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Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Jaime Nickeson, Editors

Volume 95

BOREAS Landsat MSS Imagery: Digital Counts

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Space Administration

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BOREAS Landsat MSS Imagery: Digital Counts

Richard Strub, Jefferey A. Newcomer

Summary

The BOREAS Staff Science Satellite Data Acquisition Program focused on providing the research teams with the remotely sensed satellite data products they needed to compare and spatially extend point results. The Earth Resources Technology Satellite (ERTS) Program launched the first of a series of satellites (ERTS-1) in 1972. Part of the NASA Earth Resources Survey Program, the ERTS Program and the ERTS satellites were later renamed Landsat to better represent the civil satellite program's prime emphasis on remote sensing of land resources. Landsat satellites 1 through 5 carry the MSS sensor. CCRS and BOREAS personnel gathered a set of MSS images of the BOREAS region from Landsat satellites 1, 2, 4, and 5 covering the dates of 21-Aug-1972 to 05-Sep-1988. The data are provided in binary image format files of various formats.

Note that the Landsat MSS images are not contained on the BOREAS CD-ROM set. An inventory file of the available images is provided on the CD-ROM to inform users of the data that are available. See Section 15 for information on how to acquire the data.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS Landsat MSS Imagery: Digital Counts

1.2 Data Set Introduction

The BOReal Ecosystem-Atmosphere Study (BOREAS) Staff Science effort covered those activities that were BOREAS community-level activities, or required uniform data collection procedures across sites and time. These activities included the acquisition of the relevant satellite data. Data from the Landsat Multispectral Scanner (MSS) instruments on the Landsat satellites were acquired from the

Canada Centre for Remote Sensing (CCRS) and the United States Geological Survey (USGS) Earth Resources and Observational Systems (EROS) Data Center (EDC) and provided for use by BOREAS researchers.

1.3 Objective/Purpose

For BOREAS, the Landsat MSS imagery, along with the other remotely sensed images, were collected in order to provide spatially extensive information over the primary study areas. Many of the MSS images were acquired early on in the project and were useful tools in the site selection process. The MSS data provide a historical baseline of landcover information from as far back as 1972.

1.4 Summary of Parameters

Landsat MSS data in the BOREAS Information System (BORIS) contains the following parameters:

Original image header information, image coordinates, calibration transformation tables, and gains and offset values for each of the image bands 1 through 4.

1.5 Discussion

BORIS personnel developed software to extract needed information from the image data files to verify its content and inventory the information from each scene. The image data remain in the original formats, which are:

- CCRS Landsat Ground Station Operations Working Group (LGSOWG) Band Interleaved by Line (BIL) and Band Sequential (BSQ).
- BIP2 format from USGS EDC. Some of this data originated from the Federally Owned Landsat Database (FOLD).

1.6 Related Data Sets

BOREAS Level-3s Landsat TM Imagery: Scaled At-sensor Radiance in LGSOWG Format

2. Investigator(s)

2.1 Investigator(s) Name and Title

BOREAS Staff Science

2.2 Title of Investigation

BOREAS Staff Science Satellite Data Acquisition Program

2.3 Contact Information

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3. Theory of Measurements

Since 1972, the Landsat program satellites have provided repetitive, synoptic, global coverage of high-resolution multispectral imagery. The characteristics of the different channels of the MSS and Thematic Mapper (TM) sensors aboard the Landsat satellites were selected to maximize their capabilities for detecting and monitoring various Earth resources.

Through its onboard instruments, Landsat monitors Earth's mountain ranges, deserts, forests, and crops by measuring the light waves they reflect. For example, MSS band 1 can be used to detect green reflectance from healthy vegetation, and band 2 of MSS is designed for detecting chlorophyll absorption in vegetation. MSS bands 3 and 4 are ideal for recording near-IR reflectance peaks in healthy green vegetation and for detecting water-land interfaces.

