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Wood Decomposition and its Role in the Forest Carbon Cycle:

The FACE Wood Decomposition Experiment

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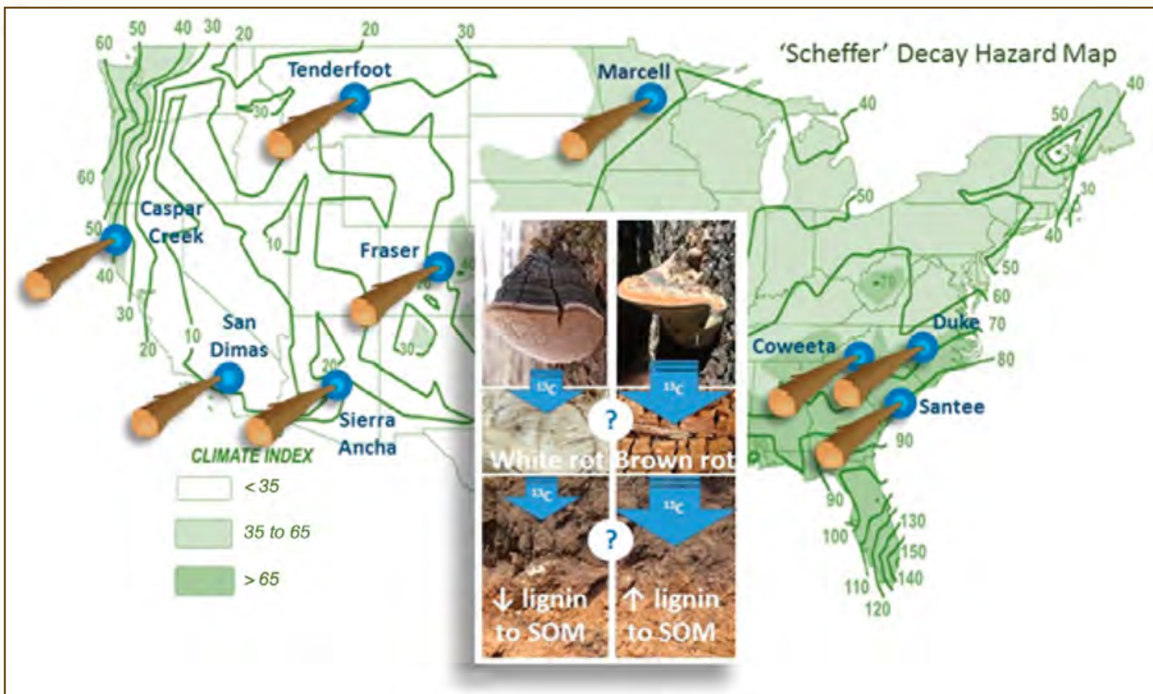

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Abstract

Dead wood is the largest detrital component within forests, comprising a significant portion of the total carbon (C) pool. Despite its ecological importance, there is insufficient information on the factors affecting wood decomposition, and there are no mechanistic models that effectively simulate wood decay and the incorporation of wood C into soil across North America. Therefore, the objective of this experiment is to establish a long-term experimental framework to serve as a foundation to study decomposition processes in wood and the associated interactions with the underlaying soil. The basic approach is to assess the interactions of site conditions with biological processes mediating wood decomposition by incubating common wood substrates, loblolly pine (*Pinus taeda* L.), aspen (*Populus tremuloides* Michx.), and birch (*Betula papyrifera* Marshall) logs in forest ecosystems with different soil and environmental conditions. The unique aspect of this study is the use of logs from Free Air Carbon Dioxide Enrichment (FACE) sites in North Carolina and Wisconsin, which have a distinct $\delta^{13}C$ signature that can be followed through the wood decomposition process, thereby providing the capacity to assess the translocation of wood C into soil organic matter pools. In 2011, FACE logs were placed horizontally on the soil surface and vertically without soil contact to simulate standing dead trees, the two dominate positions of dead wood in forest ecosystems. Those samples are to facilitate the study of wood decomposition and associated changes to the soil C pools. The experimental design facilitates the assessment of wood-soil food web, and it capitalizes on the strong foundation of research in the nationwide U.S. Department of Agriculture Forest Service (USDA-FS) Experimental Forest and Range Network.

Keywords: Coarse woody debris, Free Air Carbon Dioxide Enrichment, soil carbon, soil fungi, termites, wood decay.

CONTENTS

INTRODUCTION

The dead wood detrital pool is typically classified into standing-dead and downed-dead material, which comprise approximately 15 percent (4 to 30 mg/ha) of forest biomass across the United States (Woodall and others 2008). Consequently, forest managers, policy analysts, and climate change scientists need information on the factors affecting the decomposition process, the role of coarse wood in soil carbon (C) cycling, and the potential effects of climate change on wood decomposition. While the literature is replete with decomposition studies of leaf litter and fine roots (e.g., Harmon and others 2009), relatively few have considered decay processes in large dead wood boles. There is a critical need to quantify the effects of climate (i.e., moisture and temperature) regimes on coarse wood decomposition, determine the relative effects of decomposer communities (e.g., microbial, arthropods), and reconcile the role of wood decomposition in forest nutrient and C cycles. As climate change affects temperature and moisture gradients across the United States, the turnover rates of woody biomass will be altered by changes in the distribution and activity of decomposer organisms. Accordingly, our goal is to establish a comprehensive decomposition experiment across the conterminous United States using wood from the U.S. Department of Energy Free Air Carbon Dioxide Enrichment (FACE) experiment (Norby and Zak 2011) to address knowledge gaps, provide a framework for the development of models and assessment tools, and to make available a set of experimental forest sites for forest soil C cycling research.

The objectives of the FACE Wood Decomposition Experiment (FWDE) are to: (a) synthesize the state of knowledge of wood decomposition in U.S. forests, (b) implement a unified decomposition experiment across the United States to provide a common platform for study and linkage to regional-scale research, (c) develop modeling tools for use in estimating the dynamics of C cycling from dead wood, and (d) obtain information on the activities and functions of microbial and macro-invertebrate decomposer communities in different forest ecosystems. This information is needed to ensure effective resource management that addresses climate change and other forest disturbance regimes.

Background

The premise for the FWDE is that: (1) woody debris is the major detrital biomass pool in forests; (2) it is a major food source for arthropods (e.g., termites, ants, beetles) and micro-organisms, and thereby integral to the food web for larger organisms (e.g., amphibians, birds, mammals); (3) no large-scale wood decomposition study designed to provide needed information on the interactions of factors affecting wood decay processes and soil carbon pools has been established in the United States; and (4) models of organic matter (OM) decomposition generally assume the decay process is mediated by microbial activity, and do not consider the effects of macro-arthropods.

Due to its inherent complexities, addressing the full wood decay cycle is difficult and requires relatively long periods of study (Oberle and others 2019), which has resulted in a paucity of information on the functional roles of dead wood in C and nutrient cycles in U.S. forests. The classic textbook figure of OM decay typically depicts the "shredders and chewers" as one of the major decomposition agents; however, there is very little information about the specific functions or their influence on rates of decay. Of particular concern is the limited information on the role of arthropods, especially subterranean termites (i.e., Termopsidae, Kalotermitidae, Termitidae, and Rhinotermitidae) in the wood decomposition process (Ulyshen 2016). These organisms are also a sensitive barometer of the soil environment (e.g., soil moisture and temperature regimes) which suggests their activity will be affected by climate change.

In the FACE studies, wood developed under elevated atmospheric CO_2 conditions has a distinct $\delta^{13}C$ signature compared to wood developed under ambient atmospheric conditions. Accordingly, use of this wood in a decomposition experiment should facilitate tracking the C flux from the decayed wood into the atmosphere, soil, water, and food chain. Correspondingly, the $\delta^{13}C$ signature in litter from one of the FACE sites was used to discern the C sources for fungi (Hobbie and others 2014). Employing the material across a broad range of vegetation, soil, climate, and geomorphic conditions provides a basis for a comprehensive assessment of wood decomposition processes, thereby providing needed information for the development of modeling tools for better-informed assessments of the forest C cycle and the potential interactions with climate change and forest management. Use of the FACE wood grown under elevated CO_2 conditions will enhance the sensitivity of soil C analyses, thereby circumventing issues associated with multiple sources of OM that cannot be differentiated (Spears and others 2003).

The USDA-FS Experimental Forest and Range Network is used as a focal point for this wood decomposition experiment, providing sites that represent a broad range of biogeographic and climatic conditions. An inherent strength in using experimental forests is that they provide additional context from complimentary long-term forest ecosystem research, as well as a stable infrastructure for a long-term experiment.

METHODS AND MATERIALS

The basic approach to the study is to document the flux of C from dead wood and understand the processes that mediate decomposition across a broad biogeographic and climatic gradient. This approach has proven effective in assessing litter dynamics (Currie and others 2010) and associated ecosystem functions (Bassler and others 2010), and incorporation of process-based modeling will capitalize on the long-term, multi-site data. Initiating a study with a common substrate in natural form (e.g., log sections or bolts) will obviate problems associated with using coarse-wood surrogates (Currie and others 2010) and chronosequence studies that attempt to address decay processes over long periods of time (Schowalter and others 1992). Instead, it will provide a coherent basis for assessing decomposition processes, validating modeling approaches (Radtke and others 2009, Zell and others 2009), or developing others.

Study Sites

The FWDE uses nine experimental forests (EF) to encompass a wide range of vegetation, soil, climatic conditions, and geomorphic positions (table 1). Mean annual precipitation varies from 596 mm on the Fraser EF in Colorado to 2157 mm in the Coweeta Hydrologic Laboratory in western North Carolina. The mean annual temperatures range from 1.7 °C in the Tenderfoot Creek EF to 17.2 °C at the Santee EF site in South Carolina (table 1); while the biological warmth index varies from 6.1 on the Tenderfoot Creek EF site to 90.7 on the Santee EF. The Scheffer Decay Hazard Index (Carll 2009) ranges from <10 (San Dimas EF) to >80 (Santee EF), spanning the Hazard Index range that exists throughout the continental United States, except for Florida. Elevations range from 8 m at the Santee to 2710 m at the Fraser EF. Additional information about each of the study sites can be found in the appendix.

Experimental Design and Setup

This study uses a blocked design (e.g., sites) with random placement of measurement units (e.g., logs) within each site. There are four factors considered in the design: (1) site, (2) species, (3) log development environment, and (4) incubation position (table 2). The log development environment is the atmospheric growing condition within the FACE study (e.g., elevated CO_2 or ambient). Logs of each of the three species were placed on the soil surface (e.g., horizontal incubation position); additionally, pine logs were incubated by suspending them above the soil surface to emulate standing-dead wood (e.g., vertical incubation position). Since this is a long-term study, two sets of logs are included: (1) a sample set—available for periodic sampling, and (2) a reserve set—retained onsite without disturbance. There are six replicates of each species for a total of 24 logs per site per incubation position: 12 control and 12 elevated CO_2 logs, with one-half designated as reserve. Additional metrics available for use in the analyses include: (a) log dimensions, and (b) bole position within the tree, for pine only.

