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Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Andrea Papagno, Editors

Volume 145
BOREAS TE-6 Biomass and Foliage Area Data

S.T. Gower and J.G. Vogel

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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BOREAS TE-6 Biomass and Foliage Area Data

Stith T. Gower and Jason G. Vogel, University of Wisconsin-Madison

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BOREAS TE-6 Biomass and Foliage Area Data

Stith T. Gower, Jason G Vogel

Summary

The BOREAS TE-6 team collected several data sets in support of its efforts to characterize and interpret information on the plant biomass, allometry, biometry, sapwood, leaf area index, net primary production, soil temperature, leaf water potential, soil CO_2 flux, and multivegetation imagery of boreal vegetation. This data set contains measurements of estimates of the standing biomass and leaf area index for the plant species at the TF, CEV, and AUX sites in the SSA and NSA during the growing seasons of 1994 and 1995. The data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-06 Biomass and Foliage Area Data

1.2 Data Set Introduction

Biomass, sapwood volume, and Leaf Area Index (LAI) estimates were conducted at the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) and Northern Study Area (NSA) during the growing seasons of 1994 and 1995 as part of an effort by the Terrestrial Ecology (TE)-06 team to develop carbon budgets for various Canadian boreal forest types. The biomass of a forest provides information on the amount of carbon sequestered by a given forest type over the stand history and thereby provides information regarding its successional status and functional characteristics. LAI provides information on the area of photosynthesizing material within a forest. Sapwood volume can be used to estimate stem respiration. The biomass data are reported in kg carbon/ha, the LAI is reported in m^2 of leaf area/m^2 of ground based on needle hemisurface area (Chen et al., 1997) for conifer sites, and sapwood volume estimates are in m^3 of sapwood/m^2 of ground. All estimates were derived from plots located at each site and allometric equations. Understory biomass estimates for the Tower Flux (TF) and Carbon Evaluation (CEV) sites are also provided.

1.3 Objective/Purpose

The purpose of this work was to quantify the standing biomass, sapwood volume, and LAI for the TF, CEV, and Auxiliary (AUX) sites and the forest floor for the TF and CEV sites.

1.4 Summary of Parameters

The data records include measurements of stem biomass, sapwood volume, foliage biomass, understory biomass, and LAI.

1.5 Discussion

Biomass, sapwood volume, and LAI are important, if not defining, characteristics of forests. These variables not only indicate the past growth of a forest, but also are key variables for models that describe the exchange of heat, energy, carbon dioxide, and water between the forest and the atmosphere as well as for models that describe the forest's biogeochemical cycle.

To determine the biomass, sapwood volume, and LAI for each of the TF, CEV, and AUX sites, diameter measurements were made for variable radius and fixed area plots. Allometric equations that use the diameter as the independent variable were developed to predict biomass (i.e., stem, branch, foliage), sapwood volume, and leaf area for each tree within the plot. Based on the plot size or the variable radius factor used, each tree in a plot represented a number of other trees per hectare (Dilworth and Bell, 1979), and this 'scaling factor' was then used to scale all biomass and leaf area estimates to the hectare. Allometric equations were developed for the dominant overstory species (Pinus banksiana, Populus tremuloides, Picea mariana, Picea glauca) at each TF site and some CEV sites from a harvest in August 1994. A complete description of the development of the allometry equations is provided in the TE-06 allometry documentation. Equations for Alnus crispa were developed from an allometry harvest in August 1995. The allometric equations for Populus tremuloides were used for Populus balsamifera, Salix sp., and Betula papyrifera, while equations for Larix laricina are from Kloeppel and Vogel (unpublished data); contact J.G. Vogel for information. Biomass equations for Abies balsamea were from Singh (1986).

Biomass, sapwood volume, and LAI estimates for the TF and CEV sites are of good quality because they were derived from site-specific allometric equations. Some of the AUX site foliage biomass and LAI estimates suffered from not being derived from site-specific allometric equations, and some estimates were excluded from the data set for this reason. Sapwood volume estimates were not provided for the AUX sites. From a spatial perspective, the tower site plots were located in areas that approximated the forest within the Wind-Aligned Blob (WAB), while the CEV and AUX plots were located to describe the forest within a 30- x 30-m area. The WAB was the area around a flux tower where most of the measured fluxes originated. During BOREAS, access to this area was limited to prevent contamination of flux measurements.

