NASA/TM—2000–209891, Vol. 144

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

Forrest G. Hall and Shelaine Curd, Editors

Volume 144

BOREAS TE-6 Predawn Leaf Water Potentials and Foliage Moisture Contents

J.G. Vogel

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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BOREAS TE-6 Predawn Leaf Water Potentials and Foliage Moisture Contents

Jason G. Vogel

Summary

The BOREAS TE-6 team collected several data sets to examine the influence of vegetation, climate, and their interactions on the major carbon fluxes for boreal forest species. This data set contains summaries of predawn leaf water potentials and foliage moisture contents collected at the TF and CEV sites that had canopy access towers. The data were collected on a nearly weekly basis from early June to late August 1994 by TE-6, members of the BOREAS staff, and employees of Environment Canada. The data are provided in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-06 Predawn Leaf Water Potentials and Foliage Moisture Contents

1.2 Data Set Introduction

The data referenced in this documentation are summaries of predawn leaf water potentials (LWPs) and foliage moisture contents collected at the BOReal Ecosystem-Atmosphere Study (BOREAS) Tower Flux (TF) and Carbon Evaluation (CEV) sites that had canopy access towers. In the Northern Study Area (NSA), data were collected from the Upland Black Spruce (UBS), Old Aspen (OA), Old Black Spruce (OBS), Old Jack Pine (OJP), and Young Jack Pine (YJP) sites. In the Southern Study Area (SSA), data were collected from the OA, Young Aspen (YA), Mixed Stand (MIX), OBS, OJP, and YJP sites. The data were collected on a nearly weekly basis from early June to late August 1994. This data set provides an assessment of the water status of key tree species at sites where physiological measurements were being made.

1.3 Objective/Purpose

The objective of this study was to provide an assessment of the water status of key tree species at sites where physiological measurements were being made.

1.4 Summary of Parameters

Predawn LWP and foliage moisture content.

1.5 Discussion

Predawn LWP has long been assumed to be a good indicator of the hydrological status of trees. Essentially, the matric potential of tree foliage is assumed to come into equilibrium with the matric potential of the soil over the course of an evening. An increase or decrease in the matric potential of the soil reflects an increase or decrease in available water for plant transpiration. This equilibrium between the soil and foliage matric potentials may also be reflected in the foliage moisture content.

1.6 Related Data Sets

BOREAS TE-06 1996 Soil and Air Temperatures in the NSA
BOREAS TE-06 Allometry Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Tom Gower, Professor
University of Wisconsin-Madison

2.2 Title of Investigation

Predawn Leaf Water Potentials and Foliage Moisture Contents in Boreal Forest Trees

2.3 Contact Information

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(301) 286-0239 (fax)
shelaine.curd@gsfc.nasa.gov

3. Theory of Measurements

Predawn LWP has long been assumed to be a good indicator of the hydrological status of trees. Essentially, the matric potential of tree foliage is assumed to come into equilibrium with the matric potential of the soil over the course of an evening. An increase or decrease in the matric potential of the soil reflects an increase or decrease in available water for plant transpiration. This equilibrium between the soil and foliage matric potentials may also be reflected in the foliage moisture content. The foliar matric potential is measured by determining the pressure required to remove water from the foliage of a small foliated twig that has been removed from the upper portion of the tree.

4. Equipment

4.1 Sensor/Instrument Description

Shotgun (12 gauge), pressure bomb.

4.1.1 Collection Environment

The measurements were taken under various climatic conditions on the given sampling days. Measurements were not made during evenings that had experienced a substantial rain event because this may cause a re-equilibration of the trees with the soil that would not be captured by a single predawn measurement.

4.1.2 Source/Platform

All samples were collected from canopy access towers or the ground.

4.1.3 Source/Platform Mission Objectives

Not applicable.

4.1.4 Key Variables

Not applicable.

4.1.5 Principles of Operation

The sample foliage is secured in an airtight chamber that is attached to a pressure gauge and a gas source. The pressure in the chamber is increased while the pressure gauge and the foliage tip are being watched. When water/sap begins to "ooze" from the foliage, it is considered to be at equilibrium with pressure in the chamber, and this pressure is recorded as the predawn LWP.

4.1.6 Sensor/Instrument Measurement Geometry

Not applicable.

4.1.7 Manufacturer of Sensor/Instrument
Pressure Bomb
PMS Instruments Inc.
2750 NW Royal Oaks Dr.
Corvallis, OR 97330
(503) 752-7926

4.2 Calibration

4.2.1 Specifications
None given.

4.2.1.1 Tolerance
None given.

4.2.2 Frequency of Calibration
None given.

4.2.3 Other Calibration Information
None given.

5. Data Acquisition Methods

A foliage sample was shot down from the southfacing upper one-third of a canopy in the early morning hours before sunrise. The sample foliage was secured in an airtight chamber that was attached to a pressure gauge and a gas source. The pressure in the chamber was increased while the gauge and the tip of the foliage were being watched. When water/sap began to ooze from the foliage, it was considered to be at equilibrium with pressure in the chamber, and this pressure was recorded as the predawn LWP.