Table 1—General characteristics of experimental forests providing sites for the FACE Wood Decomposition Experiment

Experimental forest	State	Station	Ecoregion[a]		Forest type	Elevation (m)	Mean annual precipitation (mm)	Mean annual air temperature (°C)	Mean annual biological warmth index[a] (°C)	Scheffer index
			Domain	Division						
Caspar Creek	CA	CaDFFP/PSW	Humid Temperate	Mediterranean	Redwood	240	1215.3	10.16	16.41	45.00
Coweeta	NC	SRS	Humid Temperate	Hot Continental Regime Mountains	Oak/Hickory	910	2156.9	11.60	45.65	62.00
Duke	NC	Duke University	Humid Temperate	Subtropical	Loblolly pine	170	1042.9	15.22	76.30	63.00
Fraser	CO	RMRS	Dry	Temperate Steppe Regime Mountains	Lodgepole pine/ Subalpine fir/ Aspen	2710	596.2	2.75	8.52	36.00
Marcell	MN	NRS	Humid Temperate	Warm Continental	Red pine/Jack pine/Aspen	430	693.5	3.32	24.81	39.00
San Dimas	CA	PSW	Humid Temperate	Mediterranean Regime	Coast live oak	670	798.0	16.81	81.43	9.00
Santee	SC	SRS	Humid Temperate	Subtropical	Loblolly pine/Mixed hardwoods	8	1335.6	17.16	90.72	84.00
Sierra Ancha	AZ	RMRS	Dry	Tropical/Subtropical Steppe	Ponderosa pine	2220	810.0	10.15	33.91	15.00
Tenderfoot Creek	MT	RMRS	Dry	Temperate Steppe Regime Mountains	Lodgepole pine/ Subalpine fir/ Aspen	2130	836.4	1.67	6.08	30.00

FACE = Free Air Carbon Dioxide Enrichment; CADFFP/PSW = California Department of Forestry Fire Protection/Pacific Southwest Research Station; SRS = Southern Research Station; RMRS = Rocky Mountain Research Station; NRS = Northern Research Station; PSW = Pacific Southwest Research Station.

[a] Biological Warmth Index = $\sum(MT-10)$, for months $MT > 10$, where MT = monthly mean temperature (average daily temperature, averaged for the month).

Sources: Bailey (1980), Carll (2009).

Table 2—ANOVA factors and co-variates for the study design, representing two sets of logs (reserve and sample)

Factor	Classes	N	Description
Site	Site (see table 1)	9	Individual experimental forest sites
Species	Loblolly pine Aspen Birch	3	Species of wood
Log development environment	Ambient CO_2 Elevated CO_2	2	Loblolly pine grown under ambient and elevated CO_2
Incubation position	Horizontal Vertical (pine only)	1 (1)	Logs incubated on the soil surface Logs suspended above soil surface
	Replicates	6	Replicates per species and incubation position within a site
Log diameter	Loblolly pine Aspen Birch		Co-variate
Log position	Upper, mid, lower (pine only)		Co-variate

N = Number of classes.

Experimental Material and Deployment

Loblolly pine (*Pinus taeda*) logs were obtained from the Duke Forest FACE site in North Carolina (Schlesinger and others 2006), and both aspen (*Populus tremuloides*) and birch (*Betula papyrifera*) logs were obtained from the FACE site in Wisconsin (Kubiske and others 2015). Wood was produced on the FACE sites in (a) trees grown under ambient CO_2, and (b) trees grown under elevated CO_2 conditions (Norby and Zak 2011). The ambient-grown wood serves as the reference (control) to wood grown under elevated CO_2 conditions.

In 2010, the pine trees on the Duke FACE site were harvested. Following harvesting, the tree-length stems were stored in a pond until processed for this study in 2011. Pine logs were obtained by cutting six 2-m bolts from each tree, and categorizing them into upper-, mid-, and lower-stem positions (fig. 1), since wood decomposition is affected by the size of the bole and its position within the stem (Yatskov and others 2003). A total of 48 pine logs were placed on each EF site: 4 ambient trees and 4 elevated CO_2 trees with each tree sectioned into 6 bolts. A set of 24 logs were used for periodic sampling and the remaining 24 were used for non-invasive measurements.

The aspen and birch trees on the Aspen FACE site were harvested in the winter of 2009–2010. Following harvest, the lower 2 m of each stem was cut into 1-m bolts, air-dried, and stored. These logs are considered to be lower-stem position. The 48 loblolly pine logs (24 aspen, 24 birch) were deployed on each site between May and August of 2011 (table 3). Each log was randomly assigned a number, tagged, measured (the diameter at the midpoint and the length of each deployed log), and recorded. The stem position (for pine only: upper, mid, lower) and the treatment (ambient or elevated CO_2) were also recorded. The selection of tree orientation (pine only: horizontal or vertical) and sample type (sample or reserve) were then randomly assigned. The average diameter of the loblolly pine logs at the time of deployment was 17.3 cm. The average diameter of the aspen and birch logs were 7.0 cm and 6.7 cm, respectively.

The logs were distributed randomly across the site (approximately 0.2 ha) with a minimum of 4-m spacing between the sets (one pine, one aspen, and one birch log); without consideration of the treatment assignment (fig. 2). Horizontal logs within a three-log set were placed on the surface of the forest

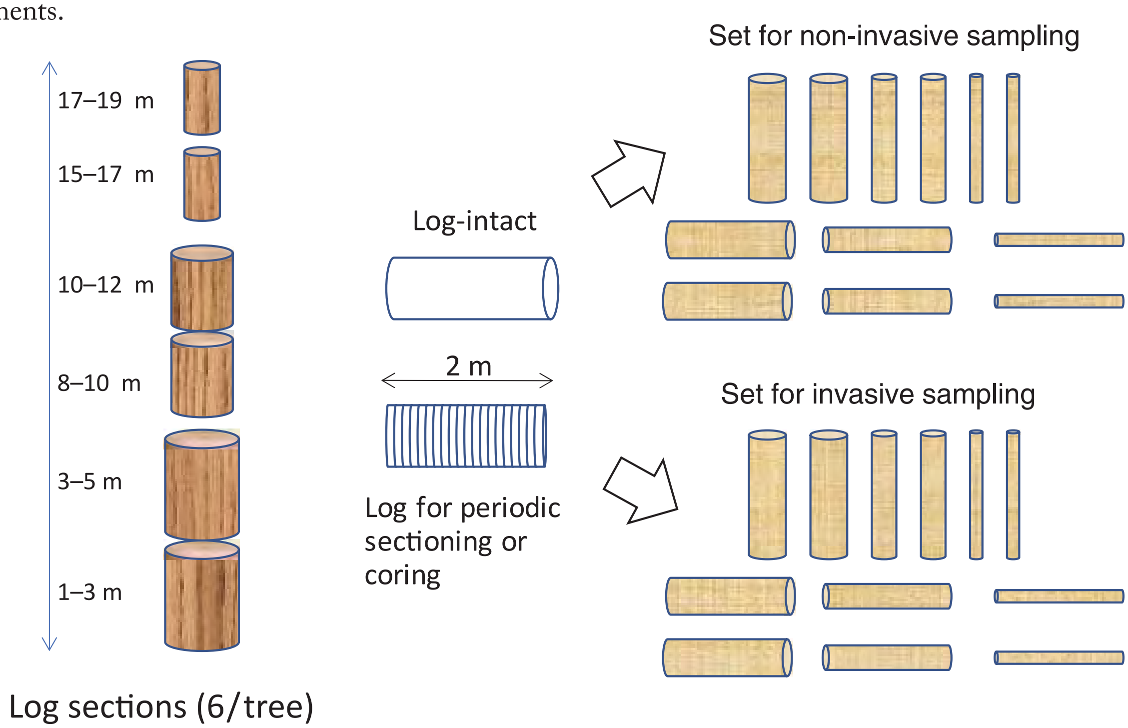

Figure 1—Loblolly pine log sections, orientation, and sampling type.

Table 3—Summary of logs deployed at each experimental forest

Forest	State	Log deployment date	Loblolly pine		Aspen		Birch		Local species	
			Number of logs	Average diameter (cm)	Number of logs	Average diameter (cm)	Number of logs	Average diameter (cm)	Number of logs	Average diameter (cm)
Caspar Creek	CA	July-2011	48	17.00	24	7.03	24	6.18	4	21.90
Coweeta	NC	May-2011	48	17.00	24	7.00	24	7.22	–	–
Duke	NC	May-2011	48	17.20	24	6.89	24	6.68	–	–
Fraser	CO	August-2011	48	16.60	24	6.89	24	6.07	21	15.40
Marcell	MN	June-2011	48	15.80	24	6.93	24	6.52	–	–
San Dimas	CA	June-2011	48	17.60	24	6.92	24	6.17	–	–
Santee	SC	May-2011	48	19.40	24	6.99	24	6.87	–	–
Sierra Ancha	AZ	August-2011	48	19.10	24	7.24	24	6.70	–	–
Tenderfoot Creek	MT	August-2011	48	16.20	24	7.09	24	7.26	–	–

– = no local species included at this site.

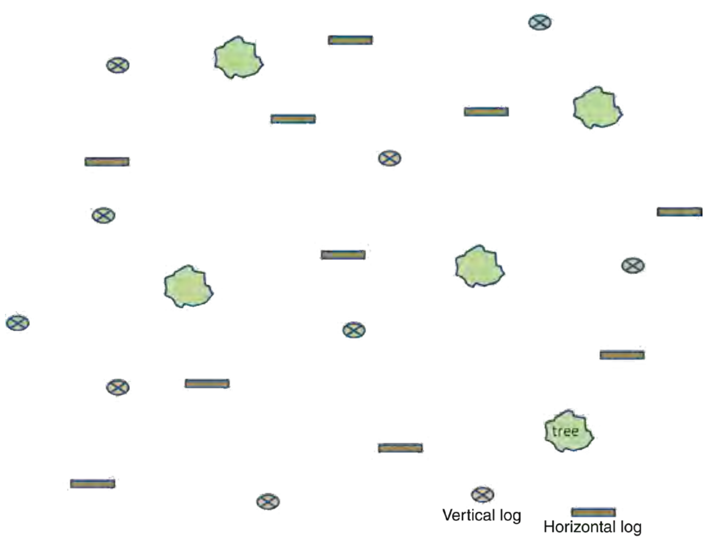

Figure 2—Conceptual distribution of horizontal log sets and vertical loblolly pine logs within the forest stand (left), and a set of pine, aspen and birch logs deployed on a site (right). Note that there are actually 24 log sets and 24 vertical loblolly pine logs at each site.

floor, 0.5 to 1 m apart. The vertical logs were placed upright within large PVC pipes supported by steel bars and cables (fig. 3). The vertical logs were capped with aluminum flashing to keep bird droppings and precipitation from pooling on the top of the logs (see inset of fig. 3). This treatment was to emulate the lower portion of a standing dead snag.

Two sites included logs from native trees as a companion to the deployment of the FACE logs in 2011: (1) Fraser Experimental Forest—14 lodgepole pine (*Pinus contorta*) and 7 subalpine fir (*Abies lasiocarpa*) logs placed horizontally within the study plot, and (2) Caspar Creek—4 redwood (*Sequoia sempervirens*) logs horizontally on the soil surface.