1.6 Related Data Sets

BOREAS RSS-04 1994 Southern Study Area Jack Pine LAI and FPAR Data
BOREAS TE-06 1994 Soil and Air Temperatures in the NSA
BOREAS TE-06 Predawn Leaf Water Potentials and Foliage Moisture Contents
BOREAS TE-06 Multiband Vegetation Imager Data
BOREAS TE-06 Allometry Data
BOREAS TE-06 NPP for the Tower Flux, Carbon Evaluation, and Auxiliary sites

2. Investigator(s)

2.1 Investigator(s) Name and Title

Tom Gower, Professor

2.2 Title of Investigation

Measurement and Scaling of Carbon Budgets for Contrasting Boreal Forest Sites

2.3 Contact Information

Contact 1:
Stith T. Gower
1630 Linden Drive
Madison, WI 53706
(608) 262-0532
stgower@facstaff.wisc.edu

Contact 2:
Jason G Vogel
1630 Linden Drive
Madison, WI 53706
(608) 262 6369
vogel@calshp.cals.wisc.edu

Contact 3:
Andrea Papagno
Raytheon ITSS
NASA GSFC
Code 923
Greenbelt, MD 20771
(301) 286-3134
(301) 286-0239 (fax)
Andrea.Papagno@gsfc.nasa.gov

Contact 4:
Shelaine Curd
Raytheon ITSS
NASA GSFC
Code 923
Greenbelt, MD 20771
(301) 286-2447
(301) 286-0239 (fax)
Shelaine.Curd@gsfc.nasa.gov

3. Theory of Measurements

The amount of biomass and leaf area produced by a plant is the net result of photosynthesis. The use of allometric equations that are based on a subsample of trees to predict biomass, sapwood volume, and LAI for the forest overall is a common practice. Fairly accurate total or stem biomass estimates can often be made using generalized equations; however, site-specific equations yield the best estimates for foliage mass and leaf.

4. Equipment

4.1 Sensor/Instrument Description
10 Basal Area Factor (BAF) prism, tree diameter tape, 50-m measuring tape.

4.1.1 Collection Environment
Measurements were made under a variety of field conditions that had no effect on the quality of estimates.

4.1.2 Source/Platform
Not applicable.

4.1.3 Source/Platform Mission Objectives
Not applicable.

4.1.4 Key Variables
```
DIAMETER
MEAN_BASAL_AREA
TREE_STEM_DENSITY
PLOT_ID
NEW_FOLIAGE_BIOMASS_DENSITY
PREV_YRS_FOLIAGE_BIOMASS_DENS
TOTAL_FOLIAGE_BIOMASS_DENSITY
NEW_BRANCH_BIOMASS_DENSITY
PREV_YRS_BRANCH_BIOMASS_DENS
TOTAL_BRANCH_BIOMASS_DENSITY
LIVE_STEM_BIOMASS_DENSITY
LIVE_TOTAL_TREE_BIOMASS_DENS
MEAN_DEAD_TREE_BIOMASS_DENSITY
SAPWOOD_VOLUME_DENSITY
NEW_FOLIAGE_AREA_INDEX
PREV_YRS_FOLIAGE_AREA_INDEX
TOTAL_FOLIAGE_AREA_INDEX
```

4.1.5 Principles of Operation
Not applicable.

4.1.6 Sensor/Instrument Measurement Geometry
Not applicable.

4.1.7 Manufacturer of Sensor/Instrument
Not applicable.

4.2 Calibration
Not applicable.

4.2.1 Specifications
Not applicable.

4.2.1.1 Tolerance
Not applicable.

4.2.2 Frequency of Calibration
Not applicable.

4.2.3 Other Calibration Information

Not applicable.

5. Data Acquisition Methods

Plots were established using a either a 10 BAF prism or a measuring tape. The diameter of each tree was measured at diameter at breast height (DBH) (1.37 m). At a number of sites, tree diameters were measured at the base (10 cm) to better facilitate accurate biomass estimates; these sites are marked by (&) in the data sets. One site, G2L7S, had trees measured both at the base and at DBH. The diameter measured from each tree was then used in an allometric equation to determine biomass, leaf area, etc., for each tree. The AUX sites measured at the base are listed below:

```
SSA          NSA
-----        -----
G8L6P        T7R9S
H1E4S        T8S4S
G2L7S        T8S9P
             T8T1P
             U5W5S
             U6W5S
             T4U5A
```

Understory vegetation was sampled from a 2- x 2-m or 1- x 1-m subplot that was randomly located in each of the plots. The subplot size varied depending on plant density. All vegetation in the plot was clipped and stored in a cold room (3 °C) until processed. Samples were separated into three categories: ephemeral, new foliage and twig from perennial plants, and old foliage and twig from perennial plants. Samples were dried and weighed to the nearest 0.1 g.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Four replicate plots were established immediately outside the footprint of the tower. The plots were located in areas that reasonably represented the vegetation within the WAB and should provide accurate stand-level descriptions. The WAB was the area around a flux tower where most of the measured fluxes originated. During BOREAS, access to this area was limited to prevent contamination of flux measurements. The plot size varied from 7.5 x 7.5 m to 30 x 30 m depending upon tree density. The number of trees per plot ranged from 60 to 120. The CEV and AUX sites were sampled to describe the biomass within a 30- x 30-m area.

