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

Forrest G. Hall and Andrea Papagno, Editors

Volume 132
BOREAS TE-2 Root Respiration Data

Michael G. Ryan, USDA Forest Service, Fort Collins, Colorado
Michael Lavigne, Forestry Canada, Maritimes Region, Fredericton, New Brunswick, Canada

October 2000
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 includes means of tree root respiration measurements on roots having diameters ranging from 0 to 2 mm conducted in the NSA during the growing season of 1994. The data are stored in tabular ASCII files.

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1. Data Set Overview

1.1 Data Set Identification
BOREAS TE-02 Root Respiration Data

1.2 Data Set Introduction
Field studies of tree root respiration were conducted at the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) during the growing season of 1994.

1.3 Objectives/Purpose
The purposes of the work were to:
- Characterize respiration of roots 0-2 mm (fresh diameter) at the primary forested BOREAS sites in the northern and southern study areas (Old Jack Pine (OJP), Old Black Spruce (OBS), and Old Aspen (OA)) with respect to biomass and nutrient content, and determine whether respiration rates, corrected to a common temperature, differed among species and sites or varied seasonally.
- Determine if there was any relationship between fine root respiration and root nitrogen content.
or root carbohydrate content.

- Use our estimates of root respiration, Gower and Steele's estimates of root biomass (Steele et al., 1997), and soil temperature to throughout the year to estimate the annual carbon cost for fine root respiration.

1.4 Summary of Parameters

Each data record includes the mean, standard deviation, and the number of cases included in the measurement of each of the following: root respiration, soil temperature, CO₂ concentration in the chamber, nitrogen content, phosphorus content, carbon content, sugars as a percent of dry weight, starch as a percent of dry weight and total nonstructural carbohydrates.

1.5 Discussion

In the NSA, we measured fine root respiration rates for OA (Populus tremuloides), OBS (Picea mariana), and OJP (Pinus banksiana) in 1994 during June, July, and August, corresponding with the BOREAS Intensive Field Campaigns (IFCs).

1.6 Related Data Sets

- BOREAS TE-02 Wood Respiration Data
- BOREAS TE-02 Foliage Respiration Data
- BOREAS TE-02 Stem Growth and Sapwood 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:
Dr. Michael G. Ryan
USDA Forest Service
Rocky Mountain Research Station
240 West Prospect Rd.
Fort Collins, CO 80526-2098
(970) 498-1012
mryan@lamar.colostate.edu

Contact 2:
Dr. Michael Lavigne
Forestry Canada, Maritimes Region
P.O. Box 4000
Fredericton, New Brunswick E3B 5P7
Canada
3. Theory of Measurements

Respiration oxidizes sugars, producing energy, water, and CO2 and absorbing oxygen. In most plant cells, the ratio between the oxygen absorbed and CO2 produced in respiration is close to one. Therefore, because small changes in CO2 concentration in the air are easier to measure than small changes in the oxygen content of the air, respiration is typically measured as CO2 evolution from plant tissues. CO2 evolution is typically measured with an infrared gas analyzer (IRGA), operating in one of three modes: open, closed, or differential. The system that we used was a closed system, which estimates molar flux of CO2 from plant tissue respiration as the rate of increase in CO2 concentration in the chamber times the molar volume of the air inside the chamber enclosing the sample [Field et al., 1991]. Respiration rates are typically expressed as moles CO2 per kg of dry weight per second.

4. Equipment

4.1 Instrument Description

4.1.1 Collection Environment
Respiration measurements were made on intact roots in the field. All other measurements took place under laboratory conditions.

4.1.2 Source/Platform
Measurements were taken from the ground in the field and nutrient measurements were taken in the laboratory.

4.1.3 Source/Platform Mission Objectives
The objective of the platforms was to support the equipment and samples.

4.1.4 Key Variables
Root respiration, soil temperature, CO2 concentration in the chamber, nitrogen content, phosphorus content, carbon content, sugars as a percent of dry weight, starch as a percent of dry weight, and total nonstructural carbohydrates.

