Leaf Photosynthesis Rates (FIFE)

Summary:

The objective of the Leaf Photosynthesis study was to measure the response of leaf photosynthesis and stomatal conductance to light, temperature, vapor pressure deficit, carbon dioxide and water potential for the most abundant C4 species at the FIFE study area. To this end, photosynthesis measurements were made on 6 days in June, July and August of 1987 at three different locations in the northwest quadrant of the FIFE study area.

Leaf photosynthetic rate is measured by enclosing a leaf in a closed, transparent chamber and measuring the decrease in carbon dioxide concentration as a function of time. Light flux density is measured outside of the chamber and must be corrected for the chamber transmittance, which is 0.9.

These data can be fit to various models of leaf photosynthesis and stomatal conductance by providing the responses to light, temperature leaf water potential, and carbon dioxide under field conditions on intact plants.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Leaf Photosynthesis Rates (FIFE).

Data Set Introduction:

The Leaf Photosynthesis measurements were made on 6 days in June, July and August of 1987 at three different locations in the northwest quadrant of the FIFE study area. The Leaf Photosynthesis Data Set contains leaf photosynthetic rates, total leaf water potential, leaf osmotic potential, incoming photosynthetically active radiation, temperatures, vapor pressures, and species information.

Objective/Purpose:

The objective of this research was to measure the response of leaf photosynthesis and stomatal conductance to light, temperature, vapor pressure deficit, carbon dioxide and water potential for the most abundant C4 species at the FIFE study area. The effect of leaf temperature on dark respiration was also studied.

Summary of Parameters:

Leaf photosynthetic rate, total leaf water potential, leaf osmotic potential, incoming photosynthetically active radiation, temperature, vapor pressure, and species.

Discussion:

The physiological responses of three species (Big bluestem, Indian grass, and Switchgrass) of C4 grasses to various environmental factors are similar to each other. The plant-to-plant variability is large so considerable spatial sampling was done to characterize each species. The light responses are typical for C4 species but maximum rates are lower than found for cultivated species such as corn or sorghum. The response of photosynthesis to leaf water potential indicated that these grasses can operate under dryer conditions that cultivated C4 species. The response of dark respiration to temperature was similar to that for other C4 species. The coupling between leaf photosynthetic rate and stomatal conductance was very strong. Photosynthesis measurements were made on 6 days in June, July and August of 1987 at three different locations in the northwest quadrant of the FIFE study area.

Related Data Sets:

- Canopy Photosynthesis.
- Leaf Angle Data.
- Vegetation Species and Cover Abundance.
- Vegetation Species Reference.
- Biophysical Properties of Vegetation.
- Leaf Pigmentation from within the FIFE site.

FIS Data Base Table Name:

PHOTOSYN_LEAF_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. John M. Norman
University of Wisconsin

Title of Investigation:

Leaf Gas Exchange on C4 Species in a Tallgrass Prairie.

Contact Information:

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Requested Form of Acknowledgment.

Please cite the following paper in any work or publication using these data:

Polley, H.W., J.M. Norman, T.J. Arkebauer, W.A. Walter-Shea, D.H. Greegor and B. Bramer. 1992. Leaf gas exchange of Andorpogon gerardii Vitman, Panicum virgatum L., and Sorghastrum nutans (L) NASH in a tallgrass prairie. J. Geophys. Res. 97:18,837-18,844.

3. Theory of Measurements:

Leaf photosynthetic rate is measured by enclosing a leaf in a closed, transparent chamber and measuring the decrease in carbon dioxide concentration as a function of time. Water vapor pressure is held constant in this chamber as a function of time by partially drying the recirculating air so that stomatal conductance is calculated from vapor pressure changes (if they occur) and the flow rate of dry recirculated air. Light flux density (PAR), air temperature, vapor pressure and carbon dioxide concentration are measured in the chamber along with the temperature of the leaf. The theory for this LI-6200 instrument is described in the LI-COR instruction manuals available from LI-COR, Inc., 4421 Superior Street, P.O. Box 4425, Lincoln, NE 68504. Light flux density is measured outside of the chamber and must be corrected for the chamber transmittance, which is 0.9.

