Leaf Angle Data (FIFE)

Summary:

The Leaf Angle Data Data Set contains leaf angle distributions (LAD) obtained during the 1987 growing season for ten types of plant canopies, from the Konza Long-Term Ecological Research (LTER) area. These data were collected using a direct measurement technique (i.e., a Spatial Coordinate Apparatus (SCA)). The species selected were major species common on the prairie with the leaves were of sufficient size to allow SCA measurement.

The objective of this study was to obtain detailed LAD information on the major canopy species of the tallgrass prairie and selected agricultural crops. The LAD information for specific canopies can be used as input for a canopy radiation model. Canopy leaf orientation is an important parameter for plant growth modeling. Four categories of zenith angle distributions were found among the 14 species. These were planophile, plagiophile, erectophile, and uniform. Some canopies were found to have non-uniform leaf azimuth angle distribution. Also there were deferences between the upper and lower parts of the canopies for some species.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Leaf Angle Data (FIFE).
(Leaf Angle Data).

Data Set Introduction:

The Leaf Angle Data Data Set contains leaf angle distributions (LAD) obtained during the 1987 growing season for ten types of plant canopies, from the Konza Long-Term Ecological Research (LTER) area. These data were collected using a direct measurement technique (i.e., a Spatial Coordinate Apparatus (SCA)).

Objective/Purpose:

In this study, leaf angle distributions (LAD) were obtained for ten plant species from a tallgrass prairie using a direct measurement technique developed by Lang (1973). The objective of this study was to obtain detailed LAD information on the major canopy species of the tallgrass prairie and selected agricultural crops. The LAD information for specific canopies can be used as input for a canopy radiation model.

Summary of Parameters:

Zenith Angle, Azimuth Angle, Percent Leaf Area and Total Leaf Area.

Discussion:

Canopy leaf orientation is an important parameter for plant growth modeling. A leaf surface may be approximately represented by a set of continuous triangles (Lang 1973). In this study direct measurements of the leaf angle distribution of 10 types of plant canopies, from the Konza Long-Term Ecological Research (LTER) area, were taken during the 1987 growing season, using a Spatial Coordinate Apparatus (SCA). The species selected were major species common on the prairie with the leaves were of sufficient size to allow SCA measurement.

Distributions of the direct measurements are reported in this data set. Four categories of zenith angle distributions were found among the 14 species. These were planophile, plagiophile, erectophile, and uniform. Some canopies were found to have non-uniform leaf azimuth angle distribution. Also there were deference's between the upper and lower parts of the canopies for some species.

Related Data Sets:

- Total Leaf Tissue Water Potential. This data set contains leaf water potential data collected with a Scholander pressure chamber by the University of Nebraska group.
- Biophysical Properties of Vegetation. This data set contains measurements of leaf area index and biomass of difference canopy components.
- Vegetation Species and Cover Abundance. This data set contains species composition data, by site and data.

- Vegetation Species Reference. Konza LTER species names, codes, types and other reference information.
- Leaf Area Index and PAR Determined from UNL Light Bar Measurements. This data set contains data from the light bar (LICOR LI-191SA) collected by University of Nebraska group. The variables collected were photosynthetically active radiation, Absorbed photosynthetically active radiation, Intercepted photosynthetically active radiation and Leaf Area Index.
- Leaf Area Index and PAR Determined from KSU Light Bar Measurements. This data set contains data from the light bar collected by the Kansas State University Staff Science. Leaf Area Index and photosynthetically active radiation above and below the canopy were measured.
- Indirect Leaf Area Index Obtained from the UNL Light Wand. This data set contains data from the LICOR LAI-2000 Plant Canopy Analyzer collected by KSU staff science and the UNL group.

FIS Data Base Table Name:

LEAF_ANGLE_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Yuangui Li
Keystone Lab Houston

Title of Investigation:

Staff Science Data Acquisition Program.

Contact Information:

Contact 1:
Dr. Yuangui Li
Keystone Lab Houston
Houston, TX
Tel. (713) 975-2728

Requested Form of Acknowledgment.

The Leaf Angle Data were collected and analyzed by Dr. Yuangui Li as part of his Ph.D. dissertation work at Kansas State University.

