NASA/TM—2000–209891, Vol. 188

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

Forrest G. Hall and Andrea Papagno, Editors

Volume 188
BOREAS TE-23 Map Plot Data

P.M. Rich and R. Fournier

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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BOREAS TE-23 Map Plot Data

Paul M. Rich, Richard Fournier

Summary

The BOREAS TE-23 team collected map plot data in support of its efforts to characterize and interpret information on canopy architecture and understory cover at the BOREAS tower flux sites and selected auxiliary sites from May to August 1994. Mapped plots (typical dimensions 50 m x 60 m) were set up and characterized at all BOREAS forested tower flux and selected auxiliary sites. Detailed measurement of the mapped plots included:

- stand characteristics (location, density, basal area)
- map locations DBH of all trees
- detailed geometric measures of a subset of trees (height, crown dimensions)
- understory cover maps.

The data are stored in tabular ASCII files.

Table of Contents

1) Data Set Overview
2) Investigator(s)
3) Theory of Measurements
4) Equipment
5) Data Acquisition Methods
6) Observations
7) Data Description
8) Data Organization
9) Data Manipulations
10) Errors
11) Notes
12) Application of the Data Set
13) Future Modifications and Plans
14) Software
15) Data Access
16) Output Products and Availability
17) References
18) Glossary of Terms
19) List of Acronyms
20) Document Information

1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-23 Map Plot Data

1.2 Data Set Introduction

This canopy architecture and understory cover data set provides BOReal Ecosystem-Atmosphere Study (BOREAS) investigators with a common ground-truth site characterization for the major study sites at tree and stand levels, and provides links between the various disciplines involved in BOREAS. Mapped plots (typical dimensions 50 m x 60 m) were set up and characterized at all forested tower flux and selected auxiliary sites.

1.3 Objective/Purpose

These mapped plots serve two general functions:

- To provide comprehensive canopy architecture measurements for a site representative of a specific type of forest.
- To provide a study area for field measurements, such as studies of light regime, leaf area index (LAI), and tree population dynamics.

More specifically, the mapped plots serve as the location for:

- Intercomparison and calibration of techniques used to estimate LAI, fraction of intercepted photosynthetically active radiation (FIPAR), and fraction of absorbed photosynthetically active radiation (FAPAR).
- Testing geometric models concerning radiant transport in canopies.

1.4 Summary of Parameters

- General information about mapped plot: study area, forest type, grid dimensions, direction and distance from flux tower or other georeferenced location, stand density, basal area, average height, average crown radius.
- Measurements for all trees (> 2 m height) in the mapped plot: X-Y location in the local grid coordinate system, diameter at breast (DBH), dominance class (dominant, codominant, suppressed, juvenile, dead standing, dead leaning).
- Measurements for a subset of trees: height, height to base of first branches, height to base of green crown, crown radius in four azimuth directions.
- Understory cover for 10-m x 10-m subplots: hand-drawn maps of major cover classes, description of dominant species and understory features, catalog of photographs.

1.5 Discussion

A total of 13 mapped plots were set up and characterized for 1) the Old Aspen (OA), Old Black Spruce (OBS), Old Jack Pine (OJP), and Young Jack Pine (YJP) tower flux sites in the Southern Study Area (SSA); 2) the OBS, OJP, and YJP tower flux sites in the Northern Study Area (NSA); 3) four locations representing a successional series within a mixed aspen - white spruce site Terrestrial Ecology (TE) tower site in the SSA; and 4) the OA TE tower site and a Young Aspen (YA) auxiliary site in the NSA. Site characterization involved setting up a reference grid, mapping and labeling individual trees, measuring basic crown geometry, and mapping understory cover.

Our site characterization at the tree and canopy levels is part of a hierarchical sampling approach for characterization of canopy architecture (Fournier et al., 1995). This approach involves a series of three sets of scale-tailored measurements spanning from leaf to stand levels: 1) tree vectorization (Landry et al., 1994), involving detailed sampling of the three-dimensional distribution of canopy elements and crown form; 2) site characterization (this data set), involving detailed measurements of individual tree location, crown geometry, and understory cover; and 3) measurement of canopy geometry as seen from beneath, involving acquisition of a multitemporal catalog of hemispherical photographs. The tree vectorization data set has been provided by R. Landry, Canada Centre for Remote Sensing (CCRS). The catalog of hemispherical photographs has been provided to the BOREAS Information System (BORIS) by P.M. Rich, University of Kansas (KU) (TE-23). This text focuses on the description of the measurements taken for the site characterization at the crown and site level.

1.6 Related Data Sets

BOREAS RSS-04 1994 Southern Study Area Jack Pine LAI and FPAR Data
BOREAS RSS-07 LAI, Gap Fraction, and fPAR Data
BOREAS RSS-07 Regional LAI and FPAR Images From Ten-Day AVHRR-LAC Composites
BOREAS RSS-07 Landsat TM Maps of LAI and Fpar
BOREAS RSS-19 1994 CASI At-sensor Radiance and Reflectance Images
BOREAS RSS-19 1996 CASI At-sensor Radiance and Reflectance Images
BOREAS RSS-19 1994 Seasonal Understory Reflectance Data
BOREAS TE-23 Canopy Architecture and Spectral Data from Hemispheric Photography

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Paul M. Rich (TE-23)
Associate Professor
University of Kansas

Dr. Richard A. Fournier (TE-23, RSS-19, and TE-9)
Research Scientist
Canadian Forest Service

2.2 Title of Investigation

Canopy Architecture of Boreal Forests: Using Hemispherical Photography for Study of Radiative Transport and Leaf Area Index

2.3 Contact Information

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3. Theory of Measurements

Most measurements involved simple procedures and instrumentation. However, the complete data set is large and required a labor-intensive campaign. The following brief description of all measurements is provided by category for those who are not familiar with standard forestry procedures.

- X-Y locations: Location of the grid was determined based on distance and direction from a known reference location (typically the Tower Flux (TF) or TE tower). Location of each grid marker was determined by measuring distances and directions relative to other grid markers. X-Y grid coordinates of each tree within the mapped plot were determined by triangulation from distance measurements taken from two adjacent grid markers.
- Height measurements: Height was calculated based on measurements of the horizontal distance from the observer to the target, the angle from the observer's eye level to the top of the target, and the angle from the observer's eye level to the base of the target. Height was then calculated as the sum of the tangent of each of the two angles times the horizontal distance.
- DBH measurements: DBH was measured directly at 1.3 m ht with a diameter tape, which was marked in units of diameter (pi x circumference).
- Crown radius: Crown radius was calculated by locating points directly beneath the outermost extent of the crown and then calculating the distance to the center of the trunk.
- Dominance class: Dominance class (dominant, codominant, suppressed, juvenile, dead standing, dead leaning) was estimated visually based on influence of surrounding crowns on the crown of interest.
- Understory cover: Understory features were characterized by 1) mapping cover in 10-m by 10-m subplots; 2) calculating cover by dominant plants, lichens, and other features; 3) taking a catalog of 35-mm color photographs of each subplot.

