

## BIGFOOT FIELD DATA FOR NORTH AMERICAN SITES, 1999-2003

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### Summary:

This data set reports measurements of FPAR, nitrogen content, allometry equations, root biomass, LAI, tree biomass, soil respiration, and NPP field data in comma-separated ASCII files for BigFoot Project selected EOS Land Validation Sites in North America from 1999 to 2003. Derived landcover images and vegetation inventories for selected sites are presented as GeoTIFF files.

The BigFoot project gathered field data for selected EOS Land Validation Sites in North America from 1999 to 2003. Data collected and derived for varying intervals at the BigFoot sites and archived with this data set include FPAR, nitrogen content, allometry equations, root biomass, LAI, tree biomass, soil respiration, NPP, landcover images, and vegetation inventories.

Each site is representative of one or two distinct biomes, including the Arctic tundra; boreal evergreen needleleaf forest; temperate cropland, grassland, and deciduous broadleaf forest; desert grassland and shrubland. The project collected multi-year, in situ measurements of ecosystem structure and functional characteristics related to the terrestrial carbon cycle at the sites listed in Table 1. Companion files include documentation of measurement data, site and plot locations (Figure 2), and plot photographs for the SEVI and TUND sites (Figure 3).

**BigFoot Project Background:** Reflectance data from MODIS, the Moderate Resolution Imaging Spectrometer onboard NASA's Earth Observing System (EOS) satellites Terra and Aqua ( <http://landval.gsfc.nasa.gov/MODIS/index.html> ), was used to produce several science products including land cover, leaf area index (LAI), gross primary production (GPP), and net primary production (NPP). The overall goal of the BigFoot Project was to provide validation of these products. To do this, BigFoot combined ground measurements, additional high-resolution remote-sensing data, and ecosystem process models at six flux tower sites representing different biomes to evaluate the effects of the spatial and temporal patterns of ecosystem characteristics on MODIS products. BigFoot characterized up to a 7 x 7 km area (49 1-km MODIS pixels) surrounding the CO<sub>2</sub> flux towers located at six of the nine BigFoot sites. The sampling design allowed the Project to examine scales and spatial patterns of these properties, the inter-annual variability and validity of MODIS products, and provided for a field-based ecological characterization of the flux tower footprint. BigFoot was funded by NASA's Terrestrial Ecology Program.

### Additional Documentation:

The BigFoot Field Manual (Campbell et al., 1999) provides background information on site and plot locations and measurements. [[BigFoot Field Manual 1999.pdf](#)]

For more details on the BigFoot Project, please visit the website: <http://www.fsl.orst.edu/larse/bigfoot/index.html>.

Additional site characteristics information is available on the ORNL DAAC FLUXNET web site [ <http://www.fluxnet.ornl.gov/fluxnet/index.cfm> ].

Carbon and energy flux data may be available for selected sites on the AmeriFlux Network web site [ <http://public.ornl.gov/ameriflux/index.html> ].

**Table 1. BigFoot data are reported for the following six sites and parameters collected during the indicated years.**

Site	Site Location	Biome	FPAR	Nitrogen	Allometry	Roots	LAI	Biomass	Soil Resp.	NPP	Landcover & Veg.	Measurement Documentation
<b>NOBS</b>	BOREAS NSA, Canada	boreal forest	2000			2000	1999, 2000, 2 *.tif (2000, 2001)	2000		1999, 2000	1999, 2 *.tif (2000, 2001)	<a href="#">NOBS_README.pdf</a>
<b>ARGO</b>	Bondville, Illinois, USA	cropland (corn and soybean rotation)	2000	1999, 2000	2000	2000	1999, 2000, 2 *.tif (2000)	1999, 2000			1999, *.tif (2000)	<a href="#">ARGO_README.pdf</a> and Figure 1.
<b>HARV</b>	Harvard Forest LTER, Massachusetts, USA	temperate mixed forest	2000, 2001, 2002			2000	2000, 2001, 2002, 2 *.tif (2000, 2001)	2000		2000, 2001, 2002	2000, 2 *.tif (2000, 2001)	<a href="#">HARV_README.pdf</a>
<b>KONZ</b>	Konza Prairie LTER, Kansas, USA	tallgrass prairie	2000, 2001	2000		2000	2000, 2001, 3 *.tif (2000, 2001)	2000, 2001		2000, 2001	2 *.tif (2000, 2001)	<a href="#">KONZ_README.pdf</a>
<b>SEVI</b>	Sevilleta LTER, New Mexico, USA	desert		2002	2002, 2003		2002, 2003	2002, 2003	2002, 2003	2002, 2003		<a href="#">SEVI_README.pdf</a> Plot Photos Included
<b>TUND</b>	Barrow, AK, USA	arctic tundra		2002			2002	2002	2002	2002		<a href="#">TUND_README.pdf</a> Plot Photos Included

