Seedling Canopy Reflectance Spectra, 1992-1993 (ACCP)

Summary:

This is a data set of spectral reflectance (400-2500 nm) of small, monospecific canopies formed from seedlings of Douglas-fir (*Pseudotsuga menziesii*) and bigleaf maple (*Acer macrophyllum*). The trees were provided different levels of fertilization in order to produce canopies with varying nitrogen and chlorophyll concentration. For the Douglas-fir, fertilization was provided during the dormant season, so there were no differences in growth or leaf area among canopies, and canopies were at a constant density with varying foliar chemistry. For the maple, seedlings were aggregated at various densities, producing a matrix of leaf area as well as chemistry variations. Canopy reflectance was measured under natural sunlight, and canopies were then destructively analyzed for chemical content and leaf area (see ACCP Seedling Canopy Chemistry Data).

Citation:

Cite this data set as follows (citation revised on September 30, 2002):

Yoder, B., and L. Johnson. 1999. Seedling Canopy Reflectance Spectra, 1992-1993 (ACCP). [Seedling Canopy Reflectance Spectra, 1992-1993 (Accelerated Canopy Chemistry Program)]. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/423.

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1. Data Set Overview:

Data Set Identification:

SEEDLING CANOPY REFLECTANCE SPECTRA, 1992-1993 (ACCP)

Data Set Introduction:

This is a data set of spectral reflectance (400-2500 nm) of small, monospecific canopies formed from seedlings of Douglas-fir (*Pseudotsuga menziesii*) and bigleaf maple (*Acer macrophyllum*). The trees were provided different levels of fertilization in order to produce canopies with varying nitrogen and chlorophyll concentration. For the Douglas-fir, fertilization was provided during the dormant season, so there were no differences in growth or leaf area among canopies, and canopies were at a constant density with varying foliar chemistry. For the maple, seedlings were aggregated at various densities, producing a matrix of leaf area as well as chemistry variations. Canopy reflectance was measured under natural sunlight, and canopies were then destructively analyzed for chemical content and leaf area (see ACCP Seedling Canopy Data Set).

Objective/Purpose:

The experiments were designed to study the relationships between chemistry and spectral reflectance of canopies under very controlled conditions. In the case of the Douglas-fir, the purpose was to investigate the propagation of the reflectance signature from dried ground foliage to fresh foliage to whole canopies, where foliar chemistry varied and all other biophysical properties remained constant. In the case of the bigleaf maple, the purpose was to study the interactive effects of variable LAI and foliar chemistry on spectral reflectance of canopies. In both cases, the measurements were designed to minimize sources of spectral variation due to atmosphere, soils, etc. that are common in studies of natural vegetation.

Summary of Parameters:

Percent reflectance (R) and transformations of reflectance (e.g., 1st difference of log 1/R).

Discussion:

None (see References)

Related Data Sets:

- Site AVIRIS Images, 1992 (ACCP)
- Seedling Canopy Chemistry, 1992-1993 (ACCP)

2. Investigator(s):

Investigator(s) Name and Title:

Barbara Yoder, Assistant Professor of Forest Science (bigleaf maple) Lee Johnson, Sr. Research Scientist (Douglas-fir)

Title of Investigation

Spectral reflectance of seedling canopies

Contact Information:

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3. Theory of Measurements:

Not applicable.

4. Equipment:

Sensor/Instrument Description:

Spectral reflectance of the maple canopies was measured with a Single Field-of-View Infrared Intelligent Spectrometer (SIRIS), manufactured by Geophysical Environmental Research (GER) Corp. (New York).

Measurements of the Douglas-fir canopies were made with the GER and also a Spectron SE590 spectroradiometer (Spectron Engineering, Denver CO)

Collection Environment:

Measurements were made under solar illumination on clear days in an open field near NASA/Ames Research Center (ARC), Moffett Field, California. Simultaneous sky observations were made with a solar radiometer to detect the presence of sub-visible clouds or jet contrails. The experimental apparatus was placed near the center 15-m square of mowed grass. Seedling canopies were placed on a rotating platform, which was painted with krylon flat black paint. Douglas-fir measurements were made in November 1992 and maple measurements in March 1993.

