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BOREAS TE-9 NSA Canopy Biochemistry

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Available from:

BOREAS TE-9 NSA Canopy Biochemistry

Hank Margolis , Martin Charest, Mikailou Sy

Summary

The BOREAS TE-9 team collected several data sets related to chemical and photosynthetic properties of leaves. This data set contains canopy biochemistry data collected in 1994 in the NSA at the YJP, OJP, OBS, UBS, and OA sites, including biochemistry lignin, nitrogen, cellulose, starch, and fiber concentrations. These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing. The data are available in tabular ASCII files.

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1. Data Set Overview

1.1 Data Set Identification
BOREAS TE-09 NSA Canopy Biochemistry

1.2 Data Set Introduction
These data describe the canopy biochemistry (lignin, nitrogen, cellulose, starch, fiber) at the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) Young Jack Pine (YJP), Old Jack Pine (OJP), Old Black Spruce (OBS), Upland Black Spruce (UBS), and Old Aspen (OA) sites.

These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing.

1.3 Objective/Purpose

These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing. Canopy biochemistry (lignin, nitrogen, cellulose, starch, fiber) can be related to a number of ecosystem processes, such as litter decomposition, nutrient cycling rates, soil CO_2 fluxes, carbon allocation between below ground and above ground components, and photosynthetic capacity. There is some evidence suggesting that several aspects of canopy biochemistry can be estimated using high-resolution reflectance data in the mid-infrared. While several biochemical components can be accurately measured in the laboratory with ground plant material, making reliable estimates in real forests is difficult because the structure of shoots, branches, and trees influences the reflectance spectra.

1.4 Summary of Parameters

Sampling period, site identification, sample identification, fiber concentration (%), cellulose concentration (%), lignin concentration (%), total soluble sugars (%), nitrogen concentration (%), and starch concentration (%).

1.5 Discussion

At the NSA (Thompson, Manitoba), foliage from the upper third of the canopies of the YJP, OJP, OBS, and UBS stands was sampled five times during 1994 in conjunction with each field campaign (Focused Field Campaign Winter (FFC-W), FFC-Thaw (FFC-T), Intensive Field Campaign (IFC)-1, IFC-2, and IFC-3), while samples from OA were taken only during IFCs. Samples were taken either on the day of or on the day following the Airborne Visible and Infrared Imagining Spectrometer (AVIRIS) missions in the NSA. Five samples were taken from five different dominant trees at each site at each date. Trees sampled were black spruce (Picea mariana), jack pine (Pinus banksiana), and aspen (Populus tremuloides). Samples were lyophilisated and ground (Tecator Cyclotec 1093 sample mill) to pass through a 0.40-mm mesh screen. For each biochemical component, analyses were conducted on two random subsamples that were equivalent to 100 mg dry weight for total soluble sugars or starch concentration; 1 g for fiber, cellulose, or lignin concentrations; and 500 mg for nitrogen concentration. Data given in TABLE1 were averaged for the two subsamples.

1.6 Related Data Sets

BOREAS TE-09 NSA Photosynthetic Capacity and Foliage Nitrogen Data
BOREAS TE-09 PAR and Leaf Nitrogen Data for NSA Species
BOREAS TE-09 In Situ Diurnal Gas Exchange of NSA Boreal Forest Stands

2. Investigator(s)

2.1 Investigator(s) Name and Title
Hank Margolis, Ph.D.
Universite Laval
Faculte de foresterie et de geomatique

2.2 Title of Investigation
Relationship Between Measures of Absorbed and Reflected Radiation and the Photosynthetic Capacity of Boreal Forest Canopies and Understories

2.3 Contact Information

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3. Theory of Measurements

For total soluble sugars and starch concentrations, each subsample was extracted in a 15-ml aliquot of methanol-chloroform-water solvent (M-C-W: 12-5-3). Extracts were centrifuged three times for 5 minutes each time at 3,500 rpm. Two 75-ml aliquots were used to quantify soluble sugars (Dubois et al., 1956), and another group of two 75-ml aliquots was used for starch (Boehringer Mannheim Company, 1993). Spectrophotometric measurements were made using a Spectronic 20 (Bausch and Lomb). Transmittance readings first were made using glass cells and were then converted to corresponding absorbencies.