Log characteristics—Time zero (T0) voucher samples were collected on the logging deck at the Duke Forest prior to log shipment to the study sites. A 3- to 4-cm wide disk was cut from the end of each log and tagged with the corresponding log

Figure 3—Vertical log suspended above ground (left), vertical log supported by steel cables capped with aluminum flashing (right).

number (fig. 4). After the samples were oven-dried at 105 ˚C, a sub-sample was cut out of each disk for density analysis. The sub-samples were then ground for further analysis. The T0 voucher samples were stored in the permanent sample archive located at the Santee Experimental Forest (SEF). Similar samples of aspen and birch were collected at Michigan Technological University prior to log shipment, with sample drying performed at 65 ˚C. Archived samples of aspen and birch are stored at the Michigan Technological University, College of Forest Resources and Environmental Science.

Initial wood density—Initial wood density of the fresh pine logs was measured by emersion of a fresh sample from the T0 disk followed by

Figure 4—Voucher samples of the logs were collected from each log, tagged with the corresponding log number, and stored in the Santee Experimental Forest sample archive. Photo shows pine logs being processed at the Duke Forest.

oven-drying (105 °C). The sample included a section from the pith to the edge, representing the entire radial increment. The wood density as a function of log diameter is shown in figure 5; the median density of logs grown under elevated CO_2 conditions (0.539 g/cm^3) was greater than those grown under ambient conditions (0.519 g/cm^3) ($p < 0.001$). Overall, the average diameter of logs in the elevated treatment group (18.2 cm) was greater than those in the control group (16.2 cm) ($p < 0.01$), and that difference was consistent among the three log size classes (table 4). Similarly, the wood density was consistently greater ($p < 0.001$) in the elevated logs among the log classes (table 4).

At the Duke FACE site, the elevated CO_2 treatment was imposed within an established loblolly pine plantation 14 years after the trees were planted. Accordingly, wood properties were measured within sections of the log representing the two environments to test for differences at T0. Sub-samples from the T0 log disk were cut after the 14th growth ring to separate the ambient growth from the subsequent growth under elevated CO_2 conditions; the total radial increment of each growth section was also measured. Wood density was measured on both elevated and ambient CO_2 sub-samples within each elevated log T0 sample (fig. 6). Overall, there was a significant difference ($p < 0.001$) in the density, with

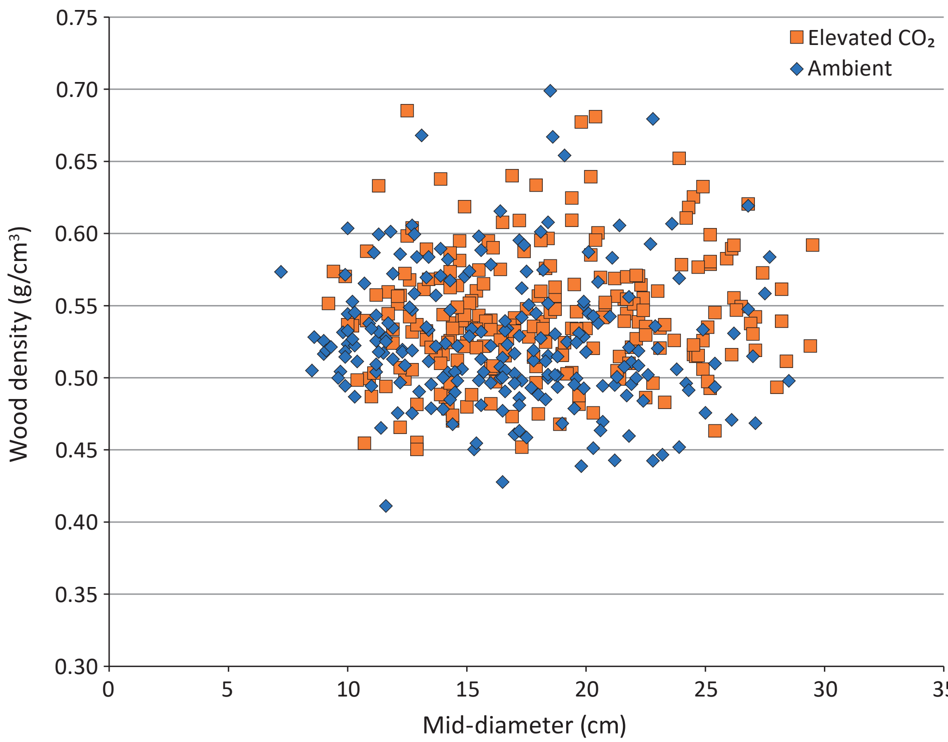

Figure 5—Wood density of pine logs grown under elevated CO_2 and ambient conditions as a function of mid-log diameter at T0.

Table 4—Average diameter and density of pine T0 log samples, comparing representative cross-section of pine logs grown under elevated CO_2 and ambient conditions

Bole position	Elevated CO_2		Ambient	
	Average diameter (with bark) (cm)	Average density (with bark) (g/cm^3)	Average diameter (with bark) (cm)	Average density (with bark) (g/cm^3)
Upper	15.32	0.53	13.82	0.51
Mid	17.96	0.54	15.96	0.52
Lower	21.22	0.55	18.96	0.54

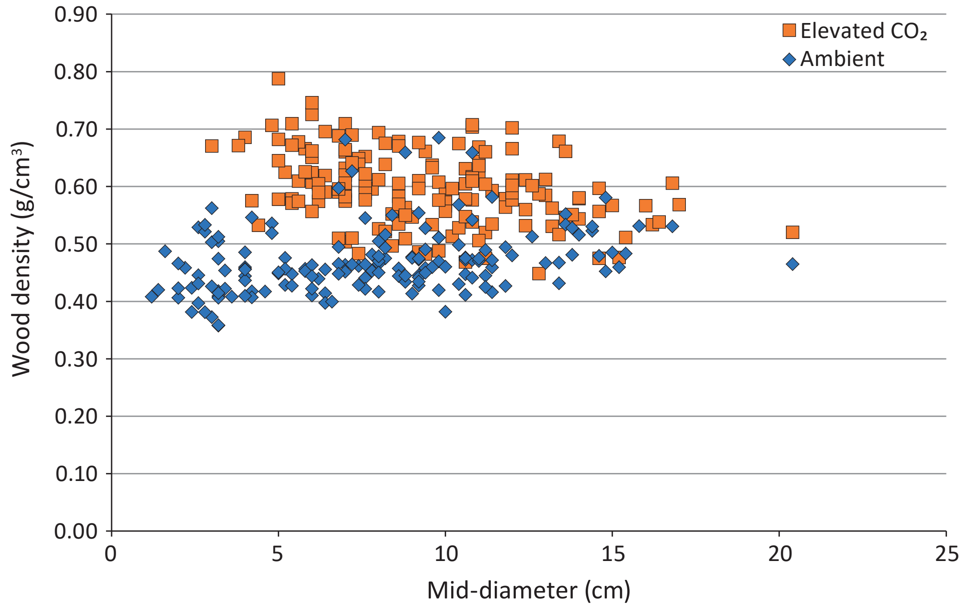

Figure 6—Wood density versus radial increment for pine grown in the elevated CO_2 treatment. The ambient growth represents tree age between 1–14 years, and subsequent growth under the elevated CO_2 treatment.

a mean of 0.59 and 0.46 g/cm^3 for wood grown under elevated CO_2 and ambient conditions, respectively. That difference was also reflected among logs from different portions of the bole (table 5).

δ^{13}C concentration in the hardwood and pine logs—A subset of samples collected for wood density (see section Initial Wood Density) were analyzed to characterize the δ^{13}C signature at T0, for logs grown under elevated CO_2 and ambient conditions for each of the species. These samples were analyzed at the Michigan Technological University, College of Forest Resources and Environmental Science using a Costech™ Elemental Combustion System 4010 connected to a Thermo Finnigan™ ConfloIII Interface and Deltaplus Continuous Flow-Stable Isotope Ratio Mass Spectrometer. Values are reported on the Vienna Pee Dee Belemnite (known as VPDB) scale for δ^{13}C. The largest difference in δ^{13}C (15.1 ‰) was among the elevated and control aspen logs (table 6), whereas the δ^{13}C difference between control and elevated logs for birch and pine was 12.9 and 12.0 ‰, respectively.

Carbon and nitrogen content of the forest floor and surface mineral soil—T0 forest floor and soil samples were collected at the time of log installation at each site. Forest floor was collected using a 27- by 27-cm square in 10 random locations within the study area. The 10 samples from each site were composited

Table 5—Average radial increment and wood density of pine logs from different bole positions of trees grown in the elevated CO_2 treatment of the FACE experiment[a]

Bole position	Elevated CO_2 growth		Ambient growth	
	Average radial increment (without bark) (cm)	Average density (without bark) (g/cm^3)	Average radial increment (without bark) (cm)	Average density (without bark) (g/cm^3)
Upper	5.6	0.56	2.1	0.44
Mid	4.8	0.59	3.4	0.46
Lower	4.2	0.62	5.0	0.49

FACE = Free Air Carbon Dioxide Enrichment.

Note: Radial increment: cumulative radial increment (cm) of the log section grown under ambient or elevated CO_2 conditions.

[a] Ambient growth represents tree age 1–14, before the imposition of the elevated CO_2 atmosphere.

Table 6—Average $\delta^{13}C$ concentration (‰) in T0 log samples grown under elevated CO_2 and ambient conditions

	Control logs			Elevated CO_2 logs		
Species	N	Average	SE	N	Average	SE
Aspen	54	-26.413	0.121	53	-41.493	0.261
Birch	53	-27.879	0.320	56	-40.800	0.306
Pine	40	-28.056	0.120	39	-40-059	0.347

N = number of analyzed samples; SE = standard error.

to create one homogeneous sample for each study site. A sample of the top 5 cm of surface soil was collected beneath each vertical and horizontal pine log. The 12 soil samples (0–5 cm) collected beneath the ambient logs were composited for each site. Similarly, the 12 soil samples collected beneath the 12 elevated CO_2 logs were composited for each site. The T0 forest floor and soil samples were dried at 60 °C and ground for C and N analysis at the Coweeta Hydrologic Laboratory using the Dumas method on a Flash EA® 1112 NC Analyzer. Forest floor samples were also analyzed for stable isotope ratios ($\delta^{13}C$) on a Finnigan™ MAT 252 Isotope Ratio Mass Spectrometer at the University of Georgia Center for Applied Isotope Studies.

Forest floor C concentration ranged from 35 percent C at the Caspar Creek and Sierra Ancha sites to 45 percent C at the Coweeta and Duke sites (table 7). Forest floor N concentration ranged from 0.67 percent N at the Duke site to 1.20 percent N at the Fraser site. Forest floor samples were not collected at the San Dimas study site because this site lacks a developed forest floor layer. The average C concentration in the surface mineral soil beneath the ambient and elevated CO_2 logs ranged from 1.87 percent at the Tenderfoot Creek site to 10.33 percent at the Coweeta site (table 7). Those two sites also exhibited the range in N concentration in the mineral soil, 0.08 and 0.54 percent, respectively. The forest floor $\delta^{13}C$ was highest on the Sierra Ancha study site (-27.02 ‰) and lowest on the Santee site (-29.98 ‰) (table 7).

