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BOREAS TE-8 Aspen Bark Spectral Reflectance Data

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BOREAS TE-8 Aspen Bark Spectral Reflectance Data

Shannon Spencer, Barret N. Rock

Summary

The BOREAS TE-8 team collected in-lab spectral reflectance data for aspen bark and leaves from three sites within the BOREAS SSA from 24-May-1994 to 16-Jun-1994 (IFC-1), 19-Jul-1994 to 08-Aug-1994 (IFC-2), and 30-Aug-1994 to 19-Sep-1994 (IFC-3). One to nine trees from each site were sampled during the three IFCs. Each tree was sampled in five different locations for bark spectral properties: BS, US, BR, BT, and BO. Additionally, a limited number of LV were collected. Bark samples were removed from the stem of the tree and placed in ziplock bags for transport to UNH, where they were scanned with a spectroradiometer in a controlled environment. Each sample was scanned twice: the first set of measurements was made with the bark surface moistened, and the second set was made with the bark surface air-dried for a period of 30 minutes. These data represent continuous spectra of bark reflectance. Each sample was scanned three times, rotating the sample when possible. The reported values for each sample are an average over the three scans. The data are stored in tabular ASCII files.

Note that although the data are divided into daily files, they may be too large to be viewed using a spreadsheet program (i.e., > 16K records). The files can be viewed and manipulated/subset using most word processing programs.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-08 Aspen Bark Spectral Reflectance Data

1.2 Data Set Introduction

The data contained within the 11 files are in-lab continuous spectral reflectance curves of aspen bark samples and aspen leaf samples from four sites within the BOREal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA). Bark samples were collected in the field during the three Intensive Field Campaigns (IFCs) of 1994. Bark sections were peeled off the stem or branch wood, placed in ziplock bags with wet napkins, and kept cool until samples could be spectrally scanned at the University of New Hampshire (UNH).

The Visible Infrared Intelligent Spectroradiometer (VIRIS) was used to measure the spectral reflectance. The samples were scanned indoors under controlled temperature and lighting conditions using a hemispherical light source (Spencer, 1996). The VIRIS simultaneously recorded radiance from the target and a Halon reference panel to calculate % reflectance from 400 nm to 2500 nm in 2- or 4-nm intervals, producing a continuous reflectance spectrum.

Aspen bark samples were scanned from four different sites at the SSA and from several trees. Each tree was sampled in five different locations for bark spectral properties: basal stem (BS) section, which was any bark sample taken below one-half the tree height; upper stem (US) section, which was any bark sample taken from the main stem above one-half the tree height; bark taken from branches (BR) up to 3 years old; a 2-year-old (BT) branch segment; and a 1-year-old (BO) branch segment. Additionally, a limited number of leaves (LV) were spectrally characterized for comparison to bark spectra.

1.3 Objective/Purpose

The purpose of this work was to understand the potential influence of aspen bark and aspen bark photosynthesis on data collected by remote sensing systems over aspen stands.

1.4 Summary of Parameters and Variables

The parameters included sample location on the tree, sample geometry, moisture condition of the sample surface at time of scanning, and sample size relative to the instrument (VIRIS) field-of-view (FOV).

1.5 Discussion

The bark of aspen (*Populus tremuloides*) is green and photosynthetic. The phenomenon of bark photosynthesis in aspen has been studied extensively; it has been shown that bark photosynthesis can account for 5-40% of whole tree photosynthesis. BOREAS used remote sensing systems as a primary means for data collection to better understand the ecosystem-atmosphere interactions. Aspen is a dominant forest cover type, especially in the SSA. Therefore, bark spectral properties could significantly affect data collected and analyzed by remote sensing instruments in BOREAS.

This study was undertaken to quantify the spectral properties of aspen bark samples. The results of this study provide an initial understanding of the potential influence of aspen bark photosynthesis on remotely collected data and carbon budget for aspen stands. A more intensive study should be conducted to scale lab-based spectral measurements to airborne and spaceborne platforms. Additionally, direct measurements of bark photosynthesis would be required to determine the significance to the boreal carbon budget.

The quality of the spectral data can be stated as initial, in the sense that measurements were taken in the lab and several variables influenced the measured reflectance. Tree and stand-level reflectance measurements during the leaf-off condition should be pursued. The quality of the spectral data themselves is good; the spectroradiometer was operated under controlled conditions and data were screened for bad scans.