MSS Bands 4, 2, and 1 can be combined to make false-color composite images where band 4 controls the amount of red, band 2 the amount of green, and band 1 the amount of blue. This band combination makes vegetation appear as shades of red, brighter reds indicating more vigorously growing vegetation. Soils with no or sparse vegetation will range from white (sands) to greens or browns depending on moisture and organic matter content. Water bodies will appear blue. Deep, clear water will be dark blue to black in color, while sediment-laden or shallow waters will appear lighter in color. Urban areas will appear blue-gray in color. Clouds and snow will be bright white, and they are usually distinguishable from each other by the shadows associated with the clouds.

4. Equipment

4.1 Sensor/Instrument Description

The MSS system uses a scanning mirror in conjunction with a Ritchey-Chretien Cassegrainian telescope to focus radiance from Earth's surface onto a focal plane. Scanning 185-kilometer swaths, radiant energy is collected in west-to-east scans. During reverse scans, a shutter blocks the detectors. A fiber optic bundle receives light from the telescope and transmits it to the focal plane (correlates to one fiber for each detector). A total of 24 detectors and filters correspond to four spectral bands.

The MSS sensors flown aboard Landsat 4 and 5 are similar to the MSS sensors that were flown aboard Landsat 1, 2, and 3. However, the optics of the MSS system for Landsat 4 and 5 were adjusted so that the Instantaneous Field of View (IFOV) would still approximate an 80- by 80-meter ground area. This optical adjustment provided compatibility between the earlier and later MSS data collections.

Designators for the four spectral bands also were adjusted from the first series of MSS sensors (MSS 1, 2, 3) and those that flew with the TM sensor (MSS 4, 5), as shown in the table below. The MSS system on Landsat 3 was designed with a thermal channel; however this channel developed operating problems that caused the channel to subsequently fail.

The IFOV is 86.0 microradians, equating to a nominal ground resolution of 79 meters.

Landsat 1-3	Landsat 4-5	Wavelength (micrometers)
Band 4	Band 1	0.5 - 0.6
Band 5	Band 2	0.6 - 0.7
Band 6	Band 3	0.7 - 0.8
Band 7	Band 4	0.8 - 1.1
Band 8		10.4 - 12.6

4.1.1 Collection Environment

The Landsat satellites orbit Earth at altitudes of 920 km for Landsat 1, 2, and 3 and 705 km for Landsat 4 and 5.

4.1.2 Source/Platform

The MSS imagery collected for BOREAS include data from the MSS sensors aboard Landsat 1, 2, 4, and 5.

4.1.3 Source/Platform Mission Objectives

The Landsat MSS is designed to respond to and measure both reflected and emitted Earth surface radiation to enable the investigation, survey, inventory, and mapping of Earth's natural resources.

4.1.4 Key Variables

Reflected radiation.

4.1.5 Principles of Operation

An oscillating mirror scans across-track in a west-to-east direction in 185-kilometer swaths. During reverse scans, a shutter blocks the detectors. During every other mirror retrace, the individual sensors in the MSS bands are exposed to a rotating, variable density-wedge optical filter illuminated by an onboard calibration lamp. The resulting calibration data are subsequently utilized to make radiometric corrections on the MSS detector signals. The thermal-band detectors are exposed to temperature references during alternate mirror retraces when the spectral bands are not being calibrated. Nominal mirror frequency is 13.62 hertz.

4.1.6 Sensor/Instrument Measurement Geometry

A full MSS image contains 3,240-3,500 pixels in each of 2,340 lines (see Sections 6.1 and 11.1). Before any geometric corrections, the ground resolution is 80 m for bands 1, 2, 3, and 4 at nadir. The pixel values of the images can range from 0 to 128.

The MSS sensor depends on the forward motion of the spacecraft for the along-track scan and uses moving mirror assembly to scan in the cross-track direction (perpendicular to the spacecraft). The IFOV for each detector is equivalent to an 80-m square when projected to the ground at nadir.

