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Data Article

Soil and plant-based ecosystem functions dataset of three land-use types in northwestern Virginia

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ABSTRACT

Variables that quantify nutrient cycling in terrestrial ecosystems, including aboveground and belowground biomass, litter biomass, inorganic nitrogen (NH_4^+ and NO_3^-), and soil CO_2 efflux were measured *in situ*. From measured variables, seasonal litter inputs and nitrogen mineralization were also estimated. Data were collected over the course of one to two growing seasons (2017 and 2018) across three different land-use types under variable human management: an agricultural field (cultivating millet for the duration of the first growing season of the study and left fallow for the duration of the second growing season), a restored native C_4 tallgrass prairie, and an approximately 16-year-old successional field. The area of focus within each field was approximately 1 hectare. Five representative 5 m x 5 m plots were randomly chosen in each of the three fields. Within each 5 m x 5 m plot, three 1 m^2 subplots were randomly chosen for replicate sampling. These raw data can be utilized to calculate the ecosystem functions of net nitrogen (N) mineralization, decomposition, soil respiration, aboveground primary productivity, and N leaching, which are foundational components of supporting ecosystem services in terrestrial soils and plants. These data can be used in conjunction with other datasets that describe a suite of ecosystem functions in different land-use types under variable management.

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Specifications Table

Subject	Environmental Science
Specific subject area	This dataset directly measures or can be used to quantify ecosystem functions occurring in and between plants and soil in terrestrial ecosystems.
Type of data	Table
How the data were acquired	Data were either measured *in situ* or calculated based on measured variables. Variables directly measured were: biomass, litter, root biomass, soil NH_4^+ and NO_3^-, and foliar C and N. Variables calculated based on measured variables were: net N mineralization and seasonal litter inputs.
Data format	Raw Derived
Description of data collection	Peak aboveground biomass and litter were collected in the early successional field and native prairie. In 2017, biomass was collected from two single individual millet plants and scaled to 1 m^2. Each biomass sample was dried and ground to calculate foliar C and N. Root mass, C, N, NH_4^+ and NO_3^- were measured to a 30 cm depth.
Data source location	Institution: Blandy Experimental Farm, University of Virginia City/Town/Region: Boyce, Virginia Country: U.S.A. Latitude and longitude for collected samples/data: 39.06, -78.06
Data accessibility	Repository name: Mendeley Data identification number: 10.17632/h56z69wk8z.1 Direct URL to data: https://data.mendeley.com/datasets/h56z69wk8z/1

Value of the Data

- Can be used to calculate ecosystem functions of net N mineralization, decomposition, soil respiration, aboveground primary productivity, and N leaching.
- Land managers or researchers producing ecosystem models based on terrestrial soils and plants may find these data useful.
- In conjunction with other datasets, can be used to estimate a suite of ecosystem functions in different land-use types.

1. Objective

This dataset includes a suite of ecosystem functions measured *in situ* in three land-use types: an early successional field, a native plant meadow, and an agricultural field when planted. The ecosystem functions measured are associated with three supporting ecosystem services (ES): soil formation, nutrient cycling, and primary productivity. The importance of supporting ES, paired with a lack of thorough exploration of their underlying functions in the broader field provided the motivation for this study [1,2].

This suite of ecosystem functions were also measured with a multifunctionality approach in mind. Ecosystem function multifunctionality is the ability of ecosystems to simultaneously provide multiple ecosystem functions [3]. Though it provides a holistic evaluation of a system's ability to provide supporting ES, how to conceptualize and measure multifunctionality is unresolved [4–6].

This dataset would be an appropriate addition to studies that attempt to quantify the underlying functions of ES, studies that utilize a multifunctionality approach to analyze ecosystem functioning, or studies that examine ecosystem functions of various land-use types. These

ecosystem functions are foundational to understanding larger scale areas of concern in ecology, ES, nutrient cycling, primary productivity, soil formation, and land-use.

