1. TITLE

1.1 Data Set Identification.

Leaf Angle Data.

1.2 FIS Data Base Table Name.

LEAF\_ANGLE\_DATA.

1.3 CD-ROM File Name.

\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 Section 8.2) and is

equal to .LAD for this data set.

1.4 Revision Date of This Document.

April 24, 1994.

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.

2. INVESTIGATOR(S)

2.1 Investigators Names and Titles.

Dr. Yuangui Li

Keystone Lab Houston

2.2 Title of Investigation.

Staff Science Data Acquisition Program.

2.3 Contacts (For Data Production Information).

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| | Contact 1 |

|\_\_\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_|

|2.3.1 Name |Dr. Yuangui Li |

|2.3.2 Address |Keystone Lab Houston|

| |8300 W. Park |

| City/St |Houston, TX |

| Zip Code|77063 |

|2.3.3 Tel. |(713) 975-2728 |

|2.3.4 Email | |

|\_\_\_\_\_\_\_\_\_\_\_\_\_\_|\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_|

2.4 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. INTRODUCTION

3.1 Objectives/Purpose.

In this study, leaf angle distributions (LAD) were obtain 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.

3.2 Summary of Parameters.

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

3.3 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.

4. 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.

5. EQUIPMENT

5.1 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.

5.1.1 Platform.

Not available at this revision.

5.1.2 Mission Objectives.

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

canopy.

5.1.3 Key Parameters.

Leaf zenith angle and leaf azimuth angle.

5.1.4 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.

5.1.5 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.

5.1.6 Manufacturer of Instrument.

Not available at this revision.

5.2 Calibration.

Not available at this revision.

5.2.1 Specifications.

Not available at this revision.

5.2.1.1 Tolerance.

Not available at this revision.

5.2.2 Frequency of Calibration.

Not available at this revision.

5.2.3 Other Calibration Information.

Not available at this revision.

6. PROCEDURE

6.1 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.

6.2 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.

6.2.1 Spatial Coverage.

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

6.2.2 Spatial Resolution.

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

6.3 Temporal Characteristics.

6.3.1 Temporal Coverage.

The leaf angle distribution measurements were made at

approximately noon on 7 selected dates between June 9, 1987 and

August 4, 1987.

6.3.2 Temporal Resolution.

Not applicable.

7. OBSERVATIONS

7.1 Field Notes.

None available at this revision.

8. DATA DESCRIPTION

8.1 Table Definition With Comments.

The SQL definition for this table is found in the LEAF\_ANG.TDF file

found on CD-ROM Volume 1.

8.2 Type of Data.

--------------------------------------------------------------------------------

| 8.2.1 | | | |

|Parameter/Variable Name | | | |

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| | 8.2.2 | 8.2.3 | 8.2.4 | 8.2.5 |

| |Parameter/Variable Description |Range |Units |Source |

--------------------------------------------------------------------------------

|SITEGRID\_ID | | | |

| |This is a FIS grid location code. | | |FIS |

| |Site grid codes (SSEE-III) give | | | |

| |the south (SS) and east (EE) cell | | | |

| |number in a 100x100 array of 200m | | | |

| |square cells. The last 3 | | | |

| |characters (III) are an instrument | | | |

| |identifier. | | | |

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|STATION\_ID | | | |

| |The station ID designating the |999 | |FIS |

| |location of the observations. | | | |

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|OBS\_DATE | | | |

| |The date of the observations. |min = 09-JUN-87| |FIS |

| | |, | | |

| | |max = 04-AUG-87| | |

--------------------------------------------------------------------------------

|DISTRIBUTION\_TYPE | | | |

| |This is the type of distribution |min = AZIMUTH, | |FIS |

| |of the leaf angle measurements, |max = ZENITH | | |

| |ZENITH or AZIMUTH. | | | |

--------------------------------------------------------------------------------

|LEAF\_BIN\_CENTER\_ANG | | | |

| |The center angle of the bin |min = 0, |[degrees] |FIS |

| |distribution of leaves. There are |max = 360, | | |

| |10 zenith bins (9 degrees each) |missing = -99.9| | |

| |and 10 azimuth bins (36 degrees | | | |

| |each). | | | |

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|LTER\_SPECIES\_CODE | | | |

| |The LTER species code. More |2, | |FIS |

| |information on this species can be |15, | | |

| |found in the VEG\_SPECIES\_REF table.|18, | | |

| | |41, | | |

| | |43, | | |

| | |56, | | |

| | |128, | | |

| | |140, | | |

| | |164, | | |

| | |234 | | |

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|SPECIES\_NAME | | | |

| |The common name of the plant. |11 names from B| |FIS |

| | |ig Bluestem to | | |

| | |Switchgrass | | |

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|PRCNT\_LEAF\_AREA | | | |

| |The percent of the total leaf |min = 0, |[percent] |FIS |

| |area which is facing the direction |max = 0.353 | | |

| |listed in LEAF\_BIN\_CENTER\_ZEN and | | | |

| |LEAF\_BIN\_CENTER\_AZIM. | | | |

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|TOTAL\_LEAF\_AREA | | | |

| |The total leaf area measured, in |min = 327.17, |[cm^2] |FIS |

| |square cm. |max = 3909.98 | | |

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|FIFE\_DATA\_CRTFCN\_CODE | \* | | |

| |The FIFE Certification Code for |CPI=Checked by | |FIS |

| |the data, in the following format: |Principal Inves| | |

| |CPI (Certified by PI), CPI-??? |tigator | | |

| |(CPI - questionable data). | | | |

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|LAST\_REVISION\_DATE | | | |

| |The last revision date for the |min = 27-JAN-90| |FIS |

| |data, in the format (DD-MMM-YY). |, | | |

| | |max = 27-JAN-90| | |

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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.

