TOS SITE CHARACTERIZATION REPORT: DOMAIN 07

PREPARED BY	ORGANIZATION	DATE
Rachel Krauss	SCI	04/27/2018
Courtney Meier	SCI	04/27/2018
Michael Patterson	SCI	01/27/2017
Oliver Smith	SCI	10/27/2017

APPROVALS	ORGANIZATION	APPROVAL DATE
Kate Thibault	SCI	11/12/2018
Mike Stewart	SYS	11/12/2018

RELEASED BY	ORGANIZATION	RELEASE DATE
Judy Salazar	CM	11/20/2018

See configuration management system for approval history.

The National Ecological Observatory Network is a project solely funded by the National Science Foundation and managed under cooperative agreement by Battelle. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

CHANGE RECORD

REVISION	DATE	ECO#	DESCRIPTION OF CHANGE
A	12/22/2017	ECO-05338	Initial Release
B	11/20/2018	ECO-05648	• Added soil pit information table • Added percent cover of bryophyte to the plant diversity table

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

1 DESCRIPTION

1.1 Purpose

Domain and site-specific information collected and described here is used to inform the execution of protocols for the NEON Terrestrial Observation System (TOS), and complements the official NEON TOS data products generated from each site. In addition, the TOS spatial layout and plot allocation is described for each site within the domain.

1.2 Scope

This document includes any site specific characterization methods and the results of characterization efforts for each of the three sites in the Appalachians & Cumberland Plateau domain. For more information about the sampling methods, reference the TOS Site Characterization Methods Document (RD[06]). The geographic coordinates for all TOS sampling locations can be found in the Reference Documents area of the NEON Data Portal and are provided with TOS data product downloads.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain information that shall be applied in the current document. Examples are higher level requirements documents, standards, rules and regulations.

AD[01]	NEON.DOC.004300	EHSS Policy, Program, and Management Plan
AD[02]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[03]	NEON.DOC.000909	TOS Science Design for Ground Beetle Abundance and Diversity
AD[04]	NEON.DOC.000910	TOS Science Design for Mosquito Abundance, Diversity and Phenology
AD[05]	NEON.DOC.000912	TOS Science Design for Plant Diversity
AD[06]	NEON.DOC.000915	TOS Science Design for Small Mammal Abundance and Diversity
AD[07]	NEON.DOC.000914	TOS Science Design for Plant Biomass and Productivity
AD[08]	NEON.DOC.000001	NEON Observatory Design

2.2 Reference Documents

Reference documents contain information complementing, explaining, detailing, or otherwise supporting the information included in the current document.

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]	NEON.DOC.000913	TOS Science Design for Spatial Sampling
RD[04]	NEON.DOC.011036	TIS Site Characterization Report
RD[05]	NEON.DOC.001372	AIS Site Characterization Report
RD[06]	NEON.DOC.003885	TOS Site Characterization Methods
RD[07]	NEON.DOC.000481	TOS Protocol and Procedure: Small Mammal Sampling
RD[08]	NEON.DOC.014041	TOS Protocol and Procedure: Breeding Landbird Abundance and Diversity
RD[09]	NEON.DOC.014042	TOS Protocol and Procedure: Plant Diversity Sampling
RD[10]	NEON.DOC.000987	TOS Protocol and Procedure: Measurement of Vegetation Structure
RD[11]	NEON.DOC.014040	TOS Protocol and Procedure: Plant Phenology
RD[12]	NEON.DOC.001709	TOS Protocol and Procedure: Bryophyte Productivity

2.3 Acronyms

Acronym	Definition
BOLD	Barcode of Life Datasystems
NLCD	National Land Cover Database

3 DOMAIN 07 OVERVIEW: APPALACHIANS & CUMBERLAND PLATEAU DOMAIN

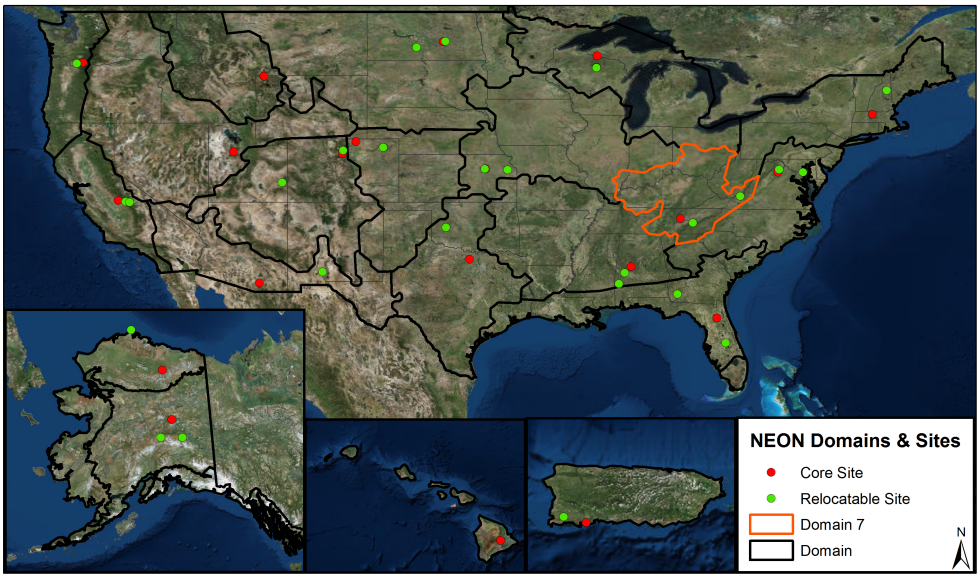

Figure 1: NEON project map with Domain 07 highlighted in red.

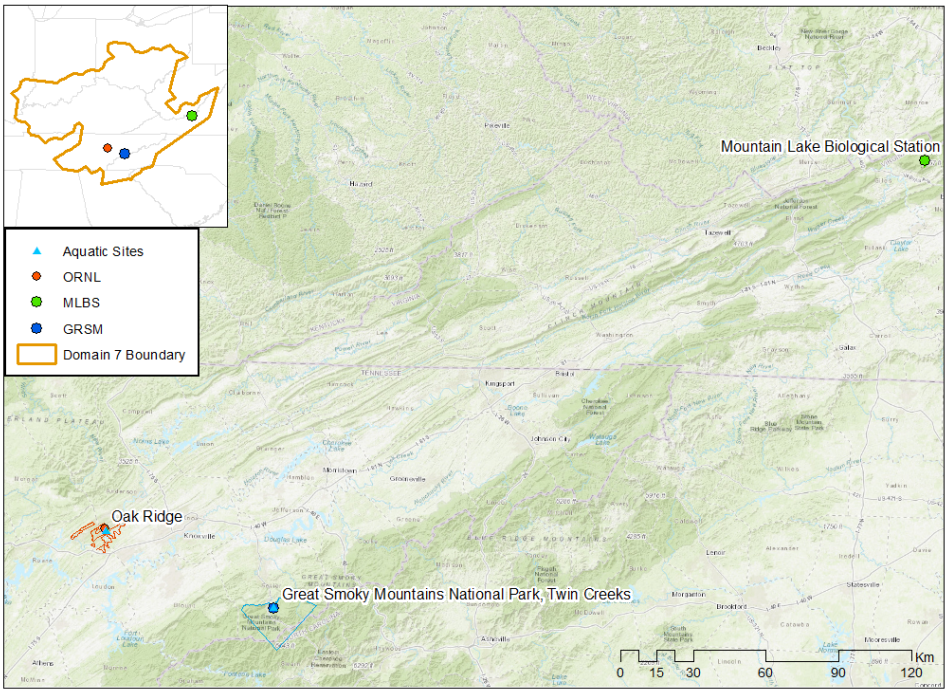

Figure 2: Site boundaries within Domain 07.

The Appalachians & Cumberland Plateau Domain is a patchwork of forest and grassland often situated in rugged terrain. The domain has a high level of biodiversity, especially in the Eastern Appalachians, but is also heavily impacted by invasive plant and animal species including kudzu (*Pueraria montana*), Oriental bittersweet (*Celastrus orbiculatus*), wild hogs (*Sus scrofa*), and Hemlock woolly adelgid (*Adelges tsugae*)(Non-native Species, 2017).

- States included in the domain: Alabama, Georgia, Illinois, Indiana, Kentucky, North Carolina, Ohio, South Carolina, Tennessee, Virginia, and West Virginia.
- Core site: Oak Ridge
- Relocatable 1: Mountain Lake Biological Station
- Relocatable 2: Great Smoky Mountains National Park
- Science themes: Climate Impacts

4 CORE SITE- OAK RIDGE (ORNL)

Oak Ridge National Laboratory (ORNL) is located at the U.S. Department of Energy's Oak Ridge Reservation in Roane County, Tennessee. Oak Ridge National Laboratory is situated north of the Clinch River. The NEON TOS plots at ORNL are located within or adjacent to the Walker Branch Watershed. The watershed has served as the site for long-term environmental studies by the Environmental Sciences Division at ORNL, NOAA, and many visiting university researchers.

Figure 3: Phenocamera image for ORNL. The phenocamera is located at the top of the NEON tower and faces north. Phenocamera images are available at https://phenocam.sr.unh.edu/webcam/network/table/.

Key Characteristics:

- Site host: U.S. Department of Energy
- Located in: Anderson and Roane counties, Tennessee
- Sampling Area: 138.1 km^2
- Plot Elevation: 230-360 m
- Dominant vegetation type- Vegetation within ORNL is a mixture of deciduous species in the valleys with patches of shortleaf pine (*Pinus echineta*) and Virginia pine (*Pinus virginiana*) on the ridges. Mixed hardwoods include chestnut oak (*Quercus prinus*), tulip poplar (*Liriodendron tulipifera*), red maple (*Acer*

rubrum), white oak (*Quercus alba*), and American beech (*Fagus grandifolia*) (Johnson and Van Hook 1989).

- General management: The Walker Branch watershed has a long history of ecological research. Outside of the NEON site boundaries, the U.S. Department of Energy's research facility includes the Y-12 National Security Complex, used for nuclear weapons processing and materials storage. This area, in addition to the East Tennessee Technology Park (ETTP), is considered a sensitive area with national security concerns.
- The NEON aquatic site Walker Branch is within the TOS sampling boundary. See the AIS site characterization report for more details (RD[05]).
- Plot Selection: NEON TOS Plots were allocated across the site following NEON standard criteria and avoiding existing research. Throughout the Oak Ridge National Laboratory plots were not allocated to areas that required additional security clearance, see Figure 4.

4.1 TOS Spatial Sampling Design

TOS plots were allocated at ORNL according to a spatially balanced and stratified-random design (RD[3]). The 2006 National Land Cover Database (NLCD) was selected for stratification because of the consistent and comparable data availability across the United States. TOS Tower Plots were allocated according to a spatially balanced design in and around the NEON tower airshed (RD[03]). The maps below depict the plot locations for the first year of NEON sampling. Some plot locations may change over time due to logistics, safety, and science requirements. Please visit the NEON website (http://www.neonscience.org) for updated plot locations at each site.

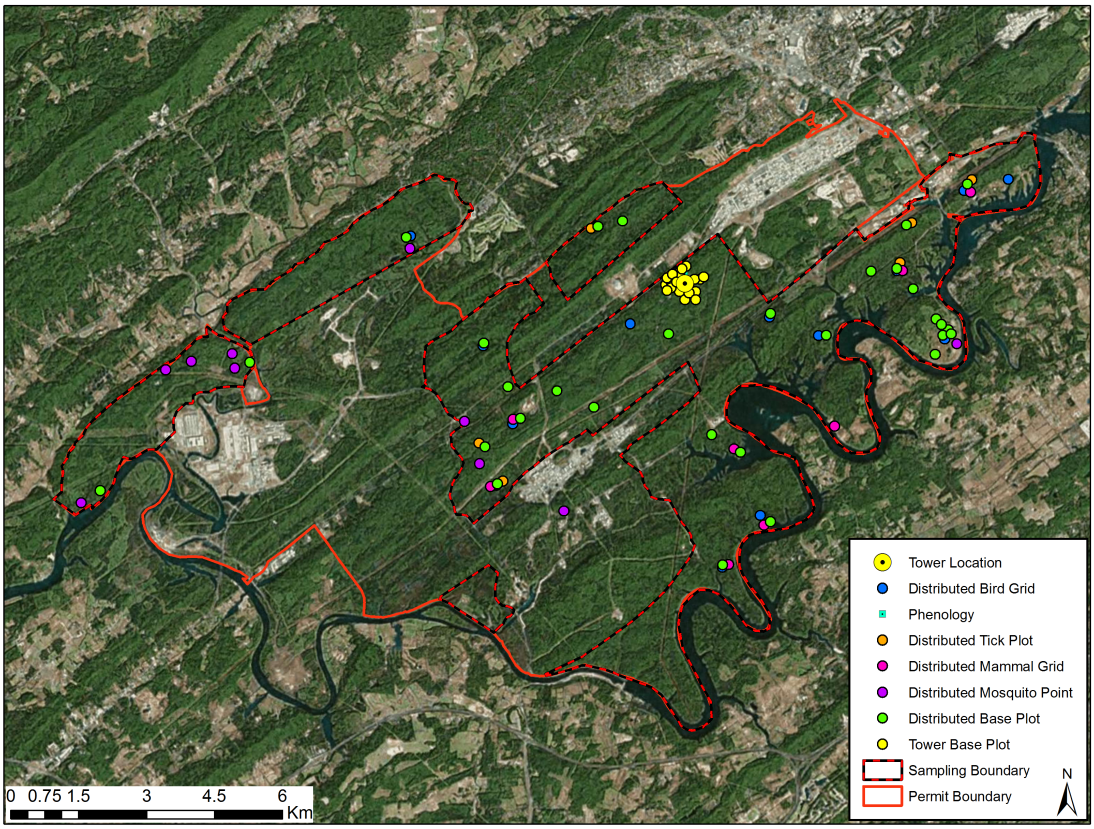

Figure 4: Map of TOS plot centroids within the NEON TOS sampling boundary at ORNL.

For a list of protocols associated with each plot see tables below; for additional spatial design information see RD[03].

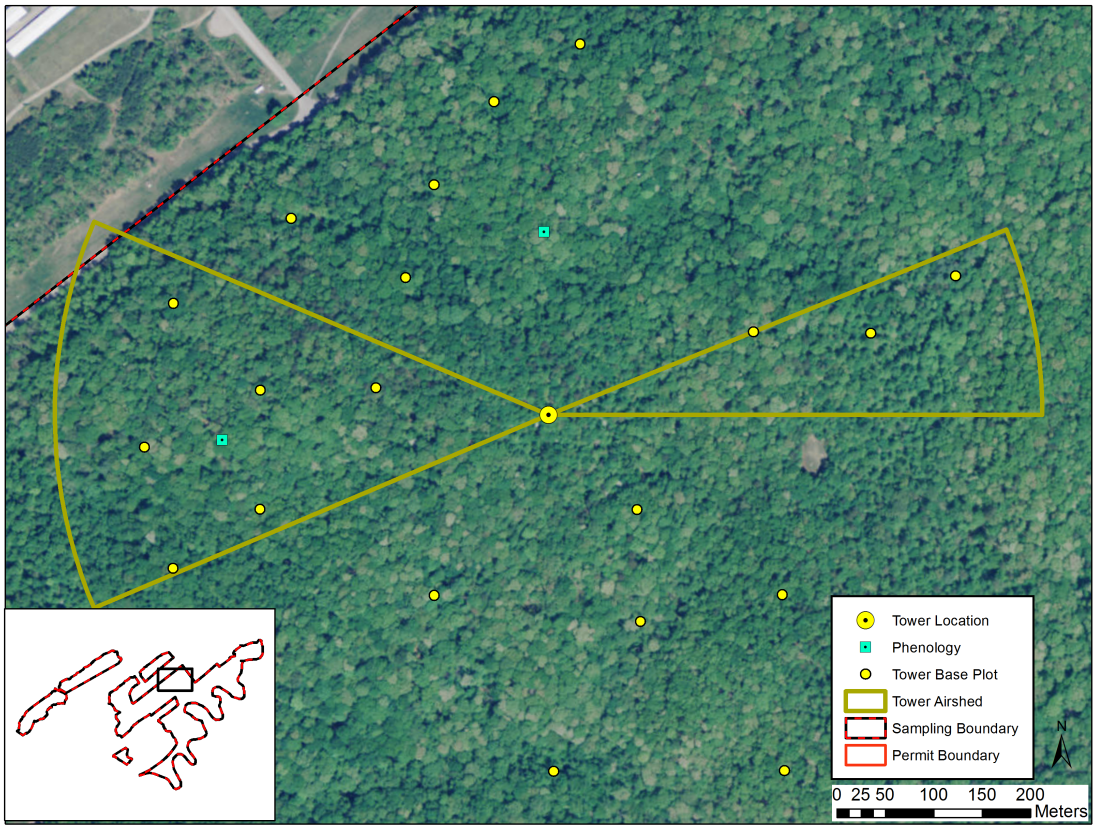

Figure 5: Map of the tower airshed and TOS plot centroids at ORNL.