4.1.7 Manufacturer of Sensor/Instrument

Hughes Aircraft Company
Santa Barbara Remote Sensing Division
Santa Barbara, CA

4.2 Calibration

Significant changes in calibration data occurred between instruments and within the data collected from a single instrument. For a chronological history of MSS calibration, refer to the "MSS Radiometric Calibration Handbook."

4.2.1 Specifications

Ground IFOV	80 m
Avg. Altitude	920 and 705 km (Landsat 1, 2, 3 and 4, 5, respectively)
Data Rate	86.8 kbps
Quantization levels	128
Orbit angle	189 degrees
Orbital Nodal Period	103 minutes
Scan width	185 km
Scan angle	14.9 degrees
Image overlap at Equator	14 %
Repeat Coverage	18 days

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

Internal calibration wedge data were acquired with every scan.

4.2.3 Other Calibration Information

A rotating shutter wheel was located between the telescope and the fiber optic bundle. This device was synchronized with the scan mirror to block the detectors during reverse scans. At the end of every other scan, the detectors viewed a calibration lamp through a graded density filter on the shutter wheel. This process allowed the detectors to respond to a continuously varying radiance. The data record was commonly referred to as the calibration wedge or the cal wedge.

Prior to launch, a calibrated integrating sphere was used to measure detector response to known radiance values. At the same time, detector response to the onboard calibration lamp also was recorded. By using detector responses at precise locations on the calibration wedge, a linear regression technique could be implemented to transfer the calibration of the integrating sphere to the calibration lamp. Therefore, the detector response was known in an absolute sense before launch such that values recorded by the detectors could be converted to physical units of radiance. After launch, the calibration lamp was used to maintain the absolute calibration that was recorded before launch.

However, there were many factors that could cause errors in the absolute calibration (e.g., changes to the lamp that occurred during or after launch or changes in the optical path between the calibration lamp and the detectors, which included the optical fiber bundle, the shutter wheel, and the spectral filters). Therefore, the absolute radiometric accuracy of MSS data is unknown.

Following ground transmission, the MSS data were decompressed, calibration wedge values were extracted, and the data were radiometrically corrected.

5. Data Acquisition Methods

The BOREAS Landsat MSS images were acquired through the CCRS and the USGS EDC. A full MSS image contains 3,240-3,500 pixels in each of 2,340 lines (see Sections 6.1 and 11.1). Before any geometric corrections, the ground resolution is 80 m at nadir. The pixel values of the images can range from 0 to 128. This allows each pixel to be stored in a single-byte field.

6. Observations

6.1 Data Notes

The BORIS MSS data came from several sources and platforms. Thus, individual characteristics and formats vary. For explicit information on data formats, see the following:

- The Standard Landsat MSS CCT Format Technical Memo DPD-TM-79-103C from the Data Processing Division of the CCRS.
- The LAS Image Processing System has software and help on the BIP2 format.

6.2 Field Notes

Not applicable.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The BOREAS Landsat MSS images primarily cover the Southern Study Area (SSA) and the Northern Study Area (NSA). A few images were acquired for the transect area between the SSA and the NSA. The SSA and the NSA are located in the southwest and northeast portions of the overall region.

The North American Datum of 1983 (NAD83) corner coordinates of the SSA are:

	Latitude	Longitude
Northwest	54.321 N	106.228 W
Northeast	54.225 N	104.237 W
Southwest	53.515 N	106.321 W
Southeast	53.420 N	104.368 W

The NAD83 corner coordinates of the NSA are:

	Latitude	Longitude
Northwest	56.249 N	98.825 W
Northeast	56.083 N	97.234 W
Southwest	55.542 N	99.045 W
Southeast	55.379 N	97.489 W

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

Before any geometric corrections, the spatial resolution is 80 m at nadir. These values increase with scan angle away from the nadir path. The LGSOWG images have had systematic geometric corrections applied to create a high level of internal spatial integrity; but without geometric registration, the actual geographic corner and center coordinates contained on the tape can be offset from their actual positions by as much as 20 km. The BIP2 data are in their original format and have not had any geometric corrections applied.

