BOREAS FOLLOW-ON DSP-01 NBIOME LEVEL-4 AVHRR LAND COVER, CANADA, VER. 1.1, 1995
Get Data

Summary

This land cover product was produced by NBIOME to generate an up-to-date, spatially and temporally consistent land cover map of the landmass of Canada for use by scientists and other users interested in environmental information at national and regional scales. The data were acquired by CCRS and were provided to BORIS for use. This data set is gridded and was produced from 10-day composite data of surface parameters. Temporally, the 10-day compositing periods begin 11-April-95 and ends 31-Oct-95. Spatially, the data cover the entire landmass of Canada. The data are stored in binary image format files. Note that some of the data files have been compressed using Zip compression. See Section 8.2 for details.

Data Citation

Cite this data set as follows (citation revised on October 29, 2002):

Cihlar, J., J. Beaubien, and B. Park. 2001. BOREAS Follow-On DSP-01 NBIOME Level-4 AVHRR Land Cover, Canada, Ver[sion] 1.1, 1995. Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS Follow-On DSP-01 NBIOME Level-4 AVHRR Land Cover, Canada, Ver.1.1, 1995

1.2 Data Set Introduction

This land cover product was produced by the Northern BIOsphere and Modeling Experiment (NBIOME) project to generate an up-to-date, spatially and temporally consistent land cover map of the land mass of Canada. The updated landcover map was developed for users interested in environmental information at national and regional scales.

1.3 Objective/Purpose

The goal of NBIOME is to improve the understanding of the relationship between the climate and the northern ecosystems, including their seasonal and interannual dynamics and their role in the global carbon cycle. The objective of the work which produced this land cover product was to generate an up-to-date, spatially and temporally consistent land cover map of the land mass of Canada for subsequent use by NBIOME scientists and other users interested in environmental information at national and regional scales.

1.4 Summary of Parameters

Land cover type

1.5 Discussion

This product is based on the BOREAS level-4c data, which had been processed to remove or mitigate some artifacts caused by the input data or the compositing process. The processing was carried out at CCRS using specifically designed software and procedures. Land cover was extracted using the Enhancement-Classification Method (Beaubien et al., 1997; Cihlar et al., 1998). The ECM relies on a visual identification of the important classes in enhanced images to be classified, and their subsequent labeling with the help of ancillary information. The processing steps are discussed in section 9.

1.6 Related Data Sets

BOREAS Level-3b AVHRR-LAC Imagery: Scaled At-sensor Radiance in LGSOWG Format
BOREAS Level-4b AVHRR-LAC Ten-Day Composite Images: At-sensor Radiance
NBIOME Level-2 AVHRR product
NBIOME Level-2B AVHRR product

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2. Investigator(s)

2.1 Investigator(s) Name and Title

Josef Cihlar, NBIOME Principal Investigator

2.2 Title of Investigation

Northern Biosphere Observation and Modeling Experiment (NBIOME)

2.3 Contact Information

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3. Theory of Measurements

The AVHRR sensor is a four- or five-channel scanning radiometer capable of providing global daytime and nighttime information about ice, snow, vegetation, clouds, and the sea surface. These data are obtained on a daily basis primarily for use in weather analysis and forecasting; however, a variety of other applications are possible. The AVHRR-LAC data collected for the BOREAS project were from instruments onboard NOAA-9, -11, and -12 polar orbiting platforms. The radiometers measured emitted and reflected radiation in the visible, near-infrared, one middle-infrared, and one or two thermal channels.

The primary use of each channel and the wavelength ranges at 50% relative spectral response for the NOAA-14 platform is given in the following table:

Channel	Wavelength [micrometers]	Primary Use
1	0.570 - 0.699	Daytime Cloud and Surface Mapping
2	0.714 - 0.983	Surface Water Delineation, Vegetation Cover
3	3.525 - 3.931	Sea Surface Temperature (SST), Nighttime Cloud Mapping
4	10.330 - 11.250	Surface Temperature, Day/Night Cloud Mapping
5	11.390 - 12.340	Surface Temperature

The AVHRR is capable of operating in both real-time and recorded modes. Direct readout data were transmitted to ground stations of the automatic picture transmission (APT) class at low resolution (4 x 4 km) and to ground stations of the high-resolution picture transmission (HRPT) class at high resolution (1 x 1 km). AVHRR HRPT data were received for the BOREAS region by the CCRS Prince Albert Satellite Station (PASS).

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4. Equipment

4.1 Sensor/Instrument Description

The AVHRR is a cross-track scanning system featuring one visible, one near-infrared, one middle-infrared, and two thermal channels. The analog data output from the sensors is digitized onboard the satellite at a rate of 39,936 samples per second per channel. Each sample step corresponds to an angle of scanner rotation of 0.95 milliradians. At this sampling rate, there are 1.362 samples per instantaneous field of view (IFOV). A total of 2,048 samples are obtained per channel per Earth scan, which spans an angle of +/-55.4 degrees from nadir.

4.1.1 Collection Environment

The NOAA satellites orbit Earth at an altitude of 833 km. From this space platform, the data are transmitted to a ground receiving station.

4.1.2 Source/Platform

Satellite	Launch Date	Date Range
NOAA-14	30-Dec-1994	15-May-1995 to present

4.1.3 Source/Platform Mission Objectives

The AVHRR is designed for multispectral analysis of meteorologic, oceanographic, and hydrologic parameters. The objective of the instrument is to provide radiance data for investigation of clouds, land water boundaries, snow and ice extent, ice or snow melt inception, day and night cloud distribution, temperatures of radiating surfaces, and SST. The AVHRR sensor is an integral member of the payload on the advanced TIROS spacecraft and its successors in the NOAA series, and as such contributes data required to meet a number of operational and research-oriented meteorological objectives.

4.1.4 Key Variables

Cover type (see section 7).

4.1.5 Principles of Operation

The AVHRR is a four- or five-channel scanning radiometer that detects emitted and reflected radiation from Earth in the visible, near-, middle-, and thermal-infrared regions of the electromagnetic spectrum. A fifth channel was added to the follow-on instrument designated AVHRR/2 and flown on NOAA-7, -9, -11, and -14 to improve the correction for atmospheric water vapor. Scanning is provided by an elliptical beryllium mirror rotating at 360 rpm about an axis parallel to that of Earth. A two-stage radiant cooler is used to maintain a constant temperature for the infrared detectors of 95 K. The operating temperature is selectable at either 105 or 110 K. The telescope is an 8-inch afocal, all-reflective Cassegrain system. Polarization is less than 10 percent. Instrument operation is controlled by 26 commands and monitored by 20 analog housekeeping parameters.