More information about the tower airshed can be found in the FIU site characterization report (RD[04]).

Table 1: NLCD land cover classes and area within the TOS site boundary at ORNL.

NLCD Class	Site Area (km^2)	Percent (%)
Deciduous Forest	77.68	56.22
Evergreen Forest	9.68	7.01
Developed Low Intensity	7.61	5.51
Developed Open Space	7.37	5.33
Pasture Hay	6.78	4.9
Open Water	6.6	4.77
Woody Wetlands	5.2	3.77
Developed Medium Intensity	4.83	3.5
Mixed Forest	4.3	3.11
Developed High Intensity	3.53	2.55
Grassland Herbaceous	3.2	2.32
Barren Land	0.69	0.5
Shrub Scrub	0.59	0.43
Cultivated Crops	0.11	0.08

Note: Any NLCD land cover classes less than 5% will not be sampled. At ORNL, Pasture Hay (4.9%) was rounded up to 5% to be included in TOS sampling. Additionally, no sampling will take place in Water, Developed, or Barren Land NLCD classes.

Table 2: NLCD land cover classes and TOS plot numbers at ORNL.

Plot Type	Plot Subtype	NLCD Class	Number of Plots Established
Distributed	Base Plot	Deciduous Forest	17
Distributed	Base Plot	Evergreen Forest	7
Distributed	Base Plot	Pasture Hay	6
Distributed	Bird Grid	Deciduous Forest	8
Distributed	Bird Grid	Evergreen Forest	1
Distributed	Bird Grid	Pasture Hay	1
Distributed	Mammal Grid	Deciduous Forest	6
Distributed	Mammal Grid	Evergreen Forest	1
Distributed	Mammal Grid	Pasture Hay	1
Distributed	Mosquito Point	Deciduous Forest	8
Distributed	Mosquito Point	Evergreen Forest	1
Distributed	Mosquito Point	Pasture Hay	1

Plot Type	Plot Subtype	NLCD Class	Number of Plots Established
Distributed	Tick Plot	Deciduous Forest	5
Distributed	Tick Plot	Evergreen Forest	1
Tower	Base Plot	NA	20
Tower	phenology	NA	2

NLCD land cover classes are not used to stratify Tower Plots which are located in and around the NEON tower airshed. The dominant NLCD land cover type within the airshed is deciduous forest.

Table 3: Number of Distributed Base Plots per NLCD land cover class per protocol at ORNL.

Plot Type	Plot Subtype	NLCD Class	Protocols	Number of Plots
Distributed	Base Plot	Deciduous Forest	Beetles	5
Distributed	Base Plot	Evergreen Forest	Beetles	3
Distributed	Base Plot	Pasture Hay	Beetles	2
Distributed	Base Plot	Deciduous Forest	Canopy Foliage Chemistry	8
Distributed	Base Plot	Evergreen Forest	Canopy Foliage Chemistry	1
Distributed	Base Plot	Pasture Hay	Canopy Foliage Chemistry	1
Distributed	Base Plot	Deciduous Forest	Coarse Downed Wood	11
Distributed	Base Plot	Evergreen Forest	Coarse Downed Wood	5
Distributed	Base Plot	Pasture Hay	Coarse Downed Wood	4
Distributed	Base Plot	Deciduous Forest	Digital Hemispherical Photos for Leaf Area Index	11
Distributed	Base Plot	Evergreen Forest	Digital Hemispherical Photos for Leaf Area Index	5
Distributed	Base Plot	Pasture Hay	Digital Hemispherical Photos for Leaf Area Index	4
Distributed	Base Plot	Deciduous Forest	Herbaceous Biomass	11
Distributed	Base Plot	Evergreen Forest	Herbaceous Biomass	5
Distributed	Base Plot	Pasture Hay	Herbaceous Biomass	4
Distributed	Base Plot	Deciduous Forest	Plant Diversity	17
Distributed	Base Plot	Evergreen Forest	Plant Diversity	7
Distributed	Base Plot	Pasture Hay	Plant Diversity	6
Distributed	Base Plot	Deciduous Forest	Soil Biogeochemistry	5
Distributed	Base Plot	Evergreen Forest	Soil Biogeochemistry	1
Distributed	Base Plot	Deciduous Forest	Soil Microbes	5
Distributed	Base Plot	Evergreen Forest	Soil Microbes	1

Plot Type	Plot Subtype	NLCD Class	Protocols	Number of Plots
Distributed	Base Plot	Deciduous Forest	Vegetation Structure	17
Distributed	Base Plot	Evergreen Forest	Vegetation Structure	5
Distributed	Base Plot	Pasture Hay	Vegetation Structure	4

Note: Distributed Base Plots typically support more than one TOS protocol; 'Number of Plots' cannot be added to get total TOS Distributed Base Plot number.

Table 4: Number of Tower Plots per protocol at ORNL.

Plot Type	Plot Subtype	Protocols	Number of Plots
Tower	Base Plot	Canopy Foliage Chemistry	4
Tower	Base Plot	Coarse Downed Wood	20
Tower	Base Plot	Digital Hemispherical Photos for Leaf Area Index	3
Tower	Base Plot	Herbaceous Biomass	20
Tower	Base Plot	Litterfall and Fine Woody Debris	20
Tower	Base Plot	Plant Belowground Biomass	20
Tower	Base Plot	Plant Diversity	3
Tower	Base Plot	Soil Biogeochemistry	4
Tower	Base Plot	Soil Microbes	4
Tower	Base Plot	Vegetation Structure	20
Tower	Phenology	Plant Phenology	2

Note: Tower Base Plots typically support more than one TOS protocol; 'Number of Plots' cannot be added to get the total TOS Tower Base Plot number.

4.2 Sampling Season Characterization: ORNL

For numerous TOS protocols, the length of the sampling season, the number of bouts, and when those bouts occur is dictated by the seasonal status of the plant community. By monitoring 'greenness' on a 16 day interval, the MODIS/Terra EVI phenology product provides consistent, reliable insight into plant community phenology and intensity at the continental scale. For those protocols for which timing is standardized by greenness transitions and/or peak green status, NEON has utilized these data as the primary means of guiding temporal aspects of TOS sampling at each site.

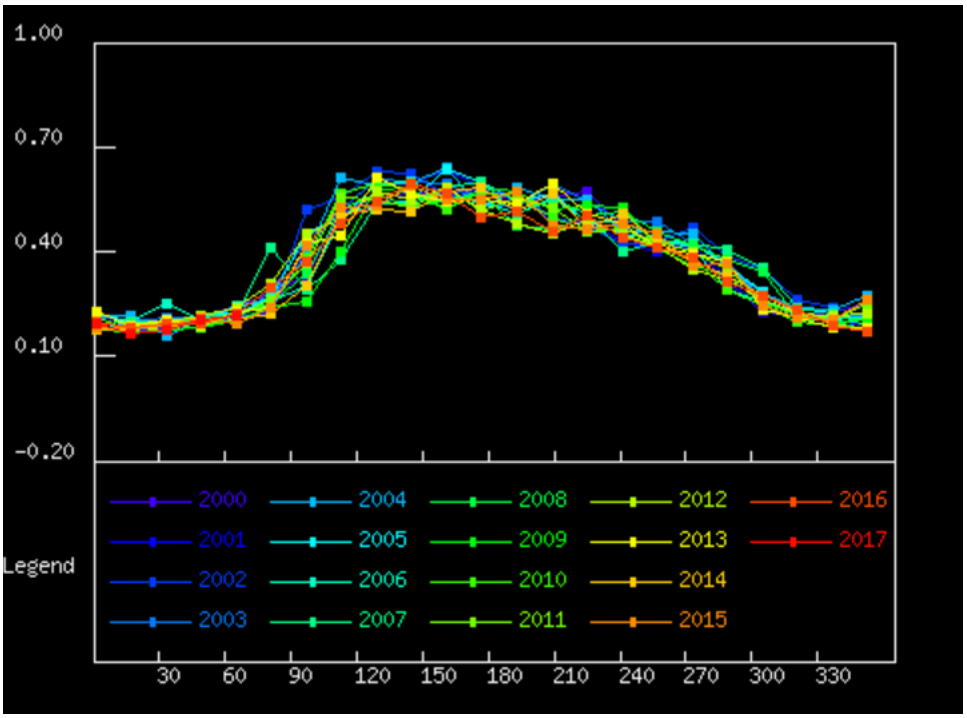

Figure 6: MODIS-EVI greenness (y-axis = EVI ratio) as a function of time (x-axis = DOY) for the years 2000-2017 at the NEON ORNL site.

Table 5: Average MODIS-EVI greenness dates for the NEON ORNL site, based on data from 2000-2017 (DOY, with MM/DD in parentheses).

Average Increase	Average Maximum	Average Decrease	Average Minimum
90 (04/01)	140 (05/21)	210 (07/30)	315 (11/12)

MODIS Product Details

- Product: MODIS-EVI phenology product, 16 day interval, 250 m grid, data included from all pixels with acceptable quality within user-defined square that roughly overlaps the TOS site boundary.
- Date range: 2000-2017
- User selected area: 6.25 km x 6.25 km box, centroid 35.964, Longitude: -84.283 (WGS84 datum)

4.3 Belowground Biomass

4.3.1 Site-Specific Methods

Belowground biomass characterization data were collected down to a depth of 180 cm by NEON staff in September 2013. Since the NEON protocol for long-term, operational sampling of belowground biomass only collects data to a depth of 30 cm, the belowground biomass site characterization data are critical for scaling belowground biomass measurements to greater depths; see the TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index (AD[7]) for more information. Samples were collected following the standard methods outlined in TOS Site Characterization Methods (RD[6]). Roots were sorted to two diameter size categories ($\leq$ 2 mm and 2-30 mm) and by root status (live or dead). The tables below summarize all the belowground biomass less than or equal to 30 mm diameter; size class data and more information can be found by searching the NEON data portal for the data product numbers in Appendix A.

4.3.2 Results

Table 6: Soil Pit Information at ORNL.

Latitude	Longitude	Soil Family	Soil Order
35.57525	-84.16581	Fine - kaolinitic - thermic Typic Paleudults	Ultisol

Soil Profile was described by Natural Resource Conservation Service (NRCS).

Table 7: Fine root mass per depth increment (cm) at ORNL.

Upper Depth	Lower Depth	Mean (mg per cm^3)	Std Dev
0	10	10.84	6.5
10	20	3.21	1.59
20	30	0.78	0.38
30	40	1.72	1.73
40	50	0.71	0.71
50	60	0.42	0.34
60	70	0.24	0.2
70	80	0.12	0.02
80	90	0.28	0.34
90	100	0.68	0.91
100	120	0.25	0.21
120	140	0.31	0.31
140	160	0.21	0.15

Upper Depth	Lower Depth	Mean (mg per cm^3)	Std Dev
160	180	0.15	0.18

Table 8: Cumulative fine root mass as a function of depth (cm) at ORNL.

Upper Depth	Lower Depth	Mean Cumulative (g per m^2)	Cumulative Std Dev
0	10	1083.98	650.08
10	20	1405.01	491.19
20	30	1482.66	468.89
30	40	1654.45	330.64
40	50	1725.17	295.14
50	60	1766.92	327.51
60	70	1790.55	337.34
70	80	1802.45	338.86
80	90	1830.11	372.58
90	100	1898.16	463.7
100	120	1948.76	504.03
120	140	2011.6	561.5
140	160	2053.14	588.31
160	180	2083.01	624.07

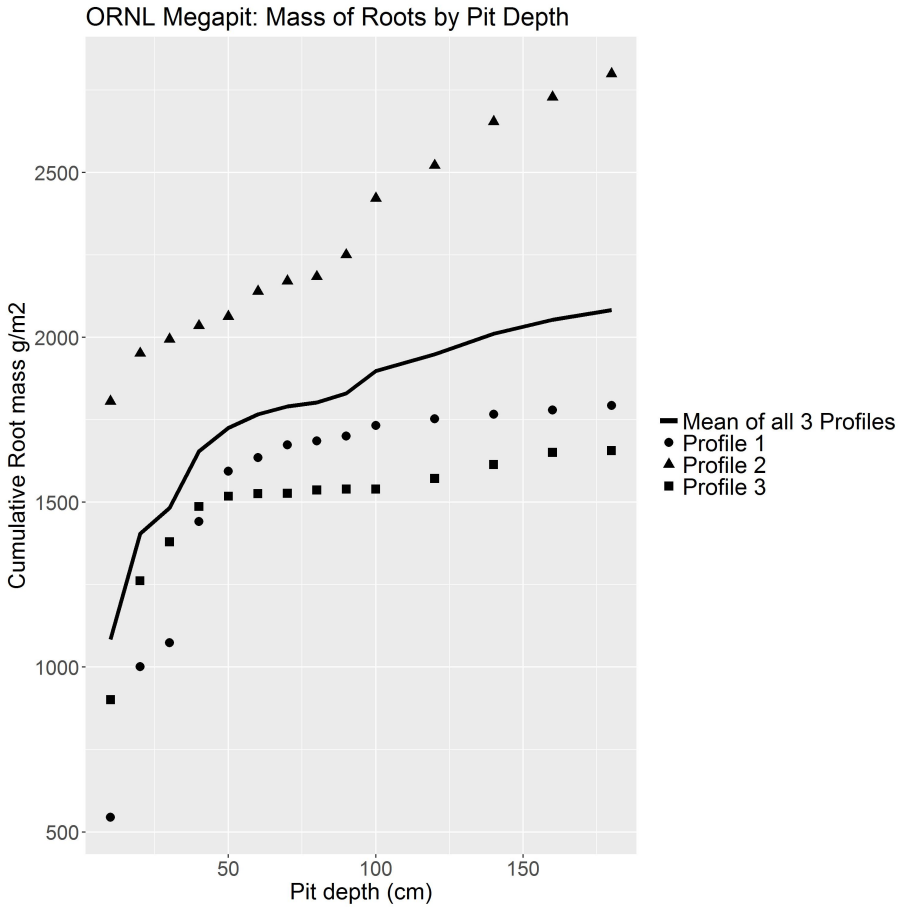

Figure 7: Cumulative root mass by pit depth at ORNL.

Table 9: Fine root biomass sampling summary data at ORNL.

Total Pit Depth (cm)	180
Total Mean Cumulative Mass at 30cm (g per m^2)	1482.66
Total Mean Cumulative Mass at 100cm (g per m^2)	1898.16
Total Mean Cumulative Mass (g per m^2)	2083.01

4.4 Plant Characterization and Phenology Species Selection

4.4.1 Site-Specific Methods

Plant characterization data were collected by an external contractor during August of 2013. Plant characterization data informs sampling procedures for plant phenology and plant productivity protocols.

The overall ranking ("Rank" in the table below) was calculated based on three separate measurements. Overall ranking weights are influenced by the number of species within each grouping.

1. Mean percent cover values were calculated based on species specific cover estimation for all plant species under 3m tall in eight 1m by 1m subplots per plot; see the TOS Protocol and Procedure: Plant Diversity Sampling (RD[09]) for more information.
2. Mean canopy area values were calculated based on all species specific shrub canopy diameter measurements within the entire plot or subplot; see the TOS Protocol and Procedure: Measurement of Vegetation Structure (RD[10]) for more information.
3. Mean ABH (area at breast height) measurements were calculated based on diameter at breast height measurements for all woody vegetation with a diameter greater than 1cm at 130cm height within the entire plot or subplot; see the TOS Protocol and Procedure: Measurement of Vegetation Structure (RD[10]) for more information.

The standard field methods and ranking calculations are further outlined in TOS Site Characterization Methods (RD[6]). For more information on this protocol and data product numbers see Appendix A.

4.4.2 Results

Table 10: Site plant characterization and phenology species summary at ORNL.

