October 27, 2021

Data for “Fast-decaying plant litter enhances soil carbon in temperate forests, but not through microbial physiological traits”

Summary

This data pacakges contains data and code used in the paper “Fast-decaying plant litter enhances soil carbon in temperate forests, but not through microbial physiological traits”.

This paper details results from two studies: 1) a laboratory leaf litter incubation experiment (lab experiment) and 2) a multi-site observational field study (field study). Both studies were designed to test the relationships among litter quality, microbial physiological traits, and mineral-assocaited soil carbon (C). In the lab experiment, we incubated 16 temperate tree litters of differing chemical quality with isotopically distinct soil, measuring microbial physiological traits and the flow of litter-derived C into the mineral-associated soil C pool. In the field study, we sampled soils (0-5 cm) across six eastern US temperate forests, measuring microbial physiological traits, soil abiotic properties, and leaf litter chemistry.

The analysis data are provided in two .csv files corresponding to either the lab experiment or field study. Both files contain data on litter chemistry, microbial physiological traits (growth and turnover rates, and carbon use efficiency [CUE]), and the mineral-associated soil C pool. The lab experiment dataset additionally contains litter-derived versus soil-derived soil C, respiration, and litter decomposition parameters. The field study dataset additionally contains site-level climatic information, ectomycorrhizal dominance of plots, and plot-level soil properties.

Also provided is the R code and output reproducing the results in the related publication.

Related Publication:

A description and analysis of these data, as well as supporting information are presented in the following publication:

Craig ME, Geyer KM, Beidler KV, Brzostek ER, Frey SD, Grandy AS, Liang C, Phillips RP. Fast-decaying plant litter enhances soil carbon in temperate forests, but not through microbial physiological traits.

Acknowledgments:

Data were compiled by Matthew E. Craig (Research Associate Scientist at Oak Ridge National Laboratory, Environmental Sciences Division and Climate Change Science Institute) with contributions from Eddie R. Brzostek, Kevin M. Geyer, Chao Liang, Richard P. Phillips,

October 27, 2021

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Table of Contents

1. Data Set Overview:

We conducted a lab experiment and a field study to test relationships among litter quality, microbial physiological traits (growth, turnover, and carbon use efficiency), and mineral-associated soil C. The field dataset contains plot-level data from nine plots within six study sites (n=54) resulting from field measurements and lab procedures (litter combustion and chemical fractionation analysis; soil texture and pH analysis; extraction and analysis of metals and amino sugars, nitrogen mineralization assays, microbial biomass, growth, CUE, and turnover analysis; mineral-associated and total soil C concentration analysis). The lab dataset contains carbon pools (mineral-associated and particulate) and respiration after 30 and 185 days of incubating litter-soil mixtures. Pools and fluxes are partitioned into litter-derived C and soil-derived C based on a carbon isotope mixing model (described in related publication). The lab dataset also contains microbial biomass, growth, CUE, and turnover; litter elemental and chemical fractionation contents (including $\delta^{13}C$); and litter mass loss and decomposition parameters from a double exponential fit to litter decomposition. Data in the lab data set represent means of 4 analytical replicates. Standard errors are given for these mean values. R code for deriving additional varables, statistical analysis, and figure reproduction is included along with this data set.

2. Data Characteristics:

Temporal Coverage:
The lab experiment incubation was conducted from 10 June 2018 until 12 December 2018. Samples for field study were collected during Summer 2017, with some additional data collection in Summer 2018.

Temporal Resolution:

For the lab experiment, respiration data were taken on a daily to weekly time scale to start, decreasing the frequency of measurements as the incubation went on. These data were used to calculate cumulative fluxes at day 30 and day 185. Litter chemistry data were collected once prior to the experiment. All other data were collected at two time points during the 185 day

incubation. For the field experiment, most data were collected at one time point during the growing season. Litter was collected at least twice.

Spatial Coverage:

The lab experiment was conducted in a laboratory at Indiana University in Bloomington, Indiana, USA:

The field sites were scattered across eastern USA temperate forests:

Site	Latitude	Longitude
Harvard Forest	42.53	-72.18
Lilly-Dickey Woods	39.23	-86.22
Smithsonian Conservation Biology Insitute	38.90	-78.15
Smithsonian Environmental Research Center	38.88	-76.57
Tyson Research Center	38.52	-90.55
Wabikon Lake Forest	45.55	-88.80

Within each of these forests, nine plots were selected within approximately 1km^2.