The measurement sites and associated North American Datum of 1983 (NAD83) coordinates are:

Site Name	Site ID	Latitude	Longitude	UTM Zone	UTM Northing	UTM Easting
SSA-9OA-FLXTR	C3B7T	53.62889°N	106.19779°W	13	5,942,899.9	420,790.5
SSA-YJP-FLXTR	F8L6T	53.87581°N	104.64529°W	13	5,969,762.5	523,320.2
SSA-OJP-FLXTR	G2L3T	53.91634°N	104.69203°W	13	5,974,257.5	520,227.7
SSA-OBS-FLXTR	G8I4T	53.98717°N	105.11779°W	13	5,982,100.5	492,276.5
NSA-OBS-FLXTR	T3R8T	55.88007°N	98.48139°W	14	6,192,853.4	532,444.5
NSA-OJP-FLXTR	T7Q8T	55.92842°N	98.62396°W	14	6,198,176.3	523,496.2
NSA-YJP-FLXTR	T8S9T	55.89575°N	98.28706°W	14	6,194,706.9	544,583.9
SSA-ASP-AUX02	B9B7A	53.59098°N	106.18693°W	13	5,938,447.2	421,469.8
SSA-9BS-AUX01	D0H6S	53.64877°N	105.29534°W	13	5,944,263.4	480,508.7
SSA-ASP-AUX03	D6L9A	53.66879°N	104.6388°W	13	5,946,733.2	523,864
SSA-ASP-AUX05	D9G4A	53.74019°N	105.46929°W	13	5,954,718.4	469,047.1
SSA-ASP-AUX06	E7C3A	53.84741°N	106.08112°W	13	5,966,863.1	428,905.9
SSA-MIX-AUX01	F1N0M	53.80594°N	104.533°W	13	5,962,031.8	530,753.7
SSA-9JP-AUX02	F5I6P	53.86608°N	105.11175°W	13	5,968,627.1	492,651.3
SSA-9JP-AUX04	F7J0P	53.88336°N	105.05115°W	13	5,970,323.3	496,667
SSA-9JP-AUX03	F7J1P	53.88211°N	105.03226°W	13	5,970,405.6	497,879.4
SSA-9JP-AUX05	G1K9P	53.9088°N	104.74812°W	13	5,973,404.5	516,546.7
SSA-9BS-AUX03	G2I4S	53.93021°N	105.13964°W	13	5,975,766.3	490,831.4
SSA-9BS-AUX02	G2L7S	53.90349°N	104.63785°W	13	5,972,844.3	523,793.6
SSA-MIX-AUX02	G4I3M	53.9375°N	105.14246°W	13	5,976,354.9	490,677.3
SSA-9JP-AUX06	G4K8P	53.91883°N	104.76401°W	13	5,974,516.6	515,499.1
SSA-9BS-AUX04	G6K8S	53.94446°N	104.759°W	13	5,977,146.9	515,847.9
SSA-9JP-AUX07	G7K8P	53.95882°N	104.77148°W	13	5,978,963.8	514,994.2
SSA-9JP-AUX08	G8L6P	53.96558°N	104.63755°W	13	5,979,752.7	523,778
SSA-9BS-AUX05	G9I4S	53.99877°N	105.11805°W	13	5,983,169.1	492,291.2
SSA-9JP-AUX09	G9L0P	53.97576°N	104.73779°W	13	5,980,856	517,197.7
SSA-9BS-AUX06	H1E4S	54.04093°N	105.73581°W	13	5,988,326.1	451,815.7
SSA-MIX-AUX03	H2D1M	54.06535°N	105.92706°W	13	5,991,190.3	439,327.7
SSA-9BS-AUX07	H2D1S	54.06199°N	105.92545°W	13	5,990,814.4	439,428.1
SSA-MIX-AUX04	H3D1M	54.066°N	105.92982°W	13	5,991,042.3	439,178.4
SSA-9JP-AUX10	I2I8P	54.11181°N	105.05107°W	13	5,995,963.1	496,661.4
NSA-ASP-AUX01	P7V1A	55.50253°N	98.07478°W	14	6,151,103.7	558,442.1
NSA-MIX-AUX01	Q1V2M	55.54568°N	98.03769°W	14	6,155,937.3	560,718.3
NSA-9JP-AUX01	Q3V3P	55.55712°N	98.02473°W	14	6,157,222.2	561,517.9
NSA-ASP-AUX03	R8V8A	55.67779°N	97.8926°W	14	6,170,774.8	569,638.4
NSA-9BS-AUX01	S8W0S	55.76824°N	97.84024°W	14	6,180,894.9	572,761.9
NSA-ASP-AUX05	S9P3A	55.88576°N	98.87621°W	14	6,193,371.6	507,743.3
NSA-MIX-AUX02	T0P5M	55.88911°N	98.85662°W	14	6,193,747.3	508,967.7
NSA-9BS-AUX08	T0P7S	55.88371°N	98.82345°W	14	6,193,151.1	511,043.9
NSA-9BS-AUX07	T0P8S	55.88351°N	98.80225°W	14	6,193,132	512,370.1
NSA-9BS-AUX02	T0W1S	55.78239°N	97.80937°W	14	6,182,502	574,671.7
NSA-9OA-9TETR	T2Q6A	55.88691°N	98.67479°W	14	6,193,540.7	520,342
NSA-9BS-AUX03	T3U9S	55.83083°N	97.98339°W	14	6,187,719.2	563,679.1
NSA-ASP-AUX04	T4U5A	55.84757°N	98.04329°W	14	6,189,528.2	559,901.6
NSA-9BS-AUX05	T4U8S	55.83913°N	97.99325°W	14	6,188,633.4	563,048.2
NSA-9BS-AUX04	T4U9S	55.83455°N	97.98364°W	14	6,188,132.8	563,657.5
NSA-9BS-AUX14	T5Q7S	55.9161°N	98.64022°W	14	6,196,800.5	522,487.2

