Leaf Area Index Data (OTTER)

Summary:

LAI estimates computed from unweighted openness by the canopy program from digitized canopy photographs.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Leaf Area Index Data (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 gound observations. OTTER is an interdisciplinary project that tested a model that 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 vegetaion 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 stand mean and variability in the Leaf Area Index.

Summary of Parameters:

One parameter was investigated in this study: The leaf area index of various sites in the OTTER project.

Discussion:

The stand mean and the variability in the Leaf Area Index are important to both direct estimates of gas exchange parameters and for validation of remotely sensed image interpretation. Indirect methods for estimating light extinction and relating this property to gap fraction and leaf area index are well established since direct measures are impractical if not impossible. The basic assumption of these methods is that the one-sided canopy leaf area can be inferred from measurements of canopy gap area. Several instruments have been designed to measure this canopy property, including line quantum sensors, hemispherical light sensors, and hemispheric photographs. Computer software for analysis of digitized photographs is available (Rich 1989, 1990). The program CANOPY computes the "unweighted canopy openness" from the zenith and azimuth cells in the digitized fish-eye image. This matrix can then be analyzed using a one-dimensional extinction model (e.g., Norman and Campbell, 1989) or more simply by using the Beer-Lambert Law and assuming an extinction coefficient. Jarvis and Leverenz (1983) found that extinction coefficients ranged from 0.28-0.65 for 13 needle- and broad-leaved tree species, with an average of 0.47.

Related DataSets:

Canopy Chemistry Forest-BGC Model Leaf Reflectances: LICOR 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

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Title of Investigation:

OTTER Hemispherical Photographs and LAI Estimates

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3. Theory of Measurements:

The basic assumption of the methods which characterize the stand mean and variability is that the one-sided canopy leaf area can be inferred from measurements of canopy gap area. Several instruments have been designed to measure this canopy property, including line quantum sensors, hemispherical light sensors, and hemispheric photographs. Computer software for analysis of digitized photographs is also available for final determinations of the results.

4. Equipment:

Sensor/Instrument Description:

Camera: Canon 9 mm fisheye lens camera with Kodak Tri-X, ISO 400 black and white film.

Collection Environment:

Open-air forest

Source/Platform:

Field investigation

Source/Platform Mission Objectives:

To take 20 hemispherical photographs per site and analyze for the Leaf Area Index.

Key Variables:

MTA: Mean Tip Angle, or the leaf inclination angle. Z: Zenith, a cell in the digitized fish-eye image. Az: Azimuth, a cell in the digitized fish-eye image.

Principles of Operation:

The camera body is oriented with a compass so that the top is pointing toward the north and is leveled using a bubble level. The focal is set at infinity, exposure set with light meter, and no back filter was used. The assumption of the measurement is that the sky is uniformly bright relative to canopy elements and can be readily separated by differences in DN values in digitized images. Diffuse lighting is required to avoid specular reflections from stems and foliage to permit good separation between canopy and sky elements.

Sensor/Instrument Measurement Geometry:

A camera with a hemispheric lens was mounted on a tripod 0.5 m above the ground, in a direction oriented vertically up.

Manufacturer of Sensor/Instrument:

Canon

Calibration:

Specifications:

Blank exposed film was used to calibrate the film in the digitizing process.

Tolerance:

Information not available.

Frequency of Calibration:

Information not available.

Other Calibration Information:

Information not available.

5. Data Acquistion Methods:

All photographs for the Juniper, Metolius, and Santiam sites were taken were taken between sundown and sunset during a 3 day period between June 17-19, 1990. The Scio and Warings Wood sites were measured on a second trip to the OTTER sites in August, 1990. One roll per site of 20 hemispherical photographs (180 degrees FOV) were made on black and white film (Kodak Tri-X, ISO 400) with a Canon 9 mm fisheye lens. Locations for making the hemispherical photographs were made by randomly selecting an azimuth and walking a transect line in that orientation. Sites for photos were determined by pacing and stopping at 20 m intervals. After 10 slides, the transect direction was changed 90 degrees, paced off 40 m and returned to the origin

along the heading 180 degrees opposite the initial transect. The transects were continued until 20 slides were obtained. If the stand depth did not permit sufficient photos with 20 m spatial separation, then the direction was again turned 90 degrees, paced 40 m and finally reversed direction 180 degrees from the previous orientation.

6. Observations:

Data Notes:

Normally developed negatives were digitized using hardware and software (CANOPY program) described by Rich (1990). Software to compute the LAI from the unweighted openness produced by the CANOPY program was written by Scott N. Martens. Values for unweighted openness in each photograph were ratioed to those for a blank negative to obtain gap fraction for each of 160 segments (8 azimuth sectors and 20 zenith classes). When using Norman and Campbell's inversion model, the LAI was calculated for each of the eight azimuth sectors and then these values were averaged to provide the LAI for the image. This is essentially the same as using a log-average of the gap fractions about the azimuth as suggested by the work of Lang and Yuequin (1986). A second method of computing LAI using a Beer-Lambert Extinction model was also computed in the program. The two estimates do not give equivalent predictions and the user needs to determine which analytical method they prefer to accept. A comparison of methods for calculating gap fraction can be found in Martens et al. (1993). Finally an estimate of the mean tip angle (leaf inclination) was derived from the analysis.