1.6 Related Data Sets

BOREAS TE-09 In Situ Understory Spectral Reflectance within the NSA
BOREAS TE-10 Leaf Optical Properties
BOREAS TE-12 Leaf Optical Data for SSA Species

The authors conducted some preliminary research on bark area:leaf area ratios that is not reported here.

2. Investigator(s)

2.1 Investigator(s) Name and Title

The investigators were part of the BOREAS Terrestrial Ecology (TE)-08 team. The principal investigator for the team was Dr. Kharouk. All measurements and data were made, processed, and stored at UNH.

Dr. Slava Kharouk, Scientist
Dr. Barret N. Rock, Associate Professor

2.2 Title of Investigation

The Tree's Bark Input in Tree-Atmosphere Interactions

2.3 Contact Information

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3. Theory of Measurements

The in-lab spectral reflectance of bark samples was measured in order to quantify the spectral properties of the surface under a variety of conditions. Because the spectroradiometer used for this study was not available for field use at the BOREAS site, bark and leaf samples were collected at the BOREAS site, stored, and transported to the lab at UNH for spectral analysis under controlled temperature, lighting, and moisture conditions.

Bark samples from different locations within the tree were collected and analyzed to determine the effects of sample geometry on measured reflectance. All samples were scanned three times and averaged to reduce instrument noise. Samples were placed in an FOV 5 cm by 2 cm in dimension on top of a flat, black photography cloth to reduce the effect of diffuse room light on measured sample reflectance. Samples were placed 50 cm directly below the scan head. A certified Halon reflectance panel was used as the reference and was also placed on top of the black cloth 50 cm from the scan head. The instrument is designed such that there are two FOVs, one for the target sample and one for the reference panel. The target and reference panel were placed side by side, approximately 25 cm apart. The target and reference panel were scanned simultaneously by the VIRIS spectroradiometer to calculate % reflectance of the target sample.

A hemispherical light source is used with an incident angle of 35 degrees at a distance of 50 cm from the scan head, target, and reference panel. This light source is a spectralon-coated hemisphere/baffle system using four high-intensity, quartz line, 30 W bulbs.

The instrument operates reliably at a temperature up to 28 °C. All samples were scanned between a temperature of 18-26 °C.

All bark samples were cut from the stem and laid as flat as possible. They were placed perpendicular to the scanning device and then rotated 90 degrees, when possible, for three scans per sample. An attempt was made to determine what a remote sensor would use when looking at the surface of aspen bark or leaves; therefore, the outside of the bark and the top of the leaves were measured. Bark samples were scanned under moist and dry conditions because the surface reflectance properties change significantly with moisture. Bark samples dipped in a bath of water were used to simulate bark reflectance following a rain event, and samples that were air-dried for 50 minutes were used to simulate bark reflectance on a dry, sunny day. The air-dried samples were scanned between 1 and 5 days after the moistened samples were scanned. The three scans of a moistened sample were averaged (comprising one moist sample), and the three scans of an air-dried sample were averaged (comprising one dry sample).

Leaves were scanned as they were removed from the sample bag because of their differing morphology. Since leaves were stored in the ziplock bags with a moistened napkin, leaves were generally moist. The top surface of the leaf (the side facing upwards when attached to the branch) was measured.

To test what kind of effect the difference in days made in the measurements, a set of bark samples was scanned upon returning from the Canadian field site and then rescanned 1 week (7 days) later. No significant differences were noted in the indices or ratios reported between the two scanings; therefore, 1-3 days were allowed between the moistened condition and air-dried condition. Samples were kept in ziplock bags in a cool environment (a refrigerator). Other tests conducted using leaves and needles in the lab have shown that as long as samples are kept cool and are sealed in ziplock bags with moistened paper towels, they can be kept for 1-2 weeks without showing a significant change in spectral reflectance. See Section 10.1 for more information.

4. Equipment

4.1 Sensor/Instrument Description

VIRIS was used to spectrally characterize the bark and leaf samples. This was used with a hemispherical light source as discussed in Section 3. The VIRIS (IRIS Mark IV) was developed by Geophysical Environmental Research (GER), Inc. It provides approximately 2-nm spectral resolution from 400 nm to 1100 nm, and 4-nm resolution from 1100 nm to 2500 nm. The instrument makes simultaneous radiance measurements from a target and a reference panel to calculate % reflectance of the target. Data were downloaded to a laptop and processed using software that converted the binary data to American Standard Code for Information Interchange (ASCII) format and conducted a nine-point smoothing operation to reduce channel-to-channel noise (Rock et al., 1994).

