# Vegetation Inventory of Oak-Hickory Forest at Missouri Ozark (MOFLUX) Site: 2004-2017

ORNL TERRESTRIAL ECOSYSTEM SCIENCE

SCIENTIFIC FOCUS AREA

Climate Variability and Extreme Events

## Summary:

Vegetation inventory observations have been taken during years 2004 through 2017 at the second-growth upland oak-hickory forest at the Missouri Ozark AmeriFlux (MOFLUX) site. The MOFLUX site is located in the University of Missouri Baskett Wildlife Research area (BWREA), situated in the Ozark Border Region of central Missouri, USA, and is part of the AmeriFlux network (site ID: US-MOz).

During 2003–2004, 24 circular vegetation plots (each 0.08 ha) were established and individuals with diameter at breast height (DBH; 1.3 m above the ground) > 9 cm were inventoried.

The plots were situated 50 m apart on 5 linear transects radiating out from the MOFLUX flux tower base in SE, S, SW, W and NW directions—there were 5 plots per transect except for the NW one, which had only 4 due to the presence of a small pond at the terminus (Fig. 1).

On each plot, living individuals were identified with numbered aluminum tags, identified to species, measured for DBH, and geographic position measured using GPS.

In subsequent years, mortality observations are made at approximately monthly intervals during the growing season, ingrowth is added annually in the autumn, and DBH of all individuals is measured at two to three-year intervals, with DBH observations in the current record occurring in 2005, 2008, 2011, 2013, and 2016.

There is one comma separated (.csv) data file of vegetation inventory in this data set, with related published articles included as companion files (Gu, et al., 2015 and Wood et al., 2018).

## Data Citation:

**Cite this data set as follows:**

Pallardy, S.G., Gu, L., Wood, J.D., Hosman, K.P., and Hook, L.A. 2019. Vegetation Inventory of Oak-Hickory Forest at Missouri Ozark (MOFLUX) Site: 2004-2017. Oak Ridge National Laboratory, TES SFA, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. Access on-line at: https://doi.org/10.25581/ornlsfa.016/1498529

**Please include these citations to the related publications:**

Gu L, Pallardy SG, Hosman KP, and Sun Y.: Drought-influenced mortality of tree species with different predawn leaf water dynamics in a decade-long study of a central US forest, Biogeosciences, 12, 2831-2845, doi:10.5194/bg-12-2831-2015, 2015.

Wood JD, Knapp BO, Muzika R-M, Stambaugh MC and Gu L. 2018. The importance of drought-pathogen interactions in driving oak mortality events in the Ozark Border Region, Environmental Research Letters, 13:015004, doi: 10.1088/1748-9326/aa94fa.