4. Equipment

4.1 Sensor/Instrument Description

Sonic Rangefinder, model Sonin Combo Pro. Conventional forestry instruments included compasses, clinometers, diameter tapes, and 50-m fiberglass tape measures.

4.1.1 Collection Environment

Measurements were made in ambient outdoor conditions from May to August 1994.

4.1.2 Source/Platform

Measurements were taken from the ground.

4.1.3 Source/Platform Mission Objectives

The ground supported the trees and observers.

4.1.4 Key Variables

- General information about mapped plot: study area, forest type, grid dimensions, direction and distance from flux tower or other georeferenced location, stand density, basal area, average height, average crown radius.
- Measurements for all trees (> 2 m height) in the mapped plot: X-Y location in the local grid coordinate system, DBH, dominance class (dominant, codominant, suppressed, juvenile, dead standing, dead leaning).
- Measurements for a subset of trees: height, height to base of first branches, height to base of green crown, crown radius in four azimuth directions.
- Understory cover for 10-m x 10-m subplots: hand-drawn maps of major cover classes, description of dominant species and understory features, catalog of photographs.

4.1.5 Principles of Operation

Distances, for the reference grid markers and tree X-Y locations, were measured using a sonic rangefinder, model Sonin Combo Pro (Sonin, Inc., Scarsdale, NY). This instrument operates in a dual unit mode, with a master and a target unit. An infrared (IR) signal is sent by the master unit in the direction of the target unit. The IR signal triggers an ultrasound signal (25 KHz) that is sent back from the target unit to the master unit and used for distance calculation. When used in dual unit mode, the rangefinder provides distance measurements with an accuracy of 99.5% for a range from 90 cm to 90 m assuming appropriate environmental conditions. Measurements made with the Sonin are affected by several factors: high levels of noise (e.g., machinery), low or high relative humidity levels (RH < 30 % or > 70 %), altitude or barometric pressure (altitude < -0.1 km or > 0.1 km), and significant wind. In addition, the instrument was designed for operation in the 0 to 30 °C range. Therefore, care was taken to make measurements under favorable conditions.

Other measurements were obtained using conventional forestry instruments: compasses, clinometers, diameter tapes, and 50-m fiberglass tape measures. All azimuth measurements were collected relative to magnetic north. Corrections for magnetic declination were performed, using values published in the BOREAS Experimental Plan (Sellers and Hall, 1994) or calculated using United States Geological Survey (USGS) geomagnetism models for Canada.

Real-world map coordinates were provided by BOREAS staff using a global positioning system (GPS).

4.1.6 Sensor/Instrument Measurement Geometry

None given.

4.1.7 Manufacturer of Sensor/Instrument

Sonic Rangefinder
Model Sonin Combo Pro
Sonin, Inc.
Scarsdale, NY

4.2 Calibration

4.2.1 Specifications

4.2.1.1 Tolerance

No calibration was required because of the nature of the instruments used. However, the rangefinder, compasses, and clinometers were tested to assess proper functionality. The sonic rangefinder provided distance values with 99.5% accuracy. More specifically, the manufacturer claims that for a distance of 4.27 m, the reading will be within 3 cm of the real distance. Also, an 18-m distance should be read with less than 10-cm error. The typical distance in the map plots ranged from 1 to 12 m. We tested the rangefinder measurement against tape measure for that range and found that the error was well within the manufacturer's specifications even for cases where branches were obstructing the field of view.

4.2.2 Frequency of Calibration

The instrumentation was calibrated once.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

The site characterization involved producing a stand map of individual crown locations and dimensions. Mapped plots, with dimensions of 50 m by 60 m (50 m by 40 m for YJP, and 40 m by 40 m for NSA-YA), were placed in areas representative of the "major canopy stratum," as determined by aerial photographs and verified on the ground. These representative stands were selected for relative homogeneity of species composition, age, and soil drainage characteristics. A grid, consisting of painted stakes placed every 10 m (every 5 m for YJP), was installed to establish the coordinate system for all measurements. Each tree in the mapped plot is labeled with numbered aluminum tags nailed in the trunk at eye level. All measured parameters refer to the tree identification numbers.

Once the reference grid was set up and the trees were labeled, we produced a comprehensive site characterization that consisted of measurements of location, DBH, height, and crown extent for trees within the plot. In addition, we produce a map of understory cover. First, we mapped X-Y positions of all trees relative to the grid coordinate system. Next, we measured the DBH of all trees and categorized every tree crown into a standard forestry dominance category: dominant, codominant, suppressed, juvenile, dead standing, or dead leaning. Then, we established stand-specific allometric relationships that permitted calculation of height and crown radius from DBH, based on a statistically significant sample of tree height and crown extent measurements. Crown extent was estimated by averaging measurements made for four azimuth directions. Where warranted, we recorded an estimate of the terrain topography. Finally, we characterized understory cover by dividing the mapped plot into 10-m by 10-m subplots, hand-drawing maps of cover by main understory features for each subplot, and identifying major plant and lichen species within each cover class. We took a catalog of color photographs, consisting of views of each 10-m by 10-m subplot and characteristic views of the canopy.

6. Observations

6.1 Data Notes

All pertinent data are contained in the data files.

6.2 Field Notes

Field notes were recorded in notebooks and data sheets and are available from the Oak Ridge National Laboratory (ORNL).

7 Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The overall BOREAS project was conducted at a 1,000-km by 1,000-km regional area. The SSA was defined to cover a 130-km by 90-km area, and the NSA was defined to cover a 40-km by 30-km area. Each tower flux site was at the scale of approximately 1 km by 1 km.

In terms of spatial coverage, the 13 mapped plots were located at tower flux sites or auxiliary sites throughout both the SSA and NSA. The SSA and NSA measurement sites and associated North American Datum of 1983 (NAD83) coordinates are:

- NSA-OA, site id T2Q6A, Lat/Long: 55.88691°N, 98.67479°W, Universal Transverse Mercator (UTM) Zone 14, N: 6,193,540.7, E: 520,342.
- NSA-ASP-AUX09, site id W0Y5A, Lat/Long: 56.00339°N, 97.3355°W, UTM Zone 14, N: 6,207,706.6, E: 603,796.6.
- NSA-OBS, site id T3R8T, Lat/Long: 55.88007°N, 98.48139°W, UTM Zone 14, N: 6,192,853.4, E: 532,444.5.