Data File Descriptions:

The compiled data are provided in two .csv files: (1) the lab experiment and (2) the field study. Also provided is the R code for reproducing the results in the related publication, and the output produced by running this code.

Data Dictionary:

Lab experiment: Cbud.csv

Column Number	Column Name	Data Type	Units	Description
1	SP	factor		Species of leaf litter. Acer rubrum (AR), Acer saccharum (AS), Asimina triloba (AT), Carya cordiformis (CC), Carya glabra (CG), Carya ovata (CO), Fraxiunus americana (FA), Fagus grandifolia (FG), Liriodendron tulipifera (LT), Nyssa sylvatica (NS), Quercus alba (QA), Quercus prinus (QP), Quercus rubrum (QR), Quercus

				velutina (QV), Sassafras albidum (SA), Tilia americana (TA)
2	Day	factor	-	Day of incubation on which carbon harvest occurred (30 or 185)
3	maomc	numeric	mg C	total mineral-associated soil C contained in the microcosm
4	pomc	numeric	mg C	total particulate soil C contained in the microcosm
5	ldmaomc	numeric	mg C	total litter-derived mineral-associated soil C contained in the microcosm
6	sdmaomc	numeric	mg C	total soil-derived (i.e. pre-existing) mineral-associated soil C contained in the microcosm
7	ldpomc	numeric	mg C	total litter-derived particulate soil C contained in the microcosm
8	sdpomc	numeric	mg C	total soil-derived (i.e. pre-existing) particulate soil C contained in the microcosm
9	litCadded	numeric	mg C	total litter carbon added to microcosm at start of experiment
10	CumFs	numeric	mg C	Cumulative soil-derived C respired since start of experiment
11	CumFl	numeric	mg C	Cumulative litter-derived C respired since start of experiment
12	LitCrem	numeric	mg C	Litter carbon remaining since start of experiment
13	ldmaomc.perc	numeric	%	Litter-derived mineral-associated soil C (as a percentage of total added litter C)
14	resid	numeric	mg C	Litter carbon not recovered in mineral-associated, particulate, or CO_2 pools
15	maom.resp	numeric	ratio	ratio of litter-derived mineral-associated C to cumulative litter-derived respiration C
16	mse	numeric	%	Matrix stabilization efficiency. Percentage of lost litter-derived carbon (i.e. fraction not recovered in particulate pool) that was recovered in the mineral-associated pool.
17	maomc.se	numeric	mg C	standard error (n = 4) for maomc
18	pomc.se	numeric	mg C	standard error (n = 4) for pomc
19	ldmaomc.se	numeric	mg C	standard error (n = 4) for ldmaomc
20	sdmaomc.se	numeric	mg C	standard error (n = 4) for sdmaomc

21	ldpomc.se	numeric	mg C	standard error (n = 4) for ldpomc
22	sdpomc.se	numeric	mg C	standard error (n = 4) for sdpomc
23	mic.harv.day	factor	-	day of harvest for microbial measures representing approximate mid-point of incubation period for carbon budget harvests.
24	Resp	numeric	µg C g soil^{-1} day^{-1}	respiration rate during microbial growth assay
25	MGR.a	numeric	µg C g soil^{-1} day^{-1}	Microbial Growth rate determined by ^{18}O method
26	CUE.a	numeric	proportion	Microbial Carbon use efficiency determined by ^{18}O method
27	MBC.a	numeric	µg C g soil^{-1}	Microbial biomass determined by chloroform fumigation and extraction
28	MTR.a	numeric	d^{-1}	Microbial biomass turnover rate determined by ^{18}O method
29	Resp.se	numeric	µg C g soil^{-1} day^{-1}	standard error (n = 4) for Resp
30	MGR.a.se	numeric	µg C g soil^{-1} day^{-1}	standard error (n = 4) for MGR.a
31	CUE.a.se	numeric	proportion	standard error (n = 4) for CUE.a
32	MTR.a.se	numeric	d^{-1}	standard error (n = 4) for MTR.a
33	d13C	numeric	per mil	leaf litter δ^{13}C vs Vienna Pee Dee Belemnite
34	pN	numeric	% of mass	leaf litter nitrogen concentration
35	pC	numeric	% of mass	leaf litter carbon concentration
36	CN	numeric	ratio	leaf litter carbon-to-nitrogen ratio
37	psoluble	numeric	% of mass	leaf litter soluble fraction concentration
38	phemicellulose	numeric	% of mass	leaf litter hemicellulose concentration
39	plignin	numeric	% of mass	leaf litter acid unhidrolyzable residue content (proxy for lignin content)
40	lci	numeric	ratio	leaf litter lignocellulose index
41	pash	numeric	% of mass	leaf litter ash concentration
42	ligN	numeric	ratio	leaf litter lignin-to-nitrogen ratio
43	s	numeric	proportion	leaf litter proportion fast decaying fraction. Decay parameter estimated from double exponential decay model (see methods
44	k1	numeric	d^{-1}	leaf litter decay rate for fast decaying fraction. Decay parameter

