LAI & PAR Data: Light Bar - KSU (FIFE)

Summary:

The purpose of the Leaf Area Index and PAR Determined from KSU Light Bar Measurements study was to collect extensive non-destructive measurements of Leaf Area Index (LAI) at the flux sites during IFC-5 (August 1989). These data were collected at thirteen locations which were coincident with the surface flux measurements within the FIFE study area from July 3, 1989 through August 18, 1989.

The various fractions of the Photosynthetically Active Radiation (PAR) (i.e., diffuse, reflected, transmitted and total) were measured using a Line Quantum meter from LI-COR Inc. From these fractions the ratio of reflected to total incoming PAR was computed. LAI can be estimated from light bar measurements of PAR transmittance from measurements above and below a vegetation canopy. The use of the light bar allows rapid, multiple, and repeatable measurements of LAI at the FIFE sites. This type of measurements could not be done using destructive measurements of LAI.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

LAI & PAR Data: Light Bar - KSU (FIFE).
(Leaf Area Index and PAR Determined from KSU Light Bar Measurements).

Data Set Introduction:

The Leaf Area Index and PAR Determined from KSU Light Bar Data Set was collected at thirteen locations which were coincident with the surface flux measurements within the FIFE study area from July 3, 1989 through August 18, 1989. The data set contains the total incoming reflected, diffuse and transmitted PAR, and the ratio of reflected to total PAR collected using non-destructive techniques.

Objective/Purpose:

The purpose of this study is to collect extensive non-destructive measurements of Leaf Area Index (LAI) at the flux sites during IFC-5 (August 1989).

Summary of Parameters:

Total incoming reflected, diffuse and transmitted PAR, and the ratio of reflected to total PAR.

Discussion:

The various fractions of the Photosynthetically Active Radiation (PAR) - diffuse, reflected, transmitted and total - were measured using a Line Quantum meter from LI-COR Inc. From these fractions an indirect measure of Leaf Area Index (LAI) was computed as well as the ratio of reflected to total incoming PAR. These data were collected at thirteen locations which were coincident with the surface flux measurements within the FIFE study area from July 3, 1989 through August 18, 1989.

Related Data Sets:

- SE-590 Reflectance Factors and Radiances from UNL. This data set contains nadir and off nadir SE590 (ground measured) spectrometer radiances and reflectances measurements from the University of Nebraska group.
- SE-590 Reflectance Factors and Radiances Measured from a Helicopter. This data set contains reflectance measured with the helicopter mounted SE590 spectrometer.
- SE-590 Spectroradiometer Reflectance Factors from GSFC. This data set contains nadir and off nadir SE-590 (ground measured) spectrometer radiances and reflectances measurements from the Goddard Space Flight Center SRB group.
- Surface Reflectance Measured by the PARABOLA. This data set contains Don Deering's PARABOLA data; sky and ground radiance values collected using a sphere-scanning radiometer. This data has been averaged to give equal intervals of viewing angles.
- Leaf Angle Data. This data set contains data on the orientation of leaves of 10 different species.
- 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 the 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.
- 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 the UNL group.
- Indirect Leaf Area Index Obtained from the KSU Light Wand. This data set contains data from the LICOR LAI-2000 Plant Canopy Analyzer collected by KSU staff science.

FIS Data Base Table Name:

LIGHT_BAR_KSU_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Tanvir Shah
Alabama A & M University

Dr. E.T. Kanemasu (Head)
University of Georgia

Title of Investigation:

Measuring and Modeling Near-Surface Reflected and Emitted Radiation Fluxes at the FIFE Site.

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Requested Form of Acknowledgment.

The Leaf Area Index and PAR Determined from KSU Light Bar Measurements was collected as part of the KSU staff science effort directed by Dr. E.T. Kanemasu.

