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

Forrest G. Hall and Andrea Papagno, Editors

Volume 133

BOREAS TE-2 Stem Growth and Sapwood Data

M.G. Ryan and M. Lavigne

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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BOREAS TE-2 Stem Growth and Sapwood Data

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BOREAS TE-2 Stem Growth and Sapwood Data

Michael G. Ryan, Michael Lavigne

Summary

The BOREAS TE-2 team collected several data sets in support of its efforts to characterize and interpret information on the respiration of the foliage, roots, and wood of boreal vegetation. This data set contains measurements of growth and sapwood of the stems conducted in the NSA during the growing season of 1994. The data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-02 Stem Growth and Sapwood Data

1.2 Data Set Introduction

Field studies of woody tissue respiration were conducted at the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) in 1994. This data set includes the characteristics of the stem (growth, sapwood volume, etc.) for samples measured for wood respiration on tree stems conducted in the boreal forest during the growing season of 1994. These characteristics were sampled after the end of the 1994 growth season at the end of September 1994.

1.3 Objectives/Purpose

The objectives of the work were to:

- Determine whether respiratory parameters vary among three boreal tree species (black spruce, jack pine, and trembling aspen).
- Compare respiration parameters from the cold northern sites with those from the warmer, southern sites.

- Provide estimates of respiratory parameters for ecosystem process models.
- Use our estimates of wood respiration, estimates of wood biomass, and wood temperature throughout the year to estimate the annual carbon cost for wood respiration.

1.4 Summary of Parameters

Each data set includes the location of chamber: (1.3 m or 6 m), diameter (outside bark) of tree where chamber was located (cm), specific gravity of sapwood (g dry weight/cm^3 wood), sapwood volume (cm^3) assigned to segment, growth volume (cm^3) assigned to segment, growth (g dry weight) assigned to segment, phloem volume (cm^3) assigned to segment, percent nitrogen by dry weight in sapwood, percent phosphorus by dry weight in sapwood, percent sugars by dry weight in sapwood, percent starch by dry weight in sapwood, and percent nonstructural carbohydrates by dry weight in sapwood.

1.5 Discussion

In the NSA, the Terrestrial Ecology (TE)-02 team measured stem sapwood volume, growth in 1994, percent nitrogen, percent phosphorus, percent sugars, percent starch, percent nonstructural carbohydrates (all in sapwood or water-conducting xylem only) for Old Aspen (OA) (Populus tremuloides), Old Black Spruce (OBS) (Picea mariana), Old Jack Pine (OJP) (Pinus banksiana), and Young Jack Pine (YJP) (Pinus banksiana) in 1994 after the end of the 1994 growth season at the end of September 1994.

1.6 Related Data Sets

BOREAS TE-02 Wood Respiration Data
BOREAS TE-02 Foliage Respiration Data
BOREAS TE-02 Root Respiration Data
BOREAS TE-02 Continuous Wood Respiration Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Michael G. Ryan
Dr. Michael Lavigne

2.2 Title of Investigation

Autotrophic Respiration in Boreal Ecosystems

2.3 Contact Information

Contact 1:

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(301) 286-0239 (fax)
Andrea.Papagno@gsfc.nasa.gov

3. Theory of Measurements

Respiration of woody tissues is estimated as the CO_2 efflux at the boundary of the bark-air interface. Respiration of woody tissues will vary with temperature, sapwood volume, and perhaps sapwood nitrogen, phosphorus, or carbohydrate content. Sampling for nitrogen, phosphorus, or carbohydrate content or determining sapwood cross-sectional area of a stem involves destructive measurements. Therefore, samples are generally taken after the respiration measurements have been completed. Samples were taken with an increment borer, or for the smaller trees, we harvested and removed a short cylinder (about 1 cm thick from the stem). The sapwood/heartwood boundary was determined by holding the core or "stem cookie" up to a strong light (the sun). Sapwood is translucent, and heartwood is opaque.

4. Equipment

4.1 Instrument Description

Samples were taken with an increment borer, or with a chainsaw or handsaw.

