# Leaf Reflectances: LICOR (OTTER)

# Summary:

The variability of bi-directional spectral reflectance of cut conifer foliage between age classes, species and sites measured by LICOR.

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# 1. Data Set Overview:

### Data Set Identification:

Leaf Reflectances: LICOR (OTTER)

### Data Set Introduction:

The Oregon Transect Ecosystem Research (OTTER) Project was a cooperative effort between NASA and several universities to discern the ecology of western coniferous forests using remote sensing technology supported by ground observations. OTTER is an interdisciplinary project that tested a model which estimated the major fluxes of carbon, nitrogen, and water through a temperate coniferous forest ecosystem.

Six Oregon sites across an elevational and climatic gradient were intensively studied. The transect began at the Pacific coast at the site called Cascade Head, passed through the outskirts of Corvallis, through a dense Douglas fir forest at Scio, through a mountain hemlock/subalpine fir community at Santiam Pass, through a Ponderosa pine community near Metolius, and ended at a site east of Sisters called Juniper. In all, the transect stretched some 300 kilometers west to east.

Goals of the project were to simulate and predict ecosystem processes such as photosynthesis, transpiration, above-ground production, nitrogen transformation, respiration, decomposition, and hydrologic processes; combine field, lab, and remote sensing techniques to estimate key vegetation and environmental parameters; construct a "geo-referenced" database for extrapolation and testing of principles, techniques, and prediction; and verify the predictions through direct measurements of process rates or controls on processes.

### Objective/Purpose:

To characterize the spectral variability in conifer foliage between age classes, species, and sites.

### Summary of Parameters:

Two parameters were investigated in this study: The emitted radiation and the reflected radiation.

### Discussion:

The spectral variability in conifer foliage between age classes, species, and sites is important to the study of both emitted radiation and reflected radiation. The bi-directional spectral reflectance factor of cut branches (removed from the trees) was measured between 400 to 800 nanometers. The purpose was to build a spectral library and the expected analysis tool was to use them in a spectral mixture model (Smith et al., 1990a,b; Ustin et al. 1993). The principle of the library is to use them to identify the major components of landscape variation found in the AVIRIS imagery. The library spectra should represent all major classes of spectral diversity found within the image data. In this study, other OTTER investigators were relied upon to measure reflectance in other categories of landscape components (e.g., soil, bark, and litter samples) in the field to complete the library. The LICOR spectrometer did not measure in the SWIR region, which is most critical for distinguishing soils and dry plant materials.

### Related DataSets:

Canopy Chemistry Forest-BGC Model Leaf Area Index Data Leaf Reflectances: Perkin-Elmer Meteorology Optical Thickness Data: Aircraft Optical Thickness Data: Ground Reflectance Reference Targets SE-590 Field-Measured Reflectances SE-590 Lab-Measured Reflectances SE-590 Landscape Reflectances SE-590 Low Altitude Reflectances Timber Measurements

## 2. Investigator(s):

### Investigator(s) Name and Title:

Name: Susan L. Ustin, Assistant Professor Assistant Professor of Resource Science

Addresses: University of California - Davis

Telephone Numbers: 1-(916)-752-0621

Electronic Mail Address: slustin@ucdavis.edu

### Title of Investigation:

LI-COR 1800 Spectroradiometer Data

### Contact (for Data Production Information):

Name: ORNL DAAC User Services Office

Address: Oak Ridge National Laboratory U.S.A.

Telephone Number: 1-(865)-241-3952

Electronic Mail Address: ornldaac@ornl.gov

# 3. Theory of Measurements:

Information not available.

# 4. Equipment:

## Sensor/Instrument Description:

Spectroradiometer: LI-COR 1800 spectroradiometer with 1800-10 fiber optic link to the 1800-06 telescope optics head. Owned by Susan Ustin/University of California at Davis.

**Collection Environment:**

Open-air forest

**Source/Platform:**

Laboratory

**Source/Platform Mission Objectives:**

To measure the bi-directional reflectance with a dispersive grating spectroradiometer.