Site Name	Site ID	Latitude	Longitude	UTM Zone	UTM Northing	UTM Easting
NSA-9BS-9TETR	T6R5S	55.90802°N	98.51865°W	14	6,195,947	530,092
NSA-9BS-AUX06	T6T6S	55.87968°N	98.18658°W	14	6,192,987.9	550,887.9
NSA-9BS-AUX13	T7R9S	55.91506°N	98.44877°W	14	6,196,763.6	534,454.5
NSA-9JP-AUX03	T7S9P	55.89486°N	98.30037°W	14	6,194,599.1	543,752.4
NSA-9BS-AUX09	T7T3S	55.89358°N	98.22621°W	14	6,194,505.6	548,391.8
NSA-9JP-AUX06	T8Q9P	55.93219°N	98.6105°W	14	6,198,601.4	524,334.5
NSA-ASP-AUX07	T8S4A	55.91856°N	98.37041°W	14	6,197,194.6	539,348.3
NSA-9BS-AUX15	T8S4S	55.91689°N	98.37111°W	14	6,197,008.6	539,306.4
NSA-9JP-AUX04	T8S9P	55.90456°N	98.28385°W	14	6,195,688.9	544,774.3
NSA-9JP-AUX05	T8T1P	55.90539°N	98.26269°W	14	6,195,795.3	546,096.3
NSA-9JP-AUX07	T9Q8P	55.93737°N	98.59568°W	14	6,199,183.2	525,257.1
NSA-9BS-AUX10	U5W5S	55.9061°N	97.70986°W	14	6,196,380.8	580,655.5
NSA-9BS-AUX12	U6W5S	55.91021°N	97.70281°W	14	6,196,846.5	581,087.8
NSA-ASP-AUX08	V5X7A	55.97396°N	97.48565°W	14	6,204,216.6	594,506.1
NSA-ASP-AUX09	W0Y5A	56.00339°N	97.3355°W	14	6,207,706.6	603,796.6
NSA-9JP-AUX02	99O9P	55.88173°N	99.03952°W	14	6,192,917.5	497,527.8
NSA-ASP-AUX02	Q3V2A	55.56227°N	98.02635°W	14	6,157,793.5	561,407.9
SSA-MIX-9TETR	D9I1M	53.7254°N	105.20643°W	13	5,952,989.7	486,379.7
SSA-OJP-FLXTR	G2L3T	53.91634°N	104.69203°W	13	5,974,257.5	520,227.7

7.1.2 Spatial Coverage Map
Not applicable.

7.1.3 Spatial Resolution
These data are point source measurements at the given locations.

7.1.4 Projection
Not applicable.

7.1.5 Grid Description
Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
The biomass estimates were made for 1994 and 1995.