- NSA-OJP, site id T7Q8T, Lat/Long: 55.92842°N, 98.62396°W, UTM Zone 14, N: 6198176.3, E: 523496.2.
- NSA-YJP, site id T8S9T, Lat/Long: 55.89575°N, 98.28706°W, UTM Zone 14, N: 6194706.9 E: 544583.9.
- SSA-9OA, site id C3B7T, Lat/Long: 53.62889°N, 106.19779°W, UTM Zone 13, N: 5,942,899.9 E: 420,790.5.
- SSA-MIX (1,2,3,4), site id D9I1M, Lat/Long: 53.7254°N, 105.20643°W, UTM Zone 13, N: 5,952,989.7 E: 486,379.7.
- SSA-OBS, site id G8I4T, Lat/Long: 53.98717°N, 105.11779°W, UTM Zone 13, N: 5,982,100.5 E: 492,276.5.
- SSA-OJP, site id G2L3T, Lat/Long: 53.91634°N, 104.69203°W, UTM Zone 13, N: 5,974,257.5 E: 520,227.7.
- SSA-YJP, site id F8L6T, Lat/Long: 53.87581°N, 104.64529°W, UTM Zone 13, N: 5,969,762.5 E: 523,320.2.

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

In terms of spatial resolution, the mapped plot data were measured across scales ranging from approximately 20 cm to approximately 60 m. Accuracy of tree X-Y maps is generally better than 20-cm resolution. Each mapped plot is typically 50 m by 60 m.

7.1.4 Projection

The plot location is given in reference to the tower site location. The tree location is given in relation to the local reference point (usually the TF or TE tower).

7.1.5 Grid Description

Location of the X-Y grid was determined based on distance and direction from a known reference location (typically the TF or TE tower). The following is a summary of the grid layout:

Site	Location	Width	Grid Interval
SSA-OBS	150 to 230 m (SE)*	+/- 20 m	10 m
SSA-OJP	130 to 180 m (SE)	+/- 30 m	10 m
SSA-YJP	30 to 80 m (SE)	+/- 30 m	10 m
SSA-OA	70 to 120 m (SW)	+/- 20 m	10 m
NSA-OBS	80 to 130 m (SE)	+/- 30 m	10 m
NSA-OJP	70 to 120 m (SE)	+/- 30 m	10 m
NSA-YJP	120 to 150 m (SE)	+/- 20 m	5 m

Location of the grid refers to the distance and direction from the flux tower (reference location) along the optical (Jing Chen's Remote Sensing Science (RSS)-07) transect "B" line (called the center line) in the azimuth direction from North (0°) to the center point of the plot edge closest to the reference location. All transect lines were clearly marked by pink flags, and the sample locations within the mapped plots are marked with stakes (orange wooden stakes in most sites, blue PVC tubes at SSA-OBS). The mapped plot coordinates are marked on the stakes, with the distance from the tower as the x-coordinate and the distance from the centerline as the y-coordinate (except for SSA-OBS, where the x-coordinate of the first mapped location is 0 for consistency with the TE-20/TE-22 mapped plot). SE (135°) or SW (225°) refers to the direction from the tower. Width refers to dimensions of the mapped plot on either side of the optical transect "B" line, except in the case of SSA-OBS, where a "D" line is used, i.e., along the Y=20 line of the grid. Grid interval refers to spacing of grid stakes.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

The mapped plots were set up and characterized between May and August 1994.

7.2.2 Temporal Coverage Map

The canopy architecture site characterization should generally apply to all of the summer of 1994, because most aspects of a forest stand typically do not change to an appreciable degree during a growing season. For example, changes in DBH and height because of growth would not generally be detected over this time scale. Likewise, modification of stand structure caused by mortality would also not typically be important. No major disturbance (fires, storms, etc.) occurred in any of the mapped plots during the summer of 1994.

7.2.3 Temporal Resolution

Mapped plot characteristics generally apply to all of the summer of 1994, and are thus annual measurements.

7.3 Data Characteristics

7.3.1 Parameter/Variable

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

TE23_MAP_PLOT_SUMMARY

```
         Column Name
------------------------------
SITE_NAME
SUB_SITE
MEASUREMENT_YEAR
REF_UTM_EASTING
REF_UTM_NORTHING
UTM_ZONE
REF_DISTANCE
REF_AZIMUTH_DIRECTION
PLOT_DIMENSION_X_AXIS
PLOT_DIMENSION_Y_AXIS
REF_X_GRID_COORD
REF_Y_GRID_COORD
MIN_X_GRID_COORD
MAX_X_GRID_COORD
MIN_Y_GRID_COORD
MAX_Y_GRID_COORD
TREE_STEM_DENSITY_2M
TREE_STEM_DENSITY_2M_50MM_DBH
TREE_STEM_DENSITY_2M_100MM_DBH
BASAL_AREA_2M
MEAN_DIAMETER_BREAST_HT
SDEV_DIAMETER_BREAST_HT
MAX_DIAMETER_BREAST_HT
NUM_DIAMETER_BREAST_HT
MEAN_TREE_HEIGHT
SDEV_TREE_HEIGHT
MAX_TREE_HEIGHT
NUM_OBS_TREE_HEIGHT
MEAN_CALC_TREE_HEIGHT
```

SDEV_CALC_TREE_HEIGHT
MAX_CALC_TREE_HEIGHT
NUM_OBS_CALC_TREE_HEIGHT
COEFF_A_HEIGHT
COEFF_B_HEIGHT
COEFF_C_HEIGHT
COEFF_D_HEIGHT
CRTFCN_CODE
REVISION_DATE

TE23_MAP_PLOT_SITE

Column Name
SITE_NAME
SUB_SITE
MEASUREMENT_YEAR
PLOT_ID
TREE
SPECIES
UTM_ZONE
UTM_EASTING
UTM_NORTHING
X_GRID_COORD
Y_GRID_COORD
TREE_DIAMETER_BREAST_HT
DOMINANCE_CLASS
TREE_HEIGHT
CALC_TREE_HEIGHT
LOWEST_BRANCH_HEIGHT
LOWEST_GREEN_FOLIAGE_HEIGHT
CROWN_RADIUS_NORTH
CROWN_RADIUS_SOUTH
CROWN_RADIUS_EAST
CROWN_RADIUS_WEST
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:

TE23_MAP_PLOT_SUMMARY

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, TRN, 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.
MEASUREMENT_YEAR	The year in which the data were collected.
REF_UTM_EASTING	The UTM easting map coordinate of the reference location, usually the flux tower.
REF_UTM_NORTHING	The UTM northing map coordinate of the reference location, usually the flux tower.
UTM_ZONE	The zone on which the given UTM northing and easting coordinates are based.
REF_DISTANCE	The distance from the reference location to the center point of the plot edge closest to the reference location.
REF_AZIMUTH_DIRECTION	The azimuth direction from the reference location to the centerline of the mapped plot.
PLOT_DIMENSION_X_AXIS	The plot dimension along the X grid axis.
PLOT_DIMENSION_Y_AXIS	The plot dimension along the Y grid axis.
REF_X_GRID_COORD	The X grid coordinate that corresponds to the reference location.
REF_Y_GRID_COORD	The Y grid coordinate that corresponds to the reference location.
MIN_X_GRID_COORD	The minimum grid X value, which defines an edge of the mapped plot along the X axis.
MAX_X_GRID_COORD	The maximum grid X value, which defines an edge of the mapped plot along the X axis.
MIN_Y_GRID_COORD	The minimum grid Y value, which defines an edge of the mapped plot along the Y axis.
MAX_Y_GRID_COORD	The maximum grid Y value, which defines an edge of the mapped plot along the Y axis.
TREE_STEM_DENSITY_2M	The areal density of trees having stems greater than 2 meters tall
TREE_STEM_DENSITY_2M_50MM_DBH	The areal density of trees having stems greater than 2 meters tall and diameter at breast height of 50 mm or greater.
TREE_STEM_DENSITY_2M_100MM_DBH	The areal density of trees having stems greater than 2 meters tall and diameter at breast height of 100 mm or greater.
BASAL_AREA_2M	The tree stem basal area for all stems greater than 2 meters tall.
MEAN_DIAMETER_BREAST_HT	The mean diameter at breast height (137 cm above the ground) of the measured trees.
SDEV_DIAMETER_BREAST_HT	The standard deviation of the diameter at breast height (137 cm above the ground) of the measured trees.
MAX_DIAMETER_BREAST_HT	The maximum diameter at breast height (137 cm above the ground) of the measured trees.
NUM_DIAMETER_BREAST_HT	The number of trees for which diameter at breast height was measured.
MEAN_TREE_HEIGHT	The mean height of the measured trees.
SDEV_TREE_HEIGHT	The standard deviation of the height of the measured trees.
MAX_TREE_HEIGHT	The maximum height of the measured trees.
NUM_OBS_TREE_HEIGHT	The number of trees whose height was measured.
MEAN_CALC_TREE_HEIGHT	The mean height of the trees calculated from diameter at breast height with allometric

	equations
SDEV_CALC_TREE_HEIGHT	The standard deviation of the calculated tree height based on diameter at breast height and allometric equations.
MAX_CALC_TREE_HEIGHT	The maximum height of the trees calculated from diameter at breast height with allometric equations.
NUM_OBS_CALC_TREE_HEIGHT	The number of trees for which the height of the trees was calculated from diameter at breast height with allometric equations.
COEFF_A_HEIGHT	Stand specific linear regression A coefficient for calculating the height of the tree using the diameter at breast height (DBH), of the form: tree_ht_calc = ht_coeff_A (hcA)*DBH^3 + (hcB)*DBH^ 2 + (hcC)*DBH + hcD.
COEFF_B_HEIGHT	Stand specific linear regression B coefficient for calculating the height of the tree using the diameter at breast height (DBH), of the form: tree_ht_calc = ht_coeff_A (hcA)*DBH^3 + (hcB)*DBH^2 + (hcC)*DBH + hcD.
COEFF_C_HEIGHT	Stand specific linear regression C coefficient for calculating the height of the tree using the diameter at breast height (DBH), of the form: tree_ht_calc = ht_coeff_A (hcA)*DBH^3 + (hcB)*DBH^ 2 + (hcC)*DBH + hcD.
COEFF_D_HEIGHT	Stand specific linear regression D coefficient for calculating the height of the tree using the diameter at breast height (DBH), of the form: tree_ht_calc = ht_coeff_A (hcA)*DBH^3 + (hcB)*DBH^ 2 + (hcC)*DBH + hcD.
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.

TE23_MAP_PLOT_SITE

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, TRN, 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.
MEASUREMENT_YEAR	The year in which the data were collected.

PLOT_ID	The identifier for the plot from which the measurement came.
TREE	The individual tree from which measurements were taken.
SPECIES	Botanical (Latin) name of the species (Genus species).
UTM_ZONE	The zone on which the given UTM northing and easting coordinates are based.
UTM_EASTING	The NAD83 based UTM easting coordinate of the site.
UTM_NORTHING	The NAD83 based UTM northing coordinate of the site.
X_GRID_COORD	The X grid coordinate where the measurements were taken. Corresponds to the distance from the reference, which was the tower, except at the black spruce site. See documentation for more details.
Y_GRID_COORD	The Y grid coordinate where the measurements were taken. Corresponds to the distance from the reference, which was the tower, except at the black spruce site. See documentation for more details.
TREE_DIAMETER_BREAST_HT	The diameter of the tree at breast height (137 cm above the ground).
DOMINANCE_CLASS	The dominance class of the tree.
TREE_HEIGHT	The height of the tree.
CALC_TREE_HEIGHT	The height of the tree calculated from the diameter at breast height, based on allometry.
LOWEST_BRANCH_HEIGHT	The height of the lowest branch on the tree.
LOWEST_GREEN_FOLIAGE_HEIGHT	The height of the lowest green foliage on the tree.
CROWN_RADIUS_NORTH	The crown radius on the north side of the crown.
CROWN_RADIUS_SOUTH	The crown radius on the south side of the crown.
CROWN_RADIUS_EAST	The crown radius on the east side of the crown.
CROWN_RADIUS_WEST	The crown radius on the west side of the crown.
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:

TE23_MAP_PLOT_SUMMARY

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
MEASUREMENT_YEAR	[unitless]
REF_UTM_EASTING	[meters]
REF_UTM_NORTHING	[meters]
UTM_ZONE	[unitless]

REF_DISTANCE	[meters]
REF_AZIMUTH_DIRECTION	[degrees]
PLOT_DIMENSION_X_AXIS	[meters]
PLOT_DIMENSION_Y_AXIS	[meters]
REF_X_GRID_COORD	[meters]
REF_Y_GRID_COORD	[meters]
MIN_X_GRID_COORD	[meters]
MAX_X_GRID_COORD	[meters]
MIN_Y_GRID_COORD	[meters]
MAX_Y_GRID_COORD	[meters]
TREE_STEM_DENSITY_2M	[number of trees][hectare^-1]
TREE_STEM_DENSITY_2M_50MM_DBH	[number of trees][hectare^-1]
TREE_STEM_DENSITY_2M_100MM_DBH	[number of trees][hectare^-1]
BASAL_AREA_2M	[meters^2][hectare^-1]
MEAN_DIAMETER_BREAST_HT	[meters]
SDEV_DIAMETER_BREAST_HT	[meters]
MAX_DIAMETER_BREAST_HT	[meters]
NUM_DIAMETER_BREAST_HT	[count]
MEAN_TREE_HEIGHT	[meters]
SDEV_TREE_HEIGHT	[meters]
MAX_TREE_HEIGHT	[meters]
NUM_OBS_TREE_HEIGHT	[count]
MEAN_CALC_TREE_HEIGHT	[meters]
SDEV_CALC_TREE_HEIGHT	[meters]
MAX_CALC_TREE_HEIGHT	[meters]
NUM_OBS_CALC_TREE_HEIGHT	[count]
COEFF_A_HEIGHT	[meters][meters^-3]
COEFF_B_HEIGHT	[meters][meters^-2]
COEFF_C_HEIGHT	[meters][meters^-1]
COEFF_D_HEIGHT	[meters]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