ASCII data file was output for each individual scan with a column of data for the wavelength and a corresponding column of % reflectance data. For each sample under each moisture condition, three scans were made. These three scans were further processed by averaging the % reflectance data.

4.1.1 Collection Environment

Spectral measurements were made in the lab under controlled conditions of lighting and temperature. The temperature range was between 18-26 °C while the VIRIS was operating.

4.1.2 Source/Platform

The VIRIS is a ground-based instrument that sits on a tripod. The scan head is positioned 50 cm above the level of the target sample and Halon reference panel.

4.1.3 Source/Platform Mission Objectives

The purpose of the tripod is to hold and position the instrument.

4.1.4 Key Variables

Calibrated radiance data, converted to % reflectance by rationing the target radiance to the Halon reference panel radiance. Percent reflectance is calculated by the instrument software.

The spectroradiometer is a dual-beam instrument; therefore, it measures the radiance from both a Halon reference panel and the target simultaneously. The instrument software then calculates % reflectance by a straight division of the target radiance by reference radiance. The output files then provide only the wavelength and percent reflectance (although the output program could be programmed differently to also provide target and reference radiance).

Wavelength is the wavelength of the center-point of each spectral channel.

4.1.5 Principles of Operation

See Section 4.1.

4.1.6 Sensor/Instrument Measurement Geometry

See Sections 4.1-4.1.3.

4.1.7 Manufacturer of Sensor/Instrument

VIRIS (IRIS Mark IV)
GER Inc., Millbrook, NY, USA.

The light source was modified from Williams and Woods (1987) (see Rock et al., 1994).

4.2 Calibration

4.2.1 Specifications

The instrument is designed to self calibrate during each scan.

4.2.1.1 Tolerance

Although the instrument operates at temperatures between 0-50 °C, best performance has been achieved using it below 28 °C.

4.2.2 Frequency of Calibration

The instrument is inspected regularly by GER.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

See Sections 3 and 4.

6. Observations

6.1 Data Notes

The heat produced from the light source tended to dry the surface of bark samples slightly as they were scanned. This was minimized for moist samples by keeping the sample moistened between scans. Air-dried samples tended to be affected slightly as well. This was observed both visually and in the resulting data. For further discussion, please see Spencer, 1996.

Sample geometry tended to have an affect on the resulting spectra, depending on sample shape, convexity and size in relation to the FOV.

6.2 Field Notes

Samples were collected at field sites, placed in ziplock bags, and kept cool until processing.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Four sites were sampled during the three 1994 IFCs. Not all sites were sampled during each IFC because of destructive sampling logistics. Two BOREAS tower sites were used: Old Aspen (OA) and Young Aspen (YA). Additionally, the originally identified BOREAS YA site was sampled during all three IFCs and is identified in these data sets as the Young Aspen-Auxiliary 04 site (YA-AUX04), and a non-BOREAS mixed aspen and white spruce site is identified as YA-AUX07. One to five trees were destructively harvested during each IFC.

The following is sample collection information at the four SSA locations:

- OA: One tree was harvested during IFC-2. Branch samples only were collected during IFC-1 and no samples were collected from OA during IFC-3 because of the logistics of destructive sampling.
- YA-AUX04: Three trees were destructively harvested during each of the three IFCs.
- YA: Five trees were harvested during IFC-2 and -3.
- YA-AUX07: This is a non-BOREAS site that exists within the BOREAS SSA and was established in order to harvest a second mature (>60 yr. old tree) aspen stand for TE-08 research. This site was a mixed site of mature aspen overstory and white spruce understory. It was located on the property of Snow Castle Lodge approximately 3 km N of the SSA-YA site (see Spencer, 1996, for more details). One tree was harvested from this site during IFC-3.