3. Theory of Measurements:

In this study, each leaf was divided into several continuous triangles. Within each triangle, the surface was flat enough to be presented by one normal. This study used the Spatial Coordinate Apparatus (SCA), to obtain the coordinates of the apices of each triangle, which were then used to calculate the "area" and "normal" of the upper surface of each triangle in terms of its zenith and azimuth angles.

4. Equipment:

Sensor/Instrument Description:

The instrument used in this study is called the Spatial Coordinate Apparatus (SCA) (Lang 1973). The SCA consists of four arms connected to potentiometers. The top three arms can move in a vertical plane while the fourth arm can rotate upon its longitudinal axis. As the arms rotate, the angles of the rotation are measured in terms of voltages from the potentiometers and recorded in a computer. These voltage readings were then converted into 3-dimensional coordinates (x, y, z) of the endpoint of the top arm.

Collection Environment:

Ground-based.

Source/Platform:

Not available at this revision.

Source/Platform Mission Objectives:

To measure leaf zenith angle and leaf azimuth angle in a plant canopy.

Key Variables:

Leaf zenith angle and leaf azimuth angle.

Principles of Operation:

A leaf surface may be approximately represented by a set of contiguous triangles so that when the coordinates of apices of each triangle are determined the leaves are completely defined in space. The greater the number of triangles the better the approximation.

Sensor/Instrument Measurement Geometry:

The SCA instrument consists of four arms which are pivoted so that they moved in effect in a single plane, while the angles between the arms are measured by potentiometers.

Manufacturer of Sensor/Instrument:

Not available at this revision.

Calibration:

Not available at this revision.

Specifications:

Not available at this revision.

Tolerance:

Not available at this revision.

Frequency of Calibration:

Not available at this revision.

Other Calibration Information:

Not available at this revision.

5. Data Acquisition Methods:

Leaf Angle distribution measurements were conducted on ten plant species using the Spatial Coordinate Apparatus. The measurements were made at the Konza Long Term Ecological Research Area. Measurements were taken at about full canopy for each species. A large number of leaves were measured plant by plant and the number of plants measured ranged from 20 to 100 depending on the size of leaf. During the measurements, plants were shielded from the wind by using plastic boards, thereby reducing the leaf movement. Since a leaf surface is usually not flat, it is not adequate to assume one normal for each leaf.

6. Observations:

Data Notes:

Not available.

Field Notes:

None available at this revision.

7. Data Description:

Spatial Characteristics:

The FIFE study area, with areal extent of 15 km by 15 km, is located south of the Tuttle Reservoir and Kansas River, and about 10 km from Manhattan, Kansas, USA. The northwest corner of the area has UTM coordinates of 4,334,000 Northing and 705,000 Easting in UTM Zone 14.

Spatial Coverage:

Not applicable since this is a non-geographic data set.

Spatial Coverage Map:

Not available.

Spatial Resolution:

The total leaf area for a species is reported in square cm.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

The leaf angle distribution measurements were made at approximately noon on 7 selected dates between June 9, 1987 and August 4, 1987.

Temporal Coverage Map:

Not available.

Temporal Resolution:

Not applicable.

Data Characteristics:

The SQL definition for this table is found in the LEAF_ANG.TDF file located on CD-ROM Volume 1.

Parameter/Variable Name			
Parameter/Variable Description	**Range**	**Units**	**Source**
SITEGRID_ID This is a FIS grid location code. Site grid codes (SSEE-III) give the south (SS) and east (EE) cell number in a 100 x 100 array of 200 m square cells. The last 3 characters (III) are an instrument identifier.			FIS
STATION_ID The station ID designating the location of the observations.	999		FIS
OBS_DATE The date of the observations.	min = 09-JUN-87 max = 04-AUG-87		FIS
DISTRIBUTION_TYPE This is the type of distribution of the leaf angle measurements, ZENITH or AZIMUTH.	min = AZIMUTH, max = ZENITH		FIS
LEAF_BIN_CENTER_ANG The center angle of the bin distribution of leaves. There are 10 zenith bins (9 degrees each) and 10 azimuth bins (36 degrees each).	min = 0, max = 360, missing = -99.9	[degrees]	FIS
LTER_SPECIES_CODE The LTER species code. More information on this species can be found in the VEG_SPECIES_REF table.	2, 15, 18, 41, 43, 56, 128, 140, 164, 234		FIS