2. Data Description

These data were collected during 2017 and 2018 growing seasons at Blandy Experimental Farm in northwestern Virginia from three fields: an agricultural field, early successional field, and a native prairie. Five sampling plots were established in each field. Total live biomass was harvested and averaged per plot from three 0.25 m^2 subplots within each plot at the end of the 2017 and 2018 growing seasons. Biomass was also separated into woody and foliar components for each year. The foliar biomass harvested in 2017 was separated by functional group (forbs, graminoids, and shrubs) and ground and analyzed for carbon and nitrogen. Likely and maximum seasonal litter inputs were estimated for both 2017 and 2018. Likely seasonal litter inputs were based on deciduous leafy biomass only, and maximum seasonal litter inputs included standing dead biomass. Each estimate was based on the average measurements from three 0.25 m^2 subplots within each plot. Soil NH_4^+ and NO_3^- measurements were also collected from the top 10 cm of soil at three locations in each plot during the 2017 and 2018 growing seasons. Using these values, net N mineralization was estimated early- and mid-2017 growing season and mid-2018 growing season. Soil NH_4^+ and NO_3^- concentrations were also measured in July and October at 10 cm increments to a 30 cm depth. To provide context for potential leaching of inorganic N, roots within and below each depth range are provided. Soil CO_2 efflux was measured at three subplot locations in each plot and averaged for each date for 7 days during the 2018 growing season: days 157, 163, 171, 178, 209, 221, and 228.

3. Experimental Design, Materials and Methods

Research plots were located in three different land use types: restored native prairie, early successional field, and agricultural field. The area of focus within each field was approximately 1 hectare. Five representative 5 m x 5 m plots were randomly chosen in each of the three fields. Within each 5 m x 5 m plot, three 1 m^2 subplots were randomly chosen for replicate sampling.

Peak season aboveground biomass components were harvested from three 0.25 m^2 subplots within each plot in the early successional field (Ea) and native prairie (NP) in 2017 and 2018. In the laboratory, all clipped samples of aboveground biomass were oven-dried for 72 h at 60 °C in a forced-air oven. Dry weights were recorded for the total standing dead and live material of each plant functional type (graminoid, forb, and shrub) for each of the three replicate subsamples from each plot in these fields. The amount of woody and foliar biomass (gm^{-2}) of each plot in the early successional field and native prairie was determined by scaling the average mass of the three 0.25 m^2 subplot samples. Given the spatially uniform nature of the agricultural field, two millet plants were sampled from each plot in this field. Because only two millet plants were sampled from each plot, the numbers of plants within multiple 1 m^2 areas were counted, then multiplied by the mean mass of the two harvested individuals to obtain peak season biomass.

From the 2017 harvested biomass, representative subsamples of foliar components from each functional type were ground. Approximately 5 mg were taken from the ground subsamples for dry combustion in a CN analyzer (Flash 2000; Thermo Fisher Scientific, Inc., Milan, Italy). The analyzer was calibrated before each use with standard samples of peach ranging from 3 mg to 12 mg with known CN values. Using %C and %N, the C:N ratio of live foliage of each functional type was determined.

Litter was collected from an undisturbed 0.25 m^2 corner of each of the three 1-m^2 subplots in each plot at the beginning of the 2018 growing season. Each sample was oven-dried and weighed in order to estimate the litter pool, established from litter fall of multiple previous growing seasons. Seasonal litter inputs were estimated for 2017 and 2018 based on the amount

of live foliar biomass (there were no evergreen species present in the plots used in this study) in each land-use type, under the assumption that all foliar biomass would become litter at the end of the growing season. The maximum possible seasonal litter inputs were also estimated by adding the standing dead biomass to the total foliar biomass.