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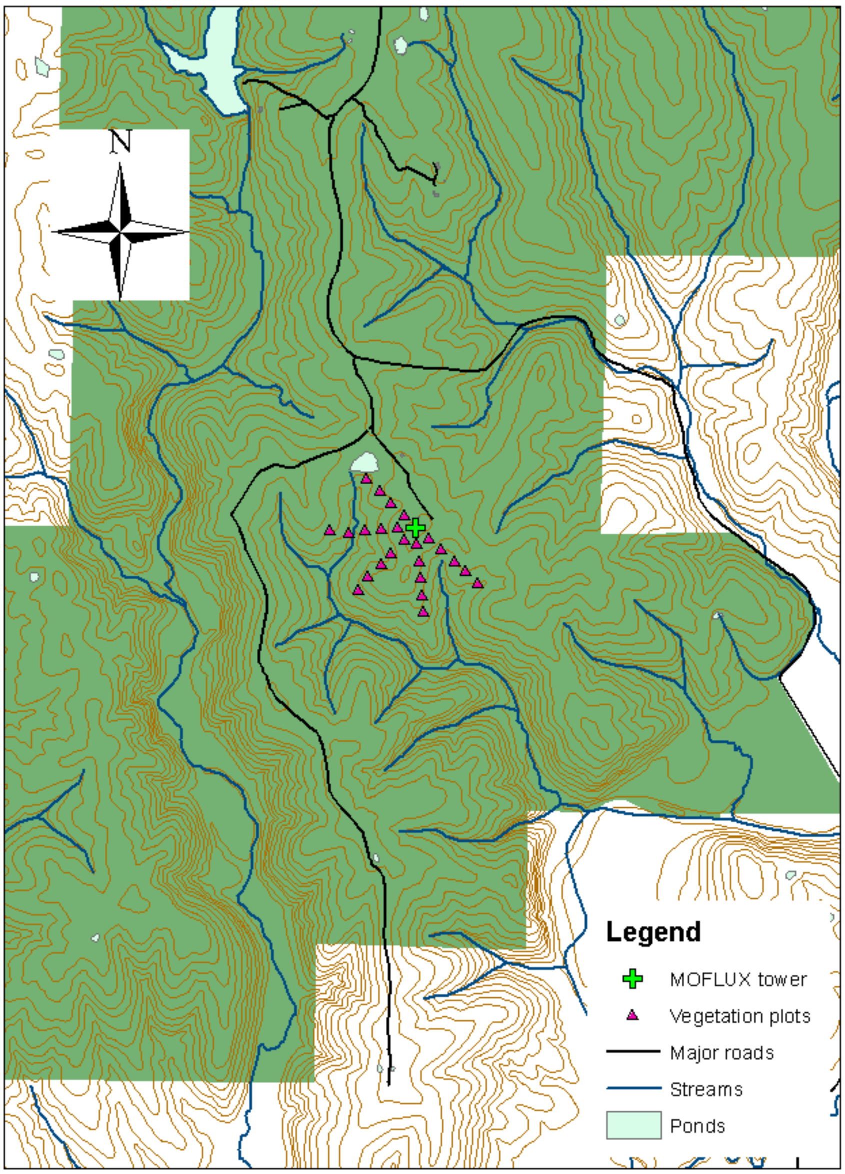


Figure 1. Map showing the spatial distribution of vegetation plots relative to the MOFLUX tower site at the Baskett Wildlife Research and Education Center (green shaded area) near Ashland MO. The brown lines represent 20' contours.