7.2.2 Temporal Coverage Map
Not applicable.

7.2.3 Temporal Resolution
Some but not all of the sites were sampled each year to determine values for 1994 and 1995.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

Column Name
SITE_NAME
SUB_SITE
START_DATE
END_DATE
SPECIES
NUM_TREES_SAMPLED
DIAMETER_MEAS_LOCN
MEAN_BASAL_AREA
TREE_STEM_DENSITY
PLOT_ID
NEW_FOLIAGE_BIOMASS_DENSITY
PREV_YRS_FOLIAGE_BIOMASS_DENS
TOTAL_FOLIAGE_BIOMASS_DENSITY
NEW_BRANCH_BIOMASS_DENSITY
PREV_YRS_BRANCH_BIOMASS_DENS
TOTAL_BRANCH_BIOMASS_DENSITY
LIVE_STEM_BIOMASS_DENSITY
LIVE_TOTAL_TREE_BIOMASS_DENS
MEAN_DEAD_TREE_BIOMASS_DENSITY
SAPWOOD_VOLUME_DENSITY
NEW_FOLIAGE_AREA_INDEX
PREV_YRS_FOLIAGE_AREA_INDEX
TOTAL_FOLIAGE_AREA_INDEX
UNDERSTORY_BIOMASS_DENSITY
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, YRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
START_DATE	The date on which the collection of data commenced.
END_DATE	The date on which the collection of the data was terminated.

SPECIES	Botanical (Latin) name of the species (Genus species).
NUM_TREES_SAMPLED	The number of trees sampled.
DIAMETER_MEAS_LOCN	The location on the tree where the diameter measurement was taken.
MEAN_BASAL_AREA	The mean basal area of the tree.
TREE_STEM_DENSITY	The number of trees per hectare.
PLOT_ID	The identifier for the plot from which the measurement came.
NEW_FOLIAGE_BIOMASS_DENSITY	The mass of carbon in this year's foliage per unit area.
PREV_YRS_FOLIAGE_BIOMASS_DENS	The mass of carbon in previous years' foliage per unit area.
TOTAL_FOLIAGE_BIOMASS_DENSITY	The mass of carbon in all foliage per unit area.
NEW_BRANCH_BIOMASS_DENSITY	The mass of carbon in this year's branches per unit area.
PREV_YRS_BRANCH_BIOMASS_DENS	The mass of carbon in previous years' branches per unit area.
TOTAL_BRANCH_BIOMASS_DENSITY	The mass of carbon in all branches per unit area.
LIVE_STEM_BIOMASS_DENSITY	The mass of carbon in all live tree stems per unit area.
LIVE_TOTAL_TREE_BIOMASS_DENS	The mass of carbon in all live trees per unit area.
MEAN_DEAD_TREE_BIOMASS_DENSITY	The mean mass of carbon in all dead trees per unit area.
SAPWOOD_VOLUME_DENSITY	The sapwood volume of the trees per unit area.
NEW_FOLIAGE_AREA_INDEX	The area of this year's foliage per unit area.
PREV_YRS_FOLIAGE_AREA_INDEX	The area of previously grown foliage per unit area.
TOTAL_FOLIAGE_AREA_INDEX	The area of the total foliage grown during the current year and the previous years per unit area.
UNDERSTORY_BIOMASS_DENSITY	The mass of carbon in the understory per unit area.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
START_DATE	[DD-MON-YY]
END_DATE	[DD-MON-YY]
SPECIES	[none]
NUM_TREES_SAMPLED	[counts]
DIAMETER_MEAS_LOCN	[none]
MEAN_BASAL_AREA	[meters^2][hectare^-1]

