SNF LEAF OPTICAL PROPERTIES: CARY-14

Summary:

Knowledge of the optical properties of the components of the forest canopy is important to the understanding of how plants interact with their environment and how this information may be used to determine vegetation characteristics by means of remote sensing.

During the summers of 1983 and 1984, samples of the major components of the boreal forest canopy (needles, leaves, branches, moss, litter) were collected in the Superior National Forest (SNF) of Minnesota and sent to the Johnson Space Center (JSC). At JSC, the spectral reflectance and transmittance characteristics of the samples were determined for wavelengths between 0.35 and 2.1 micrometers by means of the Cary-14 radiometer. This report presents plots of these data as well as averages to the Thematic Mapper Simulator (TMS) bands.

There were two main thrusts to the SNF optical properties study. The first was to collect the optical properties of many of the components of the boreal forest canopy. The second goal of the study was to investigate the variability of optical properties within a species. The results of these studies allow a comparison of the optical properties of a variety of different species and a measure of the variability within species. These data provide basic information necessary to model canopy reflectance patterns.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

SNF Leaf Optical Properties: Cary-14.

Data Set Introduction:

During the summers of 1983 and 1984, samples of the major components of the boreal forest canopy (needles, leaves, branches, moss, litter) were collected in the Superior National Forest (SNF) of Minnesota and sent to the Johnson Space Center (JSC). At JSC, the spectral reflectance and transmittance characteristics of the samples were determined for wavelengths between 0.35 and 2.1 micrometers by means of the Cary-14 radiometer. This report presents plots of these data as well as averages to the Thematic Mapper Simulator (TMS) bands.

Objective/Purpose:

There were two main thrusts to the SNF optical properties study. The first was to collect the optical properties of many of the components of the boreal forest canopy. The second goal of the study was to investigate the variability of optical properties within a species. The results of these studies allow a comparison of the optical properties of a variety of different species and a measure of the variability within species. These data provide basic information necessary to model canopy reflectance patterns.

Summary of Parameters:

Canopy component reflectance and transmittance measured by Cary-14 spectometer.

Discussion:

Leaf Optical Properties Introduction

Knowledge of the optical properties of the components of the forest canopy is important to the understanding of how plants interact with their environment and how this information may be used to determine vegetation characteristics by means of remote sensing.

During the summers of 1983 and 1984, samples of the major components of the boreal forest canopy (needles, leaves, branches, moss, litter) were collected in the Superior National Forest (SNF) of Minnesota and sent to the Johnson Space Center (JSC). At JSC, the spectral reflectance and transmittance characteristics of the samples were determined for wavelengths between 0.35 and 2.1 micrometers by means of the Cary-14 radiometer. This report presents plots of these data as well as averages to the Thematic Mapper Simulator (TMS) bands.

There were two main thrusts to the SNF optical properties study. The first was to collect the optical properties of many of the components of the boreal forest canopy. The reflectance and transmittance properties of the leaves and needles of eight major overstory tree species and three understory shrubs were measured. Also, reflectance measurements were made for the bark of several tree species, sphagnum moss and leaf litter. The second goal of the study was to investigate the variability of optical properties within a species. Measurements of reflectance and transmittance of quaking aspen leaves and black spruce needles were made at three levels in the canopy and for three stand densities. The results of these studies allow a comparison of the optical properties of a variety of different species and a measure of the variability within species. These data provide basic information necessary to model canopy reflectance patterns.

Methodology

The vegetation samples were collected in the SNF and placed in zip-lock plastic bags. These bags were packed in cardboard boxes and sent to JSC by priority mail. Samples were collected from late August through September in 1983. In 1984 samples were collected May 23, June 25 and August 14 and mailed the same day. It took between three and six days for the samples to reach JSC.

The handling of the samples at JSC evolved over time. In 1983 and early 1984, the samples were stored in plastic bags and refrigerated at JSC. Later, due to problems with too much wetness on the leaves, the branches were not refrigerated and their ends were put in water to keep the leaves alive.

The optical properties were measured by using the Cary-14 system at JSC. The Cary-14 has a wavelength range between 0.35 and 2.1 micrometers. The sampling interval varies between 0.002 and 0.01 micrometers, depending on the rate of change between the values in each sample interval. Each measurement samples at approximately 250 different wavelengths.

Optical property measurements were made for both the tops and bottoms of leaves. When leaf top or bottom is refered to in these observations it indicates the side of the leaf which is illuminated by the Cary-14. For observing broad leaves, a sample of the leaf without holes or visible defects was used, however, for needle leaves either a collection of individual needles were aligned in the instrument holder or a section of twig with needles attached was used.