SPECIES_NAME The common name of the plant. Big Bluestem to Switchgrass	11 names from		FIS
PRCNT_LEAF_AREA The percent of the total leaf area which is facing the direction listed in LEAF_BIN_CENTER_ZEN and LEAF_BIN_CENTER_AZIM.	min = 0, max = 0.353	[percent]	FIS
TOTAL_LEAF_AREA The total leaf area measured, in square cm.	min = 327.17, max = 3909.98	[cm^2]	FIS
FIFE_DATA_CRTFCN_CODE The FIFE Certification Code for the data, in the following format: CPI (Certified by PI), CPI-??? (CPI - questionable data).	* CPI=Checked by Principal Investigator		FIS
LAST_REVISION_DATE data, in the format (DD-MMM-YY).	max = 27-JAN-90		

Footnotes:

* Valid levels

The primary certification codes are: EXM Example or Test data (not for release) PRE Preliminary (unchecked, use at your own risk) CPI Checked by Principal Investigator (reviewed for quality) CGR Checked by a group and reconciled (data comparisons and cross checks)

The certification code modifiers are: PRE-NFP Preliminary - Not for publication, at the request of investigator. CPI-MRG PAMS data that is "merged" from two separate receiving stations to eliminate transmission errors. CPI-??? Investigator thinks data item may be questionable.

Sample Data Record:

SITEGRID_ID	STATION_ID	OBS_DATE	DISTRIBUTION_TYPE	LEAF_BIN_CENTER_ANG
FIFE-LAM	99	09-JUN-87	ZENITH	85.500
FIFE-LAM	99	09-JUN-87	ZENITH	76.500
FIFE-LAM	99	09-JUN-87	ZENITH	67.500
FIFE-LAM	99	09-JUN-87	ZENITH	58.500

LTER_SPECIES_CODE	SPECIES_NAME	PRCNT_LEAF_AREA

```
2           BIG BLUESTEM         .0090
2           BIG BLUESTEM         .0150
2           BIG BLUESTEM         .0600
2           BIG BLUESTEM         .0410
```

TOTAL_LEAF_AREA	FIFE_DATA_CRTFCN_CODE	LAST_REVISION_DATE
1371.280	CPI	27-JAN-90
1371.280	CPI	27-JAN-90
1371.280	CPI	27-JAN-90
1371.280	CPI	27-JAN-90

8. Data Organization:

Data Granularity:

The total leaf area for a species is reported in square cm. The leaf angle distribution measurements were made at approximately noon on 7 selected dates between June 9, 1987 and August 4, 1987.

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

Data Format:

The CD-ROM file format consists of numerical and character fields of varying length separated by commas. The character fields are enclosed with a single apostrophe. There are no spaces between the fields. Each file begins with five header records. Header records contain the following information: Record 1 Name of this file, its table name, number of records in this file, path and name of the document that describes the data in this file, and name of principal investigator for these data.

Record 2 Path and filename of the previous data set, and path and filename of the next data set. (Path and filenames for files that contain another set of data taken at the same site on the same day.)

Record 3 Path and filename of the previous site, and path and filename of the next site. (Path and filenames for files of the same data set taken on the same day for the previous and next sites (sequentially numbered by SITEGRID_ID)).

Record 4 Path and filename of the previous date, and path and filename of the next date. (Path and filenames for files of the same data set taken at the same site for the previous and next date.)

Record 5 Column names for the data within the file, delimited by commas.

Record 6 Data records begin.

Each field represents one of the attributes listed in the chart in the *Data Characteristics Section* and described in detail in the TDF file. These fields are in the same order as in the chart.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

The measured leaf azimuth angles and leaf zenith angles were distributed into bins based their angle values. The azimuth angle bins have an interval of 36 degrees. The zenith angle bins have an interval of 9.5 degrees. The angle values for the center of the bin is reported for both leaf azimuth angles and leaf zenith angles.

The percent leaf area for each directional class was calculated by dividing the area in each directional class by the total measured leaf area.

The Switchgrass canopy was divided into upper and lower halves to examine the difference in leaf angle distributions between the two.

Data Processing Sequence:

Processing Steps:

Not available at this revision.

Processing Changes:

Not available at this revision.

Calculations:

For each selected species, corresponding pairs of azimuth and zenith angles of measured areas were plotted as points in polar coordinates to show the relative position of each measured area with respect to the solar position. The leaf angle distributions were calculated by first classifying the measured areas by their normal directions. These areas were then summed and the area in each directional class was divided by the total measured area. The canopy for Switchgrass was further analysis by dividing the canopy into upper and lower halves to see the differences in leaf angle distributions between the two.