3. Theory of Measurements:

Light traveling through a vegetation canopy is attenuated by interception with leaves. The fraction of photosynthetically active radiation transmitted through the canopy is related to the distribution and amount of leaves in the canopy. If the leaves are assumed to be randomly distributed in the canopy and opaque in the PAR wavelengths the irradiance at the bottom of the canopy is given by the following:

I = Io * exp(-k * LAI)

where **Io** is the incoming irradiance, **LAI** is the leaf area index, and **k** is an extinction coefficient. The exponent, **k * LAI**, is the area of the shadow of the leaves projected onto a horizontal plane. Assuming a spherical leaf angle distribution, i.e., the distribution of leaf inclination and orientation angles is similar to those found on the surface of a sphere, **k**, can be calculated from the solar zenith angle, **SZA**:,

k = 05. * cos(SZA)

These equations can be combined to solve for **LAI** from light bar measurements of PAR transmittance from measurements above and below the canopy. The use of the light bar allows rapid, multiple, and repeatable measurements of **LAI** at the FIFE sites. This type of measurements could not be done using destructive measurements of **LAI**.

4. Equipment:

Sensor/Instrument Description:

The quantum sensors measured photosynthetically active radiation (PAR) in the 0.4 to 0.7 micron waveband and produced an analog voltage response proportional to the scene irradiance. The fraction of photosynthetically active radiation (PAR) intercepted by vegetation at the flux stations was measured using 3 point PAR quantum sensors (LI-190 SB quantum sensors, LI-COR Inc.) and a 50 cm long line PAR quantum sensor (light-bar, Evapotranspiration Laboratory #1). All the PAR sensors were covered with white diffusers. The commercially available 1m long light-bar (from LI-COR Inc.) was not used, because it caused too much disturbance of the grass canopy. The LI-COR light-bar has a cross section area of 2.5 x 2.5 [cm^2]. When grass is

short or brush-like, the large light bar under estimates interception because it either projects above the canopy, or parts the grass unnaturally allowing excessive amounts of light to reach the sensor. The 50 cm long light-bar was made from approximately 100 GaAsP photodiodes (CP-1511C, from Centronic Inc.) connected in parallel. The array of diodes was mounted in 0.9 cm x 0.9 cm x 50 cm long aluminum bar. The window of the light bar was made of a 1/16 inch thick white Plexiglas to act as diffuser.

Collection Environment:

Ground-based.

Source/Platform:

The light bar was hand held in a horizontal position.

Source/Platform Mission Objectives:

Not applicable.

Key Variables:

Incoming, reflected, and transmitted photosynthetically active radiation (PAR) measured with a Light Bar, and Leaf Area Index calculated from the PAR measurements.

Principles of Operation:

Not available at this revision.

Sensor/Instrument Measurement Geometry:

The line quantum sensor was hand-held in a horizontal position. Incoming photosynthetically active radiation (PAR) were measured with the sensor held upright above the canopy at an approximate height of 1.5 m above the soil surface. Reflected PAR were measured with the sensor held inverted above the canopy at an approximate height of 0.5 m above the canopy surface. Transmitted PAR were measured with the sensor held upright in the canopy at the soil surface. The sensor has a near hemispherical field-of-view along its 1 m length.

Manufacturer of Sensor/Instrument:

LI-COR, inc.
4421 Superior Street
P.O. Box 4425
Lincoln, Nebraska 68504
(402) 467-3576

Calibration:

The calibration factors for the three point PAR sensors used were supplied by LI-COR Inc. and were as follows:

PAR sensor	LI-COR Serial #	Calibration ([mV][1000 microEinstein^-1] [m^-2][sec^-1])
up-looking	570-7302	2.76
down-looking	4203	3.76
up-looking (shaded)	566-7302	2.43

Specifications:

The light-bar was calibrated against the above 3 point quantum sensors over a two-day period at a CO2 enrichment experimental site about one and half miles north of Kansas State University's Campus. The calibration factor for the light-bar (Evapotranspiration Laboratory. #1) is:

18.34 [mV][1000 microEinstein^-1][m^-2][sec^-1]

The dark level outputs of the PAR sensors was less than 0.0005 mV and no correction for dark level output was applied during data processing.

Tolerance:

Not known.

Frequency of Calibration:

June 28 and 29, 1989.

Other Calibration Information:

Not available at this revision.