4.1.6 Sensor/Instrument Measurement Geometry

The AVHRR is a cross-track scanning system. The IFOV of each sensor is approximately 1.4 milliradians, giving a spatial resolution of 1.1 km at the satellite subpoint. There is about a 36-percent overlap between IFOVs (1.362 samples per IFOV). The scanning rate of the AVHRR is six scans per second, and each scan spans an angle of ± 55.4 degrees from the nadir.

4.1.7 Manufacturer of Sensor/Instrument

Not available at this revision.

4.2 Calibration

AVHRR channels 1 and 2 have no on-board calibration, and calibration coefficient estimates are obtained by NOAA from reference (nominally stable) ground targets. The thermal infrared channels are calibrated in-flight using a view of a stable blackbody and of space as a reference. Channel 3 data are noisy due to a spacecraft problem and may not be usable, especially when satellite is in daylight (Kidwell, 1991).

4.2.1 Specifications

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IFOV                1.4 mrad
RESOLUTION          1.1 km
ALTITUDE            833 km
SCAN RATE           360 scans/min (1.362 samples per IFOV)
SCAN RANGE          -55.4 to 55.4 degrees
SAMPLES/SCAN        2,048 samples per channel per Earth scan
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4.2.1.1 Tolerance

The AVHRR infrared channels were designed for a Noise Equivalent Differential Temperature (NEdT) of 0.12 K (at 300 K) and a signal-to-noise ratio of 3:1 at 0.5-percent albedo.

4.2.2 Frequency of Calibration

Data from NOAA-14 AVHRR Channels 1 and 2 were calibrated using reference data derived from stable surface targets (refer to Cihlar and Teillet, 1995). AVHRR channels 3-5 were calibrated using on-board reference black bodies.

4.2.3 Other Calibration Information

For additional calibration information see the documentation for the input data sets (section 1.6).

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5. Data Acquisition Methods

The NOAA-14 AVHRR satellite data were acquired as part of the NBIOME data collection effort by the Canada Centre for Remote Sensing at its Prince Albert Satellite Station (PASS). Raw data are available from the PASS facility. Supplementary coverage of eastern Canada (one orbit per day) was obtained by the Atmospheric Environment Service of Environment Canada.

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6. Observations

6.1 Data Notes

None.

6.2 Field Notes

See section 10.2.

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7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Data covering the entire Canadian land mass were acquired for the land cover product. See section 7.1.5 for coverage extent.

The AVHRR provides for global (pole-to-pole) on-board collection of data from all spectral channels. The 110.8 degree scan equates to a swath 27.2 degrees in longitude (at the equator) centered on the sub-satellite track. This swath width is greater than the 25.3 degree separation between successive orbital tracks and provides overlapping coverage (side-lap) anywhere on the globe.

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

The instantaneous field-of-view (IFOV) of each sensor is approximately 1.4 milliradians, leading to a resolution of about 1.1 km by 1.1 km at nadir for a nominal altitude of 833 km. At the extremes of the swath the IFOV is an ellipse with dimensions 2.5 km x 6.8 km. The composite AVHRR images have had geometric corrections applied so that the (sampled) pixel size is 1 km.

7.1.4 Projection

Geographic projection: Lambert Conformal Conic (LCC)

7.1.5 Grid Description

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Earth Ellipsoid E008 NAD83

Map corners (in metres):
                Easting   Northing
               --------   --------
Upper Left     -2600000   10500000
Upper Right     3100000   10500000
Lower Left     -2600000    5700000
Lower Right     3100000    5700000
Pixel Size         1000       1000

Map corners (in degrees):
                       Longitude          Latitude
                    -----------------   ----------------
Upper Left  Corner  177° 17' 32.21" W   66° 54' 22.82" N
Upper Right Corner    9° 58' 39.57" W   62° 25' 50.45" N
Image Center         89° 56' 43.00" W   62° 46' 47.18" N
Lower Left Corner   122° 54' 49.00" W   36° 12' 53.87" N
Lower Right Corner   62° 32' 49.65" W   34° 18' 05.61" N

Map Origin           95° 00' 00.00" W    0° 00' 00.00" N

1st, 2nd Standard parallels     49° 00'00.00" N, 77° 00'00.00" N
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7.2 Temporal Characteristics

7.2.1 Temporal Coverage

At northern latitudes, once per day or better (due to overlapping swaths) coverage is provided by the AVHRR. Virtually all raw data recorded from daytime overpasses were received. The overall time period of data acquisition for this data set was from April 11 through October 31, 1995.

7.2.2 Temporal Coverage Map

Not available.

7.2.3 Temporal Resolution

There are generally 2 overpasses per day by NOAA-14 at approximate times of 0200 and 1400 GMT. Each scan of the AVHRR views the Earth for a period of 51.282 msec. During this period each channel of the analog data output is digitized to obtain a total of 2048 samples at intervals of 25.0 microseconds (The sampling rate of the AVHRR sensors is 39,936 samples/sec/channel). Successive scans occur at the rate of 6 per second, or at intervals of 167 msec. Only afternoon overpass data were used for the land cover product.

7.3 Data Characteristics

7.3.1 Parameter/Variable

Cover type.

7.3.2 Variable Description/Definition

The land cover product portrays the distribution of various Canadian land cover types. This section contains the definitions of the various classes as well as additional comments. (Note: numbers in the parentheses following the class name refer to the value or digital number (DN) associated with each class in the digital map file.)