Fiber, lignin, and cellulose analyses were conducted following material extraction in a mixture of H_2SO_4 0.5 M and cetyltrimethylammonium bromide (Ryan et al., 1990). Fiber concentration was analyzed from these first extracts while lignin and cellulose were conducted on insoluble residues (Ryan et al., 1990). A second extraction in 72% H_2SO_4 for 3 hours at 20-23 °C removed the cellulose

concentration (Ryan et al., 1990). Residues were then ashed at 450 °C for 8 hours to obtain the ash-free lignin concentration (Ryan et al., 1990).

Nitrogen concentration analysis was conducted using the micro-Kjeldahl method (Parkinson and Allen, 1975). The sample distillation was conducted using a Kjeltec 1030 autoanalyzer, which is a single unit for fast and automatic distillation, titration, and calculation using the Kjeldahl method. Results from this distillator model are presented on a digital display or printed.

4. Equipment

4.1 Sensor/Instrument Description

Shotgun, cooler with icebags, plastic bags, pruner, automatic dispenser, glass test tubes, Eppendorf pipet, high-precision balance grinding machine, centrifuge, distillator, spectrophotometer, glass cells, chemical products, lysophilisator.

4.1.1 Collection Environment

Sites: Samples were collected from five sites at the NSA in Thompson, Manitoba. The sites are described in Appendix I and can be identified in Figure 5.1.5a of the BOREAS Experiment Plan, Version 3.0.

NSA-YJP: T8S9T
NSA-OJP: T7Q8T
NSA-OBS: T3R8T
NSA-BS: T6R5S
NSA-OA: T2Q6A

Sampling: Sampling dates, except those in the winter and thaw periods, correspond with either the day of or the day following the AVIRIS missions in the NSA. For each site, branches were taken from the upper third of the canopy of five dominant trees in a representative location using a shotgun. Branches were kept in labeled plastic bags, stored in a cooler containing icebags, and transported to the laboratory in Thompson. From each bag, an appropriate amount of foliage was lyophilisated and ground. Two equivalent subsamples were then taken and extracted for each biochemical component. Analyses were conducted on those extracts.

Extractions: Automatic dispensers were used to deliver the 15-ml aliquots of methanol-chloroform-water solvent (M-C-W: 12-5-3) in glass test tubes containing ground material for soluble sugars and starch analysis.

Raw fiber concentration is strongly correlated to the proximate carbon fraction (Ryan et al., 1990) and is used in entomology to estimate the non-nutritive component of foliage. It was determined from a mixture of H_2SO_4 0.5 M and cetyltrimethyl-ammonium extracts. Residues of this first extraction were extracted in 72% H_2SO_4 for 3 hours at 20-23 °C to remove cellulose concentration. Residues were then ashed at 450 °C for 8 hours to obtain the ash-free lignin concentration. For nitrogen analysis, samples were digested using a solution mixing 350 ml of H_2O_2, 0.42 g Se powder, and 14 g Li_2SO_4. H_2O in a flat-bottomed, boiling flask and carefully adding 420 ml H_2SO_4 while swirling and cooling the mixture was stored at 1 °C.

Quantities estimated: Components were calculated according to respective references and were expressed in percentage of foliage material dry weight basis.

4.1.2 Source/Platform

One or two persons collected branches at all sites, put them in labeled plastic bags in a cooler containing icebags, and transported them to laboratory. Foliage was then sampled, lyophilisated, and ground. Subsamples were taken for extractions and analyses.

4.1.3 Source/Platform Mission Objectives

The mission was undertaken to establish the relationship between biochemical patterns and high-resolution mid-infrared reflectance data taken with AVIRIS on the National Aeronautics and Space Administration (NASA) ER-2 aircraft.

4.1.4 Key Variables

Foliar concentrations in fiber (%), cellulose (%), lignin (%), total soluble sugars (%), nitrogen (%), and starch (%).

4.1.5 Principles of Operation

Not applicable.

