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

Forrest G. Hall and Shelaine Curd, Editors

Volume 166

BOREAS TE-12 Leaf Gas Exchange Data

Timothy J. Arkebauer and Litao Yang
University of Nebraska-Lincoln

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000
BOREAS TE-12 Leaf Gas Exchange Data

Timothy J. Arkebauer, Litao Yang

Summary

The BOREAS TE-12 team collected several data sets in support of its efforts to characterize and interpret information on the reflectance, transmittance, and gas exchange of boreal vegetation. This data set contains measurements of leaf gas exchange conducted in the SSA during the growing seasons of 1994 and 1995 using a portable gas exchange system. The data are stored in tabular ASCII files.

Table of Contents

1) Data Set Overview
2) Investigator(s)
3) Theory of Measurements
4) Equipment
5) Data Acquisition Methods
6) Observations
7) Data Description
8) Data Organization
9) Data Manipulations
10) Errors
11) Notes
12) Application of the Data Set
13) Future Modifications and Plans
14) Software
15) Data Access
16) Output Products and Availability
17) References
18) Glossary of Terms
19) List of Acronyms
20) Document Information

1. Data Set Overview

1.1 Data Set Identification
BOREAS TE-12 Leaf Gas Exchange Data

1.2 Data Set Introduction
Field studies of single leaf gas exchange properties of dominant vascular plant species were conducted at the BOREal Ecosystem-Atmosphere Study (BOREALS) Southern Study Area (SSA) in 1994 and 1995 using a portable gas exchange system.

1.3 Objective/Purpose
The purposes of the work were to:
• Quantify the response of leaf gas exchange properties (e.g., net CO₂ assimilation rate and stomatal conductance) to environmental conditions in the field.
• Determine diurnal and seasonal changes in leaf gas exchange properties.
1.4 Summary of Parameters
Each data record includes the date and time of measurements, leaf properties (species, leaf area, boundary layer conductance, leaf temperature, net CO₂ assimilation rate, stomatal conductance, internal CO₂ concentration), and environmental conditions (Photosynthetic Photon Flux Density (PPFD), air temperature, CO₂ concentration, relative humidity, air vapor pressure).

1.5 Discussion
The overall project goal was to investigate the interactions between single leaf (or shoot) gas exchange properties and leaf (or shoot) optical properties. Leaf-level gas exchange measurements were made in the field on the dominant broadleaf and coniferous woody plant species growing in the SSA. The primary focus was on Populus tremuloides (aspen) at the SSA Young Aspen (YA) site and Pinus banksiana (jack pine) at the SSA Young Jack Pine (YJP) site. Measurements were also obtained from Picea mariana (black spruce) at the SSA Old Black Spruce (OBS) site, old Populus tremuloides (old aspen) and Picea glauca (white spruce) at the SSA Mixed site (MIX), old aspen and Corylus cornuta Marsh (hazelnut) from the SSA Old Aspen (OA) site, and hazelnut and Populus balsamifera (balsam-poplar) from the SSA-YA site.

1.6 Related Data Sets
BOREAS TE-04 Gas Exchange Data from Boreal Tree Species
BOREAS TE-05 Leaf Gas Exchange Data
BOREAS TE-12 Leaf Optical Data for SSA Species
BOREAS TE-12 SSA Water Potential Data
BOREAS TE-12 SSA Shoot Geometry Data

2. Investigator(s)

2.1 Investigator(s) Name and Title
Dr. Timothy J. Arkebauer, Associate Professor

2.2 Title of Investigation
Radiation and Gas Exchange of Canopy Elements in a Boreal Forest

2.3 Contact Information

Contact 1:
Dr. Timothy J. Arkebauer
Department of Agronomy
106 KCR Building
University of Nebraska
Lincoln, NE 68583-0817
USA
(402) 472-2847

Contact 2:
Shelaine Curd
Raytheon ITSS
NASA GSFC
Code 923
Greenbelt, MD 20771
(301) 286-2447
(301) 286-0239 (fax)
shelaine.curd@gsfc.nasa.gov
3. Theory of Measurements

Gas exchange measurements were made using an LI-6200 CO₂ Infrared Gas Analyzer (IRGA) system in the closed-circuit mode. The net CO₂ assimilation rate is calculated via the change in CO₂ concentration in the sample chamber with time. Stomatal conductance is calculated from the rate of change of water vapor concentration with time, the fraction of the total system flow through the desiccant, and the (previously determined) boundary layer conductance of the leaf. Further details can be found in the LI-6200 Technical Reference Manual (LI-COR, Inc., 1990).

