



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

*Forrest G. Hall and Shelaine Curd, Editors*

### **Volume 140**

## **BOREAS TE-5 Leaf Carbon Isotope Data**

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# **BOREAS TE-5 Leaf Carbon Isotope Data**

Jim Ehleringer, J.Renee Brooks, Larry Flanagan

## **Summary**

The BOREAS TE-5 team collected measurements in the NSA and SSA on gas exchange, gas composition, and tree growth. This documentation describes leaf carbon isotope data that were collected in 1993 and 1994 at the NSA and SSA OJP sites, the SSA OBS site, and the NSA UBS site. In addition, leaf carbon isotope data were collected in 1994 only at the NSA and SSA OA sites. These data were collected to provide seasonal integrated physiological information for 10 to 15 common species at these 6 BOREAS sites. The data are stored in tabular ASCII files.

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## **1. Data Set Overview**

### **1.1 Data Set Identification**

BOREAS TE-05 Leaf Carbon Isotope Data

### **1.2 Data Set Introduction**

Leaf carbon isotope data were collected in 1993 and 1994 at the BOREal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) and Southern Study Area (SSA) Old Jack Pine (OJP) sites, the SSA Old Black Spruce (OBS) site, and the NSA T6R5S Terrestrial Ecology (TE) Upland Black Spruce (UBS) site. Leaf carbon isotope data were collected in 1994 only at the NSA and SSA Old Aspen (OA) sites.

### **1.3 Objective/Purpose**

Leaf carbon isotope data were collected to provide seasonal integrated physiological information for 10 to 15 common species at six BOREAS sites.

#### **1.4 Summary of Parameters**

Site, collection date, species, foliage age (relevant for conifers), replicate, delta  $^{13}\text{C}$ .

#### **1.5 Discussion**

These measurements were made at both the NSA and the SSA in 1993 and 1994 at jack pine and black spruce sites and in 1994 only at aspen sites.

#### **1.6 Related Data Sets**

BOREAS TE-05 Surface Meteorological and Radiation Data

BOREAS TE-05 Leaf Gas Exchange Data

BOREAS TE-05 Air Stable Isotope Data

BOREAS TE-05 Tree Ring and Carbon Isotope Ratio Data

## **2. Investigator(s)**

### **2.1 Investigator(s) Name and Title**

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### **2.2 Title of Investigation**

Vegetation-Atmosphere  $\text{CO}_2$  and  $\text{H}_2\text{O}$  Exchange Processes: Stable Isotope Analyses

### **2.3 Contact Information**

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### **3. Theory of Measurements**

For complete information on stable carbon isotope ratios, please refer to Carbon Isotope Techniques (1991), D.C. Coleman and B. Fry (eds.), Academic Press, Inc. The stable carbon isotope ratios ( $^{13}\text{C}/^{12}\text{C}$ ) are not presented as an absolute but as the relative difference between the isotope ratios of the sample and standard gases:  $\delta^{13}\text{C} (\text{o/oo}) = (\text{R}_{\text{sample}} / \text{R}_{\text{standard}} - 1) * 1000$  where  $\text{R}_{\text{sample}}$  and  $\text{R}_{\text{standard}}$  are the  $^{13}\text{C}/^{12}\text{C}$  ratios of the plant sample and standard Pee Dee Belemnite (PDB). The overall precision of the measurements of plant materials was  $\pm 0.11$  o/oo.

### **4. Equipment**

#### **4.1 Sensor/Instrument Description**

Isotope ratio mass spectrometer (delta S, Finnigan MAT, San Jose, CA).

##### **4.1.1 Collection Environment**

Environmental conditions on sampling day should be included in the BOREAS TE-05 meteorological data.

##### **4.1.2 Source/Platform**

Leaves were sampled from the upper canopy of each plant. Samples were taken from all sides to ensure a representative sample.

##### **4.1.3 Source/Platform Mission Objectives**

Leaf carbon isotope data were collected to provide seasonal integrated physiological information for the common species at six BOREAS sites.

##### **4.1.4 Key Variables**

Site, collection date, species, foliage age (relevant for conifers), replicate,  $\delta^{13}\text{C}$ .

#### **4.1.5 Principles of Operation**

The mass spectrometer is run by the Stable Isotope Ratio Facility for Ecological Research (SIRFER) at the University of Utah.

#### **4.1.6 Sensor/Instrument Measurement Geometry**

None given.