The optical properties measured by the Cary-14 are provided in this data set "SNF Leaf Optical Properties: Cary-14". Since the Cary-14 does not sample in exactly the same wavelengths in each measurement, the data were resampled using a one-dimensional quasi-cubic hermite interpolation before averaging. These Cary-14 reflectance and transmittance values were then averaged to Thematic Mapper Simulator wavelength bands and are provided in the data set "SNF Leaf Optical Properties: TMS".

Results

Three species of broad leafed deciduous trees were sampled: paper birch (*Betula papyrifera*), red maple (*Acer rubum*) and quaking aspen (*Populus tremuloides*). In the visible spectral region (0.4 to 0.7 �m), most of the radiation is absorbed by the leaf and little is reflected or transmitted. Reflectance and transmittance minima occur at approximately 0.45 and 0.65 �m due to chlorophyll absorption. The near infrared region (0.7 to 1.3 �m) is characterized by very high reflectance and transmittance and low absorptance. The internal structure of the leaf determines the optical properties in this region. The middle infrared (1.3 to 3.0 �m) is dominated by strong water absorption bands at approximately 1.4 and 1.9 �m. Reflectance and transmittance in the mid infrared is related to the amount of water in the leaf.

The birch and maple leaves were all collected on the same day and received the same treatment. The leaf top reflectance and transmittance are very close for all four samples in all wavelengths measured. However, there is a great deal of variation in the leaf bottom transmittance. The differences in leaf optical properties for these four samples do not seem to be related to the differences in species or canopy height.

Quaking aspen leaves were sampled for three canopy heights and three stand densities. When the aspen optical properties were plotted, a striking differences between the optical properties of healthy and diseased leaves was noted. The diseased leaves had a much lower reflectance in both the near and mid infrared regions. This effect occured even when the leaf appeared green. In one example, the leaf sample was described as being "most uniform in color and clean", but, once more, in the near and mid infrared the reflectance was much lower than the healthy leaves. The diseased leaves also had a much higher transmittance in all wavelength bands.

The leaf top reflectance for aspen show that in the visible region the high density stand has a lower reflectance. In the infrared regions the reflectances do not distinguish between stand density or crown height. The mid infrared wavelengths show the most separability between the different samples. The variability between different aspen leaves is greater than the variability between the birch and maple samples. The leaf top reflectances of the birch and maple match up well with aspen from the high density stand in the visible. However, aspen has a much higher reflectance in the near infrared. In the mid infrared the birch and maple reflectances fall within the range of the aspen, but the aspen tends to have a slightly higher reflectance.

The aspen leaf bottom reflectances tend to be higher than the leaf top reflectances in all wavelengths. In the visible, this is readily seen in the light color of the aspen leaf bottoms. The aspen leaf bottom reflectances do not show any pattern due to canopy height or stand density. The leaf bottom reflectance is similar between aspen, birch and maple in the visible but in the infrared the aspen has the higher leaf bottom reflectance.

Aspen leaf transmittance is slightly greater in the infrared for high density stands versus low density stands. The maple and birch leaf transmittances tend to be greater in all wavelengths than the aspen.

Bark reflectance for aspen varies greatly in all wavelengths. There are two spectral reflectance patterns for the bark. The first pattern has a steep jump in reflectance at 0.7 �m and high near infrared reflectance values. The second bark reflectance pattern does not have the jump at 0.7 �m and increases monotonically through the visible and near infrared. Both bark types have similar patterns in the mid infrared. The first type of bark tends to be found in the upper crown of the aspen. The second type of bark is found low in the aspen canopy suggesting that it is older bark.

Five species of needle leafed trees were sampled in this study: jack pine (*Pinus banksiana*), red pine (*Pinus resinosa*), larch (*Larix laricina*), balsam fir (*Abies balsamea*) and black spruce (*Picea glauca*). While the reflectance pattern of the needle leafed trees is similar to broad leaves, the reflectance of the needles is much more variable in all wavelengths. The variability in needle reflectance is not just a function of species since jack pine has both high and low reflectance values. In the visible region, the red pine and larch reflectances are similar to broad leaf reflectance, but fir and the low value for jack pine are much less. In the near infrared plateau, there are two depressions occuring around 1.0 and 1.2 �m. These depressions are also present in broad leaves but are less pronounced. Broad leaf reflectance in the near infrared falls in the middle of the range of needle near infrared reflectances. In the mid infrared region, broad leaf reflectance is much higher than that of needles. The needle bottom reflectance has similar characteristics as the needle top reflectance. In the visible region, fir has a greater bottom reflectance than top reflectance.