**Key Variables:**

Bi-directional Reflectance

**Principles of Operation:**

Dispersive grating spectroradiometer.

**Sensor/Instrument Measurement Geometry:**

The spectrometer head was mounted on a tripod approximately 0.5 meters above the stage, nadir-looking, with a 15 degree field of view. Two stabilized halogen lamps (Smith-Victor Corporation, Model 750; Griffith, Indiana) were used to illuminate the stage, each with an

emittance-angle of approximately 45 degrees. The lamps and the stage thus formed a triangle with the telescope receptor mounted in the center in a nadir orientation.

**Manufacturer of Sensor/Instrument:**

LI-COR 4421 Superior Street PO Box 4425 Lincoln, NE 68504 1-(402)-467-3576

## Calibration:

**Specifications:**

Measurements are reported in terms of reflectance made by comparison to a highly reflective reference panel. One spectrum was taken of a reference panel made from powdered haylon (polytetrafluoroethylene), ground, and packed to NBS specification (Weidner and Hsia, 1981; Weidner et al., 1985).

**Tolerance:**

A spectral calibration was performed by J. Dungan on this spectrometer on June 17, 1990 in Sisters, Oregon, using a helium neon laser with light output at 632.8 nm which indicated that the instrument performance was within the range of variation of other OTTER spectrometers (Dungan, personal communication with Dungan, 1991).

**Frequency of Calibration:**

Calibration scans were taken from the stage at approximately 30 minute intervals. Scans were made before and after each set of foliage measurements.

**Other Calibration Information:**

These values were examined for drift by ratioing them to the first calibration spectra in the file and visually examining the ratio for deviance from a straight line and for albedo offsets.

# 5. Data Acquisition Methods:

All spectrometer measurements for the Juniper, Metolius, and Santiam sites were taken under artificial illumination in the hotel room in Sisters, Oregon during a 3 day period between June 17-19, 1990. The next two days were spent with the system set up in a hotel room in Eugene, Oregon, measuring field samples obtained from the Scio and Warings Wood sites en route between Sisters and Eugene. Branch samples were collected by the OSU participants from selected trees by shotgun or pruning poles. All spectral measurements were made within 15 hours of collection. Samples were immediately tagged and placed into plastic bags and stored in a cooler until spectral measurements were made. After reflectance measurements were made using the LI-COR 1800 on the branches, the sample spectra were immediately measured under the same lamp arrangement by Dr. Carol Wessman (University of Colorado) using a GER SIRIS

spectroradiometer. Following her measurements, the branch samples were bagged and were taken to Dr. Wessman's laboratory for biochemical analyses.

A stage was constructed to measure the foliage while minimizing reflectance from background objects. A cardboard box, approximately 3 ft x 2 ft x 1.5 ft, was painted inside, around the opening, and over the upper surface with Krylon flat-black spray paint. An 18 cm diameter rectangular hole was cut in the center of the upper surface and conifer branch samples were placed across the hole for measurement. The hole edges were spray painted black. Corrugated cardboard dividers were also spray painted black and then assembled into an interwoven net and placed inside the box to act as baffles. The resulting stage produced a flat spectral response approximately 2% that of the reflectance panel.

Two tripods were placed on either side of the box to hold the power stabilized (PH Stabilizer, Model AVR-1000W) 1000 watt halogen lamps at 45 degree angles. This resulted in overlapping beam spots at the stage. The power output of the lamps was checked at the stage surface to determine the stability of light intensity across the FOV of the sensor and box opening. The LI-COR telescope lens was placed approximately 0.5 meters above the stage and the 15 degree (approximately circular) FOV entrance aperture was used. At 0.5 m height the FOV was approximately 13.1 cm. The lens aperture in the telescope was opened to permit visual inspection to ensure that the location of the FOV was within the opening of the box and for aligning the calibration panel.

# 6. Observations:

### Data Notes:

Information not available.