The SSA measurement sites and their associated North American Datum of 1983 (NAD83) coordinates are:

- OA, site id C3B7T, Lat/Long: 53.62889 N, 106.19779 W, Universal Transverse Mercator (UTM) Zone 13, N: 5,942,899.9 E: 420,790.5.
- YA, site id D0H4T, Lat/Long: 53.65601 N, 105.32314 W, UTM Zone 13, N: 5,945,298.9 E: 478,644.1.
- YA-AUX04, site id D6H4A, Lat/Long: 53.70828 N, 105.31546 W, UTM Zone 13, N: 5,951,112.1 E: 479,177.5.
- YA-AUX07, located 3 km N of SSA-YA on the property of Snow Castle Lodge, UTM Zone 13. This was a mixed site of mature aspen overstory (>60 yrs) and white spruce understory.

7.1.2 Spatial Coverage Map

See Spencer, 1996.

7.1.3 Spatial Resolution

The FOV of the lab spectrometer is approximately 2 cm x 5 cm. The instrument is spectral only (i.e., does not produce an image). The data represent point measurements taken from the given locations.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

Not applicable.

7.2.1 Temporal Coverage

Measurements were taken from 24-May-1994 to 16-Jun-1994 (IFC-1), 19-Jul-1994 to 08-Aug-1994 (IFC-2), and 30-Aug-1994 to 19-Sep-1994 (IFC-3).

7.2.2 Temporal Coverage Map

Not applicable.

7.2.3 Temporal Resolution

Each site was sampled one time during each of the three measurement periods.

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_COLLECTED
DATE_OBS
TREE_ID
SAMPLE_DESCR
SCAN_ID
SPECIES
WAVELENGTH
```

MEAN_REFL
 CRTFCN_CODE
 REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-III III, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and III III is the identifier for sub-site, often this will refer to an instrument.
DATE_COLLECTED	The date on which the samples were collected.
DATE_OBS	The date on which the data were collected.
TREE_ID	Identifier of the mapped tree or plant stem.
SAMPLE_DESCR	Description of the sample.
SCAN_ID	The scan identifier.
SPECIES	Botanical (Latin) name of the species (Genus species).
WAVELENGTH	Spectral wavelength at which the measurement was acquired.
MEAN_REFL	The mean reflectance factor.
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_COLLECTED	[DD-MON-YY]
DATE_OBS	[DD-MON-YY]
TREE_ID	[none]
SAMPLE_DESCR	[unitless]
SCAN_ID	[unitless]
SPECIES	[none]
WAVELENGTH	[micrometers]
MEAN_REFL	[percent]

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_COLLECTED	[Human Observer]
DATE_OBS	[Human Observer]
TREE_ID	[Human Observer]
SAMPLE_DESCR	[Human Observer]
SCAN_ID	[Human Observer]
SPECIES	[Human Observer]
WAVELENGTH	[Human Observer]
MEAN_REFL	[Laboratory 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	SSA-90A-FLXTR	SSA-ASP-AUX07	None	None	None	None
SUB_SITE	9TE08-BK001	9TE08-BK001	None	None	None	None
DATE_COLLECTED	16-AUG-93	08-SEP-94	None	None	None	None
DATE_OBS	20-AUG-93	21-SEP-94	None	None	None	None
TREE_ID	1	5	None	None	None	None
SAMPLE_DESCR	N/A	N/A	None	None	None	None
SCAN_ID	1	776	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
WAVELENGTH	.40145	2.49765	None	None	None	None
MEAN_REFL	2	88.84	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	06-NOV-98	06-NOV-98	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 Clcltd -- 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,DATE_COLLECTED,TREE_ID,SAMPLE_DESCR,SCAN_ID,SPECIES,
WAVELENGTH,MEAN_REFL,CRTFCN_CODE,REVISION_DATE
'SSA-90A-FLXTR','9TE08-BKO01',20-AUG-93,16-AUG-93,1,'LEAF SAMPLES',388,
'Populus tremuloides',.40145,24.51,'CPI',06-NOV-98
'SSA-90A-FLXTR','9TE08-BKO01',20-AUG-93,16-AUG-93,1,'LEAF SAMPLES',388,
'Populus tremuloides',.40312,22.97,'CPI',06-NOV-98
```

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. Note that although the data are divided into daily files, they may be too large to be viewed using a spreadsheet program (i.e., > 16K records). The files can be viewed and manipulated/subset using most word processing programs.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain 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

Three scans were acquired for each sample for two moisture conditions (moist and air-dried). These three scans were averaged to reduce noise and are presented in the data files described under Section 1.1.