#### **4.1.7 Manufacturer of Sensor/Instrument**

Finnigan MAT  
355 River Oaks Parkway  
San Jose, CA 95134  
(404) 424-5284

### **4.2 Calibration**

#### **4.2.1 Specifications**

The mass spectrometer is calibrated to standard PDB gas. This international standard was a limestone of fossil *Belemnitella americana* from the Cretaceous Pee Dee formation in South Carolina.

##### **4.2.1.1 Tolerance**

None given.

#### **4.2.2 Frequency of Calibration**

Samples are always run in comparison to the standard gas. The TE-05 team ran its own standard cabbage sample after every 12 to 24 leaf samples.

#### **4.2.3 Other Calibration Information**

None.

## **5. Data Acquisition Methods**

Five replicate samples were collected for 10 to 15 of the most common species at each site. Samples were collected from all sides of the plant to ensure a representative sample. Plant leaf material was dried for 48 hours at 70 °C and then ground with a mortar and pestle to a fine powder. A 2-mg subsample was combusted and analyzed for  $^{13}\text{C}/^{12}\text{C}$  composition using an isotope ratio mass spectrometer (delta S, Finnigan MAT, San Jose, CA). A standard sample was run after every 12 to 24 samples.

## **6. Observations**

### **6.1 Data Notes**

None given.

### **6.2 Field Notes**

None given.

## **7. Data Description**

### **7.1 Spatial Characteristics**

#### **7.1.1 Spatial Coverage**

Samples were collected at NSA OJP, SSA OJP, SSA OBS, and NSA UBS in 1993 and all the sites listed below in 1994. The North American Datum of 1983 (NAD83) coordinates of the sites are:

- NSA OJP flux tower site: Lat/Long = 55.927°N, 98.62°W, UTM Zone 14, N:6,197,997 E:523,501.
- SSA OJP flux tower site: Lat/Long = 53.916°N, 104.69°W, UTM Zone 13, N:5,951,000 E:479,400.
- NSA OA canopy access tower site: auxiliary site number T2Q6A, BOREAS Experiment Plan, Version 3.
- SSA OA flux tower site: Lat/Long = 53.629°N, 106.197°W, UTM Zone 13, N:5,942,688 E:420,874.
- NSA UBS canopy access tower site: auxiliary site number T6R5S, BOREAS Experiment Plan, Version 3).
- SSA OBS flux tower site: Lat/Long = 53.985°N, 105.122°W, UTM Zone 13, N:5,981,904 E:492,000.

#### **7.1.2 Spatial Coverage Map**

Not available.

#### **7.1.3 Spatial Resolution**

These data are point source measurements at the locations given.

#### **7.1.4 Projection**

Not applicable.

#### **7.1.5 Grid Description**

Not applicable.

### **7.2 Temporal Characteristics**

#### **7.2.1 Temporal Coverage**

- SSA OBS: 26-May-1994, 21-Jul-1994, 10-Aug-1994, 31-Aug-1994, 13-Sep-1994.
- SSA OA: 30-May-1994, 25-Jul-1994, 03-Sep-1994.
- SSA OJP: 25-May-1994, 23-Jul-1994, 10-Aug-1994, 11-Aug-1994, 12-Aug-1994, 13-Aug-1994, 06-Sep-1994.
- NSA UBS: 04-Jun-1994, 08-Jun-1994, 29-Jul-1994, 18-Aug-1994, 15-Sep-1994.
- NSA OA: 11-Jun-1994, 07-Aug-1994, 06-Sep-1994, 07-Sep-1994.
- NSA OJP: 04-Jun-1994, 07-Jun-1994, 25-Jul-1994, 16-Aug-1994, 30-Aug-1994.

#### **7.2.2 Temporal Coverage Map**

Not available.

#### **7.2.3 Temporal Resolution**

Nominally, each site was visited once per month with some higher frequency measurements as time permitted.