**Table 2. General Data Descriptions**

Please refer to the site-specific Measurement Documentation referenced in Table 1 for additional information about the specific measurement methods and units reported for each Site.

Parameter	Description	Units
<b>FPAR</b>	Fraction of Photosynthetically Active Radiation intercepted by the vegetation	Values range from 0 to 1.
<b>Nitrogen</b>	Vegetation tissue nitrogen concentration	Values are reported in total percent nitrogen.
<b>Allometry</b>	Equations for converting measured physical vegetation characteristics (e.g., tree diameter at breast height (DBH)) to biomass.	text
<b>Roots</b>	Root biomass data	All values reported on a dry weight basis as kg/ha
<b>LAI</b>	Leaf area index.	All data are reported as one-half total leaf surface area. All LAI values are unitless (m <sup>2</sup> /m <sup>2</sup> ).
<b>Biomass</b>	Vegetation biomass	Biomass data are reported as kg dry mass per hectare
<b>Soil Respiration</b>	Soil CO <sub>2</sub> flux	Grams of carbon per meter squared per second
<b>NPP</b>	Net primary production	All values reported as kg dry mass per hectare (per year).
<b>Landcover/Veg</b>	Site landcover and vegetation inventory	



**Figure 1.** Example of .tif file provided for LAI (leaf area index) data. This is an image of LAI from August 11, 2000 at the AGRO site (bf\_agro\_lai\_aug\_11\_2000\_x10\_them\_with\_defaults.tif). For detailed information about the \*.tif files provided for LAI and Landcover at selected sites, please refer to the site-specific Measurement Documentation referenced in Table 1.

## Data Citation:

### Cite this data set as follows:

Gower, S. T. and A. A. Kirschbaum. 2008. BigFoot Field Data for North American Sites, 1999-2003. Data set. Available online [<http://www.daac.ornl.gov>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/868.

## Related Data Sets:

- BIGFOOT GPP SURFACES FOR NORTH AND SOUTH AMERICAN SITES, 2000-2004
- BIGFOOT LAND COVER SURFACES FOR NORTH AND SOUTH AMERICAN SITES, 2000-2003
- BIGFOOT LEAF AREA INDEX SURFACES FOR NORTH AND SOUTH AMERICAN SITES, 2000-2003
- BIGFOOT NPP SURFACES FOR NORTH AND SOUTH AMERICAN SITES, 2000-2004

## Data Description:

Data are organized by site with accompanying documentation that contains measurement information, data file contents, and \*.tif file descriptions for the data reported for that site. See Table 1.

## Site Locations:

Center and Tower coordinates for BigFoot sites are shown in Table 2 (below) and are provided as **BigFoot\_site\_locations.csv**.

## Site Measurement Data and Sampling Plot Locations

Data files for each BigFoot site have been compiled and compressed (e.g., agro.zip). Each site's zipped file contains tabular data files and Geotif files as indicated in Table 1, and a file of sampling plot locations.

### Data File Naming Syntax for Tabular Data Files:

BigFoot Site \_ variable \_ year.csv  
For example, AGRO\_biomass\_2000.csv

### Data File Naming Syntax for Geotiff Files:

bf\_agro\_lai\_aug\_11\_2000\_x10\_them\_with\_defaults.tif  
bf\_agro\_lai\_aug\_11\_2000\_x10\_them\_with\_defaults.tfw (metadata file)  
These are the file names used by the data provider. Each .tif file also has an identified readme file in the their respective Site's companion document. These readmes have general, layer, map, attribute, and additional information.