Internal CO₂ concentrations of the leaves were calculated based on the measured net CO₂ assimilation rates and leaf conductances. Additional information on the theory related to leaf gas exchange measurements can be found in Ball (1987).

4. Equipment

4.1 Instrument Description

4.1.1 Collection Environment

All gas exchange measurements were made on intact plants in the field at the various SSA sites mentioned in Section 1.5.

4.1.2 Source/Platform

In most cases, measurements were made from the ground. At the SSA-OA, SSA-MIX, and SSA-OBS sites, measurements were made at the top of the Terrestrial Ecology (TE) scaffold towers.

4.1.3 Source/Platform Mission Objectives

Not applicable.

4.1.4 Key Variables

Leaf properties: net CO₂ assimilation rate, stomatal conductance, internal CO₂ concentration, leaf temperature. Environmental conditions: air temperature, air vapor pressure, incident PPFD, air CO₂ concentration.

4.1.5 Principles of Operation

Measurements were made with an LI-6200 Portable Photosynthesis System operated in the closed mode. Net CO₂ assimilation rate was determined from the time rate of change of CO₂ concentration in the sample chamber. Stomatal conductance was determined from the time rate of change of water vapor concentration in the chamber, in conjunction with the fraction of the system flow diverted through the desiccant and the (previously determined) leaf boundary layer conductance. CO₂ concentrations are measured with an IRGA. A pump circulates the air from the sample chamber, through the analyzer, and back into the sample chamber. Water vapor concentrations in the sample chamber are determined by a Vaisala humidity chip and a thermistor sensing the air temperature. Leaf temperatures are
determined by a thermocouple pair that measures the temperature difference between the air thermistor and a thermocouple appressed to the leaf. Additional information is found in the LI-COR LI-6200 Technical Reference Manual.

4.1.6 Sensor/Instrument Measurement Geometry
None.

4.1.7 Manufacturer of Instrument
LI-6200 CO2 Gas IRGA
LI-COR, Inc.
P.O. Box 4425
4421 Superior Street
Lincoln, NE 68504 USA
(402) 467-3576
(402) 467-2819 (fax)

4.2 Calibration

4.2.1 Specifications
The IRGAs, the humidity chips, the flow meters, and the quantum sensors were calibrated by the manufacturer prior to each field season. The zero and span of the LI-6200 CO2 analyzer were calibrated against known standard gases in the field.

4.2.1.1 Tolerance
None.

4.2.2 Frequency of Calibration
Annual calibration of the IRGAs, the humidity chips, the flow meters, and the quantum sensors was done by the manufacturer. Daily calibration of the zero and span of the IRGAs was performed in the field. The CO2 zero and the flow meter zero were checked and adjusted several times daily.

4.2.3 Other Calibration Information
Calibration gases for the IRGAs were obtained from Acklands, 1042 Quebec Ave., Saskatoon, Saskatchewan CANADA, S7K 1V5 (Primary supplier: Linde Gas, Alberta, CANADA). These gases were calibrated against gases of known concentration traceable to the National Oceanic and Atmospheric Administration (NOAA), Boulder, CO.

5. Data Acquisition Methods

Samples from the coniferous species (e.g., Pinus banksiana, Picea mariana) were excised immediately after gas exchange measurements for leaf area determination. Leaf areas (i.e., surface areas of the needles enclosed in the gas exchange cuvette) were determined at the Paddockwood School Laboratory in the evening following the daily field work.

A positive net CO2 assimilation rate (e.g., photosynthesis) means that the net flux of CO2 is into the leaf. A negative net CO2 assimilation rate (e.g., respiration) indicates that the net flux of CO2 is out of the leaf.