These data are intended to provide general site characterization information for guiding subsequent work. We anticipate that the forest floor and mineral soil will be sampled independently over the course of the study to assess changes associated with the wood decomposition.

Table 7—Carbon, $\delta^{13}C$, and nitrogen concentration in the forest floor, and carbon and nitrogen in the mineral soil (0–5 cm) sampled beneath control and FACE logs on each of the FWDE sites at T0

	Forest floor			Mineral soil	
Site	C (%)	$\delta^{13}C$ (‰)	N (%)	C (%)	N (%)
Caspar Creek	35.40	-28.00	0.73	4.85	0.20
Coweeta	44.74	-29.22	1.08	10.33	0.54
Duke	44.74	-29.39	0.67	2.03	0.10
Fraser	37.60	-27.83	1.20	3.67	0.16
Marcell	40.11	-27.99	1.01	2.70	0.13
San Dimas	–	–	–	1.84	0.11
Santee	43.65	-29.98	0.99	4.63	0.19
Sierra Ancha	34.66	-27.02	0.82	3.92	0.17
Tenderfoot Creek	44.39	-27.23	1.10	1.87	0.08

– = no forest floor present.

FACE = Free Air Carbon Dioxide Enrichment; C = Carbon; N = Nitrogen.

MONITORING

Ambient Log Monitoring

Moisture content and temperature of three horizontal pine logs and three vertical pine logs were instrumented on each site (fig. 7). In addition, soil temperature was instrumented at 10 cm below the soil surface. The sensors are monitored by a Campbell Scientific CR1000®, recording measurements every 4 hours (table 8) (fig. 8). The data is physically downloaded periodically by local staff and transmitted to the SEF for processing (fig. 9). Local technicians and scientists observe and report any issues such as data logger power loss, sensors damaged by wildlife, or fallen vertical logs to the SEF.

Ambient Climate Monitoring

To monitor ambient climate conditions, air temperature and precipitation data are obtained from local weather stations close to each FWDE site (table 9).

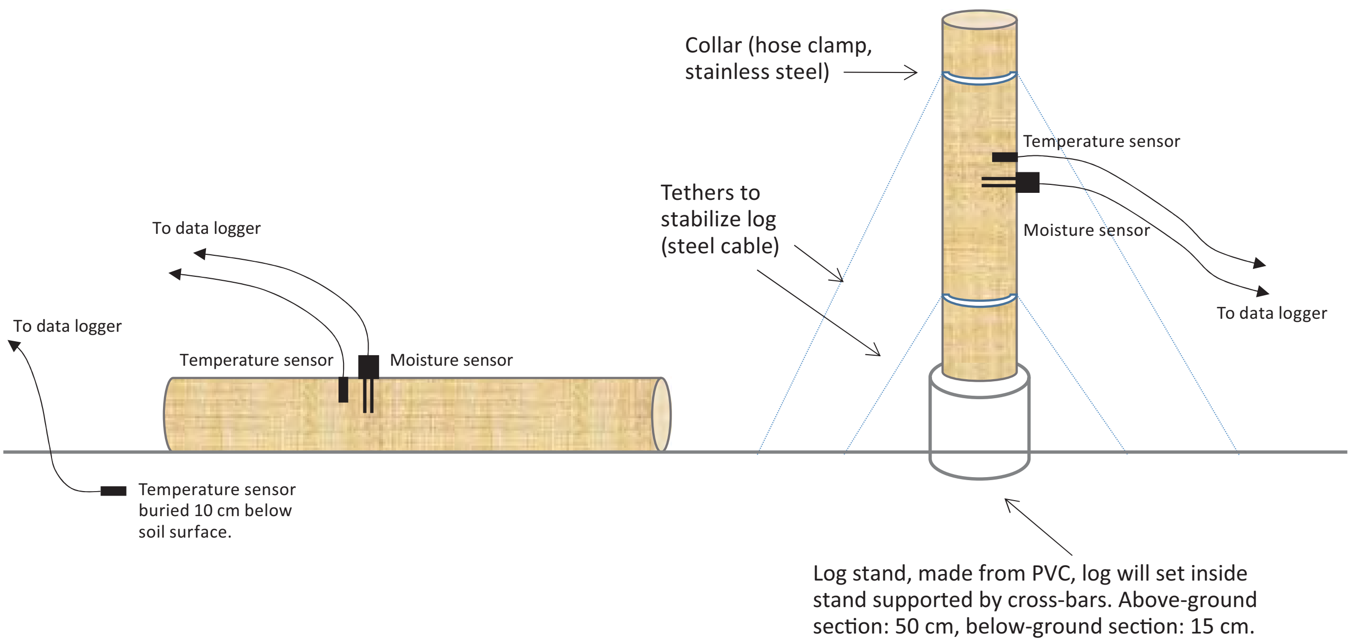

Figure 7—General setup and provisions monitoring conditions in the horizontal and vertical logs.

Table 8—Summary of monitoring measurements on each site

Metric	Method	Location	Frequency	Reference/Mfg.
Soil temperature	Thermistor	Soil interface below log, 10 cm depth	Continuous, with data logger	Campbell Scientific CR 1000®
Log temperature (vertical and horizontal)	Thermistor	Inserted in mid-bole	Continuous, with data logger	Campbell Scientific CR 1000®
Log moisture content (vertical and horizontal)	Time domain reflectometry	Inserted in mid-bole	Continuous, with data logger	Campbell Scientific CR 1000®

Figure 8—Temperature and moisture in loblolly pine logs (Tenderfoot Creek).

Figure 9—Datalogger monitoring powered by deep cell marine battery and solar panel (San Dimas).

Table 9—FWDE climate data collected from local weather stations

Site location	Weather stations	Media	Provider	Precipitation/ rainfall measurement
Caspar Creek	NFC408 & ArfTemp	Physical download	Local hydrologist/data mgr. (Jayme Seehafer)	Rain and snow
Coweeta	CS28 and RRG12	Physical download	Local technician (Patsy Clinton)	Rain and snow
Duke	Duke Forest North Carolina	Online (RAWS)	National Interagency Fire Center	Rain and snow
Fraser	Rail Road Met Station	Physical download	Local ecologist (Banning Starr)	Rain and snow
Marcell	Bog Lake	Physical download	Local technician (Tyler Roman)	Rain and snow
San Dimas	Tanbark California	Online (RAWS)	National Interagency Fire Center	Rain and snow
Santee	Witherbee South Carolina	Online (RAWS)	National Interagency Fire Center	Rain and snow
Sierra Ancha	Workman Creek Arizona	Online (SNOTEL)	Natural Resources Conservation Service	Rain and snow
Tenderfoot Creek	Onion Park Montana	Online (SNOTEL)	Natural Resources Conservation Service	Rain and snow

FWDE = FACE Wood Decomposition Experiment; RAWS Rain Gauge (Duke, San Dimas, Santee); SNOTEL = Snow Telemetry.

Note: Precipitation is the amount of water falling upon the earth as rain or in frozen form such as snow, sleet, and hail. It is expressed as the depth of water that would cover a flat surface. Rainfall output will be the cumulative total of rainfall for the rain year determined by the Agency or maintenance cycle. Year-round precipitation information is not necessary for NFDRS. However, if the weather station reports year-round and the user determines the need for collecting year-round precipitation information, a winterized gauge (heated gauges, weighing-gauge, etc.) may be necessary. (Please note that weather stations, which do not have winterized precipitation gauges, will often show a large rain event in early spring due to normal thawing cycles.)

SUMMARY

The FWDE is intended to provide the basis for large-scale assessments across multiple sites as well as fine-scale assessments of decomposition processes within a site. The common substrates across the sites provide a coherent basis for assessing the influence of soils, vegetation, and climate on decomposition processes. Moreover, the incorporation of local species or other standard substrates would provide a basis for further study among organic matter substrates.

These sites are open for use by other investigators, and the basic installation can be augmented to address the objectives from new studies. The archive facility at the SEF contains voucher specimens from the establishment of the experiment, and it will retain samples from subsequent samplings to assess wood decomposition and changes in soil properties.

ACKNOWLEDGMENTS

This experiment would not be possible without the logs provided from the Duke Forest (Duke University) and Rhinelander (Michigan Technological University) FACE sites that were produced as a result of the U.S. Department of Energy Free Air Carbon Dioxide Enrichment (FACE) project. The installation of this experiment could not have been possible without the creativity and diligence of Julie Arnold and Roman Powers (USDA Forest Service-Southern Research Station, Santee Experimental Forest), Joanne Tirocke (USDA Forest Service–Rocky Mountain Research Station), John Forsman, Wendy Jones-Joyal, and Jennifer Eikenberry (Michigan Technological University). Julie Arnold has done a masterful job maintaining the FWDE records. Installation of the FWDE could not have been possible without the effective collaboration of local scientists: Elizabeth Kepler and Joe Wagenbrenner (Caspar Creek), Pete Wohlgemuth and Mike Oxford (San Dimas), Dan Neary and Jackson Leonard (Sierra Ancha), Kelly Elder (Fraser), Helen Smith (Tenderfoot Creek), Randy Kolka (Marcel), and Chelcy Miniat (Coweeta). We appreciate Jonathan Schilling developing the cover concept figure. Funding for the installation of this experiment was provided by the USDA Forest Service-Southern Research Station and Michigan Technological University. Subsequent operational support of the FWDE has been provided by the U.S. Department of Energy (16SC503106 to USDA Forest Service) and the National Science Foundation (DEB 1754603 to Michigan Technological University; DEB 1754616 to University of Minnesota).

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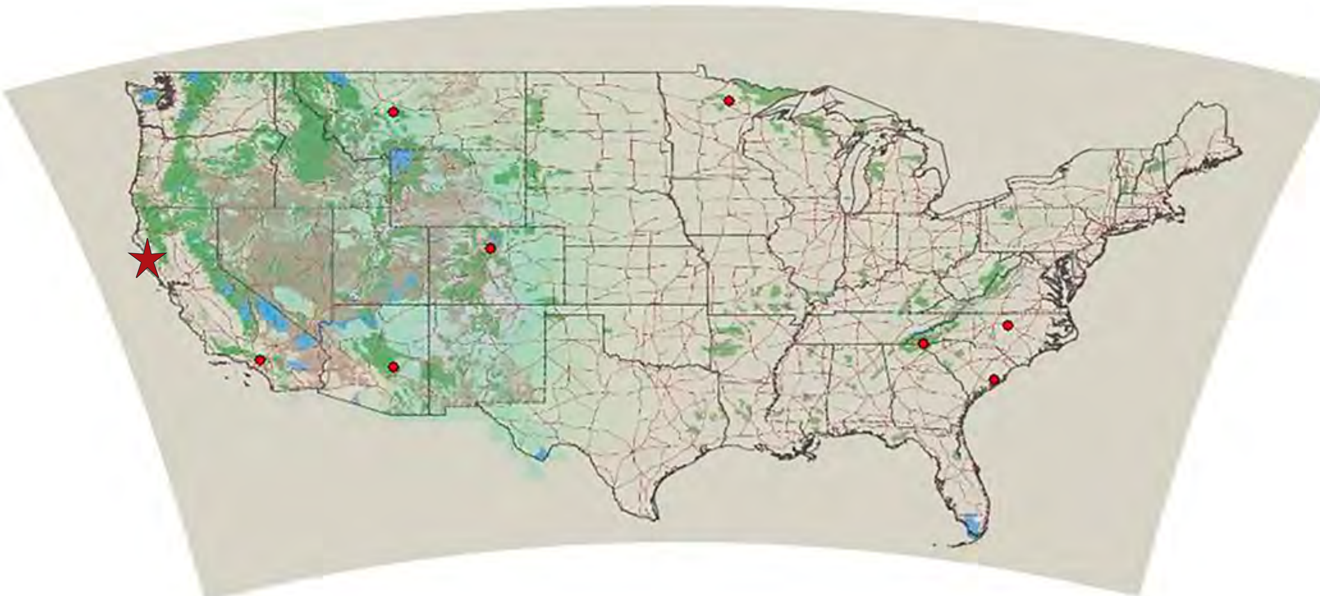
APPENDIX

Description of Study Sites

FACE Wood Decomposition Experiment (FWDE)

Caspar Creek Experimental Watershed



The Caspar Creek Experimental Watershed FWDE site is located at 39.37022 N, 123.70457 W in Fort Bragg, CA. The elevation at the site is 240 m.