Special Corrections/Adjustments:

Not available at this revision.

Calculated Variables:

- Percent leaf area for each directional class, and
- Leaf angle distributions.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

Not available at this revision.

Quality Assessment:

Data Validation by Source:

Not available at this revision.

Confidence Level/Accuracy Judgment:

Not available at this revision.

Measurement Error for Parameters:

The precision of the measurement was estimated by repeatedly measuring areas of 2 cm square with known azimuth and zenith angle. The relative error was found to be 6.7%. It should be noted that this relative error decreases as the size of measured area increases.

Additional Quality Assessments:

Not available at this revision.

Data Verification by Data Center:

The data verification performed by the ORNL DAAC deals with the quality of the data format, media, and readability. The ORNL DAAC does not make an assessment of the quality of the data itself except during the course of performing other QA procedures as described below.

The FIFE data were transferred to the ORNL DAAC via CD-ROM. These CD-ROMs are distributed by the ORNL DAAC unmodified as a set or in individual volumes, as requested. In addition, the DAAC has incorporated each of the 98 FIFE tabular datasets from the CD-ROMs into its online data holdings. Incorporation of these data involved the following steps:

- Copying the entire FIFE Volume 1, maintaining the directory structure on the CD-ROM;

- Using data files, documentation, and SQL code provided on the CD-ROM to create a database in Statistical Analysis System (SAS); and
- Creating transfer files to transfer the SAS metadata database to Sybase tables.

Each distinct type of data (i.e. "data set" on the CD-ROM), is accompanied by a documentation file (i.e., .doc file) and a data format/structure definition file (i.e., .tdf file). The data format files on the CD-ROM are Oracle SQL commands (e.g., "create table") that can be used to set up a relational database table structure. This file provides column/variable names, character/numeric type, length, and format, and labels/comments. These SQL commands were converted to SAS code and were used to create SAS data sets and subsequently to input data files directly from the CD-ROM into a SAS dataset. During this process, file names and directory paths were captured and metadata was extracted to the extent possible electronically. No files were found to be corrupted or unreadable during the conversion process.

Additional Quality Assurance procedures were performed as follows:

- Statistical operations were performed to calculate minimum and maximum values for all numeric fields and to create a listing of all values of the character fields. During this process, it was determined that various conventions were used to represent missing values. (Note: no modifications were made to any data by the DAAC). In most cases, missing value identification conventions were discussed in the accompanying .doc file. Based on a visual check of the minimum and maximum values, no glaring errors or holes were identified that might indicate errors introduced during CD-ROM mastering by the FIFE project or data ingest by the DAAC.
- Some minor inconsistencies and typographical errors were identified in some of the character fields and column labels, however, no modifications were made to the data by the DAAC.
- Some conversions of ASCII data were necessary to move the data from a DOS platform to a UNIX platform. Standard operating system conversion utilities were used (e.g., dos2unix).
- Much of the metadata required for archival is imbedded in the narrative documentation accompanying the data sets and extracted manually by DAAC staff who have read the .doc files provided on the CD-ROM and have hand entered this information into the metadata database maintained by the DAAC. QA procedures have been performed on these metadata to identify and eliminate typographical errors and inconsistencies in naming conventions, to ensure that all required metadata is present, and to ensure the accuracy of file names and paths for retrieval.
- Data requested for distribution to users are checked to verify that files copied from disk to other media remain uncorrupted.

As errors are discovered in the online tabular data by investigators, users, or DAAC staff, corrections are made in cooperation with the principal investigators. These corrections are then distributed to users. CD-ROM data are corrected when re-mastering occurs for replenishment of CD-ROM stock.

11. Notes:

Limitations of the Data:

Not available.

Known Problems with the Data:

None reported at this revision.

Usage Guidance:

Not available at this revision.

Any Other Relevant Information about the Study:

Not available at this revision.

12. Application of the Data Set:

The LAD information for specific canopies can be used as input for a canopy radiation model.

13. Future Modifications and Plans:

The FIFE field campaigns were held in 1987 and 1989 and there are no plans for new data collection. Field work continues near the FIFE site at the Long-Term Ecological Research (LTER) Network Konza research site (i.e., LTER continues to monitor the site). The FIFE investigators are continuing to analyze and model the data from the field campaigns to produce new data products.