### Field Notes:

Five branches of each major tree species/site were cut from the trees used for the physiological measurements at the OTTER sites. The branch samlpes were selected, cut, and tagged (named and numbered) by OSU participants. The five branches of each tree were separately measured by stacking them individually over the hole in the stage and each one was scanned three times. The branches were rearranged and rotated 90 and 180 degrees and re-scanned. This procedure was done to decrease bias introduced by the architecture of the stacking. For ponderosa pine (Metolius fertilized and control sites), foliage was cut into five annual age class segments (stem area between each years needles was cut) and the spectra was recorded age class. This age class separation was not possible for other species and where possible, branches were arranged over the stage to maximize foliage from current years needles (for three replicates with rearranging their orientation between measurements) and regrouped to measure all older needle age classes in the FOV. Age class numbering is indicated as zero (current) year, one (one year old needles) year, to n-year age classes.

# 7. Data Description:

## Spatial Characteristics:

### Spatial Coverage:

Site 3C: Scio - Control Latitude 44.67 N, Longitude 122.61 W Site 3F: Scio - Single Fertilized Latitude 44.67 N, Longitude 122.61 W Site 4: Santiam Pass Latitude 44.42 N, Longitude 121.84 W Site 5F: Metolius - Fertilized Latitude 44.38 N, Longitude 121.68 W Site 5UH: Metolius - Control Latitude 44.38 N, Longitude 121.68 W Site 6: Juniper Latitude 44.29 N, Longitude 121.33 W

### Spatial Coverage Map:

Not applicable.

### Spatial Resolution:

Not applicable.

### Projection:

Not applicable.

### Grid Description:

Not applicable.

## Temporal Characteristics:

### Temporal Coverage:

19 June 1990 through 21 June 1990

### Temporal Coverage Map:

Not applicable.

### Temporal Resolution:

Not applicable.

## Data Characteristics:

### Parameter/Variable:

Emitted Radiation Reflected Radiation

**Variable Description/Definition:**

- Emitted Radiation: Energy (propogated in the form of electromagnetic waves) that is released into the atmosphere from the surface of the earth and other substances on the earth's surface.
- Reflected Radiation: A measure of the amount of radiation that is turned back from the surface upon which it strikes.

**Unit of Measurement:**

nm: Nanometers

**Data Source:**

Laboratory

**Data Range:**

Reflectance: (-15) <--> 50

### Sample Data Record:

Wavelength: 350.0 352.0 354.0 356.0 358.0 360.0 362.0 364.0 v366.0 368.0 370.0 Reflected Radiation: -5.882 -10.526 0.000 4.762 4.762 9.524 7.692 3.846 0.000 6.897 -3.226

# 8. Data Organization:

### Data Granularity:

The data are organized into two columns. The first column is the wavelength (nm) region in which the data have been measured. The second column is the measured hemispherial reflectance.

### Data Format:

There are 251 ASCII data sets available. All data sets have an accompanied XY plot of the data contained within. In addition, there is an ASCII dataset companion file: licor.doc, included with the complete data set.

# 9. Data Manipulations:

### Formulae:

**Derivation Techniques and Algorithms:**

Information not available.

### Data Processing Sequence:

Data processing information is not available.

### Calculations:

#### Special Corrections/Adjustments:

Percent reflectance was calculated for each foliage sample by ratioing the values to the mean calibration standard. Samples were then grouped by estimating the average and standard deviation of the species and age class categories. The wavelength range was between 400 nm to 800 nm. The nominal wavelength resolution was 3 nm.

#### Calculated Variables:

Information not available.

### Graphs and Plots:

An XY Plot is available for all data sets to show obvious discrepancies with the data.

## 10. Errors:

### Sources of Error:

It is possible that branch spectra changed during the storage time before measurements due to changes in pigment concentrations. Previous studies on ponderosa pine have shown that the spectra and chlorophyll contents remain stable (within measurement error) for more than 48 hours when stored using methods employed in this study. Changes in color and the loss of chlorophyll were visually noticed by the end of the set of scan measurements (ca. 1.5 minutes) on some samples, thus it is believed that it was possible for the light and/or heat of the lamps to have caused some deterioration and spectral changes in the samples during the measurement period.