Introduction

In 1962, the Caspar Creek Experimental Watershed was established. The experimental watershed is located within the Jackson Demonstration State Forest (see map) and includes two watersheds totaling 908 hectares of land (Adams and others 2004). Detailed information about the Caspar Creek Experimental Watershed can be found at http://www.fs.fed.us/psw/topics/water/caspar/.

Soils

The clay-loam soil in this watershed is derived from sandstone. It is well-drained Vandamme-loam and is found on 9–30 percent slopes. The permeability is slow, and available water capacity is moderate. Weathered sandstone exists at a depth of about 42 inches. Medium to rapid surface runoff leads to moderate water erosion if the surface is left bare (Rittiman and others 1999).

Vegetation

Coast redwood (*Sequoia sempervirens*), Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and grand fir (*Abies grandis*) make up the second-growth forest type of the experimental watershed (Adams and others 2004) (see photos). The ecological subregion of the FWDE is located in the Humid Temperate Domain, the Mediterranean Division, the California Coastal Steppe-Mixed Forest-Redwood Forest Province, and the Northern California Coast Section (McNab and others 2005).

Caspar Creek Experimental Watershed (continued)

Climate

Cool, dry summers have an average monthly air temperature of 15.6 °C. Mild, wet winters have an average monthly air temperature of 6.7 °C. The mean annual precipitation is 1190 mm, with a range from 305 to 2007 mm (Ziemer 1998). Snowfall is rare, so most of this precipitation occurs as rain from October through April (Adams and others 2004).

Photos of vegetation within the Caspar Creek FWDE site.

References

Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Experimental forests and ranges of the U.S. Department of Agriculture, Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 178 p. https://doi.org/10.2737/NE-GTR-321.

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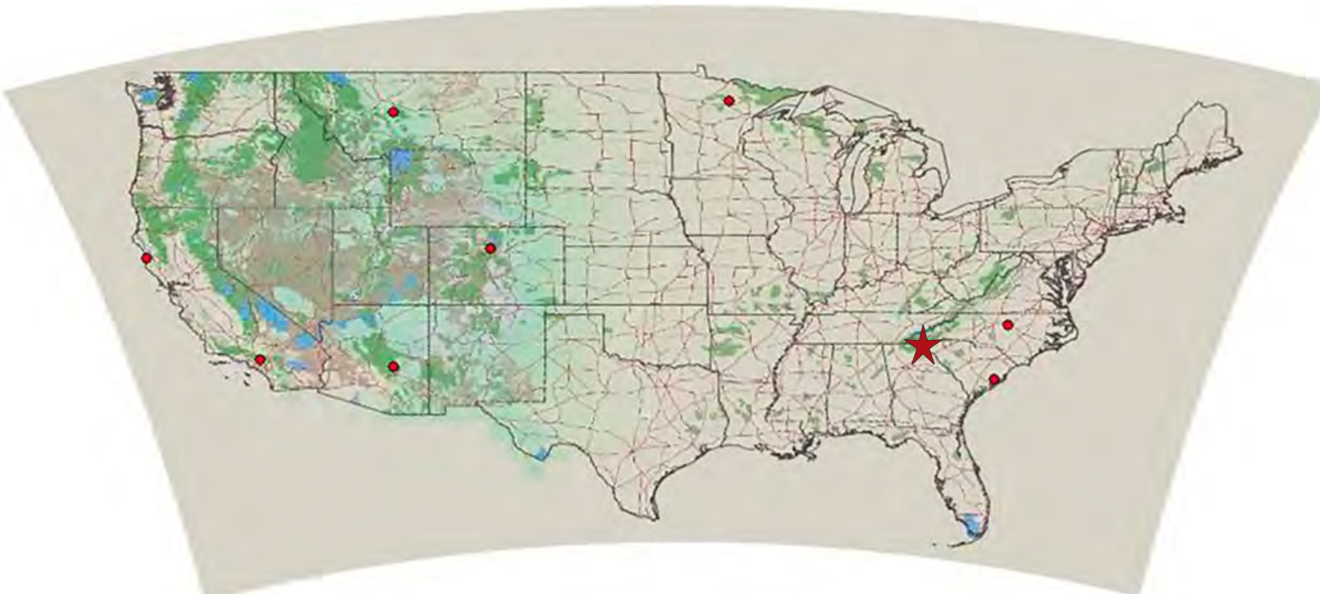
FACE Wood Decomposition Experiment (FWDE)

Coweeta Hydrologic Laboratory



The Coweeta Hydrologic Laboratory FWDE site is located at 35.055494 N, 83.477189 W in Otto, NC. The elevation at the site is 910 m.

Introduction

In 1934, the Coweeta Experimental Forest was established; it was renamed the Coweeta Hydrologic Laboratory in 1948 (Adams and others 2004). Coweeta is located within the Nantahala National Forest (see map) and consists of 2185 hectares of land (Coweeta 2011). Detailed information about the Coweeta Hydrologic Laboratory can be found at https://www.srs.fs.usda.gov/coweeta/.

Soils

The Evard-Coweeta complex of the Coweeta FWDE site consists of well-drained soils on 30–50 percent mountain slopes. The soil has a loamy surface layer and sub-soil with widely scattered stones on the surface. The parent material is affected by soil creep over weathered igneous and metamorphic rock. The depth to bedrock is 20 to 40 inches. Available water in the upper 60 inches is low and waterflow in the most restrictive layer is moderately high (NRCS 2010).

Vegetation

Northern hardwoods, cove hardwoods, xeric oak/pine, oak/hickory, and mixed oak make up the second-growth forest type of Coweeta (Adams and others 2004). The FWDE site consists of mostly yellow poplar (*Liriodendron tulipifera*) and sweetgum (*Liquidambar styraciflua*) (see photos). The ecological sub-region of the FWDE is located in the Humid Temperate Domain, the Hot Continental Regime Mountains Division, the Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province, and the Blue Ridge Mountains Section (McNab and others 2005).

Coweeta Hydrologic Laboratory (continued)

Climate

Coweeta has a maritime, humid, temperate climate. The weather is strongly influenced by the oceanic atmosphere. It receives high levels of rainfall throughout the year (1800–2360 mm) and the average annual temperature is 12.6 ˚C (Adams and others 2004).


Photos of vegetation within the Coweeta FWDE site.

References

Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Experimental forests and ranges of the U.S. Department of Agriculture Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 178 p. https://doi.org/10.2737/NE-GTR-321.

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McNab, W.H.; Cleland, D.T.; Freeouf, J.A. [and others], comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture Forest Service. 80 p.

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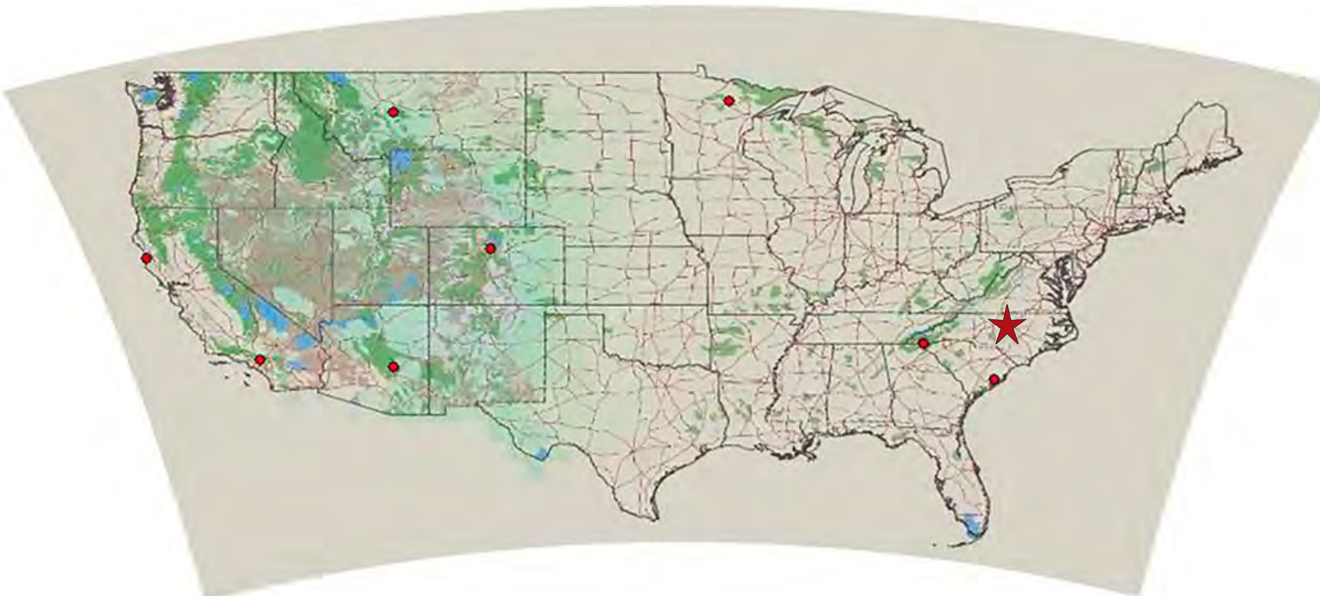
FACE Wood Decomposition Experiment (FWDE)

Duke Forest



The Duke Forest FWDE site is located at 35.973312 N, 79.097018 W in Chapel Hill, NC. The elevation at the site is 170 m.

Introduction

In the mid-1920s, Duke University purchased 1900 hectares of land as a buffer and expansion land for the new campus. This land, comprised of small farms and forest land, became the Duke Forest in 1931. Over the years, more land was purchased, and the forest now covers 2857 hectares of land (Duke Forest 2011). The FWDE site is located on a loblolly pine (*Pinus taeda*) stand that was planted in 1983 in the Blackwood Division of the Duke Forest (see map). Detailed information about the Duke Forest can be found at http://www.dukeforest.duke.edu/.

Soils

The Enon loam soil of the FWDE site consists of well-drained soils on 2–6 percent upland slopes. In some areas, a sandy loam surface layer can be found. The depth to bedrock is > 60 inches. The permeability is slow, and the available water capacity is medium. The high water table is between 12 and 24 inches below the surface (Dunn 1977).