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
ACRU	*Acer rubrum* L.	1	21	NA	3.7
QURU	*Quercus rubra* L.	10	<1	NA	1.69
ACSA3	*Acer saccharum* Marshall	11	2	NA	0.88
VIMI2	*Vinca minor* L.	12	3	NA	NA
SAAL5	*Sassafras albidum* (Nutt.) Nees	13	2	NA	0.04
CAAL27	*Carya tomentosa* (Lam.) Nutt.	14	<1	NA	0.84
CECA4	*Cercis canadensis* L.	15	2	NA	0.03
PIST	*Pinus strobus* L.	16	1	NA	0.16
LIST2	*Liquidambar styraciflua* L.	17	1	NA	0.05
QUCO2	*Quercus coccinea* Münchh.	18	<1	NA	0.92
VIRO3	*Vitis rotundifolia* Michx.	19	1	NA	NA
NYSY	*Nyssa sylvatica* Marshall	2	7	NA	0.59
CACA18	*Carpinus caroliniana* Walter	20	1	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
PRSE2	*Prunus serotina* Ehrh.	21	<1	NA	0.32
TORA2	*Toxicodendron radicans* (L.) Kuntze	22	<1	NA	NA
POAC4	*Polystichum acrostichoides* (Michx.) Schott	23	<1	NA	NA
VAPA4	*Vaccinium pallidum* Aiton	24	<1	NA	NA
LOJA	*Lonicera japonica* Thunb.	25	<1	NA	NA
VACO	*Vaccinium corymbosum* L.	26	<1	NA	NA
AMBR2	*Amphicarpaea bracteata* (L.) Fernald	27	<1	NA	NA
CAOV3	*Carya ovalis* (Wangenh.) Sarg.	28	<1	NA	0.31
MATR	*Magnolia tripetala* (L.) L.	29	<1	NA	0.02
QUPR2	*Quercus montana* Willd.	3	<1	NA	5.31
FRAM2	*Fraxinus americana* L.	30	<1	NA	NA
PIEC2	*Pinus echinata* Mill.	31	NA	NA	0.33
ILMO	*Ilex montana* Torr. & A. Gray ex A. Gray	32	<1	NA	NA
AMAR3	*Amelanchier arborea* (Michx. f.) Fernald	33	<1	NA	0.06
LIBE3	*Lindera benzoin* (L.) Blume	34	<1	NA	NA
CAOV2	*Carya ovata* (Mill.) K. Koch	35	NA	NA	0.21
DENU4	*Desmodium nudiflorum* (L.) DC.	36	<1	NA	NA
CAGL8	*Carya glabra* (Mill.) Sweet	37	<1	NA	NA
ULRU	*Ulmus rubra* Muhl.	38	<1	NA	0.07
PAQU2	*Parthenocissus quinquefolia* (L.) Planch.	39	<1	NA	NA
QUAL	*Quercus alba* L.	4	<1	NA	5.45
SMRO	*Smilax rotundifolia* L.	40	<1	NA	NA
JUNI	*Juglans nigra* L.	41	NA	NA	0.12
DIVI5	*Diospyros virginiana* L.	42	<1	NA	NA
CANI3	*Carex nigromarginata* Schwein.	43	<1	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
ILOP	*Ilex opaca* Aiton	44	<1	NA	NA
VAST	*Vaccinium stamineum* L.	45	<1	NA	NA
DIVI4	*Dioscorea villosa* L.	46	<1	NA	NA
CACO15	*Carya cordiformis* (Wangenh.) K. Koch	47	NA	NA	0.09
POVI2	*Polygonum virginianum* L.	48	<1	NA	NA
SMGL	*Smilax glauca* Walter	48	<1	NA	NA
LITU	*Liriodendron tulipifera* L.	5	<1	NA	4.25
ULAM	*Ulmus americana* L.	50	NA	NA	0.07
HEAR6	*Hexastylis arifolia* (Michx.) Small	52	<1	NA	NA
VEOC	*Verbesina occidentalis* (L.) Walter	52	<1	NA	NA
MIRE	*Mitchella repens* L.	56	<1	NA	NA
RHPE4	*Rhododendron periclymenoides* (Michx.) Shinners	56	<1	NA	NA
RUFL	*Rubus flagellaris* Willd.	58	<1	NA	NA
QUFA	*Quercus falcata* Michx.	59	<1	NA	NA
FAGR	*Fagus grandifolia* Ehrh.	6	6	NA	0.2
VIRU	*Viburnum rufidulum* Raf.	60	<1	NA	NA
DIBO2	*Dichanthelium boscii* (Poir.) Gould & C.A. Clark	61	<1	NA	NA
FRCA13	*Frangula caroliniana* (Walter) A. Gray	62	<1	NA	NA
MIVI	*Microstegium vimineum* (Trin.) A. Camus	63	<1	NA	NA
PIVI2	*Pinus virginiana* Mill.	64	NA	NA	0.03
ULAL	*Ulmus alata* Michx.	65	<1	NA	0.02
JUVI	*Juniperus virginiana* L.	66	<1	NA	0.01
BOVI	*Botrychium virginianum* (L.) Sw.	67	<1	NA	NA
EUAM9	*Euonymus americanus* L.	67	<1	NA	NA
VIAE	*Vitis aestivalis* Michx.	67	<1	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
VIRO2	*Viola rotundifolia* Michx.	67	<1	NA	NA
COFL2	*Cornus florida* L.	7	5	NA	0.02
RUAR2	*Rubus argutus* Link	71	<1	NA	NA
ASTR	*Asimina triloba* (L.) Dunal	72	<1	NA	NA
BRER2	*Brachyelytrum erectum* (Schreb. ex Spreng.) P. Beauv.	73	<1	NA	NA
ASPL	*Asplenium platyneuron* (L.) Britton, Sterns & Poggenb.	74	<1	NA	NA
HYAR	*Hydrangea arborescens* L.	74	<1	NA	NA
ARSE3	*Aristolochia serpentaria* L.	76	<1	NA	NA
CALE10	*Carex leptalea* Wahlenb.	76	<1	NA	NA
CAPE6	*Carex pensylvanica* Lam.	76	<1	NA	NA
RUCA4	*Ruellia caroliniensis* (J.F. Gmel.) Steud.	76	<1	NA	NA
UVSE	*Uvularia sessilifolia* L.	76	<1	NA	NA
OXAR	*Oxydendrum arboreum* (L.) DC.	8	2	NA	1.05
CHMA3	*Chimaphila maculata* (L.) Pursh	81	<1	NA	NA
HENOO	*Hepatica nobilis* Schreb. var. *obtusa* (Pursh) Steyerm.	81	<1	NA	NA
BODI2	*Botrychium dissectum* Spreng.	83	<1	NA	NA
CIAR2	*Cinna arundinacea* L.	83	<1	NA	NA
DELA2	*Desmodium laevigatum* (Nutt.) DC.	83	<1	NA	NA
IPPA	*Ipomoea pandurata* (L.) G. Mey.	83	<1	NA	NA
PRENA	*Prenanthes* sp.	83	<1	NA	NA
SACA15	*Sanicula canadensis* L.	83	<1	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
SYLA4	*Symphyotrichum lateriflorum* (L.) Á. Löve & D. Löve	83	<1	NA	NA
THTH2	*Thalictrum thalictroides* (L.) Eames & B. Boivin	83	<1	NA	NA
VITR4	*Viola tripartita* Elliott	83	<1	NA	NA
GECA7	*Geum canadense* Jacq.	83	<1	NA	NA
QUVE	*Quercus velutina* Lam.	9	<1	NA	1.9
ELUM	*Elaeagnus umbellata* Thunb.	94	<1	NA	NA
ACGR2	*Acalypha gracilens* A. Gray	95	NA	NA	NA
AGPU	*Agrimonia pubescens* Wallr.	95	NA	NA	NA
ANQU	*Anemone quinquefolia* L.	95	NA	NA	NA
ARTR	*Arisaema triphyllum* (L.) Schott	95	NA	NA	NA
AULA	*Aureolaria laevigata* (Raf.) Raf.	95	NA	NA	NA
BICA	*Bignonia capreolata* L.	95	NA	NA	NA
CAST9	*Carex styloflexa* Buckley	95	NA	NA	NA
DICO2	*Dichanthelium commutatum* (Schult.) Gould	95	NA	NA	NA
DIQU	*Dioscorea quaternata* J.F. Gmel.	95	NA	NA	NA
EUME4	*Euphorbia mercurialina* Michx.	95	NA	NA	NA
GACI2	*Galium circaezans* Michx.	95	NA	NA	NA
GAVO	*Galactia volubilis* (L.) Britton	95	NA	NA	NA
GOPU	*Goodyera pubescens* (Willd.) R. Br.	95	NA	NA	NA
LISI	*Ligustrum sinense* Lour.	95	NA	NA	NA
MARA7	*Maianthemum racemosum* (L.) Link	95	NA	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
PALU2	*Passiflora lutea* L.	95	NA	NA	NA
PHLE5	*Phryma leptostachya* L.	95	NA	NA	NA
POPE	*Podophyllum peltatum* L.	95	NA	NA	NA
PRSE	*Prenanthes serpentaria* Pursh	95	NA	NA	NA
ROSA5	*Rosa* sp.	95	NA	NA	NA
SOCU	*Solidago curtisii* Torr. & A. Gray	95	NA	NA	NA
VEGI	*Vernonia gigantea* (Walter) Trel.	95	NA	NA	NA
VIBL	*Viola blanda* Willd.	95	NA	NA	NA
VIHI2	*Viola hirsutula* Brainerd	95	NA	NA	NA
VIOLA	*Viola* sp.	95	NA	NA	NA
VIPA18	*Viola* ×*palmata* L. (pro sp.)	95	NA	NA	NA
VISO	*Viola sororia* Willd.	95	NA	NA	NA

Note:Taxon IDs and scientific names are based on the USDA Plants database (plants.usda.gov).

Table 11: Per plot breakdown of species richness, diversity, and herbaceous cover at ORNL.

Plot ID	Species Richness	Shannon Diversity Index	Percent Total Herbaceous Cover
20843	25	2.32	49
22891	10	1.73	14
28011	13	2.05	32
363	14	1.63	21
39227	16	1.85	21
6459	24	2.39	86
6507	27	2.92	31
69995	25	2.4	72
864619	27	2.01	175
9579	30	2.77	67
ORNL_036	26	2.58	33
ORNL_037	19	2.55	37

Plot ID	Species Richness	Shannon Diversity Index	Percent Total Herbaceous Cover
ORNL_043	21	1.79	82
ORNL_046	12	1.16	8
ORNL_049	27	1.81	84
ORNL_053	15	2.15	19
ORNL_058	31	2.76	39
ORNL_060	23	2.29	21
ORNL_061	13	1.87	8
ORNL_063	27	2.3	54

Note: Percent herbaceous cover was measured by species and then added together to calculate the percent total herbaceous cover for each plot. Plot IDs that do not contain "ORNL" were plots used for site characterization sampling only and are within 250m of ORNL Tower Base Plots.

Bryophyte percent cover data were used to determine which sites qualify for implementation of the Bryophyte Productivity protocol. However, bryophyte productivity sampling was discontinued in 2018 and NEON no longer implements this protocol. No bryophyte cover was recorded in ORNL Tower Base Plots.

4.5 Beetles

4.5.1 Site-Specific Methods

Beetle site characterization was conducted in June 2013 by NEON staff following the standard methods outlined in TOS Site Characterization Methods (RD[6]). All beetles collected at ORNL were pooled before being sent for identification. Beetle site characterization data were collected to start site level teaching collections. For DNA sequence data generated as a result of these efforts, visit the Barcode of Life Datasystems (BOLD) at http://www.boldsystems.org. For more information on this protocol and data product numbers see Appendix A.

4.5.2 Results

Table 12: Beetle identification results at ORNL.

Sample ID	Scientific Name
NEONTcarabid8122	*Cyclotrachelus fucatus*
NEONTcarabid8123	*Cyclotrachelus sodalis sodalis*
NEONTcarabid8118	*Cyclotrachelus fucatus*
NEONTcarabid8119	*Cyclotrachelus fucatus*
NEONTcarabid8120	*Cyclotrachelus fucatus*

Sample ID	Scientific Name
NEONTcarabid8121	*Cyclotrachelus sodalis sodalis*
NEONTcarabid8124	*Trichotichnus autumnalis*

4.6 Mosquitoes

4.6.1 Site-Specific Methods

Mosquito site characterization was conducted in June 2013 by NEON staff following the standard methods outlined in TOS Site Characterization Methods (RD[6]) to test protocol methods and start site level species lists. All samples were pooled into vials before being sent for identification. No pathogen testing was performed. For more information on this protocol and data product numbers see Appendix A.

4.6.2 Results

Table 13: Mosquito identification results at ORNL.

Vial ID	Scientific Name	sex	Individual Count
ORNL.May2013.SC.1	*Aedes sticticus*	female	44
ORNL.May2013.SC.1	*Aedes vexans*	female	24
ORNL.May2013.SC.1	*Aedes* spp	male	28
ORNL.May2013.SC.1	*Anopheles punctipennis*	female	3
ORNL.May2013.SC.1	*Culex* spp	female	1
ORNL.May2013.SC.2	*Aedes sticticus*	female	71
ORNL.May2013.SC.2	*Aedes triseriatus*	female	3
ORNL.May2013.SC.2	*Aedes vexans*	female	18
ORNL.May2013.SC.2	*Aedes* spp	female	5
ORNL.May2013.SC.2	*Anopholes punctipennis*	female	1
ORNL.May2013.SC.2	*Culex restuans*	female	2

4.7 Ticks

4.7.1 Site-Specific Methods

Tick site characterization was conducted in June 2013 by NEON staff following the standard methods outlined in TOS Site Characterization Methods (RD[6]) to test protocol methods and start site level species lists. All samples were pooled into vials before being sent for identification. No pathogen testing was performed. For more information on this protocol and data product numbers see Appendix A.

4.7.2 Results

Table 14: Tick identification results at ORNL.

Vial ID	Scientific Name	Adult Male	Adult Female	Nymph
ORNL.000.20130529.SC.1	*Dermacentor variabilis*	2	8	0
ORNL.000.20130529.SC.1	*Amblyomma americanum*	49	71	10

4.8 Species Reference Lists

A review of the literature for taxonomic lists of interest for each site was conducted prior to field work. In the case of vertebrates that NEON may capture (e.g., reptiles, amphibians, small mammals), these lists were often required to secure permits. Key references identified in this effort are listed below. Species lists and associated references for small mammals and breeding landbirds can be found in the appendices of the respective protocols (RD[07], RD[08]).

Awl, D. J., L. R. Pounds, B. A. Rosensteel, A. L. King, and P. A. Hamlett. 1996. Survey of Protected Vascular Plants on the Oak Ridge Reservation, Oak Ridge, Tennessee. ES/ER/TM-194. Oak Ridge National Laboratory, Oak Ridge, TN. Retrieved from http://www.esd.ornl.gov/facilities/nerp/awl_et_al.pdf.

Bousquet, Y. 2012. Catalogue of Geadephaga (Coleoptera, Adephaga) of America, north of Mexico. ZooKeys, (245), 1-1722.

Darsie Jr., R. F., and R. A. Ward. 2005. Identification and geographical distribution of the mosquitoes of North America, North of Mexico. University Press of Florida, Gainesville.

Durr, Paul. 2009. Graminoid Survey of the Oak Ridge Reservation. Water Resouces. Retrieved from http://www.esd.ornl.gov/facilities/nerp/Durr_Graminoid-Survey-2009.pdf.

Klein, J.A. 1989. A Check List of the Reptiles and Amphibians on the Department of Energy Oak Ridge Reservation, Anderson and Roane Counties, Tennessee. Journal of the Tennessee Academy of Science, (64:4).

Oak Ridge National Environmental Research Park: Available Data. http://www.esd.ornl.gov/facilities/nerp/data.html. November 12, 2009.

Parr, Patricia D., and Joan F. Hughes. 2006. Oak Ridge Reservation Physical Characteristics and Natural Resources. ORNL/TM-2006/110. Retrieved from http://www.esd.ornl.gov/facilities/nerp/ORNL-TM2006-110.pdf.

5 RELOCATABLE SITE 1- MOUNTAIN LAKE BIOLOGICAL STATION (MLBS)

Located 20 kilometers northwest of Blacksburg, VA, Mountain Lake Biological Station is a high elevation site along the Appalachian Mountains. MLBS sits on the divide between the Atlantic and Mississippi drainage basins and is surrounded by USFS land. The site has a long history of terrestrial and aquatic field biology research (About the Station, 2015).

Figure 8: Phenocamera image for MLBS. The phenocamera is located at the top of the NEON tower and faces north. Phenocamera images are available at https://phenocam.sr.unh.edu/webcam/network/table/.

Key Characteristics:

- Site host: University of Virginia, United States Forest Service, Private Landowner
- Located in: Giles County, VA
- Sampling Area: 11.14 km^2
- Plot Elevation: 750-1320m
- Dominant vegetation type: The vegetation at MLBS is typical of Southern Appalachian forests and is a mosaic of deciduous species. Red maple (*Acer rubrum*) and white oak (*Quercus alba*) dominate the canopy. Witch-hazel (*Hamamelis virginiana*) and shadbush (*Amelanchier laevisare*) are common throughout the understory and pockets of eastern white pine (*Pinus strobus*) are found along the creeks.