The values of LAI computed by the two models and the mean tip angle are recorded by slide number. Values were initially inspected to determine whether they fell within physically reasonable limits (greater than 0 and less than an LAI=8). The LAI for the stands were averaged and standard deviations computed.

Field Notes:

Information not available.

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

Site 2: Warings Woods Latitude 44.60 N, Longitude 123.27 W 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:

Data gathered: 17 June 1990 through 19 June 1990 August 1990 Data run: 13 May 1991 through 15 May 1991

Temporal Coverage Map:

Not applicable.

Temporal Resolution:

Not applicable.

Data Characteristics:

Parameter/Variable:

Leaf Area Index.

Variable Description/Definition:

The total area of leaves (one-sided) in relationship to the ground below them.

Unit of Measurement:

Ratio (%)

Data Source:

Field investigation.

Data Range:

2.0 <--> 8.0

Sample Data Record:

Photo:0 0 0 0 0 0 0 0 0 1 1 Z: 20 20 20 20 20 20 20 20 20 20 NO: 5 6 2 2 4 6 8 7 5 5 Az: 1 2 3 4 5 6 7 8 1 2 LAI: 3.5689 3.6681 3.1393 3.2816 3.0302 3.4336 4.0148 3.8625 2.8769 3.5133 X: 9.9956 9.9956 9.9956 6.5327 8.7827 9.9956 9.9956 9.9956 8.6772 9.9956 MTA: 9.5470 9.5470 9.5470 12.0898 10.0031 9.5470 9.5470 9.5470 10.0574 9.5470

8. Data Organization:

Data Granularity:

The data are organized into seven columns within the data set. The first column (Photo) is the photo number and organization. The second column (Z) is the zenith sector, while the fourth column (Az) is the azimuth sector. The third column is the slide number. The fifth column (LAI) is the Leaf Area Index value. The seventh column (MTA) is the mean tip angle value.

Data Format:

There are seven ASCII data sets available: site2.dat, site3c.dat, site3f.dat, site4.dat, site5f.dat, site5uh.dat, and site6.dat. Datasets 2-6 each contain an XY Plot of the data contained within. In addition, there is an ASCII datset companion file: lai.doc, included with the complete data set.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

The matrix obtained from the zenith and azimuth data can be analyzed using a one-dimensional extinction model, or by using the Beer-Lambert Law.

Data Processing Sequence:

No information on the data processing is available.

Calculations:

Special Corrections/Adjustments:

If the stand depth at the site being analyzed did not permit sufficient photos with a 20 m spatial separation, then the investigators turned 90 degrees, paced 40 m and reversed direction 190 degrees from the previous orientation.

Calculated Variables:

Information not available.

Graphs and Plots:

There is an XY Plot available for the following data sets: site3c.dat, site3f.dat, site4.dat, site5f.dat, and site5uh.dat to show obvious discrepancies with the data.

10. Errors:

Sources of Error:

There are sources of error throughout all procedures. Probably the largest error is in the selection and number of field photographic measurements and the non-homogeneity of the forests. The next largest source of error is due to the violation of assumptions implicit in the analysis by conifers which have both highly non-random foliage distributions and small elongated foliage units (relative to distance from camera) that are subject to penumbra and resolution errors. Although the estimate of "mean tip angle (MTA)" or the leaf inclination angle is computed in the gap fraction analysis, it is particularly adversely affected by the non-homogeneity of the canopy and these values are probably substantially in error.

Quality Assessment:

Data Validation by Source:

The film was visually inspected before and after digitizing. The threshold to discriminate sky versus canopy DNs is selected by the interpreter and subject to bias. A student with considerable experience, Ms. Huoa Lo, digitized all the slides for this study.

Confidence Level/Accuracy Judgment:

There are no known problems with the data.

Measurement Error for Parameters:

Information not available.

Additional Quality Assessments:

Information not available.

Data Verification by Data Center:

Information not available.

11. Notes:

Notes about the data are not available.

12. Application of the Data Set:

The leaf area index 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 field work with laboratory study 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 diplay 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.

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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:

Lang, A. R. G. and X. Yuequin, 1986, Estimation of leaf area index from transmission of direct sunlight in a discontinuous canopies. Agri. Forest Meteor. 37: 220-243.

Martens, S. N., S. L. Ustin, and R. A. Rousseau, 1993, Estimation of tree canopy leaf area index by gap fraction analysis. Forest Ecology and Management (in press).

Norman, J. M. and G. S. Campbell, 1989, Canopy Structure. In: R. W. Pearcy, J. Ehleringer, H. A. Mooney and P. W. Rundel (Eds.), Plant Physiological Ecology: field methods and instrumentation. Chapman and Hall, New York, pp. 301-325.

Rich, P. M., 1989, A manual for analysis of hemispherical canopy photography. Los Alamos National Laboratory Report LA-11733-M.

Rich, P. M., 1990, Characterizing plant canopies with hemispherical photographs. Remote Sensing of Environment 5: 13-29.

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.

ESD Environmental Science Division (Oak Ridge National Laboratory) FTP File Transfer Protocol LAI Leaf Area Index MTA Mean Tip Angle NASA National Aeronautics and Space Administration ORNL Oak Ridge National Laboratories Oak Ridge, Tennessee, U.S.A OTTER Oregon Transect Ecosystem Research

20. Document Information:

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