Source/Platform:

A large "saw horse" was constructed to suspend the spectroradiometer(s) approximately 2 m above the ground level and 1 m above the target canopies. The all supporting materials were painted with krylon flat black paint. Another small platform supported a calibrated spectralon reference panel so that it could swing into the field of view of the radiometer.

Source/Platform Mission Objectives:

Not applicable.

Key Variables:

Spectral reflectance (400-2500 nm).

Principles of Operation:

The GER instrument uses a diffraction grating with silicon and lead sulfide detectors to measure radiance between 400nm and 2500nm. Band widths vary with wavelength from approximately 3nm at shortest wavelengths to 12nm at the longest.

The Spectron is a single grating instrument with a 256-element silicon detector array. Wavelength range was 370-1100 nm with a spectral sampling interval of 3 nm and spectral resolution of about 13 nm.

Sensor/Instrument Measurement Geometry:

The field of view of the GER was 1 degree x 15 degrees. The plane of the lens was parallel to and 1 m above the top of the canopies; the long axis of the field of view at the canopy top was approximately 24 cm. Spectron field of view was 6 degrees, roughly circular. Both the platform and the radiometers were leveled before each set of measurements.

Manufacturer of Sensor/Instrument:

Geophysical Environmental Research Corp. (111 8th Ave. #1007, New York, NY 10011; tel: 212-741-5558)

Spectron Engineering, Inc. (800 W. 9th Ave., Denver CO 80204; tel: 303-623-8987)

Calibration:

Specifications:

Before measurements, wavelengths of GER bands were calibrated by Mark Helmlinger (Jet Propulsion Laboratory, Pasadena, CA) with 60 emission lines from AR, Hg, and Kr vapor sources. A third-order polynomial (R2 approximately 1.0) relating channel number to wavelength was developed for each of the two sensors. The signal-to-noise ratio was evaluated from laboratory measurements of instrument noise and from values for typical reflected radiance of vegetation canopies under the measurement conditions. The Spectron was spectrally calibrated using four lines from a krypton gas lamp. For both instruments, canopy reflectance was calculated as a proportion of reflectance from a spectralon reference panel; the spectral reflectance of the reference panel was factory calibrated.

Tolerance:

Not applicable.

Frequency of Calibration:

Wavelength calibration was performed before the measurements began. For radiometric calibration, scans were made of the reference panel approximately every 15 min.

Other Calibration Information:

Not applicable.

5. Data Acquisition Methods:

For each measurement, a canopy was placed on the rotating platform. Strips of poster board, painted with Krylon flat black paint were inserted between trees at their base to cover soil. Eighteen spectra were then acquired for each maple canopy, one at each 20 degree rotation of the platform through a full 360 degrees. The reported spectra for each of the canopies are the mean values from these repeated scans.

Douglas-fir canopy GER spectra were collected at up to 30 turntable orientations for each of the three canopies and then averaged per canopy. Nearly 900 canopy spectra were collected and averaged per fertilization treatment with the Spectron.

6. Observations:

Data Notes:

Not applicable.

Field Notes:

For the measurements of the maple canopies, it was reasonably windy during measurements of the high and medium fertilization treatments.

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

NASA Ames Research Center. Latitude: 37.4015 Longitude: -122.0481

Spatial Coverage Map:

Not applicable.

Spatial Resolution:

Not applicable.

Projection:

Not applicable.

Grid Description:

Not applicable.

Temporal Characteristics:

Temporal Coverage:

November 1992 and March 1993.

Temporal Coverage Map:

Not applicable.

Temporal Resolution:

Not applicable.