TE23_MAP_PLOT_SITE

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
MEASUREMENT_YEAR	[unitless]
PLOT_ID	[none]
TREE	[none]
SPECIES	[none]
UTM_ZONE	[unitless]
UTM_EASTING	[unitless]
UTM_NORTHING	[unitless]
X_GRID_COORD	[meters]
Y_GRID_COORD	[meters]
TREE_DIAMETER_BREAST_HT	[meters]
DOMINANCE_CLASS	[none]
TREE_HEIGHT	[meters]
CALC_TREE_HEIGHT	[meters]
LOWEST_BRANCH_HEIGHT	[meters]
LOWEST_GREEN_FOLIAGE_HEIGHT	[meters]
CROWN_RADIUS_NORTH	[meters]

CROWN_RADIUS_SOUTH	[meters]
CROWN_RADIUS_EAST	[meters]
CROWN_RADIUS_WEST	[meters]
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:

TE23_MAP_PLOT_SUMMARY

Column Name	Data Source
SITE_NAME	[BORIS Designation]
SUB_SITE	[BORIS Designation]
MEASUREMENT_YEAR	[Human Observer]
REF_UTM_EASTING	[BORIS Designation]
REF_UTM_NORTHING	[BORIS Designation]
UTM_ZONE	[BORIS Designation]
REF_DISTANCE	[Human Observer]
REF_AZIMUTH_DIRECTION	[Compass]
PLOT_DIMENSION_X_AXIS	[Human Observer]
PLOT_DIMENSION_Y_AXIS	[Human Observer]
REF_X_GRID_COORD	[Human Observer]
REF_Y_GRID_COORD	[Human Observer]
MIN_X_GRID_COORD	[Human Observer]
MAX_X_GRID_COORD	[Human Observer]
MIN_Y_GRID_COORD	[Human Observer]
MAX_Y_GRID_COORD	[Human Observer]
TREE_STEM_DENSITY_2M	[Laboratory Equipment]
TREE_STEM_DENSITY_2M_50MM_DBH	[Laboratory Equipment]
TREE_STEM_DENSITY_2M_100MM_DBH	[Laboratory Equipment]
BASAL_AREA_2M	[Laboratory Equipment]
MEAN_DIAMETER_BREAST_HT	[Laboratory Equipment]
SDEV_DIAMETER_BREAST_HT	[Laboratory Equipment]
MAX_DIAMETER_BREAST_HT	[Laboratory Equipment]
NUM_DIAMETER_BREAST_HT	[Laboratory Equipment]
MEAN_TREE_HEIGHT	[Laboratory Equipment]
SDEV_TREE_HEIGHT	[Laboratory Equipment]
MAX_TREE_HEIGHT	[Laboratory Equipment]
NUM_OBS_TREE_HEIGHT	[Laboratory Equipment]
MEAN_CALC_TREE_HEIGHT	[Laboratory Equipment]
SDEV_CALC_TREE_HEIGHT	[Laboratory Equipment]
MAX_CALC_TREE_HEIGHT	[Laboratory Equipment]
NUM_OBS_CALC_TREE_HEIGHT	[Laboratory Equipment]
COEFF_A_HEIGHT	[Laboratory Equipment]
COEFF_B_HEIGHT	[Laboratory Equipment]
COEFF_C_HEIGHT	[Laboratory Equipment]
COEFF_D_HEIGHT	[Laboratory Equipment]
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

TE23_MAP_PLOT_SITE

Column Name	Data Source
SITE_NAME	[BORIS Designation]
SUB_SITE	[BORIS Designation]
MEASUREMENT_YEAR	[Human Observer]
PLOT_ID	[Human Observer]
TREE	[Human Observer]
SPECIES	[Human Observer]
UTM_ZONE	[BORIS Designation]
UTM_EASTING	[BORIS Designation]
UTM_NORTHING	[BORIS Designation]
X_GRID_COORD	[Human Observer]
Y_GRID_COORD	[Human Observer]
TREE_DIAMETER_BREAST_HT	[Laboratory Equipment]
DOMINANCE_CLASS	[Human Observer]
TREE_HEIGHT	[Laboratory Equipment]
CALC_TREE_HEIGHT	[Laboratory Equipment]
LOWEST_BRANCH_HEIGHT	[Laboratory Equipment]
LOWEST_GREEN_FOLIAGE_HEIGHT	[Laboratory Equipment]
CROWN_RADIUS_NORTH	[Laboratory Equipment]
CROWN_RADIUS_SOUTH	[Laboratory Equipment]
CROWN_RADIUS_EAST	[Laboratory Equipment]
CROWN_RADIUS_WEST	[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.

TE23_MAP_PLOT_SUMMARY

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9OA-9TETR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE23-MSM01	9TE23-MSM04	None	None	None	None
MEASUREMENT_YEAR	1994	1994	None	None	None	None
REF_UTM_EASTING	420842.9	544479.4	-999	None	None	None
REF_UTM_NORTHING	5942911.1	6198222.7	-999	None	None	None
UTM_ZONE	13	14	None	None	None	None
REF_DISTANCE	0	150	-999	None	None	None
REF_AZIMUTH_DIRECTION	0	315	-999	None	None	None
PLOT_DIMENSION_X_AXIS	30	60	None	None	None	None
PLOT_DIMENSION_Y_AXIS	20	60	None	None	None	None
REF_X_GRID_COORD	0	130	-999	None	None	None
REF_Y_GRID_COORD	0	0	-999	None	None	None
MIN_X_GRID_COORD	-20	130	None	None	None	None
MAX_X_GRID_COORD	20	180	None	None	None	None
MIN_Y_GRID_COORD	-30	0	None	None	None	None