1.0 Forest Land Land dominated by vegetation with a tree (woody plants with a height exceeding approximately 5 metres in most cases) crown density (percentage of the surface covered by projected tree crown perimeters) greater than 10%.
1.1 Evergreen Needleleaf Forest Land occupied by forest containing more than 80% needleleaf trees.
1.1.1 High Density (1) Evergreen needleleaf forest (southern boreal; see Rowe, 1972) with crown density of the needleleaf species above approximately 60%. Often contains small water bodies in the landscape. Occasionally, it contains stands with less than 80% needleleaf trees (higher proportion of water compensates spectrally for the increased proportion of broadleaf trees).
1.1.2 Medium Density Evergreen needleleaf forest with crown density of the needleleaf species between approximately 40-60% . Due to the low resolution of the data, the pixels may include a mosaic of denser and thinner tree cover.
1.1.2.1 Southern Forest (2) Medium density evergreen needleleaf forest which often occurs within, or adjacent to, high density forest (1.1.1 above). In most cases, it has a higher proportion of broadleaf trees or shrubs (woody plants less than 2-3 m high) than the

high density forest. Occurs mostly in the southern part of the boreal forest zone. Occasionally may be confused with younger high density needleleaf tree canopies (higher reflectance of the young needleleaf trees compensates for the higher reflectance of broadleaf trees in the stands).
1.1.2.2 Northern Forest (3) Medium density evergreen needleleaf forest with shrubs and lichens commonly present in the understory. Occurs in the northern part of the boreal forest zone but in some cases, patches are found in more southern areas after old perturbations such as fire.
1.1.3 Low Density Evergreen forest with crown density of the needleleaf species approximately 10-40%. Due to the low resolution of the data, pixels may contain a mosaic of denser and lower tree cover, including openings such as cut-overs or others.
1.1.3.1 Southern Forest (4) Low density evergreen needleleaf forest with a higher proportion of broadleaf trees or shrubs species than high density forest (1.1.1 above). Occurs mostly in the southern part of the boreal forest zone, with some latitudinal overlaps with northern low density forest where broadleaf species are more abundant. Occasionally may be confused with younger higher density needleleaf trees canopies (higher reflectance of the young needleleaf trees compensates for the high reflectance of broadleaf trees in the low density stands). In some cases it may also be confused with treed wetlands.
1.1.3.2 Northern Forest (5) Low density evergreen needleleaf forest with shrubs and lichens commonly present in the understory. Occurs mostly in the northern part of the boreal forest zone. When the tree crown density is low (near 10%), this class may consist of treed muskeg or wetlands. Occasionally, it may contain lower tree crown density (less than 10%, south of the tree line) or treeless cover (north of the tree line) where abundant water bodies are present (water reflectance has a similar effect as a denser needleleaf tree cover). In some cases (mostly after perturbations (burns) or on more humid sites), there is some latitudinal overlap with southern forest (1.1.3.1) because of the similarity of the ground cover (especially regarding low shrubs).
1.2 Deciduous Broadleaf Forest (6) Concentrated occurrence of deciduous broadleaf forest, generally with a high crown density. In Quebec and Ontario, this class represents primarily the shade-tolerant hardwood species (maples, yellow birch). Due to the low resolution of AVHRR data, most of the broadleaf forest elsewhere in Canada is included in the mixed forest classes (mainly mixed broadleaf, class #10, see 1.3.3).
1.3 Mixed Forest Land occupied by forest containing 20-80% evergreen needleleaf or deciduous broadleaf trees (determined as the percentage of the number of the trees present, not as tree crown

density). Due to the low resolution of the data, pixels may contain a mosaic of needleleaf and broadleaf cover types.

1.3.1 Mixed Needleleaf Forest (7)

Mixed forest with the proportion of evergreen needleleaf trees exceeding approximately 60% (as % of all trees present). Occasionally may contain a higher proportion of needleleaf trees (>80% of the tree population) but in a younger canopy (higher reflectance of the young needleleaf trees compensates for the higher reflectance of broadleaf trees in older stands).

1.3.2 Mixed Intermediate Forest

Mixed forest with the proportion of evergreen needleleaf (or deciduous broadleaf) trees approximately 40-60% (as proportion of all trees present). The proportion of needleleaf trees may be higher in young stands (higher reflectance of the young needleleaf trees compensates for the higher reflectance of broadleaf trees in older stands).

1.3.2.1 Mixed Intermediate Uniform Forest (8)

Mixed intermediate forest with a relatively uniform distribution of trees in the landscape, typically with a higher crown density.

1.3.2.2 Mixed Intermediate Heterogenous Forest (9)

Mixed intermediate forest with a lower crown density or forest with a patchy distribution of trees in the landscape, typically after old disturbance (due to natural or human intervention). Patches may vary in size from tens to hundreds of metres. This class generally contains younger canopies.

1.3.3 Mixed Broadleaf Forest (10)

Mixed forest with the proportion of deciduous broadleaf trees exceeding approximately 60% (as % of all trees present). Due to the low resolution of AVHRR data, most of the broadleaf forest in Canada is included in this mixed class.

1.4 Burns

Land previously occupied by forest which was subject to fire. At present it may contain broadleaf or needleleaf trees with a tree crown density of less than 10% or standing dead trees. Occasionally this category may contain vegetated landscape with concentrations of water bodies. Depending on site conditions, fire intensity and age, land cover after burns may be quite variable. It varies from bare soil to vegetation cover approaching low density forest canopy. This is the reason why some burns or parts of burns, after few years, are classified as low density northern forest with a shrubby ground cover; or as another type of open land. Usually, the typical patchy pattern of post-burn cover types is diagnostic. Burn classes are more reliable in the northern forest types where vegetation regrowth is slower while in more southern areas, the change from burn to other classes can be quite rapid (within <4 years).

1.4.1 Low Green Vegetation Cover (11)

Burns with small amounts of green vegetation present, probably burned within the last 5 years (but depends on the fire intensity and site). Standing dead trees are commonly present.

1.4.2 Green Vegetation Cover (12)

Burns with greater amount of green vegetation present, implying earlier fires or more favourable site conditions. Also may occur near the perimeter of the burns when adjacent to undisturbed vegetation.