Other data processing includes that done by the instrument software in order to convert the data from binary radiance to % reflectance in ASCII format. Additionally, the software conducts a nine-point smoothing function on the data to reduce channel-to-channel noise. This is a weighted

smoothing function conducted to produce a smooth, continuous reflectance curve. For more information and for the actual smoothing equation, please see Vogelmann et al. (1993), Spencer (1996), and Rock et al. (1994).

For the average of three scans, a statistical mean was calculated. For the smoothing function used by the software, please refer to Rock et al., 1994.

9.1.1 Derivation Techniques and Algorithms

Not applicable.

9.2 Data Processing Sequence

9.2.1 Processing Steps

- Scan the sample three times, rotating the sample if possible between scans.
- Download radiance data from onboard CPU.
- Process raw binary radiance data to binary reflectance using system-supplied software.
- Process binary reflectance to ASCII data and apply the smoothing function.
- Print a quick-look spectrum for each scan. The software that prints the quick-look graphs of spectra is supplied by the manufacturer (GER) and can be printed as part of the VIRIS operating system.
- Inspect quick-look spectra for bad scans: A bad scan was identified as a very flattened spectrum, or a spectrum that had values out of the expected range. Additionally, the quick-look software procedure prints out the Normalized Difference Vegetation Index (NDVI), the Red Edge Inflection Point (REIP), and simulated Thematic Mapper bands. If any of these values were zero or negative, then the scan was considered bad. Bad scans were discarded.
- Delete bad scans.
- Import raw ASCII reflectance data into a spreadsheet package and average the good scans of the same sample.
- Add header data and group data by sampling location.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

No calculations were performed for these data, other than the steps described under Section 9.2.1.

9.3.2 Calculated Variables

The values presented are statistical means of multiple scans.

9.4 Graphs and Plots

None given.

10. Errors

10.1 Sources of Error

Because of the logistics of the research, samples were collected in the field, kept moistened in ziplock bags, and kept either in coolers with blue-ice or in the refrigerator until measurement. Measurement was conducted at UNH 1 to 3 weeks after harvesting. This naturally is a potential source of error because of the delay in measurement following bark sample collection. A test was done to determine the effect of storage on the samples. A set of samples was scanned 1 week following collection and then rescanned 2 weeks later; no significant difference was noted between the two data

sets.

Errors in the spectral reflectance may have been caused by sample morphology. These include sample three-dimensional shape, which could cause a rounding of the scanned bark surface; shadowing; and the extent to which the sample filled the FOV of the instrument. Rounding and shadowing did not necessarily create bad scans. The rounding and shadowing would result in not enough light entering the scanning head, yielding in a low spectral reflectance. The data were inspected following scanning to be sure enough light was entering the device to produce valuable data. This is a general observation that the sample shape (morphologic condition) could affect the relative amplitude of spectral reflectance. TE-08 controlled for this as much as possible. The data for samples on which this occurred are not provided. As noted, the data were hand checked and this would only result in relative amplitude of the reflectance across the whole scan. Scans were discarded and rescanned when this condition was not met.

Additionally, sample morphology affected the spectral properties because the light source dried the surface of the samples. An attempt was made to minimize this factor by scanning samples moistened and predried, but some intrascan drying may have occurred. An attempt was made to always keep the FOV filled with the sample material; where the background cloth depressed reflectance values significantly, those scans were discarded.

For a detailed analysis of the potential errors and effects of morphology on reflectance, see Spencer, 1996.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Leaf scan data were checked with data submitted by TE-10, and results were not significantly different.

10.2.2 Confidence Level/Accuracy Judgment

It is felt that the sample reflectance data are of good quality, keeping in mind the effects of sample geometry on reflectance. Please see Section 10.1.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

All scans were checked for potential problems and discarded if problems were evident.

10.2.5 Data Verification by Data Center

Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data

These spectral data are in-lab measurements under controlled conditions of light and temperature. Data were collected for a preliminary analysis of the effect of bark photosynthesis on spectral properties.

11.2 Known Problems with the Data

None given.

11.3 Usage Guidance

Note that although the data are divided into daily files, they may be too large to be viewed using a spreadsheet program (i.e., > 16K records). The files can be viewed and manipulated/subset using most word processing programs.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

The data provide spectral properties of bark created by green, chlorophyll-containing bark cortex tissue in young and mature samples of trembling aspen. This phenomenon is quite extensive, as is the aspen coverage in the boreal region. The data suggest that bark spectral properties may affect data collected by remote sensing systems over aspen stands. Additionally, bark photosynthesis and carbon exchange should be considered when predicting carbon dynamics of aspen-dominated regions. More work should be conducted to assess the rate/amount of carbon assimilation and the in situ reflectance of aspen canopies.