MAX_Y_GRID_COORD	20	40	None	None	None	None
TREE_STEM_DENSITY_2M	1186.7	5543.8	-999	None	None	None
TREE_STEM_DENSITY_ 2M_50MM_DBH	505	4366.7	-999	None	None	None
TREE_STEM_DENSITY_2M 2M_100MM_DBH	55	1955.6	-999	None	None	None
BASAL_AREA_2M	3.3	41.6	-999	None	None	None
MEAN_DIAMETER_ BREAST_HT	.041	.206	-999	None	None	None
SDEV_DIAMETER_ BREAST_HT	.018	.053	-999	None	None	None
MAX_DIAMETER_BREAST_ HT	.114	.34	-999	None	None	None
NUM_DIAMETER_BREAST_ HT	267	1441	-999	None	None	None
MEAN_TREE_HEIGHT	4.1	23.2	-999	None	None	None
SDEV_TREE_HEIGHT	1.5	4.5	-999	None	None	None
MAX_TREE_HEIGHT	7.5	33.2	-999	None	None	None
NUM_OBS_TREE_HEIGHT	18	361	-999	None	None	None
MEAN_CALC_TREE_ HEIGHT	5.6	22	-999	None	None	None
SDEV_CALC_TREE_ HEIGHT	.9	4	-999	None	None	None
MAX_CALC_TREE_HEIGHT	9	28.2	-999	None	None	None
NUM_OBS_CALC_TREE_ HEIGHT	267	1441	-999	None	None	None
COEFF_A_HEIGHT	-20	1800	-999	None	None	None
COEFF_B_HEIGHT	-853	-101	-999	None	None	None
COEFF_C_HEIGHT	49.57	198.81	-999	None	None	None
COEFF_D_HEIGHT	-2.675	7.12517	-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	09-DEC-98	09-DEC-98	None	None	None	None

TE23_MAP_PLOT_SITE

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-ASP-AUX09	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE23-MST01	9TE23-MST04	None	None	None	None
MEASUREMENT_YEAR	1994	1994	None	None	None	None
PLOT_ID	N/A	N/A	None	None	None	None
TREE	1	d9	None	None	None	Blank
SPECIES	N/A	N/A	-999	None	None	None
UTM_ZONE	13	14	None	None	None	None
UTM_EASTING	420736.8	603802.3	None	None	None	Blank
UTM_NORTHING	5942809.5	6207805.5	None	None	None	Blank
X_GRID_COORD	-20.27	179.66	-999	None	None	Blank
Y_GRID_COORD	-30.81	44.36	-999	None	None	Blank
TREE_DIAMETER_ BREAST_HT	.002	.34	-999	None	None	None
DOMINANCE_CLASS	N/A	N/A	-999	None	None	Blank
TREE_HEIGHT	1	33.2	-999	None	None	None

CALC_TREE_HEIGHT	-9	28.2	None	None	None	Blank
LOWEST_BRANCH_HEIGHT	0	16.26	-999	None	None	Blank
LOWEST_GREEN_FOLIAGE_HEIGHT	0	61.2	-999	None	None	Blank
CROWN_RADIUS_NORTH	0	4.8	-999	None	None	Blank
CROWN_RADIUS_SOUTH	0	5.5	-999	None	None	Blank
CROWN_RADIUS_EAST	0	4.4	-999	None	None	Blank
CROWN_RADIUS_WEST	0	6.48	-999	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	09-DEC-98	09-DEC-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.

TE23_MAP_PLOT_SUMMARY

```
SITE_NAME,SUB_SITE,MEASUREMENT_YEAR,REF_UTM_EASTING,REF_UTM_NORTHING,UTM_ZONE,
REF_DISTANCE,REF_AZIMUTH_DIRECTION,PLOT_DIMENSION_X_AXIS,PLOT_DIMENSION_Y_AXIS,
REF_X_GRID_COORD,REF_Y_GRID_COORD,MIN_X_GRID_COORD,MAX_X_GRID_COORD,
MIN_Y_GRID_COORD,MAX_Y_GRID_COORD,TREE_STEM_DENSITY_2M,
TREE_STEM_DENSITY_2M_50MM_DBH,TREE_STEM_DENSITY_2M_100MM_DBH,BASAL_AREA_2M,
MEAN_DIAMETER_BREAST_HT,SDEV_DIAMETER_BREAST_HT,MAX_DIAMETER_BREAST_HT,
NUM_DIAMETER_BREAST_HT,MEAN_TREE_HEIGHT,SDEV_TREE_HEIGHT,MAX_TREE_HEIGHT,
NUM_OBS_TREE_HEIGHT,MEAN_CALC_TREE_HEIGHT,SDEV_CALC_TREE_HEIGHT,
MAX_CALC_TREE_HEIGHT,NUM_OBS_CALC_TREE_HEIGHT,COEFF_A_HEIGHT,COEFF_B_HEIGHT,
COEFF_C_HEIGHT,COEFF_D_HEIGHT,CRTFCN_CODE,REVISION_DATE
'NSA-9OA-9TETR','9TE23-MSM01',1994,-999.0,-999.0,14,70,315,50,60,70,0,70,120,-20,
40,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999,-999.0,-999.0,-999.0,
-999,-999.0,-999.0,-999.0,-999,-999,-999.0,-999.0,-999.0,'CPI',09-DEC-98
```

```
'NSA-ASP-AUX09','9TE23-MSM01',1994,-999.0,-999.0,14,0,0,40,40,0,0,-20,20,-20,20,
5543.8,2093.8,56.3,11.5,.048,.018,.116,887,6.9,1.6,9.8,25,5.6,.9,9.0,887,-999,
-999.0,49.57,3.20909,'CPI',09-DEC-98
```