Measurements of leaves from the broadleaf species (Populus tremuloides, Populus balsamifera, and Corylus cornuta) were made by enclosing entire leaves, or portions thereof, inside the sample cuvette. Small shoots of the coniferous species (Pinus banksiana, Picea mariana, Picea glauca), consisting of a number of needles, were placed into the sample cuvette for gas exchange determination. The coniferous samples consisted of needles from one age class only. The other age class needles were either excluded from the cuvette or were clipped off from the branch.
The LI-6200 measurements were made with either a 0.25-liter or a 1-liter sample chamber. Most measurements were made under natural illumination (sunlight); however, a limited number of measurements were made with an incandescent light source in conjunction with a dichroic mirror. Leaves to be measured were placed in the sample chamber without altering their original orientation. The sample chamber was held with a tripod standing on the soil (or scaffold) surface. Light response curves were usually made by attenuating natural illumination with neutral density filters. Respiration rates were determined after enclosing leaves in an opaque film-changing bag.

Assimilation rate versus internal CO2 concentration responses were determined using a transient technique. The net CO2 assimilation rate and the internal CO2 concentrations for these studies were corrected for chamber leaks, and an external fan was used to moderate chamber temperatures (for details see McDermitt et al., 1989).

Leaf areas for the broadleaf species were determined by tracing the leaf outline on ruled graph paper. Leaf areas for the coniferous species were determined by the volume displacement method. Shoots were submerged in a water-filled container (containing 3-5% detergent in order to wet all surfaces) and the volume of water they displaced was recorded. The displaced volume was proportional to the total surface area of the shoot (see below). All gas exchange values are expressed on half the total surface area of the sample (for the broadleaf species this is the area projected normal to the leaf surface).

6. Observations

6.1 Data Notes
None.

6.2 Field Notes
A limited set of field notes and observations is available by request from T.J. Arkebauer.

7. Data Description

7.1 Spatial Characteristics

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

- SSA-YA canopy access tower, site id D0H4T, Lat/Long: 53.65601°N, 105.32314°W, Universal Transverse Mercator (UTM) Zone 13, N:5,945,298.9, E:478,644.1
- SSA-OA canopy access tower located 100 m up the path to the flux tower site, site id C3B7T, Lat/Long: 53.62889°N, 106.19779°W, UTM Zone 13, N:5,942,899.9 E:420,790.5
- SSA-OBS canopy access tower located at flux tower site, site id G8I4T, Lat/Long: 53.98717°N, 105.11779°W, UTM Zone 13, N:5,982,100.5 E:492,276.5
- SSA-MIX canopy access tower, site id D9I1M, Lat/Long: 53.7254°N, 105.20643°W, UTM Zone 13, N:5,952,989.7 E:486,379.7
- SSA-YJP near flux tower site, site id F8L6T, Lat/Long: 53.87581°N, 104.64529°W, UTM Zone 13, N:5,969,762.5 E:523,320.2

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
Measurements were made from 29-May-1994 through 08-Sep-1994 and from 01-Jul-1995 through 07-Aug-1995. For each species and each year, data are arranged chronologically in the data file.

7.2.2 Temporal Coverage Map
None given.

7.2.3 Temporal Resolution
Multiple measurements were made at the SSA-YA, SSA-OA, SSA-OBS, SSA-MIX, and SSA-YJP sites on several days per month from 29-May-1994 through 08-Sep-1994 and from 01-Jul-1995 through 07-Aug-1995.

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
TIME_OBS
SPECIES
SAMPLE_GROWTH_YEAR
SAMPLE_ID
DOWN_PPFD
LEAF_TEMP
AIR_TEMP_CHAMBER
CO2_CONC_CHAMBER
AIR_FLOW_CHAMBER
REL_HUM_CHAMBER
VAPOR_PRESS_CHAMBER
BOUND_LAYER_MOLAR_CONDUCT_H2O
LEAF_AREA
PHOTOSYNTHETIC_RATE
STOMATAL_MOLAR_CONDUCT_H2O
INTERCELL_CO2_CONC
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:

<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>TIME_OBS</td>
<td>The Greenwich Mean Time (GMT) when the data were collected.</td>
</tr>
<tr>
<td>SPECIES</td>
<td>Botanical (Latin) name of the species (Genus species).</td>
</tr>
<tr>
<td>SAMPLE_GROWTH_YEAR</td>
<td>The year in which the collected sample first grew.</td>
</tr>
<tr>
<td>SAMPLE_ID</td>
<td>The sample identifier used by data collectors (see documentation for a detailed description).</td>
</tr>
<tr>
<td>DOWN_PPFD</td>
<td>The downward photosynthetic photon flux density.</td>
</tr>
<tr>
<td>LEAF_TEMP</td>
<td>The leaf or shoot temperature.</td>
</tr>
<tr>
<td>AIR_TEMP_CHAMBER</td>
<td>The temperature of the air in the chamber.</td>
</tr>
<tr>
<td>CO2_CONC_CHAMBER</td>
<td>The CO2 concentration in the chamber.</td>
</tr>
<tr>
<td>AIR_FLOW_CHAMBER</td>
<td>The total air flow rate through the system.</td>
</tr>
<tr>
<td>REL_HUM_CHAMBER</td>
<td>The relative humidity of the air in the chamber.</td>
</tr>
<tr>
<td>VAPOR_PRESS_CHAMBER</td>
<td>Vapor pressure of the air in the chamber.</td>
</tr>
<tr>
<td>BOUND_LAYER_MOLAR_CONDUCT_H2O</td>
<td>The boundary layer conductance for water vapor of the sample.</td>
</tr>
<tr>
<td>LEAF_AREA</td>
<td>The area of the leaf (or needles) enclosed in the chamber, this value is always half the total surface area of the sample.</td>
</tr>
<tr>
<td>PHOTOSYNTHETIC_RATE</td>
<td>Measured Net Photosynthesis</td>
</tr>
<tr>
<td>STOMATAL_MOLAR_CONDUCT_H2O</td>
<td>Stomatal conductance of water vapor.</td>
</tr>
<tr>
<td>INTERCELL_CO2_CONC</td>
<td>Intercellular CO2 concentration</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>TIME_OBS</td>
<td>[HHMM GMT]</td>
</tr>
<tr>
<td>SPECIES</td>
<td>[none]</td>
</tr>
<tr>
<td>SAMPLE_GROWTH_YEAR</td>
<td>[unitless]</td>
</tr>
<tr>
<td>SAMPLE_ID</td>
<td>[none]</td>
</tr>
<tr>
<td>DOWN_PPFD</td>
<td>[micromoles][meter^-2][second^-1]</td>
</tr>
<tr>
<td>LEAF_TEMP</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>AIR_TEMP_CHAMBER</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>CO2_CONC_CHAMBER</td>
<td>[parts per million]</td>
</tr>
<tr>
<td>AIR_FLOW_CHAMBER</td>
<td>[micromoles][second^-1]</td>
</tr>
<tr>
<td>REL_HUM_CHAMBER</td>
<td>[percent]</td>
</tr>
<tr>
<td>VAPOR_PRESS_CHAMBER</td>
<td>[millibars]</td>
</tr>
<tr>
<td>BOUND_LAYER_MOLAR_CONDUCT_H2O</td>
<td>[mole H2O][meter^-2][second^-1]</td>
</tr>
<tr>
<td>LEAF_AREA</td>
<td>[millimeter^2]</td>
</tr>
<tr>
<td>PHOTOSYNTHETIC_RATE</td>
<td>[micromoles CO2][meter^-2][second^-1]</td>
</tr>
<tr>
<td>STOMATAL_MOLAR_CONDUCT_H2O</td>
<td>[millimoles H2O][meter^-2][second^-1]</td>
</tr>
<tr>
<td>INTERCELL_CO2_CONC</td>
<td>[parts per million]</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>TIME_OBS</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>SPECIES</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>SAMPLE_GROWTH_YEAR</td>
<td>[Human Observer]</td>
</tr>
<tr>
<td>SAMPLE_ID</td>
<td>[Field Equipment]</td>
</tr>
<tr>
<td>DOWN_PPFD</td>
<td>[Thermometer]</td>
</tr>
<tr>
<td>LEAF_TEMP</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>AIR_TEMP_CHAMBER</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>CO2_CONC_CHAMBER</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>AIR_FLOW_CHAMBER</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>REL_HUM_CHAMBER</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>VAPOR_PRESS_CHAMBER</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>BOUND_LAYER_MOLAR_CONDUCT_H2O</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>LEAF_AREA</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>PHOTOSYNTHETIC_RATE</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>STOMATAL_MOLAR_CONDUCT_H2O</td>
<td>[Laboratory Equipment]</td>
</tr>
<tr>
<td>INTERCELL_CO2_CONC</td>
<td>[BORIS Designation]</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>[BORIS Designation]</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td></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>Missing Data Value</th>
<th>Unrel Data Value</th>
<th>Below Data Detect Limit</th>
<th>Data Not Cllctd</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>SSA-9OA-FLXTR</td>
<td>SSA-YJP-FLXTR</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>9TE12-LGS01</td>
<td>9TE12-LGS01</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>29-MAY-94</td>
<td>07-AUG-95</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>515</td>
<td>2010</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SPECIES</td>
<td>SSA-9OA-FLXTR</td>
<td>SSA-YJP-FLXTR</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SAMPLE_GROWTH_YEAR</td>
<td>9TE12-LGS01</td>
<td>9TE12-LGS01</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>29-MAY-94</td>
<td>07-AUG-95</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>515</td>
<td>2010</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SPECIES</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SAMPLE_ID</td>
<td>1</td>
<td>9</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DOWN_PPFD</td>
<td>-2.232</td>
<td>3998</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>LEAF_TEMP</td>
<td>3.846</td>
<td>42.62</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>AIR_TEMP_CHAMBER</td>
<td>3.8</td>
<td>41.47</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Blank</td>
</tr>
<tr>
<td>CO2_CONC_CHAMBER</td>
<td>46.32</td>
<td>899.5</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>AIR_FLOW_CHAMBER</td>
<td>11.69</td>
<td>90.73</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>REL_HUM_CHAMBER</td>
<td>1.326</td>
<td>60.25</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>VAPOR_PRESS_CHAMBER</td>
<td>4.417</td>
<td>44.69</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>BOUND_LAYER_MOLAR_H2O</td>
<td>1.4</td>
<td>9.99</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CONDUCT_H2O</td>
<td>1.74</td>
<td>39.84</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>PHOTOSYNTHETIC_RATE</td>
<td>-39.59</td>
<td>31.53</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>STOMATAL_MOLAR_H2O</td>
<td>-.15</td>
<td>3.46</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>INTERCELL_CO2_CONC</td>
<td>-3983</td>
<td>7427</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</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>24-NOV-97</td>
<td>24-NOV-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.