Because of the sensitivity of these grass species (Big bluestem, Indian grass, Switchgrass) to dry air, the fan in the LI-6200 chamber was slowed down to reduce stomatal closure. Boundary layer conductance in the chamber as it is delivered from LI-COR with the fan running at full speed is 3.5 [mol][m^-2] [s^-1]. With a voltage of about four volts on the 12-volt fan, the boundary layer conductance was 1.4 [mol][m^-2][s^-1]. This is discussed in Polley et al., 1992. The procedures for measuring assimilation versus internal carbon dioxide concentration at various incident PAR levels with neutral density filters is also discussed in Polley et al. (1992) as well as in LI-COR Application Note #103. Assimilation measurements were made at four PAR levels (full Sun, 45% full Sun, 20% full Sun and 5% full Sun) and in the dark (only respiration).

These data can be fit to various models of leaf photosynthesis and stomatal conductance by providing the responses to light, temperature leaf water potential, and carbon dioxide under field conditions on intact plants.

4. Equipment:

Sensor/Instrument Description:

The instrument used to measure leaf photosynthesis was a LI-COR, Inc., Model LI-6200 Gas Exchange System with a ¼ liter chamber. The instrument is described in detail in LI-COR manuals. Total leaf water potential was measured with a pressure chamber built by Precision Machine Co., Lincoln, NE 68504, and was especially made to work with grasses. It could measure water potentials to -40 bars. Osmotic potential was measured with an osmometer, model HR-33, manufactured by Wescor, Inc., Logan, Utah.

Collection Environment:

Ground-based.

Source/Platform:

Ground.

Source/Platform Mission Objectives:

The focus of this research was to measure the dependence of photosynthetic rate and stomatal conductance on light, carbon dioxide concentration temperature, atmospheric humidity, and leaf water potential for individual leaves of the predominant species of C4 grasses in the FIFE site.

Key Variables:

Leaf respiratory flux, leaf photosynthetic flux and stomatal conductance.

Principles of Operation:

A part of a leaf was enclosed in a ¼ liter LI-COR chamber, which is attached to a LI-6200 gas exchange system. Gas is recirculated between the leaf chamber and the LI-6200 console, which contains a computer to do all calculations from various sensors monitoring the operation of the system. Neutral density filters about 30 cm x 30 cm are placed over the chamber to achieve various light intensities from full sun (with no filter) to 5% of full sun.

A leaf is placed in the chamber and the dry-air flow rate adjusted to maintain the chamber relative humidity at the value of the ambient air. A small amount of carbon dioxide is injected into the chamber so that the concentration does not drop significantly during this initial period. Then logging on the LI-6200 is begun with concentration of carbon dioxide near the ambient value. As the leaf photosynthesizes the carbon dioxide concentration in the chamber drops and it is possible to determine the leaf photosynthetic rate as a function of carbon dioxide concentration inside the leaf and outside of the leaf.

After the carbon dioxide concentration in the chamber has dropped so that the leaf photosynthetic rate is about half of its initial rate, some carbon dioxide is injected into the chamber to raise the concentration to about 400 to 500 micromol/mol. Then the photosynthetic rate as a function of higher carbon dioxide concentrations is measured until the leaf photosynthetic rate returns to the original value. Matching of initial and final leaf photosynthetic rates and internal CO2 concentrations is a requirement for acceptable data because it provides some assurance that the leaf is functioning in a stable mode.

This procedure is repeated for four light intensities on the same leaf beginning with full sun and decreasing to 5% of full sun; then the procedure is repeated with different leaves on different days with different ambient conditions. Measurements were only made on clear days.

Total leaf water potential is measured by excising grass leaves from a plant and placing them in the pressure chamber. The chamber is pressurized until the sap in the xylem just begins to exude, and this pressure is taken to be the total potential that existed in the leaf before it was cut. Because grass leaves are transpiring when they are cut, and because they have very small water storage in the leaf, transpiration must be stopped before leaves are cut. This is done by exhaling breath into a plastic bag to saturate the air in the bag, and then placing the bag over a leaf before cutting it. The leaf is kept in the bag inside the pressure chamber during the measurement. Two pressure readings are taken and used to estimate the leaf water potential at the time the leaf was cut.

The osmotic potential of the leaf can be measured when it is removed from the pressure chamber by placing the leaf on dry ice. Later the leaf is removed from the dry ice, sap pressed out, and put into the Wescor Osmometer.