TREE_STEM_DENSITY	[count]
PLOT_ID	[none]
NEW_FOLIAGE_BIOMASS_DENSITY	[kilograms carbon][hectare^-1]
PREV_YRS_FOLIAGE_BIOMASS_DENS	[kilograms carbon][hectare^-1]
TOTAL_FOLIAGE_BIOMASS_DENSITY	[kilograms carbon][hectare^-1]
NEW_BRANCH_BIOMASS_DENSITY	[kilograms carbon][hectare^-1]
PREV_YRS_BRANCH_BIOMASS_DENS	[kilograms carbon][hectare^-1]
TOTAL_BRANCH_BIOMASS_DENSITY	[kilograms carbon][hectare^-1]
LIVE_STEM_BIOMASS_DENSITY	[kilograms carbon][hectare^-1]
LIVE_TOTAL_TREE_BIOMASS_DENS	[kilograms carbon][hectare^-1]
MEAN_DEAD_TREE_BIOMASS_DENSITY	[kilograms carbon][hectare^-1]
SAPWOOD_VOLUME_DENSITY	[meters^3][hectare^-1]
NEW_FOLIAGE_AREA_INDEX	[meters^2][meter^2]
PREV_YRS_FOLIAGE_AREA_INDEX	[meters^2][meter^2]
TOTAL_FOLIAGE_AREA_INDEX	[meters^2][meter^2]
UNDERSTORY_BIOMASS_DENSITY	[kilograms carbon][hectare^-1]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[BORIS Designation]
SUB_SITE	[BORIS Designation]
START_DATE	[Human Observer]
END_DATE	[Human Observer]
SPECIES	[Human Observer]
NUM_TREES_SAMPLED	[Human Observer]
DIAMETER_MEAS_LOCN	[Human Observer]
MEAN_BASAL_AREA	[Laboratory Equipment]
TREE_STEM_DENSITY	[Human Observer]
PLOT_ID	[Human Observer]
NEW_FOLIAGE_BIOMASS_DENSITY	[Laboratory Equipment]
PREV_YRS_FOLIAGE_BIOMASS_DENS	[Laboratory Equipment]
TOTAL_FOLIAGE_BIOMASS_DENSITY	[Laboratory Equipment]
NEW_BRANCH_BIOMASS_DENSITY	[Laboratory Equipment]
PREV_YRS_BRANCH_BIOMASS_DENS	[Laboratory Equipment]
TOTAL_BRANCH_BIOMASS_DENSITY	[Laboratory Equipment]
LIVE_STEM_BIOMASS_DENSITY	[Laboratory Equipment]
LIVE_TOTAL_TREE_BIOMASS_DENS	[Laboratory Equipment]
MEAN_DEAD_TREE_BIOMASS_DENSITY	[Laboratory Equipment]
SAPWOOD_VOLUME_DENSITY	[Laboratory Equipment]
NEW_FOLIAGE_AREA_INDEX	[Laboratory Equipment]
PREV_YRS_FOLIAGE_AREA_INDEX	[Laboratory Equipment]
TOTAL_FOLIAGE_AREA_INDEX	[Laboratory Equipment]
UNDERSTORY_BIOMASS_DENSITY	[Laboratory Equipment]
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9BS-9TETR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE06-BIO01	9TE06-BIO01	None	None	None	None
START_DATE	12-JUN-94	14-OCT-95	None	None	None	None
END_DATE	12-JUN-94	14-OCT-95	None	None	None	None
SPECIES	N/A	N/A	None	None	None	Blank
NUM_TREES_SAMPLED	1	617	None	None	None	None
DIAMETER_MEAS_LOCN	N/A	N/A	None	None	None	None
MEAN_BASAL_AREA	0	76.7	None	None	None	None
TREE_STEM_DENSITY	10	458371	None	None	None	None
PLOT_ID	1	WEST	None	None	None	Blank
NEW_FOLIAGE_BIOMASS_DENSITY	0	1815	-999	None	None	None
PREV_YRS_FOLIAGE_BIOMASS_DENS	0	14452	-999	None	None	None
TOTAL_FOLIAGE_BIOMASS_DENSITY	0	13771	-999	None	None	None
NEW_BRANCH_BIOMASS_DENSITY	0	239	-999	None	None	None
PREV_YRS_BRANCH_BIOMASS_DENS	0	14282	-999	None	None	None
TOTAL_BRANCH_BIOMASS_DENSITY	0	14436	-999	None	None	None
LIVE_STEM_BIOMASS_DENSITY	0	102655	-999	None	None	None
LIVE_TOTAL_TREE_BIOMASS_DENS	0	124872	-999	None	None	None
MEAN_DEAD_TREE_BIOMASS_DENSITY	0	28576	-999	None	None	None
SAPWOOD_VOLUME_DENSITY	0	427	-999	None	None	None
NEW_FOLIAGE_AREA_INDEX	0	999	-999	None	None	None
PREV_YRS_FOLIAGE_AREA_INDEX	0	9.6	-999	None	None	None
TOTAL_FOLIAGE_AREA_INDEX	0	10.6	-999	None	None	None
UNDERSTORY_BIOMASS_DENSITY	0	4282	-999	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	21-OCT-98	21-OCT-98	None	None	None	None

```
Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value  -- The value that indicates missing data. This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the attempt was unsuccessful.
Unrel Data Value   -- The value that indicates unreliable data.  This is used
```

```
                        to indicate an attempt was made to determine the
                        parameter value, but the value was deemed to be
                        unreliable by the analysis personnel.
Below Detect Limit --   The value that indicates parameter values below the
                        instruments detection limits.  This is used to
                        indicate that an attempt was made to determine the
                        parameter value, but the analysis personnel determined
                        that the parameter value was below the detection
                        limit of the instrumentation.
Data Not Cllctd    --   This value indicates that no attempt was made to
                        determine the parameter value.  This usually
                        indicates that BORIS combined several similar but
                        not identical data sets into the same data base table
                        but this particular science team did not
                        measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
--------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following are wrapped versions of data record from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,START_DATE,END_DATE,SPECIES,NUM_TREES_SAMPLED,
DIAMETER_MEAS_LOCN,MEAN_BASAL_AREA,TREE_STEM_DENSITY,PLOT_ID,
NEW_FOLIAGE_BIOMASS_DENSITY,PREV_YRS_FOLIAGE_BIOMASS_DENS,
TOTAL_FOLIAGE_BIOMASS_DENSITY,NEW_BRANCH_BIOMASS_DENSITY,
PREV_YRS_BRANCH_BIOMASS_DENS,TOTAL_BRANCH_BIOMASS_DENSITY,
LIVE_STEM_BIOMASS_DENSITY,LIVE_TOTAL_TREE_BIOMASS_DENS,
MEAN_DEAD_TREE_BIOMASS_DENSITY,SAPWOOD_VOLUME_DENSITY,NEW_FOLIAGE_AREA_INDEX,
PREV_YRS_FOLIAGE_AREA_INDEX,TOTAL_FOLIAGE_AREA_INDEX,UNDERSTORY_BIOMASS_DENSITY,
CRTFCN_CODE,REVISION_DATE
'SSA-9BS-AUX01','9TE06-BIO01',12-JUN-94,12-JUN-94,'Larix laricina',2,
'BREAST HEIGHT',1.15,86,'',36,0,36,0,0,505,1765,2263,0,-999,.1,0.0,.1,,'CPI',
