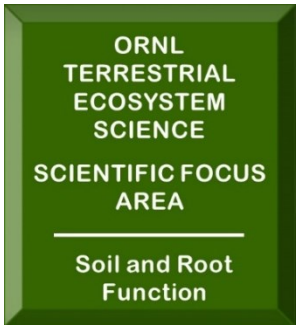
NIST: Soil Respiration, Moisture, Temperature, Chemistry; and Fine Root Measurements from a Transect Through a Forest Edge, Gaithersburg, Maryland, 2017-2021



Summary:

This dataset contains soil respiration, moisture, temperature, and chemistry, as well as fine root measurements from the National Institute of Standards and Technology (NIST) Forested Optical Reference for Evaluating Sensor Technology (FOREST) research facility at Gaithersburg, Maryland. Measurements were taken at an existing transect array that begins in a grassy meadow, crosses a sharp forest edge, then a small stream, and finally extends upwards in the interior of the forest at the top of a ridge. There are 6 different landscape positions replicated across three transects in the array. Soil respiration was measured during growing seasons in 2017-2019 (2017-06-02 to 2020-02-27). Pedons (1 m^3) were isolated from surrounding tree roots using trenching and a fabric to inhibit root ingrowth. Flux measurements inside the pedons were thus assumed to represent heterotrophic only respiration in 2019, and these fluxes were paired with nearby fluxes assumed to represent total respiration. Deep vertical probes measured volumetric moisture content and temperature at the same points in the array every 10 cm in depth to either 90 cm or 120 cm total depth, at 15 minute intervals, from 2019-2021 (2019-07-09 to 2021-09-10). Soil core samples were collected from each of the array points for three different months in early- to mid-2019 (2019-03-19 to 2019-07-10), at three depths each. Soils were analyzed for gravimetric moisture content; pH; total carbon, nitrogen, and phosphorus; texture; microbial biomass carbon, nitrogen, and phosphorus; extractable dissolved organic carbon, nitrogen, and phosphorus; extractable nitrate and ammonia; and extracellular hydrolytic enzyme activities. The fine roots were separated from the cores and segregated by plant functional type (grass or tree species) and if they were dead or alive. Fine roots were then measured for length, surface area, diameter, and dry mass.

This dataset contains four data files in comma separated (*.csv) format.

Relevant Publication:

Portions of the measurements and results of this study have been described in the following publication:

Abramoff, R.Z., Warren, J.M., Harris, J., Ottinger, S., Phillips, J.R., Garvey, S.M., Winbourne, J., Smith, I., Reinmann, A., Hutyra, L., Allen, D.W., Mayes, M.A. *Shifts in belowground processes along a temperate forest edge*. Manuscript in accepted in Landscape Ecology.

Data Citation:

Cite this data set as follows:
RZ Abramoff, JM. Warren, J Harris, S Ottinger, JR Phillips, JM Brenner, SM Garvey, J Winbourne, I Smith, A Reinmann, L Hutyra, DW Allen, and MA Mayes. 2024. **NIST: Soil Respiration, Moisture, Temperature, Chemistry; and Fine Root Measurements from a Transect Through a Forest Edge, Gaithersburg, Maryland, 2017-2021**. Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. https://doi.org/10.25581/ornlsfa.024/1837084.

Data and Documentation Access

Get Data

For public access to data from the US Department of Energy Terrestrial Ecosystem Science Scientific Focus Ares (TES-SFA) please visit: https://tes-sfa.ornl.gov/node/80

The NIST Experiment

The National Institute of Standards and Technology (NIST) FOREST research facility is located within the temperate broadleaf deciduous forest biome in Gaithersburg, Maryland (39.1267° N 77.2208° W, https://www.nist.gov/programs-projects/forest). The NIST experiment was established in 2016 and is focused on assessing the biology, biogeochemistry, hydrology and energy dynamics at a forest edge, and how they change with distance from edge into the forest interior. Five parallel transects were established beginning at the forest edge and extending to 100 m inside the interior forest. One hectare of the FOREST site was initially instrumented, and the edge and canopy have been optically imaged through remote sensing techniques. Total soil respiration measurements were conducted using static flux chambers from 2017-2019 (Smith et al. 2019). The site is further described in Marrs et al. (2021) and Winbourne et al. (2022).