7.1.4 Projection

The LGSOWG Landsat MSS images are in a Universal Transverse Mercator (UTM) projection based on the NAD83.

7.1.5 Grid Description

None given.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Many of the MSS images were acquired early on in the project and were useful tools in the site selection process. The MSS data provide a historical baseline of landcover information from as far back as 1972.

7.2.2 Temporal Coverage Map

Date	Coverage	Date	Coverage
21-AUG-72	Transect	22-JUL-80	SSA
22-AUG-72	Region	13-JUL-81	NSA
22-AUG-72	Transect	18-JUL-81	SSA
23-AUG-72	Transect	01-AUG-81	Transect
24-AUG-72	Region	22-AUG-81	SSA
24-AUG-72	Transect	05-JUL-83	Transect
30-JUL-73	Transect	27-AUG-83	SSA
01-AUG-73	Transect	31-AUG-83	NSA
15-AUG-73	NSA	22-JUN-84	NSA
02-SEP-73	NSA	11-JUL-84	Region
10-JUL-75	Transect	19-JUL-84	Region
10-JUN-76	Transect	01-AUG-84	NSA
18-JUN-76	Transect	12-AUG-84	Region
16-JUL-76	Transect	17-AUG-84	NSA
25-JUL-76	SSA	01-JUN-88	NSA
08-AUG-76	NSA	04-AUG-88	NSA
22-AUG-76	Region	20-AUG-88	NSA
21-JUL-77	SSA	05-SEP-88	NSA
15-JUL-78	SSA		
03-AUG-78	SSA		
14-AUG-78	Region		
07-JUL-79	Transect		

7.2.3 Temporal Resolution

The Landsat MSS satellite revisit frequency is 18 days for each path/row; however, in the BOREAS region the overlap between adjacent scene paths is about 50% at the latitude of the BOREAS study area.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The main parameter contained in the image data files is scaled at-sensor radiance. The parameters contained in the inventory listing file on the CD-ROM are:

Column Name
SPATIAL_COVERAGE
DATE_OBS
START_TIME
END_TIME
PLATFORM
INSTRUMENT
NUM_BANDS
BAND_QUALITY
CLOUD_COVER
PATH_NUM
ROW_NUM
NW_LATITUDE
NW_LONGITUDE
NE_LATITUDE
NE_LONGITUDE
SW_LATITUDE
SW_LONGITUDE
SE_LATITUDE
SE_LONGITUDE
PLATFORM_ALTITUDE
MIN_SOLAR_ZEN_ANG
MAX_SOLAR_ZEN_ANG
MIN_SOLAR_AZ_ANG
MAX_SOLAR_AZ_ANG
CRTFCN_CODE

7.3.2 Variable Description/Definition

For the image data files:

Scaled at-sensor radiance - The scaled value representing the radiant energy incident on the sensor aperture at the time of data collection in the specific TM wavelength regions.

The descriptions of the parameters contained in the inventory listing file on the CD-ROM are:

Column Name	Description
SPATIAL_COVERAGE	The general term used to denote the spatial area over which the data were collected.
DATE_OBS	The date on which the data were collected.
START_TIME	The starting Greenwich Mean Time (GMT) for the data collected.
END_TIME	The ending Greenwich Mean Time (GMT) for the data collected.
PLATFORM	The object (e.g., satellite, aircraft, tower, person) that supported the instrument.
INSTRUMENT	The name of the device used to make the measurements.
NUM_BANDS	The number of spectral bands in the data.