### Quality Assessment:

#### Data Validation by Source:

To evaluate the above errors and others (e.g., measurement and/or recording errors), the spectra were displayed on computer and visually examined for obvious problems. The scans included in the data set seem reasonable. The mean and standard deviations of all spectra were examined for especially large standard deviations.

**Confidence Level/Accuracy Judgment:**

Information not available.

**Measurement Error for Parameters:**

Information not available.

**Additional Quality Assessments:**

Information not available.

**Data Verification by Data Center:**

Information not available.

# 11. Notes:

No notes about the data are available.

# 12. Application of the Data Set:

The emitted and reflected radiation measurements are a key portion in the OTTER project goals. They give hard, physical data about the sites in the study. The combination of this laboratory study with field work and remote sensing techniques will help to simulate and predict ecosystem processes.

# 13. Future Modifications and Plans:

No future plans, the OTTER campaign is complete.

# 14. Software:

## Software Description:

The public domain software package, Imdisp, is provided for image display on IBM compatibles. The popular shareware program, Stuffit, is necessary to extract the execution file for the Macintosh image display program, Image4pds.

## Software Access:

Software to display most of the OTTER image data (except Aviris and Asas data) on Macintosh and IBM personal computers (and compatibles) is provided on the CD-Rom disc containing the data sets.

# 15. Data Access:

### Contacts for Archive/Data Access Information:

Name: ORNL DAAC User Services Office

Address: ORNL DAAC User Services Office Oak Ridge National Laboratory U.S.A.

Telephone Number: 1-(865)-241-3952

Electronic Mail Address: ornldaac@ornl.gov

### Data Center Identification:

ORNL DAAC

### Procedures for Obtaining Data:

Contact the ORNL DAAC User Services Office Oak Ridge National Laboratory U.S.A.

Telephone: 1-(865)-241-3952 FAX: 1-(865)-574-4665 Internet: ornldaac@ornl.gov

### Data Center Status/Plans:

To be determined.

# 16. Output Products and Availability:

Available via FTP file or on CD-ROM.

Also available on-line via the World Wide Web at http://daac.ornl.gov.

# 17. References:

Dungan, J., Field Spectroradiometer Calibration Progress Report, Interoffice Memorandum, NASA/Ames Research Center, 5 January 1991.

Smith, M. O., S. L. Ustin, J. B. Adams, and A. R. Gillespie, 1990a, Vegetation in deserts I. A regional measure of abundance's from multispectral images, Remote Sensing of Environment, 29, pp. 1-26.

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Ustin, S. L., M. O. Smith, and J. D. Adams, 1993, Remote Sensing of Ecological Processes: A strategy for Developing Ecological Models Using Spectral Mixture Analysis. In J. Ehlringer and C. Field (Eds.) Scaling Processes Between Leaf and Landscape Levels. Academic Press, p.339-357. (in press)

Weidner, V. R. and J. J. Hsia, 1981, Reflection properties of pressed polytetrafluoroethylene powder. J. Opt. Soc. Am. 71: 856-861.

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# 18. Glossary of Terms:

Glossary terms can be found in the Glossary list.

# 19. List of Acronyms:

Additional acronyms can be found in the Acronyms list.

AVIRIS Airborne Visible Infrared Imaging Spectrometer ESD Environmental Science Division (Oak Ridge National Laboratory) FOV Field of View FTP File Transfer Protocol NASA National Aeronautics and Space Administration nm nanometers ORNL Oak Ridge National Laboratories Oak Ridge, Tennessee, U.S.A. OSU Oregon State University OTTER Oregon Transect Ecosystem Research SWIR Shortwave Infrared

# 20. Document Information:

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## Curator:

DAAC Staff

## Document

http://daac.ornl.gov/OTTER/guides/LICOR_Spectral_Reflectance_Data.html