In 2019, Oak Ridge National Laboratory (ORNL) joined the NIST team to help understand belowground ecosystem activities. ORNL used three of the preexisting transects, beginning at the forest edge and extending to 50 m inside the forest interior, where A = 25 m, B = 50 m, C = 75 m from the southern corner along the X direction in Figure 1. ORNL also extended these three transects in the Y direction, 25 m from the forest edge and into the meadow, resulting in three, 75 m long transects. The transects extend from an open meadow (maintained by deer

browsing) into the forest interior from the southeastern aspect. Along each transect, landscape type changes from meadow to edge to the interior forest creating a landscape gradient. Each landscape type was defined by a landscape site number and name with distances along the y axis (Figure 1) as follows: 1: Meadow (-25m), 2: Canopy (approx. canopy dripline -12.5 m), 3: Edge (in line with tree boles +0m), 4: Edge/creekbed (+12.5 m), 5: Slope (+25m), 6: Ridge (+50m).

Trenching was conducted around 11 of the preexisting flux chamber locations (Smith et al. 2019) to manually isolate heterotrophic from total respiration (Figure 1). Soil water content and temperature were monitored at 15-minute intervals using deep vertical probes with sensors located every 10 cm. Core sampling was also conducted to determine basic physical, chemical, and microbiological parameters.

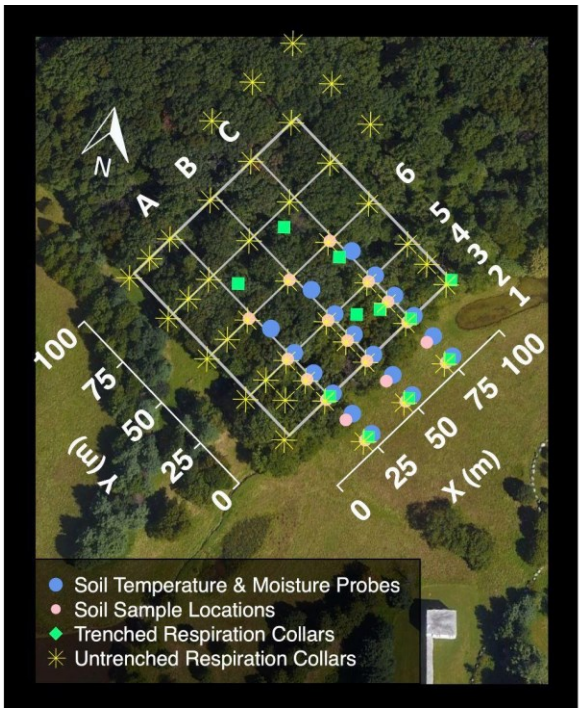


Figure 1 – NIST experimental forest design, instrumentation, and soil sampling

Sponsor

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

Table of Contents:

1. Data Set Overview:

This dataset contains environmental and soil measurements from the National Institute of Standards and Technology (NIST) Forested Optical Reference for Evaluating Sensor Technology (FOREST) research facility at Gaithersburg, Maryland. The data was anchored to a pre-existing transect array that begins in a grassy meadow, crosses a sharp forest edge, then a small stream, and finally extends upwards in the interior of the forest at the top of a ridge. There are 6 different landscape positions replicated across three transects in the array. Soil respiration was measured during growing seasons in 2017-2019. Pedons (1 m^3) were isolated from surrounding tree roots using trenching and a fabric to inhibit root ingrowth. Flux measurements inside the pedons were thus assumed to represent heterotrophic only respiration in 2019, and these fluxes were paired with nearby fluxes assumed to represent total respiration. Deep vertical probes measured volumetric moisture content and temperature at the same points in the array every 10 cm in depth to either 90 cm or 120 cm total depth, at 15 minute intervals, from 2019-2021. Soil core samples were collected from each of the array points for three different months in early- to mid-2019, at three depths each. Soils were analyzed for gravimetric moisture content; pH; total carbon, nitrogen, and phosphorus; texture; microbial biomass carbon, nitrogen, and phosphorus; extractable dissolved organic carbon, nitrogen, and phosphorus; extractable nitrate and ammonia; and extracellular hydrolytic enzyme activities. The fine roots were separated from the cores and segregated by plant functional type (grass or tree species) and if they were dead or alive. Fine roots were then measured for length, surface area, diameter, and dry mass.