5. Data Acquisition Methods:

The 3 point quantum sensors were mounted on a tripod with attachments for holding the sensors. The tripod and attachments were oriented to minimize any shading of the plot by the mounting frame-work. One point quantum sensor looked upwards for monitoring the incoming light. Another sensor looked downwards from a height of about 1 m above the canopy for obtaining the reflected PAR. The third point sensor was set up for monitoring the diffuse incoming PAR. It looked upwards and was shaded with a 1.5 cm wide strip of metal from a distance of about 14 cm. The light-bar was slid into the base of the grass canopy so as to cause minimum disturbance. All sensors were leveled before taking a reading. The output of all 4 sensors was recorded simultaneously on a data logger (Omnidata polycorder). The light-bar was then taken out and re-inserted at the base of the grass canopy about 10-20 cm away from its previous position within the plot, and a second replicate set of readings were taken. Light bar measurements were also

made in conjunction with destructive sampling measurements of LAI for some plots for comparison of the methodologies. These measurements have an SAMPLE_TYPE of 'DS'. Some of the plots that were destructively sampled were watered prior to the light bar measurements. This was done to cause the leaves to uncurl to get a better measurement of LAI. (see the *Field Notes Section* to see when this was done). These measurements have an SAMPLE_TYPE of 'DSWW'.

6. Observations:

Data Notes:

Not available.

Field Notes:

DATE	SITE SAMPLED	1989 PLOTS	WHERE AND REPS	APPROX. # OF	REMARKS
906	7/03	behind	4 plots 2 readings/plot	measurements,	well-watered before destructively sampled after measurements
910	7/04	behind	4 plots 2 readings/plot	measurements,	well-watered before destructively sampled after measurements
911	7/05	behind	4 plots 2 readings/plot	measurements,	well-watered before destructively sampled after measurement
944	7/06	behind	4 plots 2 readings/plot	measurements,	well-watered before destructively sampled after measurement
921	7/07	behind	4 plots 2 readings/plot	measurements,	well-watered before destructively sampled after measurement
908	7/10	in WAB	27 plots 2 readings/plot		data set not complete
906	7/10	in WAB	50 plots 2 readings/plot		
919	7/11	in WAB	18 plots 2 readings/plot		data set not complete
921	7/11	in WAB	50 plots 2 readings/plot		
902	7/12	in WAB	25 plots 2 readings/plot		
911	7/12	in WAB	50 plots 2 readings/plot		
910	7/13	in WAB	25 plots		

2 readings/plot
912 7/13 in WAB 25 plots
2 readings/plot
936 7/13 in WAB 25 plots
2 readings/plot
913 7/14 in WAB 25 plots
2 readings/plot
944 7/14 in WAB 25 plots
2 readings/plot
925 7/14 in WAB 25 plots
2 readings/plot
938 7/14 in WAB 25 plots
2 readings/plot
910 7/17 behind 20 plots destructively
WAB 2 readings/plot sampled after
measurement
910 7/17 in WAB 25 plots
2 readings/plot
944 7/18 behind 20 plots destructively
WAB 2 readings/plot sampled after
measurement
944 7/18 in WAB 25 plots
2 readings/plot
911 7/19 behind 20 plots destructively
WAB 2 readings/plot sampled after
measurement
911 7/19 in WAB 50 plots
2 readings/plot
906 7/20 behind 20 plots destructively
WAB 2 readings/plot sampled after
measurement
906 7/20 in WAB 30 plots incomplete data set
2 readings/plot
921 7/21 behind 20 plots destructively
WAB 2 readings/plot sampled after
measurement
921 7/21 in WAB 50 plots
2 readings/plot
908 7/24 in WAB 24 plots
2 readings/plot
910 7/24 in WAB 25 plots
2 readings/plot
902 7/24 in WAB 25 plots
2 readings/plot
938 7/25 in WAB 25 plots
2 readings/plot
936 7/25 in WAB 25 plots
2 readings/plot
944 7/25 in WAB 25 plots
2 readings/plot
912 7/26 in WAB 25 plots
2 readings/plot
921 7/26 in WAB 50 plots
2 readings/plot
913 7/27 in WAB 25 plots
2 readings/plot
925 7/27 in WAB 24 plots