2.0 Open Land Land with a tree crown density of less than 10%.
2.1 Transition Treed Shrubland (13) Land in which tree crown density is usually below 10%. This class contains many past disturbances, mainly fires. It occurs mainly in northern boreal forest (see Rowe, 1972), but is occasionally found in more southern areas following disturbance. It may include significant proportions of shrubs.
2.2 Wetland/Shrubland Land covered mainly by low (less than 1 metre in height) to intermediate woody shrubs (woody vegetation generally less than 2-3 m high). Generally the proportion of high shrubs is higher than in the Barren Land classes (2.3). May include broadleaf tree canopy in early regeneration stages after perturbations. Most of the large wetlands occur in these classes.
2.2.1 High Density (14) The cover density of shrubs is higher than 60%. Many wetlands are in this class.
2.2.2 Medium Density (15) Mixture of shrubs (approximately 40-60%) and herbaceous cover. Some wetlands are in this class (especially fens).
2.3 Grassland (16) Land with herbaceous (non-woody) vegetation cover, tree or shrub cover being less than 10%. This class is limited to the prairie region.
2.4 Barren Land Land containing usually less than 10% of tree crown density. It often contains shrubs, mainly low shrubs (less than 1 m in height), lichen, herbaceous vegetation cover, bare soil, rock, or small water bodies. It is found mostly north of the tree line, but also in mountainous regions and after disturbance in more southern areas. In barren land classes, reflectance depends on the proportions of five main cover types: shrubs, lichens, herbaceous species, bare soil (rock outcrop) and water bodies. The subcategories are differentiated by the dominance of one or more of these cover types.
2.4.1 Shrub and Lichen Dominated Barren land in which shrubs and lichen are the dominant cover type. Generally, the shrubs are lower than in the Shrubland classes (2.2). The two classes (2.3.1.1 and 2.3.1.2) have a latitudinal gradient. They occur mainly north of the treeline, but also in northern boreal forest or mountainous areas sparsely treed.
2.4.1.1 Lichen and others (17) Varying amount of land cover in which lichen exert a strong effect on reflectance. In northern boreal forest (Rowe, 1972), it may represent low to very low density needleleaf forest with lichen understory. North of the tree line, this class may also include abundant water bodies. This class has a latitudinal gradient. Reflectances are lowered by trees in northern boreal forest, and by small water bodies, or rock outcrops north of the tree line.
2.4.1.2 Shrub/Lichen Dominated (18) Shrub-dominated barren land in which lichen exerts some effect on reflectance. South of the tree line, trees are occasionally present in this class. This class has also a latitudinal gradient. It occurs mainly north of the tree line,

but also in mountainous areas or in northern boreal forest, mostly after perturbations.

2.4.2 Treeless
Barren land occurring north of the tree line, but also in mountainous areas.

2.4.2.1 Heather and Herbs (19)
Treeless barren land in which shrubs, herbs and lichen are the prevalent vegetation cover. The landscape typically consists of a pattern of shrubs, lichen, herbs, bare soil, and rock outcrops.

2.4.2.2 Low Vegetation Cover (20)
Treeless barren land in which vegetation cover (shrubs, lichen, herbs) do not exceed approximately 40% of the ground cover.

2.4.2.3 Very Low Vegetation Cover (21)
Treeless barren land in which vegetation cover (shrubs, lichen, herbs) do not exceed approximately 20% of the ground cover area.

2.4.2.4 Bare soil and rock (22)
Treeless barren in which bare soil and rock outcrop is the prevalent land cover. Patches of snow cover may occur.

3.0 Developed Land

3.1 Cropland
Land covered with herbaceous (typically annual) crops which may contain a small proportion (less than 10%) of trees or shrubs.

3.1.1 High Biomass (23)
Cropland dominated by crops with higher biomass, due to cover type (e.g., corn) or climate (adequate precipitation). May contain small proportions of other vegetation types (less than 10%).

3.1.2 Medium Biomass (24)
Cropland dominated by crops with medium biomass, due to cover type or climate (subhumid). This class occurs in the prairie region.

3.1.3 Low Biomass (25)
Cropland dominated by crops with lower biomass, due to cover type (e.g., grain) or climate (semiarid region). This class occurs in the prairie region.

3.2 Mosaic Land
Land containing a mix of cropland, forest, shrubland, grassland or built-up areas in which no one component comprises more than about 70% (by area) of the landscape.

3.2.1 Cropland-Woodland (26)
Mosaic land in which cropland is more prevalent than forest cover (mostly broadleaf deciduous forest). Depending on the region, lower cropland biomass may be compensated for by a higher proportion of forest. Occasionally, this class may occur in areas where herbaceous vegetation replaces the cropland component (e.g., in parks).

3.2.2 Woodland-Cropland (27)
Mosaic land in which tree cover (mostly needleleaf species) and shrubs are more prevalent than cropland. This class occurs in the prairie region in the medium biomass region.

3.2.3 Cropland-Other (28)

Mosaic land in which cropland is more prevalent than other cover types. These could be forest, shrubland, or built-up areas. Compared to Cropland-Woodland (3.2.1), the common characteristic of these cover types is lower green biomass.
3.3 Urban and Built-up (29) Land covered by buildings and other man-made structures. In most cases, built-up areas are spectrally similar to various unvegetated or low-vegetated cover types. For larger cities, this class was therefore imported from another data base. However, confusion with other classes occurs for smaller urban areas.
4.0 Non-Vegetated Land Land covered with water (in solid or liquid form).
4.1 Water (30) Land covered with liquid water.
4.2 Snow/ ice (31) Land covered with permanent ice or snow.

7.3.3 Unit of Measurement

Unitless (digital number).

7.3.4 Data Source

These NOAA AHVRR data were processed and provided by CCRS.

7.3.5 Data Range

Land cover values range between 0 and 31.

7.4 Sample Data Record

Not applicable for image data.

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8. Data Organization

8.1 Data Granularity

None given.

8.2 Data Format(s)

8.2.1 Uncompressed Data Files

There are two forms of this data set. One is a flat binary image file, the other is a GIF image with color and annotation. The GIF image was originally delivered as a TIFF image that was quite large. The GIF image is available in two sizes: "canada_landcover_95.gif" (6000x4800 pixels, 3.7 Mb) and "canada_landcover_95_sm.gif" (800x640 pixels, 212K). The binary image "canada_landcover_95.img" has been Zip compressed, and is a single-byte image with a size of 5700 pixels by 4800 lines.

8.2.2 Compressed Files

The image files have been compressed with the MS Windows-standard Zip compression scheme. These files were compressed using Aladdin's DropZip on a Macintosh. DropZip uses the Lempel-Ziv algorithm (Welch, 1994), also used in Zip and PKZIP programs. The compressed files may be uncompressed using PKZIP (with the -expand option) on MS

Windows and UNIX, or with StuffIt Expander on the Mac OS. You can get newer versions from the PKZIP Web site at http://www.pkware.com/shareware/ [Internet Link].

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9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

The AVHRR processing involved three phases: conversion of raw satellite data into 'raw composites'; transformation of these into refined composite products; and extraction of land cover information from the composite data. Raw composite image description is given by Buffam (1994) and in abbreviated form by Cihlar et al. (1997). Refined composite product description is given in section 9.2.1 and in references identified within. The extraction of land cover information is described in section 9.2.2.