4.1.6 Sensor/Instrument Measurement Geometry

Samples were harvested from the upper third of the canopy of five dominant trees for all sites at all sampling dates.

4.1.7 Manufacturer of Sensor/Instrument

Grinding machine
Tecator Cyclotec 1093 sample mill
Tecator, Inc.
P.O. Box 405
Herndon, VA 22070 USA
(703) 435-3300

Weighing balance
Mettler-Toledo AG, Type AB104
IM Langacher, CH-8606 Greifensee
Switzerland
(01) 944 22 11
Telex: 82 61 50

Chemical Products
Sigma Chemical Company
P.O. Box 14508
St. Louis, MO 63178-9916 USA
1 (800) 325-3010

Centrifuge
IEC Model HN-SII Centrifuge
300 Second Avenue
Needham Heights, MA 02194 USA

Spectrophotometer
Spectronic 20
Bausch and Lomb
Glass cells
Hellma
Fisher Scientific,
8505 Devonshire Rd., Montreal (Quebec)
Canada H4P 2 L4

Starch test kit
Boehringer Mannheim, UV-method, Cat. No. 207748
Sigma Chemical Company
P.O. Box 14508
St. Louis, MO 63178-9916 USA
1 (800) 325-3010

Distillator
Kjeltec auto1030 analyzer
Tecator, Inc.
P.O. Box 405
Herndon, VA 22070 USA
(703) 435-3300

Dispenser
Compet, 5 ml bottle top dispenser
Nichiryo Co. LTD.
Tokyo, Japan

4.2 Calibration

4.2.1 Specifications
The weighing balance was accurate to within 0.0001 g. The automatic dispenser was accurate to within 1%. The spectrophotometer was accurate to within 0.001 absorbance unit.

4.2.1.1 Tolerance
Not applicable.

4.2.2 Frequency of Calibration
The control level on the spectrophotometer was verified (0 absorbance unit) after each group of five samples.

4.2.3 Other Calibration Information
Not available.

5. Data Acquisition Methods

Sites: Samples were collected from five NSA sites in Thompson, Manitoba. The sites are described in Appendix I and can be identified in Figure 5.1.5a of the BOREAS Experiment Plan (Version 3.0).

NSA-YJP: T8S9T
NSA-OJP: T7Q8T
NSA-OBS: T3R8T
NSA-BS: T6R5S
NSA-OA: T2Q6A

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Extractions: Automatic dispensers were used to deliver the 15-ml aliquots of methanol-chloroform-water solvent (M-C-W: 12-5-3) in glass test tubes containing ground material for soluble sugars and starch analysis.

Raw fiber concentration is strongly correlated to the proximate carbon fraction (Ryan et al., 1990) and is used in entomology to estimate the non-nutritive component of foliage. It was determined from a mixture of H_2SO_4 0.5 M and cetyltrimethyl-ammonium extracts. Residues of this first extraction were extracted in 72% H_2SO_4 for 3 hours at 20-23 °C to remove cellulose concentration. Residues were then ashed at 450 °C for 8 hours to obtain the ash-free lignin concentration. For nitrogen analysis, samples were digested using a solution of 350 ml of H_2O_2, 0.42 g of Se powder, and 14 g of Li_2SO_4. H_2O in a flat-bottomed 1-liter boiling flask and carefully adding 420 ml H_2SO_4 while swirling and cooling the mixture, which was stored at 1 °C.

Quantities estimated: Components were calculated according to respective references and were expressed in percentage of foliage material dry weight basis.