2 readings/plot
906 7/27 in WAB 50 plots
2 readings/plot
919 7/28 in WAB 25 plots
2 readings/plot
911 7/28 in WAB 50 plots
2 readings/plot
944 7/31 behind 10 plots destructively
WAB 2 readings/plot sampled after
measurement
944 7/31 in WAB 25 plots
2 readings/plot
910 8/01 behind 10 plots destructively
WAB 2 readings/plot sampled after
measurement
910 8/01 in WAB 25 plots
2 readings/plot
921 8/02 behind 10 plots destructively
WAB 2 readings/plot sampled after
measurement
921 8/02 in WAB 50 plots
2 readings/plot
906 8/04 behind 10 plots destructively
WAB 2 readings/plot sampled after
measurement
906 8/04 in WAB 50 plots
2 readings/plot
911 8/04 behind 10 plots destructively
WAB 2 readings/plot sampled after
measurement
911 8/05 in WAB 50 plots
2 readings/plot
902 8/07 in WAB 25 plots
2 readings/plot
910 8/07 behind 4 plots well-watered before
WAB 2 readings/plot measurements,
destructively sampled
after measurements
906 8/07 behind 4 plots well-watered before
WAB 2 readings/plot measurements,
destructively sampled
after measurements
921 8/08 behind 4 plots well-watered before
WAB 2 readings/plot measurements,
destructively sampled
after measurements
911 8/08 behind 4 plots well-watered before
WAB 2 readings/plot measurements,
destructively sampled
after measurements
944 8/08 behind 4 plots well-watered before
WAB 2 readings/plot measurements,
destructively sampled
after measurements
908 8/08 in WAB 25 plots
2 readings/plot
938 8/09 in WAB 25 plots

```
2 readings/plot
936   8/09  in WAB   25 plots
2 readings/plot
912   8/10  in WAB   25 plots
2 readings/plot
925   8/10  in WAB   25 plots
2 readings/plot
913   8/11  in WAB   25 plots
2 readings/plot
919   8/11  in WAB   25 plots
2 readings/plot
906   8/14  behind   20 plots          destructively
WAB      2 readings/plot   sampled after
measurement. Plot #s
13-20 were in the
PARABOLA area
906   8/14  in WAB   50 plots
2 readings/plot
921   8/15  behind   20 plots          destructively
WAB      2 readings/plot   sampled after
measurement Plot
#s 1-9 were in
the PARABOLA area
921   8/15  in WAB   50 plots
2 readings/plot
911   8/16  behind   20 plots          destructively
WAB      2 readings/plot   sampled after
measurement. Plot #s
13-20 were in the
PARABOLA area.
911   8/16  in WAB   50 plots
2 readings/plot
910   8/17  behind   20 plots          destructively
WAB      2 readings/plot   sampled after
measurement
910   8/17  in WAB   25 plots
2 readings/plot
944   8/18  behind   20 plots          destructively
WAB      2 readings/plot   sampled after
measurement
944   8/18  in WAB   25 plots
2 readings/plot
```

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:

This is point data collected at specific locations within the FIFE study area. Measurements were taken at thirteen stations during FIFE 1989. These stations were coincident with the surface flux stations during 1989. The locations and characteristics of these locations are listed below.

	SITEGRID	STN_ID	NORTHING	EASTING	LATITUDE	LONGITUDE	ELEV
1478-BRS	938	4331223	720664	39 06 15	-96 26 53	375	
1916-BRK	902	4330282	708259	39 05 55	-96 35 30	351	
1942-BRL	944	4330133	713414	39 05 46	-96 31 56	422	
2133-ECA	906	4329726	711604	39 05 34	-96 33 12	443	
2330-BRK	908	4329314	711066	39 05 22	-96 33 35	424	
2655-BRL	936	4328787	716070	39 05 00	-96 30 07	367	
3129-BRK	912	4327822	710820	39 04 33	-96 33 47	431	
3317-BRK	910	4327395	708485	39 04 22	-96 35 24	427	
4168-SAM	925	4325704	718646	39 03 18	-96 28 24	438	
4439-PAM	911	4325219	712795	39 03 07	-96 32 27	445	
6735-BRL	913	4320652	712073	39 00 40	-96 33 03	385	
6735-PAM	813	4320652	712073	39 00 40	-96 33 03	385	
6912-PAM	919	4320178	707307	39 00 29	-96 36 21	385	
8639-SAM	921	4316771	712827	38 58 33	-96 32 36	440	

	SITEGRID	SLOPE	ASPECT
1478-BRS	2	N	
1916-BRK	2	N	
1942-BRL	1	TOP	
2133-ECA	1	TOP	
2330-BRK	5	E	
2655-BRL	4	E	
3129-BRK	14	E	
3317-BRK	15	W	
4168-SAM	1	TOP	
4439-PAM	2	N	
6735-BRL	1	BOTTOM	
6735-PAM	1	BOT	
6912-PAM	2	N	
8639-SAM	1	TOP	

The number of plots measured at each site (by date) and their position in relation to the Wind Aligned Blobs (WAB) are listed in the *Field Notes Section*.