8.3 Sample Data Base Data Record.

SITEGRID\_ID STATION\_ID OBS\_DATE DISTRIBUTION\_TYPE LEAF\_BIN\_CENTER\_ANG

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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

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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

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1371.280 CPI 27-JAN-90

1371.280 CPI 27-JAN-90

1371.280 CPI 27-JAN-90

1371.280 CPI 27-JAN-90

8.4 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

section 8.2 and described in detail in the TDF file (see section 8.1).

These fields are in the same order as in the chart.

8.5 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.

9. DATA MANIPULATIONS

9.1 Formulas.

9.1.1 Derivation Techniques/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.

9.2 Data Processing Sequence.

9.2.1 Processing Steps and Data Sets.

Not available at this revision.

9.2.2 Processing Changes.

Not available at this revision.

9.3 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.

9.3.1 Special Corrections/Adjustments.

Not available at this revision.

9.4 Graphs and Plots.

None.

10. ERRORS

10.1 Sources of Error.

Not available at this revision.

10.2 Quality Assessment.

10.2.1 Data Validation by Source.

Not available at this revision.

10.2.2 Confidence Level/Accuracy Judgment.

Not available at this revision.

10.2.3 Measurement Error for Parameters and Variables.

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.

10.2.4 Additional Quality Assessment Applied.

Not available at this revision.

11. NOTES

11.1 Known Problems With The Data.

None reported at this revision.

11.2 Usage Guidance.

Not available at this revision.

11.3 Other Relevant Information.

Not available at this revision.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation.

Not available at this revision.

12.2 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.

Bonhomme, R. and P. Chartier. 1972. The interpretation

automatic measurement of hemispheric photograph to obtain

sunlit foliage area and gap frequency. Isr. J. Agric. Res.

22: 53-61.

Goudriaan, J. 1977. Crop micormeteoroloy: a simulation study.

Center for Agricultural Publication and Documentation.

Wageningen. pp. 1-249.

Lang, A.R.G. 1973. Leaf orientation of a cotton plant. Agric.

Meteorol. 11:37-51.

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.

Myneni, R.B., G. Asrar, E.T. Kanemasu, D.J. Lawlor, and I.

Impens. 1986b. Canopy architecture, irradiance distribution

in leaf surfaces and consequent photosynthetic efficiencies

in heterogeneous plant canopies. Part II. Results and

discussion. Agric. and For. Meteorol. 37:205-218.

Norman, J.M. 1982. Simulation of microclimates. Biometeorology

and Integrated Pest Management Eds. J.L. Hatfield and I.J.

Thomason. Academic Press. NY. pp. 65-99.

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.

Perry, S.G. 1985. Remote sensing of plant canopy structure

with simple radiation measurements. Ph.D. Dissertation. The

Pennsylvania State University. University Park, PA 16802. 199

pp.

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.

12.3 Archive/DBMS Usage Documentation.

The Collected Data of the First ISLSCP Field Experiment is archived at

the EOS Distributed Active Archive Center (DAAC) at Oak Ridge National

Laboratory (ORNL), Oak Ridge, Tennessee (Section 13 below).

Documentation about using the archive and/or online access to the data

at the ORNL DAAC is not available at this revision.

13. DATA ACCESS

13.1 Contacts for Archive/Data Access Information.

ORNL DAAC User Services

P.O. Box 2008

Mail Stop 6490

Oak Ridge National Laboratory

Oak Ridge, TN 37831-6490

(615) 241-3952

13.2 Archive Identification.

EOSDIS Distributed Active Archive Center

P.O. Box 2008

Mail Stop 6490

Oak Ridge National Laboratory

Oak Ridge, TN 37831-6490

USA

Telephone: (615) 241-3952

FAX: (615) 574-4665

Internet Email: ornldaac@onrl.gov

13.3 Procedures for Obtaining Data.

Users may place requests by letter, telephone, electronic mail, FAX, or

personal visit.

13.4 ORNL DAAC Status/Plans.

FIFE data will be available from the ORNL DAAC. Please contact the

ORNL DAAC User Services Office for the most current information about

these data.

14. OUTPUT PRODUCTS AND AVAILABILITY

14.1 Tape Products.

None.

14.2 Film Products.

None.

14.3 Other Products.

Leaf Angle Data are available on FIFE CD-ROM Volume 1.

15. GLOSSARY OF ACRONYMS

CD-ROM Compact Disk (optical), Read-Only Memory

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