BAND_QUALITY	The data analyst's assessment of the quality of the spectral bands in the data.
CLOUD_COVER	The data analyst's assessment of the cloud cover that exists in the data.
PATH_NUM	For Landsat and SPOT, the sequential number given to the orbital paths trending from northeast to southwest and extending around the earth.
ROW_NUM	For Landsat and SPOT, the sequential number given to the nominal scene acquisition points along the orbital paths which trend from northeast to southwest.
NW_LATITUDE	The NAD83 based latitude coordinate of the north-west corner of the minimum bounding rectangle for the data.
NW_LONGITUDE	The NAD83 based longitude coordinate of the northwest corner of the minimum bounding rectangle for the data.
NE_LATITUDE	The NAD83 based latitude coordinate of the north east corner of the minimum bounding rectangle for the data.
NE_LONGITUDE	The NAD83 based longitude coordinate of the north east corner of the minimum bounding rectangle for the data.
SW_LATITUDE	The NAD83 based latitude coordinate of the south west corner of the minimum bounding rectangle for the data.
SW_LONGITUDE	The NAD83 based longitude coordinate of the southwest corner of the minimum bounding rectangle for the data.
SE_LATITUDE	The NAD83 based latitude coordinate of the south east corner of the minimum bounding rectangle for the data.
SE_LONGITUDE	The NAD83 based longitude coordinate of the southeast corner of the minimum bounding rectangle for the data.
PLATFORM_ALTITUDE	The nominal altitude of the data collection plat form above the target.
MIN_SOLAR_ZEN_ANG	The minimum angle from the surface normal (straight up) to the sun during the data collection.
MAX_SOLAR_ZEN_ANG	The maximum angle from the surface normal (straight up) to the sun during the data collection.
MIN_SOLAR_AZ_ANG	The minimum azimuthal direction of the sun during data collection expressed in clockwise increments from North.
MAX_SOLAR_AZ_ANG	The maximum azimuthal direction of the sun during data collection expressed in clockwise increments from North.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).

7.3.3 Unit of Measurement

The units for the scaled at-sensor radiance values vary by band. To obtain at-sensor radiance values in Watts/(m^2 * sr * μm) use the formula:

```
At-sensor Radiance = Scaled Value * Gain + Offset
```

where the Gain and Offset values are contained in the ASCII header file. The measurement units for the parameters contained in the inventory listing file on the CD-ROM are:

Column Name	Units
SPATIAL_COVERAGE	[none]
DATE_OBS	[DD-MON-YY]
START_TIME	[HHMM GMT]
END_TIME	[HHMM GMT]
PLATFORM	[none]
INSTRUMENT	[none]
NUM_BANDS	[counts]
BAND_QUALITY	[none]
CLOUD_COVER	[none]
PATH_NUM	[unitless]
ROW_NUM	[unitless]
NW_LATITUDE	[degrees]
NW_LONGITUDE	[degrees]
NE_LATITUDE	[degrees]
NE_LONGITUDE	[degrees]
SW_LATITUDE	[degrees]
SW_LONGITUDE	[degrees]
SE_LATITUDE	[degrees]
SE_LONGITUDE	[degrees]
PLATFORM_ALTITUDE	[meters]
MIN_SOLAR_ZEN_ANG	[degrees]
MAX_SOLAR_ZEN_ANG	[degrees]
MIN_SOLAR_AZ_ANG	[degrees]
MAX_SOLAR_AZ_ANG	[degrees]
CRTFCN_CODE	[none]

7.3.4 Data Source

The sources of the parameter values contained in the inventory listing file on the CD-ROM are:

Column Name	Data Source
SPATIAL_COVERAGE	Determined by BORIS software from latitude and longitude information contained in the data files.
DATE_OBS	Determined by BORIS software from data and time information contained in the data files.
START_TIME	Determined by BORIS software from data and time information contained in the data files.
END_TIME	Determined by BORIS software from data and time information contained in the data files.
PLATFORM	Determined by BORIS software from platform information contained in the data files.
INSTRUMENT	Constant software value
NUM_BANDS	Determined by BORIS software from processing of