The LI-6200 gas exchange system is portable and battery operated so that it can be carried to the location of plants.

These gas exchange measurements then are made on intact leaves that are attached to their respective plants. Data are recorded in the memory of the LI-6200 and later down loaded to a computer

Sensor/Instrument Measurement Geometry:

Not applicable.

Manufacturer of Sensor/Instrument:

LI-6200: LI-COR, Inc.
P.O. Box 4425
Lincoln, NE 68504.

Pressure Chamber: Precision Machine, Inc.
Lincoln, NE 68504

Osmometer: Wescor, Inc.
Logan, UT 84321

Calibration:

Every day before beginning measurements with the LI-6200, the relative humidity sensor was checked against an Assman psychrometer and the carbon dioxide analyzer was calibrated with a standard gas, accurate to one micromole/mole concentration. Other sensors were calibrated at the beginning of the season. In addition, every day a leak test was done on the chamber and analyzer system to insure its integrity.

The pressure gauge on the pressure chamber was a rugged mechanical device and did not need calibration. The zero was checked daily, but never needed adjustment.

The osmometer was calibrated every time it was used with two potassium chloride solutions of known concentrations to bracket the potentials of the tissue samples.

Specifications:

- LI-6200: Available from LI-COR, Inc.
- Pressure chamber: Range 0 to -40 bars
- Osmometer: Available from Wescor, Inc.

Tolerance:

LI-6200: Accuracy of photosynthetic rate 5-10%.
Accuracy of stomatal conductance 10-20%.

Pressure chamber: Precision 1/3 bar
Accuracy 1 bar

Osmometer: Precision and accuracy 1 bar

Frequency of Calibration:

LI-6200 and osmometer were calibrated every time that they were used. The pressure chamber was not calibrated.

Other Calibration Information:

None.

5. Data Acquisition Methods:

LI-6200: Data were recorded in the field, stored in the memory unit and dumped to a computer at the end of the day.

Pressure chamber: Data were recorded by hand from the dial of the mechanical pressure gauge and recorded in a field note-book. Later, it was hand entered into a spreadsheet.

Osmometer: Data were read manually from the dial of an electrical meter and recorded by hand into a notebook. These measurements were done in the lab because of their extreme sensitivity to temperature changes.

6. Observations:

Data Notes:

Not available.

Field Notes:

None.

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:

Leaves were collected at four stations. At each of these sites, upper canopy leaves which were perpendicular to the direct beam of the Sun were selected for measurement. Only leaves, which

were perpendicular to the direct rays of the Sun, could be used to obtain the full range of light flux densities.

SITEGRID	STN_ID	NORTHING	EASTING	LATITUDE	LONGITUDE	ELEV	SLOPE
1608-LCN	91	4330845	706572	39 06 15	-96 36 40	345	
3225-LCN	92	4327606	710096	39 04 27	-96 34 17	430	2
3414-LCN	10	4327286	707854	39 04 19	-96 35 51	410	

Spatial Coverage Map:

Not available.

Spatial Resolution:

These were point data.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

Leaf gas exchange measurements were made during the four IFCs in 1987. Data were collected from June 6, 1987 through August 16, 1987. However, only data from 6 days during the first three IFCs are included in the data set. Data from the fourth IFC in October 1987 showed that very few leaves were alive, so measurements were not reported for this IFC.

Temporal Coverage Map:

Not available.

Temporal Resolution:

Data were collected on the following days, June 6, July 6, August 10 and 11, and August 15th of 1987. Various times during 1987 and 1988. Approximately 1 to 2 hours were required to complete measurements on a single leaf. On average, about 35 measurements are made in one day.

Data Characteristics:

The SQL definition for this table is found in the PHO_LEAF.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 the east (EE) cell number in a 100 x 100 array of 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_TYPE The plot code number : 1=burned, 2=unburned, 3=Nitrogen only application, 4=Nitrogen control plot.			
LTER_SPECIES_CODE The LTER species code (see table VEG_SPECIES_REF) for the species of the leaf measured.			
LEAF_AREA The leaf area enclosed in the LI-6200 chamber.		[cm^2]	