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 North American Datum of 1983 (NAD83) coordinates for the sites are:
- NSA-YJP flux tower site: Lat/Long: 55.89575°N, 98.28706°W; UTM Zone 14, N: 6194706.9, E: 544583.9
- NSA-OJP flux tower site: Lat/Long: 55.842°N, 98.62396°W; UTM Zone 14, N: 6198176.3, E: 523496.2
- NSA-OA canopy access tower site (auxilliary site number T2Q6A, BOREAS Experiment Plan, Version 3.0): Lat/Long: 55.88691°N, 98.67479°W; UTM Zone 14, N 6193540.7, E 520342
- NSA-OBS flux tower site: Lat/Long: 55.88007°N, 98.48139°W; UTM Zone 14, N:6192853.4, E: 532444.5
- NSA-UBS canopy access tower site (auxilliary site number T6R5S, BOREAS Experiment Plan, Version 3.0): Lat/Long: 55.90802°N, 98.51865°W; UTM Zone 14, N 6195947 E 530092

7.1.2 Spatial Coverage Map
Not applicable.

7.1.3 Spatial Resolution
These data represent point source measurements that may be generally representative.

7.1.4 Projection
Not applicable.

7.1.5 Grid Description
Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
The overall time period of sample acquisition was from 01-Feb-1994 through 18-Sep-1994.

7.2.2 Temporal Coverage Map
Samples were collected on the following dates:

IFC	Sites (NSA) and Dates
FFC-W	OJP, OBS, and YJP on 17-Feb-1994 TE-BS on 18-Feb-1994
FFC-T	OJP, OBS, and YJP on 28-Apr-1994 TE-BS on 29-Apr-1994
IFC-1	OA, OJP, and YJP on 08-Jun-1994 OBS and BS on 09-Jun-1994
IFC-2	OASP, OJP, and BS on 04-Aug-1994 OBS and YJP on 05-Aug-1994
IFC-3	OBS on 15-Sep-1994 OASP, YJP, OJP, and BS on 16-Sep-1994

7.2.3 Temporal Resolution
For each sampling date, branches were collected at 6:00 a.m. (local time) for OBS, at 8:00 a.m. for YJP, and between 3:00 p.m. and 6:00 p.m. for the UBS, OJP, and OA sites.

7.3 Data Characteristics

7.3.1 Parameter/Variable
The parameters contained in the data files on the CD-ROM are:

```
BIOCHEM_AVG_DATA
          Column Name
------------------------------
SITE_NAME
SUB_SITE
START_DATE
END_DATE
SPECIES
MEAN_FIBER_CONTENT
STD_ERR_FIBER_CONTENT
MEAN_CELLULOSE_CONTENT
STD_ERR_CELLULOSE_CONTENT
MEAN_LIGNIN_CONTENT
STD_ERR_LIGNIN_CONTENT
MEAN_TS_SUGAR_CONTENT
STD_ERR_TS_SUGAR_CONTENT
MEAN_NITROGEN_CONTENT
```

```
STD_ERR_NITROGEN_CONTENT
MEAN_STARCH_CONTENT
STD_ERR_STARCH_CONTENT
CRTFCN_CODE
REVISION_DATE
```