Note that the input data for the land cover map are the same as BOREAS level 4C, with further steps to get the growing season and the specific 3 channels used (representing growing season means). The levels described in the previous paragraph are those used by CCRS and NBIOME and do not necessarily match those used by BORIS.

9.2 Data Processing Sequence.

9.2.1 Processing Steps and Data Sets for Level-2B input products.

The input data were 20 'raw' image composites for 10 day periods (11 April to 31 October) with a pixel spacing of 1 km (Cihlar et al., 1997). The follwing steps were taken:

1. Top-of-the-atmosphere reflectance. TOA reflectance for channel 1 or 2 is calculated from the corrected radiance, L*(new), with the formula given by Teillet (1992). Gain and offset values were calculated with consideration of post-launch sensor degradation (Cihlar and Teillet, 1995; Teillet and Holben, 1994).
2. Atmospheric correction of AVHRR channels 1 and 2. The SMAC algorithm (Simplified Method for Atmospheric Correction; Rahman and Dedieu, 1994) was employed in the processing. The processing was carried out assuming water content of 2.3 g/cm^2 and ozone content 0.319 cm-atm. A constant value of 0.05 was used for optical depth at 550 nm. The corrections were computed on a pixel basis using the solar zenith, view zenith, and relative azimuth channels.
3. Identification of contaminated pixels. A new procedure was developed to identify the contaminated pixels, i.e. pixels where the surface vegetation or soil signal is obscured by atmospheric or surface effects (Cihlar, 1996). The procedure, dubbed CECANT (Cloud Elimination from Composites using Albedo and NDVI Trend) is based on the high sensitivity of NDVI to the presence of clouds, aerosol and snow. Three features of the annual surface reflectance trend are used, 1) the high contrast between the albedo (represented by AVHRR channel 1) of land, especially when fully covered by green vegetation, and clouds or snow/ice, 2) the average NDVI value (expected value for that pixel and compositing period), and 3) the monotonic trend in NDVI. Four thresholds are required in CECANT to identify partially contaminated pixel (i,j,t) where i and j are pixel coordinates and t is the compositing period:

- ◊ C1(t): the maximum channel 1 reflectance of a clear-sky, snow- or ice-free land pixel in the data set
- ◊ Rmin(t): the maximum acceptable deviation of the measured value NDVI(i,j,t) below the estimated NDVIa(i,j,t)
- ◊ Rmax(t): the maximum acceptable deviation of the measured value NDVI(i,j,t) above the estimated NDVIa(i,j,t)
- ◊ Zmax(t): the maximum acceptable deviation of the measured value NDVI(i,j,t) above the estimated NDVImax(i,j,t).

NDVImax(i,j,t) and NDVIa(i,j,t) were calculated using the FASIR model of Sellers et al. (1994) which approximates the seasonal NDVI curve with a third-order Fourier transform. Before the computation, missing NDVI values between first and last measurements were replaced through linear interpolation after finding the seasonal peak for each pixel, using the rationale and algorithm of Cihlar and Howarth (1994). NDVI corrections for solar zenith angle effects were also made before deriving R and Z values, using the method of Sellers et al. (1994) and their coefficients for the various land cover classes. A new set of NDVI values was then computed for a reference solar zenith angle of 45 degrees, based on the equations of Sellers et al. (1994). A constant value of 0.30 was used for C1(t). The upper and lower limits for the R and Z thresholds were determined separately for each composite period using R and Z histograms (Cihlar, 1996). Using these thresholds, a cloud mask was prepared for each composite period.

4. Corrections for bi-directional reflectance effects in channels 1 and 2. The model of Roujean et al. (1992) as modified by Wu et al. (1995) was used to characterize the seasonal bi-directional reflectance function for each cover type. Land cover-dependent model coefficients were derived (Wu et al., 1995) using a map of Canada with pixel size of 1 km prepared with AVHRR data (Pokrant, 1991). Only cloud-free pixels were included in the derivation of the model coefficients, and no bi-directional corrections for snow- or ice-covered areas were made. The resulting models were used to compute channel 1 and 2 reflectance for view zenith of 0 degrees and solar zenith of 45 degrees.
5. Replacement of contaminated pixels for AVHRR channels 1 and 2. Two cases were recognized, pixels contaminated a) during, or b) at the end of, the growing season. For pixels during the growing season, the new values were found through linear interpolation for both channels 1 and 2. At the end of the growing season it was assumed that the annual trajectory for individual channels as well as for NDVI could be approximated by a second degree polynomial. The polynomial was fitted to the plot or corrected reflectance for all clear-sky periods, starting with the first clear-sky composite period after 1 August, 1993. After determining the best fit coefficients, the new values were calculated using the polynomial coefficients to replace contaminated pixels in each channel prior to the first clear pixel or after the last such pixel.
6. Channel 4 correction. The modified split window method of Coll et al. (1994) was used which accounts for both atmospheric and surface emissivity effects. Coefficients estimating atmospheric effects were derived by Coll et al. (1994), alpha and beta were obtained from their Figure 2. Surface emissivity was estimated using a log-linear relationship between NDVI and emissivity; the emissivity coefficients were derived from literature data. The formulas and coefficients were:

   Ts = T4 + (a0 + a1*(T4-T5))*(T4-T5) + B(eps);

   B(eps) = alpha * (1-eps4) - beta * (eps4 - eps5);

eps4 = 0.98968 + 0.0288 * ln(NDVI);

eps4-eps5 = 0.010185 + 0.013443 * ln(NDVI);

where:

T4, T5 are brightness temperatures (top-of-the atmosphere) in AVHRR channels 4,5;
eps4, eps5 are emissivities in AVHRR channels 4,5;
coefficients a0=1.29, a1=0.28, alpha=45 K, beta= 40 K.

After the atmospheric and emissivity corrections the contaminated values were replaced through interpolation in the same manner as for channels 1 and 2 (Step 5 above).