Vegetation

The major forest types in the Duke Forest are pine, pine-hardwood, upland hardwood, and bottomland hardwood (Duke Forest 2011). The FWDE site is located in a loblolly pine plantation (see photos). The ecological sub-region of the FWDE is located in the Humid Temperate Domain, the Subtropical Division, the Southeastern Mixed Forest Province, and the Southern Appalachian Piedmont Section (McNab and others 2005).

Duke Forest (continued)

Climate

Moderate climate conditions exist at this site due to the central location of the forest between the mountains and the ocean. The maximum daily temperature in the colder months is 10 °C, whereas minimum daily temperature is 0 °C. During the warmer months, the maximum daily temperature is 31 °C and the minimum daily temperature is 20 °C. Precipitation is well distributed throughout the year and averages about 1118 mm annually (Duke Forest 2011).

Photos of vegetation within the Duke Forest FWDE site.

References

Duke Forest at Duke University. 2011. Duke University, Nicolas School of the Environment. http://www.dukeforest.duke.edu. [Date accessed: November 11, 2011].

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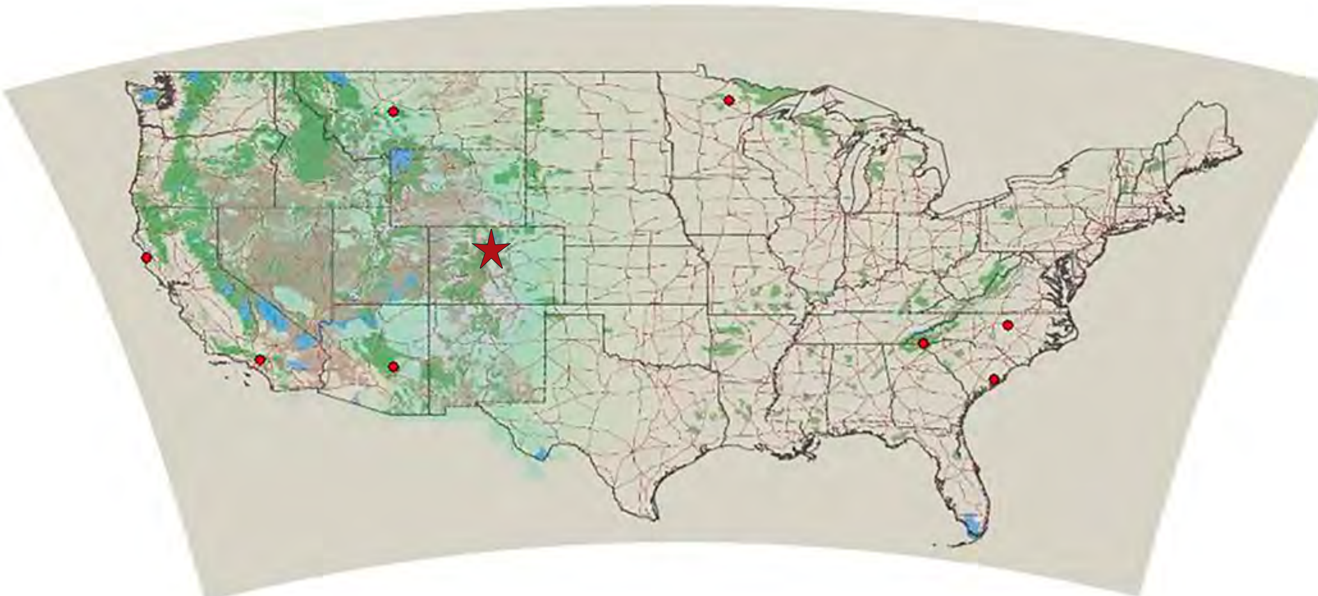
McNab, W.H.; Cleland, D.T.; Freeouf, J.A. [and others], comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture Forest Service. 92 p.

FACE Wood Decomposition Experiment (FWDE)

Fraser Experimental Forest



The Fraser Experimental Forest FWDE site is located at 39.92959 N, 105.86598 W in Fraser, CO. The elevation at the site is 2710 m.

Introduction

In 1937, the Fraser Experimental Forest was established. This experimental forest is located within the Arapaho National Forest (see map) and covers 9308 hectares of land (Adams and others 2004). Detailed information about the Fraser Experimental Forest can be found at https://www.fs.usda.gov/main/fraser/home.

Soils

The Cowdrey-Gateway loam soil of the FWDE site consists of well-drained soils on 2–15 percent slopes. It was formed from the glacial drift and residue of shale and mudstone. The depth to bedrock ranges between 20 and 60 inches. The permeability is slow, and the available water capacity is medium. The shrink-swell potential is high and can easily lead to erosion (Alstatt and Miles 1983).

Vegetation

The major tree species on the Fraser FWDE site are subalpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta*) (see photos). A few Engelmann spruce (*Picea engelmannii*) also exist on the site. The ecological sub-region of the FWDE is located in the Dry Domain, the Temperate Steppe Regime Mountains Division, the Southern Rocky Mountain Steppe-Open Woodland-coniferous Forest-Alpine-Meadow Province, and the Northern Parks and Ranges Section (McNab and others 2005).

Fraser Experimental Forest (continued)

Climate

The climate is strongly influenced by elevation. The elevation at the forest headquarters, which is located close to the FWDE site, is 2710 meters. At the forest headquarters, the average annual temperature is 0.5 °C and the average annual precipitation is 584 mm. Most of the precipitation falls in the form of snow between October and May (Adams and others 2004).

Photos of vegetation within the Fraser Experimental Forest FWDE site.

References

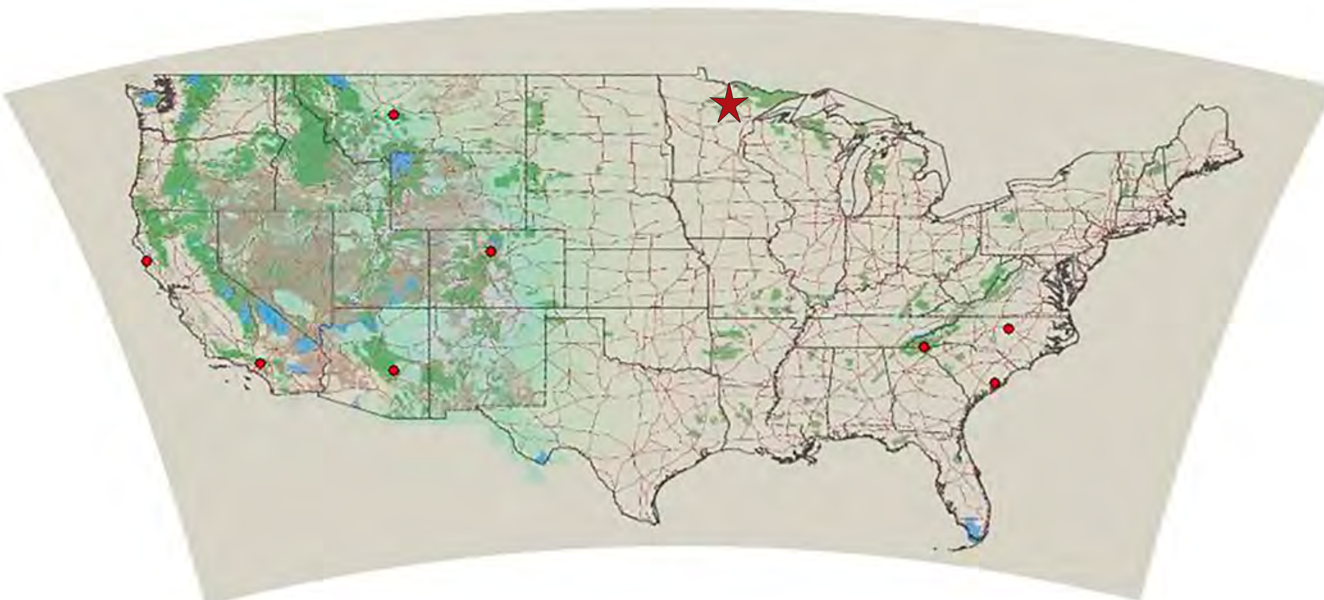
Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Experimental forests and ranges of the USDA Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 178 p. https://doi.org/10.2737/NE-GTR-321.

Alstatt, D.; Miles, R.L. 1983. Soil survey of Grand County Area, Colorado. U.S. Department of Agriculture Forest Service, Soil Conservation Service. 172 p.

McNab, W.H.; Cleland, D.T.; Freeouf, J.A. [and others], comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture Forest Service. 80 p.

FACE Wood Decomposition Experiment (FWDE)

Marcell Experimental Forest



The Marcell Experimental Forest FWDE site is located at 47.50563 N, 93.48623 W in Bovey, MN. The elevation at the site is 430 m.

Introduction

In 1962, the Marcell Experimental Forest was established. This experimental forest is located within the Chippewa National Forest (see map) and covers 898 hectares of land (Adams and others 2004). Detailed information about the Marcell Experimental Forest can be found at http://nrs.fs.fed.us/ef/marcell/.

Soils

The Cutaway loamy sand soil type typically occurs on 0–8 percent slopes. The permeability is rapid in the upper surface of the soil and slow in the subsoil. The available water capacity is moderate. The acidity of the surface soil is strong to medium, whereas the subsoil is strong to slight. The natural fertility of the organic matter is low (Nyberg 1987).

Vegetation

The Marcell FWDE site is located in a red pine (*Pinus resinosa*) plantation that was planted in 1935 (see photos). The ecological sub-region of the FWDE is located in the Humid Temperate Domain, the Warm Continental Division, the Laurentian Mixed Forest Province, and the Northern Minnesota Drift and Lake Plains Section (McNab and others 2005).

Marcell Experimental Forest (continued)

Climate

The climate of the Marcell Experimental Forest is warm and moist in the summer and cold and dry in the winter. The average annual temperature is 3.3 °C. The average annual precipitation is 780 mm, falling mostly in the form of rain (Adams and others 2004).

Photos of vegetation within the Marcell Experimental Forest FWDE site.