2. Data Characteristics:

Spatial Coverage

The National Institute of Standards and Technology (NIST) FOREST research facility is located within the temperate broadleaf deciduous forest biome in Gaithersburg, Maryland (39.1267° N 77.2208° W). The site is further described in Smith et al. (2019) and Marrs et al. (2021).

Temporal Coverage

Soil respiration was measured from June of 2017 to February of 2020 (2017-06-02 to 2020-02-27), but mostly during the growing season. Soil volumetric water content and temperature were continuously measured beginning in March 2019 through September 2021 2020 (2019-07-09 to 2021-09-10). In 2019, soil cores were collected in March, May, and July (2019-03-19 to 2019-07-10) and analyzed.

Data File Description

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.

This dataset contains 4 files in comma separated (*.csv) format:

- NIST_Respiration_Datasheet.csv contains measurements of soil respiration.
- NIST_Root_Traits_Datasheet.csv contains root biomass and other root trait measurements.
- NIST_Soil_Datasheet.csv contains soil characteristics and microbial biomass and enzyme fraction measurements.
- NIST_Temp_Moisture_Datasheet.csv contains soil moisture and temperature measurements

Missing Values – Missing values are represented by blanks.
Errant Values – Errant values or obvious errors are represented by -9999. This value is only used in *NIST_Temp_Moisture_Datasheet.csv*
Zero Values – Zero values for root traits means no roots were found in the core.

Data Dictionary for *NIST_Respiration_Datasheet.csv*

Column Name	Units	Description
Collar_ID		Unique ID of each respiration collar.
DOY		Julian day of year that the observation was made on
Soil_T	degrees Celsius	Soil temperature (degrees C) as measured at 10 cm depth concurrent with the respiration observation
Chamber_T	degrees Celsius	Air temperature (degrees C) of the system chamber at the time of the respiration observation
VSM	percent	Volumetric soil moisture (%) integrated to a 10cm depth and measured at the time of the respiration observation
Slope		slope of the gas flux curve
R2		R^2 of gas flux curve
Flux_umol_m2_s	umol CO_2 m^{-2} s^{-1}	Rate of soil CO_2efflux (micro mol CO_2 per meter^2 per second)
Latitude	decimal degrees	Latitude
Longitude	decimal degrees	Longitude
X	m	X coordinate of collar relative to origin. See Figure 1.

Y	m	Y coordinate of collar relative to origin. See Figure 1.
Date_time	YYYY-MM-DD HH:MM:SS	Date and time (00:00:00 - 23:59:59) of the observation
Trench_ID		Binary column where 1 indicates the collar was trenched at the time of measurement and 0 indicates the collar was not trenched at the time of measurement
Pairs_ID		ID for paired collars; different collar IDs sharing the same Pairs ID are considered paired collars

Data Dictionary for *NIST_Root_Traits_Datasheet.csv*

Column Name	Units	Description
Sample_ID		Unique Identifier for each soil core section sampled (e.g. 2019-03-G-A17.5, sample collected in 2019, in March, plant functional type (PFT) is G=Grass, sample name = A17.5)
Sampling_Date	YYYY-MM-DD	The month, day, and year the sample was collected.
Sample_Name		The original field sample name (e.g. A17.5, transect A, landscape number 1, 0-7.5 cm depth zone).
X	m	Depicts where samples were obtained along the x-axis of the NIST sampling site (A=25, B=50, C=75). See Figure 1.
Y	m	Depicts where samples were obtained along the y-axis of each letter transect of the NIST sampling site (Meadow: -25, Canopy: -12.5, Edge: 0, Edge/creekbed: 12.5, Slope: 25, Ridge: 50). See Figure 1.
Transect_Letter		The three different 65 m long transects where sampling was conducted at NIST based on distance from corner of plot (X coodinates: A=25m, B=50m, C=75m).
Landscape_Number		Transect Number (1-6
Landscape_Name		Landscape positions (1-6) along each transect. 1: Meadow (+25m), 2: Canopy (approx. canopy dripline +12.5 m), 3: Edge (in line with tree boles+0m), 4: Edge/creekbed (-12.5 m), 5: Slope (-25m), 6: Ridge (~40m).
Soil_depth_Sampling_depth_interval	cm	Two soil cores were obtained (0-15 cm, 15-30 cm), with the first core sectioned into two (0-7.5, 7.5-15). Three core sections(0-7.5, 7.5-15, 15-30 cm) were obtained in total for each location.
Soil_depth_Upper_sampling_depth	cm	The beginning value of the depth interval. It is the top of the soil core.
Soil_depth_Lower_sampling_depth	cm	The end value of the depth interval. It is the bottom of the soil core.