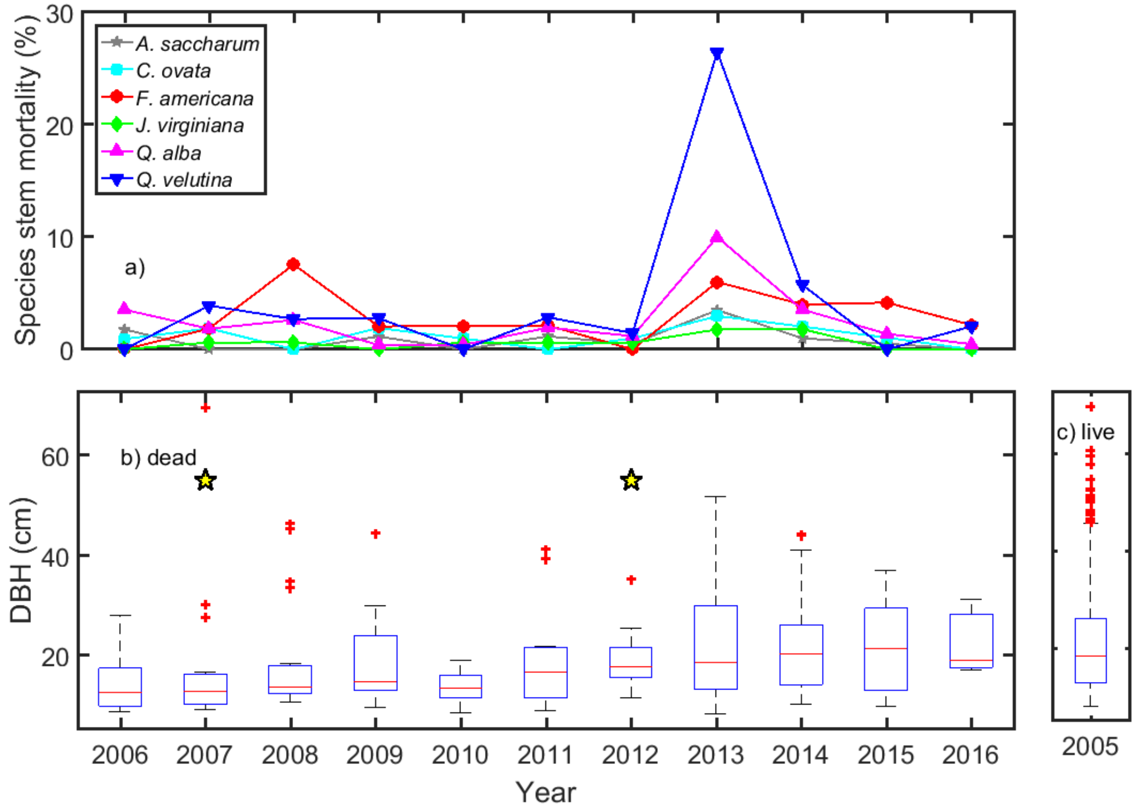


Figure 2. Time series of MOFLUX (a) species stem mortality, (b) the distribution of (community) diameter at breast height (DBH) of individuals that died, and (c) the DBH distribution of live individuals in 2005. In (b), the stars indicate the two years with the most severe drought. The major species included in the (a) panel are white oak (*Quercus alba* L.), black oak (*Q. velutina* Lam.), shagbark hickory (*Carya ovata* (Mill.) K. Koch), eastern redcedar (*Juniperus virginiana* L.), sugar maple (*Acer saccharum* Marsh.), and white ash (*Fraxinus americana* L.).

# Data and Documentation Access:

**<u>Get Data</u>**

**For public access to data please visit the ORNL TES-SFA Web Site:** https://tes-sfa.ornl.gov/home

**Published Papers included as companion files:** Gu, et al., (2015) and Wood et al., (2018).

**<u>Links to Supplemental Data and Information</u>**

AmeriFlux: Missouri Ozark / US-MOz (http://ameriflux.lbl.gov/sites/siteinfo/US-MOz)

**Related Data Sets:**

Pallardy, S.G., Gu, L., Wood, J.D., Hosman, K.P., and Sun, Y. 2018. Predawn Leaf Water Potential of Oak-Hickory Forest at Missouri Ozark (MOFLUX) Site: 2004-2017. Oak Ridge National Laboratory, TES SFA, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. https://doi.org/10.3334/CDIAC/ornlsfa.004

**ORNL TES-SFA Data Policy:** **Archiving, Sharing, and Fair-Use**

# Project Description

Investigators have been monitoring the mortality of tree species at the Missouri Ozark AmeriFlux (MOFLUX) site since 2005 and predawn leaf water potential since 2004.

The different tree species monitored at the MOFLUX site exhibited a range of drought tolerance. During the study period, a wide range of precipitation regimes from abundant rain to extreme drought occurred at the MOFLUX site, resulting in large inter-annual fluctuations in plant water stress levels and associated tree mortality.

# Table of Contents:

1 Data Set Overview
2 Data Characteristics
3 Applications and Derivation
4 Quality Assessment
5 Acquisition Materials and Methods
6 References
7 Data Access

# 1. Data Set Overview:

This data set reports vegetation inventory data that have been collected during the 2004 to 2017 growing seasons of the second-growth upland oak-hickory forests at the Missouri Ozark AmeriFlux (MOFLUX) site. The MOFLUX site is located in the University of Missouri Baskett Wildlife Research area (BWREA), situated in the Ozark region of central Missouri, USA.

# 2. Data Characteristics:

**Spatial Coverage**

Vegetation inventory was observed on 24 circular plots, for which centers were within ~250 m of the tower (Fig. 1). See location in Site boundary table below and Figure 1 for the layout of the site.

