LEAF AREA INDEX MAPS AT 30-M RESOLUTION, SELECTED SITES, CANADA

Summary:

This data set provides local LAI maps for the selected measured sites in Canada. These derived maps may also be useful for validating other LAI maps over these same sites given that the areas are protected from disturbance. The maps should be used for the given period of validity. The LAI data are suitable for use in modeling the carbon, water, energy, energy and trace gas exchange between the land surface and the atmosphere at regional scales. The data set may also be useful for monitoring changes in the land surface.

The Leaf Area Index (LAI) maps are at 30-m resolution for the selected sites. LAI is defined here as half the total (all-sided) live foliage area per unit horizontal projected ground surface area. Overstory LAI corresponds to all tree foliage except for treeless areas where it corresponds to total foliage. The algorithms were developed from ground measurements and Landsat TM and ETM+ images (Fernandes et. al., 2003). A mask was developed using the Landsat ETM+/TM5 image and available land cover map to identify only those areas with land cover belonging to the sample land cover classes and with Landsat ETM+/TM5 spectral reflectance values that fell within the convex hull of the spectral reflectance values over the plots. LAI was mapped within the masked region using the Landsat ETM+/TM5 image and the developed transfer function. The final LAI map was scaled by a factor of 20 (offset 0). The LAI maps are in Tagged Image File Format (TIFF).

Data Citation:

Cite this data set as follows:

Fernandes, R. A., A. Abduelgasim, L. Sylvain, S. K. Khurshid, and C. Butson. 2005. Leaf Area Index Maps at 30-m Resolution, Selected Sites, Canada. Data set. Available on-line [http://daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/816.

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1. Data Set Overview:

Project: Derivation of LAI maps at 30-m resolution by the Natural Resources Canada (NRCAN), Earth Sciences Sector (ESS), Canada Centre of Remote Sensing (CCRS), Groundwater Program.

The lead investigator was R.A. Fernandes. You may contact him at Richard.Fernandes@ccrs.nrcan.gc.ca.

Site-Specific Map Product Overviews:

Kejimikujik National Park (Nova Scotia) region for July, 2000. The map was produced by scaling a set of in-situ optically based LAI estimates over 31 plots of approximately 1 ha each within the mapped area. Plots were located using a stratified random sampling with stratification by land cover. In-situ LAI estimates were derived using multiple (>10) LAI-2000 measurements per plot and 2 50m TRAC transects per plot for both the overstory and processing using the LAI-2000 and TRAC software provided by Sylvain Leblanc of CCRS. A regression based transfer function was applied to paired in-situ LAI and Landsat ETM+ at surface reflectance values over each plot. A mask was developed using the Landsat ETM+ image and available land cover map to identify only those areas with land cover belonging to the sample land cover classes and with Landsat ETM+ spectral reflectance values that fell within the convex hull of the spectral reflectance values over the plots. LAI was mapped within the masked region using the Landsat ETM+ image and the developed transfer function. The final LAI map was scaled by a factor of 20 (offset 0). This data set represents a version 2 map of the region chiefly due to the restriction of the mapped area to a conservative extent represented well by field data.

BOREAS Northern Study Area (Thompson, Manitoba), Canada region for July, 2001. The map was produced by scaling a set of in-situ optically based LAI estimates over 20 plots of approximately 1 ha each within the mapped area. Plots were located with a bias towards conifer and aspen stands and stratified along a perceived time since disturbance gradient. In-situ LAI estimates were derived using multiple (>10) digital hemispherical photgraph measurements per plot except for three plots at the BOREAS Old Black Spruce (Northern) Site where 50m square grids of multipleTRAC transects were performed for 3 plots. All measurements were overstory only with a nominal 50cm TRAC height and 1m camera height. Data was processed using TRACWIN software with CCRS Based digital camera processing software used to pre-process the camera images. A regression based transfer function was applied to paired in-situ LAI and Landsat ETM+ at surface reflectance values over each plot. A mask was developed using the Landsat ETM+ image and available land cover map to identify only those areas with land cover belonging to the sample land cover classes and with Landsat ETM+ spectral reflectance values that fell within the convex hull of the spectral reflectance values over the plots. LAI was mapped within the masked region using the Landsat ETM+ image and the developed transfer function. The final LAI map was scaled by a factor of 20 (offset 0). This data set represents a version 2 map of the region. The previous version produced by CCRS by Dr. Jing Chen was based on field data acquired and processed circa 1994-1996 and Landsat 5 imagery processed using nominal correction procedures (Chen et al. 1997). Both the field data and imagery were reprocessed where possible for this current version but the time difference (>5 years) was to great to allow for mixing of 1994-1996 data with current data.