Soil_depth_Soil_core_depth	cm	The total depth for the soil core section. It is the depth from the top to the bottom of the soil core (0-7.5 = 7.5 cm, 7.5-15 = 7.5 cm, and 15-30 = 15 cm).
Soil Core_Volume	cm^{-3}	The soil core volume for the soil core section as it was sampled (includes root and soil volumes). For depth zones 0-7.5 and 7.5-15 cm, V = 152.012 cm^3, 15-30 cm; V = 308.89 cm^3
PFT		Plant Functional Type, G: Grasses, T: Trees
Alive_root_length_from_base_to_tip	cm	Alive root length from base to tip. A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Dead_root_length_from_base_to_tip	cm	Dead root length from base to tip. A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Alive_specific_root_length	$cm\ g^{-1}$	Length of roots divided by the volume of the roots. A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Alive_root_length_density	$cm\ cm^{-1}$	Alive root length divided by the sampled soil volume (0-7.5, 7.5-15 = 152.012 cm^3, 15-30 cm = 308.89 cm^3). A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Dead_root_length_density	$cm\ cm^{-3}$	Dead root length divided by the sampled soil volume (0-7.5, 7.5-15 = 152.012 cm^3, 15-30 cm = 308.89 cm^3). A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Alive_root_tissue_density	$g\ cm^{-3}$	Weight of alive roots sampled divided by the volume of the alive roots. A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Dead_root_tissue_density	$g\ cm^{-3}$	Weight of dead roots sampled divided by the volume of the dead roots. A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Alive_root_diameter	mm	Diameter of alive roots observed. NA value demonstrates that no roots were observed for the sample at the specified PFT, depth, and vitality status.
Dead_root_diameter	mm	Diameter of dead roots observed. NA value demonstrates that no roots were observed for the sample at the specified PFT, depth, and vitality status.

Alive_root_surface_area_per_soil_volume	cm^2	Surface area of alive roots observed divided by soil volume (0-7.5, 7.5-15 = 152.012 cm^3, 15-30 cm = 308.89 cm^3). A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Dead_root_surface_area_per_soil_volume	cm^2	Surface area of dead roots observed divided by soil volume (0-7.5, 7.5-15 = 152.012 cm^3, 15-30 cm = 308.89 cm^3). A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Belowground_alive_biomass_per_soil_volume	g cm^{-3}	Grams of alive root mass/soil core volume (0-7.5, 7.5-15 = 152.012 cm^3, 15-30 cm = 308.89 cm^3). A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.
Belowground_necromass_per_soil_volume	g cm^{-3}	Grams of dead root mass per cubic meter of soil (0-7.5 and 7.5-15 cm depth zones = 152.012 cm^3, 15-30 cm depth = 308.89 cm^3). A value of 0 means that there were no roots found for the sample at the specified PFT, depth, and vitality status.