BIOCHEM_POINT_DATA
```
        Column Name
--------------------------------

SITE_NAME
SUB_SITE
START_DATE
END_DATE
SPECIES
BAG_SAMPLE_ID
FIBER_CONTENT
CELLULOSE_CONTENT
LIGNIN_CONTENT
TS_SUGAR_CONTENT
NITROGEN_CONTENT
STARCH_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:

BIOCHEM_AVG_DATA

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 the reference data commenced.
END_DATE	The date on which the collection of the referenced data was terminated.
SPECIES	Botanical (Latin) name of the species (Genus species).
MEAN_FIBER_CONTENT	The mean fiber content of the sample.
STD_ERR_FIBER_CONTENT	Standard error for the fiber content of the sample.
MEAN_CELLULOSE_CONTENT	The mean cellulose content of the sample.
STD_ERR_CELLULOSE_CONTENT	Standard error for the cellulose content of the

	sample.
MEAN_LIGNIN_CONTENT	The mean lignin content of the sample.
STD_ERR_LIGNIN_CONTENT	Standard error for the lignin content of the sample.
MEAN_TS_SUGAR_CONTENT	The mean total soluble sugars content in the sample.
STD_ERR_TS_SUGAR_CONTENT	Standard error for the total soluble sugars content in the sample.
MEAN_NITROGEN_CONTENT	The mean nitrogen content of the sample.
STD_ERR_NITROGEN_CONTENT	Standard error for the nitrogen content of the sample.
MEAN_STARCH_CONTENT	The mean starch content of the sample.
STD_ERR_STARCH_CONTENT	Standard error for the starch content of the sample.
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.

BIOCHEM_POINT_DATA

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 the reference data commenced.
END_DATE	The date on which the collection of the referenced data was terminated.
SPECIES	Botanical (Latin) name of the species (Genus species).
BAG_SAMPLE_ID	Branches collected from each tree were stored in two bags identified as 1, 2, or A, B. Example: 1.1 = sample 1 from bag 1-- 5.A sample 5 from bag A.
FIBER_CONTENT	The fiber content of the sample.
CELLULOSE_CONTENT	The cellulose content of the sample.
LIGNIN_CONTENT	The lignin content of the sample.
TS_SUGAR_CONTENT	The total soluble sugars content of the sample.
NITROGEN_CONTENT	The nitrogen content of the sample.
STARCH_CONTENT	The starch content of the sample.
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:

BIOCHEM_AVG_DATA

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
START_DATE	[DD-MON-YY]
END_DATE	[DD-MON-YY]
SPECIES	[none]
MEAN_FIBER_CONTENT	[percent]
STD_ERR_FIBER_CONTENT	[percent]
MEAN_CELLULOSE_CONTENT	[percent]
STD_ERR_CELLULOSE_CONTENT	[percent]
MEAN_LIGNIN_CONTENT	[percent]
STD_ERR_LIGNIN_CONTENT	[percent]
MEAN_TS_SUGAR_CONTENT	[percent]
STD_ERR_TS_SUGAR_CONTENT	[percent]
MEAN_NITROGEN_CONTENT	[percent]
STD_ERR_NITROGEN_CONTENT	[percent]
MEAN_STARCH_CONTENT	[percent]
STD_ERR_STARCH_CONTENT	[percent]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

BIOCHEM_POINT_DATA

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
START_DATE	[DD-MON-YY]
END_DATE	[DD-MON-YY]
SPECIES	[none]
BAG_SAMPLE_ID	[none]
FIBER_CONTENT	[percent]
CELLULOSE_CONTENT	[percent]
LIGNIN_CONTENT	[percent]
TS_SUGAR_CONTENT	[percent]
NITROGEN_CONTENT	[percent]
STARCH_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:

BIOCHEM_AVG_DATA

Column Name	Data Source
SITE_NAME	BORIS Designation
SUB_SITE	BORIS Designation
START_DATE	BORIS Designation
END_DATE	BORIS Designation
SPECIES	Human Observer
MEAN_FIBER_CONTENT	Laboratory Equipment
STD_ERR_FIBER_CONTENT	Laboratory Equipment
MEAN_CELLULOSE_CONTENT	Laboratory Equipment
STD_ERR_CELLULOSE_CONTENT	Laboratory Equipment
MEAN_LIGNIN_CONTENT	Laboratory Equipment
STD_ERR_LIGNIN_CONTENT	Laboratory Equipment
MEAN_TS_SUGAR_CONTENT	Laboratory Equipment
STD_ERR_TS_SUGAR_CONTENT	Laboratory Equipment
MEAN_NITROGEN_CONTENT	Laboratory Equipment
STD_ERR_NITROGEN_CONTENT	Laboratory Equipment
MEAN_STARCH_CONTENT	Laboratory Equipment
STD_ERR_STARCH_CONTENT	Laboratory Equipment
CRTFCN_CODE	BORIS Designation
REVISION_DATE	BORIS Designation

BIOCHEM_POINT_DATA

Column Name	Data Source
SITE_NAME	BORIS Designation
SUB_SITE	BORIS Designation
START_DATE	BORIS Designation
END_DATE	BORIS Designation
SPECIES	Human Observer
BAG_SAMPLE_ID	Human Observer
FIBER_CONTENT	Laboratory Equipment
CELLULOSE_CONTENT	Laboratory Equipment
LIGNIN_CONTENT	Laboratory Equipment
TS_SUGAR_CONTENT	Laboratory Equipment
NITROGEN_CONTENT	Laboratory Equipment
STARCH_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.

BIOCHEM_AVG_DATA

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	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE09-BCA01	9TE09-BCA01	None	None	None	None
START_DATE	01-FEB-94	30-AUG-94	None	None	None	None
END_DATE	16-FEB-94	19-SEP-94	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
MEAN_FIBER_CONTENT	13.69	37.38	None	None	None	None
STD_ERR_FIBER_CONTENT	.285	2.538	None	None	None	None
MEAN_CELLULOSE_CONTENT	11.52	21.36	None	None	None	None
STD_ERR_CELLULOSE_CONTENT	.208	3.531	None	None	None	None
MEAN_LIGNIN_CONTENT	11.86	21.74	None	None	None	None
STD_ERR_LIGNIN_CONTENT	.058	3.028	None	None	None	None
MEAN_TS_SUGAR_CONTENT	6.906	14.292	None	None	None	None
STD_ERR_TS_SUGAR_CONTENT	.22	1.581	None	None	None	None
MEAN_NITROGEN_CONTENT	.586	2.092	None	None	None	None
STD_ERR_NITROGEN_CONTENT	.014	.333	None	None	None	None
MEAN_STARCH_CONTENT	1.538	16.211	None	None	None	None
STD_ERR_STARCH_CONTENT	.176	2.497	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	18-SEP-96	18-SEP-96	None	None	None	None

BIOCHEM_POINT_DATA

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	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE09-BCP01	9TE09-BCP01	None	None	None	None
START_DATE	01-FEB-94	30-AUG-94	None	None	None	None
END_DATE	16-FEB-94	19-SEP-94	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
BAG_SAMPLE_ID	1.1	5.A	None	None	None	None
FIBER_CONTENT	12.26	38.5	-999	None	None	None
CELLULOSE_CONTENT	8.837	28.135	-999	None	None	None
LIGNIN_CONTENT	5.416	28.035	-999	None	None	None
TS_SUGAR_CONTENT	5.808	16.558	-999	None	None	None