	the data files.
BAND_QUALITY	Not assessed.
CLOUD_COVER	Not assessed.
PATH_NUM	Determined by BORIS software from location information contained in the data files.
ROW_NUM	Determined by BORIS software from location information contained in the data files.
NW_LATITUDE	Determined by BORIS software from location information contained in the data files.
NW_LONGITUDE	Determined by BORIS software from location information contained in the data files.
NE_LATITUDE	Determined by BORIS software from location information contained in the data files.
NE_LONGITDE	Determined by BORIS software from location information contained in the data files.
SW_LATIUDE	Determined by BORIS software from location information contained in the data files.
SW_LONGITUDE	Determined by BORIS software from location information contained in the data files.
SE_LATITUDE	Determined by BORIS software from location information contained in the data files.
SE_LONGITUDE	Determined by BORIS software from location information contained in the data files.
PLATFORM_ALTITUDE	Determined by BORIS software from platform information contained in the data files.
MIN_SOLAR_ZEN_ANG	Calculated with software from latitude and longitude and time information.
MAX_SOLAR_ZEN_ANG	Calculated with software from latitude and longitude and time information
MIN_SOLAR_AZ_ANG	Calculated with software from latitude and longitude and time information.
MAX_SOLAR_AZ_ANG	Calculated with software from latitude and longitude and time information.
CRTFCN_CODE	Assigned by BORIS based on processing.

7.3.5 Data Range

The maximum range of digital numbers in each Landsat MSS image band is limited from 0 (zero) to 128. The following table gives information about the parameter values found in the inventory table on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SPATIAL_COVERAGE	N/A	N/A	None	None	None	None
DATE_OBS	21-AUG-72	05-SEP-88	None	None	None	None
START_TIME	800	1734	None	None	None	None
END_TIME	800	1734	None	None	None	None
PLATFORM	LANDSAT-1	LANDSAT-5	None	None	None	None
INSTRUMENT	N/A	N/A	None	None	None	None
NUM_BANDS	4	4	None	None	None	None
BAND_QUALITY	N/A	N/A	None	None	None	None
CLOUD_COVER	N/A	N/A	None	None	None	None
PATH_NUM	33	88	None	None	None	None
ROW_NUM	12	22	None	None	None	None

```
NW_LATITUDE           55.09167       68.91718       None    None    None    None
NW_LONGITUDE          -163.08096     -99.41002      None    None    None    None
NE_LATITUDE           53.7818        67.51253       None    None    None    None
NE_LONGITUDE          -164.9836      -95.69717      None    None    None    None
SW_LATITUDE           53.02074       68.13619       None    None    None    None
SW_LONGITUDE          -159.07222     -98.33821      None    None    None    None
SE_LATITUDE           52.8364        66.77645       None    None    None    None
SE_LONGITUDE          -161.1463      -96.47385      None    None    None    None
PLATFORM_ALTITUDE     705300         920000         None    None    None    None
MIN_SOLAR_ZEN_ANG     36.5           56             None    None    None    None
MAX_SOLAR_ZEN_ANG     36.5           56             None    None    None    None
MIN_SOLAR_AZ_ANG      128            156            None    None    None    None
MAX_SOLAR_AZ_ANG      128            156            None    None    None    None
CRTFCN_CODE           PRE            PRE            None    None    None    None
-------------------------------------------------------------------------------
Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value  -- The value that indicates missing data. This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the attempt was unsuccessful.
Unrel Data Value   -- The value that indicates unreliable data.  This is used
                      to indicate an attempt was made to determine the
                      parameter value, but the value was deemed to be
                      unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the
                      instruments detection limits.  This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the analysis personnel determined
                      that the parameter value was below the detection
                      limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                      determine the parameter value.  This usually
                      indicates that BORIS combined several similar but
                      not identical data sets into the same data base table
                      but this particular science team did not
                      measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
-------------------------------------------------------------------------------
```