### **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
DATE_OBS
SPECIES
NEEDLE_AGE
DEL_13C
COMMENTS
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-III II, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and III II is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
SPECIES	Botanical (Latin) name of the species (Genus species).
NEEDLE_AGE	Age of the sampled needles, (0 = current year, 1 = 1 year old, 2 = 2 years old, etc.).
DEL_13C	The del 13C is a relative difference between the sample and the PeeDee Belemnite standard, relative to the PeeDee Belemnite standard.
COMMENTS	Descriptive information to clarify or enhance the understanding of the other entered data.
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]
DATE_OBS	[DD-MON-YY]
SPECIES	[none]
NEEDLE_AGE	[years]
DEL_13C	[per mil]
COMMENTS	[none]
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]
DATE_OBS	[Human Observer]
SPECIES	[Human Observer]
NEEDLE_AGE	[Human Observer]
DEL_13C	[Laboratory Equipment]
COMMENTS	[Human Observer]
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

### 7.3.5 Data Range

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

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9BS-9TETR	SSA-OJP-FLXTR	None	None	None	None
SUB_SITE	9TE05-LCI01	9TE05-LCI01	None	None	None	None
DATE_OBS	10-AUG-93	13-SEP-94	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
NEEDLE_AGE	0	9	None	None	None	Blank
DEL_13C	-35.2	-23.6	None	None	None	Blank
COMMENTS	N/A	N/A	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	07-DEC-97	07-DEC-97	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,DATE_OBS,SPECIES,NEEDLE_AGE,DEL_13C,COMMENTS,CRTFCN_CODE,
REVISION_DATE
'NSA-90A-9TETR','9TE05-LCI01',11-JUN-94,'Alnus crispa',0,-26.8,'Cur','CPI',
07-DEC-97
'NSA-90A-9TETR','9TE05-LCI01',11-JUN-94,'Alnus crispa',0,-27.0,'Cur','CPI',
07-DEC-97
```

## 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)

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 given.

#### **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**

None given.

#### **9.3.2 Calculated Variables**

None given.

### **9.4 Graphs and Plots**

None given.

## **10. Errors**

### **10.1 Sources of Error**

All known errors have been removed from the data set.

### **10.2 Quality Assessment**

Standard carbon samples were run every 12 to 24 leaf samples.

#### **10.2.1 Data Validation by Source**

None.

#### **10.2.2 Confidence Level/Accuracy Judgment**

The overall precision of the measurements of plant materials was  $\pm 0.11$  o/oo.

#### **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 given.

### **11.2 Known Problems with the Data**

All known problems have been removed.

### **11.3 Usage Guidance**

None given.

### **11.4 Other Relevant Information**

None.

## **12. Application of the Data Set**

Leaf carbon isotope data were collected to provide seasonal integrated physiological information for 10-15 common species at 6 BOREAS sites.

## **13. Future Modifications and Plans**

None.

## **14. Software**

### **14.1 Software Description**

None.

### **14.2 Software Access**

None.

## **15. Data Access**

The leaf carbon isotope 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: [ornl daac@ornl.gov](mailto:ornl daac@ornl.gov) or [ornl@eos.nasa.gov](mailto: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**

Coleman, D.C. and B. Fry (eds.). 1991. Carbon Isotope Techniques. Academic Press, Inc.

## **17.2 Journal Articles and Study Reports**

Flanagan, L.B., J.R. Brooks, and J.R. Ehleringer. 1997. Photosynthesis and carbon isotope discrimination in boreal forest ecosystems: a comparison of functional characteristics in plants from three mature forest types. *Journal of Geophysical Research* 102(D24): 28,861-28,869.

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

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

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

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

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

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

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

### **17.3 Archive/DBMS Usage Documentation**

None.

## **18. Glossary of Terms**

None.

## **19. List of Acronyms**

ASCII	- American Standard Code for Information Interchange
BOREAS	- BOReal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
CD-ROM	- Compact Disk-Read-Only Memory
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
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
PDB	- Pee Dee Belemnite
SIRFER	- Stable Isotope Ratio Facility for Ecological Research
SSA	- Southern Study Area
TE	- Terrestrial Ecology
UBS	- Upland Black Spruce
URL	- Uniform Resource Locator
UTM	- Universal Transverse Mercator

## **20. Document Information**

### **20.1 Document Revision Date**

Written: 04-May-1997

Revised: 02-Jun-1999

### **20.2 Document Review Date(s)**

BORIS Review: 11-Jun-1997

Science Review:

### **20.3 Document ID**

### **20.4 Citation**

When using these data, please contact the investigators listed in Section 2.3 as well as citations of relevant papers in Section 17.2.

If using data from the BOREAS CD-ROM series, also reference the data as:

Ehleringer, J.R. and L. Flanagan, "Vegetation-Atmosphere CO<sub>2</sub> and H<sub>2</sub>O Exchange Processes: Stable Isotope Analyses." 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**

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