#### Missing 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.

Page 9
7.4 Sample Data Record
The following are wrapped versions of data recordS from a sample data file on the CD-ROM.

<table>
<thead>
<tr>
<th>SITE_NAME</th>
<th>SUB_SITE</th>
<th>DATE_OBS</th>
<th>TIME_OBS</th>
<th>SPECIES</th>
<th>SAMPLE_GROWTH_YEAR</th>
<th>SAMPLE_ID</th>
<th>DOWN_PPFD</th>
<th>LEAF_TEMP</th>
<th>AIR_TEMP_CHAMBER</th>
<th>CO2_CONC_CHAMBER</th>
<th>AIR_FLOW_CHAMBER</th>
<th>REL_HUM_CHAMBER</th>
<th>VAPOR_PRESS_CHAMBER</th>
<th>BOUND_LAYER_MOLAR_CONDUCT_H2O</th>
<th>LEAF_AREA</th>
<th>PHOTOSYNTHETIC_RATE</th>
<th>STOMATAL_MOLAR_CONDUCT_H2O</th>
<th>INTERCELL_C02_CONC</th>
<th>CRTFCN_CODE</th>
<th>REVISION_DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>'SSA-9OA-FLXTR', '9TE12-LGS01', 06-JUN-94, 1228, 'Populus tremuloides', '1994', '1', 1962.0, 27.05, 25.61, 328.4, 17.84, 15.0, 1.965, 17.81, 6.88, 'CPI', 24-NOV-97</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</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

11. Notes

11.1 Limitations of the Data
None given.

11.2 Known Problems with the Data
Other than the few times measurements were made on moist leaves (as discussed above), there are no known problems with the data set.

11.3 Usage Guidance
The normal caveat of 'use at your own risk' applies. Correspondence with T.J. Arkebauer is encouraged when questions arise.

11.4 Other Relevant Information
Ms. Litao Yang was responsible for most of the day-to-day coordination of the field measurements. Mr. Runsheng Xu assisted with field data collection in 1994. Their assistance was greatly appreciated.

12. Application of the Data Set
These data can be used to study the gas exchange of boreal vegetation.

13. Future Modifications and Plans
None given.
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


The BOREAS TE-12 team collected several data sets in support of its efforts to characterize and interpret information on the reflectance, transmittance, and gas exchange of boreal vegetation. This data set contains measurements of leaf gas exchange conducted in the SSA during the growing seasons of 1994 and 1995 using a portable gas exchange system. The data are stored in tabular ASCII files.