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
Foliage samples were collected as close to the tower as possible, but generally at least 50 m from the tower to ensure that no stray shotgun BBs interfered with instruments or sleepy researchers operating on the towers. The North American Datum of 1983 (NAD83) coordinates of the sites are:

SITE	LATITUDE	LONGITUDE
NSA-UBS	55.90802° N	98.51865° W
NSA-OA	55.88691° N	98.67479° W
NSA-OBS	55.88007° N	98.48139° W
NSA-OJP	55.92842° N	98.62396° W
NSA-OJP	55.92842° N	98.62396° W
NSA-YJP	55.89575° N	98.28706° W
SSA-OA	53.62889° N	106.19779° W
SSA-YA	53.65601° N	105.32314° W
SSA-MIX	53.7254 ° N	105.20643° W
SSA-OBS	53.98717° N	105.11779° W
SSA-OJP	53.91634° N	104.69203° W
SSA-YJP	53.87581° N	104.64529° W

7.1.2 Spatial Coverage Map
Not available.

7.1.3 Spatial Resolution
The data represent point source measurements from the sample locations.

7.1.4 Projection
Not applicable.

7.1.5 Grid Description
Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
The measurements began in mid-June and continued approximately weekly through the summer until late August and early September of 1994. Start and end times varied between the SSA and NSA. Specific dates are included in the data set.

7.2.2 Temporal Coverage Map
Not available.

7.2.3 Temporal Resolution
We attempted to make the measurements within 10 days of one another in order to make possible some degree of interpolation.

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
NUM_OBS
MEAN_WATER_POTENTIAL

SDEV_WATER_POTENTIAL
MEAN_FOLIAGE_MOISTURE
SDEV_FOLIAGE_MOISTURE
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-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.
DATE_OBS	The date on which the data were collected.
SPECIES	Botanical (Latin) name of the species (Genus species).
NUM_OBS	Number of observations of the given sample used to calculate given measurements.
MEAN_WATER_POTENTIAL	The mean water potential.
SDEV_WATER_POTENTIAL	The standard deviation of the water potential.
MEAN_FOLIAGE_MOISTURE	The mean foliage moisture content, calculated as the ratio (wet weight-dry weight)/dry weight.
SDEV_FOLIAGE_MOISTURE	The standard deviation of the foliage moisture content.
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]
NUM_OBS	[counts]
MEAN_WATER_POTENTIAL	[megaPascals]
SDEV_WATER_POTENTIAL	[megaPascals]

MEAN_FOLIAGE_MOISTURE	[unitless]
SDEV_FOLIAGE_MOISTURE	[unitless]
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]
NUM_OBS	[Human Observer]
MEAN_WATER_POTENTIAL	[Field Equipment]
SDEV_WATER_POTENTIAL	[Field Equipment]
MEAN_FOLIAGE_MOISTURE	[Field Equipment]
SDEV_FOLIAGE_MOISTURE	[Field Equipment]
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