The permanent (140-240 degree) WABs at the super-sites (sites 906, 911, and 921) were marked with 100 flags with the density of flags varying with distance from the flux station as follows:

Radial Distance (m):	10	20	30	40	50	60	70	80	90	100
Sample Frequency:	2	7	10	12	13	13	13	12	10	8

These flag positions are referred to as plots within the sites. The positions of these plots within the permanent WABs were fixed throughout the duration of FIFE 89. These plots were

numbered sequentially. Plot 1 was the first plot just in from the 240 degree compass bearing on the 10 m arc from the apex of the WAB, and plot 100 was 100 m away from the apex on the 240 degree compass bearing. Plots at the non-supersites (all other flux sites) were marked out at half the density of plots at the super- sites (i.e. 50 plots in the 140-240 degree WAB). PAR readings in the WAB were taken at odd numbered plots while light-wand readings were taken at every plot in the WAB. A given plot number in any data set corresponds to the same location at the site. In the case of in-WAB measurements these locations were fixed throughout the duration of FIFE 89. In addition to readings in the WABs PAR and light-wand readings were also taken behind the WABs at positions where destructive samples (for LAI and biomass) were due to be taken. The non-destructive measurements were always taken just before (less than ½ hour prior to) destructive sampling. The destructive plots were usually positioned 5 - 10m apart along a linear east-west transect about 20 m or so behind the WAB apex, i.e., within the 270-90 degree compass bearings from the flux measuring apparatus. The plots were labeled sequentially. Also a limited number of PAR and LAI-2000 readings were taken in the PARABOLA areas at the super-sites. On August 14, 15, and 16 the transects to examine drought stress on leaf curl and those used for destructive sampling passed through the PARABOLA areas. These transects are identified with a SAMPLE_TYPE of DS for destructive sampling, or DSWW for destructive sampling and well watered. For these plots a full set of destructive and non-destructive measurements is available. On August 14 at site 906 destructive plots 13 - 20 were in the PARABOLA area. On August 15 at site 921 destructive plots 1 - 9 were in the PARABOLA area. On August 16 at site 911 destructive plots 13 - 20 were in the PARABOLA area.

Spatial Coverage Map:

Not available.

Spatial Resolution:

The LI-COR LI-191SA line quantum sensor and LI-COR LI-190 SA quantum sensor have a near hemispherical field-of-view. The plot size was approximately 3 m x 3 m.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

One set of two measurements took approximately 1 minute. The time (5 to 60 minutes) to complete all the measurements at a site depended on the number of plots at the site.

Temporal Coverage:

The data was collected between July 3, 1989 and August 18, 1989. The measurement time ranged from 1249 to 2400 GMT. Measurements were not continuously made over this range but were in discrete measurement periods. Some observation dates only have morning or evening measurements.

Temporal Coverage Map:

Not available.

Temporal Resolution:

The optimum time interval between plot measurements was approximately 1-2 minutes. The typical time interval between plots was approximately 5 minutes. The time interval depended on the distance between the plots, the terrain, and sky conditions.

Data Characteristics:

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

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 m 200 m square cells. The last 3 characters (III) are an instrument identifier.

STATION_ID
The station ID designating the location of the observations.

OBS_DATE
The date of the observations, in the format (DD-MMM-YY).

OBS_TIME
The time that the observation was taken in GMT. The format is (HHMM). [GMT]