21-OCT-98
'SSA-9BS-AUX01','9TE06-BIO01',12-JUN-94,12-JUN-94,'Picea mariana',65,
'BREAST HEIGHT',35.65,7224,'',502,6434,6158,129,6901,7061,39700,49699,1932,-999,
.6,6.1,7.6,,'CPI',21-OCT-98
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was the data collected at a given site on a given date.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

Tree biomass was calculated from a diameter measurement and an allometric equation, and then scaled to the hectare level using a plot scaling factor that reflects the tree's representative size in relation to the plot size (Dilworth and Bell, 1979). Allometric equations are generally developed on a log-log basis to correct for nonhomogeneous variance (see TE-06 allometry documentation).

Biomass by component: (1)
(Kg/hemisurface area) = (INVLOG(a + b (LOG (diameter)))) * PLOT SCALING FACTOR

Where a (the slope) and b (the y intercept) are in the equation y = a(x)+b.

9.1.1 Derivation Techniques and Algorithms

Not applicable.

9.2 Data Processing Sequence

Not applicable.

9.2.1 Processing Steps

Not applicable.

9.2.2 Processing Changes

Not applicable.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

Not applicable.

9.3.2 Calculated Variables

Not applicable.

9.4 Graphs and Plots

Not applicable.

10. Errors

10.1 Sources of Error

The greatest potential source of error other researchers need to be aware of for the TF sites is not from our data collection or calculation, but rather from differences in vegetation between where other researchers may have worked and where we located our plots. Researchers should contact Tom Gower if they feel plot location may be affecting any corroboration between their and our estimates. A second error that may affect the agreement between the numbers provided here and the numbers found by other researchers for the TF sites are differences in dates between the time of DBH measurement (October 1993) and the time the allometric equations were developed (August 1994). This error had the greatest effect on the foliage biomass and leaf area measurements, although it is likely small in either case.

For the auxiliary sites, difficulty surrounding the efficacy of non-site-specific allometric equations in estimating LAI and foliage biomass is a problem for a number of sites. Estimating overstory biomass from non-site-specific equations for wood and branch biomass is problematic when the diameters of the trees measured are smaller or larger than the diameters of the trees that were harvested to develop the allometric equation. For this reason, in plots where there were trees larger or smaller than the trees harvested for the allometric equation, only the total biomass is reported.

10.2 Quality Assessment

The data provided are of generally good quality with the above considerations taken into account.

10.2.1 Data Validation by Source

It is not possible to validate the data without developing new allometric equations and/or installing new plots. A check was performed using published allometric equations, and there was generally good agreement for total biomass (<10%) at all sites, but poor agreement for foliage mass and LAI, which is not unexpected. Because of the paucity of sapwood volume equations in the literature, this variable was not checked.

10.2.2 Confidence Level/Accuracy Judgment

Confidence level for the tower sites is high for the data submitted and slightly less so for some auxiliary sites. Researchers should note Section 10.1.

10.2.3 Measurement Error for Parameters

Not applicable.

10.2.4 Additional Quality Assessments

Not applicable.

10.2.5 Data Verification by Data Center

Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data

The AUX biomass, LAI, and sapwood volume estimates are limited to the 30- x 30-m area surrounding their location.

11.2 Known Problems with the Data

See Section 10.1.

11.3 Usage Guidance

None.

11.4 Other Relevant Information

None.

12. Application of the Data Set

These data provide important input parameters for models that develop carbon budgets for these forests.

13. Future Modifications and Plans

Researchers wanting to estimate the standing biomass for 1995 or 1996 should consult the TE-06 net primary production (NPP) data.

14. Software

14.1 Software Description

Not applicable.

14.2 Software Access

Not applicable.

15. Data Access

The biomass and foliage area data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

None.

17.2 Journal Articles and Study Reports

Chen, J.M., P.M. Rich, S.T. Gower, J.M. Norman, and S. Plummer. 1997. Leaf area index of boreal forests: Theory, techniques, and measurements. Journal of Geophysical Research 102(D24):29,429-29,443.

Dilworth, J.R. and J.F. Bell. 1979. Variable probability sampling-variable plot and three-P. O.S.U. Book Stores, Inc. Corvallis, Oregon.

Gower, S.T., J.G. Vogel, J.M. Norman, C.J. Kucharik, S.J. Steele, and T.K. Stow 1997. Carbon distribution and aboveground net primary production in aspen, jack pine, and black spruce stands in Saskatchewan and Manitoba, Canada. Journal of Geophysical Research 102(D24):29,029-29,041.

Kloeppel and J.G. Vogel (unpublished data). Contact J.G. Vogel for information.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

Singh, T. 1986. Generalizing biomass equations for the boreal forest region of west-central Canada. For. Ecol. and Manag. 17:97-107.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