7. Identification of the growing season. Growing season was defined as the period in 1995 between the first day and the last day when the surface temperature (derived in Step 6) exceeded 10 degrees Celsius. The satellite-measured value was assumed to apply to the middle date of the compositing period, and the exact day was determined through linear interpolation between adjacent compositing periods.
8. Derivation of mean seasonal values. Mean AVHRR pixel values were derived for the growing season of 1995 as the average values for a compositing period multiplied by the number of growing season days in that period, summed over the growing season and divided by the growing season length. Mean values were computed for Channel 1, 2, and NDVI (derived from the channel 1 and 2 fully corrected for bi-directional reflectance effects; see Steps 4, 5 above). The resulting values were transformed from 16 bits to 8 bits using the following limits:

	Original limits (16 bits)	New limits (8 bits)
Channel 1:	0 to 255 (=0 to 0.255)	0 to 255
Channel 2	2 to 385 (=0.002 to 0.385)	0 to 255
NDVI	9000 to 17925 (=0 to 0.79)	0 to 255

9.2.2 Extraction of land cover information.

Land cover was extracted using the Enhancement-Classification Method (ECM) (Beaubien et al., 1997; Cihlar et al., 1998). The ECM relies on a visual identification of the important classes in enhanced images to be classified, and their subsequent labeling with the help of ancillary information. Briefly, it consists of the following steps:

1. Contrast enhancement. The purpose of the enhancement is to bring out the distinctions among various classes of interest so that they can be more easily differentiated in the later steps. The limits for the contrast stretch are chosen to incorporate the reflectance extremes (dark and bright) of interest, and then expanding the range between these extremes into the entire dynamic range. The following values were employed:

Channel	Original limits (8 bits)	New limits (8 bits)
1	30 to 200	0 to 255
2	60 to 160	0 to 255
NDVI	40 to 215	0 to 255

The contrast stretch was linear for Channel 2 and NDVI but logarithmic (exponent = 0.8) for Channel 1; this was done to allow better differentiation in various forest cover classes.

2. Image quantization. The purpose of image quantization was to reduce the number of the actual combinations of the spectral values in the three bands as much as possible, without noticeably reducing the information content of the data. Based on previous experience, the histogram in each channel was divided into 10 segments with the following thresholds (output value refers to the value which replaced the original digital value):

```
min :  max ; output value
------------------------
  0 :   14 ;     0
 15 :   42 ;    28
 43 :   70 ;    56
 71 :   98 ;    84
 99 :  126 ;   112
127 :  154 ;   140
155 :  182 ;   168
183 :  211 ;   197
212 :  240 ;   226
241 :  255 ;   255
```

   The same limits were applied in each channel.
3. Image filtering. The three quantized images were individually filtered, using a 5x5 mode filter, to emphasize spatially important clusters and thus facilitate the selection of significant cluster means. The effect of quantization and filtering is to 'flatten' the image, i.e. create an incipient classification in which colours become uniform over groups of adjacent pixels.
4. Selection of spectral clusters. Important clusters in the image were identified and their spectral values in each band were recorded. 'Important' means clusters that are present in the image to a significant extent, as determined from the visual examination of the enhanced image. The spectral mean values were extracted from this contrast-enhanced, quantized and filtered image.
5. Clustering. Using a minimum distance classifier, all pixels in the full-resolution enhanced image (from Step 1) were classified into one of the spectral clusters identified in Step 4. To facilitate the subsequent agglomeration of the clusters (Step 6), the clusters were displayed using colours associated with the cluster means from Step 4.
6. Cluster agglomeration and labeling The purpose of this step is to group spectral clusters considered by the analyst to represent the same ground class and to assign a cover type label. This step is facilitated by the visual similarity of the classified image to the original image, and by available ancillary data. Landsat TM images and personal knowledge of land cover distribution in Canada was employed in the agglomeration and labeling process. This is the most analyst-dependent step; results of the agglomeration can vary with analyst experience and knowledge of land cover distribution.
7. Post-classification operations. Because of the imperfect relationship between land cover types and their spectral expressions (including spectral overlaps of certain classes, mainly due the low resolution of the data) in the three channels, several image processing operations were performed in cases of known confusion. Specifically:

◊ Built-up areas were incorporated from another data source. This class can often be distinguished from the surrounding through a spectral contrast but it is generally confused with barren land cover types.

◊ Cropland classes may be spectrally confused with natural cover types. In general, high biomass cropland cover has a unique signature. Medium biomass cropland is occasionally confused with shrubland (medium density). Low biomass cropland can be confused with some northern or mountainous barren land, and grassland is commonly confused with some barren classes. Although these overlaps occur only occasionally they may disproportionately affect the credibility of the map by a general user. Thus to remedy these problems, cropland was separated from isolated, spectrally similar pixels in the boreal and treeless regions by preparing a mask for the area south of the boreal forest and changing the class assignment. In the Hudson Bay Lowland the needleleaf forest density was overestimated as a result of many small water bodies leading to low reflectance. The medium density forest cover in this area was re-labeled as low density forest.

◊ In the Version 1.0 of the land cover map, the needleleaf forest was underrepresented in eastern Quebec, New Brunswick and Nova Scotia. This determination was made by the provincial evaluators of the map product, and it is attributed to the influence of the deciduous and herbaceous tree cover in this region. Therefore, the area was masked out and a new agglomeration and labeling of the classes was carried out locally (i.e., Step 6 from section 9.2.2 was repeated inside the masked area); Landsat Thematic Mapper images were used to assign labels to the clusters.

◊ Isolated forest burn pixels were reassigned to water class when they occurred in isolated groups (see Section 10.1 for rationale). This was accomplished in three passes: (i) an isolated single pixel; (ii) an isolated pixel group in a 3x3 window with other classes surrounding the window; and (iii) an isolated pixel group in a 5x5 window with other classes surrounding the window.

9.2.3 Processing Changes.

Snow and ice class:

Since the AVHRR correction methodology eliminates snow and ice as well as clouds, it was not possible to map this class directly from satellite data. The class of permanent snow was therefore obtained by identifying all land pixels which did not belong to any other class and assigning the appropriate label; it is thus the difference between the total land mass and the pixels classified as other cover types.

Water class:

In the case of pure water pixels the maximum NDVI-based compositing process (leading to Level-2B product) preferentially selects cloudy days over cloud-free days. The water class could not thus be identified directly from the satellite data. It was therefore inserted into the data set prior to the classification process, using water mask from the World Data Bank database (Pokrant, 1991).

9.3 Calculations.

See Section 9.2.

9.3.1 Special Corrections/Adjustments.

See Step 7, Section 9.2.2 above.

9.3.2 Calculated Variables

See Section 9.2.2 above.