				estimated from double exponential decay model (see methods)
45	k2	numeric	d^{-1}	leaf litter decay rate for slow-decaying fraction. Decay parameter estimated from double exponential decay model (see methods)
46	d13C.se	numeric	‰	standard error (n = 4) for d13C
47	pN.se	numeric	% of mass	standard error (n = 4) for pN
48	pC.se	numeric	% of mass	standard error (n = 4) for pC
49	CN.se	numeric	ratio	standard error (n = 4) for CN
50	psoluble.se	numeric	% of mass	standard error (n = 4) for psoluble
51	phemicellulose.se	numeric	% of mass	standard error (n = 4) for phemicellulose
52	plignin.se	numeric	% of mass	standard error (n = 4) for plignin
53	pash.se	numeric	% of mass	standard error (n = 4) for pash
54	ligN.se	numeric	ratio	standard error (n = 4) for ligN
55	LCI.se	numeric	ratio	standard error (n = 4) for LCI
56	s.se	numeric	proportion	standard error (n = 4) for s
57	k1.se	numeric	d^{-1}	standard error (n = 4) for k1
58	k2.se	numeric	d^{-1}	standard error (n = 4) for k2
59	avCloss30	numeric	mg C	leaf litter carbon lost after 30 days of decomposition
60	avCloss30.se	numeric	mg C	standard error (n = 4) for avCloss30
61	avCloss185	numeric	mg C	leaf litter carbon lost after 185 days of decomposition
62	avCloss185.se	numeric	mg C	standard error (n = 4) for avCloss185

*Note: soil mass expressed as dry weight.

Field study: field_data.csv

Column Number	Column Name	Data Type	Units	Description
1	ID	character	-	Unique plot identifier
2	Site	factor	-	Site. Harvard Forest (HF), Lilly-Dickey Woods (LDW), Smithsonian Conservation Biology Institute (SCBI), Smithsonian Environmental Research Center (SRC), Tyson Research Center (TRC), Wabikon Lake Forest (WLF)
3	MAT	numeric	°C	Site-level mean annual temperature pulled from Anderson-Teixera et al. (2014)

4	MAP	numeric	mm year^{-1}	Site-level mean annual precipitation pulled from Anderson-Teixera et al. (2014)
5	Plot	character	-	Within-site plot ID
6	Myco	factor	-	Mycorrhizal category. Plots dominated by arbuscular mycorrhizal-associated trees (AM), ectomycorrhizal-associated trees (ECM), or a mixture (MIX)
7	ECM	numeric	% of total basal area	Basal area of trees that associate with ectomycorrhizal fungi (as percentage of total basal area)
8	LitCN	numeric	ratio	Plot level leaf-litter C:N ratio. To calculate, individual species values were determined for most dominant species and plot value was determined as average weighted by basal area dominance of species in plot. Litter chemistry determined in Fall 2017 on composited samples from at least two collections.
9	LitLCI	numeric	ratio	Plot level leaf-litter lignocellulose index (Acid unhdrolyzable fraction / (hemicellulose fraction + acid unhydrolyzable fraction). To calculate, individual species values were determined for most dominant species and plot value was determined as average weighted by basal area dominance of species in plot.
10	LitLigN	numeric	ratio	Plot level leaf-litter Lignin:N ratio (acid unhydrolyzable residue to N ratio). To calculate, individual species values were determined for most dominant species and plot value was determined as average weighted by basal area dominance of species in plot.
11	LitSol	numeric	% of mass	Plot level leaf-litter soluble fraction content. To calculate, individual species values were determined for most dominant species and plot value was determined as average weighted by basal area dominance of species in plot.
12	LitLig	numeric	% of mass	Plot level leaf-litter acid unhydrolyzable fraction content. To calculate, individual species values were determined for most dominant species and plot value was

