a 0.5-m wide buffer strip. The soil-atmosphere fluxes of CO2, NO, N2O and CH4 were measured weekly for approximately 10 weeks following the trenching treatment and N2O and CH4 were measured monthly after that until July 2001. After the weekly sampling ended CO2 and NO were measured monthly at these plots for 5 months and then every 2.5 months through May 2001.

Two chamber bases were inserted approximately 2 cm depth in the soil at randomly selected points in the sampled plots within 30 minutes of the weekly flux measurement. These chamber bases were removed immediately after flux measurements were completed. Dynamic flow-through chambers were used for measurement of NO and CO2 and static vented chambers were used for measurements of N2O and CH4 (Keller and Reiners, 1994). The measurement of these two pairs of gases was sequential after lifting the chamber top to equilibrate the headspace with ambient air.

An integrated backpack system was used to measure NO and CO2 over 3 to 10 minutes from enclosures. The flow through the chamber was regulated to about 300 cm3 min-1. Air entered the chamber through a chimney-like air-gap that was specifically designed to minimize exchange with the outside air and to avoid pressure fluctuations within the chamber. Air flowed from the soil enclosure through a Teflon-lined polyethylene sample line 30 m in length and then it entered an infrared gas analyzer (Li-Cor 6262) for CO2 measurement. From the Li-6262, the sampled air then passed through a flow control manifold where it was mixed with a make-up air flow of about 1200 cm3 min-1 and a flow of NO (1 ppm) standard gas that varied from 3 to 10 cm3 min-1 as measured on an electronic mass flowmeter (Sierra Top-Trak). The make-up air and standard addition maintain optimum and linear performance of the NO2 chemiluminescent analyzer (Scintrex LMA-3). The mixed sample stream passed through a Cr2O3 catalyst for conversion of NO to NO2 (Levaggi et al., 1974). The NO2 chemiluminescent analyzer was standardized by a two-point calibration approximately hourly. The intra-day stability of the calibration on each sampling date was checked by comparison of each standard run to a linear interpolation between the standards runs at the beginning and end of the daily measurement period. The concentration of the field NO standard was compared periodically with laboratory standards to assure that they did not drift (Veldkamp and Keller, 1997). Signals from the CO2 and NO2 analyzers and the mass flow meter for the NO standard gas were recorded on a datalogger (Campbell CR10). Fluxes were calculated from the linear increase of concentration versus time.

Static enclosure measurements were made for CH4 and N2O fluxes using the same bases and vented caps (Keller and Reiners, 1994). Four enclosure headspace samples were taken over a 30-minute sampling period with 20-ml nylon syringes. Analysis of grab samples for CH4 and N2O were completed within 36 hours by FID and ECD gas chromatography. Gas concentrations were calculated by comparing peak areas for samples to those for standards.

Root Biomass

Roots were sampled using a root corer with a 6-cm internal diameter (Vogt and Persson, 1991). Roots were sorted and dried at 65 degree C and weighed.

Root Chemistry

Root C chemistry was measured using sequential extractions (Ryan et al. 1989) at the Center for Water and the Environment of the Natural Resources Research Institute, University of Minnesota, Duluth, MN. One bulked root sample was used per plot and date. The C fractions measured were nonpolar extractives, water soluble and acid soluble extracts, tannins, and water and acid soluble fractions expressed as glucose equivalents. Lignin was determined as the difference between the whole sample and the sum of the nonpolar extractives, and water and acid soluble fractions. Total C and N were measured on a CN analyzer (CE Elantec, Lakewood, NJ, USA) at UC Berkeley. All root data are expressed on an oven dry equivalent, ash-free basis.

Soil Moisture and N Pools and Fluxes

For this study, we measured gravimetric soil moisture, soil temperature, soil N pools, and net N mineralization and nitrification rates from trench plots and controls. Soil moisture was sampled in close proximity to the surface flux chambers using three 2.5 cm diameter by 10 cm deep soil cores. Samples were collected during 15 dates (all but four of the trace gas sampling periods). Soils were dried at 105 degrees C until reaching a constant weight and then weighed to determine moisture loss. Water-filled pore space (WFPS) was estimated from soil moisture and porosity (porosity x bulk density/particle density)for trench plots and controls. Bulk density values were taken from Silver et al. (2000) and particle density was assumed to be 2.65 g cm-3. Soil N pools were determined on fresh samples (0 to 10cm depth) during the five dates that we sampled the trench plots for root biomass. We took three replicate samples per plot with a 2.5 cm diameter corer to 10 cm depth (n= 20 plots and 60 samples per time period). Soils were extracted with 2M KCl the same day of collection. Soil extract N concentrations were determined at U.C. Berkeley on a Lachat QC 8000 autoanalyzer (Lachat Instruments, Loveland, CO, USA). Net N mineralization and nitrification rates were estimated for the first three measurement periods according to Hart et al. (1994).

6. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Data Archive Center:

Contact for Data Center Access Information:
E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

7. References:

Hart SC, Stark JM, Davidson EA et al. (1994). Nitrogen mineralization, immobilization, and nitrification. In: Methods of Soil Analysis, Part 2. Microbiological and Biochemical Properties(ed.Weaver RW pp. 985-1018. Soil Science Society of America, Madison.

Keller, M., et al., (2001). Biomass in the Tapajos National Forest, Brazil: Examination of sampling and allometric uncertainties, Forest Ecol. Manage., 154, 371-382. doi:10.1016/S0378-1127(01)00509-6.

Keller, M., and W. A. Reiners, (1994). Soil-atmosphere exchange of nitrous oxide, nitric oxide, and methane under secondary succession of pasture to forest in the Atlantic lowlands of Costa Rica, Global Biogeochem. Cycles, 8, 399-410. doi:10.1029/94GB01660.

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