Data Dictionary for *NIST_Soil_Datasheet.csv*

Column Name	Units	Description
Sample_ID		Unique Identifier for each soil core section sampled (e.g. 2019-03-SC-A17.5, sample collected in 2019, in March, Soil Chemistry (SC), sample name = A17.5)
Sample_name		The original field sample name (e.g. A17.5, transect A, Landscape Position 1, 0-7.5 cm depth zone).
X	m	Depicts where samples were obtained along the x-axis of the NIST sampling site (A=25, B=50, C=75). See Figure 1.
Y	m	Depicts where samples were obtained along the y-axis of each letter transect of the NIST sampling site (Meadow: -25, Canopy: -12.5, Edge: 0, Edge/creekbed: 12.5, Slope: 25, Ridge: 50). See Figure 1.
Transect_letter		The three different 65 m long transects where sampling was conducted at NIST based on distance from corner of plot (X coordinate: A=25m, B=50m, C=75m).
Landscape_number		Transect Numbers (1-6)
Landscape_name		Landscape positions (1-6) along each transect. 1: Meadow (+25m), 2: Canopy (approx. canopy dripline +12.5 m), 3: Edge (in line with tree boles+0m), 4: Edge/creekbed (-12.5 m), 5: Slope (-25m), 6: Ridge (~40m).

Soil_depth_interval	cm	Two soil cores were obtained (0-15 cm, 15-30 cm), with the first core sectioned into two (0-7.5, 7.5-15). Three core sections(0-7.5, 7.5-15, 15-30 cm) were obtained in total for each location.
Soil_depth_upper	cm	The beginning value of the depth interval. It is the top of the soil core.
Soil_depth_lower	cm	The end value of the depth interval. It is the bottom of the soil core.
Soil_core_length	cm	The total depth for the soil core section. It is the depth from the top to the bottom of the soil core (0-7.5 = 7.5 cm, 7.5-15 = 7.5 cm, and 15-30 = 15 cm).
Soil_core_volume	cm^{-3}	The soil core volume for the soil core section as it was sampled (includes root and soil volumes). For depth zones 0-7.5 and 7.5-15 cm, V = 152.012 cm^3, 15-30 cm; V = 308.89 cm^3
Date	YYYY-MM-DD	The month, day, and year the sample was collected.
Field_replicate		Field replicate
Lab_replicate		Lab replicate
Soil_pH_water		Soil water pH
Soil_moisture_wet	percent	Gravimetric percent wet soil moisture content
Soil_moisture_dry	percent	Gravimetric percent dry soil moisture content
Soil_extractable_NH4	ug NH4 g^{-1} soil	Dissolved extractable ammonium
Soil_extractable_NO3	ug NO3 g^{-1} soil	Dissolved extractable nitrate
Soil_extractable_P	mg P g^{-1} soil	Dissolved extractable phosphorus
Microbial_P	mg P g^{-1} soil	Microbial biomass phosphorus
Soil_extractable_N	ug N g^{-1} soil	Dissolved extractable nitrogen
Microbial_N	ug N g^{-1} soil	Microbial biomass nitrogen
DOC	ug C g^{-1} soil	Dissolved extractable organic carbon
Microbial_C	ug C g^{-1} soil	Microbial biomass carbon
CB	nmol activity g^{-1} dry soil hr^{-1}	b-D-cellobiosidase
AG	nmol activity g^{-1} dry soil hr^{-1}	a-glucosidase
BG	nmol activity g^{-1} dry soil hr^{-1}	b-1,4-glucosidase EC 3.2.1.21
NAG	nmol activity g^{-1} dry soil hr^{-1}	b-N-acetylglucosaminidase EC 3.2.1.14
PHOS	nmol activity g^{-1} dry soil hr^{-1}	phosphomonoesterase
DIPHOS	nmol activity g^{-1} dry soil hr^{-1}	phosphodiesterase
XYL	nmol activity g^{-1} dry soil hr^{-1}	b-xylosidase
Soil_texture_sand	percent	Percent sand
Soil_texture_silt	percent	Percent silt
Soil_texture_clay	percent	Percent clay
Percent_N	percent	Percent nitrogen

Percent_C	percent	Percent carbon
Soil_CN_ratio		Carbon:Nitrogen ratio
Soil_P	mg P kg^{-1} soil	Total Phosphorus