				determined as average weighted by basal area dominance of species in plot.
13	Froot	numeric	mg cm^{-3}	Fine root biomass (i.e. roots < 2mm diameter). LDW, TRC, and WLF collected in summer 2017 (same time as other measurements), but HF, SCBI, and SRC collected in summer 2019.
14	Croot	numeric	mg cm^{-3}	Coarse root biomass (i.e. roots > 2mm diameter). LDW, TRC, and WLF collected in summer 2017 (same time as other measurements), but HF, SCBI, and SRC collected in summer 2019.
15	Sand	numeric	%	soil % sand; determined on 5-15 cm sample to avoid effects of org. matter in 0-5 cm
16	Silt	numeric	%	soil % silt; determined on 5-15 cm sample to avoid effects of org. matter in 0-5 cm
17	Clay	numeric	%	soil % clay; determined on 5-15 cm sample to avoid effects of org. matter in 0-5 cm
18	Feo	numeric	mg Fe g $soil^{-1}$	Oxalate-extractable Iron
19	Alo	numeric	mg Al g $soil^{-1}$	Oxalate-extractable Aluminum
20	Gwc	numeric	g water g dry wt $soil^{-1}$	Gravimetric water content
21	Whc	numeric	g water g dry wt $soil^{-1}$	Water holding capacity
22	Nmin	numeric	mgN-InorgN g $soil^{-1}$ d^{-1}	N mineralization from laboratory incubations at field capacity
23	Nit	numeric	mgN-NO_3 g $soil^{-1}$ d^{-1}	N mineralization from laboratory incubations at field capacity
24	SoilT	numeric	°C	Soil temperature measured Summer 2017; SERC and SCBI were estimated from nearby NEON site
25	pH	numeric		soil pH in 0.01M $CaCl_2$
26	Glu	numeric	mg kg $soil^{-1}$	Glucosamine concentration
27	Gal	numeric	mg kg $soil^{-1}$	Galactosamine concentration
28	Mur	numeric	mg kg $soil^{-1}$	Muramic acid concentration
29	DOC	numeric	µg C g $soil^{-1}$	Organic C extractable with 0.5M K_2SO_4
30	CFE	numeric	µg C g $soil^{-1}$	Chloroform-fumigation Extraction microbial biomass (difference in DOC between unfumigated and 24-hr chloroform fumigated sample)
31	Growth	numeric	µg C g $soil^{-1}$ d^{-1}	Microbial Growth rate determined by ^{18}O method

32	CUE	numeric	proportion	Microbial Carbon use efficiency determined by ^{18}O method
33	ResTime	numeric	days	Microbial biomass average residence time determined by ^{18}O method
34	Cup	numeric	µg C g soil^{-1} d^{-1}	Microbial carbon uptake rate determined by ^{18}O method
35	N	numeric	mg N g soil^{-1}	soil N concentration
36	C	numeric	mg C g soil^{-1}	soil C concentration
37	MAOMN	numeric	mg MAOM N g soil^{-1}	soil mineral-associated organic matter N concentration; <53µm fraction
38	MAOMC	numeric	mg MAOM C g soil^{-1}	soil mineral-associated organic matter C concentration; <53µm fraction

*Note: soil mass expressed as dry weight.

3. Applications and Derivation:

Data can be used to examine the relationship among litter quality, microbial processes, and soil carbon processes in the lab study, or field data could be used to explain patterns examine soil carbon or microbial physiological process patterns at fine (i.e. within a forest) or broad (i.e. eastern US temperate forest region) scales. Additional studies have been published using the same field sites which could augment this dataset. For example:

Mushinski, R. M., Payne, Z. C., Raff, J. D., Craig, M. E., Pusede, S. E., Rusch, D. B., White, J. R., & Phillips, R. P. (2021). Nitrogen cycling microbiomes are structured by plant mycorrhizal associations with consequences for nitrogen oxide fluxes in forests. *Global Change Biology*, *27*(5), 1068–1082. https://doi.org/10.1111/gcb.15439

Keller, A. B., Brzostek, E. R., Craig, M. E., Fisher, J. B., & Phillips, R. P. (2021). Root-derived inputs are major contributors to soil carbon in temperate forests, but vary by mycorrhizal type. *Ecology Letters*, *24*(4), 626–635. https://doi.org/10.1111/ele.13651

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. We note that the internal consistency applies within a data set (i.e. within the field or lab data). Select variables were measured using different procedures or different instruments between the two studies. These differences are detailed in the related publication.

5. Data Acquisition Materials and Methods:

Methods are thoroughly detailed in the related open access publication. For further inquiry or additional supporting data, direct correspondence to Matt Craig: craigme@ornl.gov.