Data Characteristics:

Parameter/Variable:

Douglas Fir Variables (column headings)

band=index for wavelength

wavelength=wavelength of light, from approximately 400-2498 nm at 2 nm intervals

'DF_high'=example of canopy/treatment identifier used as column heading for average spectral reflectance values.
definition=unique sample (canopy) identifier (syntax: DF= Douglas Fir and low, med, or high=fertilizer treatment level)

'DF_high_stddev'=example of canopy/treatment identifier used as column heading for standard deviation of averaged spectral reflectance values.
definition=unique sample (canopy) identifier (syntax: DF= Douglas Fir and low, med, or high=fertilizer treatment level)

spectral reflectance (as absorbance [log(1/Reflectance)])
units=unitless
minimum=0.0015
maximum=0.6701

Big Leaf Maple Variables (column headings)

band=index for wavelength

wavelength=wavelength of light, from approximately 400-2498 nm at 2 nm intervals

'MAP_high_f '=example of canopy/treatment/LAI identifier used as column heading for spectral reflectance values.
definition=unique sample (canopy) identifier (syntax: MAP= Big Leaf Maple; low, med, high=fertilizer treatment level;
full(f), half(h), and quarter(q)=quantity of seedlings used to construct canopy and determines LAI)

spectral reflectance (as absorbance [log(1/Reflectance)])
units=unitless
minimum=0.00
maximum=32.19

Sample Data Record:

Douglas Fir df_can_sp.dat 1527 records

band wavelength DF_high DF_high_stddev DF_med DF_med_stddev DF_low DF_low_stddev
5 387.30 0.0221 0.0062 0.0237 0.0034 0.0231 0.0052
6 388.17 0.0212 0.0063 0.0241 0.0036 0.0227 0.0055
...
1930 2481.40 0.0064 0.0063 0.0075 0.0094 0.0015 0.0224
1931 2482.60 0.0049 0.0085 0.0018 0.0085 0.0043 0.0460

Big Leaf Maple
map_can_sp.dat 784 records
band wavelength MAP_high_f MAP_high_h MAP_high_q MAP_med_h MAP_med_h MAP_med_q MAP_low_f MAP_low_h MAP_low_q
1 385.30 2.92 2.33 2.56 2.36 2.58 1.93 2.34 2.44 2.48
2 387.90 2.90 2.28 2.57 2.32 2.55 1.94 2.34 2.37 2.48
...
783 2504.40 4.82 2.71 5.21 5.09 5.77 5.97 2.93 3.27 3.23
784 2506.70 3.87 4.94 6.65 5.58 5.24 2.86 3.08 2.92 1.95

8. Data Organization:

Data Granularity:

Douglas fir and Big Leaf maple seedling canopy spectral reflectance data are in separate data files as described in Section 7.

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary.

Data Format:

The data files are ASCII files. The first two lines are metadata. The first line contains the filename and the number of data records to follow. The second line contains the variables/column headings. The data records are numerical fields. The fields are space delimited.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

Not applicable.

Data Processing Sequence:

Processing Steps:

Digital numbers from the canopy spectra were converted to reflectance (%) using factory-calibrated reflectance factors provided for the spectralon reference panel by the manufacturer. These values are derived from a hemispheric source, but the reflectance factor of the reference varies with the incidence angle of the source (i.e., the solar angle). A set of 4th-order polynomials was used with equations and procedures described by Jackson et al. (1992) to describe reflectance of the reference panel as a function of wavelength for each 1 degree solar incidence angle between 40 degrees and 65 degrees. The incidence angle for each reference panel was determined from the date, time and location, and the appropriate polynomial was used for determining reflectance factors for each band. Digital numbers from the reference scans were divided by these reflectance factors for an estimate of 100% reflectance. Finally, estimates of 100% reflectance at the time of each canopy measurement were made by linear interpolation between pairs of reference panel measurements before and after the canopy scan.