4.1.1 Collection Environment

Twenty trees were measured in the NSA at the OJP, OBS, and OA sites, and 10 trees were measured at the YJP site.

4.1.2 Source/Platform

Measurements were taken in the field.

4.1.3 Source/Platform Mission Objectives

Not applicable.

4.1.4 Key Variables

Location of chamber (1 = 1.3 m, 2 = about 6 m), diameter (outside bark) of tree where chamber was located, specific gravity of sapwood, sapwood volume assigned to segment, growth volume assigned to segment, growth (gm dry weight) assigned to segment, phloem volume assigned to segment, percent nitrogen by dry weight in sapwood, percent phosphorus by dry weight in sapwood, percent sugars by dry weight in sapwood, percent starch by dry weight in sapwood, percent nonstructural carbohydrates by dry weight in sapwood.

4.1.5 Principles of Operation

Stem respiration was measured on 20 trees in the NSA at the OJP, OBS, and OA sites and on 10 trees at the YJP site; tree diameters spanned the range of the stand. At the OJP, OBS, and OA sites, aluminum chamber plates with an external neoprene gasket were attached to the north side of the tree with putty; loose bark was removed before attaching the chamber plate. Chambers were at 1.2 to 1.4 m height; on four trees per stand, additional chambers were placed at 6 m. For CO_2 efflux measurements, a Plexiglas chamber was sealed to the chamber plate with an elastic cord. Chamber area for OA, OBS, and OJP was 110 cm^2. That is counting 1/2 of the plate area (assuming 1/2 of the flux under the plate goes into the chamber and 1/2 does not). The area inside the chamber is 80.5 cm^2. For measurements at YJP, split Plexiglas chambers (23 cm) enclosed the entire stem, with neoprene gaskets creating a seal. This data file describes the characteristics of the tree associated with the respiration samples. Increment cores were taken from enclosed portions of stems after chambers were removed in late September 1994. We measured bark thickness, phloem width, width of the 1994 xylem ring, and sapwood thickness on one increment core. Wood density and nitrogen concentration of sapwood were measured on a second increment core. With these data, we estimated sapwood volume, dry matter growth, and phloem volume for the segment associated with the chamber (a segment of the tree stem with height = chamber height). Growth estimates were converted to molar units by assuming a 50% carbon content for oven-dried wood. Nitrogen and phosphorus were measured with a micro-Kjeldal procedure [Lachat Instruments 1992a, b]; phosphorus was undetectable in many of the initial samples, so we stopped looking for it. Soluble sugar and starch were extracted from plant material as described by Tissue and Wright [1995]. Starch and sugar concentration was determined colorimetrically using the phenol-sulfuric acid method of Dubois et al. [1956]. Methods are more fully described in Lavigne and Ryan [1997] and Ryan et al. [1995].

4.1.6 Sensor/Instrument Measurement Geometry

None.

4.1.7 Manufacturer of Instrument

Increment borers, rulers, etc., are those commonly available to the forestry trade.

4.2 Calibration

Nitrogen and carbohydrate samples were calibrated according to blanks and standards.

4.2.1 Specifications

None given.

4.2.1.1 Tolerance

None.

4.2.2 Frequency of Calibration

Standard procedures were followed to ensure quality of the nitrogen and carbohydrate samples - blanks and standards.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