Needle transmittance is much lower in all wavelengths than that of broad leaves. While the reflectance of the bark of needle leafed treesshows a great deal of variability, the pattern of the reflectance is the same as that of aspen bark from the lower canopy. The needle leaved tree bark does not show a jump at the visible-near infrared boundary as does some of the aspen bark.

Several samples of black spruce needles were measured to look at the variability of optical properties within a conifer species. Spruce needle top reflectance falls mid range with other needle reflectances. Within spruce, needles from high density stands have highest reflectance in near and mid infrared. Needles from a middle density stand have lower reflectance in the near and mid infrared, with reflectances of needles from a low density stand being lowest in the near infrared and about the same as the mid density needles in the mid infrared. Spruce needle reflectance data taken in 1983 were of a combination of both the tops and bottoms of the needles. The results are comparable with the 1984 data in the near and mid infrared, however the 1983 visible reflectances are much higher than the 1984 data. This is not due to the effects of needle bottom reflectance in 1983 samples since the 1984 needle bottom reflectances in the visible are not much different than that of the needle tops and much lower than the 1983 visible reflectances. Spruce needle reflectance in comparison with aspen leaf reflectance is a little lower in the visible, much lower in the near infrared, and greatly lower in the mid infrared.

Spruce needle transmittance is slightly higher than other needle transmittance in the visible and near infrared regions. In comparison with aspen leaf transmittance, they are nearly equal in the visible, spruce is slightly lower in the near infrared, and much lower in the mid infrared.

Three species of understory shrubs were sampled: beaked hazel (*Corylus cornuta*), labrador tea (*Ledum groenlandicum*) and leatherleaf (*Chamaedaphne calyculata*). Only leaf top reflectance was determined for labrador tea and leatherleaf. The labrador tea and leatherleaf have very high reflectances in the near infrared compared to other leaves or needles sampled. The hazel has much lower reflectance in the near infrared. The water absorption bands at 1.4 and 1.9 �m are not very deep for the hazel.

Sphagnum moss (*Sphagnum* spp.) reflectance is extremely variable in all bands. The difference between samples may be caused by differences in location, moisture or type of sphagnum.

Background reflectance can have a significant effect on the total canopy reflectance. If sphagnum is the background, the reflectance may vary with place and time. This variable background can be an important complication in the understanding of reflectance images of the boreal forest regions.

In contrast to the sphagnum reflectance is the reflectance of aspen leaf litter. The leaf litter reflectance is much different than that of the sphagnum and appears to be more like the needle leafed tree bark.

Related Data Sets:

- SNF Leaf Optical Properties: TMS
- SNF NS001-TMS Canopy Reflectance 1983-84
- Helicopter MMR Reflectance Data

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Forrest G. Hall
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Dr. K. Fred Huemmrich
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Versar, Inc.

Dr. Scott J. Goetz
University of Maryland

Ms. Jamie E. Nickeson
NASA Goddard Space Flight Center

Ms. K. D. Woods
NASA Goddard Space Flight Center

Dr. Celeste Jarvis
NASA Headquarters

Title of Investigation:

Biophysical, Morphological, Canopy Optical Property, and Productivity Data on the Superior National Forest.

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3. Theory of Measurements:

Not available.

4. Equipment:

Sensor/Instrument Description:

Collection Environment:

Ground-based.

Source/Platform:

Field Investigation.

Source/Platform Mission Objectives:

Not available.

Key Variables:

Canopy component reflectance and transmittance measured by Cary-14 spectometer.

Principles of Operation:

Not available.

Sensor/Instrument Measurement Geometry:

Not available.

Manufacturer of Sensor/Instrument:

Not available.

Calibration:

Not available.

5. Data Acquisition Methods:

Not available.

6. Observations:

Data/Field Notes:

Not available.

7. Data Description:

Spatial Characteristics:

The study area covered a 50 x 50 km area centered at approximately 48 degrees North latitude and 92 degrees West longitude in northeastern Minnesota at the southern edge of the North American boreal forest.