- General management: MLBS was established in 1930 by the University of Virginia's (UVA) Department of Biology as a summer facility for teaching and research, but took off as a national research station in the late 1960's and early 1970's. It is a full service research station managed by UVA that supports summer field courses, Research Experiences for Undergraduates, and numerous research projects (About the Station, 2015). The northern two parcels that are owned by the USFS are currently managed for white oak (*Quercus alba*) and recreational activities.
- Plot Selection: NEON TOS Plots were allocated across the site following NEON standard criteria and avoiding existing research. The three separate sampling areas are discontinuous to avoid U.S. Wilderness Areas located near the tower site.

5.1 TOS Spatial Sampling Design

TOS Distributed Plots were allocated at MLBS according to a spatially balanced and stratified-random design (RD[3]). The 2011 National Land Cover Database (NLCD) was selected for stratification because of the consistent and comparable data availability across the United States. After multiple site visits and ground truthing exercises it was decided to absorb the area NLCD classifies as mixed forest into the area NLCD classifies as deciduous forest. The site is managed for white oak (*Quercus alba*) and there are not enough evergreen trees to warrant a mixed forest layer. TOS Tower Plots were allocated according to a spatially balanced design in and around the NEON tower airshed (RD[03]). The maps below depict the plot locations for the first year of NEON sampling. Some plot locations may change over time due to logistics, safety, and science requirements. Please visit the NEON website (http://www.neonscience.org) for updated plot locations at each site.

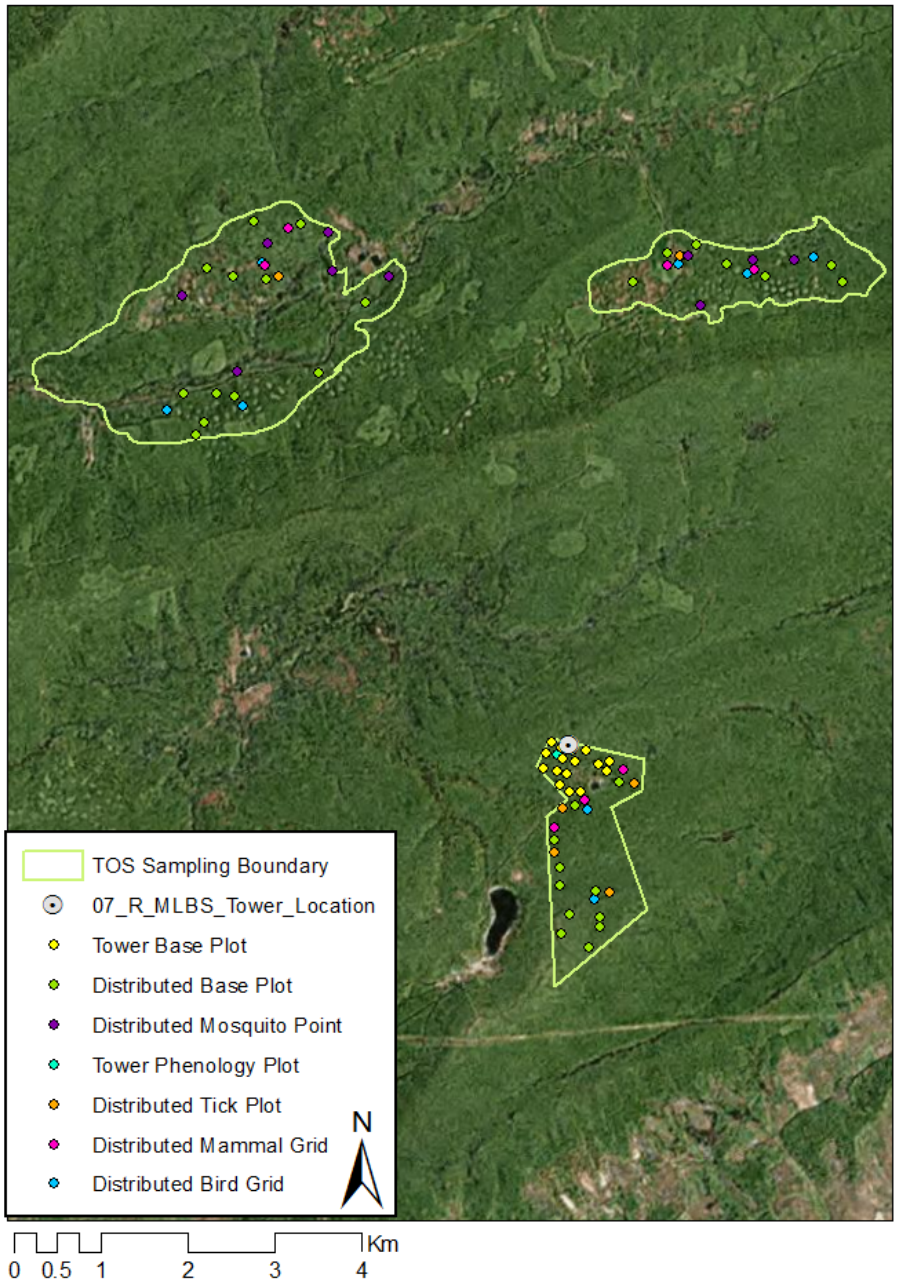

Figure 9: Map of TOS plot centroids within the NEON TOS sampling boundary at MLBS.

For a list of protocols associated with each plot see tables below; for additional spatial design information see

RD[03].

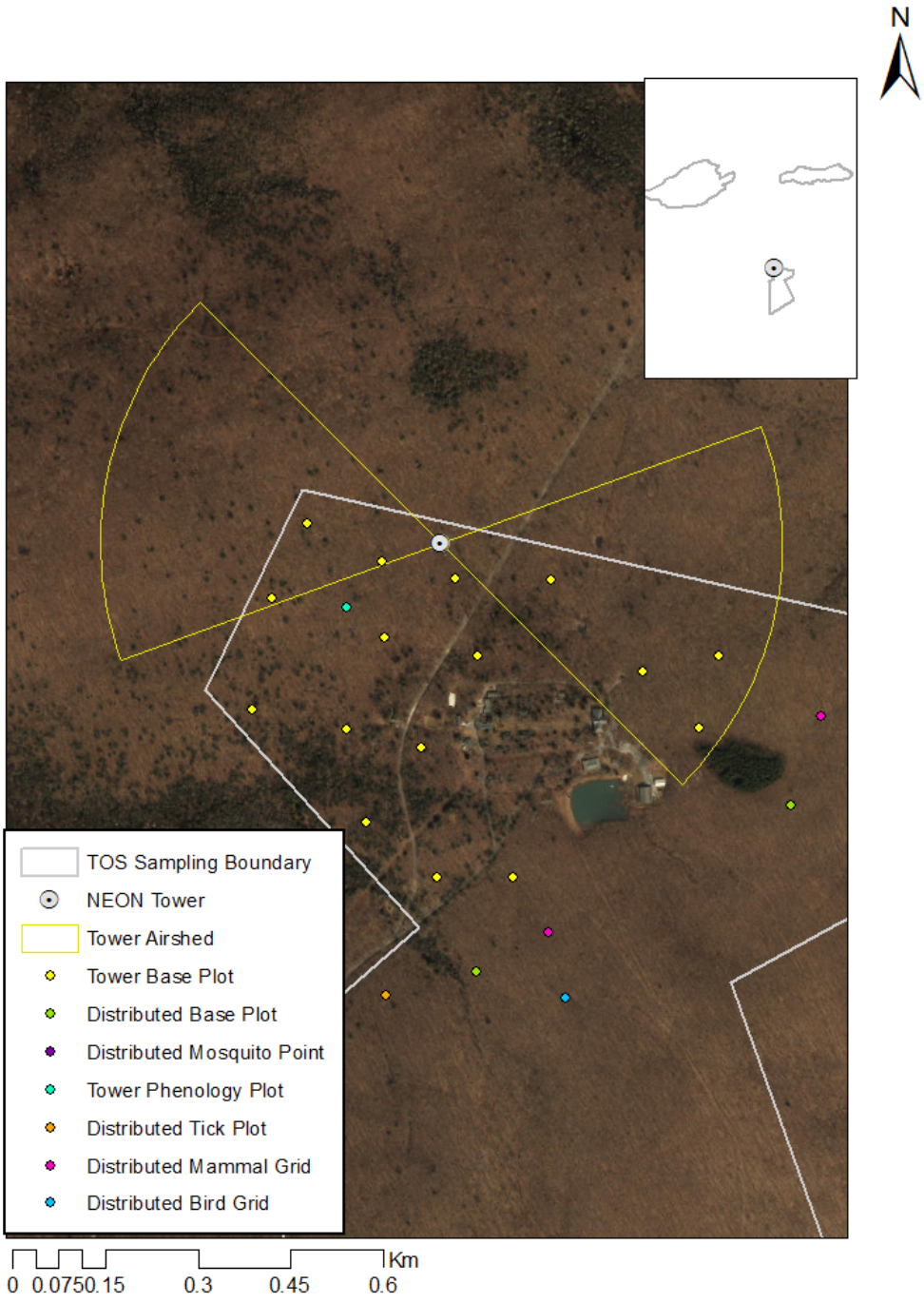

Figure 10: Map of the tower airshed and TOS plot centroids at MLBS.

More information about the tower airshed can be found in the FIU site characterization report (RD[04]).

Table 15: NLCD land cover classes and area within the TOS site boundary at MLBS.

NLCD Class	Site Area (km^2)	Percent (%)
Deciduous Forest	8.99	80.58
Evergreen Forest	1.25	11.23
Mixed Forest	0.44	3.94
Developed Open Space	0.24	2.14
Grassland Herbaceous	0.2	1.81
Woody Wetlands	0.02	0.19
Emergent Herbaceous Wetlands	0.01	0.06
Open Water	0.01	0.05

Note: Any NLCD land cover classes less than 5% will not be sampled. Additionally, no sampling will take place in Water, Developed, or Barren Land NLCD classes.

Table 16: NLCD land cover classes and TOS plot numbers at MLBS.

Plot Type	Plot Subtype	NLCD Class	Number of Plots Established
Distributed	Base Plot	Deciduous Forest	30
Distributed	Bird Grid	Deciduous Forest	8
Distributed	Mammal Grid	Deciduous Forest	6
Distributed	Mosquito Point	Deciduous Forest	10
Distributed	Tick Plot	Deciduous Forest	6
Tower	Base Plot	NA	16
Tower	Phenology Plot	NA	1

Note:NLCD land cover classes are not used to stratify Tower Plots which are located in and around the NEON tower airshed. The dominant NLCD land cover type within the airshed is deciduous forest.

Table 17: Number of Distributed Base plots per NLCD land cover class per protocol at MLBS.

Plot Type	Plot Subtype	NLCD Class	Protocols	Number of Plots
Distributed	Base Plot	Deciduous Forest	Beetles	10
Distributed	Base Plot	Deciduous Forest	Canopy Foliage Chemistry	10
Distributed	Base Plot	Deciduous Forest	Coarse Downed Wood	20
Distributed	Base Plot	Deciduous Forest	Digital Hemispherical Photos for Leaf Area Index	20

Plot Type	Plot Subtype	NLCD Class	Protocols	Number of Plots
Distributed	Base Plot	Deciduous Forest	Herbaceous Biomass	20
Distributed	Base Plot	Deciduous Forest	Plant Diversity	30
Distributed	Base Plot	Deciduous Forest	Soil Biogeochemistry	6
Distributed	Base Plot	Deciduous Forest	Soil Microbes	6
Distributed	Base Plot	Deciduous Forest	Vegetation Structure	20

Note: Distributed Base Plots typically support more than one TOS protocol; 'Number of Plots' cannot be added to get total TOS Distributed Base Plot number.

Table 18: Number of Tower Plots per protocol at MLBS.

Plot Type	Plot Subtype	Protocols	Number of Plots
Tower	Base Plot	Canopy Foliage Chemistry	4
Tower	Base Plot	Coarse Downed Wood	16
Tower	Base Plot	Digital Hemispherical Photos for Leaf Area Index	3
Tower	Base Plot	Herbaceous Biomass	16
Tower	Base Plot	Litterfall and Fine Woody Debris	16
Tower	Base Plot	Plant Belowground Biomass	16
Tower	Base Plot	Plant Diversity	3
Tower	Base Plot	Soil Biogeochemistry	4
Tower	Base Plot	Soil Microbes	4
Tower	Base Plot	Vegetation Structure	16
Tower	Phenology	Plant Phenology	1

Note: Tower Base Plots typically support more than one TOS protocol; 'Number of Plots' cannot be added to get total TOS Tower Base Plot number.

5.2 Sampling Season Characterization: MLBS

For numerous TOS protocols, the length of the sampling season, the number of bouts, and when those bouts occur is dictated by the seasonal status of the plant community. By monitoring 'greenness' on a 16 day interval, the MODIS/Terra EVI phenology product provides consistent, reliable insight into plant community phenology and intensity at the continental scale. For those protocols for which timing is standardized by greenness transitions and/or peak green status, NEON has utilized these data as the primary means of guiding temporal aspects of TOS sampling at each site.

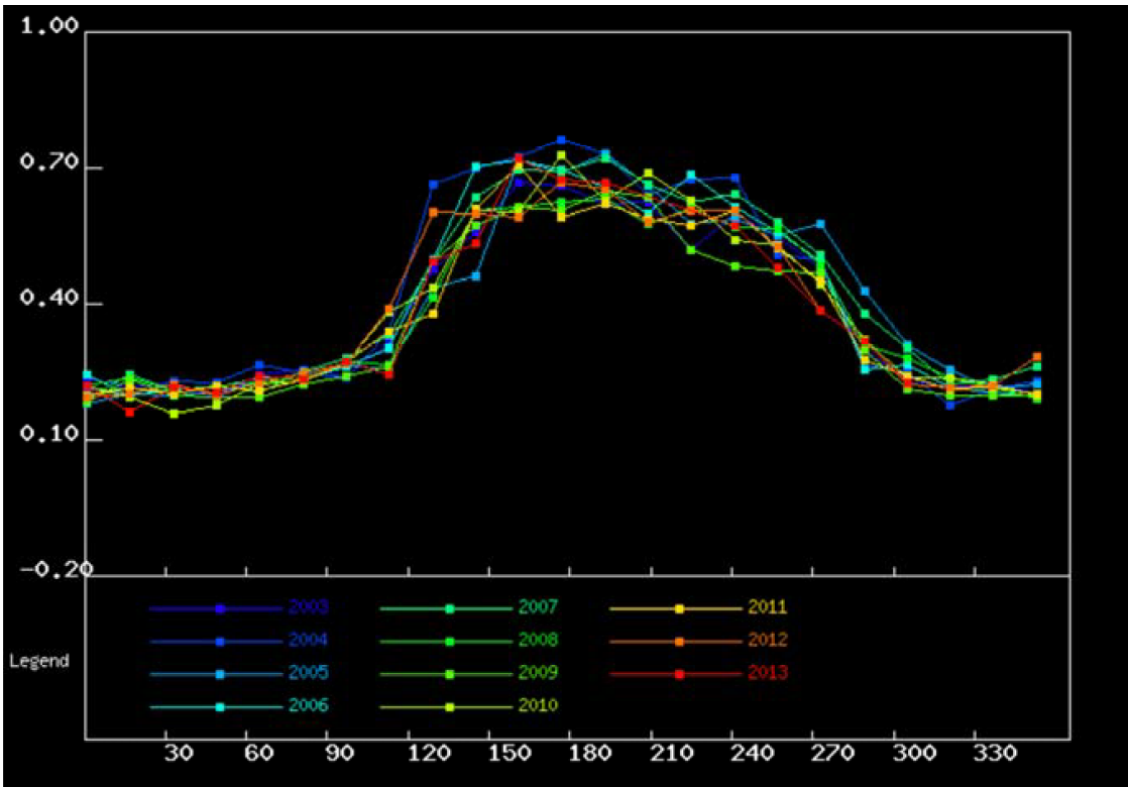

Figure 11: MODIS-EVI greenness (y-axis = EVI ratio) as a function of time (x-axis = DOY) for the years 2003-2013 at the NEON MLBS site.

Table 19: Average MODIS-EVI greenness dates for the NEON MLBS site, based on data from 2003-2013 (DOY, with MM/DD in parentheses).