Stem respiration was measured on 20 trees in the NSA at OJP, OBS, and OA sites and on 10 trees at the YJP site; tree diameters spanned the range of the stand. At the OJP, OBS, and OA sites, aluminum chamber plates with an external neoprene gasket were attached to the north side of the tree with putty; loose bark was removed before attaching the chamber plate. Chambers were at 1.2 to 1.4 m height; on four trees per stand, additional chambers were placed at 6 m. For CO_2 efflux measurements, a Plexiglas chamber was sealed to the chamber plate with an elastic cord. Chamber area for OA, OBS, and OJP was 110 cm^2. That is counting 1/2 of the plate area (assuming 1/2 of the flux under the plate goes into the chamber and 1/2 does not). The area inside the chamber is 80.5 cm^2. For measurements at YJP, split Plexiglas chambers (23 cm) enclosed the entire stem, with neoprene gaskets creating a seal. This data file describes the characteristics of the tree associated with the respiration samples. In the NSA, the respiration cuvettes enclosed only a portion of the circumference of the sample tree, except for the YJP site, where the cuvette enclosed the entire circumference. In the description below, 'segment' refers to a cylinder of the bole the length of which is equal to the height of the cuvette. Each data record includes the diameter (outside bark) of tree where the chamber was located (segment midpoint, cm), specific gravity of sapwood (g dry weight/cm^3 wood), sapwood volume (cm^3) assigned to segment, growth volume (cm^3) assigned to segment, growth (g dry weight per year) assigned to segment, phloem volume (cm^3) assigned to segment, percent nitrogen by dry weight, percent phosphorus by dry weight, percent sugars by dry weight, percent starch by dry weight, and percent nonstructural carbohydrates by dry weight. The measurements here are linked to the respiration measurements by site, tree number, and position on tree.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

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

- OA canopy access, 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
- OBS canopy access tower, site id T3R8T, Lat/Long: 55.88007°N, 98.48139°W, UTM Zone 14, N: 6,192,853.4, E: 532,444.5
- OJP, site id T7Q8T, Lat/Long: 55.92842Q°N, 98.62396°W, UTM Zone 14, N: 6,198,176.3, E: 523,496.2
- YJP, site id, T8S9T, Lat/Long: 55.89575°N, 98.28706°W, UTM Zone 14, N: 6,194,706.9, E: 544,583.9

7.1.2 Spatial Coverage Map

Not available.

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
Measurements were taken from 24-May-1994 to 25-Sep-1994.

7.2.2 Temporal Coverage Map
None given.

7.2.3 Temporal Resolution
None given.

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
SAMPLE_ID
CHAMBER_HEIGHT
NITROGEN_CONTENT
TREE_DIAMETER_CHAMBER_HEIGHT
SAPWOOD_SPECIFIC_GRAVITY
SAPWOOD_VOLUME_SEGMENT
SAPWOOD_GROWTH_VOLUME
SAPWOOD_GROWTH_WEIGHT
PHLOEM_VOLUME
PHOSPHOROUS_CONTENT
SUGAR_CONTENT
STARCH_CONTENT
NONSTRUCTURAL_CARBOHYD_CONTENT
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, 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.
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).
SAMPLE_ID	The sample identifier used by data collectors (see documentation for a detailed description).
CHAMBER_HEIGHT	The height above the ground at which the chamber was placed.
NITROGEN_CONTENT	The nitrogen content of the sample based on dried sample weight.
TREE_DIAMETER_CHAMBER_HEIGHT	Diameter of the tree, measured outside of the bark where the chamber was located.
SAPWOOD_SPECIFIC_GRAVITY	The specific gravity of sapwood calculated as the grams of dry weight per cubic centimeter of fresh wood. The volume was calculated as the surface area of the bark of the segment multiplied by the radial increment. The segment was defined as a cylinder with height equal to the height of the chamber centered on the chamber.
SAPWOOD_VOLUME_SEGMENT	The sapwood volume of the segment defined as a cylinder with height equal to the height of the chamber centered on the chamber.
SAPWOOD_GROWTH_VOLUME	The volume of sapwood growth in a segment in a year. The segment is defined as a cylinder with height equal to the height of the chamber centered on the chamber.
SAPWOOD_GROWTH_WEIGHT	The dry weight of the sapwood in a segment calculated as the sapwood growth volume multiplied by the sapwood specific gravity. The segment is defined as a cylinder with height equal to the height of the chamber centered on the chamber.
PHLOEM_VOLUME	The phloem volume of a segment. The segment is