Watson Lake (Yukon Territory), Canada region for July, 2000. The map was produced by scaling up a set of in-situ optically based LAI estimates over 18 plots of approximately 1 ha each within the mapped area. Plots were located using a stratified random sampling with stratification by land cover. In-situ LAI estimates were derived using multiple (>10) LAI-2000 measurements per plot and 2 50m TRAC transects per plot for both the overstory and processing using the LAI-2000 and TRAC software provided by Sylvain Leblanc of CCRS. A regression based transfer function was applied to paired in-situ LAI and Landsat ETM+ at surface reflectance values over each plot. A mask was developed using the Landsat TM5 image and available land cover map to identify only those areas with land cover belonging to the sample land cover classes and with Landsat ETM+ spectral reflectance values that fell within the convex hull of the spectral reflectance values over the plots. LAI was mapped within the masked region using the Landsat ETM+ image and the developed transfer function. The final LAI map was scaled by a factor of 20 (offset 0).

2. Data Characteristics:

Study Area: (All latitude and longitude given in degrees and fractions)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Projection	Geodetic Datum
Kejimikujik National Park, Nova Scotia, Canada	-65.389842	-65.003513	44.505493	44.228368	UTM, zone 20 North	NAD83
Thompson, Manitoba, Canada	-99.783559	-96.002339	56.909957	54.891311	UTM, zone 14 North	NAD83
Watson Lake, Yukon territory, Canada	-132.75017	-126.0289	61.7524977	58.4157853	Lambert Conformal Conic	NAD83

Time period: The data set covers July 2000 and July 2001.

Image data:

Landsat Thematic Mapper (TM5) and Enhanced Thematic Mapper Plus (ETM+) images were collected and processed covering the study sites.

Spatial Resolution:

The Landsat TM5 and ETM+ images have a pixel resolution of 30 x 30 m.

Ground Measurements:

In-situ optically based LAI estimates were measured using optical instruments [LAI-2000, Tracing Radiation and Architecture of Canopies (TRAC), and Digital Camera Hemispherical Photographs (DHPs)] over plots of approximately 1 hectare within the mapped area.

Parameters or Variables:

LAI is defined as half the all sided area of all foliage per horizontal projected ground surface area ((UN FAO, 2002, Chen and Black, 1992).

Mask indicator designates area where LAI was mapped.

Data File Information:

These map files are provided for each site. The site name is prepended to each file to ensure unique names. The files for the Kejimikujik site are shown as an example.

File Name Description

kejim_lai30m.tif LAI map in Tagged Image File Format (TIFF)

kejim_mask30m.tif Mask map in TIFF format (Value mark with 1 are the mapped area)

3. Data Application and Derivation:

Application of data:

This data set is intended as a local LAI maps for the selected sites in Canada. The data set may also be useful for validating other LAI maps over these sites given that the area is protected from disturbance. The map should be used for the given period of validity. The data are suitable for modeling the carbon; water, energy and trace gas exchange between the land surface and the atmosphere ate regional scales. The data set may also be useful for monitoring changes in the land surface.

Kejimikujik 2000 LAI map: This data set is intended as a local LAI map for the region circa July, 2000. The data set may be used +/-3 years of the July 2000 given the slow growing conifer stands sampled. One should mask major disturbances such as forest cuts through the use of ancillary landcover data if the map is used outside of the 2000 period. We expect these disturbances to be minimal given the protected status of the park region.

Thompson (Manitoba) 2001 LAI map: This data set is intended as a local LAI map for the Larose forest region circa July 2001. The data set may be used +/-3 years of the July 2000 given the slow growing conifer stands sampled. One should mask major disturbances such as forest cuts through the use of ancillary landcover data if the map is used outside of the 2001 period. The data mask is perhaps not conservative enough. LAI was mapped for known wetland and recent burn areas where field data was not available. LAI values further from then main access highway from Thompson to the BOREAS Old Black Spruce site may exhibit some biases. We caution also that these LAI data cannot be directly mixed with other published BOREAS LAI data due to differences in processing methods, definitions, plot scale, sampling schemes and image processing. Intercomparison in underway.

Watson lake (Yukon Territory) 2000 LAI map: This data set is intended as a local LAI map for the region circa July 2000. The data set may be used +/-3 years of the July 2000 given the slow growing conifer stands sampled. One should mask major disturbances such as fire or forest cuts through the use of ancillary landcover data if the map is used outside of the 2000 period.

Theory of Measurements:

A Canada-wide sampling of Landsat-5 thematic mapper (TM) and Landsat-7 enhanced thematic mapper plus (ETM+) images was used to produce fine-resolution (30 m) LAI estimates using a uniform methodology traceable to in situ measurements (Fernandes et al. 2003). Residuals between coarse-scale LAI estimates based on data from the Satellite pour l'observation de la terre (SPOT) VEGETATION (VGT) sensor, and Landsat LAI estimates were quantified. Furthermore, a number of scaling treatments were performed on the Landsat scenes to isolate the relative contributions of land cover and reflectance scaling versus atmospheric correction and bidirectional distribution function (BRDF) normalization on coarse-scale LAI errors. Uncertainties because of atmospheric correction and acquisition geometry normalization were identified as the largest source of scene-wide bias errors.