**Spatial Resolution**

All individuals having DBH > 9 cm on the 24 plots, each of area 0.08 ha, were included in the inventory.

**Site boundaries:** Latitude and longitude given in decimal degrees.

| Site | Latitude | Longitude | Elevation (meters amsl) | Geodetic Datum | UTM Zone |
|---|---|---|---|---|---|
| Missouri Ozark Site (US-MOz) | 38.7441 | -92.2000 | 212 | WGS84 | 15S |

**Source:** AmeriFlux: Missouri Ozark/US-MOz, http://ameriflux.lbl.gov/sites/siteinfo/US-MOz

**Temporal Coverage**

The data cover the period 2004 through 2017.

**Temporal Resolution**

Mortality observations were made monthly during growing seasons, ingrowth was added annually in the autumn, and DBH was measured at two-year intervals during the non-growing season.

## Data File Description

The data are provided in one comma separated (.csv) data file of vegetation inventory. A row is uniquely defined by the TRANSECT, PLOT, TAG, and YEAR.

The attached *.csv file is sorted by TRANSECT, PLOT, TAG, and YEAR.

**Data Dictionary: MOFLUX_inventory_20190308.csv**

| Column # | Column name | Description | Range of values | Missing value |
|---|---|---|---|---|
| **1** | TRANSECT | ID of sample transect corresponding to a Cardinal direction or division. | SE, S, SW, W, NW | None |
| **2** | PLOT | ID number of transect plot | 1–5 | None |
| **3** | TAG† | ID tag number attached to individual stem within a plot.<br><br>*Note that the* TAG *values may be non-unique, and it is therefore critical that* TRANSECT, PLOT*, and* TAG *number be considered together to uniquely ID each individual.* | 1–10,005 | -9999 |
| **4** | BINOMIAL_NAME | The scientific species name | Character values | Unknown or Missing |
| **5** | COMMON_NAME | The common species name | Character values | Unknown or Missing |
| **6** | UTM_X | Universal Transverse Mercator (Zone 15S) X coordinate of individual stem | 5.692521e+05–5.697154e+05 | -9999 |
| **7** | UTM_Y | Universal Transverse Mercator (Zone 15S) Y coordinate of individual stem | 4.288425e+06–4.288841e+06 | -9999 |
| **8** | YEAR | Observation year (YYYY) | 2004–2017 | None |
| **9** | STATUS§ | Status code of tagged individual | 0 = live<br>1 = dead<br>-9999 = missing†<br><br>Merged stem STATUS Values:<br>2xxxx = stems merged, and measurements for this tag continued. | -9999 |

| Column # | Column name | Description | Range of values | Missing value |
|---|---|---|---|---|
| | | | 3xxxx = stems merged and measurements for this tag discontinued.<br><br>4xxxx = Previous TAG lost; data transferred to new TAG number xxxx. | |
| **10** | DBH | Diameter (cm) at breast height (1.3 m above ground) | | -9999 |

†Note that when trees are added as ingrowth, their tag number is propagated backwards in time so that there is a record of every tagged tree in all years. For example, a tree added in 2014, will have a missing value in the Status field from 2005 through 2013.

§Note that the STATUS column values have been defined with the capacity to handle merged stems and lost tags. These may not appear in the dataset yet, but this capacity has been built into the product description for possible future use because data collection is ongoing, and the dataset will be updated in the future.

**Example data records:**

```
TRANSECT,PLOT,TAG,BINOMIAL_NAME,COMMON_NAME,UTM_X,UTM_Y,YEAR,
STATUS,DBH
-,-,-,-,-,m,m,-,-,cm
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2005,0,39.1
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2006,0,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2007,0,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2008,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2009,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2010,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2011,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2012,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2013,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2014,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2015,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2016,1,-9999
NW,1,1,Quercus velutina Lam.,black oak,569479.1123,4288718.889,2017,1,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2005,0,41.8
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2006,0,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2007,0,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2008,0,42.7
```

```
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2009,0,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2010,0,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2011,0,42.5
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2012,0,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2013,1,42.9
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2014,1,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2015,1,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2016,1,-9999
NW,1,3,Quercus velutina Lam.,black oak,569474.8596,4288732.312,2017,1,-9999
NW,1,8,Acer saccharum Marsh.,sugar maple,569484.8173,4288704.832,2005,0,14.5
NW,1,8,Acer saccharum Marsh.,sugar maple,569484.8173,4288704.832,2006,0,-9999
```