Average Increase	Average Maximum	Average Decrease	Average Minimum
110 (04/21)	160 (06/10)	220 (08/09)	310 (11/07)

MODIS Product Details

- Product: MODIS-EVI phenology product, 16 day interval, 250 m grid, data included from all pixels with acceptable quality within user-defined square that roughly overlaps the TOS site boundary.
- Date range: 2003-2013
- User selected area: 10.25 km x 10.25 km box, centroid: 37.37818, -80.524665 (WGS84 datum)

5.3 Belowground Biomass

5.3.1 Site-Specific Methods

Belowground biomass characterization data were collected down to a depth of 120 cm by NEON staff in December 2013. Since the NEON protocol for long-term, operational sampling of belowground biomass only collects data to a depth of 30 cm, the belowground biomass site characterization data are critical for scaling belowground biomass measurements to greater depths; see the TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index (AD[7]) for more information. Samples were collected following the standard methods outlined in TOS Site Characterization Methods (RD[6]). Roots were sorted to two diameter size categories ($\leq$ 2 mm and 2-30 mm) and by root status (live or dead). The tables below summarize all the belowground biomass less than or equal to 30 mm diameter; size class data and more information can be found by searching the NEON data portal for the data product numbers in Appendix A.

5.3.2 Results

Table 20: Soil Pit Information at MLBS.

Latitude	Longitude	Soil Family	Soil Order
37.37783	-80.52425	Coarse-loamy - siliceous - semiactive - frigid Fluvaquents	Entisol

Soil Profile was described by Natural Resource Conservation Service (NRCS).

Table 21: Fine root mass per depth increment (cm) at MLBS.

Upper Depth	Lower Depth	Mean (mg per cm^3)	Std Dev
0	10	7.1	2.51
10	20	7.68	4.43
20	30	2.18	1.06
30	40	0.35	0.18
40	50	0.35	0.11
50	60	0.11	0.11
60	70	0.06	0.06
70	80	0.03	0.02
80	90	0.02	0.02
90	100	0.08	0.05
100	120	0.03	0.02

Table 22: Cumulative fine root mass as a function of depth (cm) at MLBS.

Upper Depth	Lower Depth	Mean Cumulative (g per m^2)	Cumulative Std Dev
0	10	710.33	250.84
10	20	1478.03	224.57
20	30	1695.83	225.49
30	40	1731	208.92
40	50	1765.65	199.02
50	60	1776.99	207.53
60	70	1783.07	213.34
70	80	1786.23	214.33
80	90	1788.72	212.37
90	100	1801.21	210.73
100	120	1806.71	212.68

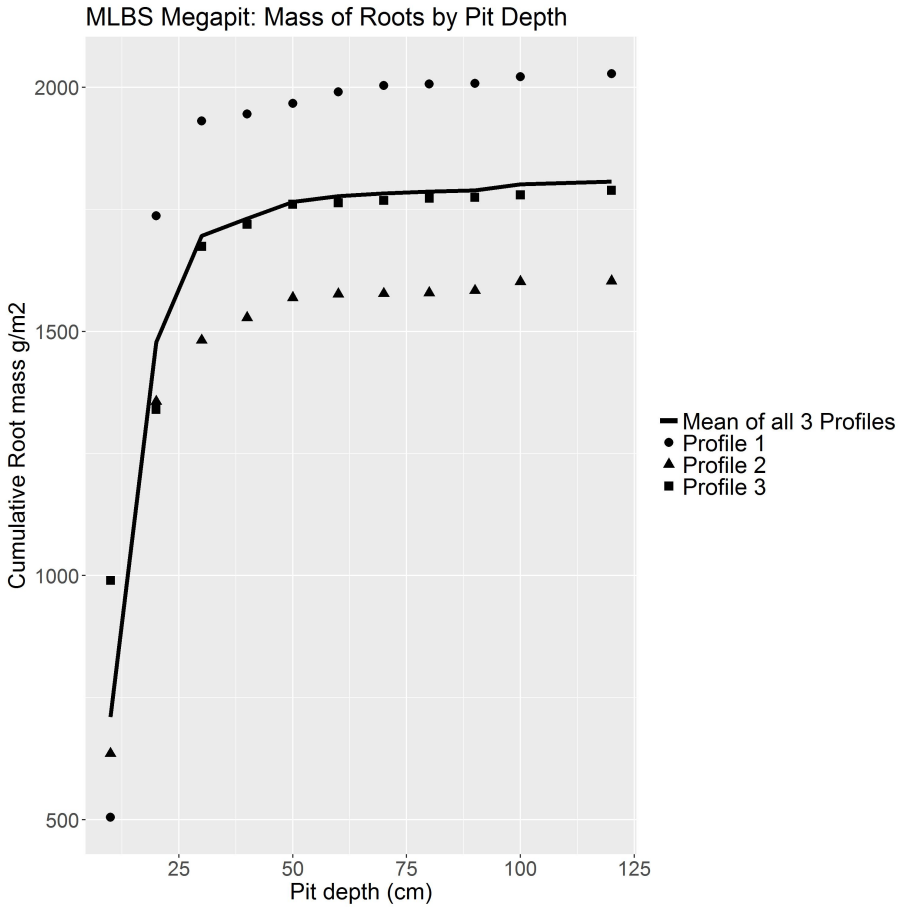

Figure 12: Cumulative root mass by pit depth at MLBS.

Table 23: Fine root biomass sampling summary data at MLBS.

Total Pit Depth (cm)	120
Total Mean Cumulative Mass at 30cm (g per m^2)	1695.83
Total Mean Cumulative Mass at 100cm (g per m^2)	1801.21
Total Mean Cumulative Mass (g per m^2)	1806.71

5.4 Plant Characterization and Phenology Species Selection

5.4.1 Site-Specific Methods

Plant characterization data were collected by NEON staff during August of 2015. Plant characterization data informs sampling procedures for plant phenology and plant productivity protocols.

The overall ranking ("Rank" in the table below) was calculated based on three separate measurements. Overall ranking weights are influenced by the number of species within each grouping.

1. Mean percent cover values were calculated based on species specific cover estimation for all plant species under 3m tall in eight 1m by 1m subplots per plot; see the TOS Protocol and Procedure: Plant Diversity Sampling (RD[09]) for more information.
2. Mean canopy area values were calculated based on all species specific shrub canopy diameter measurements within the entire plot or subplot; see the TOS Protocol and Procedure: Measurement of Vegetation Structure (RD[10]) for more information.
3. Mean ABH (area at breast height) measurements were calculated based on diameter at breast height measurements for all woody vegetation with a diameter greater than 1cm at 130cm height within the entire plot or subplot; see the TOS Protocol and Procedure: Measurement of Vegetation Structure (RD[10]) for more information.

The standard field methods and ranking calculations are further outlined in TOS Site Characterization Methods (RD[6]). For more information on this protocol and data product numbers see Appendix A. .

5.4.2 Results

Table 24: Site plant characterization and phenology species summary at MLBS.

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
ACRU	*Acer rubrum* L.	1	<1	0.01	6.24
OSCI	*Osmunda cinnamomea* L.	10	8	NA	NA
THNO	*Thelypteris noveboracensis* (L.) Nieuwl.	11	7	NA	NA
TSCA	*Tsuga canadensis* (L.) Carriére	12	<1	<1	0.76
MAAC	*Magnolia acuminata* (L.) L.	13	<1	NA	0.73
PIST	*Pinus strobus* L.	14	<1	NA	0.33
ILMO	*Ilex montana* Torr. & A. Gray ex A. Gray	15	<1	0.01	0.11
OCAC	*Oclemena acuminata* (Michx.) Greene	16	2	NA	NA
QUMO4	*Quercus montana* Willd.	17	NA	NA	0.31
KALA	*Kalmia latifolia* L.	18	<1	<1	0.06
ROPS	*Robinia pseudoacacia* L.	19	NA	NA	0.18
QUAL	*Quercus alba* L.	2	<1	NA	5.75

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
PRSE2	*Prunus serotina* Ehrh.	20	<1	NA	0.17
PIEC2	*Pinus echinata* Mill.	21	NA	NA	0.09
VIOLA	*Viola* sp.	22	<1	NA	NA
GAUR2	*Galax urceolata* (Poir.) Brummitt	23	<1	NA	NA
DRCA3	*Dryopteris campyloptera* Clarkson	24	<1	NA	NA
CADE12	*Castanea dentata* (Marshall) Borkh.	25	NA	NA	0.06
AMMU	*Amianthium muscitoxicum* (Walter) A. Gray	26	<1	NA	NA
AGPE	*Agrostis perennans* (Walter) Tuck.	27	<1	NA	NA
DACO	*Danthonia compressa* Austin	28	<1	NA	NA
VAPA4	*Vaccinium pallidum* Aiton	29	<1	NA	NA
QURU	*Quercus rubra* L.	3	<1	NA	5.45
MIVI	*Microstegium vimineum* (Trin.) A. Camus	30	<1	NA	NA
CAREX	*Carex* sp.	31	<1	NA	NA
MEVI	*Medeola virginiana* L.	31	<1	NA	NA
GABA	*Gaylussacia baccata* (Wangenh.) K. Koch	33	<1	NA	NA
CAGL8	*Carya glabra* (Mill.) Sweet	34	NA	NA	0.03
VAAN	*Vaccinium angustifolium* Aiton	35	<1	NA	NA
DICHA2	*Dichanthelium* sp.	36	<1	NA	NA
RUHI	*Rubus hispidus* L.	37	<1	NA	NA
MACA4	*Maianthemum canadense* Desf.	38	<1	NA	NA
BRER2	*Brachyelytrum erectum* (Schreb. ex Spreng.) P. Beauv.	39	<1	NA	NA
ACPE	*Acer pensylvanicum* L.	4	<1	0.06	0.41

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
DRMA4	*Dryopteris marginalis* (L.) A. Gray	40	<1	NA	NA
SMGL	*Smilax glauca* Walter	41	<1	NA	NA
ANLA	*Anemone lancifolia* Pursh	42	<1	NA	NA
GAPR2	*Gaultheria procumbens* L.	42	<1	NA	NA
UVPU2	*Uvularia puberula* Michx.	44	<1	NA	NA
DIVI4	*Dioscorea villosa* L.	45	<1	NA	NA
TRBO2	*Trientalis borealis* Raf.	45	<1	NA	NA
RHODO	*Rhododendron* sp.	47	<1	NA	<1
ARTR	*Arisaema triphyllum* (L.) Schott	48	<1	NA	NA
GLST	*Glyceria striata* (Lam.) Hitchc.	49	<1	NA	NA
SCLA2	*Scutellaria lateriflora* L.	49	<1	NA	NA
SMBO2	*Smilax bona-nox* L.	49	<1	NA	NA
QUCO2	*Quercus coccinea* Münchh.	5	NA	NA	4.13
BELE	*Betula lenta* L.	52	<1	NA	NA
DRIN5	*Dryopteris intermedia* (Muhl. ex Willd.) A. Gray	52	<1	NA	NA
MIRE	*Mitchella repens* L.	52	<1	NA	NA
AMBR2	*Amphicarpaea bracteata* (L.) Fernald	55	<1	NA	NA
BODI2	*Botrychium dissectum* Spreng.	55	<1	NA	NA
CYDA	*Cynodon dactylon* (L.) Pers.	55	<1	NA	NA
GATR3	*Galium triflorum* Michx.	55	<1	NA	NA
OXDI2	*Oxalis dillenii* Jacq.	55	<1	NA	NA
SMRO	*Smilax rotundifolia* L.	55	<1	NA	NA
SOAM3	*Sorbus americana* Marshall	55	<1	NA	NA
SYMPH4	*Symphyotrichum* sp.	55	<1	NA	NA
HAVI4	*Hamamelis virginiana* L.	6	<1	0.08	0.13

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
BOCY	*Boehmeria cylindrica* (L.) Sw.	63	<1	NA	NA
GASP5	*Galearis spectabilis* (L.) Raf.	63	<1	NA	NA
GOPU	*Goodyera pubescens* (Willd.) R. Br.	63	<1	NA	NA
HYPER	*Hypericum* sp.	63	<1	NA	NA
LYOB	*Lycopodium obscurum* L.	63	<1	NA	NA
MOUN3	*Monotropa uniflora* L.	63	<1	NA	NA
ONSE	*Onoclea sensibilis* L.	63	<1	NA	NA
QUERC	*Quercus* sp.	63	<1	NA	NA
AMLA	*Amelanchier laevis* Wiegand	7	<1	0.01	2.13
CRATA	*Crataegus* sp.	72	NA	NA	<1
NYSY	*Nyssa sylvatica* Marshall	8	<1	NA	1.86
VACO	*Vaccinium corymbosum* L.	9	<1	<1	<1

Note: Taxon IDs and scientific names are based on the USDA Plants database (plants.usda.gov). The *Crataegus* species group is a combination of *Crataegus macrosperma* and *Crataegus punctata*.

Table 25: Per plot breakdown of species richness, diversity, and herbaceous cover at MLBS.

Plot ID	Species Richness	Shannon Diversity Index	Percent Total Herbaceous Cover	Bryophyte Percent Cover
MLBS_061	19	1.49	50	3.12
MLBS_062	11	2.29	6	1.19
MLBS_063	16	1.62	39	1.38
MLBS_064	27	2.41	48	0.75
MLBS_065	32	2.76	63	7.19
MLBS_066	14	1.31	58	1.44
MLBS_067	19	2.35	23	0.75
MLBS_068	19	2.31	20	1.25
MLBS_069	23	1.95	86	1.44
MLBS_070	20	2.05	58	1.75
MLBS_071	17	1.36	74	8.88

Plot ID	Species Richness	Shannon Diversity Index	Percent Total Herbaceous Cover	Bryophyte Percent Cover
MLBS_072	25	2.17	95	7.75
MLBS_073	17	1.73	33	1.81
MLBS_074	19	1.53	104	14.25
MLBS_075	22	1.62	47	5.25
MLBS_076	19	1.87	54	4.88
Bryophyte Mean				3.94

Note: Percent herbaceous cover was measured by species and then added together to calculate the percent total herbaceous cover for each plot.

Bryophyte percent cover data were used to determine which sites qualify for implementation of the Bryophyte Productivity protocol. However, bryophyte productivity sampling was discontinued in 2018 and NEON no longer implements this protocol.

5.5 Beetles

5.5.1 Site-Specific Methods

Beetle site characterization was conducted in July 2014 by NEON staff following the standard methods outlined in TOS Site Characterization Methods (RD[6]). Beetle site characterization data were collected to start site level teaching collections. For DNA sequence data generated as a result of these efforts, visit the Barcode of Life Datasystems (BOLD) at http://www.boldsystems.org. For more information on this protocol and data product numbers see Appendix A.

5.5.2 Results

Table 26: Beetle identification results at MLBS.

Sample ID	Scientific Name	Sex
NEON8264	*Notiophilus aeneus*	M
NEON8265	*Chlaenius aestivus*	M
NEON8266	*Pterostichus atratus*	F
NEON8267	*Pterostichus atratus*	F
NEON8268	*Pterostichus stygicus*	M
NEON8269	*Pterostichus stygicus*	F
NEON8270	*Cyclotrachelus sigillatus*	M
NEON8271	*Dicaelus furvus*	F

Sample ID	Scientific Name	Sex
NEON8272	*Cyclotrachelus sigillatus*	M
NEON8273	*Cyclotrachelus sigillatus*	F
NEON8274	*Cyclotrachelus sigillatus*	F
NEON8275	*Cyclotrachelus sigillatus*	M
NEON8276	*Cyclotrachelus sigillatus*	M
NEON8277	*Cyclotrachelus sigillatus*	F
NEON8278	*Galerita bicolor*	F
NEON8279	*Carabus vinctus*	F
NEON8280	*Carabus vinctus*	F
NEONcarabid8213	*Carabus goryi*	F
NEONcarabid8214	*Pterostichus coracinus*	F
NEONcarabid8217	*Pterostichus coracinus*	M
NEONcarabid8219	*Pterostichus coracinus*	F
NEONcarabid8220	*Pterostichus coracinus*	F
NEONcarabid8222	*Pterostichus lachrymosus*	M
NEONcarabid8224	*Pterostichus lachrymosus*	M
NEONcarabid8225	*Pterostichus coracinus*	F
NEONcarabid8226	*Pterostichus coracinus*	M
NEONcarabid8229	*Pterostichus lachrymosus*	M
NEONcarabid8233	*Pterostichus coracinus*	M
NEONcarabid8236	*Pterostichus coracinus*	M
NEONcarabid8239	*Pterostichus lachrymosus*	M
NEONcarabid8241	*Pterostichus lachrymosus*	M
NEONcarabid8243	*Pterostichus lachrymosus*	M
NEONcarabid8245	*Pterostichus lachrymosus*	M
NEONcarabid8248	*Pterostichus coracinus*	M
NEONcarabid8249	*Pterostichus coracinus*	F
NEONcarabid8251	*Pterostichus coracinus*	M
NEONcarabid8253	*Harpalus spadiceus*	F
NEON8215	*Pterostichus coracinus*	M
NEON8216	*Pterostichus coracinus*	M
NEON8218	*Pterostichus coracinus*	M
NEON8221	*Pterostichus lachrymosus*	F
NEON8223	*Pterostichus lachrymosus*	M

Sample ID	Scientific Name	Sex
NEON8227	*Pterostichus lachrymosus*	F
NEON8228	*Pterostichus coracinus*	F
NEON8230	*Pterostichus lachrymosus*	F
NEON8231	*Pterostichus coracinus*	M
NEON8232	*Pterostichus lachrymosus*	M
NEON8234	*Pterostichus lachrymosus*	M
NEON8235	*Pterostichus coracinus*	M
NEON8237	*Pterostichus coracinus*	M
NEON8238	*Pterostichus lachrymosus*	F
NEON8240	*Pterostichus lachrymosus*	F
NEON8242	*Pterostichus lachrymosus*	F
NEON8244	*Pterostichus lachrymosus*	M
NEON8246	*Pterostichus lachrymosus*	F
NEON8247	*Pterostichus coracinus*	M
NEON8250	*Pterostichus coracinus*	F
NEON8252	*Pterostichus rostratus*	F

Note: Samples that include “NEONTcarabid” in their sample ID indicate BOLD records are available. Samples without “NEONTcarabid” were identified by a parataxonimist.