7.3.5 Data Range

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

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-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE06-WRP01	9TE06-WRP02	None	None	None	None
DATE_OBS	19-JUN-94	16-AUG-94	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
NUM_OBS	2	5	None	None	None	None
MEAN_WATER_POTENTIAL	1.4	19	None	None	None	None
SDEV_WATER_POTENTIAL	0	4.07	None	None	None	None
MEAN_FOLIAGE_MOISTURE	.37	69.78	None	None	None	None
SDEV_FOLIAGE_MOISTURE	.01	20.04	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	02-OCT-97	02-OCT-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,NUM_OBS,MEAN_WATER_POTENTIAL,
SDEV_WATER_POTENTIAL,MEAN_FOLIAGE_MOISTURE,SDEV_FOLIAGE_MOISTURE,CRTFCN_CODE,
REVISION_DATE
'SSA-OJP-FLXTR','9TE06-WRP01',19-JUN-94,'Pinus banksiana',5,7.2,1.2,45.41,1.58,
'CPI',02-OCT-97
'NSA-9OA-9TETR','9TE06-WRP01',20-JUN-94,'Populus tremuloides',5,4.7,1.04,.59,.03,
'CPI',02-OCT-97
```

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

9.1.1 Derivation Techniques and Algorithms

Not applicable.

9.2 Data Processing Sequence

9.2.1 Processing Steps
None.

9.2.2 Processing Changes
None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
Not applicable.

9.3.2 Calculated Variables
The mean foliage moisture content = (wet weight-dry weight)/dry weight.

9.4 Graphs and Plots
Not applicable.

10. Errors

10.1 Sources of Error
There are a number of sources of error that can occur when making this measurement. In conifers, resins may obscure the exuding sap resulting in overestimation of LWP. During the long periods of twilight (16-Jun to 27-Jun), there is the potential that the stomata of the leaves will not close long enough for the foliage to equilibrate with the soil. Unfortunately there is no way to directly test this, but we suspect the large variability seen during this period may have been the result of such a phenomenon. Operator error is also a common feature of this measurement because of its interpretative nature. Finally, there is variability between tree species in the pressure bomb's efficacy in describing an actual LWP (Kramer, 1983); we did not find anything in the literature in regard to these species and did not test the method, but we did test our measurements against soil moisture measurements where they were available (see Section 10.2.1).

10.2 Quality Assessment
The data provided are of generally good quality with an increasing level of precision and accuracy from early to late summer. The LWP measurement for aspen more closely agreed with soil moisture than did jack pine. No soil moisture data were found for black spruce so no comparison was made.

10.2.1 Data Validation by Source
We compared the predawn LWPs to soil tension measurements made with gypsum blocks at NSA-OJP and SSA-OA. Agreement between the two measurements was very good for aspen, but only fair for the jack pine. No comparison was possible for black spruce.

10.2.2 Confidence Level/Accuracy Judgment
Confidence level for the aspen sites is high and fair for the jack pine sites when the objective is the water status of the plant. An evaluation of the black spruce measurements cannot be made. Researchers should note Section 10.1.

10.2.3 Measurement Error for Parameters
Not applicable.

10.2.4 Additional Quality Assessments
Not applicable.

10.2.5 Data Verification by Data Center

Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data

Not applicable.

11.2 Known Problems with the Data

See Section 10.2.

11.3 Usage Guidance

None.

11.4 Other Relevant Information

None.

12. Application of the Data Set

These data can be used for assessment of the water status of tree species in the boreal forest.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

Not applicable.

14.2 Software Access

Not applicable.

15. Data Access

The predawn LWPs and foliage moisture contents 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

Kramer, P.J. 1983. Water relations of plants. Academic Press. pp 384-387.

17.2 Journal Articles and Study Reports

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
BS      - Black Spruce
CD-ROM  - Compact Disk-Read-Only Memory
CEV     - Carbon Evaluation Site
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
LWP     - Leaf Water Potential
MIX     - Mixed Stand
NSA     - Northern Study Area
OA      - Old Aspen
OBS     - Old Black Spruce
OJP     - Old Jack Pine
ORNL    - Oak Ridge National Laboratory
SSA     - Southern Study Area
TE      - Terrestrial Ecology
TF      - Tower Flux site
UBS     - Upland Black Spruce
URL     - Uniform Resource Locator
WAB     - Wind Aligned Blob
YA      - Young Aspen
YJP     - Young Jack Pine
```

20. Document Information

20.1 Document Revision Date
Written: 30-Jun-1998
Last Updated: 26-Jul-1999

20.2 Document Review Date(s)
BORIS Review: 30-Jun-1998
Science Review:

20.3 Document ID

20.4 Citation
When using these data, please contact the investigators listed in Section 2.3 and cite any relevant papers in Section 17.2.

If using data from the BOREAS CD-ROM series, also reference the data as:
Gower, T., "Predawn Leaf Water Potentials and Foliage Moisture Contents in Boreal Forest Trees." 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

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
October 2000

3. REPORT TYPE AND DATES COVERED
Technical Memorandum

4. TITLE AND SUBTITLE
Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)
BOREAS TE-6 Predawn Leaf Water Potentials and Foliage Moisture Contents

5. FUNDING NUMBERS
923
RTOP: 923-462-33-01

6. AUTHOR(S)
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Forrest G. Hall and Shelaine Curd, Editors

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES)
Goddard Space Flight Center
Greenbelt, Maryland 20771

8. PEFORMING ORGANIZATION REPORT NUMBER
2000-03136-0

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
TM—2000–209891
Vol. 144

11. SUPPLEMENTARY NOTES
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S. Curd: Raytheon ITSS, NASA Goddard Space Flight Center, Greenbelt, Maryland

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified–Unlimited
Subject Category: 43
Report available from the NASA Center for AeroSpace Information,
7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The BOREAS TE-6 team collected several data sets to examine the influence of vegetation, climate, and their interactions on the major carbon fluxes for boreal forest species. This data set contains summaries of predawn leaf water potentials and foliage moisture contents collected at the TF and CEV sites that had canopy access towers. The data were collected on a nearly weekly basis from early June to late August 1994 by TE-06, members of the BOREAS staff, and employees of Environment Canada. The data are provided in tabular ASCII files.

14. SUBJECT TERMS
BOREAS, terrestrial ecology, carbon flux.

15. NUMBER OF PAGES
13

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
Unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. SECURITY CLASSIFICATION OF ABSTRACT
Unclassified

20. LIMITATION OF ABSTRACT
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