	defined as a cylinder with height equal to the height of the chamber centered on the chamber.
PHOSPHOROUS_CONTENT	The phosphorous content of the sample based on dried sample weight.
SUGAR_CONTENT	The sugar content of the sample based on dried sample weight.
STARCH_CONTENT	The starch content of the sample based on dried sample weight.
NONSTRUCTURAL_CARBOHYD_CONTENT	The non-structural carbohydrates content of the sample based on dried sample weight.
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]
SAMPLE_ID	[none]
CHAMBER_HEIGHT	[meters]
NITROGEN_CONTENT	[percent]
TREE_DIAMETER_CHAMBER_HEIGHT	[meters]
SAPWOOD_SPECIFIC_GRAVITY	[grams][meter^-3]
SAPWOOD_VOLUME_SEGMENT	[meters^3]
SAPWOOD_GROWTH_VOLUME	[meters^3]
SAPWOOD_GROWTH_WEIGHT	[grams]
PHLOEM_VOLUME	[meters^3]
PHOSPHOROUS_CONTENT	[percent]
SUGAR_CONTENT	[percent]
STARCH_CONTENT	[percent]
NONSTRUCTURAL_CARBOHYD_CONTENT	[percent]
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]
SAMPLE_ID	[Human Observer]

```
CHAMBER_HEIGHT                  [Human Observer]
NITROGEN_CONTENT                [Laboratory Equipment]
TREE_DIAMETER_CHAMBER_HEIGHT    [Laboratory Equipment]
SAPWOOD_SPECIFIC_GRAVITY        [Laboratory Equipment]
SAPWOOD_VOLUME_SEGMENT          [Laboratory Equipment]
SAPWOOD_GROWTH_VOLUME           [Laboratory Equipment]
SAPWOOD_GROWTH_WEIGHT           [Laboratory Equipment]
PHLOEM_VOLUME                   [Laboratory Equipment]
PHOSPHOROUS_CONTENT             [Laboratory Equipment]
SUGAR_CONTENT                   [Laboratory Equipment]
STARCH_CONTENT                  [Laboratory Equipment]
NONSTRUCTURAL_CARBOHYD_CONTENT  [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-9OA-9TETR	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE02-SAP01	9TE02-SAP01	None	None	None	None
START_DATE	24-MAY-94	24-MAY-94	None	None	None	None
END_DATE	25-SEP-94	25-SEP-94	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
SAMPLE_ID	N/A	N/A	None	None	None	None
CHAMBER_HEIGHT	1.3	6	None	None	None	None
NITROGEN_CONTENT	.008	.14	-999	None	None	None
TREE_DIAMETER_ CHAMBER_HEIGHT	.029	.239	None	None	None	None
SAPWOOD_SPECIFIC_ GRAVITY	300000	520000	None	None	None	None
SAPWOOD_VOLUME_ SEGMENT	.000073	.004261	None	None	None	None
SAPWOOD_GROWTH_ VOLUME	.00000095	.00023103	None	None	None	None
SAPWOOD_GROWTH_ WEIGHT	.42	90.1	None	None	None	None
PHLOEM_VOLUME	.0000151	.0005183	-999	None	None	None
PHOSPHOROUS_CONTENT	0	.007	-999	None	None	None
SUGAR_CONTENT	0	1.21	-999	None	None	None
STARCH_CONTENT	.93	8.69	-999	None	None	None
NONSTRUCTURAL_ CARBOHYD_CONTENT	1.29	8.69	-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	22-OCT-98	22-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,SAMPLE_ID,CHAMBER_HEIGHT,
NITROGEN_CONTENT,TREE_DIAMETER_CHAMBER_HEIGHT,SAPWOOD_SPECIFIC_GRAVITY,
SAPWOOD_VOLUME_SEGMENT,SAPWOOD_GROWTH_VOLUME,SAPWOOD_GROWTH_WEIGHT,
PHLOEM_VOLUME,PHOSPHOROUS_CONTENT,SUGAR_CONTENT,STARCH_CONTENT,
NONSTRUCTURAL_CARBOHYD_CONTENT,CRTFCN_CODE,REVISION_DATE
'NSA-9OA-9TETR','9TE02-SAP01',24-MAY-94,25-SEP-94,'Populus tremuloides','1',1.3,
.047,.086,390000,.000546,.0000049,1.91,.0001124,.006,.2,2.07,2.27,'CPI',22-OCT-98
'NSA-9OA-9TETR','9TE02-SAP01',24-MAY-94,25-SEP-94,'Populus tremuloides','1',6.0,
.049,.07,390000,.000353,.00000466,1.82,.0000772,-999.0,.36,.93,1.29,'CPI',
22-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
None.

9.1.1 Derivation Techniques and Algorithms
None given.

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
Not applicable.

9.3.2 Calculated Variables
Not applicable.

9.4 Graphs and Plots
Not applicable.

10. Errors

10.1 Sources of Error
None given.

10.2 Quality Assessment