4.1.5 Principles of Operation
Fine root (<2 mm diameter) respiration rates were measured once during each IFC on 10-20 samples per site. Measurements were made on intact fine roots 1-5 cm below the surface of the litter. Fine roots (0.1-0.3 g) were carefully separated from the surrounding litter and soil with small brushes and water. Because CO2 concentration alters the CO2 efflux rate of fine roots [Qi et al., 1994], CO2 concentration in the cuvette was approximately that of the soil air surrounding the roots before sampling. CO2 efflux was measured using a closed system [Field et al., 1991] CID C-301 (CID, Inc., Vancouver, WA). Fine root temperature was assumed to be that of the surrounding soil, measured with a thermocouple. Temperature response was determined by measuring fine root respiration rates at
5, 15, and 25 °C with a temperature-controlled cuvette [Hubbard et al., 1995] on five samples in July at the NSA sites. Temperature response did not differ among species (p < 0.05) and the average increase of respiration with a 10 °C increase in temperature was 1.9. After the respiration measurements were taken, the sample was harvested, dried at 65 °C for 48 hours, weighed, and stored for analysis of nutrients (nitrogen and phosphorus) and nonstructural carbohydrates. Nitrogen and phosphorus were generally measured with a micro-Kjeldahl procedure [Lachat Instruments, 1992a, b]; some samples were done with a carbon-hydrogen-nitrogen analyzer (LECO CHN-1000, LECO, Inc., St. Joseph, MN). 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]. Total nonstructural carbohydrate was calculated as the sum of the soluble sugar and starch. For each sample period and site, each measurement was adjusted to a reference temperature (10 °C) using the average increase of respiration with a 10 °C increase in temperature. These temperature-corrected respiration rates were then averaged to give an estimate of respiration rate for a given site and time.

4.1.6 Sensor/Instrument Measurement Geometry
Not applicable.

4.1.7 Manufacturer of Instrument
LECO CHN-1000
LECO, Inc.
3000 Lakeview AV
St. Joseph, MN 49085
(616) 983-5531

Closed System IRGA
CID C-301
CID Inc.
4018 NE 112th Ave Suite D-8
Vancouver, WA 98682
(360) 254-7874
(360) 254-7923 (fax)

4.2 Calibration

4.2.1 Specifications
We calibrated the IRGA to a concentration standard supplied by BOREAS prior to a measurement period and every 48 hours during measurements. Typically, the analyzer drifted less than 1% between calibrations.

4.2.1.1 Tolerance
None.

4.2.2 Frequency of Calibration
We calibrated the IRGA to a concentration standard supplied by BOREAS prior to a measurement period and every 48 hours during measurements.

4.2.3 Other Calibration Information
Measurement of molar volume (moles of ideal gas in the gas circuit) depends on air pressure and circuit volume. We used standard meteorological pressure, corrected for elevation for this calculation.
5. Data Acquisition Methods

Data were taken from the IRGA, recorded in a notebook, and copied to computer files.

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: 55.92842°N, 98.62396°W, UTM Zone 14, N: 6,198,176.3, E: 523,496.2

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
We measured root respiration rates on intact roots 1 to 5 cm below the surface of the litter in 1994 during June, July, and August, corresponding with the BOREAS IFCs at NSA-OBS, NSA-OJP, and NSA-OA.

7.2.2 Temporal Coverage Map
None given.
7.2.3 **Temporal Resolution**

Measurements were made on intact fine roots located 1 to 5 cm below the surface of the litter and having a diameter range of 0 to 2 mm. The root respiration measurements took place once during each IFC on 10-20 samples per site.