## Sampling Plot Locations

Locations of the sampling plots at each of the sites are provided in a .csv file (e.g., HARV\_plot\_locations.csv)

A typical site and plot sampling design is shown in the following figure excerpted from the BigFoot Field Manual (Campbell et al., 1999).

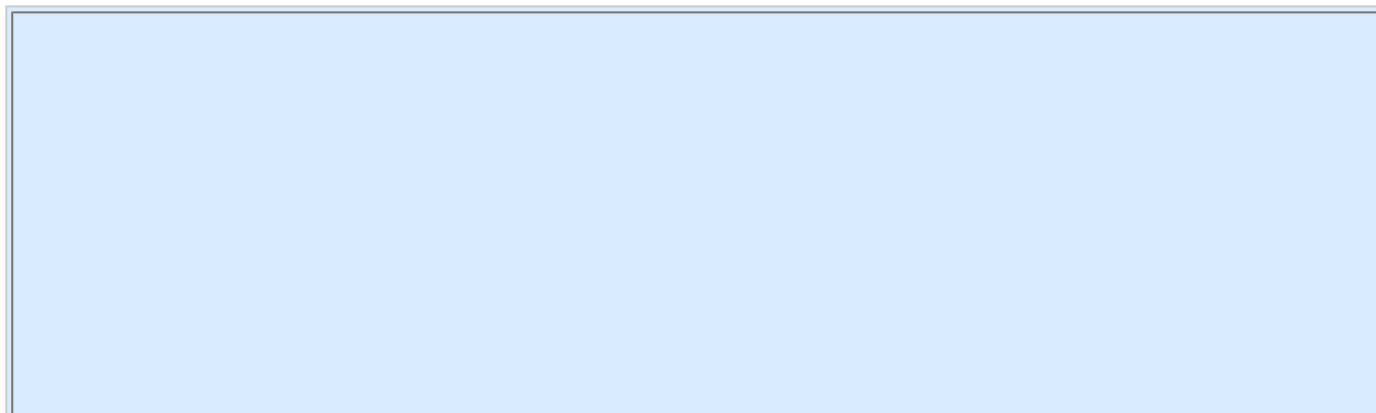


Figure 1.3. BigFoot field sampling design.