9.4 Graphs and Plots.

None.

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10. Errors

10.1 Sources of Error

There are two major sources of error in the land cover product, those due to characteristics and the imperfect corrections of the AVHRR data (Section 9.2.1) and those due to the confusion between various cover types caused by the lack of spectral uniqueness of some types. Both types of error usually occur in land cover mapping with remotely sensed data. They result in an erroneous assignment of a pixel to a cover type, and it is often not possible to identify the specific source of error. The errors can be located with the aid of ancillary information and/or through an accuracy assessment process.

A major source of errors of the first type is caused by the relatively coarse resolution of the AVHRR data. Although the intrinsic resolution of the AVHRR data is about 1.1 km at nadir (Section 6.2.2) the resolution degrades due to the nature of the compositing process and can be 3 kilometers or more in the final composite images (Cihlar et al., 1996). Thus, the classified pixels represent averaged conditions over larger areas. At this scale, many pixels are likely to consist of mixtures of land cover types, even if a thematically coarse classification scheme (e.g., land vs. water) were to be used. The averaging effect may cause an incorrect assignment of a pixel to a land cover class. For example, small water bodies present within a dense needleleaf forest may combine to produce the signature of a burned forest. As another example, young needleleaf forest may have the same spectral signature as a mature, mixed forest dominated by needleleaf species. Both cases were found to occur in the land cover product.

While it is possible that the various above sources of error may be reduced if additional information is employed (e.g., other measures of the vegetation dynamics which may be derived from the seasonal NDVI curve) they are present to various degrees in this Level-3 product. To the extent possible, they have been mitigated through the labeling step (Step 6) and post-classification operations (Step 7). Further changes may be made in future releases of this product as the problems are identified and if improvements can be implemented.

10.2 Quality Assessment.

10.2.1 Data Validation by Source

The quality of the land classification product was assessed by a comparison to enhanced Landsat Thematic Mapper images on which cover types can be visually distinguished. Some 105 Thematic Mapper images (each representing an area of approximately 34000 km^2) were used for this purpose, about one third in digital form and the remainder as prints or transparencies.

Secondly, the classification was reviewed by scientists familiar with land cover characteristics in various parts of Canada, including provincial forestry agencies, federal government scientists, and private industry (see section 15.0). The assessment was carried by a comparison with forest inventories, and was complicated by the differences between the various class legends.

Finally, a quantitative evaluation of the thematic accuracy of the land cover product is being carried out using digitally classified, pixel-by-pixel registered Landsat Thematic

Mapper images. This evaluation is underway. To date, one quantitative comparison was carried out, namely with a Landsat Thematic Mapper-derived classification of a 14,000 km^2 area in Alberta (bounded by 59.42° N, 116.59° W, 58.42° N, and 114.51° W; Klita et al., 1998). The minimum mapped area in the Thematic Mapper classification was 2 hectares and for the AVHRR classification 100 ha. On a pixel-by pixel basis, the positive identification accuracy varied between 1.3 and 66.7% because of the patchy land cover. For the entire area included in the comparison, the correspondence between the areas was reasonably close. In the following list of the fraction of the area in each class, the first number is the AVHRR value, the second is the Thematic Mapper value (both in percent of the area): closed conifer (10.82, 10.06); open conifer (26.19, 23.96); deciduous mixed-wood (15.81, 13.95); mixed-wood (7.03, 5.32); burns (9.39, 21.87); undifferentiated wetlands (7.57, 5.64); black spruce bog (17.18, 14.77); clearcuts (3.34, 0.73); water (2.67, 3.70). The burned areas were mostly confused with open conifers, closed conifers and black spruce bogs; and the difference for clearcuts was due to the small sizes of the cut patches. Further quantitative assessment of the Level-3 product accuracy will be carried out and will be incorporated in the documentation.

10.2.2 Confidence Level/Accuracy Judgment

See above.

10.2.3 Measurement Error for Parameters

See above.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

BORIS personnel viewed the imagery on a video display and checked the digital numbers in the image against the documentation. No anomalous items were found. In addition, BORIS personnel compressed the data files for distribution on CD-ROM.

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11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

To date (June 9, 1998) the following discrepancies/problems have been noted in the data: None.

11.3 Usage Guidance

Users should be aware of the limitations of the classification, as discussed in Section 10.

11.4 Other Relevant Information

None.

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12. Application of the Data Set

None given.

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13. Future Modifications and Plans

None given.

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14. Software

14.1 Software Description

Zip uses the Lempel-Ziv algorithm (Welch, 1994) used in the PKZIP commands.

14.2 Software Access

Zip is available from many Web sites across the Internet. You can get newer versions from the PKZIP Web site at http://www.pkware.com/shareware/ [Internet Link]. Versions of the decompression software for MS Windows, Mac OS, and several varieties of UNIX systems are included in this archive.

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15. Data Access

15.1 Contact for Data Center/Data Access Information

These BOREAS data are available from the Earth Observing System Data and Information System (EOS-DIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). The BOREAS contact at ORNL is:

ORNL DAAC User Services
Oak Ridge National Laboratory
(865) 241-3952
ornldaac@ornl.gov
ornl@eos.nasa.gov

15.2 Procedures for Obtaining Data

BOREAS data may be obtained through the ORNL DAAC World Wide Web site at http://www.daac.ornl.gov/ [Internet Link] or users may place requests for data by telephone or electronic mail.

15.3 Output Products and Availability

Requested data can be provided electronically on the ORNL DAAC's anonymous FTP site or on various media including, CD-ROMs, 8-MM tapes, or diskettes.

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16. Output Products and Availability

16.1 Tape Products

The land cover product can be delivered on tape media.

16.2 Film Products

None.

16.3 Other Products

The land cover product is available by ftp and can also be written to other media for mail delivery, see section 1.6 for contacts. The land cover product is available by anonymous ftp at ccrs.nrcan.gc.ca in the directory /ad/EMS/landcover95.

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17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Buffam, A. 1994. GEOCOMP User Manual. Internal Report, Canada Centre for Remote Sensing, Ottawa, Ontario.

Cihlar, J., 1996. Identification of contaminated pixels in AVHRR composite images for studies of land biosphere. Remote Sensing of Environment 56: 149-163.

Cihlar, J., and J. Howarth. 1994. Detection and removal of cloud contamination from AVHRR composite images. IEEE Transactions on Geoscience and Remote Sensing 32: 427-437.