The multiple scans for each canopy were averaged and then smoothed using a box-car procedure. For the maple data, smoothing was accomplished with two running-average passes, each plus and minus two bands. Inverse-log spectra (log 1/R) were calculated from reflectance spectra, and first-difference spectra (approximating first derivatives) of the log 1/R spectra were calculated at each band by taking the difference between the values two bands above and two bands below the band center, and divided by the wavelength range.

Processing Changes:

Not applicable.

Calculations:

Special Corrections/Adjustments:

Not applicable.

Calculated Variables:

Graphs and Plots:

Not applicable.

10. Errors:

Sources of Error:

The signal-to-noise ratio of the GER was approximately 100 between 800-1100nm. In the visible range (450-700) and longer NIR wavelenths the SNR was approximately 20. Leaf fluttering probably introduced some noise for measurements of the maple canopies, especially for the high and intermediate fertilization levels. For the Douglas-fir, a thorough analysis of variation in spectral reflectance for each canopy and between canopies is described in Dungan et al. (1996). For the maple, the limitations of the data set are discussed in Yoder and Pettigrew-Crosby (1995).

Quality Assessment:

Data Validation by Source:

Not applicable.

Confidence Level/Accuracy Judgment:

Not applicable.

Measurement Error for Parameters:

Not applicable.

Additional Quality Assessments:

Not applicable.

Data Verification by Data Center:

Not applicable.

11. Notes:

Limitations of the Data:

Not applicable.

Known Problems with the Data:

Not applicable.

Usage Guidance:

Not applicable.

Any Other Relevant Information about the Study:

Not applicable.

12. Application of the Data Set:

These seedling data sets are intended for empirical and theoretical (radiative transfer model-based) analyses of the influence of plant canopy biochemical and biophysical status on canopy reflectance.

13. Future Modifications and Plans:

No modifications to the data are planned. During the 1997-98 timeframe, as study is underway to use these experimental data sets to validate a coupled leaf- and canopy-level radiative transfer model.

14. Software:

Software Description:

Not applicable.

Software Access:

Not applicable.

15. Data Access:

Contact Information:

ORNL DAAC User Services
Oak Ridge National Laboratory
Telephone: (865) 241-3952
FAX: (865) 574-4665
Email: ornldaac@ornl.gov

Data Center Identification:

ORNL Distributed Active Archive Center
Oak Ridge National Laboratory
Telephone: (865) 241-3952
FAX: (865) 574-4665 Email: ornldaac@ornl.gov

Procedures for Obtaining Data:

Users may place requests by telephone, electronic mail, or FAX. Data is also available via the World Wide Web at http://daac.ornl.gov.

Data Center Status/Plans:

These data are available from the ORNL DAAC. Please contact the ORNL DAAC User Services Office for the most current information about these data.

16. Output Products and Availability:

Available via FTP or on CD-ROM.

A complete listing of all data sets can be found on the World Wide Web at http://daac.ornl.gov.

17. References:

Dungan, J., L. Johnson, C. Billow, P. Matson, J. Mazzurco, J. Moen, and V. Vanderbilt. 1996. High spectral resolution reflectance of Douglas-fir grown under different fertilization treatments: Experimental design and treatment effects. Rem. Sens. of Environ. 55:217-228.

Johnson, L. and C. Billow. 1995. Spectrometric estimation of total nitrogen concentration in Dougals-fir foliage. International Journal of Remote Sensing 17:489-500.

Yoder, B. J., and R. E. Pettigrew-Crosby. 1995. Predicting nitrogen and chlorophyll content and concentrations from reflectance spectra (400-2500 nm) at leaf and canopy scales. Rem. Sens. Environ. 53:199-211.

18. Glossary of Terms:

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19. List of Acronyms:

URL

Uniform Resource Locator

20. Document Information:

March 30, 1999 (citation revised on September 30, 2002)

Document Review Date:

March 30, 1999

Document Curator:

webmaster@daac.ornl.gov

Document URL:

http://daac.ornl.gov