7.4 Sample Data Record

A sample data record for the level-3s Landsat MSS images is not available here. The following are wrapped versions of sample records from the inventory table on the CD-ROM:

```
SPATIAL_COVERAGE,DATE_OBS,START_TIME,END_TIME,PLATFORM,INSTRUMENT,NUM_BANDS,
BAND_QUALITY,CLOUD_COVER,PATH_NUM,ROW_NUM,NW_LATITUDE,NW_LONGITUDE,NE_LATITUDE,
NE_LONGITUDE,SW_LATITUDE,SW_LONGITUDE,SE_LATITUDE,SE_LONGITUDE,PLATFORM_ALTITUDE,
MIN_SOLAR_ZEN_ANG,MAX_SOLAR_ZEN_ANG,MIN_SOLAR_AZ_ANG,MAX_SOLAR_AZ_ANG,CRTFCN_CODE
'TRANSECT',21-AUG-72,800,800,'LANDSAT-1','MULTI-SPECTRAL SCANNER',4,
'NOT ASSESSED','NOT ASSESSED',37,21,56.69167,-101.321,55.20957,-100.28639,
57.21594,-98.4287,55.71383,-97.49305,915000.0,48.0,48.0,150.0,150.0,'PRE'
```

8. Data Organization

8.1 Data Granularity

The smallest unit of Landsat MSS image data tracked by BORIS is a full MSS scene.

8.2 Data Format(s)

The CD-ROM inventory listing file consists of numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

The Landsat MSS data are stored in their original formats. Each scene is made up of the files as described below. There are several image processing software packages available with specific software and help for working with various forms of MSS and other sensor imagery.

The following document may help in extracting the MSS image data from tape:

- The Standard Landsat MSS CCT Format Technical Memo DPD-TM-79-103C from the Data Processing Division of the CCRS.

The data in the BOREAS archive from Landsat 1 and 2 contain data in both LGSOWG and BIP2 formats. BOREAS data from Landsat 4 and 5 contain only LGSOWG format; there are no data in the BOREAS archive from Landsat 3.

8.2.1 LGSOWG BSQ format

An image stored in the LGSOWG BSQ format contains 14 files. The files are:

File	Description
1	Volume Directory
2	Leader, Band 1
3	Image Data, Band 1
4	Trailer Data, Band 1
5	Leader, Band 2
6	Image Data, Band 2
7	Trailer Data, Band 2
8	Leader, Band 3
9	Image Data, Band 3
10	Trailer Data, Band 3
11	Leader, Band 4
12	Image Data, Band 4
13	Trailer Data, Band 4
14	Null Volume Directory

8.2.2 LGSOWG BIL format

An image stored in the LGSOWG BIL format contains 5 files. The files are:

File	Description
1	Volume Directory
2	Leader
3	Image Data
4	Trailer Data
5	Null Volume Directory

8.2.3 BIP2 format

An image stored in the LGSOWG BIP2 format (also known as the X-format) contains five files. The files are:

File	Description
1	Strip 1 Image Data in BIP2 with ID and Annotation Records
2	Strip 2 Image Data in BIP2 with ID and Annotation Records
3	Strip 3 Image Data in BIP2 with ID and Annotation Records
4	Strip 4 Image Data in BIP2 with ID and Annotation Records
5	SIAT file

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms
Not applicable.

9.2 Data Processing Sequence

9.2.1 Processing Steps
BORIS staff did not extract or reformat the Landsat MSS data. Processing involved only the extraction of selected header parameters that have been inventoried in the BORIS data base.

9.2.2 Processing Changes
None

9.3 Calculations

9.3.1 Special Corrections/Adjustments
None

9.3.2 Calculated Variables
None

9.4 Graphs and Plots
None

10. Errors

10.1 Sources of Error
Errors could arise in the acquired imagery due to location accuracy, distortion of lengths, anisomorphism, and the instrument's local coherence and multispectral registrability. Other errors could arise from inherent radiometric imperfections of the sensors.

10.2 Quality Assessment

10.2.1 Data Validation by Source
Whatever the processing level, the geometric quality of the image depends on the accuracy of the viewing geometry. Spectral errors could arise due to image-wide signal-to-noise ratio, saturation, cross-talk, spikes, and response normalization due to change in gain.

10.2.2 Confidence Level/Accuracy Judgment

The level-3s Landsat MSS imagery has had geometric corrections applied so that the spatial resolution for all pixels is 80 m in all bands. The level-3s imagery has a high level of internal spatial integrity, but the actual geographic coordinate information contained on the tape can be offset from the actual positions by as much as 20 km.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

None.