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>
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<tr>
<td>SUB_SITE</td>
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<tr>
<td>START_DATE</td>
</tr>
<tr>
<td>END_DATE</td>
</tr>
<tr>
<td>SPECIES</td>
</tr>
<tr>
<td>IFC</td>
</tr>
<tr>
<td>MEAN_RESP_PER_DRY WT 10C</td>
</tr>
<tr>
<td>SDEV_RESP_PER_DRY WT 10C</td>
</tr>
<tr>
<td>NUM_OBS_RESP_PER_DRY WT 10C</td>
</tr>
<tr>
<td>MEAN_SOIL_TEMP</td>
</tr>
<tr>
<td>SDEV_SOIL_TEMP</td>
</tr>
<tr>
<td>NUM_OBS_SOIL_TEMP</td>
</tr>
<tr>
<td>MEAN_CO2_CONC_CHAMBER</td>
</tr>
<tr>
<td>SDEV_CO2_CONC_CHAMBER</td>
</tr>
<tr>
<td>NUM_OBS_CO2_CONC_CHAMBER</td>
</tr>
<tr>
<td>MEAN_NITROGEN_CONTENT</td>
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<td>SDEV_NITROGEN_CONTENT</td>
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<td>NUM_OBS_NITROGEN_CONTENT</td>
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<td>MEAN_PHOSPHOROUS_CONTENT</td>
</tr>
<tr>
<td>SDEV_PHOSPHOROUS_CONTENT</td>
</tr>
<tr>
<td>NUM_OBS_PHOSPHOROUS_CONTENT</td>
</tr>
<tr>
<td>MEAN_CARBON_CONTENT</td>
</tr>
<tr>
<td>SDEV_CARBON_CONTENT</td>
</tr>
<tr>
<td>NUM_OBS_CARBON_CONTENT</td>
</tr>
<tr>
<td>MEAN_SUGAR_CONTENT</td>
</tr>
<tr>
<td>SDEV_SUGAR_CONTENT</td>
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<tr>
<td>NUM_OBS_SUGAR_CONTENT</td>
</tr>
<tr>
<td>MEAN_STARCH_CONTENT</td>
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<tr>
<td>SDEV_STARCH_CONTENT</td>
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<tr>
<td>NUM_OBS_STARCH_CONTENT</td>
</tr>
<tr>
<td>MEAN_NONSTRUC_CARBOHYD_CONTENT</td>
</tr>
<tr>
<td>SDEV_NONSTRUC_CARBOHYD_CONTENT</td>
</tr>
<tr>
<td>NUM_OBS_NONSTRUC_CARBOHYD_CONTENT</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
</tr>
<tr>
<td>REVISION_DATE</td>
</tr>
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</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>START_DATE</td>
<td>The date on which the collection of data commenced.</td>
</tr>
<tr>
<td>END_DATE</td>
<td>The date on which the collection of the data was terminated.</td>
</tr>
<tr>
<td>SPECIES</td>
<td>Botanical (Latin) name of the species (Genus species).</td>
</tr>
<tr>
<td>IFC</td>
<td>BOREAS Intensive Field campaign sampling period.</td>
</tr>
<tr>
<td>MEAN_RESP_PER_DRY_WT_10C</td>
<td>Mean respiration of CO2 from the sample under dark conditions and at 10 degrees Celsius per unit of dried sample weight.</td>
</tr>
<tr>
<td>SDEV_RESP_PER_DRY_WT_10C</td>
<td>Standard deviation of respiration of CO2 from the sample under dark conditions and at 10 degrees Celsius per unit of dried sample weight.</td>
</tr>
<tr>
<td>NUM_OBS_RESP_PER_DRY_WT_10C</td>
<td>The number of measurements used to calculate the mean respiration of CO2 under dark conditions and at 10 degrees Celsius per unit of dried sample weight.</td>
</tr>
<tr>
<td>MEAN_SOIL_TEMP</td>
<td>The mean soil temperature.</td>
</tr>
<tr>
<td>SDEV_SOIL_TEMP</td>
<td>The standard deviation of the soil temperature.</td>
</tr>
<tr>
<td>NUM_OBS_SOIL_TEMP</td>
<td>The number of measurements used to calculate the mean soil temperature.</td>
</tr>
<tr>
<td>MEAN_CO2_CONC_CHAMBER</td>
<td>The mean CO2 concentration in the chamber.</td>
</tr>
<tr>
<td>SDEV_CO2_CONC_CHAMBER</td>
<td>The standard deviation of the CO2 concentration in the chamber.</td>
</tr>
<tr>
<td>NUM_OBS_CO2_CONC_CHAMBER</td>
<td>The number of measurements used to calculate the mean of the CO2 concentration in the chamber.</td>
</tr>
<tr>
<td>MEAN_NITROGEN_CONTENT</td>
<td>The mean nitrogen content of the sample based on dried sample weight.</td>
</tr>
<tr>
<td>SDEV_NITROGEN_CONTENT</td>
<td>The standard deviation of the nitrogen content.</td>
</tr>
<tr>
<td>NUM_OBS_NITROGEN_CONTENT</td>
<td>The number of measurements used to calculate the mean of the nitrogen content.</td>
</tr>
<tr>
<td>MEAN_PHOSPHOROUS_CONTENT</td>
<td>The mean phosphorous content based on dried sample weight.</td>
</tr>
<tr>
<td>SDEV_PHOSPHOROUS_CONTENT</td>
<td>The standard deviation of the phosphorous content.</td>
</tr>
<tr>
<td>NUM_OBS_PHOSPHOROUS_CONTENT</td>
<td>The number of measurements used to calculate the mean of the phosphorous content.</td>
</tr>
<tr>
<td>MEANCarbon_CONTENT</td>
<td>The mean carbon content based on dried sample weight.</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:

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<td>START_DATE</td>
<td>[DD-MON-YY]</td>
</tr>
<tr>
<td>END_DATE</td>
<td>[DD-MON-YY]</td>
</tr>
<tr>
<td>SPECIES</td>
<td>[none]</td>
</tr>
<tr>
<td>IFC</td>
<td>[none]</td>
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<tr>
<td>MEAN_RESP_PER_DRY_WT_10C</td>
<td>[nanomoles][gram^-1][second^-1]</td>
</tr>
<tr>
<td>SDEV_RESP_PER_DRY_WT_10C</td>
<td>[nanomoles][gram^-1][second^-1]</td>
</tr>
<tr>
<td>NUM_OBS_RESP_PER_DRY_WT_10C</td>
<td>[count]</td>
</tr>
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<td>MEAN_SOIL_TEMP</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>SDEV_SOIL_TEMP</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>NUM_OBS_SOIL_TEMP</td>
<td>[count]</td>
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<tr>
<td>MEAN_CO2_CONC_CHAMBER</td>
<td>[parts per million]</td>
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<tr>
<td>SDEV_CO2_CONC_CHAMBER</td>
<td>[parts per million]</td>
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<tr>
<td>NUM_OBS_CO2_CONC_CHAMBER</td>
<td>[count]</td>
</tr>
<tr>
<td>MEAN_NITROGEN_CONTENT</td>
<td>[percent]</td>
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<tr>
<td>SDEV_NITROGEN_CONTENT</td>
<td>[percent]</td>
</tr>
<tr>
<td>NUM_OBS_NITROGEN_CONTENT</td>
<td>[count]</td>
</tr>
<tr>
<td>MEAN_PHOSPHOROUS_CONTENT</td>
<td>[percent]</td>
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<tr>
<td>SDEV_PHOSPHOROUS_CONTENT</td>
<td>[percent]</td>
</tr>
<tr>
<td>NUM_OBS_PHOSPHOROUS_CONTENT</td>
<td>[count]</td>
</tr>
<tr>
<td>MEAN_CARBOHYD_CONTENT</td>
<td>[percent]</td>
</tr>
<tr>
<td>MEAN_NONSTRUC_CARBOHYD_CONTENT</td>
<td>The mean total non-structural carbohydrates content based on dried sample weight.</td>
</tr>
<tr>
<td>SDEV_NONSTRUC_CARBOHYD_CONTENT</td>
<td>The standard deviation of the total non-structural carbohydrates content.</td>
</tr>
<tr>
<td>NUM_OBS_NSTRUC_CARBOHYD_CONTENT</td>
<td>The number of cases included in the mean total non-structural carbohydrates content.</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>
SDEV CARBON CONTENT [percent]
NUM_OBS_CARBNCONTENT [count]
MEAN SUGAR CONTENT [percent]
SDEV SUGAR CONTENT [percent]
NUM_OBS_SUGAR_CONTENT [count]
MEAN STARCH CONTENT [percent]
SDEV STARCH CONTENT [percent]
NUM_OBS_STARCH_CONTENT [count]
MEAN_NONSTRUC CARBOHYD CONTENT [percent]
SDEV_NONSTRUC CARBOHYD CONTENT [percent]
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7.3.4 Data Source