PAR_DOWN The downward (incoming) Photosyntheticly Active Radiation (PAR).	[microMols] [meter^-2] [sec^-1]
CHAMBER_TEMP The temperature of the chamber.	[degrees Celsius]
LEAF_TEMP The temperature of the leaf in the chamber.	[degrees Celsius]
VAPOR_PRESS The vapor pressure of the air in the chamber.	[millibars]
CHAMBER_CO2_CONTENT The CO2 concentration in the chamber.	[microMols] [Mol^-1]
LEAF_CO2_CONTENT The CO2 concentration inside the leaf.	[microMols] [Mol^-1]
LEAF_STOMTL_CONDCTNC The leaf stomatal conductance, which is the ease with which moisture travels throughout the leaf structure.	[Mols] [meter^-2] [sec^-1]
PHOTOSYN_RATE The photosynthesis rate (CO2 assimilation rate) of the leaf sample. [sec^-1]	[microMols of CO2] [meter^-2]
TOTAL_WATER_POTNTL The total water potential of the leaf.	[-megaPascals]
OSMOTIC_POTNTL The osmotic potential of the leaf.	[-megaPascals]
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).
```

Footnote:

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 are "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_TYPE	LTER_SPECIES_CODE
3414-LCN	10	16-AUG-87	2059	99	15
3414-LCN	10	16-AUG-87	2059	99	15
3414-LCN	10	16-AUG-87	2059	99	15
3414-LCN	10	16-AUG-87	2059	99	15

LEAF_AREA	PAR_DOWN	CHAMBER_TEMP	LEAF_TEMP	VAPOR_PRESS	CHAMBER_CO2_CONTENT
6.90	1582	38.3	40.1	26.79	236
6.90	1580	38.4	40.2	27.10	212
6.90	1569	38.5	40.2	27.39	189
6.90	1553	38.5	40.1	27.53	166

LEAF_CO2_CONTENT	LEAF_STOMTL_CONDCTNC	PHOTOSYN_RATE	TOTAL_WATER_POTNTL
29	.1190	13.9	9.99
26	.1203	12.6	9.99
22	.1207	11.4	9.99
22	.1240	10.1	9.99

OSMOTIC_POTNTL	FIFE_DATA_CRTFCN_CODE	LAST_REVISION_DATE
9.99	CPI	08-DEC-89
9.99	CPI	08-DEC-89
9.99	CPI	08-DEC-89
9.99	CPI	08-DEC-89

8. Data Organization:

Data Granularity:

The Leaf Photosynthesis data set includes point data that were collected from 6 days during the first three IFCs in 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:

Data reduction was done internally in the LI-6200 with the leak correction. See LI-COR, Inc., application notes for details on how assimilation versus internal CO2 concentration curves are measured and on programming changes in the LI-6200 to accommodate leak corrections.

- LI-6200: See manuals from LI-COR, Inc.
- Pressure chamber: No algorithms or equations required.
- Osmometer: No algorithms or equations required.

Data Processing Sequence:

Processing Steps:

Not applicable.

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

Leak corrections done according to LI-COR, Inc., special application note.

Calculated Variables:

Not applicable.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

All of the measured quantities are subject to error. The accuracy of the measurements are listed below. In addition, the boundary layer conductance of a leaf in the chamber must be measured. This conductance is a function of chamber fan speed. Several speeds were used before it became clear that a slow fan speed reduced stomatal closure when chambers were attached to leaves. Traditionally chambers have been designed with very high boundary layer conductance to facilitate control; however, this is not possible with leaves that have stomata that respond to atmospheric humidity. Thus, the most common chamber boundary layer conductance was 1.4 [mol][m^-2][s^-1]. This value is accurate to about 15%.

The transparency of the chamber affects the PAR value actually incident on the leaf and can vary with incident angle of the sun (which usually was near perpendicular), and residues on the chamber inside or outside surfaces. An average transparency of 0.9 was used.

Leaf absorptivity also is needed to determine the absorbed PAR and a value of 0.80 was measured for a sampling of leaves.

Leaks in the chambers can be a source of errors, but the system was checked for leaks using an established procedure every few days.

Quality Assessment:

Data Validation by Source:

Data have been screened for problems and should be of good quality.

Confidence Level/Accuracy Judgment:

The investigator believes these data to be of good quality.

Measurement Error for Parameters:

Leaf area 5-10%
Carbon dioxide conc.
Absolute 1 [umol][mol-1]
Differential in time 0.2 [umol][mol-1]
Relative humidity 3%
Air temperature 0.2 C
Leaf Temperature 0.3 C
Light 5%
Water potential 1 bar
Photosynthetic rate ~10%
Stomatal conductance ~15%

Additional Quality Assessments:

FIS staff applied a general Quality Assessment (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. An attempt was made to find an explanation for unexpected high or low values, values outside of the normal physical range for a variable, or standard deviations that appeared inconsistent with the mean. In some cases, histograms were examined to determine whether outliers were consistent with the shape of the data distribution.