TE23_MAP_PLOT_SITE

```
SITE_NAME,SUB_SITE,MEASUREMENT_YEAR,PLOT_ID,TREE,SPECIES,UTM_ZONE,UTM_EASTING,
UTM_NORTHING,X_GRID_COORD,Y_GRID_COORD,TREE_DIAMETER_BREAST_HT,DOMINANCE_CLASS,
TREE_HEIGHT,CALC_TREE_HEIGHT,LOWEST_BRANCH_HEIGHT,LOWEST_GREEN_FOLIAGE_HEIGHT,
CROWN_RADIUS_NORTH,CROWN_RADIUS_SOUTH,CROWN_RADIUS_EAST,CROWN_RADIUS_WEST,
CRTFCN_CODE,REVISION_DATE
'NSA-ASP-AUX09','9TE23-MST01',1994,'2A','3780','Populus tremuloides',14,603773.3,
6207776.5,-999.0,-999.0,.04,'JUVENILE',-999.0,5.19,-999.0,-999.0,-999.0,-999.0,
-999.0,-999.0,'CPI',09-DEC-98
'NSA-ASP-AUX09','9TE23-MST01',1994,'2A','3781','Populus tremuloides',14,603773.3,
6207774.5,-8.7,-11.39,.035,'SUPPRESSED',-999.0,4.94,-999.0,-999.0,-999.0,-999.0,
-999.0,-999.0,'CPI',09-DEC-98
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data tracked by BORIS was the data collected at a given site on a given date.

8.2 Data Format

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

9.1.1 Derivation Techniques and Algorithms

- Height: height was calculated from DBH based on allometry; for the initial data submission, a linear relationship was satisfactory.
- Summary statistics of DBH, observed height, and calculated height: mean, standard deviation, and maximum were summarized.
- Stand density: stand density was calculated as the total number of trees per unit area (units: individual/ha). The densities of individuals greater than 5 and 10 cm DBH were also summarized (units: individual/ha).
- Stand basal area: stand basal area was calculated as the total area of tree trunks per unit area (units: m^2/ha).

- X-Y location: The field measurements consisted of two distances measured from known reference positions along the border of each 10-m by 10-m subquadrant. These two distance values are converted, by triangulation, in X-Y tree locations. The triangulation calculations find the intersection of two arcs. Each arc corresponds to a circle centered at a reference position and with a radius equal to the measured distance from that reference position to the tree. For reference position a,b with an associated distance r and reference position c,d associated with distance q, the X-Y position of the tree can be calculated using the following pair of quadratic equations:

$$x = \frac{-(a^2 - c^2 + b^2 - d^2 + q^2 - r^2)}{2(c - a)} \quad (1)$$

$$y = \frac{2b +/- [\, 4b^2 - 4(b^2 + (x - a)^2 - r^2) \,]^{(1/2)}}{2} \quad (2)$$

Note that these equations give two possible X-Y position solutions. By choosing reference locations along the same edge of a subplot, one solution can readily be rejected as lying outside the subplot.

9.2 Data Processing Sequence

9.2.1 Processing Steps
None given.

9.2.2 Processing Changes
None given.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
None given.

9.3.2 Calculated Variables
See Section 9.1.1.

9.4 Graphs and Plots
None given.

10. Errors

10.1 Sources of Error
Because most of our field instruments were simple and operated with a high degree of accuracy, most error can be attributable to human errors in the field or during data entry. These errors were minimized by careful quality control. The following is a summary of sources of error.

- Reference Grid Position: Setting up the grid required use of both distance and azimuth measurements. Though the sonic rangefinder provided distance values that were about 99.5% accurate, small errors result from inexact placement of the master or target units with respect to a plane corresponding to the center of a source or target. Compass readings of azimuth are typically not as precise as distance measurement, because they are sensitive to the presence of metal and local geologic features, and because of inaccuracies in pointing the compass. Field compass measurements are typically not accurate to better than about +/- 4 degrees. Errors were minimized by using distance measurements to check grid reference positions from multiple directions before deciding on the final placement.

- Tree Position: Tree positions were located by measuring distances from known grid locations. Thus, errors could result from inaccuracies in placement of the reference grid. Also, the potential existed for misplacement of a tree because of errors in triangulation calculations. Two positions were calculated for each triangulation. In most cases, one value was outside the subplot, so it could readily discarded. In a few cases, where it was necessary to measure distances from opposite sides of the subplot, it was necessary to determine the correct X-Y location based on the sequence of trees. In a few ambiguous cases, we have eliminated trees from our maps until such time as map positions can be verified in the field. These trees are identifiable in the data set by no-data (-999) values for their X-Y position values.
- Dominance Class: The assignment of the dominance class is somewhat subjective: it depends on the visual assessment of the relative crown height compared with that of the neighboring trees. Through practice and cross-calibrating a selection of dominance classes assigned by different field workers, we were able to minimize this error.
- DBH: Error in measurement of DBH is subject to irregularities in the surface of trunk and variation in placement and tension of the diameter tape. This error was minimized by careful placement of diameter tapes.
- Height: Errors in measurement of tree heights are attributable to the visual ability to align the clinometer with the target location on the tree. Errors were minimized by careful choice of positions for viewing the target tree.
- Crown Radius: Errors in measurement of crown radius result primarily from difficulty in locating points exactly at the outermost extent of foliage. Errors were minimized by training field workers to locate the edge of the crown using a clinometer and by practicing with visual estimates.
- Understory Cover: Mapping of understory cover is subject to errors in drawing of cover category boundaries and in assigning cover categories. Errors were minimized by dividing each 10-m by 10-m subplot into four 5-m by 5-m quadrants for drawing maps. Again, practice and experience of field workers minimized errors.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Much of our quality control involved data validation while still in the field, remeasurement when necessary, and noting of any data problems. Further quality control involved checking for out-of-range values and cross-checking correspondence between data base file values and field data notebooks.

10.2.2 Confidence Level/Accuracy Judgment

Overall, our measurements are well within the accuracy necessary for our studies and for the purposes of other BOREAS researchers. We can readily assign quantitative estimates of accuracy with a high level of confidence.

10.2.3 Measurement Error for Parameters and Variables

The following are quantitative estimates of accuracy of our data. Estimates are based upon a confidence that 95% of values will lie within the specified accuracy range.