References

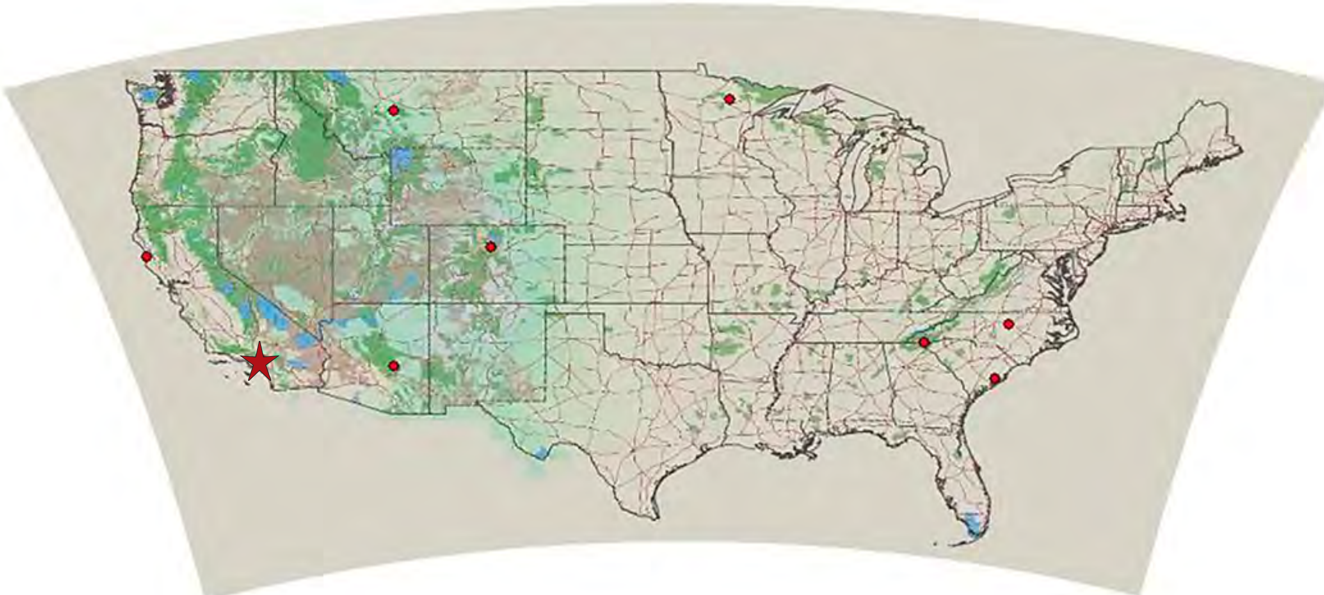
Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Experimental forests and ranges of the U.S. Department of Agriculture Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 178 p. https://doi.org/10.2737/NE-GTR-321.

McNab, W.H.; Cleland, D.T.; Freeouf, J.A. [and others], comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture Forest Service. 80 p.

Nyberg, P.R. 1987. Soil Survey of Itasca County, Minnesota. U.S. Department of Agriculture Forest Service, Soil Conservation Service. 197 p.

FACE Wood Decomposition Experiment (FWDE)

San Dimas Experimental Forest



The San Dimas Experimental Forest FWDE site is located at 34.183435 N, 117.795462 W in Glendora, CA. The elevation at the site is 670 m.

Introduction

In 1933, the San Dimas Experimental Forest was established. This experimental forest is located within the Angeles National Forest (see map) and covers 6945 hectares of land (Adams and others 2004). Detailed information about the San Dimas Experimental Forest can be found at http://www.fs.fed.us/psw/ef/san_dimas/.

Soils

The soil of the FWDE site is the Trigo, granitic substratum—Exchequer families—Rock outcrop complex, which occurs on 60–100 percent slopes. The runoff is medium to rapid. The Trigo loamy soil type is well drained and is formed from mixed sources on dissected terraces. The permeability is moderately rapid. The Exchequer loamy soil type is shallow and excessively drained. It is formed from hard andesitic breccias, schist, and metamorphosed volcanic rock. The permeability is moderate (NRCS 2010).

Vegetation

The vegetation within the San Dimas FWDE site is mostly mixed chaparral and brushfields (see photos). The dominant species include chamise (*Adenostoma fasciculatum*), California lilac (*Ceanothus* spp.), California scrub oak (*Quercus dumosa*), sumac (*Rhus* spp.), and manzanita (*Arctostaphylos* spp.). Soft chaparral species include yerba Santa (*Eriodictyon* spp.), California buckwheat (*Eriogonum fasciculatum*), lotus (*Lotus* spp.), and lupine (*Lupinus* spp.) (Berg 1990). The ecological sub-region of the FWDE is located in the Humid Temperate Domain, the Mediterranean Regime Division, the California Coastal Range Open Woodland-Shrub-Coniferous Forest-Meadow Province, and the Southern California Mountains and Valleys Section (McNab and others 2005).

San Dimas Experimental Forest (continued)

Climate

The FWDE site is located in the Tanbark Flat community of San Dimas Experimental Forest. The climate is hot and dry in the summer and cool and wet in the winter (Adams and others 2004). The average annual temperature is 14.4 °C. The average annual precipitation is 678 mm, falling mostly in the form of rain (Dunn and others 1988).

Photos of vegetation within the San Dimas Experimental Forest FWDE site.

References

Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Experimental forests and ranges of the U.S. Department of Agriculture Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 178 p. https://doi.org/10.2737/NE-GTR-321.

Berg, N.H., tech. coord. 1990. Experimental forests and ranges. Field research facilities of the Pacific Southwest Research Station. Gen. Tech. Rep. PSW-GTR 119. Berkeley, CA: U.S. Department of Agriculture Forest Service, Pacific Southwest Research Station. 67 p. https://doi.org/10.2737/PSW-GTR-119.

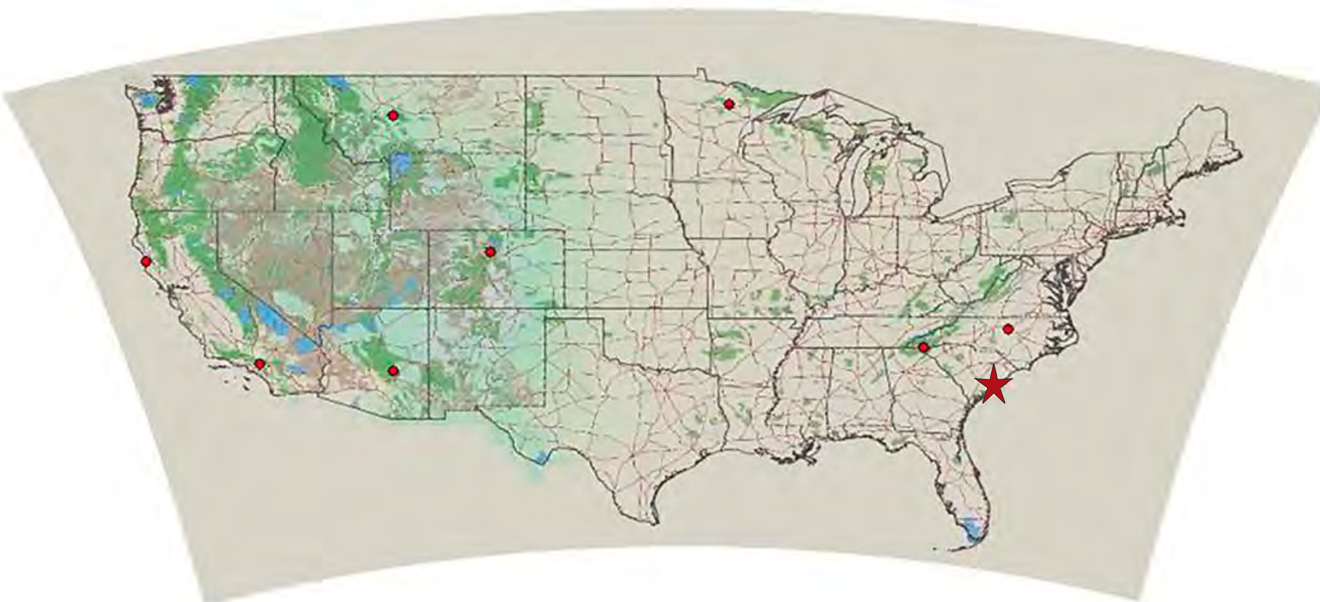
Dunn, P.H.; Barro, S.C.; Wells, W.G. [and others]. 1988. The San Dimas Experimental Forest: 50 years of research. Gen. Tech. Rep. PSW-104. Berkeley, CA: U.S. Department of Agriculture Forest Service, Pacific Southwest Forest and Range Experiment Station. 49 p.

McNab, W.H.; Cleland, D.T.; Freeouf, J.A. [and others], comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture Forest Service. 80 p.

Natural Resources Conservation Service. (NRCS) 2010. Official Soil Series Descriptions (OSD) with series extent mapping capabilities. U.S. Department of Agriculture, Natural Resources Conservation Service. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/data/?cid=nrcs142p2_053587. [Date accessed: November 8, 2011].

FACE Wood Decomposition Experiment (FWDE)

Santee Experimental Forest



The Santee Experimental Forest FWDE site is located at 33.1484 N, 79.7912 W in Cordesville, SC. The elevation at the site is 8 m.

Introduction

In 1937, the Santee Experimental Forest was established. This experimental forest is located within the Francis Marion National Forest (see map) and covers 2469 hectares of land (Adams and others 2004). Detailed information about the Santee Experimental Forest can be found at https://www.srs.fs.usda.gov/charleston/santee/.

Soils

The Wahee loam soil of the FWDE site occurs along streams and rivers on 0–4 percent slopes and is somewhat poorly drained. It is created from marine sediments and fluvial deposits and is strongly acid. The permeability and surface runoff are slow. The depth to bedrock is > 60 inches (NRCS 2010).

Vegetation

The pine-hardwood forest type of the FWDE site is dominated by loblolly pine (*Pinus taeda*). The hardwoods present include blackgum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), southern red oak (*Quercus falcata*), and water oak (*Quercus nigra*) (see photos). The ecological sub-region of the FWDE is located in the Humid Temperate Domain, the Subtropical Division, the Outer Coastal Plain Mixed Forest Province, and the Atlantic Coastal Flatlands Section (McNab and others 2005).

Santee Experimental Forest (continued)

Climate

The warm-temperate climate of the Santee Experimental Forest yields tropical storms and hurricanes during the late summer and early fall seasons. Snowfall and ice are rare. The average annual temperature is 18 °C and the average annual precipitation is 1350 mm (Adams and others 2004).


Photos of vegetation within the Santee Experimental Forest FWDE site.

References

Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Experimental forests and ranges of the U.S. Department of Agriculture Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 178 p. https://doi.org/10.2737/NE-GTR-321.

McNab, W.H.; Cleland, D.T.; Freeouf, J.A. [and others], comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture Forest Service. 80 p.