Cihlar, J., and Teillet, P.M. 1995. Forward piecewise linear model for quasi-real time processing of AVHRR data. Canadian Journal for Remote Sensing 21:22-27.

Cihlar, J., H. Ly, Z. Li, J. Chen, H. Pokrant and F. Huang. 1996. Multitemporal, multichannel data sets for land biosphere studies: artifacts and corrections. Remote Sensing of Environment 60: 35-57.

Cihlar, J., J. Beaubien, Q. Xiao, J. Chen, and Z. Li 1997. Land cover of the BOREAS Region from AVHRR and Landsat data. Canadian Journal for Remote Sensing 23(2): 163-175.

Coll, C., V. Caselles, J.A. Sobrino, and E. Valor. 1994. On the atmospheric dependence of the split-window equation for land surface temperature. International Journal for Remote Sensing 15(1): 105-122.

Kidwell, K. 1991. NOAA Polar Orbiter Data User's Guide, NCDC/SDSD. (Updated from original 1984 edition).

Li, Z., J. Cihlar, X. Zhang, L. Moreau, and H. Ly. 1996. Detection and correction of the bidirectional effects in AVHRR measurements over northern regions. IEEE Transactions of Geoscience and Remote Sensing 34: 1308-1322.

Pokrant, H. 1991. Land cover map of Canada derived from AVHRR images. Manitoba Remote Sensing Centre, Winnipeg, Manitoba, Canada.

Rahman, H., and G. Dedieu. 1994. SMAC: a simplified method for the atmospheric correction of satellite measurements in the solar spectrum. International Journal for Remote Sensing 15: 123-143.

Robertson, B., A. Erickson, J. Friedel, B. Guindon, T. Fisher, R. Brown, P. Teillet, M. D'Iorio, J. Cihlar, and A. Sancz. 1992. GEOCOMP, a NOAA AVHRR geocoding and compositing system. Proceedings of the ISPRS Conference, Commission 2, Washington, D.C.: 223-228.

Teillet, P. M. 1992. An algorithm for the radiometric and atmospheric correction of AVHRR data in the solar reflective channels. Remote Sensing of Environment 41: 185-195.

Teillet, P.M., and B.N. Holben. 1994. Towards operational radiometric calibration of NOAA AVHRR imagery in the visible and near-infrared channels. Canadian Journal of Remote Sensing 20: 1-10.

Wu, A., Z.Li, and J. Cihlar. 1995. Effects of land cover type and greenness on advanced very high resolution radiometer bidirectional reflectances: analysis and removal. Journal of Geophysical Research 100(D): 9179-9192.

17.2 Journal Articles and Study Reports

Beaubien, J. 1994. Landsat TM satellite images of forests: from enhancement to classification. Canadian Journal for Remote Sensing 20: 17-26.

Beaubien, J., and Simard, G. 1993. Mèthodologie de classification des donnèes AVHRR pour la surveillance du couvert vegetal. Proceedings of the 16th Canadian Remote Sensing Symposium, Sherbrooke, Quebec: 597-603.

Beaubien, J., Cihlar, J., Simard, G., and Xiao, Q. 1997. Land cover from Thematic Mapper data using new enhancement - classification methodology. Canadian Journal for Remote Sensing (in preparation)

Cihlar, J., Ly, H., and Xiao, Q., 1996. Land cover classification with AVHRR multichannel composites in northern environments. Remote Sensing of Environment 58: 36-51.

Cihlar, J., Chen, J., and Li. Z. ,1997. Seasonal AVHRR multichannel data sets and products for studies of surface-atmosphere interactions. Journal of Geophysical Research - Atmospheres. (in press)

Klita, D.L., Hall, R.J., Cihlar, J., Beaubien, J., Dutchak, K., Nesby, R., Drieman, J., Usher, R., and Perrott, T. 1998. A comparison between two satellite-based land cover classification programs for a boreal forest region in northwest Alberta, Canada. Proceedings of the 20th Canadian Symposium on Remote Sensing, May 1998. In print.

Roujean, J.-L., M. Leroy, and P.-Y. Deschamps. 1992. A bidirectional reflectance model of the earth's surface for the correction of remote sensing data. Journal of Geophysical Research 97(D18): 20,455-20,468.

Rowe, J.S. (1972). Forest Regions of Canada. Environment Canada, Canadian Forest Service, Publication 1300, 172 p.

Sellers, P.J., Los, S.O., Tucker, C.J., Justice C.O., Dazlich, D.A., Collatz, J.A., and Randall, D.A.. 1994. A global 1o by 1o NDVI data set for climate studies. Part 2: The generation of global fields of terrestrial biophysical parameters from the NDVI. International Journal of Remote Sensing 15: 3519-3545.

Townshend, J. (Ed.). 1994. Global data sets for the land from AVHRR. International Journal of Remote Sensing 15: 3315-3639 (special issue describing several program generating composite AVHRR image data sets).

17.3 Archive/DBMS Usage Documentation

None.

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18. Glossary of Terms

None.

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19. List of Acronyms

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AVHRR           Advanced Very High Resolution Radiometer.
BOREAS          Boreal Ecosystem-Atmosphere Study
BORIS           BOREAS Information System
BPI             Byte per inch
CCRS            Canada Centre for Remote Sensing
CCT             Computer Compatible Tape
CD-ROM          Compact Disk-Read-Only Memory
DAAC            Distributed Active Archive Center
DAT             Digital Archive Tape
FASIR           Fourier-Adjustment, Solar Zenith Angle Corrected,
                Interpolated, Reconstructed
GAC             Global Area Coverage
GEOCOMP         Geocoding and Compositing System
GSFC            Goddard Space Flight Center
HRPT            High Resolution Picture Transmission.
IFC             Intensive Field Campaign.
IFOV            Instantaneous Field-of-View
LAC             Local Area Coverage
MRSC            Manitoba Remote Sensing Centre
NASA            National Aeronautics and Space Administration
NDVI            Normalized Difference Vegetation Index
NOAA            National Oceanic and Atmospheric Administration
ORNL            Oak Ridge National Laboratory
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The land cover map of Canada resulted from a joint effort between NBIOME scientists at the Laurentian Forest Research Centre, Canadian Forest Service and the Canada Centre for Remote Sensing, both in Natural Resources Canada. The initial composite data were prepared by the staff of the Manitoba Remote Sensing Centre.

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