```
NITROGEN_CONTENT      .457           2.649          -999     None     None     None
STARCH_CONTENT        .501           20.28          -999     None     None     None
CRTFCN_CODE           CPI            CPI            None     None     None     None
REVISION_DATE         18-SEP-96      18-SEP-96      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 is a sample of the first few records from the data table on the CD-ROM:

BIOCHEM_AVG_DATA
```
SITE_NAME,SUB_SITE,START_DATE,END_DATE,SPECIES,MEAN_FIBER_CONTENT,
STD_ERR_FIBER_CONTENT,MEAN_CELLULOSE_CONTENT,STD_ERR_CELLULOSE_CONTENT,
MEAN_LIGNIN_CONTENT,STD_ERR_LIGNIN_CONTENT,MEAN_TS_SUGAR_CONTENT,
STD_ERR_TS_SUGAR_CONTENT,MEAN_NITROGEN_CONTENT,STD_ERR_NITROGEN_CONTENT,
MEAN_STARCH_CONTENT,STD_ERR_STARCH_CONTENT,CRTFCN_CODE,REVISION_DATE
'NSA-90A-9TETR','9TE09-BCA01',24-MAY-94,16-JUN-94,'Populus tremuloides',13.69,
.508,20.43,3.531,21.74,2.507,13.305,.617,1.81,.333,4.279,.501,'CPI',18-SEP-96
'NSA-90A-9TETR','9TE09-BCA01',19-JUL-94,08-AUG-94,'Populus tremuloides',26.22,
1.156,11.52,.34,14.0,.795,11.28,.341,2.092,.066,5.932,.41,'CPI',18-SEP-96
```

BIOCHEM_POINT_DATA
```
SITE_NAME,SUB_SITE,START_DATE,END_DATE,SPECIES,BAG_SAMPLE_ID,FIBER_CONTENT,
CELLULOSE_CONTENT,LIGNIN_CONTENT,TS_SUGAR_CONTENT,NITROGEN_CONTENT,
STARCH_CONTENT,CRTFCN_CODE,REVISION_DATE
'NSA-90A-9TETR','9TE09-BCP01',24-MAY-94,16-JUN-94,'Populus tremuloides','4.1',
13.976,20.02,19.86,12.417,1.748,2.615,'CPI',18-SEP-96
'NSA-90A-9TETR','9TE09-BCP01',24-MAY-94,16-JUN-94,'Populus tremuloides','3.1',
12.26,28.135,28.035,12.589,1.181,3.877,'CPI',18-SEP-96
```

