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 $^{13}$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
J.R. Ehleringer
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Salt Lake City, UT 84112

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(403) 380-1858
(403) 329-2082 (fax)
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2.2 Title of Investigation
Vegetation-Atmosphere CO$_2$ and H$_2$O Exchange Processes: Stable Isotope Analyses

2.3 Contact Information

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University of South Florida
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(813) 974-3250 (dept)
(813) 974-3263 (fax)
rbrook@chuma.cas.usf.edu
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 \( \text{L3C/12C} \) are not presented as an absolute but as the relative difference between the isotope ratios of the sample and standard gases: \[ \delta^{13}C (\text{o/oo}) = \left( \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right) \times 1000 \] where \( R_{\text{sample}} \) and \( R_{\text{standard}} \) 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 \( \pm 0.11 \text{ o/oo} \).

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, \( \delta^{13}C \).
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 13C/12C 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:

- 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.
- 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

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:

<table>
<thead>
<tr>
<th>Column Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
</tr>
<tr>
<td>SUB_SITE</td>
</tr>
<tr>
<td>DATE_OBS</td>
</tr>
<tr>
<td>SPECIES</td>
</tr>
<tr>
<td>NEEDLE_AGE</td>
</tr>
<tr>
<td>DEL_13C</td>
</tr>
<tr>
<td>COMMENTS</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
</tr>
<tr>
<td>REVISION_DATE</td>
</tr>
</tbody>
</table>

7.3.2 Variable Description/Definition
The descriptions of the parameters contained in the data files on the CD-ROM are:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>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.</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>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.</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>The date on which the data were collected.</td>
</tr>
<tr>
<td>SPECIES</td>
<td>Botanical (Latin) name of the species (Genus species).</td>
</tr>
<tr>
<td>NEEDLE_AGE</td>
<td>Age of the sampled needles, (0 = current year, 1 = 1 year old, 2 = 2 years old, etc.).</td>
</tr>
<tr>
<td>DEL_13C</td>
<td>The del 13C is a relative difference between the sample and the PeeDee Belemnite standard, relative to the PeeDee Belemnite standard.</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>Descriptive information to clarify or enhance the understanding of the other entered data.</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-?? (CPI but questionable).</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>The most recent date when the information in the referenced data base table record was revised.</td>
</tr>
</tbody>
</table>
7.3.3 Unit of Measurement

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

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>[none]</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>[none]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[DD-MON-YY]</td>
</tr>
<tr>
<td>SPECIES</td>
<td>[none]</td>
</tr>
<tr>
<td>NEEDLE_AGE</td>
<td>[years]</td>
</tr>
<tr>
<td>DEL_13C</td>
<td>[per mil]</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>[none]</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>[none]</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>[DD-MON-YY]</td>
</tr>
</tbody>
</table>

7.3.4 Data Source

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

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>[BORIS Designation]</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>[BORIS Designation]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>SPECIES</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>NEEDLE_AGE</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>DEL_13C</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>[BORIS Designation]</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>[BORIS Designation]</td>
</tr>
</tbody>
</table>

7.3.5 Data Range

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

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Minimum Data Value</th>
<th>Maximum Data Value</th>
<th>Missng Data Value</th>
<th>Unrel Data Value</th>
<th>Below Data Limit</th>
<th>Not Collectd</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>NSA-9BS-9TETR</td>
<td>SSA-0JF-FLXTR</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>9TE05-LC101</td>
<td>9TE05-LC101</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>10-AUG-93</td>
<td>13-SEP-94</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Blank</td>
</tr>
<tr>
<td>SPECIES</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Blank</td>
</tr>
<tr>
<td>NEEDLE_AGE</td>
<td>0</td>
<td>9</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Blank</td>
</tr>
<tr>
<td>DEL_13C</td>
<td>-35.2</td>
<td>-23.6</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Blank</td>
</tr>
<tr>
<td>COMMENTS</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Blank</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>CPI</td>
<td>CPI</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>07-DEC-97</td>
<td>07-DEC-97</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

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 Collected** -- 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-LC101', 'JUN-94', 'Alnus crispa', 0, -26.8, 'Cur', 'CPI', 07-DEC-97 |
| NSA-90A-9TETR', '9TE05-LC101', '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 ±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: 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

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

17.2 Journal Articles and Study Reports


17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
</tr>
<tr>
<td>BOREAS</td>
<td>BOReal Ecosystem-Atmosphere Study</td>
</tr>
<tr>
<td>BORIS</td>
<td>BOREAS Information System</td>
</tr>
<tr>
<td>CD-ROM</td>
<td>Compact Disk-Read-Only Memory</td>
</tr>
<tr>
<td>DAAC</td>
<td>Distributed Active Archive Center</td>
</tr>
<tr>
<td>EOS</td>
<td>Earth Observing System</td>
</tr>
<tr>
<td>EOSDIS</td>
<td>EOS Data and Information System</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GSFC</td>
<td>Goddard Space Flight Center</td>
</tr>
<tr>
<td>HTML</td>
<td>HyperText Markup Language</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NSA</td>
<td>Northern Study Area</td>
</tr>
<tr>
<td>OA</td>
<td>Old Aspen</td>
</tr>
<tr>
<td>OBS</td>
<td>Old Black Spruce</td>
</tr>
<tr>
<td>OJP</td>
<td>Old Jack Pine</td>
</tr>
<tr>
<td>ORNL</td>
<td>Oak Ridge National Laboratory</td>
</tr>
<tr>
<td>PANP</td>
<td>Prince Albert National Park</td>
</tr>
<tr>
<td>PDB</td>
<td>Pee Dee Belemnite</td>
</tr>
<tr>
<td>SIRFER</td>
<td>Stable Isotope Ratio Facility for Ecological Research</td>
</tr>
<tr>
<td>SSA</td>
<td>Southern Study Area</td>
</tr>
<tr>
<td>TE</td>
<td>Terrestrial Ecology</td>
</tr>
<tr>
<td>UBS</td>
<td>Upland Black Spruce</td>
</tr>
<tr>
<td>URL</td>
<td>Uniform Resource Locator</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
</tbody>
</table>
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:

Also, cite the BOREAS CD-ROM set as:

20.5 Document Curator

20.6 Document URL
**Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)**

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

**Authors:**
Jim Ehleringer, J. Renee Brooks and Larry Flanagan  
Forrest G. Hall and Shelaine Curd, Editors

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Goddard Space Flight Center  
Greenbelt, Maryland 20771

**Sponsoring / Monitoring Agency Name(S) and Address (Es):**
National Aeronautics and Space Administration  
Washington, DC 20546-0001

**Supplementary Notes:**
J. Ehleringer: University of Utah, Salt Lake City; J.R. Brooks: University of South Florida, Tampa; L. Flanagan: University of Lethbridge, Lethbridge, Alberta, Canada; C. Curd: Raytheon ITSS, NASA Goddard Space Flight Center, Greenbelt, Maryland

**Abstract:**
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.

**Subject Terms:**
BOREAS, terrestrial ecology, leaf carbon isotope data.