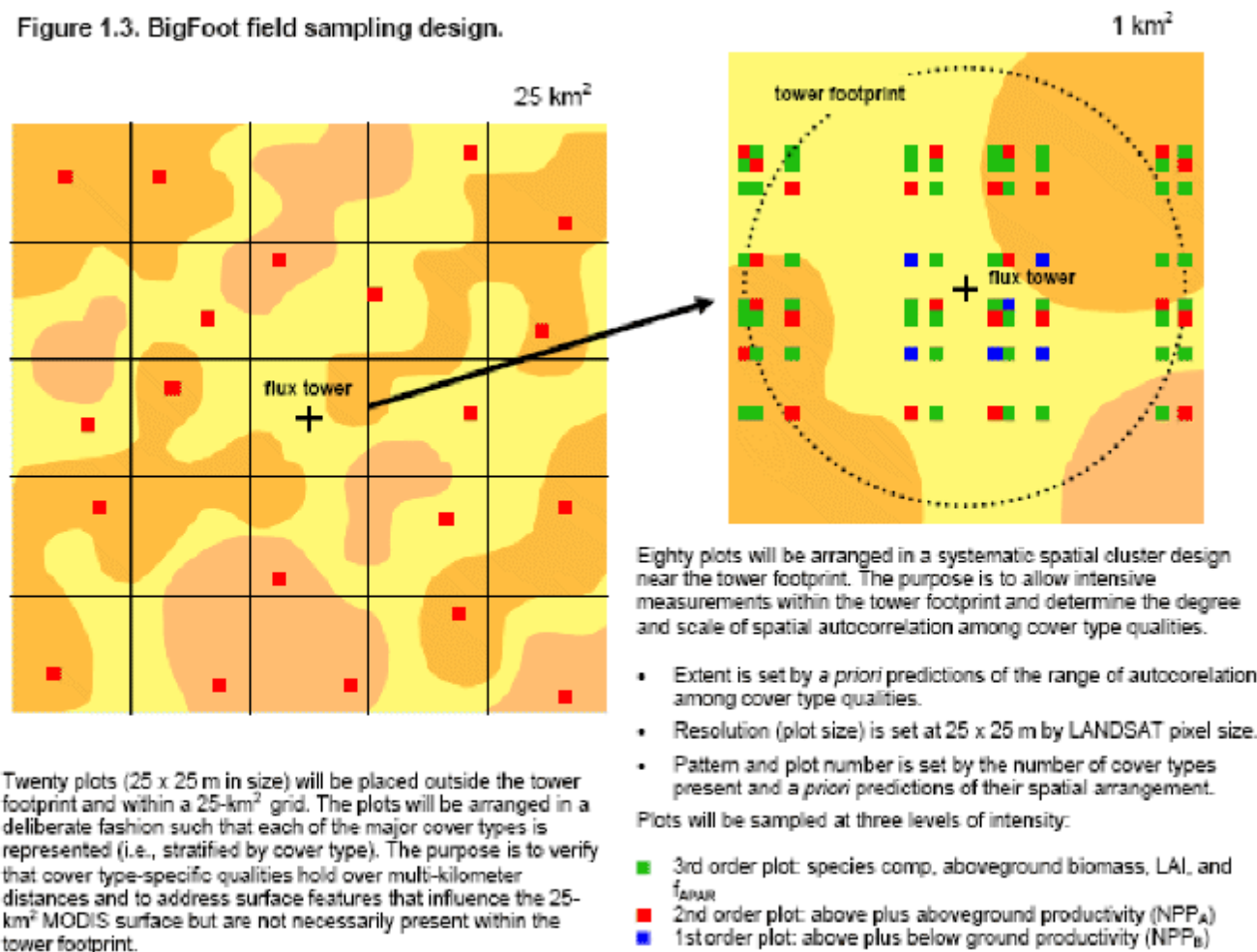


Figure 2. Site and plot sampling design excerpted from the BigFoot Field Manual (Campbell et al., 1999).

## Companion Documentation

### Site Measurement Documentation

A companion document is provided for each site with descriptions of the data reported for that site.  
For example, HARV\_README.pdf

**HARV Site: BigFoot Field Data Documentation****Contents:**

- 2000, 2001, 2002 HARV LAI FPAR README DOCUMENT
- 2000 HARV ROOT BIOMASS README DOCUMENT
- 2000 HARV BIOMASS README DOCUMENT
- 2000 HARV ALLOMETRIC EQUATIONS README DOCUMENT
- 2000, 2001, 2002 HARV ANPP README DOCUMENT
- 2000 HARV VEGETATION COVER TYPE README DOCUMENT
- README for bf\_harv\_landcover\_2000\_igbp.tif
- README for bf\_harv\_landcover\_2001\_igbp.tif
- README for bf\_harv\_lai\_aug\_4\_2000\_x10\_them\_with\_defaults.tif
- README for bf\_harv\_lai\_july\_26-28\_x10\_them\_with\_defaults.tif
- ...

**Photographs of SEVI and TUND Site Plots**

A set of five pictures was taken of each SEVI and TUND site plot during selected measurement events.

In each set of images:

- first picture is of the plot center stake
- second facing north from plot center
- third facing east from plot center
- fourth facing south from plot center
- fifth facing west from plot center

Subplots are numbered 1, 2, 3, 4, and 5 referring to center, north, east, south, and west, respectively.

**SEVI Plot Photos:**

The photos have been compiled into a single companion file (sevi\_plot\_photos.zip, 1040 MB in size). The plot pictures are organized in folders that indicated the month and year the photos were taken (e.g., 3\_02, for March of 2002).

The SEVI image file name syntax follows this template: PLOT\_SUBPLOT.jpg

For example, 00\_1.jpg is SEVI site plot 0, subplot 1

**TUND Plot Photos:**

The photos have been compiled into a single companion file (tund\_plot\_photos.zip, 346 MB in size). The plot pictures are organized in folders that indicated the month and year the photos were taken (e.g., 7\_02, for July of 2002).

The TUND image file name syntax follows this template: TUND\_PLOT\_SUBPLOT.jpg

For example, TUND\_00\_1.jpg is TUND site, plot 0, subplot 1



**Figure 3.** Example photographs of study plots taken at the SEVI site on May 21-29, 2002. Left photo is Plot 0, Subplot 1 (center) and right photo is Plot 0, Subplot 3 (east). Photos of plots and subplots are available for SEVI and TUND sites as companion files.