# 3. Data Application and Derivation:

Using these continuous observations of tree mortality and predawn leaf water potential (Pallardy et al., 2018) at the MOFLUX site, authors studied how the mortality of important tree species varied and how such variations may be predicted. Water stress determined interannual variations in tree mortality with a time delay of 1 year or more (Gu et al., 2015).

The exceptional drought of the year 2012 drastically increased the mortality of all species, including drought-tolerant oaks, in the subsequent year. The drought-influenced tree mortality was related to the species position along the spectrum of PLWP regulation capacity with those in either ends of the spectrum being associated with elevated risk of death. Regardless of species and drought intensity, the PLWP of all species recovered rapidly after sufficiently intense rain events in all droughts. This result, together with a lack of immediate leaf and branch desiccation, suggests an absence of catastrophic hydraulic disconnection in the xylem and that tree death was caused by significant but indirect effects.

A subsequent analysis of tree mortality in the MOFLUX forest and synthesis with other vegetation and tree-ring data found that it is probable that drought-pathogen interactions played an important role in driving oak mortality after the 2012 drought (Wood et al., 2018).

# 4. Quality Assessment:

These data are considered at **Quality Level 2**.  Level 2 indicates a complete, externally consistent data product that has undergone interpretative and diagnostic analyses. The data product has been subjected to quality checks and data management procedures (Level 1).

# 5. Data Acquisition Materials and Methods:

**Site Description**

The MOFLUX site is located in the University of Missouri Baskett Wildlife Research area (BWREA), situated in the Ozark region of central Missouri. The site is uniquely located in the ecologically important transitional zone between the central hardwood region and the central grassland region of the US. The land has been publically owned since the 1930s, and is on a land tract that was forested with the same dominant species before settlement in the early 1800s. BWREA is within the Ozark border region of central Missouri. Second-growth upland oak-hickory forests constitute the major vegetation type at the BWREA (Rochow, 1972; Pallardy et al., 1988). Major tree species include white oak (*Quercus alba* L.), black oak (*Q. velutina* Lam.), shagbark hickory (*Carya ovata* (Mill.) K. Koch), sugar maple (*Acer saccharum* Marsh.), and eastern redcedar (*Juniperus virginiana* L.). Although these species co-occur in MOFLUX forests, there are differences in which species dominate in particular locations.

Figure 3. View of the forest from the top of the tower looking west.

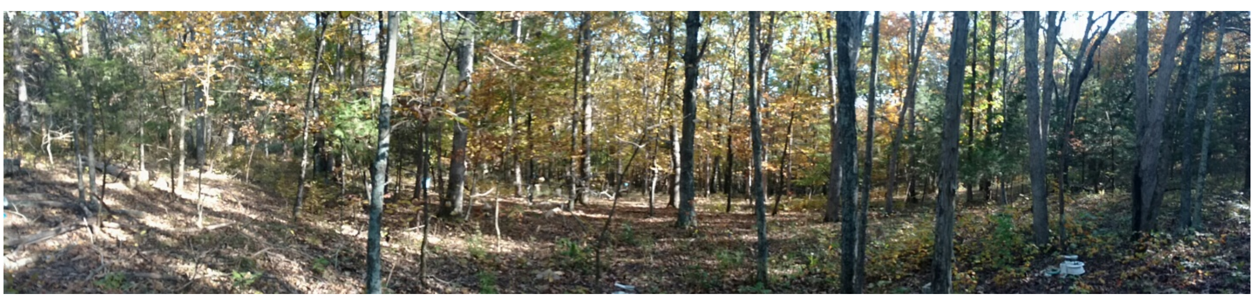

Figure 4. View of the forest from the ground looking to the southeast from near the base of the tower.