13. Future Modifications and Plans

These data have been presented in more detail in Spencer, 1996.

14. Software

14.1 Software Description

Data were initially processed using either Quattro Pro 4.0 or Excel 5.0 to produce spectral curve averages, standard deviations, and hardcopies and to calculate spectral indices and ratios. Stata 4.0 for Windows was then used on all indices and ratios for statistical comparison between the different sites, trees, bark locations within a tree, age classes, and time periods.

14.2 Software Access

None given.

15. Data Access

The aspen bark spectral reflectance 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
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Fax: (423) 574-4665
E-mail: ornl daac@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

Not applicable.

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.

Rock, B.N. et al. 1994. High-spectral resolution field and laboratory optical reflectance measurements of red spruce and eastern hemlock needles and branches. *Remote Sensing of Environment*. 47:176-189.

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

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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.

Spencer, S.L. 1996. Anatomical, Pigment, and Spectral Evidence of Cortical Photosynthesis in *Populus tremuloides* from the Canadian Boreal Region. Master's Thesis, Dept. Nat. Res., University of New Hampshire, 186 pp.

Spencer, S.L. and B.N. Rock. 1996. Assessing aspen bark carbon assimilation in the boreal region. In *Proceedings of 22nd Conference on Agricultural and Forest Meteorology with Symposium on Fire and Forest Meteorology*. 28 January-2 February, 1996, Atlanta, Georgia. American Meteorological Society, pp. 86-89.

Vogelmann, J.E., B.N. Rock, and D.M. Moss. 1993. Red edge spectral measurements from sugar maple leaves. *Int. J.R.S.* 14(8):1563-1575.

Williams, D.L. and F.M. Woods. 1987. A Transportable Hemispherical Illumination System For Making Reflectance Factor Measurements. *Remote Sensing of Environment*. 23:131-140.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

BO - A 1-year-old branch segment
BR - Branches up to 3 years old
BS - Basal stem section, which is any bark sample taken below one-half the tree height
BT - A 2-year old branch segment
LV - Leaves
US - Upper stem section which was any bark sample taken from the main stem above one-half the tree height

19. List of Acronyms

ASCII - American Standard Code for Information Interchange
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
CD-ROM - Compact Disk-Read-Only Memory
DAAC - Distributed Active Archive Center
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
FOV - Field-of-View
GER - Geophysical Environmental Research

GIS	- Geographic Information System
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
IFC	- Intensive Field Campaign
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NDVI	- Normalized Difference Vegetation Index
NOAA	- National Oceanic and Atmospheric Administration
NSA	- Northern Study Area
OA	- Old Aspen
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
REIP	- Red Edge Inflection Point
SSA	- Southern Study Area
TE	- Terrestrial Ecology
UNH	- University of New Hampshire
URL	- Uniform Resource Locator
UTM	- Universal Transverse Mercator
VIRIS	- Visible Infrared Intelligent Spectroradiometer
YA	- Young Aspen
YA-AUX	- Young Aspen-Auxiliary

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Shannon L. Spencer, Barret N. Rock, both of UNH.

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13. ABSTRACT (Maximum 200 words) The BOREAS TE-8 team collected in-lab spectral reflectance data for aspen bark and leaves from three sites within the BOREAS SSA from 24-May-1994 to 16-Jun-1994 (IFC-1), 19-Jul-1994 to 08-Aug-1994 (IFC-2), and 30-Aug-1994 to 19-Sep-1994 (IFC-3). One to nine trees from each site were sampled during the three IFCs. Each tree was sampled in five different locations for bark spectral properties: BS, US, BR, BT, and BO. Additionally, a limited number of LV were collected. Bark samples were removed from the stem of the tree and placed in ziplock bags for transport to UNH, where they were scanned with a spectroradiometer in a controlled environment. Each sample was scanned twice: the first set of measurements was made with the bark surface moistened, and the second set was made with the bark surface air-dried for a period of 30 minutes. These data represent continuous spectra of bark reflectance. Each sample was scanned three times, rotating the sample when possible. The reported values for each sample are an average over the three scans. The data are stored in tabular ASCII files.				
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