10.2.5 Data Verification by Data Center

BORIS personnel used developed software to extract image header information to enter into a relational data base. In addition, the software scanned the records of the files checking for proper record sizes. BORIS personnel did not look at the images themselves.

11. Notes

11.1 Limitations of the Data

None.

11.2 Known Problems with the Data

Early Landsat data have been known to be noisy and sometimes contain striping, particularly in the visible bands.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None.

12. Application of the Data Set

The Landsat MSS data can be used to look at landcover states and changes over the data coverage period.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

BORIS personnel developed software and command procedures to:

- Extract header information from level-3S Landsat MSS images on tape.
- Log level-3s Landsat MSS image products into the Oracle data base tables.
- Convert image header coordinates between the geographic systems of (latitude, longitude), UTM (northing, easting), and BOREAS (x,y) grid locations.

The software mentioned under items 1 to 3 is written in the C language and is operational on VAX 6410 and MicroVAX 3100 systems at GSFC. The primary dependencies in the software are the tape I/O library and the Oracle data base utility routines.

The geographic coordinate conversion utility (BOR_CORD) has been tested and used on Macintosh, IBM PC, VAX, Silicon Graphics, and Sun workstations.

14.2 Software Access

All of the described software is available upon request. BORIS staff would appreciate knowing of any problems discovered with the software, but cannot promise to fix them.

15. Data Access

The Landsat MSS imagery is available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

The Landsat MSS data can be made available on 8-mm or Digital Archive Tape (DAT) media.

16.2 Film Products

None.

16.3 Other Products

Although the image inventory is contained on the BOREAS CD-ROM set, the actual Landsat MSS images are not. See Section 15 for information about how to obtain the data.

17. References

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17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

ASCII	- American Standard Code for Information Interchange
BIL	- Band Interleaved by Line
BOREAS	- BOReal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
BPI	- Byte per inch
BSQ	- Band Sequential
CCRS	- Canada for Remote Sensing
CCT	- Computer Compatible Tape
CD-ROM	- Compact Disk-Read-Only Memory
DAAC	- Distributed Active Archive Center
DAT	- Digital Archive Tape
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
EROS	- Earth Resources and Observational Systems
ERTS	- Earth Resources Technology Satellite
FOLD	- Federally Owned Landsat Database
GICS	- Geocoded Image Correction System
GSFC	- Goddard Space Flight Center
IFOV	- Instantaneous Field-of-View
LGSOWG	- Landsat Ground Station Operations Working Group
LTWG	- LGSOWG Technical Working Group
MSS	- Multispectral Scanner
NAD27	- North American Datum 1927
NAD83	- North American Datum 1983

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NASA    - National Aeronautics and Space Administration
NSA     - Northern Study Area
ORNL    - Oak Ridge National Laboratory
SSA     - Southern Study Area
TIPS    - Thematic Mapper Image Processing System
TM      - Thematic Mapper
URL     - Uniform Resource Locator
UTM     - Universal Transverse Mercator
WWW     - World Wide Web
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BOREAS Staff Science, "BOREAS Staff Science Satellite Data Acquisition Program." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS Staff Science Satellite Data Acquisition Program focused on providing the research teams with the remotely sensed satellite data products they needed to compare and spatially extend point results. The Earth Resources Technology Satellite (ERTS) Program launched the first of a series of satellites (ERTS-1) in 1972. Part of the NASA Earth Resources Survey Program, the ERTS Program and the ERTS satellites were later renamed Landsat to better represent the civil satellite program's prime emphasis on remote sensing of land resources. Landsat satellites 1 through 5 carry the MSS sensor. CCRS and BOREAS personnel gathered a set of MSS images of the BOREAS region from Landsat satellites 1, 2, 4, and 5 covering the dates of 21-Aug-1972 to 05-Sep-1988. The data are provided in binary image format files of various formats.

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