5.6 Mosquitoes

5.6.1 Site-Specific Methods

No mosquito site characterization was conducted at MLBS. For more information on this protocol and data product numbers see Appendix A.

5.7 Ticks

5.7.1 Site-Specific Methods

No tick site characterization was conducted at MLBS. For more information on this protocol and data product numbers see Appendix A.

5.8 Species Reference Lists

A review of the literature for taxonomic lists of interest for each site was conducted prior to field work. In the case of vertebrates that NEON may capture (e.g., reptiles, amphibians, small mammals), these lists were often required to secure permits. Key references identified in this effort are listed below. Species lists and associated references for small mammals and breeding landbirds can be found in the appendices of the respective protocols (RD[07], RD[08]).

About the Station. 2015. Mountain Lake Biological Station. Retrieved from http://mlbs.virginia.edu/about

Adams H. S., and S. L. Stephenson. 1991. High-elevation coniferous forests in Virginia. Virginia Journal of Science 42:391-399.

Biological Collections. 2015. Mountain Lake Biological Station. Retrieved from http://mlbs.virginia.edu/collections

Bousquet, Y. 2012. Catalogue of Geadephaga (Coleoptera, Adephaga) of America, north of Mexico. ZooKeys, (245), 1-1722.

Centers for Disease Control and Prevention. (2015). *Geographic distribution of ticks that bite humans.* Retrieved from http://www.cdc.gov/ticks/geographic_distribution.html

Darsie Jr., R. F., and R. A. Ward. 2005. Identification and geographical distribution of the mosquitoes of North America, North of Mexico. University Press of Florida, Gainesville.

6 RELOCATABLE SITE 2- GREAT SMOKY MOUNTAINS NATIONAL PARK (GRSM)

Great Smoky Mountains National Park straddles the ridgeline of the lower section of the Blue Ridge Mountains. The border between Tennessee and North Carolina runs northeast to southwest through the centerline of the park. The variety of elevations, the abundant rainfall, and the presence of old growth forests contributes to an unusual richness of biota. Plants and animals common in the country's Northeast have found suitable ecological niches in the park's higher elevations, while southern species find homes in the balmier lower reaches. In late 2016 wildfires burned more than 10,000 acres (40 km^2) inside the park, including areas near the NEON tower.

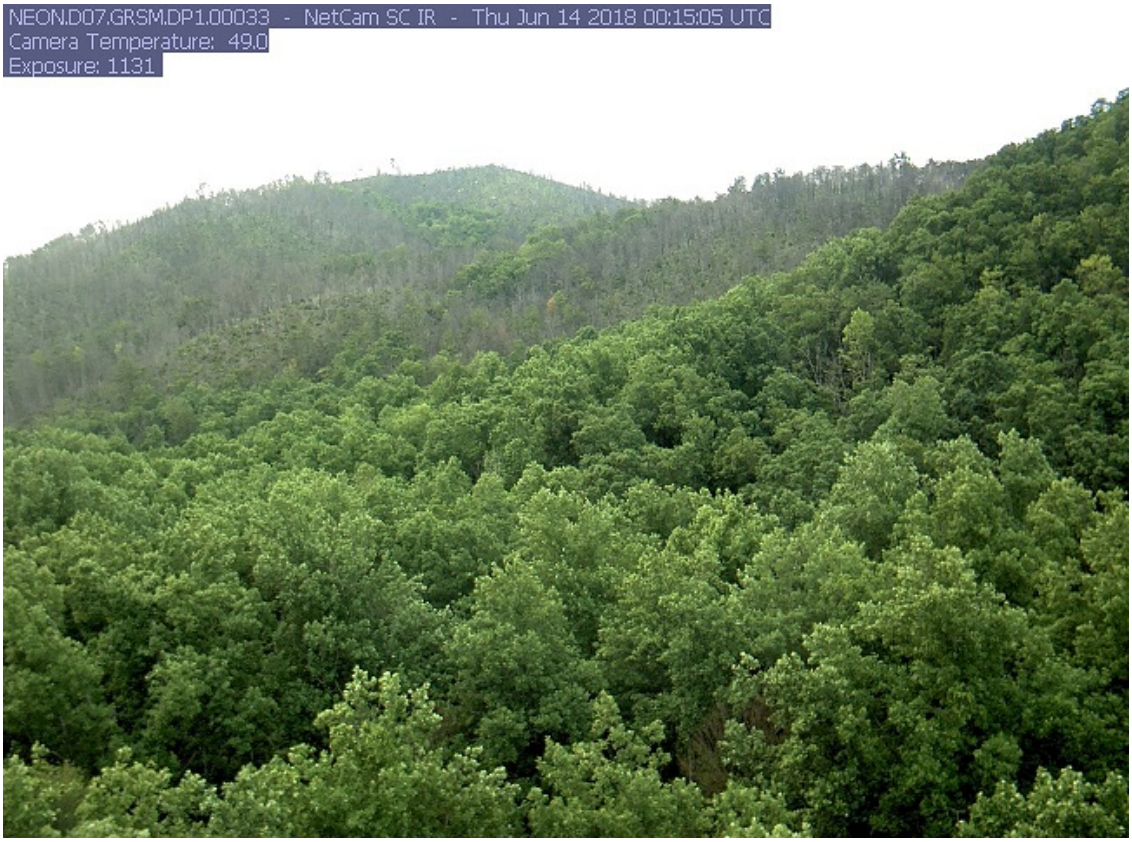

Figure 13: Phenocamera image for GRSM. The phenocamera is located at the top of the NEON tower and faces north. Phenocamera images are available at https://phenocam.sr.unh.edu/webcam/network/table/.

Key Characteristics:

- Site host: National Park Service
- Located in: Servier County, TN and Swain County, NC
- Sampling Area: 32.72 km^2
- Plot Elevation: 420-1985m
- Dominant vegetation type: Variations in elevation, rainfall, temperature, and geology in GRSM provide habitat for over 1,600 species of flowering plants (Plants, 2018). In addition, the park is one of the largest stands of deciduous old growth forest in North America. The lower region forests are dominated by deciduous leafy trees including yellow poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), and chestnut oak (*Quercus montana*). Spice bush (*Lindera benzoin*), mountain laurel (*Kalmia latifolia*) and rhododendron (*Rhododendron maximum*) dominant the dense understory. At higher altitudes, deciduous forests give way to coniferous trees like Fraser Fir (*Abies fraseri*), red cedar (*Juniperus virginiana*), and eastern hemlock (*Tsuga canadensis*).
- General management: The park was chartered by the U.S. Congress in 1934 and officially dedicated by President Franklin D. Roosevelt in 1940. It encompasses 814 square miles (2,108 km^2), making it one of the largest protected areas in the eastern U.S. Great Smokey Mountain National Park is the most visited na-

tional park in the U.S., and on its route from Maine to Georgia, the Appalachian Trail also passes through the center of the park. Research in the park includes an All Taxa Biodiversity Inventory, fire impacts, and links between terrestrial and aquatic ecology (Nature and Science, 2017).

- The NEON aquatic site LeConte Creek is located in Great Smokey National Park. See the AIS site characterization report for more details (RD[05]).
- Plot Selection: NEON TOS Plots were allocated across the site following NEON standard criteria and avoiding existing research. Due to steep topography and dense undergrowth plot allocation was constrained close to roads and existing trails. Areas in varying elevations were selected to capture the diversity of the park.

6.1 TOS Spatial Sampling Design

TOS Distributed Plots were allocated at GRSM according to a spatially balanced and stratified-random design (RD[3]). The 2006 National Land Cover Database (NLCD) was selected for stratification because of the consistent and comparable data availability across the United States. TOS Tower Plots were allocated according to a spatially balanced design in and around the NEON tower airshed (RD[03]). The maps below depict the plot locations for the first year of NEON sampling. Some plot locations may change over time due to logistics, safety, and science requirements. Please visit the NEON website (http://www.neonscience.org) for updated plot locations at each site.

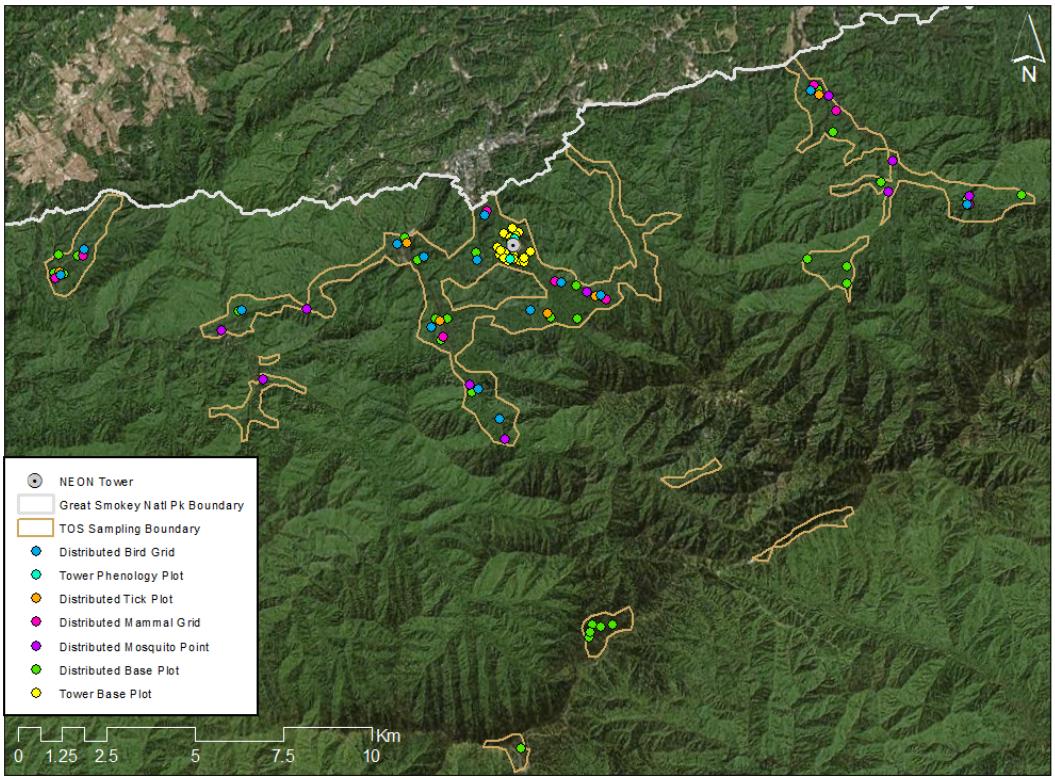

Figure 14: Map of TOS plot centroids within the NEON TOS sampling boundary at GRSM.

For a list of protocols associated with each plot see tables below; for additional spatial design information see RD[03].

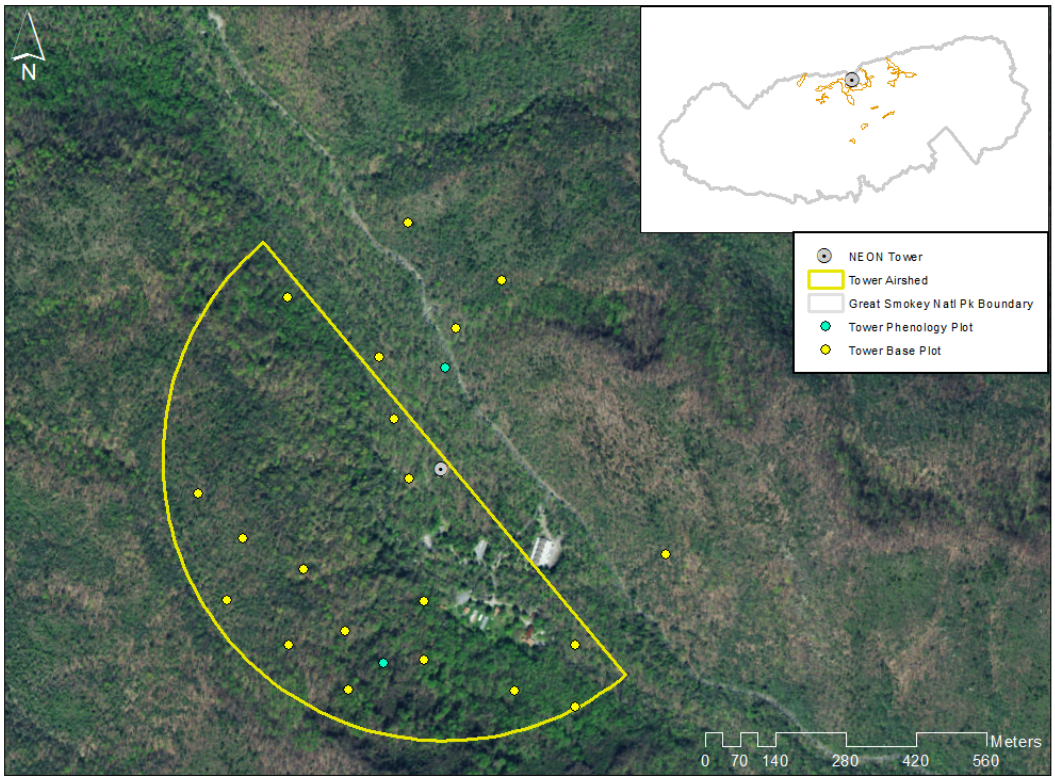

Figure 15: Map of the tower airshed and TOS plot centroids at GRSM.

More information about the tower airshed can be found in the TIS site characterization report (RD[04]).

Table 27: NLCD land cover classes and area within the TOS site boundary at GRSM.

NLCD Class	Site Area (km^2)	Percent (%)
Deciduous Forest	27.94	85.11
Evergreen Forest	2.71	8.26
Mixed Forest	1.19	3.61
Developed Open Space	0.74	2.25
Woody Wetlands	0.12	0.36
Shrub Scrub	0.11	0.33
Developed Low Intensity	0.01	0.04
Developed Medium Intensity	0.01	0.04

Note: Any NLCD land cover classes less than 5% will not be sampled. Additionally, no sampling will take place in

Water, Developed, or Barren Land NLCD classes.

Table 28: NLCD land cover classes and TOS plot numbers at GRSM.

Plot Type	Plot Subtype	NLCD Class	Number of Plots Established
Distributed	Base Plot	Deciduous Forest	23
Distributed	Base Plot	Evergreen Forest	7
Distributed	Bird Grid	Deciduous Forest	10
Distributed	Mammal Grid	Deciduous Forest	10
Distributed	Mosquito Point	Deciduous Forest	10
Distributed	Tick Plot	Deciduous Forest	6
Tower	Base Plot	NA	20
Tower	Phenology Plot	NA	2

Note: NLCD land cover classes are not used to stratify Tower Plots which are located in and around the NEON tower airshed. The dominant NLCD land cover type within the airshed is deciduous forest.

Table 29: Number of Distributed Base plots per NLCD land cover class per protocol at GRSM.