8. Data Organization

8.1 Data Granularity
The smallest unit of orderable data is data collected on one day at one site.

8.2 Data Format(s)
In BIOCHEM_AVG_DATA, data are presented for each sample (i.e., for each tree) and represent the average of two subsamples. In BIOCHEM_POINT_DATA, the subsequent averaged contents and corresponding standard errors are given on the basis of both site and sampling date.

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.

9.2 Data Processing Sequence
None.

9.2.1 Processing Steps
Data were recorded automatically by a computer and also printed on a printer. Subsequent calculations of different parameters were performed using MS Excel for Windows 5.0.

BOREAS Information System (BORIS) staff processed the data by:
- Reviewing the initial data files and loading them online for BOREAS team access.
- Designing relational data base tables to inventory and store the data.
- Loading the data into the relational data base tables.
- Working with the TE-09 team to document the data set.
- Extracting the standardized data into logical files.

9.2.2 Processing Changes
None.

9.3 Calculations
All variables were measured.

9.3.1 Special Corrections/Adjustments
None.

9.3.2 Calculated Variables
None.

9.4 Graphs and Plots
None.

10. Errors

10.1 Sources of Error
Analyses of all components were conducted on a uniform basis but there are some missing values that have been accounted for in averages and standard error calculations.

10.2 Quality Assessment
None.

10.2.1 Data Validation by Source
Data were checked for obvious problems.

10.2.2 Confidence Level/Accuracy Judgment
High.

10.2.3 Measurement Error for Parameters
None.

10.2.4 Additional Quality Assessments
None.

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.

11.2 Known Problems with the Data
None.

11.3 Usage Guidance
This data file does not contain values for subsamples. A sample represents a tree and comprises two subsamples. The averaged content in TABLE2 is that of five samples (replications). Standard errors are among samples, not between subsamples.

11.4 Other Relevant Information
None.

12. Application of the Data Set

These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing.

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 NSA canopy biochemistry 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 given

17.2 Journal Articles and Study Reports

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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.

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Ryan, M.G., J.M. Melillo, and A. Ricca. 1990. A comparison of methods for determining proximate carbon fractions of forest litter. Can. J. For. Res. 20: 166-171.
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, 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

None given.

19. List of Acronyms

```
ASCII    - American Standard Code for Information Interchange
AVIRIS   - Airborne Visible-Infrared Imaging Spectrometer
BOREAS   - BOReal Ecosystem-Atmosphere Study
BORIS    - BOREAS Information System
CD-ROM   - Compact Disk-Read-Only Memory
CGI      - Certified by Group
CPI      - Checked by Principal Investigator
DAAC     - Distributed Active Archive Center
EOS      - Earth Observing System
EOSDIS   - EOS Data and Information System
FFC-T    - Focused Field Campaign-Thaw
FFC-W    - Focused Field Campaign-Winter
GIS      - Geographic Information System
GSFC     - Goddard Space Flight Center
HTML     - Hyper-Text Markup Language
IFC      - Intensive Field Campaign
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
PRE      - Preliminary
SSA      - Southern Study Area
TE       - Terrestrial Ecology
UBS      - Upland Black Spruce
URL      - Uniform Resource Locator
UTM      - Universal Transverse Mercator
YJP      - Young Jack Pine
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13. ABSTRACT (Maximum 200 words)

The BOREAS TE-9 team collected several data sets related to chemical and photosynthetic properties of leaves. This data set contains canopy biochemistry data collected in 1994 in the NSA at the YJP, OJP, OBS, UBS, and OA sites, including biochemistry lignin, nitrogen, cellulose, starch, and fiber concentrations. These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing. The data are available in tabular ASCII files.

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