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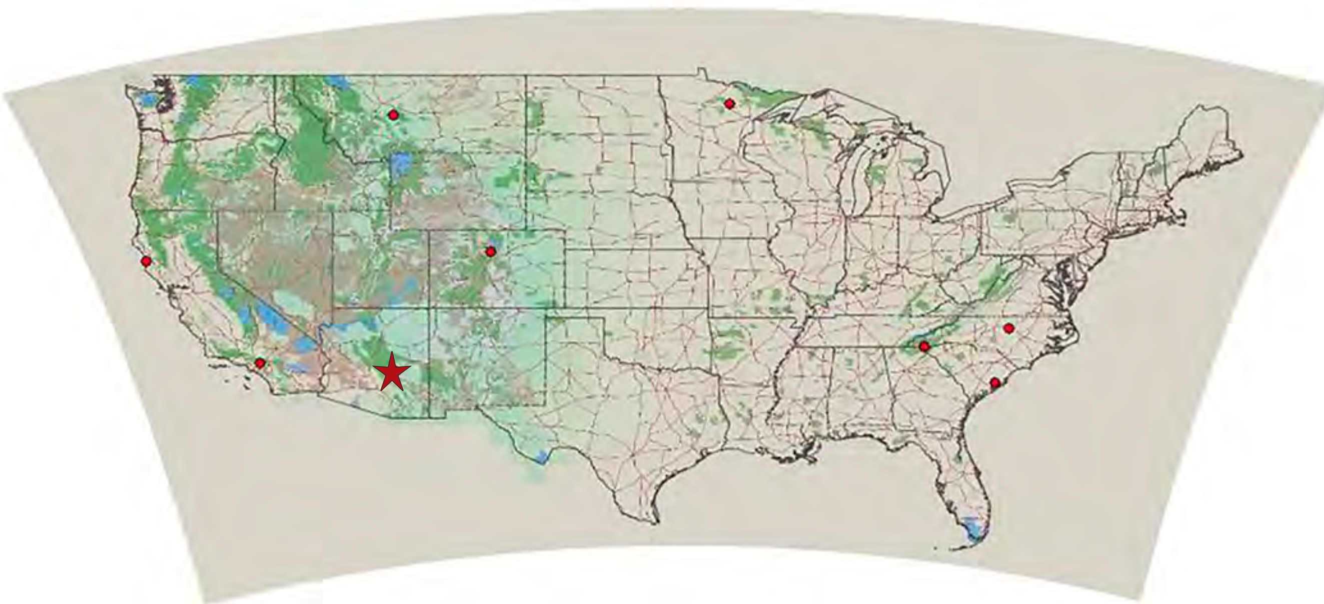
FACE Wood Decomposition Experiment (FWDE)

Sierra Ancha Experimental Forest



The Sierra Ancha Experimental Forest FWDE site is located at 33.802282 N, 110.915807 W, approximately 48 km north of Globe, AZ. The elevation at the site is 2220 m.

Introduction

In 1932, the Sierra Ancha Experimental Forest was established. This experimental forest is located within the Tonto National Forest (see map) and covers 5364 hectares of land (Adams and others 2004). Detailed information about the Sierra Ancha Experimental Forest can be found at https://www.fs.usda.gov/rmrs/experimental-forests-and-ranges/sierra-ancha-experimental-forest.

Soils

The soil of the FWDE site is the Sobega-Quintana, Kopie complex, which occurs on uplands with 2–50 percent slopes. It consists of deep, well-drained soils with moderate permeability and medium runoff. The fine Sobega loam is formed in weathered material from coarse-grained sandstone. The fine Quintana loam is derived from limestone, soft calcareous sandstone, and shale. The Kopie loam is formed in alluvium and eolian deposits from sandstone and sandy shale (NRCS 2010).

Vegetation

The vegetation within the FWDE site is dominated by ponderosa pine (*Pinus ponderosa*) (Adams and others 2004) (see photos). The ecological sub-region of the FWDE is located in the Dry Domain, the Tropical/Subtropical Steppe Division, the Colorado Plateau Semi-Desert Province, and the Tonto Transition Section (McNab and others 2005).

Sierra Ancha Experimental Forest (continued)

Climate

The NRCS Workman Creek SNOTEL station as well as a weather station maintained by the Sierra Ancha Experimental Forest are located in a meadow close to the FWDE site. From these stations, the average annual precipitation at the higher elevations is 897 mm and the average annual temperature is 11 °C.

Photos of vegetation within the Sierra Ancha Experimental Forest FWDE site.

References

Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Experimental forests and ranges of the U.S. Department of Agriculture Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 178 p. https://doi.org/10.2737/NE-GTR-321.

McNab, W.H.; Cleland, D.T.; Freeouf, J.A. [and others], comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture Forest Service. 80 p.

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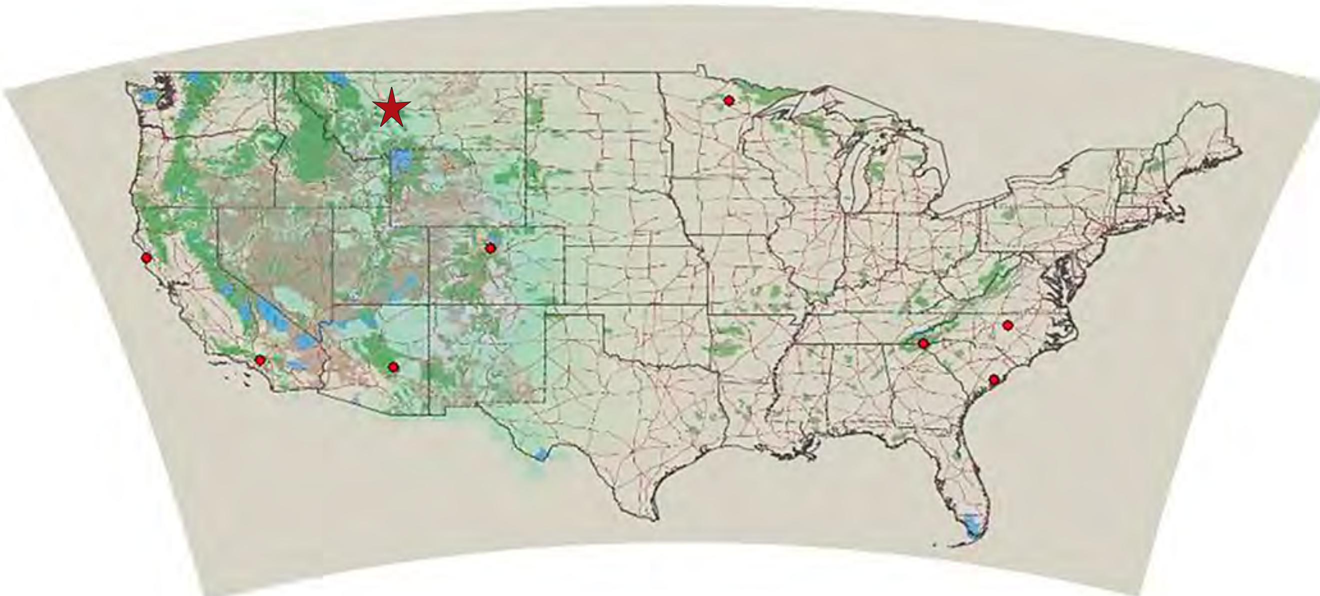
FACE Wood Decomposition Experiment (FWDE)

Tenderfoot Creek Experimental Forest



The Tenderfoot Creek Experimental Forest FWDE site is located at 46.5525 N, 110.5210 W in White Sulphur Springs, MT. The elevation at the site is 2130 m.

Introduction

In 1961, the Tenderfoot Creek Experimental Forest was established. This experimental forest is located within the Lewis and Clark National Forest (see map) and covers 3692 hectares of land (Adams and others 2004). Detailed information about the Tenderfoot Creek Experimental Forest can be found at https://www.fs.usda.gov/rmrs/experimental-forests-and-ranges/tenderfoot-creek-experimental-forest.

Soils

The soil of the FWDE site is the Tigeron-Stemple-Shadow-Garlet complex, which occurs on 2–70 percent slopes. It consists of very deep, well-drained soils with moderate permeability. The loam complex is formed in colluvium or alluvium. The Tigeron is derived from sandstone, argillie, quartzite, and other igneous rock. The Stemple is derived from igneous or metamorphic rock, or alpine till. The Shadow is derived from gneiss, schist, andesite, and granite. The Garlet is derived from mixed rock sources (NRCS 2010).

Vegetation

The vegetation within the FWDE site is dominated by lodgepole pine (*Pinus contorta*) and huckleberry (*Vaccinium* spp.) (Adams and others 2004) (see photos). The ecological sub-region of the FWDE is located in the Dry Domain, the Temperate Steppe Regime Division, the Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province, and the Belt Mountains Section (McNab and others 2005).

Tenderfoot Creek Experimental Forest (continued)

Climate

The climate is continental, occasionally influenced by the Pacific maritime climate (Adams and others 2004). The mean annual temperature is 0 °C. The average annual precipitation is 880 mm, falling mostly in the form of snow between November and May (Adams and others 2004).


Photos of vegetation within the Tenderfoot Creek Experimental Forest FWDE site.

References

Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Experimental forests and ranges of the U.S. Department of Agriculture Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service Northeastern Research Station. 178 p. https://doi.org/10.2737/NE-GTR-321.

McNab, W.H.; Cleland, D.T.; Freeouf, J.A. [and others], comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture Forest Service. 80 p.

Natural Resources Conservation Service (NRCS). 2010. Official Soil Series Descriptions (OSD) with series extent mapping capabilities. U.S. Department of Agriculture, https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/data/?cid=nrcs142p2_053587. [Date accessed: November 8, 2011].

Trettin, Carl C.; Burton, Andrew; Jurgensen, Martin F.; Page-Dumroese, Deborah S.; Dai, Zhaohua; Oren, Ram; Forschler, Brian; Schilling, Jonathan; and Lindner, Daniel. 2021. Wood decomposition and its role in the forest carbon cycle: the FACE wood decomposition experiment. Gen. Tech. Rep. SRS–262. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 33 p. https://doi.org/10.2737/SRS-GTR-262.

Dead wood is the largest detrital component within forests, comprising a significant portion of the total carbon (C) pool. Despite its ecological importance, there is insufficient information on the factors affecting wood decomposition, and there are no mechanistic models that effectively simulate wood decay and the incorporation of wood C into soil across North America. Therefore, the objective of this experiment is to establish a long-term experimental framework to serve as a foundation to study decomposition processes in wood and the associated interactions with the underlaying soil. The basic approach is to assess the interactions of site conditions with biological processes mediating wood decomposition by incubating common wood substrates, loblolly pine (*Pinus taeda* L.), aspen (*Populus tremuloides* Michx.), and birch (*Betula papyrifera* Marshall) logs in forest ecosystems with different soil and environmental conditions. The unique aspect of this study is the use of logs from Free Air Carbon Dioxide Enrichment (FACE) sites in North Carolina and Wisconsin, which have a distinct $\delta^{13}C$ signature that can be followed through the wood decomposition process, thereby providing the capacity to assess the translocation of wood C into soil organic matter pools. In 2011, FACE logs were placed horizontally on the soil surface and vertically without soil contact to simulate standing dead trees, the two dominate positions of dead wood in forest ecosystems. Those samples are to facilitate the study of wood decomposition and associated changes to the soil C pools. The experimental design facilitates the assessment of wood-soil food web, and it capitalizes on the strong foundation of research in the nationwide U.S. Department of Agriculture Forest Service (USDA-FS) Experimental Forest and Range Network.

Keywords: Coarse woody debris, Free Air Carbon Dioxide Enrichment, soil carbon, soil fungi, termites, wood decay.

Cover photos

Top left: Coweeta FACE (Free Air Carbon Dioxide Enrichment) Wood Decomposition Experiment (FWDE) site.

Top center: Caspar Creek FACE FWDE site.

Top right: San Dimas Experimental Forest FACE FWDE site.

Center left: Duke Forest FACE FWDE site.

Center right: Santee Experimental Forest FACE FWDE site.

Bottom left: Fraser Forest FACE FWDE site.

Center: Tenderfoot Creek Experimental Forest FACE FWDE site.

Bottom right: Sierra Ancha Experimental Forest FACE FWDE site.

Bottom center: Marcell Experimental Forest FACE FWDE site.

A copy of this general technical report is available for download at www.srs.fs.usda.gov/pubs/.

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Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410; or

(2) Fax: (833) 256-1665 or (202) 690-7442; or

(3) Email: program.intake@usda.gov.

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