Plot Type	Plot Subtype	NLCD Class	Protocols	Number of Plots
Distributed	Base Plot	Deciduous Forest	Beetles	10
Distributed	Base Plot	Deciduous Forest	Canopy Foliage Chemistry	9
Distributed	Base Plot	Evergreen Forest	Canopy Foliage Chemistry	1
Distributed	Base Plot	Deciduous Forest	Coarse Downed Wood	18
Distributed	Base Plot	Evergreen Forest	Coarse Downed Wood	2
Distributed	Base Plot	Deciduous Forest	Digital Hemispherical Photos for Leaf Area Index	18
Distributed	Base Plot	Evergreen Forest	Digital Hemispherical Photos for Leaf Area Index	2
Distributed	Base Plot	Deciduous Forest	Herbaceous Biomass	18
Distributed	Base Plot	Evergreen Forest	Herbaceous Biomass	2
Distributed	Base Plot	Deciduous Forest	Plant Diversity	23
Distributed	Base Plot	Evergreen Forest	Plant Diversity	7
Distributed	Base Plot	Deciduous Forest	Soil Biogeochemistry	5
Distributed	Base Plot	Evergreen Forest	Soil Biogeochemistry	1
Distributed	Base Plot	Deciduous Forest	Soil Microbes	5
Distributed	Base Plot	Evergreen Forest	Soil Microbes	1
Distributed	Base Plot	Deciduous Forest	Vegetation Structure	18

Plot Type	Plot Subtype	NLCD Class	Protocols	Number of Plots
Distributed	Base Plot	Evergreen Forest	Vegetation Structure	2

Note: Distributed Base Plots typically support more than one TOS protocol; 'Number of Plots' cannot be added to get total TOS Distributed Base Plot number.

Table 30: Number of Tower Plots per protocol at GRSM.

Plot Type	Plot Subtype	Protocols	Number of Plots
Tower	Base Plot	Canopy Foliage Chemistry	4
Tower	Base Plot	Coarse Downed Wood	20
Tower	Base Plot	Digital Hemispherical Photos for Leaf Area Index	3
Tower	Base Plot	Herbaceous Biomass	20
Tower	Base Plot	Litterfall and Fine Woody Debris	20
Tower	Base Plot	Plant Belowground Biomass	20
Tower	Base Plot	Plant Diversity	3
Tower	Base Plot	Soil Biogeochemistry	4
Tower	Base Plot	Soil Microbes	4
Tower	Base Plot	Vegetation Structure	20
Tower	Phenology	Plant Phenology	2

Note: Tower Base Plots typically support more than one TOS protocol; 'Number of Plots' cannot be added to get total TOS Tower Base Plot number.

6.2 Sampling Season Characterization: GRSM

For numerous TOS protocols, the length of the sampling season, the number of bouts, and when those bouts occur is dictated by the seasonal status of the plant community. By monitoring 'greenness' on a 16 day interval, the MODIS/Terra EVI phenology product provides consistent, reliable insight into plant community phenology and intensity at the continental scale. For those protocols for which timing is standardized by greenness transitions and/or peak green status, NEON has utilized these data as the primary means of guiding temporal aspects of TOS sampling at each site.

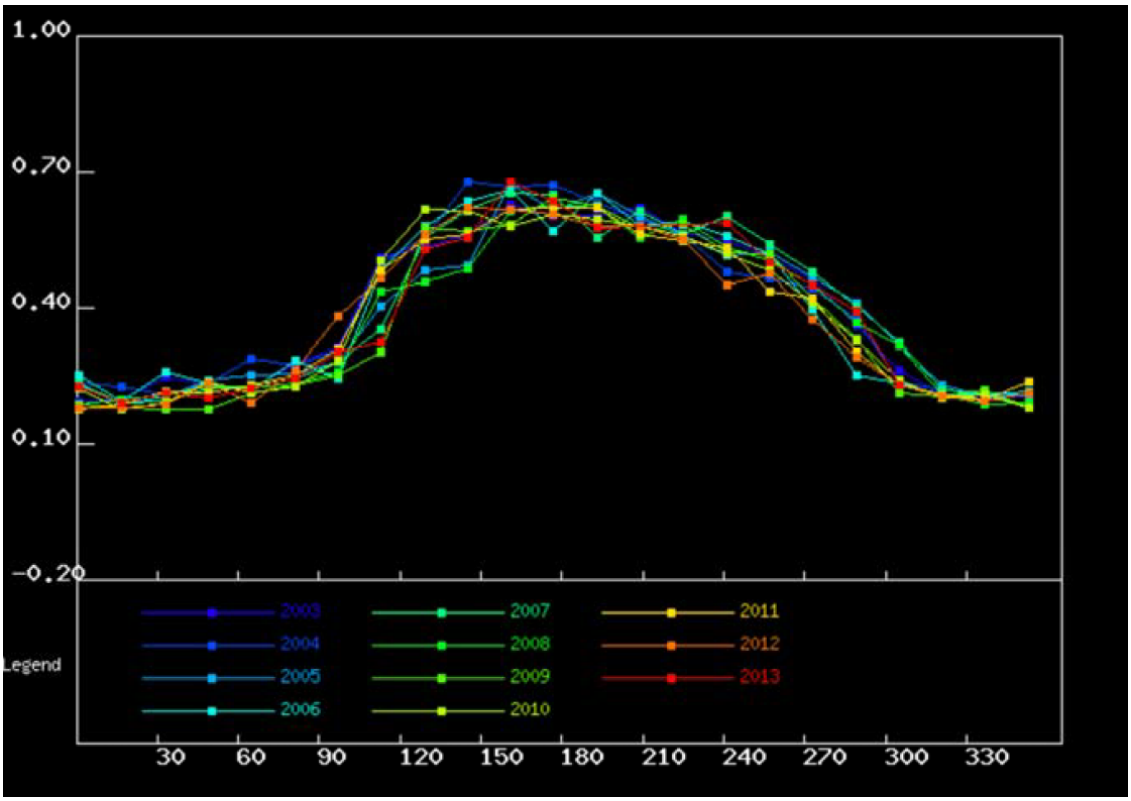

Figure 16: MODIS-EVI greenness (y-axis = EVI ratio) as a function of time (x-axis = DOY) for the years 2003-2013 at the NEON GRSM site.

Table 31: Average MODIS-EVI greenness dates for the NEON GRSM site, based on data from 2003-2013 (DOY, with MM/DD in parentheses).

Average Increase	Average Maximum	Average Decrease	Average Minimum
90 (04/01)	155 (06/05)	215 (08/04)	310 (11/07)

MODIS Product Details

- Product: MODIS-EVI phenology product, 16 day interval, 250 m grid, data included from all pixels with acceptable quality within user-defined square that roughly overlaps the TOS site boundary.
- Date range: 2003-2013
- User selected area: 26.25 km x 26.25 km box, centroid: 35.688883, -83.501722 (WGS84 datum)

6.3 Belowground Biomass

6.3.1 Site-Specific Methods

Belowground biomass characterization data were collected down to a depth of 200 cm by NEON staff in April 2015. Since the NEON protocol for long-term, operational sampling of belowground biomass only collects data to a depth of 30 cm, the belowground biomass site characterization data are critical for scaling belowground biomass measurements to greater depths; see the TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index (AD[7]) for more information. Samples were collected following the standard methods outlined in TOS Site Characterization Methods (RD[6]). Roots were sorted to two diameter size categories ($\leq$ 4 mm and 4-30 mm) and by root status (live or dead). The tables below summarize all the belowground biomass less than or equal to 30 mm diameter; size class data and more information can be found by searching the NEON data portal for the data product numbers in Appendix A.

6.3.2 Results

Table 32: Soil Pit Information at GRSM.

Latitude	Longitude	Soil Family	Soil Order
35.68839	-83.50185	Loamy-skeletal - isotic - mesic Typic Humudepts	Inceptisol

Soil Profile was described by Natural Resource Conservation Service (NRCS).

Table 33: Fine root mass per depth increment (cm) at GRSM.

Upper Depth	Lower Depth	Mean (mg per cm^3)	Std Dev
0	10	12.07	4.38
10	20	21.82	15.29
20	30	9.41	4.3
30	40	7.61	5.92
40	50	6.88	5.51
50	60	11.79	14.29
60	70	4.99	6.36
70	80	2.83	2.51
80	90	1.91	3.27
90	100	0.07	0.06
100	120	0.68	0.27
120	140	0.33	0.51
140	160	0.09	0.07

Upper Depth	Lower Depth	Mean (mg per cm^3)	Std Dev
160	180	0.38	0.11
180	200	0.45	0.39

Table 34: Cumulative fine root mass as a function of depth (cm) at GRSM.

Upper Depth	Lower Depth	Mean Cumulative (g per m^2)	Cumulative Std Dev
0	10	1206.51	437.8
10	20	3388.81	1441.02
20	30	4330.11	1459.31
30	40	5091.31	1897.61
40	50	5779.22	1900.48
50	60	6958.46	2375.7
60	70	7457.89	2729.64
70	80	7740.71	2906.01
80	90	7931.82	3120.72
90	100	7938.97	3117.24
100	120	8075.21	3165.36
120	140	8141.85	3194.11
140	160	8159.15	3192.87
160	180	8235.41	3213.59
180	200	8325.17	3144.32

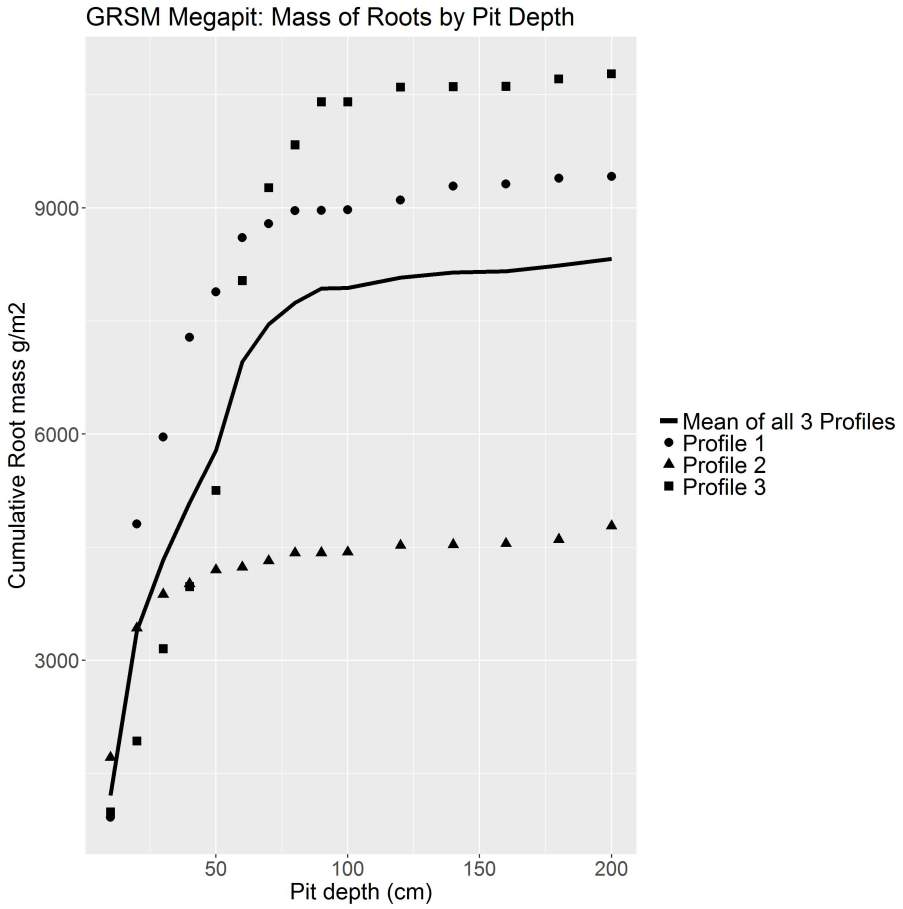

Figure 17: Cumulative root mass by pit depth at GRSM.

Table 35: Fine root biomass sampling summary data at GRSM.

Total Pit Depth (cm)	200
Total Mean Cumulative Mass at 30cm (g per m^2)	4330.11
Total Mean Cumulative Mass at 100cm (g per m^2)	7938.97
Total Mean Cumulative Mass (g per m^2)	8325.17

6.4 Plant Characterization and Phenology Species Selection

6.4.1 Site-Specific Methods

Plant characterization data were collected by NEON staff during June of 2015. Plant characterization data informs sampling procedures for plant phenology and plant productivity protocols.

The overall ranking ("Rank" in the table below) was calculated based on three separate measurements. Overall ranking weights are influenced by the number of species within each grouping.

1. Mean percent cover values were calculated based on species specific cover estimation for all plant species under 3m tall in eight 1m by 1m subplots per plot; see the TOS Protocol and Procedure: Plant Diversity Sampling (RD[09]) for more information.
2. Mean canopy area values were calculated based on all species specific shrub canopy diameter measurements within the entire plot or subplot; see the TOS Protocol and Procedure: Measurement of Vegetation Structure (RD[10]) for more information.
3. Mean ABH (area at breast height) measurements were calculated based on diameter at breast height measurements for all woody vegetation with a diameter greater than 1cm at 130cm height within the entire plot or subplot; see the TOS Protocol and Procedure: Measurement of Vegetation Structure (RD[10]) for more information.

The standard field methods and ranking calculations are further outlined in TOS Site Characterization Methods (RD[6]). For more information on this protocol and data product numbers see Appendix A.

6.4.2 Results

Table 36: Site plant characterization and phenology species summary at GRSM.