**Table 3. BigFoot Site Locations**

Site Name	Latitude	Longitude	UTM-X Coord	UTM-Y Coord	UTM Zone
<b>NOBS Center</b>	55.885260	-98.477268	532698	6193433	14N
<b>NOBS Tower</b>	55.879547	-98.480843	532479	6192795	14N
<b>KONZ Center</b>	39.089073	-96.571398	710046	4329469	14N
<b>KONZ Tower</b>	39.082286	-96.560251	711030	4328742	14N
<b>ARGO Center</b>	40.0066580	-88.291535	389764	4429295	16N
<b>ARGO Tower</b>	40.006627	-88.291030	389807	4429291	16N
<b>HARV Center</b>	42.528513	-72.172907	732194	4712333	18N
<b>HARV Tower</b>	42.538259	-72.171378	732283	4713419	18N
<b>TUND Center</b>	71.271908	-156.613307	585509	7909410	4N
<b>TUND Tower</b>	71.280866	-156.612205	585509	7910410	4N
<b>SEVI Center</b>	34.350858	-106.689897	344578	3802353	13N
<b>SEVI Tower</b>	34.360290	-106.700285	343640	3803415	13N

The Universal Transverse Mercator (UTM) coordinate system is a grid-based method of specifying locations on the surface of the Earth. It is used to identify locations on the earth, but differs from the traditional method of latitude and longitude in several respects. The UTM system is not a single map projection. The system instead employs a series of sixty zones, each of which is based on a specifically defined Transverse Mercator projection.

The easting is the projected distance in meters of the position from the central meridian, while the northing is the projected distance in meters of the point from the equator.

[http://en.wikipedia.org/wiki/Universal\\_Transverse\\_Mercator\\_coordinate\\_system](http://en.wikipedia.org/wiki/Universal_Transverse_Mercator_coordinate_system)

<http://www.ngs.noaa.gov/TOOLS/utm.html>

<http://erg.usgs.gov/isb/pubs/factsheets/fs07701.html>

### Methods of in situ measurements of land cover, LAI, fAPAR, NPP, leaf nitrogen, and soil respiration.

The complex sampling design is efficient, but it required differential processing Global Positioning System (GPS) units to accurately locate the plots in the field. Plots were located in all vegetation cover classes within the 25-km<sup>2</sup> grid to ensure adequate coverage as shown in Figure 2.

Vegetation cover, LAI, fAPAR, and NPP were measured at several subplots within each plot for at least two years. LAI was measured using standard direct and optical methods at each site (Gower et al. 1999). Direct measurement approaches included periodic area harvest for non-forest sites and application of allometric equations to tree diameter data for forest sites. LAI and fAPAR were also estimated indirectly using the Li-Cor LAI-2000 Plant Canopy Analyzers (Fassnacht et al. 1994, Chen et al. 1997, Gower et al. 1997, Gower et al. 1999). Therefore, the number of LAI/ fAPAR measurement campaigns varied among sites, as phenology of LAI development varies among biomes, among ecosystems within each biome, and between years for a given ecosystem. Consequently, LAI and fAPAR were measured three times each year at the forest sites and four to six times at other sites.

fAPAR was estimated two ways: from the DIFN variable provided by the Li-Cor LAI-2000 Plant Canopy Analyzer (Gower et al. 1999) and from a continuous PAR tram system. We designed and successfully deployed a PAR tram at NOBS in 2000. The PAR tram measured incident and reflected PAR both above and below the canopy at small increments along a 30 m track. A tram was installed at AGRO, SEVI, HARV, and NOBS in 2002 for several reasons. First, the fraction of direct to diffuse PAR influences LUE (Gower et al. 1999), and this relationship varies with canopy structure. Furthermore, the continuous measurements provide more complete characterization of daily and seasonal patterns of fAPAR.