Data Dictionary for *NIST_Temp_Moisture_Datasheet.csv*

Column Name	Units	Description
Date_time	YYYY-MM-DD HH:MM:SS	Date and time using the format M/D/YY HH:MM:SS
Var		character indicating whether the measurement is of soil temperature ("Temperature") or soil moisture ("Moisture")
Probe		probe label, either a number or letter
Depth	cm	depth of the measurement in cm, where for soil temperature the depth is a point measurement but for soil moisture the depth is a 10cm increment with the value at the mid-point (e.g., 0-10cm is reported here by the mid-point value of 5cm)
Value	cm^3 water cm^{-3} soil or degrees C	the value of either the soil temperature in degrees Celsius or volumetric soil moisture in cm^3 water / cm^3 soil (cm^3/cm^3 or %), depending on the value of the "Var" column
X	m	meters from X edge, where negative values indicate a meadow position. See Figure 1.
Y	m	meters from Y edge, where negative values indicate a meadow position. See Figure 1.

3 Applications and Derivation

These data serve to deepen our understanding of root and soil processes at forest edges and in transitional zones.

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.

5. Data Acquisition Materials and Methods:

Study Site

The National Institute of Standards and Technology (NIST) FOREST research facility is located within the temperate broadleaf deciduous forest biome in Gaithersburg, Maryland (39.1267° N 77.2208° W). The site is further described in Smith et al. (2019) and Marrs et al. (2021).

Methods

Soil Respiration

Thirty-three pairs of 15.5 cm diameter × 7 cm tall polyvinyl chloride soil collars were placed at six distances (0 m, 12.5 m, 25 m, 50 m, 75 m and 100 m; see Figure S1 in Smith et al. 2019) in the Y direction from the forest edge. Beginning in June 2017 and extending to February 2020 (but primarily in the growing season), soil respiration was measured biweekly using a backpack system with a CO_2 gas analyzer (LiCor LI-840A) following a vented design (Savage and Davidson 2001). Measurements were usually taken over two consecutive days between 8:00 and 16:00 local standard time. Additional details are available in Smith et al. (2019).

In winter 2019, 11 of the existing locations for measurement of soil respiration were chosen to measure heterotrophic respiration using trenching (Abramoff et al. 2024). Additionally, new total respiration collars and flux measurements were added in the meadow and at the edge of the forest canopy. Three of the trenched plots are in the meadow at -25 m, three at the forest edge (+0 m), two in the forest edge/creekbed (+12.5 m), and three in the interior (+50 m). Only two replicates were conducted at the forest edge/creekbed because encountering shallow bedrock and the creek reduced the possible space for the installations. Each of these locations was paired with a nearby total respiration location, in order to calculate autotrophic respiration by the difference between the two locations. In some cases where the trenched plot was near more than one representative untrenched soil respiration collar, the respiration fluxes from multiple untrenched collars were averaged before calculating autotrophic respiration by difference. Paired collars are indicated in the accompanying dataset by a Pairs ID column. To complete the trenching, NIST landscaping personnel used a bobcat with a trenching attachment to trench around a 1 m^2 area and approximately 0.5 m deep, resulting in a free-standing soil pedon connected only at the lower boundary. To protect the soil from compaction during trenching, large sheets of plywood were placed to distribute the weight of the bobcat. The pedon was then wrapped in a 1 μm nylon mesh fabric (Sefar Nitex 3A03-0001-115-00, Elko Filtering Co.) to inhibit growth of roots into the pedon and enable measurement of heterotrophic respiration. The fabric was tacked into the soil with landscape garden stakes and the trench was refilled with soil. The respiration collars were located in the center of each pedon.

In situ Soil Moisture and Temperature

Deep vertical frequency domain capacitance probes were installed to simultaneously measure in situ soil volumetric water content and temperature (Drill & Drop Probe, Sentek, Stepney, South Australia). The probes were installed at each of the same 6 landscape positions along each of the 3 transects (Figure 1). For the meadow location (+25 m), the C transect probe was broken during installation and the data was not recovered. For all ridge locations (landscape number 6), the deep vertical soil water and temperature sensors were installed at +40 m because the cables were not long enough to reach the desired location at +50 m. The probes measured water content (cm^3 cm^{-3}) and temperature (°C) every 10 cm depth to either 90 cm depth (+12.5, 0, -12.5 m landscape positions) or 120 cm depth (+25, -40 m landscape positions). Sensors are centered at 5, 15, 25, 35, 45, 55, 65, 75, 85, 95, 105, 115 cm depth and represent a point measurement of temperature and an integrated 10 cm vertical measurement of water content. Data was collected every 15 min and stored on a datalogger powered by solar panels.