PLOT_NUM The plot number at the site where the observations were made.		
SAMPLE_TYPE The information about the treatment of the plot where the data were collected, such as if the plot was watered or destructively sampled.	*	
CALC_LAI The leaf area index as calculated from the light bar, using the relationship: LINE_QUANTM_TRNS_PAR/ LINE_QUANTM_TOT_INCOM_PAR = EXP (-((0.5/COS(SOLAR_ZEN_ANG))*LAI))		
LINE_QUANTM_TOT_INCOM_PAR The Line Quantum Total Incoming PAR (Photosynthetically active radiation) [Abbreviated LT].		[microEinst] [meter^-2] [sec^-1]
LINE_QUANTM_REFL_PAR The Line Quantum Reflected PAR (Photosynthetically active radiation) [Abbreviated LR].		[microEinst] [meter^-2] [sec^-1]
LINE_QUANTM_DIFFUSE_PAR The Line Quantum Diffuse PAR (Photosynthetically Active Radiation).		[microEinst] [meter^-2] [sec^-1]
LINE_QUANTM_TRNS_PAR The Line Quantum PAR (Photosynthetically active radiation) transmitted through the canopy [Abbreviated LC].		[microEinst] [meter^-2] [sec^-1]
PAR_REFL_FACTOR The ratio of the reflected to total PAR (Photosynthetically Active Radiation). = LINE_QUANTM_REFL_PAR / LINE_QUANTM_TOT_INCOM_PAR.		
OBS_NUM The number of pairs of above and below canopy observations used in the calculations.		
FIFE_DATA_CRTFCN_CODE The FIFE Certification Code for	**	

```
the data, in the following format:
CPI (Certified by PI), CPI-???
(CPI - questionable data).
```

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

Footnotes:

* Decode the SAMPLE_TYPE field as follows: DS Destructive sampling DSWW Destructive sampling and plots are well watered

** Decode the FIFE_DATA_CRTFCN_CODE field as follows:

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	OBS_TIME	PLOT_NUM	SAMPLE_TYPE	CALC_LAI
1942-LBK	944	18-JUL-89	1611	13	DS	.320
1942-LBK	944	18-JUL-89	1611	13	DS	.347
1942-LBK	944	18-JUL-89	1612	14	DS	.543
1942-LBK	944	18-JUL-89	1612	14	DS	.239

LINE_QUANTM_TOT_INCOM_PAR	LINE_QUANTM_REFL_PAR	LINE_QUANTM_DIFFUSE_PAR
.464	.041	.398
.440	.040	.395
.584	.051	.404
.489	.042	.388

LINE_QUANTM_TRNS_PAR	PAR_REFL_FACTOR	OBS_NUM	FIFE_DATA_CRTFCN_CODE
.381	.088	1	PRE
.356	.091	2	PRE
.420	.088	1	PRE
.423	.086	2	PRE

LAST_REVISION_DATE
15-SEP-89
15-SEP-89
15-SEP-89
15-SEP-89

8. Data Organization:

Data Granularity:

This is point data collected at specific locations within the FIFE study area. Measurements were taken at thirteen stations during FIFE 1989. Measurements were not continuously made but were in discrete measurement periods.

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:

K = V * CC [1]

where:

K = photosynthetically active radiation [microEinstein][sec^-1][m^-2]
V = voltage (mV)
CC = calibration coefficient [microEinstein][sec^-1][m^-2][mV]

LAI = -2 COS(Szen) ln(Kltran / Kldwn) [2]

where:

Kltran = photosynthetically active radiation transmitted through the canopy, measurements made with the LI-191SA line quantum sensor [microEinstein] [sec^-1][m^-2].
Kldwn = incoming photosynthetically active radiation, measurements made with the LI-

191SA line quantum sensor [microEinstein][sec^-1][m^-2].
Szen = Solar zenith angle.
LAI = Leaf Area Index.

Derivation Techniques and Algorithms:

Not applicable.

Data Processing Sequence:

Processing Steps:

The calibration coefficients used are listed in the *Calibration Section*.

Equation 1 is used to convert the LI-COR LI-191SA line quantum sensor voltages to incoming, reflected and transmitted photosynthetically active radiation (PAR) [microEinstein] [sec^-1][m^-2]. Equation 3 is used to calculate Leaf Area Index (LAI) from transmitted PAR and total incoming PAR measured with the Line Quantum sensor.

Processing Changes:

Not available at this revision.

Calculations:

Special Corrections/Adjustments:

Not available at this revision.

Calculated Variables:

- Photosynthetically active radiation, and
- Leaf Area Index.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

The LAI measurements are based on assumptions of the distribution of leaves in the canopy. The difference between the actual leaf distribution and these assumptions will create errors. All material in the field of view of the Light Bar included in the LAI calculation. Thus, stems and

dead leaves will be part of the LAI. Also, the calculation assumes opaque leaves, leaves generally transmit 10 to 15 % of the PAR wavelengths.