Temporal Characteristics:

During the summers of 1983 and 1984, samples of the major components of the boreal forest canopy (needles, leaves, branches, moss, litter) were collected in the Superior National Forest (SNF) of Minnesota

Data Characteristics:

Variable Name/ Long Name Description	SAS Type	Generic Type
1 obs_datc OBS_DATE "Observation Date (Month dd, yyyy)"	$ 12	DATE
2 can_pos "Canopy Position: upper/middle/lower/etc."	$ 10	CHAR(10)
3 tree_id "Tree ID"	$ 12	CHAR(12)

4	speccode	SPECIES_CODE	$ 12	CHAR(12)
"Plant species code [see speccomm (Common Name) and spec_sci (Latin Name)]"				
5	plntpart	PLANT_PART	$ 12	CHAR(12)
"Portion of the plant measured (leaf/needle/bark/mosslitter)"				
6	obs_typc		$ 1	
"Type code: R=reflectance/T=transmittance"				
7	obs_type	OBS_TYPE	$ 18	CHAR(18)
"The type of measurement: either top reflectance, bottom reflectance, top transmittance, or bottom transmittance"				
8	obs_view		$ 6	CHAR(18)
"Instrument View: from top/bottom"				
9	stnddens		$ 6	CHAR(6)
"Stand Density: high/medium/low"				
10	wavelen	WAVELENGTH	8	NUMBER(5,4)
"Wavelength (microns) at which the reflectance measurements were taken"				
11	reflect	REFLECTANCE	8	NUMBER(6,5)
"Reflectance, in fractional percentages"				
12	transmit		8	
"Transmittance"				
13	snf_file	DATASET_ID	$ 12	CHAR(10)
"SNF spectral reflectance raw data file name containing coded information that has been interpreted and added to this data set as additional fields"				
14	speccomm	COMMON_NAME	$ 36	CHAR(20)
"Plant species common name"				
15	spec_sci	LATIN_NAME	$ 36	CHAR(25)

"The Latin (botanical) name of the species"

Sample Data Record:

obs_datc	can_pos	tree_id	speccode	plntpart	obs_typc	obs_type	obs_view	stnddens	wavelen	reflect	transmit	snf_file	speccomm	spec_sci
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.3509	0.05298	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.3607	0.05691	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.3719	0.05697	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.3839	0.0591	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.3899	0.06005	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.3981	0.06405	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.4056	0.06809	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.4139	0.07598	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"1983"	"upper"	"25"	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.4191	0.08288	.	"a25h29rb.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.7327	0.30309	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.7402	0.31138	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.7492	0.31766	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.7605	0.32248	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.7702	0.32773	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.7777	0.33215	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.786	0.33582	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.7943	0.3393	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.8018	0.34329	.	"pt3l2b1r.dat"	"Aspen, Trembling"	"Populus Tr
"MAY 23,1984"	" "	" "	"POTR"	"LEAF"	"R"	"REFL/BOTTOM"	"bottom"	"high"	0.8138	0.34735	.	"pt3l2b1r.dat"	"Aspen, Trembling"	