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

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<tr>
<td>END_DATE</td>
<td>[Human Observer]</td>
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<tr>
<td>SPECIES</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>IFC</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>MEAN_RESP_PER_DRY_WT_10C</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>SDEV_RESP_PER_DRY_WT_10C</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>NUM_OBS_RESP_PER_DRY_WT_10C</td>
<td>[Human Observer]</td>
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<tr>
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<tr>
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<tr>
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<td>[Human Observer]</td>
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<tr>
<td>MEAN_CO2_CONC_CHAMBER</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>SDEV_CO2_CONC_CHAMBER</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>NUM_OBS_CO2_CONC_CHAMBER</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>MEAN_NITROGEN CONTENT</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>SDEV_NITROGEN CONTENT</td>
<td>[Laboratory Equipment]</td>
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<tr>
<td>NUM_OBS_NITROGEN_CONTENT</td>
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<tr>
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<td>SDEV_PHOSPHOROUS_CONTENT</td>
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<tr>
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<tr>
<td>SDEV CARBON CONTENT</td>
<td>[Laboratory Equipment]</td>
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<tr>
<td>NUM_OBS_CARBNCONTENT</td>
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<td>[Human Observer]</td>
</tr>
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<td>[Laboratory Equipment]</td>
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<td>SDEV STARCH CONTENT</td>
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<td>NUM_OBS_STARCH_CONTENT</td>
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<tr>
<td>MEAN_NONSTRUC CARBOHYD CONTENT</td>
<td>[Laboratory Equipment]</td>
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### 7.3.5 Data Range
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### 7.4 Sample Data Record

The following are wrapped versions of data record from a sample data file on the CD-ROM. The data includes various parameters such as mean response per dry wt 10C, standard deviation response per dry wt 10C, number of observations for response per dry wt 10C, mean soil temperature, standard deviation soil temperature, number of observations for soil temperature, mean CO2 concentration in chamber, standard deviation CO2 concentration in chamber, number of observations for CO2 concentration in chamber, mean nitrogen content, standard deviation nitrogen content, number of observations for nitrogen content, mean phosphorus content, standard deviation phosphorus content, number of observations for phosphorus content, mean carbon content, standard deviation carbon content, number of observations for carbon content, mean sugar content, standard deviation sugar content, number of observations for sugar content, mean starch content, standard deviation starch content, number of observations for starch content, mean nonstructural carbohydrate content, standard deviation nonstructural carbohydrate content, number of observations for nonstructural carbohydrate content, and the method code.

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</table>
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
The gas analyzer gives a CO₂ concentration. We calculated flux (μmol/s) as:

\[ \text{CO}_2 \text{ concentration change (μmol/s/mol)} \times \text{volume (mol)} \]

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
Variability of the samples is estimated with the standard deviation of the mean. CO₂ concentration can have a large influence on the rate of respiration. However, it is difficult to determine the exact CO₂ concentration of the root in its natural environment. Therefore, one of the largest potential sources of error is this unknown CO₂ concentration. We estimated the CO₂ concentration of the root in its natural environment by sampling the CO₂ in the soil pore space. Another potential source of error is the effect of disturbance (from removing the root from its natural environment) on respiration rate or apparent respiration rate. We detected no significant difference in respiration rate from roots in situ and roots that had been severed. However, the effect of removing the very fine roots and associated mycorrhizae on respiration rates of fine roots is unknown.

10.2 Quality Assessment
Flux rates of CO₂, nitrogen and phosphorus concentrations, starch and sugar content, and dry weight are likely estimated for the sample within +/- 5 percent. The largest unknowns are the effect of soil CO₂ concentration and the impact of disturbance on apparent respiration rates.

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 fine root respiration rates 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 root respiration 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


17.3 Archive/DBMS Usage Documentation
None.

18. Glossary of Terms

None.

19. List of Acronyms

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<th>Description</th>
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<td>Analytical Development Company</td>
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<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
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<td>BOReal Ecosystem-Atmosphere Study</td>
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20. Document Information

20.1 Document Revision Date
Written: 10-Sep-1998
Last Updated: 17-Aug-1999

20.2 Document Review Date(s)
BORIS Review: 10-Sep-1998
Science Review:

20.3 Document ID

20.4 Citation
When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:
Dr. Michael G. Ryan, USDA Forest Service, Rocky Mountain Research Station, and Dr. Michael Lavigne, Forestry Canada, Maritimes Region

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
**Abstract**

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 includes means of tree root respiration measurements on roots having diameters ranging from 0 to 2 mm conducted in the NSA during the growing season of 1994. The data are stored in tabular ASCII files.