Soil Chemistry

In 2019, soil cores were collected in March, May, and July from the site. Soil cores were returned (on blue ice) to ORNL and then kept at 4 degrees C until analysis. At each landscape position number, a 15 cm deep soil core was collected and then split in half creating two 7.5 cm deep soil cores (0-7.5, 7.5-15 cm). A second soil core was collected from 15-30 cm depth. Samples were deposited into plastic bags and labeled based on transect letter, landscape number, and depth (e.g. “A17.5” is transect A, landscape number 1, at the 0-7.5 cm depth).

Soil subsamples were subsequently analyzed for pH in water; gravimetric moisture content (GMC) wet and dry basis; total nitrogen (N), total carbon (C), C:N, and total phosphorus (P); texture (sand, silt clay); microbial biomass carbon, nitrogen, and phosphorus (MBC, MBN, MBP, respectively); extractable dissolved organic C, dissolved N, and dissolved P (DOC, DN, DP, respectively); extractable nitrate (NO_3) and ammonia (NH_4); and the following extracellular enzyme assays for CB (b-D-cellobiosidase), AG (a-glucosidase), BG (b-1,4-glucosidase EC 3.2.1.21), NAG (b-N-acetylglucosaminidase EC 3.2.1.14) , XYL (b-xylosidase), PHOS (phosphomonoesterase), and DIPHOS (phosphodiesterase). For extracellular enzyme activities, three replicates were used for the analysis. Two replicates were used for analysis of soil pH, GMC wet and dry, TN, and TC. Only one replicate was measured for some analyses that were soil- or labor-intensive, including MBC/N/P, DOC/DN/DP, soil texture, total P, NO_3 and NH_4. Soil texture, TC, and TN were analyzed for the month of March only.

Gravimetric moisture content (GMC) (dry %) was calculated by allowing 5 g of field moist soil to air dry for three days and using the equation:

$$GMC \text{ (dry \%)} = [(m_f - m_d)/m_d] \times 100$$

where m_f is the mass of fresh field moist soil and m_d is the mass of the air dried soil. GMC (wet %) was calculated using the equation:

GMC (%) = $[(m_f - m_d)/m_f]$ x 100

Particle size analysis for soil texture (% sand, silt, clay) was evaluated with the Bouyoucos hydrometer method (Gee and Or, 2002). Soil pH was determined by shaking 1 part soil in 2 parts deionized water and measuring the pH of the supernatant using a pH probe. Total bulk soil C and N of 2-mm sieved, air-dried, and ground soils were determined by a Leco Tru-Spec CN combustion analyzer (Leco Corp., St. Joseph, MI). Total bulk soil P of 2-mm sieved, air-dried, and ground soils were determined using a Flow Injection Analyzer based on the Lachat Method No 13-115-01-1-B at the University of Missouri Soil and Plant Diagnostic Laboratories.

Subsamples (n = 3) of 7 g fresh soil were used to extract DOC, DN, and DP for each soil sample. The soil was combined with 0.035L of 0.5 M K_2SO_4, and the samples were shaken on an orbital reciprocating shaker for 1 hour. Afterward, the soil suspensions were centrifuged then gravity filtered with Whatman No. 42 filter paper, and the extracts were immediately stored at -20° C until analysis. The extracts were analyzed using a total organic carbon analyzer (Shimadzu TOC-L CSH/CSN analyzer, Baltimore, MD, USA) to obtain values for DOC and DN. Samples were analyzed for DP using high-performance liquid chromatography (HPLC) (Dionex ICS-5000+ Thermo-Fisher Waltham, MA, USA) with the Dionex IonPac AS11-HC column using a potassium hydroxide eluent and gradient elution.