In situ soil CO_2 efflux measurements and net N mineralization incubations were conducted at three locations within each plot and averaged to the plot level. NH_4^+ and NO_3^- were also collected for each 10 cm increment to a 30 cm depth at one location in each plot. *In situ* soil CO_2 efflux was measured with a portable infrared gas analyzer with attached soil respiration chamber (EGM-4; PP Systems, Amesbury, MA), to serve as a proxy for soil respiration. The EGM-4 infrared gas analyzer had been calibrated with a range of 0 to 2000 ppm concentration the previous year. Measurements were taken mid-day between 10h and 14h once per week during May and June in the three replicate subplots within the five plots of both the native prairie and early successional field (DOY 157, 163, 171, and 178) Once plots were established in the agricultural field in late July, measurements were taken in the three replicate subplots within the five plots of each land-use type on a weekly basis through August (DOY 209, 221, 228). The time of day at which land-use types were sampled was rotated in order to eliminate any time of day sampling bias. The dataset includes NA for dates over which the agricultural field was not yet planted and for dates during which some plots were not visited.

Three one-month-long net nitrogen mineralization (NNM) *in situ* resin-core incubations were conducted in three replicate subplots of the five plots in each land-use type using the resin-core method of DiStefano and Gholz [7]. Incubations were conducted in the top 10 cm of soil, as Persson and Wiren [8] found that 78% of NNM takes place there. Two of the three incubations were conducted during the 2017 growing season: the first near peak plant growth from mid-June to mid-July (although the agricultural field was excluded from this incubation, as it had not been planted yet) and the second near peak biomass from mid-July to mid-August. The last incubation was conducted during the 2018 growing season near peak biomass from mid-July to mid-August. The dataset includes NA some plots in which an incubation was not successfully conducted during the 2017 growing season. The resin bag acted to capture any NO_3^- or NH_4^+ that leached from the soil core, which also gives an estimate of vertical N flux. The resin bags were constructed of nylon and contained a mixture of 1-tablespoon each of cation (USF C-211 resin cation, Na form) and anion (USF A-464 resin, Type I anion, Cl form) resins, allowing water percolation [9] and nutrient adsorbance to the resin surface for later extraction. Soil samples and resin bags were retrieved after one month in the field and immediately frozen to minimize further microbial activity.

NO_3^- and NH_4^+ were extracted from samples using KCl extraction methods [10]. All samples were run through an autoanalyzer (Lachat QuikChem 8500; Hach Company, Loveland, CO) for detection of NO_3^--N and NH_4^+-N. Because sample concentrations often exceeded the threshold of the response curves for the analyzer, all samples were diluted with 2 M KCl to fall within the range of the response curves. The Lachat autoanalyzer was calibrated before each use with standard samples of NO_3^--N between 1.75 and 35 micromoles and NH_4^+-N between 2.25 and 45 micromoles and external standards were included to assure accuracy of the machine. The detection limit for this method was 0.005 mg/L for NO_3^--N and NH_4^+-N, so any concentration below that was assumed to be zero.

Initial cores and those incubated *in situ* were used to calculate NNM rates [11]. NNM was calculated as the change in NO_3^--N and NH_4^+-N in the cores after the one-month incubation, plus any NO_3^--N and NH_4^+-N detected in the resin bags [12].

In order to gain greater insights into leaching capacity beyond the top 10 cm of soil, which the resin bags provided, soil samples were collected from each plot across 10 cm increments to a 30 cm depth. Samples were collected twice during 2018: in the middle of the growing season (mid-July), then again after the end of the growing season (mid-October), as the greatest leaching tends to occur following the growing season [13]. The samples were immediately frozen to minimize any microbial activity and were treated in the laboratory in the same manner as in the NNM analysis.

Ethics Statements

None applicable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Ecosystem Function Components, Blandy Experimental Farm (Original data) (Mendeley Data).

CRediT Author Statement

Kelsey Huelsman: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Project administration; **Howard Epstein:** Conceptualization, Methodology, Supervision, Funding acquisition.

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