```
ASCII    - American Standard Code for Information Interchange
AUX      - Auxiliary site
BAF      - Basal Area Factor
BOREAS   - BOReal Ecosystem-Atmosphere Study
BORIS    - BOREAS Information System
CD-ROM   - Compact Disk-Read-Only Memory
CEV      - Carbon Evaluation site
DAAC     - Distributed Active Archive Center
DBH      - Diameter at Breast Height
EOS      - Earth Observing System
EOSDIS   - EOS Data and Information System
FPAR     - Fraction of Photosynthetically Active Radiation
GIS      - Geographic Information System
GSFC     - Goddard Space Flight Center
HTML     - HyperText Markup Language
LAI      - Leaf Area Index
MIX      - Mixed
NAD83    - North American Datum of 1983
NASA     - National Aeronautics and Space Administration
NPP      - Net Primary Production
NSA      - Northern Study Area
OA       - Old Aspen
OBS      - Old Black Spruce
OJP      - Old Jack Pine
ORNL     - Oak Ridge National Laboratory
PANP     - Prince Albert National Park
RSS      - Remote Sensing Science
SSA      - Southern Study Area
TE       - Terrestrial Ecology
TF       - Tower Flux site
URL      - Uniform Resource Locator
UTM      - Universal Transverse Mercator
WAB      - Wind Aligned Blob
YA       - Young Aspen
YJP      - Young Jack Pine
```

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Tom Gower and Jason G. Vogel, both of the University of Wisconsin

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Gower, T., "Measurement and Scaling of Carbon Budgets for Contrasting Boreal Forest Sites." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

Also, cite the BOREAS CD-ROM set as:

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TE-6 team collected several data sets in support of its efforts to characterize and interpret information on the plant biomass, allometry, biometry, sapwood, leaf area index, net primary production, soil temperature, leaf water potential, soil CO_2 flux, and multivegetation imagery of boreal vegetation. This data set contains measurements of estimates of the standing biomass and leaf area index for the plant species at the TF, CEV, and AUX sites in the SSA and NSA during the growing seasons of 1994 and 1995. The data are stored in tabular ASCII files.

14. SUBJECT TERMS
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