Derivation Techniques and Algorithms:

A complete description of this technique for producing 30-m resolution maps is provided in Fernandes et al. 2003. Software provided by Sylvain Leblanc, Canada Centre of Remote Sensing (CCRS) was used for processing data from LAI-2000 and TRAC instruments. CANEYE software provided by Institute National Agronomie de France was used for processing digital hemispherical photographs.

4. Quality Assessment:

Accuracy Report:

The accuracy is given by the confidence errors of prediction of the regression transfer function assuming the sample plots are representative of the region mapped and no-spatial correlations in residuals. A summary table is given below:

Site	Month_Year	# of Samples	MAE	LAI-min	LAI-median	LAI-max	P-min	P-median	P-max
Kejimikujik	July 2000	31	0.42	0.13	3.685	6.3	1	0.75	1
Thompson	July 2001	20	0.33	0.97	2.02	6.416	0.5	0.75	1.25
Watson Lake	July 2000	18	0.36	0.10	3.60	6.79	1	0.75	0.75

Note: MAE is the Median Absolute Error; P is the Prediction 1 sigma confidence interval at minimum, median and maximum estimated LAI.

Limitations of the Data:

The data set may be useful for validating other LAI maps over these sites given that the area is protected from disturbance. The map should be used for the given period of validity as noted in Section 3.

For the Kejimikujik site, accuracy is reported relative to in-situ LAI estimates. The accuracy is given by the confidence errors of prediction of the regression transfer function assuming the sample plots are representative of the region mapped and no-spatial correlations in residuals. In-situ LAI estimates should have similar levels of uncertainty as those cited in Chen et al. 1997 for the BOREAS study area, given the similarity measurement methods between BOREAS and Watson Lake. We expect slightly higher accuracies than BOREAS given the typically lower within crown LAI for the hemlock, pine and white spruce conifers versus the black spruce stands found in the Boreal zone.

5. Data Acquisition, Materials, and Methods:

Remote Sensing data: Landsat TM5 and ETM+ images were acquired with corresponding 30-m resolution (1:50,000 scale) land cover maps for all the sites (Fernandes et al. 2003).

In-situ data: A standard methodology was used to collect and process the optical in-situ data. The optical instruments used for measurements are summarized below:

Site	**Instrument**
Kejimikujik	LAI-2000 & TRAC
Thompson	TRAC
Watson Lake	LAI-2000 & TRAC

Processing Steps:

1. Acquire 30m resolution (1:50,000 scale) land cover map of region.

2. Acquire 1:50,000 scale road vector map of region (<10m positional accuracy 2 sigma).

3. Georeference land cover map using road vectors manually.

4. Sample 50 points ensuring 3 points per land cover class and balance of points placed according to area of each class. All points are separated by at least 200m.

5. Perform field survey using standard VALERI sampling scheme for both up and down looking digital hemispherical photographs (box with cross pattern + 3 random samples in box; cross extends past box for forest stands).

6. Process images for each plot (37 in total) using CANEYE software to get LAI. Only retain plots where LAIe from all zenith algorithm algorithm is within 10% of LAIe from 57 degree angle estimate (33 in total).

7. Correct LAI estimates using in-situ samples needle-to-shoot area ratios per species (3 in total for site).

8. Georeference con-current (<1 month delay) 30m resolution satellite image to road vectors.

9. Calibrate satellite image and correct to surface reflectance as in Butson et al. 2003.

10. Identify pixel values co-incident with surface plots (usually 3x3 window average).

11. Generate various vegetation indices based on pixel values and perform Thiel-Sen regression (Fernandes and Leblanc, 2005) to generate transfer function. Select transfer function with best prediction confidence intervals using lowest dimensionality data set. In this case the transfer function used the Infrared Simple Ratio (Fernandes et al. 2003). Lowest dimensionality was used to maximize mappable area.

12. Determine mappable area as those pixels within the convex hull of the spectral index values of the surface plots and matching the land cover sampled.

13. Apply the transfer function to the Landsat image to map LAI over the mappable area.

14. Scale the LAI by a factor of 20 for coding purposes and save as an 8 bit raster.

15. Save the mappable area as a value of 1 in another 8 bit raster with same extents as LAI map.

6. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) or the EOS Data Gateway.

Data Archive Center:

Contact for Data Center Access Information:

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952
FAX: +1 (865) 574-4665

Product Availability:

Requested data can be provided electronically on the ORNL DAAC's anonymous FTP site or on various media by request.

7. References:

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