14. Software:

Software to access the data set is available on the all volumes of the FIFE CD-ROM set. For a detailed description of the available software see the *Software Description Document*.

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
USA

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:

FIFE 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:

Leaf Angle Data are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

\DATA\BIOLOGY\LEAF_ANG\ydddFIFE.LAD

Note: capital letters indicate fixed values that appear on the CD-ROM exactly as shown here, lower case indicates characters (values) that change for each path and file.

The format used for the filenames is: *ydddFIFE.sfx*, where *y* is the last digit of the year (e.g., 7 = 1987, 9 = 1989), and *ddd* is the day of the year (e.g., 061 = sixty-first day of the year). The filename extension (.*sfx*), identifies the data set content for the file (see the *Data Characteristics Section*) and is equal to .LAD for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Not available at this revision.

Journal Articles and Study Reports.

Anderson, M.C. 1971. Radiation and crop structure. Plant Photosynthesis Production Manual of Methods. W. Junk Publishers. The Hague. 818 pp.

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Lang, A.R.G., X. Yuequin, and J.M. Norman. 1985. Crop structure and the penetration of direct sunlight. Agric. and For. Meteorol. 35:83-101.

Mann, J.E., G.L. Curry, D.W. DeMichele, and D.N. Baker. 1980. Light penetration in a row-crop with random plant spacing. Agron. J. 72:131-142.

Myneni, R.B., G. Asrar, E.T. Kanemasu, D.J. Lawlor, and I. Impens. 1986a. Canopy architecture, irradiance distribution in leaf surfaces and consequent photosynthetic efficiencies in heterogeneous plant canopies. Part I. Theoretical considerations. Agric. and For. Meteorol. 37:189-204.

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Oker-Blom, P. and S. Kellomaki. 1982. Effect of angular distribution of foliage in light absorption and photosynthesis in the plant canopy: theoretical computations. Agric. Meteorol. 26: 105-116.

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Ross, J. 1981. The radiation regime and architecture of plant stands. W. Junk Publishers. The Hague. Boston, London. 391 pp.

Smith, J.A., R.E. Oliver, and J.K. Berry. 1977. A comparison of two photographic techniques for estimating foliage angle distribution. Aust. J. Bot. 25:545-553.

Warren Wilson, W.J. 1959. Analysis of the spatial distribution of foliage by two-dimensional point quadrats. New Phytol. 58:92-101.

Warren Wilson, W.J. 1960. Inclined point Quadrats. New Phytol. 59: 1-8.

Warren Wilson, W.J. 1963. Estimation of foliage denseness and foliage angle by inclined point quadrats. Aust. J. Bot. 11:95-105.

Archive/DBMS Usage Documentation.

Contact the EOS Distributed Active Archive Center (DAAC) at Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee (see the *Data Center Identification Section*). Documentation about using the archive and/or online access to the data at the ORNL DAAC is not available at this revision.

18. Glossary of Terms:

A general glossary for the DAAC is located at Glossary.

19. List of Acronyms:

DAAC Distributed Active Archive Center EOS Earth Observing System EOSDIS EOS Data and Information System. FIFE First ISLSCP Field Experiment FIS FIFE Information System GMT Greenwich Mean Time IFC Intensive Field Campaign ISLSCP International Satellite Land Surface Climatology Project LAD Leaf Angle Distribution LAI Leaf Area Index LTER Long-Term Ecological Research Area ORNL Oak Ridge National Laboratory SCA Spatial Coordinate Apparatus TDF Table Definition File URL Uniform Resource Locator

A general list of acronyms for the DAAC is available at Acronyms.

20. Document Information:

April 24, 1994 (citation revised on October 14, 2002).

Warning: This document has not been checked for technical or editorial accuracy by the FIFE Information Scientist. There may be inconsistencies with other documents, technical or editorial errors that were inadvertently introduced when the document was compiled or references to preliminary data that were not included on the final CD-ROM.

Previous versions of this document have been reviewed by the Principal Investigator, the person who transmitted the data to FIS, a FIS staff member, or a FIFE scientist generally familiar with the data.

Document Review Date:

December 9, 1996.

Document ID:

ORNL-FIFE_LEAF_ANG.

Citation:

Cite this data set as follows:

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Document Curator:

DAAC Staff

Document URL:

http://daac.ornl.gov