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
LITU	*Liriodendron tulipifera* L.	1	<1	NA	16.73
GAUR	*Gaylussacia ursina* (M.A. Curtis) Torr. & A. Gray ex A. Gray	10	5	<1	<1
AGPA6	*Agrimonia parviflora* Aiton	101	<1	NA	NA
MIVI	*Microstegium vimineum* (Trin.) A. Camus	101	<1	NA	NA
MATR	*Magnolia tripetala* (L.) L.	103	NA	NA	0.01
ARTR	*Arisaema triphyllum* (L.) Schott	104	<1	NA	NA
CHMA3	*Chimaphila maculata* (L.) Pursh	104	<1	NA	NA
EUAM9	*Euonymus americanus* L.	104	<1	NA	NA
POPE	*Podophyllum peltatum* L.	104	<1	NA	NA
UVPU2	*Uvularia puberula* Michx.	104	<1	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
HENOA	*Hepatica nobilis* Schreb. var. *acuta* (Pursh) Steyerm.	109	<1	NA	NA
VIAE	*Vitis aestivalis* Michx.	109	<1	NA	NA
TSCA	*Tsuga canadensis* (L.) Carriére	11	1	<1	1.3
DIQU	*Dioscorea quaternata* J.F. Gmel.	111	<1	NA	NA
GOPU	*Goodyera pubescens* (Willd.) R. Br.	112	<1	NA	NA
RUAL	*Rubus allegheniensis* Porter	112	<1	NA	NA
VACO	*Vaccinium corymbosum* L.	114	NA	<1	NA
ASPL	*Asplenium platyneuron* (L.) Britton, Sterns & Poggenb.	115	<1	NA	NA
EUFI14	*Eutrochium fistulosum* (Barratt) E.E. Lamont	115	<1	NA	NA
EUPU21	*Eutrochium purpureum* (L.) E.E. Lamont	115	<1	NA	NA
PAQU	*Panax quinquefolius* L.	115	<1	NA	NA
SYPR6	*Symphyotrichum prenanthoides* (Muhl. ex Willd.) G.L. Nesom	115	<1	NA	NA
HATE3	*Halesia tetraptera* Ellis	12	<1	<1	0.45
CLAC3	*Clethra acuminata* Michx.	120	NA	NA	NA
PIRU	*Picea rubens* Sarg.	121	NA	NA	NA
CATH2	*Caulophyllum thalictroides* (L.) Michx.	122	<1	NA	NA
COAL2	*Cornus alternifolia* L. f.	122	<1	NA	NA
COCO3	*Commelina communis* L.	122	<1	NA	NA
HEHE	*Hedera helix* L.	122	<1	NA	NA
PIEC2	*Pinus echinata* Mill.	126	NA	NA	0.01
GAAP2	*Galium aparine* L.	127	<1	NA	NA
SMHE	*Smilax herbacea* L.	127	<1	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
VIPA18	*Viola* × palmata L. (pro sp.)	127	<1	NA	NA
PLOC	*Platanus occidentalis* L.	13	NA	NA	1.29
BICA	*Bignonia capreolata* L.	131	<1	NA	<1
AGRO3	*Agrimonia rostellata* Wallr.	132	<1	NA	NA
ANQU	*Anemone quinquefolia* L.	132	<1	NA	NA
CRCA9	*Cryptotaenia canadensis* (L.) DC.	132	<1	NA	NA
CURO	*Cuscuta rostrata* Shuttlw. ex Engelm. & A. Gray	132	<1	NA	NA
DICHA2	*Dichanthelium* sp.	132	<1	NA	NA
LYQU2	*Lysimachia quadrifolia* L.	132	<1	NA	NA
MARA7	*Maianthemum racemosum* (L.) Link	132	<1	NA	NA
MEVI	*Medeola virginiana* L.	132	<1	NA	NA
SETE3	*Sedum ternatum* Michx.	132	<1	NA	NA
THTH2	*Thalictrum thalictroides* (L.) Eames & B. Boivin	132	<1	NA	NA
VIRO3	*Vitis rotundifolia* Michx.	132	<1	NA	NA
OXAR	*Oxydendrum arboreum* (L.) DC.	14	<1	<1	0.53
OSVI	*Ostrya virginiana* (Mill.) K. Koch	143	NA	NA	<1
CADI10	*Cardamine diphylla* (Michx.) Alph. Wood	144	<1	NA	NA
CLBI3	*Cleistes bifaria* (Fernald) Catling & Gregg	144	<1	NA	NA
EPRE2	*Epigaea repens* L.	144	<1	NA	NA
HULU2	*Huperzia lucidula* (Michx.) Trevis.	144	<1	NA	NA
ISVE	*Isotria verticillata* Raf.	144	<1	NA	NA
RHCO	*Rhus copallinum* L.	149	NA	NA	<1
POAC4	*Polystichum acrostichoides* (Michx.) Schott	15	2	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
PHHI2	*Philadelphus hirsutus* Nutt.	150	NA	NA	NA
QUCO2	*Quercus coccinea* Münchh.	16	<1	NA	1.04
CACA18	*Carpinus caroliniana* Walter	17	<1	<1	0.05
QURU	*Quercus rubra* L.	18	<1	NA	1.04
FAGR	*Fagus grandifolia* Ehrh.	19	<1	NA	0.86
LIBE3	*Lindera benzoin* (L.) Blume	2	2	0.04	<1
TORA2	*Toxicodendron radicans* (L.) Kuntze	20	1	NA	<1
BELE	*Betula lenta* L.	21	<1	<1	0.37
PYPU	*Pyrularia pubera* Michx.	22	<1	<1	<1
SACA15	*Sanicula canadensis* L.	23	<1	NA	NA
MAFR	*Magnolia fraseri* Walter	24	<1	<1	0.19
PRENA	*Prenanthes* sp.	25	<1	NA	NA
NYSY	*Nyssa sylvatica* Marshall	26	<1	<1	0.33
TIAM	*Tilia americana* L.	27	<1	NA	0.38
PAQU2	*Parthenocissus quinquefolia* (L.) Planch.	28	<1	NA	<1
JUNI	*Juglans nigra* L.	29	NA	NA	0.37
ACRUR	*Acer rubrum* var. *rubrum*	3	2	<1	6.17
IMPA	*Impatiens pallida* Nutt.	30	<1	NA	NA
PIPU5	*Pinus pungens* Lamb.	31	<1	NA	0.35
VAST	*Vaccinium stamineum* L.	32	<1	NA	NA
CACO15	*Carya cordiformis* (Wangenh.) K. Koch	33	<1	NA	0.32
ACSA3	*Acer saccharum* Marshall	34	<1	NA	0.32
PRSE2	*Prunus serotina* Ehrh.	35	<1	<1	0.1
ROPS	*Robinia pseudoacacia* L.	36	<1	NA	0.29
PHLE5	*Phryma leptostachya* L.	37	<1	NA	NA
AMLA	*Amelanchier laevis* Wiegand	38	<1	NA	NA
PIRI	*Pinus rigida* Mill.	39	NA	NA	0.25

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
KALA	*Kalmia latifolia* L.	4	3	0.02	0.02
CADE12	*Castanea dentata* (Marshall) Borkh.	40	NA	<1	NA
ADPE	*Adiantum pedatum* L.	41	<1	NA	NA
COFL2	*Cornus florida* L.	42	<1	NA	0.1
SAAL5	*Sassafras albidum* (Nutt.) Nees	43	<1	NA	0.05
CAREX	*Carex* sp.	44	<1	NA	NA
FRAXI	*Fraxinus* sp.	45	<1	NA	<1
ULRU	*Ulmus rubra* Muhl.	46	<1	NA	0.21
SMRO	*Smilax rotundifolia* L.	47	<1	NA	NA
FRAM2	*Fraxinus americana* L.	48	<1	NA	0.11
CAFL22	*Calycanthus floridus* L.	49	<1	<1	NA
ACPE	*Acer pensylvanicum* L.	5	<1	<1	0.03
PIVI2	*Pinus virginiana* Mill.	50	<1	NA	0.18
JUCI	*Juglans cinerea* L.	51	NA	NA	0.19
ILOP	*Ilex opaca* Aiton	52	<1	<1	<1
MAAC	*Magnolia acuminata* (L.) L.	53	NA	<1	0.13
QUVE	*Quercus velutina* Lam.	54	<1	NA	0.15
HAVI4	*Hamamelis virginiana* L.	55	<1	<1	<1
OSCL	*Osmorhiza claytonii* (Michx.) C.B. Clarke	56	<1	NA	NA
EUDI16	*Eurybia divaricata* (L.) G.L. Nesom	57	<1	NA	NA
VIBL	*Viola blanda* Willd.	58	<1	NA	NA
AMLA	*Amelanchier laevis* Wiegand	59	<1	NA	NA
QUMO4	*Quercus montana* Willd.	6	<1	NA	3.19
DEAC4	*Deparia acrostichoides* (Sw.) M. Kato	60	<1	NA	NA
VIOLA	*Viola* sp.	61	<1	NA	NA
CAGL8	*Carya glabra* (Mill.) Sweet	62	NA	NA	0.1

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
ATFIA2	*Athyrium filix-femina* (L.) Roth ssp. *asplenioides* (Michx.) Hultén	63	<1	NA	NA
GAPR2	*Gaultheria procumbens* L.	64	<1	NA	NA
GAUR2	*Galax urceolata* (Poir.) Brummitt	64	<1	NA	NA
BOVI	*Botrychium virginianum* (L.) Sw.	67	<1	NA	NA
SYLA4	*Symphyotrichum lateriflorum* (L.) Á. Löve & D. Löve	68	<1	NA	NA
QUAL	*Quercus alba* L.	69	NA	NA	0.09
PHHE11	*Phegopteris hexagonoptera* (Michx.) Fée	70	<1	NA	NA
PINUS	*Pinus* sp.	71	NA	NA	0.08
VIPU3	*Viola pubescens* Aiton	73	<1	NA	NA
AEFL	*Aesculus flava* Aiton	74	NA	NA	<1
SMGL	*Smilax glauca* Walter	75	<1	NA	NA
SACA13	*Sanguinaria canadensis* L.	76	<1	NA	NA
ARMA7	*Aristolochia macrophylla* Lam.	77	<1	NA	NA
TICO	*Tiarella cordifolia* L.	77	<1	NA	NA
GACI2	*Galium circaezans* Michx.	79	<1	NA	NA
AMBR2	*Amphicarpaea bracteata* (L.) Fernald	8	5	NA	NA
FRPE	*Fraxinus pennsylvanica* Marshall	80	NA	NA	0.01
CILU	*Circaea lutetiana* L.	81	<1	NA	NA
STCO9	*Stachys cordata* Riddell	82	<1	NA	NA
VITIS	*Vitis* sp.	83	<1	NA	0.03
GATR3	*Galium triflorum* Michx.	84	<1	NA	NA
DIOP	*Dioscorea oppositifolia* L.	85	<1	NA	NA
GABA	*Gaylussacia baccata* (Wangenh.) K. Koch	85	<1	NA	NA

Taxon ID	Scientific Name	Rank	Mean Percent Cover	Mean Canopy Area (m^2 per m^2)	Mean ABH (cm^2 per m^2)
ACPA	*Actaea pachypoda* Elliott	88	<1	NA	NA
LOJA	*Lonicera japonica* Thunb.	88	<1	NA	NA
MOCL	*Monarda clinopodia* L.	88	<1	NA	NA
RHMA4	*Rhododendron maximum* L.	9	1	0.01	0.07
UVPE	*Uvularia perfoliata* L.	91	<1	NA	NA
PIST	*Pinus strobus* L.	92	NA	NA	0.02
ARAT	*Arnoglossum atriplicifolium* (L.) H. Rob.	93	<1	NA	NA
CLVI5	*Clematis virginiana* L.	93	<1	NA	NA
HYAR	*Hydrangea arborescens* L.	93	<1	NA	NA
ROCA4	*Rosa carolina* L.	93	<1	NA	NA
POSI2	*Potentilla simplex* Michx.	97	<1	NA	NA
POVI2	*Polygonum virginianum* L.	97	<1	NA	NA
SOCU	*Solidago curtisii* Torr. & A. Gray	97	<1	NA	NA
SYOR	*Symphoricarpos orbiculatus* Moench	97	<1	NA	NA

Note: Taxon IDs and scientific names are based on the USDA Plants database (plants.usda.gov).

Table 37: Per plot breakdown of species richness, diversity, and herbaceous cover at GRSM.

Plot ID	Species Richness	Shannon Diversity Index	Percent Total Herbaceous Cover	Bryophyte Percent Cover
GRSM_047	12	1.28	131	6.2
GRSM_048	36	2.27	158	18.57
GRSM_049	17	2.28	56	8.12
GRSM_050	27	3.08	31	1.12
GRSM_051	17	1.59	148	0.25
GRSM_052	18	1.96	56	13.75
GRSM_053	23	2.27	162	0.94
GRSM_054	31	2.59	120	2.22
GRSM_055	29	2.52	165	0.06
GRSM_056	20	2.28	95	15.38

Plot ID	Species Richness	Shannon Diversity Index	Percent Total Herbaceous Cover	Bryophyte Percent Cover
GRSM_057	37	3.02	145	1.94
GRSM_058	23	2.34	134	0
GRSM_059	19	2.34	93	3.62
GRSM_060	28	2.35	183	1.21
GRSM_061	19	2.18	89	3.5
GRSM_062	21	2.3	156	3.69
GRSM_063	28	2.86	93	7.22
GRSM_064	27	2.38	69	4.81
GRSM_065	28	2.38	103	12.07
GRSM_066	35	2.9	132	5.25
Bryophyte Mean				5.5

Note: Percent herbaceous cover was measured by species and then added together to calculate the percent total herbaceous cover for each plot.

Bryophyte percent cover data were used to determine which sites qualify for implementation of the Bryophyte Productivity protocol. However, bryophyte productivity sampling was discontinued in 2018 and NEON no longer implements this protocol.

6.5 Beetles

6.5.1 Site-Specific Methods

No beetle site characterization was conducted at GRSM. For more information on this protocol and data product numbers see Appendix A.

6.6 Mosquitoes

6.6.1 Site-Specific Methods

No mosquito site characterization was conducted at GRSM. For more information on this protocol and data product numbers see Appendix A.

6.7 Ticks

6.7.1 Site-Specific Methods

No tick site characterization was conducted at GRSM. For more information on this protocol and data product numbers see Appendix A.

6.8 Species Reference Lists

A review of the literature for taxonomic lists of interest for each site was conducted prior to field work. In the case of vertebrates that NEON may capture (e.g., reptiles, amphibians, small mammals), these lists were often required to secure permits. Key references identified in this effort are listed below. Species lists and associated references for small mammals and breeding landbirds can be found in the appendices of the respective protocols (RD[07], RD[08]).

Bousquet, Y. 2012. Catalogue of Geadephaga (Coleoptera, Adephaga) of America, north of Mexico. ZooKeys, (245), 1-1722.

Centers for Disease Control and Prevention. (2015). *Geographic distribution of ticks that bite humans.* Retrieved from http://www.cdc.gov/ticks/geographic_distribution.html

Darsie Jr., R. F., and R. A. Ward. 2005. Identification and geographical distribution of the mosquitoes of North America, North of Mexico. University Press of Florida, Gainesville.

Harmon, M., 1982. Fire history of the westernmost portion of Great Smoky Mountains National Park. Bulletin of the Torrey Botanical Club, pp.74-79.

Huheey, J.E. and Stupka, A., 1967. Amphibians and reptiles of Great Smoky Mountains National Park.

Jenkins, M.A., 2007. Vegetation communities of Great Smoky Mountains national park.

Nature and Science. 2017. Great Smokey Mountains National Park. Retrieved from https://www.nps.gov/grsm/learn/nature/index.htm

Plants. 2017. Great Smokey Mountains National Park. Retrieved from https://www.nps.gov/grsm/learn/nature/plants.htm

Sharkey, M.J., 2001. The all taxa biological inventory of the Great Smoky Mountains National Park. Florida Entomologist, pp.556-564.

White, P.S. 1982. The Flora of Great Smoky Mountains National Park: An Annotated Checklist of the Vascular Plants and a Review of Previous Floristic Work. Research/Resource Management Report SER-55. National Park Service.

7 REFERENCES

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, *PE&RS*, Vol. 77(9):858-864.

Non-native Species. 2017. Great Smokey Mountains National Park. Retrieved from https://www.nps.gov/grsm/learn/nature/non-native-species.htm

USDA, NRCS. 2016. The PLANTS Database (http://plants.usda.gov, 1 August 2016). National Plant Data Team, Greensboro, NC 27401-4901 USA.

8 APPENDIX A: DATA PRODUCT NUMBERS

For more information on the sampling protocols and the latest observatory data visit http://data.neonscience.org/data-product-catalog and search by name or code number.

Table 38: NEON data product names and descriptions.

Name	Description	Identification Code
Root sampling (megapit)	Fine root biomass in 10cm increments (first 1m depth) and 20cm increments (from 1m to 2m depth) from soil pit sampling	NEON.DOM.SITE.DP1.10066
Soil physical properties (Megapit)	Soil taxonomy, horizon names, horizon depths, as well as soil bulk density, porosity, texture (sand, silt, and clay content) in the <= 2 mm soil fraction for each soil horizon. Data were derived from a sampling location expected to be representative of the area where the Instrumented Soil Plots per site are located and were collected once during site construction. Also see distributed soil data products.	NEON.DOM.SITE.DP1.00096
Soil chemical properties (Megapit)	Total content of a range of chemical elements, pH, and electrical conductivity in the <= 2 mm soil fraction for each soil horizon. Data were derived from a sampling location expected to be representative of the area where the Instrumented Soil Plots per site are located and were collected once during site construction. Also see distributed soil data products.	NEON.DOM.SITE.DP1.00097
Woody plant vegetation structure	Structure measurements, including height, canopy diameter, and stem diameter, as well as mapped position of individual woody plants	NEON.DOM.SITE.DP1.10098

Name	Description	Identification Code
Plant presence and percent cover	Plant species presence as observed in multi-scale plots: species and associated percent cover at 1-m2 and plant species presence at 10-m2, 100-m2 and 400-m2	NEON.DOM.SITE.DP1.10058
Plant phenology observations	Phenophase status and intensity of tagged plants	NEON.DOM.SITE.DP1.10055
Plant foliar stable isotopes	Field collection metadata describing the sampling of sun-lit canopy foliar tissues for stable isotope compositions. Also includes raw data returned from the laboratory.	NEON.DOM.SITE.DP1.10053
Plant foliar physical and chemical properties	Plant sun-lit canopy foliar physical (e.g., leaf mass per area) and chemical properties reported at the level of the individual.	NEON.DOM.SITE.DP1.10026
Non-herbaceous perennial vegetation structure	Field measurements of individual non-herbaceous perennial plants (e.g. cacti, ferns)	NEON.DOM.SITE.DP1.10045.
Ground beetles sampled from pitfall traps	Taxonomically identified ground beetles and the plots and times from which they were collected.	NEON.DOM.SITE.DP1.10022
Ground beetle sequences DNA barcode	CO1 DNA sequences from select ground beetles	NEON.DOM.SITE.DP1.10020
Mosquitoes sampled from CO2traps	Taxonomically identified mosquitoes and the plots and times from which they were collected	NEON.DOM.SITE.DP1.10043
Mosquito-borne pathogen status	Presence/absence of a pathogen in a single mosquito sample (pool)	NEON.DOM.SITE.DP1.10041
Mosquito sequences DNA barcode	CO1 DNA sequences from select mosquitoes	NEON.DOM.SITE.DP1.10038
Ticks sampled using drag cloths	Abundance and density of ticks collected by drag and/or flag sampling (by species and/or lifestage)	NEON.DOM.SITE.DP1.10093
Tick-borne pathogen status	Presence/absence of a pathogen in each single tick sample	NEON.DOM.SITE.DP1.10092