NPP (the sum of the annual biomass production of each tissue for all vegetation strata) was measured for a minimum of two years at approximately 50 plots at all five newer sites. NPP is defined as equal to  $NPPW + NPPF + NPPCR + NPPFR + NPPU + NPPGC$ , where W = aboveground wood (e.g., stem + branches), F = foliage, CR = coarse roots, FR = fine roots, U = understory, and GC = ground cover (e.g., mosses and sphagnum). This equation is appropriate for any terrestrial ecosystem, but the field methods used to estimate each component vary among ecosystems (Gower et al. 1999).

- Aboveground woody biomass (e.g., stem and branch) and coarse root biomass was also estimated from investigator derived site-specific allometric equations that correlate component biomass to stem diameter at breast height (1.3 m).
- Woody biomass increment was determined from radial growth, measured using increment cores. As tropical trees do not produce reliable annual growth rings, we used rust-resistant dendrometer bands (Walker and Whiteaker 1988) to measure annual diameter growth. The number of tree species and size classes were determined during the 2001 reconnaissance trip.
- Numerous abiotic and biotic factors have been shown to influence the allometric coefficients for new foliage biomass;



therefore we estimated new foliage production from annual leaf litterfall detritus production for forests where site- and species-specific allometric equations are not available (Gower et al. 1999). This approach assumed the canopy biomass is in steady state. Total foliage biomass and leaf area equations are from the literature.

- Where appropriate, biomass and leaf area data for harvested trees of the same species, but different sites, were composited and a generalized regression equation was used.
- NPPA (aboveground NPP) of the shrub and herbaceous layers was quantified using clip plots.
- We also used clip plots throughout the growing season to quantify biomass production at the non-forest sites.
- NPPA of bryophytes, lichens, etc. was estimated using crank wires and ingrowth mesh plots (Gower et al. 1997, Bisbee et al. 2000).
- Fine root net primary production and mortality was estimated using minirhizotrons (Steele et al. 1997). Measurements on NPPB (belowground NPP) were restricted to the two dominant vegetation types within a site because of the large costs associated with obtaining and processing these data. Minirhizotrons were installed in each ecosystem and fine root growth was measured for two years.
- In the forest ecosystems, coarse root NPP was estimated from allometric equations.
- At the KONZ site, separate allometric equations were developed for each grass component relating percent cover to biomass. Allometric equations were calculated for each sampling date and for unburned and burned leaf and stem components.

Leaf nitrogen concentration as % nitrogen by mass of leaves was measured from dominant species. Five plants of each dominant species were sampled. Fresh leaves were dried, digested by Kjeldahl incubation, and colorimetrically analyzed for nitrogen.

Soil Respiration measurements at SEVI (2002 and 2003) and TUND (2002) sites were done at the same collars/plots each year. Respiration measurements were taken with a LICOR 6250 CO<sub>2</sub> analyzer using chamber size of 10759 cm<sup>3</sup>. Light and dark measurements were taken at each collar, with five collars per plot or 10 along intensively measured transects. Vegetation was not clipped prior to measurements.

The BigFoot Field Manual (Campbell et al., 1999) provides background information on NOBS, AGRO, HARV, and KONZ site and plot locations and measurements. [[BigFoot Field Manual 1999.pdf](#)]

The individual site measurement documentation listed in Table 1 provides the best documentation relating to data as reported and archived.

## References:

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## Abbreviations and Acronyms:

AGRO - agricultural cropland  
 BOREAS - Boreal Ecosystem-Atmosphere Study  
 DBH - diameter at breast height (4.5 ft above ground)  
 DIFN - is an indicator of "canopy light absorption".  
 EOS - Earth Observing System  
 fAPAR - fraction absorbed photosynthetic active radiation  
 GPP - gross primary production  
 GPS - Global Positioning System  
 HARV - Harvard Forest  
 KONZ - Konza Prairie  
 LAI - leaf area index  
 LTER - Long-Term Ecological Research  
 LUE - light use efficiency  
 MODIS - moderate resolution imaging spectrometer  
 NASA - National Aeronautics and Space Administration  
 NOBS - northern old black spruce  
 NPP - net primary production  
 NPPA - aboveground NPP  
 NPPB - belowground NPP  
 NSA - Northern Study Area  
 PAR - photosynthetically active radiation  
 SEVI - New Mexico desert, Sevietta - an LTER site in New Mexico  
 TUND - arctic tundra  
 UTM - Universal Transverse Mercator

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