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"Populus Tr
"1983"          "mixed"    "60"       "PIMA"      "NEEDLE"      "R"    "REFL (1983)"
" "        " "        1.0132    0.51036       .      "s60h01r.dat"    "Spruce, Black"
"Picea Mari
"1983"          "mixed"    "60"       "PIMA"      "NEEDLE"      "R"    "REFL (1983)"
" "        " "        1.0253    0.51332       .      "s60h01r.dat"    "Spruce, Black"
"Picea Mari
"1983"          "mixed"    "60"       "PIMA"      "NEEDLE"      "R"    "REFL (1983)"
" "        " "        1.0388    0.51491       .      "s60h01r.dat"    "Spruce, Black"
"Picea Mari
"1983"          "mixed"    "60"       "PIMA"      "NEEDLE"      "R"    "REFL (1983)"
" "        " "        1.053     0.51724       .      "s60h01r.dat"    "Spruce, Black"
"Picea Mari
"1983"          "mixed"    "60"       "PIMA"      "NEEDLE"      "R"    "REFL (1983)"
" "        " "        1.0686    0.51996       .      "s60h01r.dat"    "Spruce, Black"
"Picea Mari
"1983"          "mixed"    "60"       "PIMA"      "NEEDLE"      "R"    "REFL (1983)"
" "        " "        1.0807    0.51631       .      "s60h01r.dat"    "Spruce, Black"
"Picea Mari
```

Footnote:

> For presentation in this document, some padding blanks may have been eliminated between columns in the Sample Data Record. Due to the many fields in this data file, these columns will wrap while viewing. The actual data files, however, are column delimited with an adequate record length to prevent wrapping. See the *Data Format Section* for conventions used for missing data values in the data file.

8. Data Organization:

Data are sorted by species code (speccode), observation date (obs_datc), tree ID (tree_id), plant part (plntpart), and observation type (obs_type). Key fields in each record are speccode, obs_datc, tree_id, and plntpart.

Data Granularity:

This data set consists of a single ASCII file containing reflectance and transmittance of leaves, needles, and bark of various species of trees, with additional information on canopy position and stand density.

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

Data Format:

The data files associated with this data set consist of numeric and character fields of varying lengths aligned in columns. The first row of each data file contains the 8 character SAS variable name that links to the data format definition file. Character fields are enclosed in double quotes and numeric fields are listed without quotes.

Missing data values can be of two varieties:

1. Values that were identified as missing in the original data files. Missing numeric values of this type are identified in these data as -999.
2. Those holes that were created as a result of combining files that contained a slightly different variable set. Missing values of this type are identified in these data files as empty double quotes for character fields and a single period, '.' for numeric fields.

9. Data Manipulations:

Not available.

10. Errors:

Sources of Error:

Not available.

Quality Assessment:

Data Validation by Source:

Not available.

Confidence Level/Accuracy Judgment:

Not available.

Measurement Error for Parameters:

Not available.

Additional Quality Assessments:

Not available.

Data Verification by Data Center:

The Superior National Forest data were received from the Goddard Space Flight Center in three media:

- As data dumps from the original Oracle SNF database maintained by GSFC, transferred electronically from the GSFC system to the ORNL system;
- As ASCII files that mirrored the tables published in the Tech Memo; and
- As hard copy (Tech Memo).

Data from both electronic sources were input into SAS by ORNL DAAC data management staff and compared using computer code developed to process the SNF data. In many cases, the data values from both sources were found to be identical. In some cases, however, differences were identified and the providers of the data were consulted to resolve inconsistencies.

Additionally, some variable columns were available in one source, but not the other for various reasons. For example, some calculated variables/columns were provided in the ASCII files (reflecting the Tech Memo tables) that were not stored in the Oracle database for purposes of space conservation.

For similar reasons, coded values were used for many of the site and species identifier variables. A separate reference table was provided to link the coded variable with its definition (e.g., the SPECIES_REF file and the SITE_REF file).

The database produced by the ORNL DAAC is a hybrid product that is a composite of data and information extracted from all three source media. In data sets where coded variables were included, the code definition variables have been added to improve usability of the data set as a stand-alone product.

Therefore the ASCII files that are available through the ORNL DAAC on-line search and order systems are output from a data set that is a product of the essential core of numeric data provided by the data source (GSFC), augmented with additional descriptive information provided by GSFC and reorganized by the ORNL DAAC into a data structure consistent with other similar data sets maintained by the ORNL DAAC.

11. Notes:

Limitations of the Data:

Not available.

Known Problems with the Data:

None known at this revision.

Usage Guidance:

Not available.

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

These data provide basic information necessary to model canopy reflectance patterns.

13. Future Modifications and Plans:

None known at this revision.

14. Software:

Not available.

15. Data Access:

Contact Information:

ORNL DAAC User Services
Oak Ridge National Laboratory
Telephone: (865) 241-3952
Fax: (865) 574-4665
E-mail: ornldaac@ornl.gov

Data Center Identification:

ORNL Distributed Active Archive Center
Oak Ridge National Laboratory
Telephone: (865) 241-3952
Fax: (865) 574-4665
E-mail: ornldaac@ornl.gov

Procedures for Obtaining Data:

Users may order data by telephone, electronic mail, or fax. Data are available via FTP or on CD-ROM. Data are also available via the World Wide Web at http://daac.ornl.gov .

Data Center Status/Plans:

The Superior National Forest 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:

Available via FTP or on CD-ROM.

17. References:

Not available.

Archive/DBMS Usage Documentation.

Contact the ORNL DAAC, Oak Ridge, Tennessee (see the *Data Center Identification Section*).

18. Glossary of Terms:

A general glossary is located at EOSDIS Glossary.

19. List of Acronyms:

URL Uniform Resource Locator

A general list of acronyms is available at http://cdiac.ornl.gov/pns/acronyms.html.

20. Document Information:

October 10, 1996 (citation revised September 23, 2002).

Document Review Date:

February 19, 1997.

Document ID:

ORNL-SNF_LEAFCARY.

Citation:

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Based on F. G. Hall, K. F. Huemmrich, D. E. Strebel, S. J. Goetz, J. E. Nickeson, and K. D. Woods, Biophysical, Morphological, Canopy Optical Property, and Productivity Data from the Superior National Forest, NASA Technical Memorandum 104568, National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, U.S.A., 1992.

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http://daac.ornl.gov