Quality Assessment:

Data Validation by Source:

Not available at this revision.

Confidence Level/Accuracy Judgment:

- Errors in LAI calculations due to assumptions of the distribution of leaves in the canopy are unknown.
- Errors in LAI calculations due to the effects of stem, litter, and soil reflectance are unknown.
- Errors in LAI calculations due to the assumption that leaves are opaque are unknown.

Measurement Error for Parameters:

Not available at this revision.

Additional Quality Assessments:

FIS staff applied a general QA procedure to the data to identify inconsistencies and problems for potential users. As a general procedure, the FIS QA consisted of examining the maximum, minimum, average, and standard deviation for each numerical field in the data table. In some cases, histograms were examined to determine whether outliers were consistent with the shape of the data distribution. Inconsistencies and problems found in the QA check are described is the *Known Problems with the Data Section*.

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:

As of the revision data of this document, the following discrepancies or errors in the data have been reported. Use caution when using the data values described here.

1. LAI has 11 negative values and 2 values greater than 7.5.
2. During periods of variable cloudiness differences between the illumination between measurements of incoming and transmitted PAR may result in very small LAI values.
3. All values for LINE_QUANTM_REFL_PAR between 1624 and 1630 on July 25, 1989 at station 936 (sitegrid 2655-LBK) are unusually high, i.e., greater than 0.24.
4. Data were sometimes collected at large solar zenith angles (i.e., early and late in the daylight hours). Fraction of absorbed PAR calculated using these data will not be representative of fAPAR throughout the day.

Usage Guidance:

Before using these data the incoming radiation from the AMS station at the site or nearby site should be checked for possible cloud-induced errors.

Any Other Relevant Information about the Study:

Not available.

12. Application of the Data Set:

Not available.

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 Area Index and PAR Determined from KSU Light Bar Measurements are available on the FIFE CD-ROM Volume 1. The CD-ROM file name is as follows:

\DATA\SUR_REFL\LTBR_KSU\GRIDxxxx\ydddgrid.LBK

Where *xxxx* is the four digit code for the location within the FIFE sitegrid. 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: *ydddgrid.sfx*, where *grid* is the four-number code for the location within the FIFE sitegrid, *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 .LBK for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

LI-COR Terrestrial Radiation Sensors, Type SA Instruction Manual, LI-COR, inc. Lincoln, NE (1986).

Journal Articles and Study Reports.

Lang, A.R.G. 1986. Leaf area and average leaf angle from transmittance of direct sunlight. Aust. J. Bot. (34) 349-355.

Miller, J.B. 1967. A formula for average foliage density. Aust. J. Bot. (15) 141-144.

Warren Wilson, J. and Reeve, J.E. 1959. Analysis of the spatial distribution of foliage by two-dimensional point quadrats. New Phytol. (58) 92-101.

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:

APAR Absorbed Photosynthetically Active Radiation DAAC Distributed Active Archives Center EOSDIS Earth Observing System Data and Information System FIFE First ISLSCP Field Experiment FIS FIFE Information System IPAR Intercepted Photosynthetically Active Radiation IRT Infrared Thermometer KSU Kansas State University LAI Leaf Area Index MMR Modular Multiband Radiometer ORNL Oak Ridge National Laboratory PAR Photosynthetically Active Radiation PARABOLA Portable Apparatus for Rapid Acquisition of Bi-directional Observations of the Land and Atmosphere UNL University of Nebraska - Lincoln URL Uniform Resource Locator WAB Wind Aligned Blob

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

20. Document Information:

April 25, 1994 (citation revised on October 16, 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:

July 22, 1996.

Document ID:

ORNL-FIFE_LB_KSU.

Citation:

Cite this data set as follows:

Shah, T., and E. T. Kanemasu. 1994. LAI and PAR Data: Light Bar - KSU (FIFE). Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/41. Also published in D. E. Strebel, D. R. Landis, K. F. Huemmrich, and B. W. Meeson (eds.), Collected Data of the First ISLSCP Field Experiment, Vol. 1: Surface Observations and Non-Image Data Sets. CD-ROM. National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, U.S.A. (available from http://www.daac.ornl.gov).

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Document URL:

http://daac.ornl.gov