Subsamples (n = 3) of 7 g fresh soil were fumigated with chloroform for a total of 48 h at 25° C. The fumigated soil was then combined with 0.035 L of 0.5 M K_2SO_4, and treated identically to the DOC, DN, and DP extractions described above. Estimates for MBC, MBN, or MBP were then calculated using the equation:

$MB = K_x/E_x$

where MB refers to either MBC, MBN, or MBP; K_x is the difference between extractable elements before and after fumigation; and E_x is the extraction efficiency coefficient (Vance et al. 1987). Although extraction efficiency will vary by individual soil, standard values were used for E_x; specifically, 0.45 for C (Beck et al. 1997); 0.54 for N (Brookes et al. 1985); 0.40 for P (Bergkemper et al. 2016). Note that the calculation of K_x involves subtraction of P content of supernatants from two different soil samples - one fumigated and one unfumigated (DP). Because the samples are different, and because the P concentrations are generally quite low – occasionally a negative value of K_x may be obtained, that is translated into a negative value for MBP. There were 11 observations in our dataset, and we chose to leave the values as is, because neither value was incorrect and was merely an artifact of the subtraction.

Exchangeable NO_3 was extracted from soils under oxic conditions using 1 g soil and 0.005 L of 0.01 M $CaSO_4$ solution, shaking on an orbital reciprocating shaker for 1 h, centrifugation at 2000 rpm, and filtration using a 0.45 µm nylon filter (Keeney and Nelson 1982). The samples were stored under refrigeration until analysis by HPLC as described above. Exchangeable NH_4 was extracted from soils under oxic conditions using 1 g soil and 0.005 L of 1 M KCl solution, shaking on an orbital reciprocating shaker for 1 h, centrifugation at 2000 rpm, and filtering with Whatman No. 42 filter paper (Keeney and Nelson 1982). The samples were diluted and the pH was adjusted to 7 before analysis using Hach reagents and a spectrophotometer.

Soil hydrolytic enzyme activity assays were performed according to methods described in Steinweg et al. (2013). Briefly, blank wells on each 96-well black plate received 250 µL of acetate buffer, reference standard wells received 200 µL of acetate buffer and 50 µL of 10 µL 4-methylumbelliferone (MUB) standard, and negative-control wells received 200 µL of acetate buffer and 50 µL of 200 µM 4-MUB-linked substrates (e.g., 4-MUB-b-D-glucoside and 4-MUB-b-D-cellobioside). For each soil, quench-control wells received 200 µL of soil suspension and 50 µL of 10 µM 4-MUB standard, sample control wells received 200 µL

soil suspension and 50 µL of 50 µM acetate buffer. Activity assay wells received 200 µLof soil suspension and 50 µL of 200 µM 4-MUB-linked substrate. After a 2 h incubation, each black microplate received 10 µL of 0.5N NaOH in every well to raise the pH and enhance the fluorescence to a detectable level. Fluorescence was then detected at an excitation wavelength 365 nm, emission wavelength 450 nm, and sensitivity of 50 using a BioTec Synergy™MX Multi-Mode Microplate Reader.

Fine Roots

Fine roots < 2 mm were picked from the soil cores in the laboratory, then were floated in DI water and manually removed from soil using tweezers and then separated by plant functional type (grass or tree species), and whether they were dead or alive. Roots were then placed into scanning trays filled with water and displayed to minimize overlap, then scanned at 1400 DPI. Root length, root surface area and root diameter were then assessed using WinRhizo software before drying at 70 °C to constant weight. Once dried, samples were weighed to obtain dry root biomass values. The following calculations were completed for both alive and dead roots, and for each PFT. Root length density was calculated by dividing the root length by the soil volume. Specific root length was calculated by dividing the length of roots by the volume of roots. Root length density was calculated by dividing the length of the roots by the volume of the roots. Root tissue density was calculated by dividing the dry weight of the roots by the volume of the roots. Surface area per soil volume was also calculated. Both alive biomass and dead necromass were also calculated with respect to the soil volume.

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7. Data Access:

Get Data

For public access to data from the US Department of Energy Terrestrial Ecosystem Science Scientific Focus Ares (TES-SFA) please visit: **https://tes-sfa.ornl.gov/node/80**