Figure 5. View of the forest near the base of the tower that is located inside the fenced area at right.

**Additional Site Measurements**

The MOFLUX site is an active Ameriflux site (https://ameriflux.lbl.gov/) providing long term monitoring of carbon dioxide and water vapor concentrations, above canopy and sub-canopy energy fluxes, characterization of meteorological and environmental conditions, soil respiration, sap flow, canopy phenology, and leaf-level photosynthetic biochemistry.

Meteorological measurements include precipitation, temperature and relative humidity made at the top of the 30m flux tower and used to formulate potential meteorologically based predictors for tree mortality. Precipitation was measured with a recording tipping bucket rain gauge. Data were totaled over 30 min periods. Atmospheric vapor pressure deficit (VPD) was computed from temperature and relative humidity. At the MOFLUX site, routine meteorological measurements are made with plenty of redundant sensors to minimize the risk of measurement gaps. The full complement of AmeriFlux core site measurements are available at https://ameriflux.lbl.gov/.

**Predawn leaf water potential (PLWP)**

Since early June of 2004, measurements of PLWP have been made periodically (weekly to biweekly) during the growing seasons. In each year, except for 2004, the first measurements occurred in mid-May. In all years, the last measurements took place in late October. Leaf samples were collected before dawn for canopy and sapling individuals of common tree species at the site.

A total of 20–21 samples were obtained each day with 6–7 taken from *Quercus alba*, and the rest, with at least two samples per species, distributed among *Q. velutina*, *Acer saccharum*, *Carya ovata*, *Fraxinus americana* L. (white ash), and *Juniperus virginiana*, roughly in proportion to their relative stem abundance in the stand.

Leaves or leaflets (both oak species, shagbark hickory, and white ash) or shoots (sugar maple and eastern redcedar) were sampled from lower branches (<2 m height) thus rendering any gravitational component minimal. After excision with a razor blade, samples were immediately placed in humidified bags in a chest cooler until measurement promptly after sample collection was complete. PLWP was measured with a pressure chamber (Turner, 1981; Pallardy et al., 1991).

# 6. References:

Gu L, Pallardy SG, Hosman KP, and Sun Y (2015) Drought-influenced mortality of tree species with different predawn leaf water dynamics in a decade-long study of a central US forest, Biogeosciences, 12, 2831-2845, https://doi.org/10.5194/bg-12-2831-2015.

Gu L, Pallardy SG, Hosman KP, Sun Y (2016) Impacts of precipitation variability on plant species and community water stress in a temperate deciduous forest in the central US. Agricultural and Forest Meteorology, 217, 120-136. https://doi.org/10.1016/j.agrformet.2015.11.014.

Pallardy SG, Gu L., Wood JD, Hosman KP, Sun Y., and Hook L. Predawn Leaf Water Potential of Oak-Hickory Forest at Missouri Ozark (MOFLUX) Site: 2004-2017. United States: N. p., 2018. Web. doi:10.3334/CDIAC/ORNLSFA.004.

Pallardy SG, Nigh TA, Garrett HE (1988) Changes in forest composition in central Missouri: 1968–1982. The American Midland Naturalist, 120, 380–390.

Rochow JJ (1972) A vegetational description of a mid-Missouri forest using gradient analysis techniques, American Midland Naturalist, 87, 377–396.

Wood JD, Knapp BO, Muzika R-M, Stambaugh MC and Gu L (2018) The importance of drought-pathogen interactions in driving oak mortality events in the Ozark Border Region, Environmental Research Letters, 13:015004, doi: 10.1088/1748-9326/aa94fa.

# 7. Data Access:

For public access to ORNL TES SFA data please visit the TES SFA Web Site: https://tes-sfa.ornl.gov/home

**Contact for Data Access Information:** https://mnspruce.ornl.gov/contact