The discrepancies, which were identified, are reported as problems in 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 data sets 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).
- 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 data set. 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:

discrepancies or errors in the data have been reported:

1. The CHAMBER_CO2_CONTENT was unusually high on August 10, 1987 at 1738 hrs.
2. The LEAF_CO2_CONTENT has a couple of spikes in it.
3. The TOTAL_WATER_POTNTL has 9.99 which may be either a missing value indicator or a real value. Use with caution.
4. The OSMOTIC_POTNTL is a missing values.
5. The missing value indicator is either 9.99 or -99.9
6. The boundary layer conductance of grass leaves in the ¼ liter chamber was originally determined by using wet filter paper leaf replicates. The data calculated with the LI-6200 used these boundary layer conductances. Later, we realized that leaf temperature measurements with the leaf thermocouple were not reliable because of the very large temperature difference between the leaf and air for wet filter paper. Although this error was not a problem with normal leaves, with wet filter paper, the temperature difference between leaves and the air could exceed the maximum value of 10 degrees C built into the LI-6200, otherwise, conduction down the thermocouple leads could become appreciable. Thus, an energy balance procedure was used to derive leaf temperature and new chamber boundary layer conductances measured. The table below contains the various values:

Boundary Layer Conductance	Fan Speed	Comments
3.5	full	Final revised value
1.4	reduced	Final revised value
1.8	full	Original value(erroneous)
1.0	reduced	Original value(erroneous)

The data in data set tables used the original value that we now believe to be in error. This does not affect the leaf photosynthetic rates. Errors in the stomatal conductance are very small because of the large values of boundary layer conductance. Values of internal carbon dioxide concentration are not significantly affected.

Errors could result if these data are used to calculate the relative humidity at the surface of the leaf, since, the stomatal resistance and the boundary layer resistance are used in the calculation.

Usage Guidance:

None.

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

This data set can be used to study the dependence of photosynthetic rate and stomatal conductance on light, carbon dioxide concentration temperature, atmospheric humidity, and leaf water potential for individual leaves of the predominant species of C4 grasses in the FIFE site.

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://www daac.ornl.gov.

Data Center 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.

16. Output Products and Availability:

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

\DATA\BIOLOGY\PHO_LEAF\ydddgrid.PSL

Note: capital letters indicate fixed values that appear on CD-ROM exactly as shown here, lowercase 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 site grid, *y* is the last digit of the year (e.g., 7 = 1987, and 9 = 1989), and *ddd* is the day of the year (e.g., 061 = sixty-first day in the year). The filename extension (*.sfx*), identifies the data set content for the file (see the *Data Characteristics Section*) and is equal to .PSL for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Davis, J.E., T.J. Arkebauer, J.M. Norman, and J.R. Brandle. 1987. Rapid field measurement of the assimilation rate versus internal CO2 concentration relationship in green ash (Fraxinus pennsylvanica Marsh.): The influence of light intensity. Tree Physiol. 3:387-392.

Journal Articles and Study Reports.

Polley, H.W., J.M. Norman, T.J. Arkebauer, W.A. Walter-Shea, D.H. Greegor and B. Bramer. 1992. Leaf gas exchange of Andorpogon gerardii Vitman, Panicum virgatum L., and Sorghastrum nutans (L) NASH in a tallgrass prairie. J. Geophys. Res. 97:18,837-18,844.

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:

CD-ROM Compact Disk-Read Only Memory DAAC Distributed Active Archive Center EOSDIS Earth Observing System Data and Information System FIFE First ISLSCP Field Experiment FIS FIFE Information System ISLSCP International Satellite Land Surface Climatology Project ORNL Oak Ridge National Laboratory PAR Photosynthetically Active Radiation URL Uniform Resource Locator UTM Universal Transverse Mercator

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

20. Document Information:

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