Measurements quite accurately (+/-10%) reflect the characteristics of the wood underneath the sample chamber. How closely coupled the respiration measurements and characteristics of the wood are is unknown. Lavigne and Ryan [1997] examine how closely the respiration rates match the wood characteristics.

10.2.1 Data Validation by Source
None given.

10.2.2 Confidence Level/Accuracy Judgment
None given.

10.2.3 Measurement Error for Parameters
None given.

10.2.4 Additional Quality Assessments
None given.

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

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

None given.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

These data can be used to study the sapwood volume and stem chemistry of boreal vegetation.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The stem growth and sapwood 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

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers, and F. Smith. 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem. 28: 350-356.

Lachat Instruments. 1992a. Total Kjeldahl nitrogen in soil/plant. Lachat Instruments, Milwaukee, WI, USA.

Lachat Instruments. 1992b. Total phosphorus in Kjeldahl digests. Lachat Instruments, Milwaukee, WI, USA.

Lavigne, M.B. and M.G. Ryan. 1997. Growth and maintenance respiration rates of aspen, black spruce and jack pine stems at northern and southern BOREAS sites. Tree Physiol., BOREAS Special Issue, 17: 543-551.

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.

Ryan, M.G., M.B. Lavigne, and S.T. Gower. 1997. Annual carbon cost of autotrophic respiration in boreal forest ecosystems in relation to species and climate. Journal of Geophysical Research 102(D24):28,871-28,883.

Ryan, M.G., S.T. Gower, R.M. Hubbard, R.H. Waring, H.L. Gholz, W.P. Cropper and S.W. Running. 1995. Woody tissue maintenance respiration of four conifers in contrasting climates. Oecologia 101: 133-140.

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.

Tissue, D.T. and S.J. Wright. 1995. Effect of seasonal water availability on phenology and the annual shoot carbohydrate cycle of tropical forest shrubs. Funct. Ecol. 9: 518-527.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

ADC - Analytical Development Company
ASCII - American Standard Code for Information Interchange
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
CD-ROM - Compact Disk-Read-Only Memory
CO_2 - Carbon Dioxide
DAAC - Distributed Active Archive Center
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
GIS - Geographic Information System
GSFC - Goddard Space Flight Center
HTML - Hypertext Markup Language
IFC - Intensive Field Campaign
IRGA - Infrared Gas Analyzer
MIX - Mixed
NAD83 - North American Datum of 1983
NIR - Near Infrared Radiation
NOAA - National Oceanic and Atmospheric 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
PAR - Photosynthetically Active Radiation
PPFD - Photosynthetic Photon Flux Density
SSA - Southern Study Area
TE - Terrestrial Ecology
TF - Tower Flux site
URL - Uniform Resource Locator
UTM - Universal Transverse Mercator
YA - Young Aspen
YJP - Young Jack Pine

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The BOREAS TE-2 team collected several data sets in support of its efforts to characterize and interpret information on the respiration of the foliage, roots, and wood of boreal vegetation. This data set contains measurements of growth and sapwood of the stems conducted in the NSA during the growing season of 1994. The data are stored in tabular ASCII files.

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