```
Reference Grid Position:  +/- 0.25 m
Tree Position:            +/- 0.5 m
Dominance Class:          +/- 5%
DBH:                      +/- 0.3 cm
Height:                   +/- 0.5 m
Crown Radius:             +/- 0.5 m
Understory Cover:         +/- 10% of area
```

10.2.4 Additional Quality Assessments

All data files were checked against original field acquisition sheets.

10.2.5 Data Verification by Data Center
The data were examined for clarity and consistency.

11. Notes

11.1 Limitations of the Data
The mapped plots were selected to be representative of each forest type. Because the forests were relatively homogeneous, the measurements derived from the mapped plots are generally representative of the larger areas. However, caution should be used because of natural variability.

11.2 Known Problems with the Data
The SSA-OBS site was located in an area drier than the forest immediately surrounding the flux tower.

11.3 Usage Guidance
As with any data set, caution should be used in the interpretation and application of the data. TE-23 and collaborators have done their best to produce an accurate and useful data set, but do not assume responsibility or liability for the use of the data.

11.4 Other Relevant Information
J.M. Chen's (RSS-07) optical measurements were made on a transect that usually passes through the Y=0 center line of each mapped plot. Also, the catalog of hemispherical photographs acquired by P.M. Rich (TE-23) were taken along the same center line of each mapped plot. Various other groups are expected to supply LAI, FIPAR, and FAPAR data for an intercomparison. Finally, the vectorized trees (i.e., detailed branch segment and needle distribution within crown) measured by R. Landry (RSS-19) were characteristic of trees in the SSA-OJP, SSA-YJP and SSA-OA mapped plots.

All other relevant information is in the data files.

12. Application of the Data Set

These mapped plots serve two general categories of applications:

- Modeling applications that require provide comprehensive canopy architecture measurements for a site representative of a specific type of forest; e.g., modeling of reflectance patterns, modeling of turbulence, modeling of influences of canopy geometry on light regimes, and modeling of forest dynamics.
- Field measurement applications that require a mapped study area for field measurements; e.g., field studies of light regime, LAI, and tree population dynamics.

13. Future Modifications and Plans

Further work will involve use of these data, in conjunction with tree vectorization data to characterize the three-dimensional geometry of forests, simulate light regimes, and examine implications for ecology and remote sensing. The understory data need to be more fully developed in data summary files and map coverages before they will be fully useful.

14. Software

14.1 Software Description
Microsoft Excel v.5.x spreadsheets were used for organizing data and performing calculations.

14.2 Software Access
Original Microsoft Excel v.5.x spreadsheets are available upon request from TE-23.

15. Data Access

The map plot data are available from the Earth Observing System Data and Information System (EOSDIS) 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
Not applicable.

16.2 Film Products
Not applicable.

16.3 Other Products

The canopy architecture site characterization data set is available in ASCII format and in an ARC/INFO Geographic Information System (GIS) data base format submitted to BORIS and on local UNIX or PC computers at KU and CCRS. Data are also available in Microsoft Excel v.5.0 format from TE-23. These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Satellite/Instrument/Data Processing Documentation

Manufacturer's specifications for the sonic rangefinder, model Sonin Combo Pro, Sonin Inc., 672 White Plains Rd., Scarsdale, NY 10583, Tel (914) 725-0202, Fax (914) 725-1158.

17.2 Journal Articles and Study Reports

Fournier, R.A., P.M. Rich, Y.R. Alger, V.L. Peterson, R. Landry, and N.M. August. 1995. Canopy architecture of boreal forest: links between remote sensing and ecology. American Society for Photogrammetry and Remote Sensing Technical Papers 2:225-235.

Landry, R., R.A. Fournier, and F.J. Ahern. 1994. Tree Vectorization: a new methodology for characterizing tree architecture in support of remote sensing models. Submitted to Agricultural and Forest Meteorology.

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).

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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.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

DBH: diameter at breast height (cm).

Stand density: stand density was calculated as the total number of trees per unit area (units: individual/ha).

Stand basal area: stand basal area was calculated as the total area of tree stems per unit area (units: m^2/ha).

19. List of Acronyms

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ASCII   - American Standard Code for Information Interchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
CCRS    - Canada Centre for Remote Sensing
CD-ROM  - Compact Disk-Read Only Memory
DAAC    - Distributed Active Archive Center
DBH     - Diameter at Breast Height
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
FAPAR   - Fraction of Absorbed Photosynthetically Active Radiation
FIPAR   - Fraction of Intercepted Photosynthetically Active Radiation
GEMLab  - GIS and Environmental Modeling Laboratory
GIS     - Geographic Information System
GPS     - Global Positioning System
GSFC    - Goddard Space Flight Center
HTML    - HyperText Markup Language
IR      - Infrared
KU      - University of Kansas
LAI     - Leaf Area Index
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
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
URL     - Uniform Resource Locator
USGS    - United States Geological Survey
UTM     - Universal Transverse Mercator
YA      - Young Aspen
YJP     - Young Jack Pine
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20. Document Information

20.1 Document Revision Date
Written: 05-Mar-1997
Last Updated: 09-Sep-1999

20.2 Document Review Dates
BORIS Review: 29-Jan-1999
Science Review:

20.3 Document ID

20.4 Citation
When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:

Simplified Acknowledgment:
The canopy architecture and understory cover data were collected for BOREAS by science team TE-23 under the direction of P.M. Rich at the University of Kansas and R.A. Fournier at the Canadian Forest Service.

Acknowledgments -- People:
The canopy architecture and understory cover data were collected for BOREAS under the direction of P.M. Rich at the University of Kansas and R.A. Fournier at the Canadian Forest Service. We thank Y.R. Alger, N.M. August, C. Paquet, and V.L. Peterson for their dedicated efforts in collecting and preparing these data. We also thank J.M. Chen of the Canada Centre for Remote Sensing for his collaboration in plot layout; G. Edwards and H. Margolis of Laval University for their collaboration in data acquisition for the northern sites; M. Apps of Forestry Canada for providing accommodations; and R. Gauthier of the Centre for Remote Sensing for significant scientific, logistical, financial, and moral support.

Acknowledgments -- Organizations/Funding Sources:
This work was supported by the Canada Centre for Remote Sensing, Canadian Forest Service, the Kansas Applied Remote Sensing Program, the Kansas Biological Survey, the Kansas Center for Excellence in Computer Aided Software Engineering, NASA grant NAG5-2358, and the University of Kansas Research Development and General Research Funds.

If using data from the BOREAS CD-ROM series, also reference the data as:
Rich, P.M. and R.A. Fournier, "Canopy Architecture of Boreal Forests: Using Hemispherical Photography for Study of Radiative Transport and Leaf Area Index." 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:
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. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

20.5 Document Curator

20.6 Document URL

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 2000	Technical Memorandum

4. TITLE AND SUBTITLE
Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)
BOREAS TE-23 Map Plot Data

5. FUNDING NUMBERS
923
RTOP: 923-462-33-01

6. AUTHOR(S)
Paul M. Rich and Robert Fournier
Forrest G. Hall and Andrea Papagno, Editors

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES)
Goddard Space Flight Center
Greenbelt, Maryland 20771

8. PEFORMING ORGANIZATION REPORT NUMBER
2000-03136-0

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
TM—2000–209891
Vol. 188

11. SUPPLEMENTARY NOTES
P.M. Rich: University of Kansas, Lawrence; R. Fournier: Canadian Forest Service, Sainte-Foy, Quebec; A. Papagno: Raytheon ITSS, NASA Goddard Space Flight Center, Greenbelt, Maryland

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified–Unlimited
Subject Category: 43
Report available from the NASA Center for AeroSpace Information, 7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The BOREAS TE-23 team collected map plot data in support of its efforts to characterize and interpret information on canopy architecture and understory cover at the BOREAS tower flux sites and selected auxiliary sites from May to August 1994. Mapped plots (typical dimensions 50 m x 60 m) were set up and characterized at all BOREAS forested tower flux and selected auxiliary sites. Detailed measurement of the mapped plots included:

- stand characteristics (location, density, basal area)
- map locations DBH of all trees
- detailed geometric measures of a subset of trees (height, crown dimensions)
- understory cover maps.

14. SUBJECT TERMS
BOREAS, terrestrial ecology, canopy architecture, understory cover.

15. NUMBER OF PAGES
25

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL