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Changes in forest hydrology and soil biogeochemistry following a simulated tree mortality event of southern pine beetle

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Dataset: Changes in forest hydrology and soil biogeochemistry following a simulated tree mortality event of southern pine beetle

This document provides detailed information about a dataset that was generated through a 2015-2017 collaborative research project titled "*Changes in canopy hydrologic and biogeochemical fluxes during bark beetle-killed mortality processes in southern pine forests.*"

About the Dataset

Dataset Name:

Changes in forest hydrology and soil biogeochemistry following a simulated tree mortality event of southern pine beetle

Geographic Extent:

The study was conducted in a 60-year-old loblolly pine stand in central Mississippi (33.2639°N, 88.8884°W). The overstory basal area was 25.5 m^2 ha^{-1} with 395 trees ha^{-1}. The midstory had a basal area of 29.4 m^2 ha^{-1} with 1,664 trees ha^{-1} dominated by sweetgum (*Liquidambar styraciflua* L.), red maple (*Acer rubrum* L.), winged elm (*Ulmus alata* Michx.), and oak species (*Quercus* spp.). The soil on this site is a somewhat poorly drained Urbo silt loam, with a depth to the water table of 30–35 cm and occasional flooding (Natural Resources Conservation Service, 2015). Average temperatures in summer (June, July, and August) and winter (December, January, and February) are 26.5 °C and 6.9 °C, respectively (30-year mean: NOAA 2010). Total annual precipitation is 140.3 cm, which falls fairly evenly throughout the year with the lowest rainfall occurring in September (8.6 cm) (NOAA 2010).

General Description of Data:

A field study was established in Summer 2015 to simulate a bark beetle attack and mortality event by girdling loblolly pine trees to sever phloem and cambium tissue (Davis et al., 2017; Siegert et al., 2018b). Fifteen canopy-dominant loblolly pine trees were selected around a centrally located data logger and randomly allocated to three different treatments: 1) five trees were girdled and received inoculations of bluestain fungus (*Ophiostoma minus* (Hedgc.) Syd. & P. Syd.)), 2) five trees were girdled and inoculated with agar as negative controls, and 3) five trees were not girdled and received no inoculations as controls. Southern pine beetles are vectors of bluestain fungus, which is a non-decay fungus that colonizes the vascular system, and may accelerate death due to restrictions of plant water uptake, and preferentially attracts subterranean termites (Clay et al., 2017; N. S. Little et al., 2012). Cell stock of previously identified cultures of *O. minus* was available from prior studies (see Little *et al.*, 2012a, 2012b; Clay *et al.*, 2017) for use in this study that had been stored in the Forest Entomology Laboratory at Mississippi State University. Pure strains of the fungus were cultured on malt extract agar. Once the fungi were vigorously growing, three 0.5-cm diameter plugs were taken from each petri dish and were inoculated into the sapwood of the trees using an arch punch just above the girdling.

The data are made up of a series of datasets as follows:

- Sapflow: This dataset contains seasonal mean sapflow (L $tree^{-1}$) and standard error of girdled (G) and control (C) study trees. On all 15 study trees, 2-cm long sapflow probes were installed to measure tree water use following the heat dissipation method (Granier, 1987), which estimates

sapflow rates from the temperature deficit between an upper heated and lower reference probe. Sapflow probes were installed radially into the outermost sapwood tissue above the stem girdle and approximately 1 m above ground level. Probes were covered by reflective insulation and connected to a CR1000 datalogger and AM16/32B multiplexer (Campbell Scientific Inc., Logan, UT, USA) powered by deep cycle batteries and a solar panel located in a nearby canopy gap. Measurements were recorded every 30 seconds and averaged over 30 minute increments. These raw millivolt temperature data were imported into the BaseLiner software program (Duke University, Durham, NC, USA) to calculate sapflow velocities (g m^{-2} $_{sapwood\ area}$ s^{-1}) based on the empirical equation developed by Granier (1987). To scale measurements to the tree level, sapwood depths were calculated from diameter at breast height (DBH) measurements and an allometric equation from Blanche et al. (1984). In addition, radial decreases in sapflow velocity with depth were accounted for using data from Ford et al. (2004). Sapflow was monitored in trees until cessation of flow in girdled trees in late 2016.

- Stemflow: This dataset contains seasonal mean stemflow (L m^{-2} of basal area) and standard error of girdled (G) and control (C) study trees. All trees were outfitted with stemflow collars constructed from 2.5 cm inner diameter polyethylene tubing cut longitudinally and sealed around the trunk of each tree above the girdled location, sapflow probes and inoculation site with aluminum nails and silicone caulk. Collars drained into 20 L polyethylene bins.

- VWC: This dataset contains season deviations of mean volumetric water content (m^3 m^{-3}) and standard error measured at 0.5, 1.0, and 1.5 m distances from girdled (G) and control (C) study trees. Two sample points were randomly selected in each of the three distance intervals radiating away from the tree boles. Different random points were used for each measurement date. Volumetric water content was measured with an ECH_2O model EC-5 sensor) Decagon Devices, Inc.)

- H2O_Chem: This dataset contains season mean and standard error of stemflow dissolved organic carbon (DOC), specific UV absorbance (SUVA), nitrate-nitrogen (NO_3^--N), ammonium-nitrogen (NH_4^+-N), organic nitrogen (ON), and total nitrogen (TN) in mg L^{-1}. Water samples for chemical analysis were collected within 24 hours of the end of a storm event, filtered through a 0.45 µm membrane, and stored at 4°C until chemical analysis. Sample collection began in fall 2015 and continued through fall 2017. Water samples from stemflow, throughfall, and rainfall were analyzed for carbon and nitrogen. Dissolved organic carbon (DOC) was analyzed on a Hach DR5000 UV-Vis Spectrophotometer with the HACH Low Range Total Organic Carbon Test kit. Colored dissolved organic matter (CDOM) absorbance was measured using a Lambda 850 UV-Vis Spectrophotometer (PerkinElmer, Waltham, MA). After Milli-Q water correction and a correction for baseline fluctuations of the absorbance spectra, the absorption coefficient (a_{254}), a metric that describes the aromaticity of DOM, was calculated by

$$a_{254} = \frac{2.303 \times A(\lambda)}{l} \quad (1)$$

where $A(\lambda)$ = the absorbance at 254 nm, l = the cell path length of the instrument, set to 0.01 m (Green and Blough, 1994). The specific UV absorbance (SUVA) describes compound aromaticity and is standardized for the concentration of DOC in the sample by

$$SUVA_{254} = \frac{a_{254}}{[DOC]} \quad (2)$$

where [*DOC*] = the concentration of dissolved organic carbon in the sample (Weishaar *et al.* 2003).

Dissolved nitrogen species [total nitrogen (TN), organic nitrogen (ON), nitrate (NO_3^--N), and ammonium (NH_4^+-N)] were analyzed on a Bran+Luebbe Auto Analyzer 3. NO_3^--N was determined using cadmium reduction methods. NH_4^+-N was determined using phenate methods. TN was determined using microwave digestion in which all ON forms of nitrogen are converted to NO_3^- then analyzed using cadmium reduction methods. ON was calculated as

$$ON = TN - (NO_3^{-1} - N + NH_4^{+3} - N) \quad (3)$$

All laboratory methods follow QA/QC protocols including standards, blanks, and duplicate testing.

- Respiration: This dataset contains seasonal mean soil respiration (g C m^{-2} s^{-1}) and standard error measured at 0.5, 1.0, and 1.5 m distances from girdled (G) and control (C) study trees. Soil respiration was measured around each of the 15 individual trees. A circular grid with concentric rings of three 0.5-m intervals split into six sample quadrants was established around each tree. In the center point of each of the three concentric distance quadrants, a 20-cm inner diameter polychlorinated vinyl tube cut to a length of 10 cm was installed permanently into the soil profile. Installation locations were randomly generated, but these locations remained fixed throughout the study to limit disturbance of the soil and root profile. Respiration was measured monthly with a LI8100A Soil Automated Flux Analyzer (Li-Cor, Inc.) outfitted with a 20-cm survey chamber along with a volumetric water content sensor (ECH2O model EC-5, Decagon Devices, Inc.) and soil temperature thermistor probe (Li-Cor, Inc.). Respiration data were adjusted based on the average measured depth of each PVC collar.

- Soil_Chem: This dataset contains seasonal mean soil carbon (mg C mg^{-1} soil), soil nitrogen (µg N mg^{-1} soil), and soil C:N ratio and standard error measured at 0.5, 1.0, and 1.5 m distances from girdled (G) and control (C) study trees. Soil elemental composition was measured around each of the 15 individual trees. A circular grid with concentric rings of three 0.5-m intervals split into six sample quadrants was established around each tree. Soil samples were taken at the initiation of the study in fall 2015 and again in fall 2016 with a 2.5-cm soil auger in the A and B horizons (5 cm and 10 cm, respectively). Two sample points were randomly selected in each of the three distance intervals radiating away from the tree boles. Different random points were used for each measurement date. These samples were dried at room temperature, ground to pass through a 0.1-mm sieve, oven dried at 105 °C for 24 hours, and then stored in airtight Whirl-pak bags. Soil samples were analyzed for total carbon and nitrogen on a Costech 4010 ECS CHNO elemental analyzer.

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File Format:

Microsoft Excel