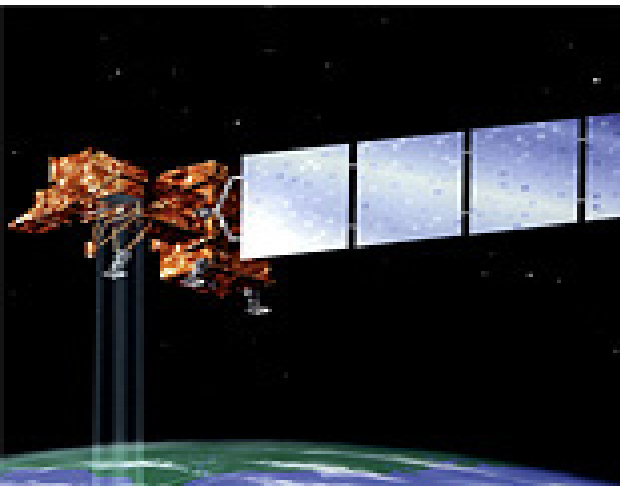
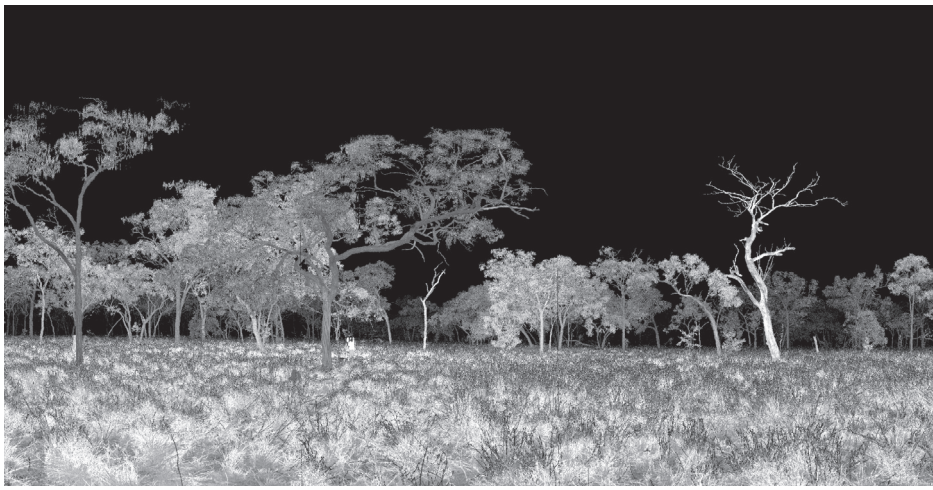
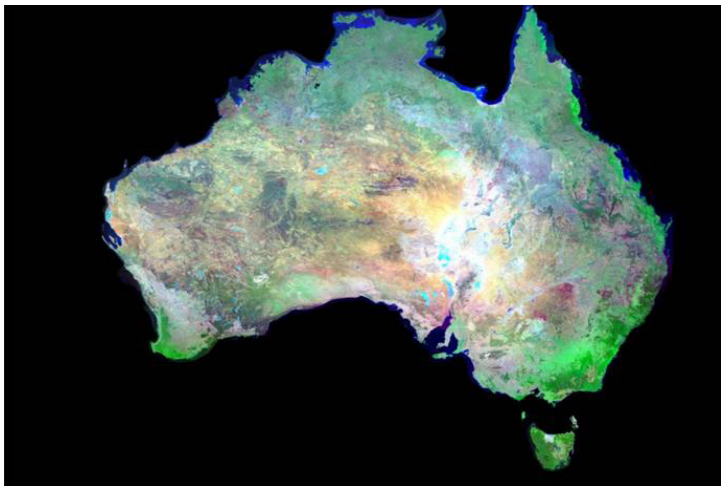
The Joint Remote Sensing Research Program

State to National Collaboration, Research to Solutions







Annual Report 2010-2011

The University Of Queensland AUSTRALIA

Queensland Government

NSW GOVERNMENT Office of Environment & Heritage

State Government Victoria Department of Sustainability and Environme

TERN Terrestrial Ecosystem Research Network AusCover

Welcome

The Joint Remote Sensing Research Program uses satellite and airborne imaging to map, monitor and model our terrestrial, atmospheric and aquatic environments and their dynamics. The program translates research to operational processes to meet government monitoring requirements.

Contents

The Joint Remote Sensing Research Program is a collaborative program combining research and research training expertise and infrastructure from the Biophysical Remote Sensing Group at the University of Queensland's Centre for Spatial Environmental Research, with remote sensing groups supporting the Queensland, New South Wales and Victorian governments. These programs also provide critical information to the space agencies in the U.S., Europe and Japan, who operate satellite imaging systems, and the global science communities who use the algorithms developed in our program.

We collect and analyse remotely sensed data to map, monitor and model the biophysical properties and processes in our ecosystems. Remote sensing provides up-to-date, detailed information about land and marine environment conditions by using equipment on satellites or in planes to produce detailed images of large areas repeatedly over time. These data sets are becoming increasingly more important for measuring, mapping and monitoring the biophysical environment.

Technological advances in satellite and airborne image data, especially radar and LiDAR, combined with increases in processing capacity and decreasing costs in data acquisition are increasing the range of information available and the frequency of monitoring.

Our program was founded to enhance the value and use of remote sensing data by developing methods and data analysis systems, with an emphasis on research and capacity building for ecosystem monitoring and management in Australia and globally. Specifically, our program ensures the highest quality science is used to build, implement and improve procedures for state governments to use satelite image data to map and monitor changes to our ecosystems.

We have brought together skilled researchers, government scientists, environmental managers and significant computing and data storage capacity. As well as substantial data sets covering most of the Australian east coast and a collection of unique field based remote sensing instruments for assessing the accuracy of the satellite image based maps.

We have connected the advanced research laboratories with the environmental management agencies, closing the gap between research and data analysis, and the implementation of management policies.

The JRSRP was initially a partnership between the University of Queensland and the Queensland Department of Environment and Resource Management (DERM) that began in 2007. Since then our program has grown to include the New South Wales Office of Environment and Heritage (OEH) in September 2008, the Terrestrial Ecosystem Research Network (TERN) Auscover (Brisbane Node) and the Victorian Department of Sustainability and Environment (DSE) in 2010.

"taking the lead to encourage greater cooperation between government and academic sectors"

Above: CIMEL Sunphotometer at UQ. http://aeronet.gsfc.nasa.gov/new_web/photo_db/Brisbane-Uni_of_QLD.html

We are taking the lead to encourage greater cooperation between government and academic sectors to create the scale and focus necessary to achieve the best outcome's for each state and Australia.

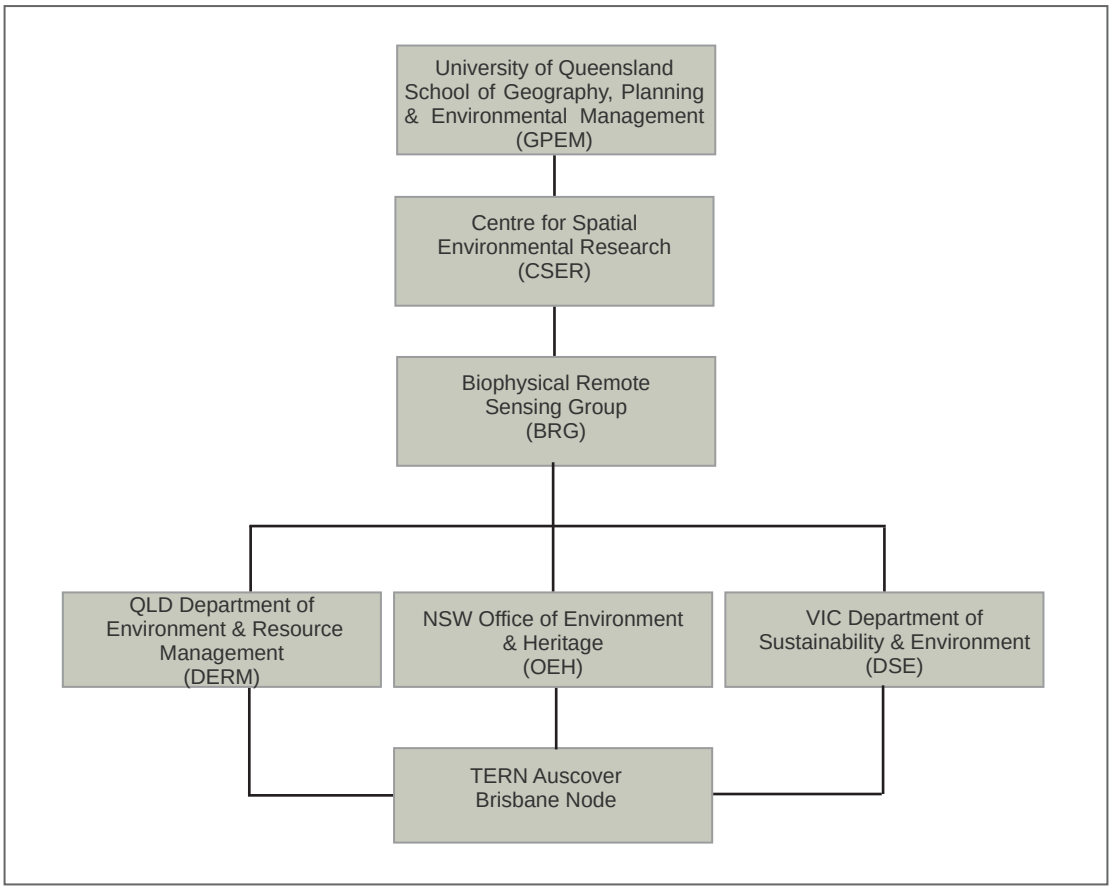
Our goal is to increase Australia's capacity to conduct pure and applied remote sensing research to implement and assess environmental management policies at local, state and national scales.

Our objectives at a glance:

- Provide the technical and human resources and knowledge to enable Australian government agencies to collect and use satellite image data on a sustainable basis to produce accurate maps of Australian ecosystems that form the basis for understanding and managing our ecosystems.
- Continue to foster partnerships and collaboration between private, government and academic sectors.
- Increase awareness and the adoption of remote sensing technologies and industry standards.
- Reduce costs for ongoing research and development by improved processes and reduction of duplication across state and national agencies.
- Provide the highest quality training to support current and future remote sensing and monitoring requirements to industry, private and government sectors.
- Attract new postgraduates to investigate new and streamlined applications and technology.
- Assist our staff to build professional careers through the support of current and future remote sensing and monitoring requirements.

Governance

The JRSRP is managed and coordinated by the Centre for Spatial Environmental Research (CSER) in the School of Geography, Planning and Environmental Mangement at The University of Queensland. Specific research activities are delivered through the programs partner facilities. Governance is managed via the Advisory Committee which has primary responsibility for the overall strategic direction, management and performance of the JRSRP.



Advisory Committee

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2010 -2011
Research Activities

Our primary focus is to conduct pure and applied remote sensing research for monitoring biophysical properties of the environment.

MAPPING & MONITORING

Our program's activities are of critical importance to the state governments of Queensland and New South Wales who use the programs research results to understand and inform policy decisions' and legislated monitoring activities for:

- vegetation management
- catchment management
- land use planning and practices
- carbon stock assessment

We ensure the highest quality science is used to build, implement, assess and improve procedures for state governments to use satellite image data to map, quantify and monitor changes to our ecosystems, specifically vegetation composition, structures and processes.

We have invested considerable resources into the development of a range of time-series image correction and analysis tools to support our research efforts. Our focus is to produce standardised, calibrated and validated biophysical map products, the JRSRP provides the scale and expertise to achieve this.

The purpose of remote sensing is to identify or measure features or processes in an environment from image data. Changes in the features or variables can be measured over time and checked for validity.

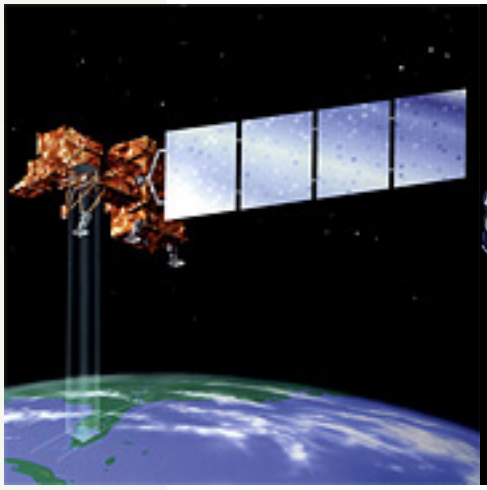
A major accomplishment for the program has been to process over 35 years of Landsat satellite imagery, collected every month over Australia, for consistent environmental monitoring. This extensive archive has significantly improved our capabilities in studying changes and trends in land cover over time.

"Our focus is to produce standardised, calibrated and validated biophysical map products"

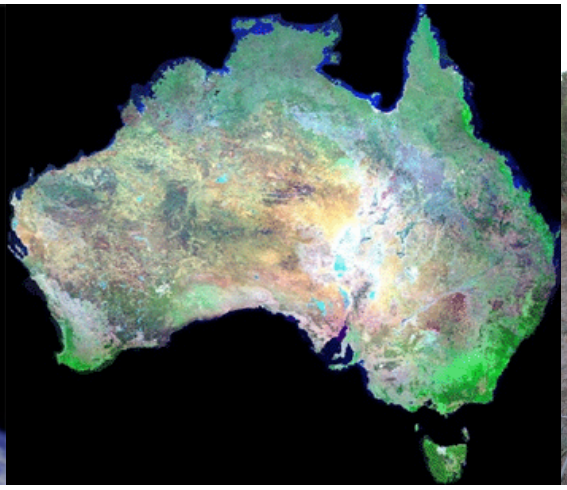
Key research initiatives:

- Development of automated image-georegistration software.
- Calibration of airborne and satellite-based camera systems.
- Development and assessment of Landsat sensor replacement options and procedures.
- Development of fully corrected time series images.
- Atmospheric correction of satellite imagery.
- Integration of field, LiDAR and imaging radar to map vegetation structure and biomass.

Left: Samples of foliage from crown tops were collected for leaf size and reflectance/transmittance measurements. These measurements are used to parameterise vegetation structure properties of radiative transfer models for mapping.



Landsat 7



Landsat mosaic

Field survey

2010 -2011
Research Highlights

FINDING SOLUTIONS

Radiometric and atmospheric correction systems

Accurate measurement of the extent of trees across Australia, and the detection of land clearing when trees are removed, is difficult using raw satellite imagery.

Satellite images are collected at different times of the year so there is considerable variation in brightness due to the differences in the sun's position and different amounts of aerosols, like smoke and dust, in the atmosphere.

Because we want to compare satellite images taken at different times of the year to measure changes on the ground, it's important that the satellite images are standardised to remote atmospheric or solar differences.

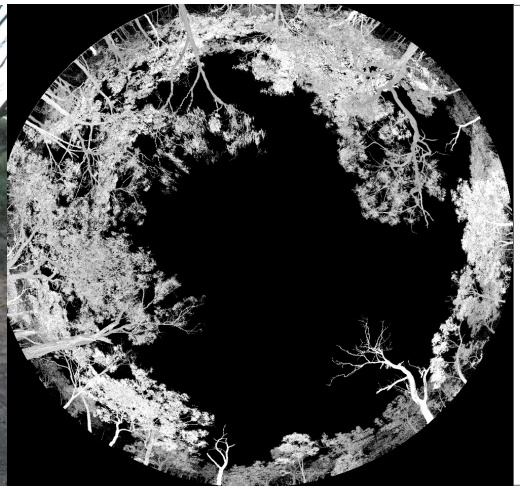
The JRSRP has developed approaches to standardise imagery, removing the effects of changing solar angles, land surface slope and atmospheric contamination, allowing the routine use of satellite imagery from sensors such as Landsat and SPOT in repeatable operational wide area land cover mapping programs. These corrections also enable us to build long-time series of fully corrected images.

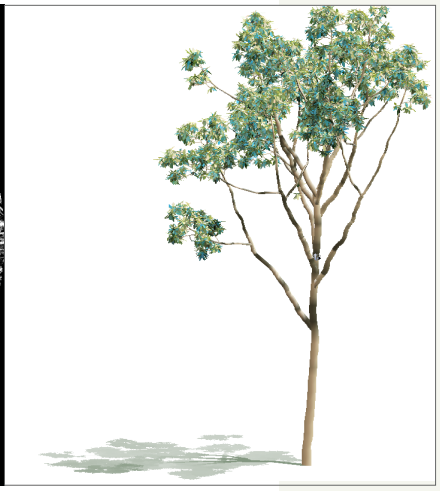
Mapping annual and rapid vegetation change and extent using USGS Landsat and SPOT5

Considerable work has been undertaken over the past 10 years by the Queensland Department of Environment and Resource Management to map vegetation extent and change across Queensland using the Landsat series of satellites.

However, in areas of intensive land cover change, such as in south east Queensland and in NSW, the 30m pixel size of the traditional Landsat mapping is often insufficient to resolve some of the more detailed changes.

To address this, the JRSRP has adapted the DERM methods for use with the SPOT 5 satellite, giving state authorities more detailed information on vegetation cover and change, down to 10m and 5m pixels.

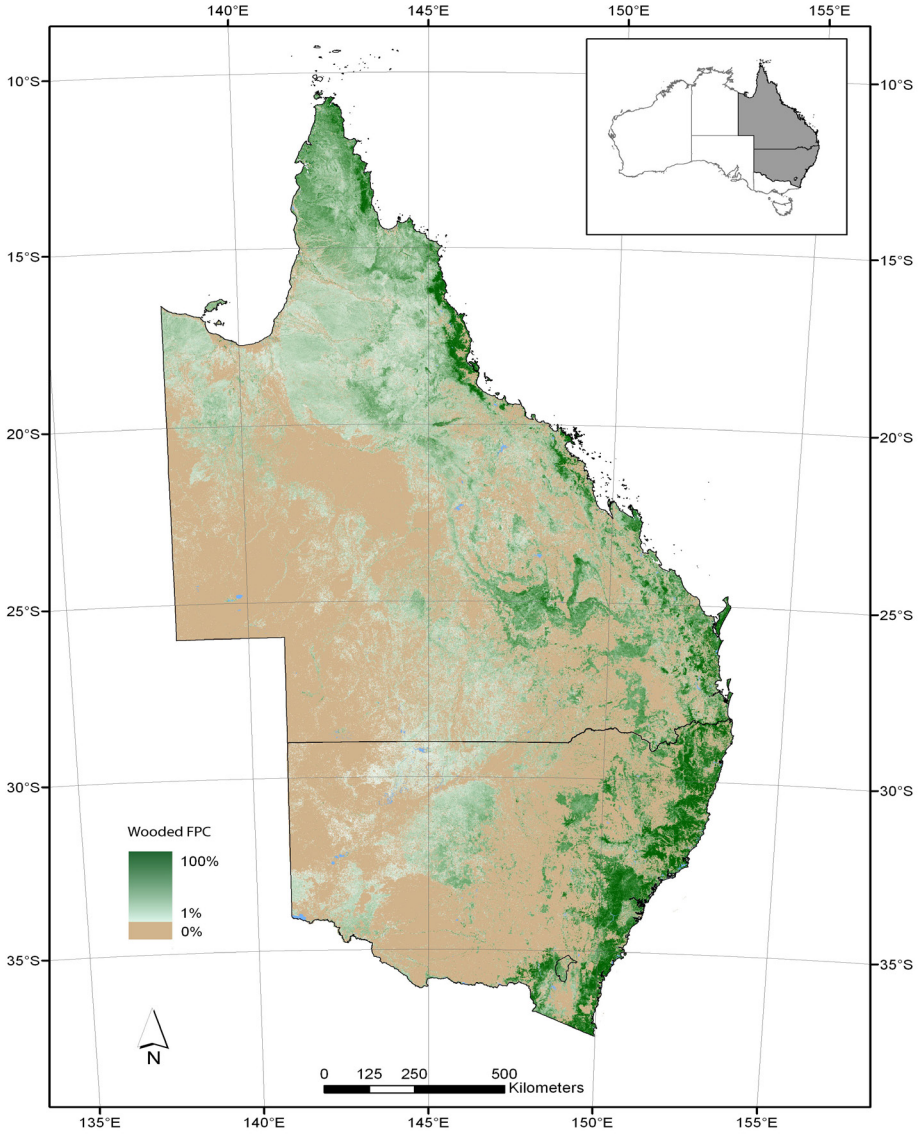




Hemispherical photography

Tree model for processing airborne and satellite data

Percentage wooded foliage projective cover derived from a time-series of Landsat-5 TM and Lansdat-7 ETM+ imagery. Application of this product include annual reporting of woody vegetation extent and loss of above-ground biomass due to clearing.



Data Portals

> Auscover http://portal.auscover.org.au/webportal/

spdlib

LiDAR (Light Detection And Ranging) uses pulses of laser light to measure the distance to targets, from either terrestrial, airborne or satellite platforms.

These data can be very useful for mapping topography, forest structure and calibrating larger area mapping programs, but requires a high level of calibration and correction before it can be used.

Through work with the University of Aberystwyth, the JRSRP researchers, an open source LiDAR processing package was developed which simplifies the management of these data and allows the lidar data to be used operationally for validation of vegetation structure, extent and change.

http://www.spdlib.org/

Training

The JRSRP conducts training programs for image processing in standard and specialised areas, including Pthyon based image analysis tools, object based mapping, hyper-temporal image analysis and integrating image and field data.

Earlier this year a training workshop was hosted in Sydney to provide staff from NSW's Office of Environment and Heritage with basic skills in GDAL, python and pymodeller.

Mapping vegetation structure using satellite imaging radar systems

There is an increasing need for robust estimates of vegetation structure, for example; tree height, cover and biomass, particularly for carbon accounting, that perform reliably and consistently across all Australian vegetation types.

By teaming up with the Japanese Space Agency (JAXA) and colleagues from the University of Aberystwyth, work has begun on producing continental scale biomass maps using satellite radar data.

This builds on a pilot project that developed radar correction techniques and a preliminary biomass mapping model for Queensland and New South Wales.

For more information visit: www.scribd.com/doc/37392042/15arspc-Submission-138

LiDAR validation of Foliage Projective Cover Maps

Maps of vegetation foliage projective cover based on Landsat imagery are used by NSW OEH for mapping woody vegetation extent and for the monitoring of changes in the extent of vegetation. As most of the calibration data used to create these products has been based on existing site measurements in Queensland, an approach for validation of these products in NSW is required. The validation is uses a combination of field measurements, high spatial resolution imagery and LiDAR data.

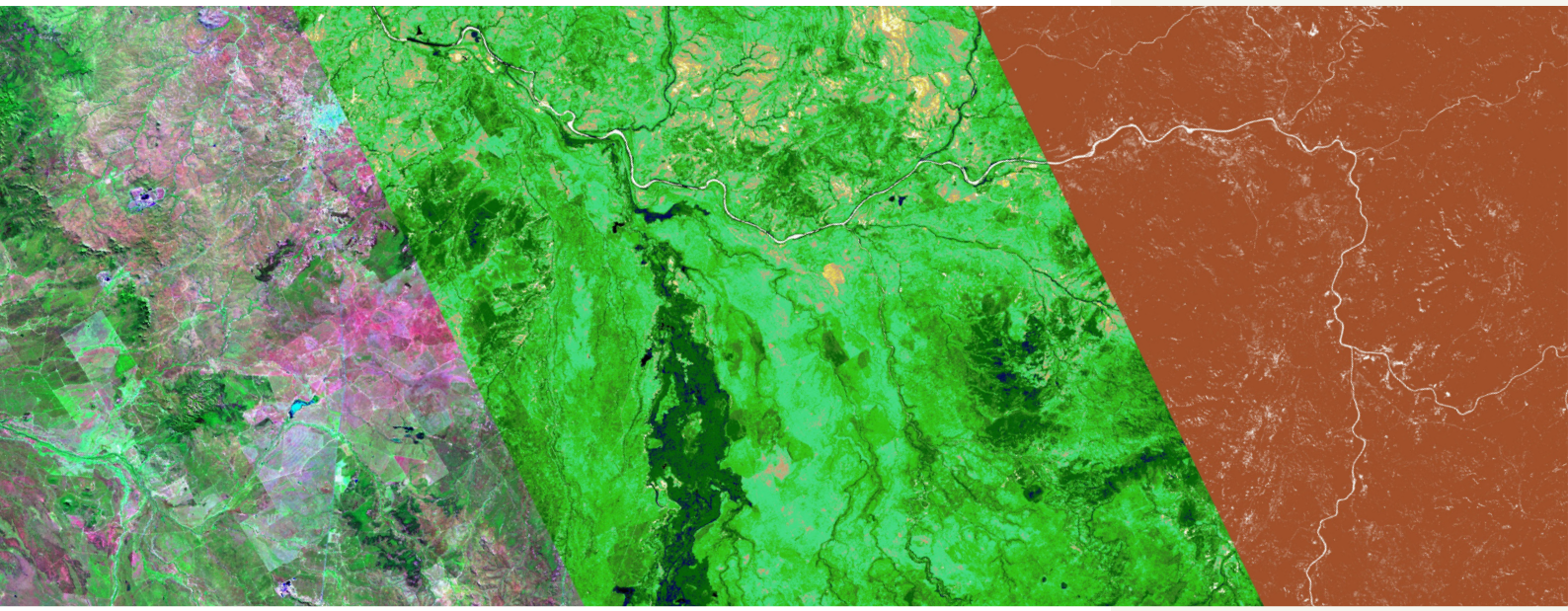
There are significant areas of NSW covered by existing LiDAR data that are suitable for analysis and comparison with FPC products. The LiDAR data will be processed to generate maps of plant projective cover (PPC) for comparison to the Landsat products. In order to calibrate the LiDAR derived PPC, field measurements of vegetation structure are being sourced from the OEH vegetation database, and from previous studies conducted by researchers at UNSW, such as Richard Kingsford.

Long time series image analysis tools for application to the Landsat TM/ETM archives

To use long time series imagery effectively to select subtle landscape trends, it is critical that the imagery is corrected to remove the effects of multiple sensor types and sensor degradation over time. In addition, to effectively use the imagery there needs to be automated methods to flag bad data due to cloud, cloud shadow as well as detecting gross changes due to water inundation or burning.

The JRSRP has developed methods to select, collate, import and curate whole of archive Landsat data.

Significant research into methods to detect cloud have also been completed and these have been used to map long term fire history in Queensland.



Above: Landsat image of Charters Towers Basalt Flow, overlayed with FPC and ground cover images.

SPOT pre-processing

The New South Wales Office of Environment and Heritage are developing a high spatial resolution vegetation monitoring system for NSW based on SPOT 5 imagery. To enable this automated analysis of imagery, there are pre-processing steps that need to be implemented.

Masking out areas in the images covered by cloud is usually done using thermal band imagery when using Landsat imagery, but a different approach is required for sensors such as SPOT that don't have a thermal band. A semi-automated cloud masking method for individual SPOT images has been developed.

A similar approach is used to identify areas of cloud shadow. This method is being used to cloud mask SPOT 5 images for OEH and at the same time is being further refined to reduce manual editing time.

A method is also being developed to mask water within SPOT images, partly as a product in itself, and partly to improve the automated masking of cloud shadows (water and shadows are very similar in SPOT images).

Links

- Joint Remote Sensing Research Program http://www.gpem.uq.edu.au/jrsrp
- Biophysical Remote Sensing Group http://www.gpem.uq.edu.au/brg
- Queensland Department of Environement and Resource Management http://www.derm.qld.gov.au/
- NSW Office of Environment and Heritage http://www.environment.nsw.gov.au/
- Victoria Department of Sustainability and Environment http://www.dse.vic.gov.au/

Above: The diameter, species and condition of trees are recorded for estimation of above-ground biomass using allometrics.

Above: JRSRP staff (Tim Danaher, Selwyn Counter) ur groundcover in a spinifex open woodland in north west

Publications

2011

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2009

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Karfs, R.A., Abbott, B.N., Scarth, P.F., and Wallace, J.F., 2009. Land condition monitoring information for reef catchments: A new era. Rangeland Journal, 31(1), 69-86.

Pringle, M.J., Schmidt, M., and Muir, J.S., 2009. Geostatistical interpolation of SLC-off landsat ETM+ images. ISPRS Journal of Photogrammetry and Remote Sensing, 64(6), 654-664.

Rosette, J.A., North, P.R.J., Suárez, J.C., and Armston, J.D., 2009. A comparison of biophysical parameter retrieval for forestry using airborne and satellite LiDAR. International Journal of Remote Sensing, 30(19), 5229-5237.

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2007

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de Vries, C., Danaher, T., Denham, R., Scarth, P., and Phinn, S., 2007. An operational radiometric calibration procedure for the landsat sensors based on pseudo-invariant target sites. Remote Sensing of Environment, 107(3), 414-429.

Below: Reference photo of foliage for species identification.

2011 - 2012
Planned Activities

Terrestrial LiDAR scans are undertaken in a savanna woodland near Charters Towers for field method development and validation of airborne LiDAR vegetation products.

RESEARCH

- TERN Auscover implementation at national scale FPC and bare ground maps and joint JAXA national biomass map.
- Development of methods for mapping fire-scars using Landsat time series imagery.
- The capture and analysis of LiDAR data in Qld to validate FPC, woody extent and trend products from Landsat, Spot 5 and other imagery.
- To investigate techniques for calibrating and processing Leica ADS-40 multi-spectral multi-angle airborne digital camera data.
- Development of Object-Based Image Analysis approaches.
- The evaluation of new high and moderate spatial resolution optical image products such as RapidEye, Worldview2, ALOS-AVNIR/PRISM.
- Development of a national lobbying capacity to promote improved alignment and collaboration of remote sensing across all levels of government.
- To investigate the need for revised national industry standardisation of LiDAR file formats to accommodate full-waveform data.
- To calibrate and validate Landsat fractional cover models using SLATS field site measurements.
- Coarse spatial scale mapping of the Lyngbya distribution in eastern banks.
- Seagrass % cover mapping to determine changes and post-flood impacts on coarse scale seagrass extent, cover and composition for Moreton Bay.

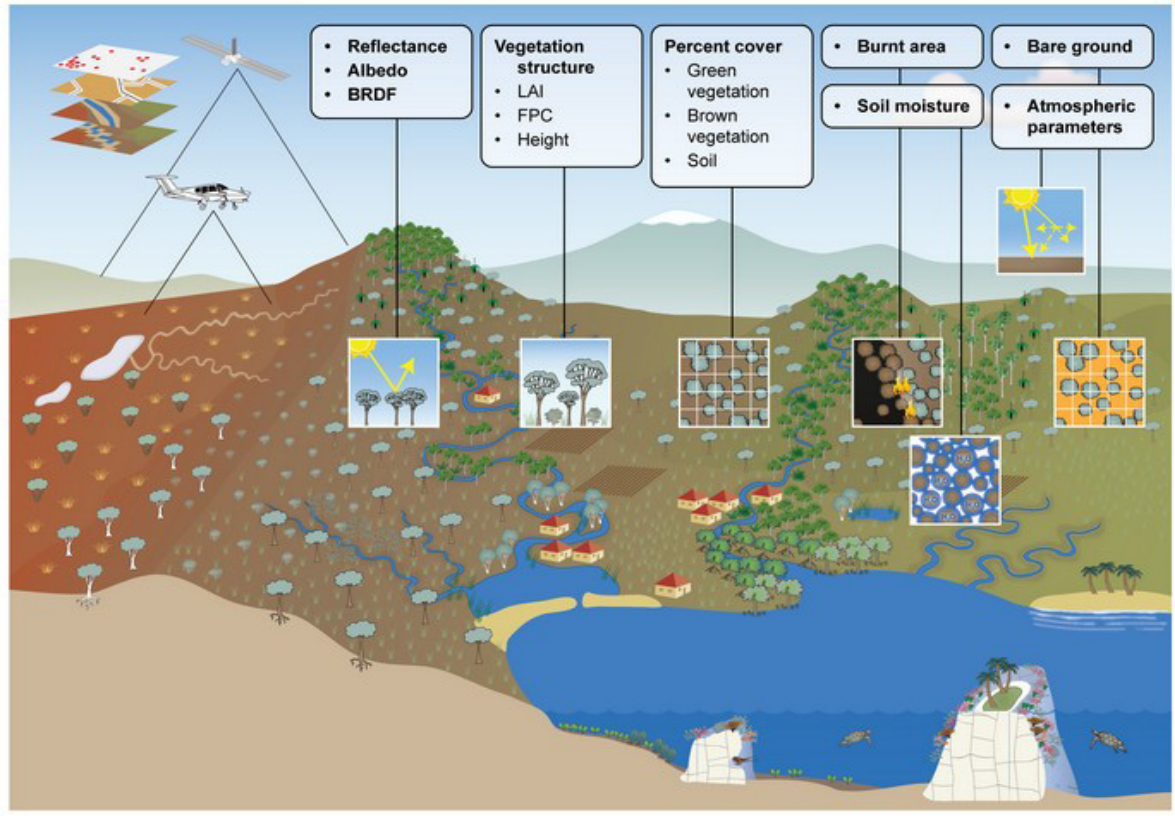
CONFERENCES

Continuing research projects also include:

- Development and provision of training programs for field data collection and image processing.
- Development and implementation of pre-processing techniques for SPOT analysis including cloud and shadow masking, pan-merging and ortho-rectification.
- Development of techniques for mapping (woody and non-woody) annual and rapid vegetation change and extent using medium resolution USGS Landsat and SPOT5 imagery.
- The design and implementation of a method for validation of FPC and FPC change products across NSW, QLD and VIC using site and LiDAR data
- Acquisition of USGS archive data over Australia for time series analysis.
- Continue to operate and maintain Cimel Sun Photometer and data capture.
- Development and testing of techniques for mapping vegetation structure and vegetation structure changes on a state-wide scale using satellite imaging radar systems, and integrated radar, Lidar and optical systems.

TERN Auscover

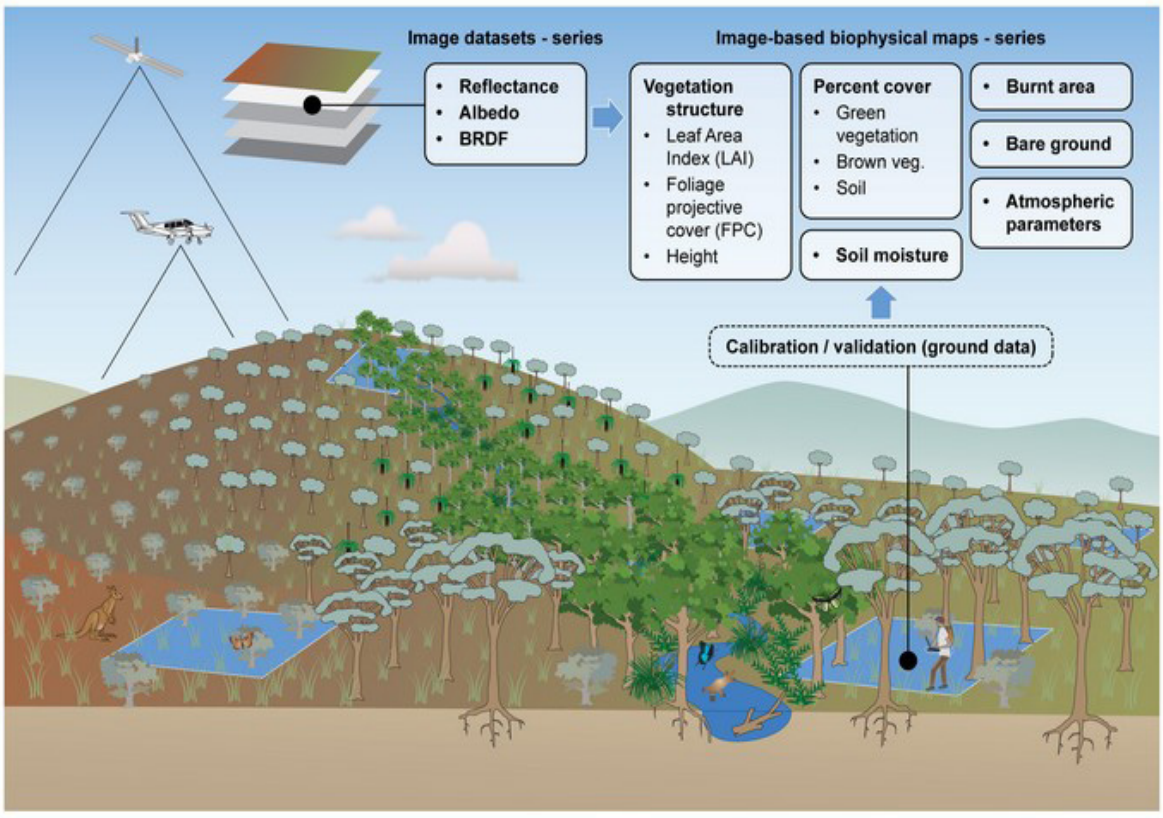
The AusCover facility within Australia's Terrestrial Ecosystem Research Network (TERN) provides a national expert network and a data delivery service for Australian biophysical remote sensing data time-series. Staff from the JRSRP forms the Brisbane node of the Auscover facility within TERN.



Biophysical image map data sets produced by the AusCover Facility

The aim of AusCover is to provide a nationally consistent approach to deliver and calibrate past, current and future satellite image based datasets and produce ecosystem science data products designed for Australian conditions.

The physical implementation of the AusCover Data facility provides standardised, calibrated and validated biophysical data products, delivered via a 24/7 Distributed Data Archive and Access Capability (DAAC) linked to the AusCover Portal http://portal.auscover.org.au/webportal/. The portal is available for research and other non-commercial applications and all data will be publicly accessible and retrievable. The DAAC comprises several regional nodes, one of those being Brisbane, with a central console located in Canberra, acting as the AusCover portal to TERN. Continental-scale time series products and associated metadata are already available on the portal, but a long list of additional products will be added to the portal over the next two years.



Biophysical image map validation data sets: shows how these will be calibrated and validated from field based infrastructure and activities

Questions that can be addressed through use of Auscover information:

- How, in space and time, have key environmental variables changed over the period of satellite image archives for Australia?
- Can we measure at regional scales the relative benefits/impacts of legislated environmental management programs on Australia's major land and coastal ecosystems?
- How accurate are each of the AusCover data sets, and what image and ground-based measurements are necessary to enable them to be used to assess natural and human induced changes or management actions in the environment?

2010 - 2011
TERN Auscover
Research Highlights

2010 saw the establishment of Auscover's Brisbane node with the appointment of Dr Kasper Johansen as Science Coordinator and Rebecca Trevithick in 2011 as data coordinator. Since then additional scientists have been appointed to contribute to AusCover work at the Brisbane node.

RESEARCH

> Preliminary releases of foliage protective cover and ground cover products of QLD are available through the trial Auscover portal. Current work within the Brisbane node of AusCover is focusing on producing Landsat based foliage projective cover and ground cover maps of Australia between 2000 and 2010.

> The first field and airborne campaign in AusCover was organised by the Brisbane node with all nodes in AusCover contributing. Field data, hyper-spectral data, LiDAR data and a WorldView-2 image was obtained in January 2011 for the Tumbarumba site in NSW. This data will be made available via the AusCover portal.

> AusCover funding has contributed to the purchase of new field equipment for the Brisbane node, to be shared nationally, including a server for image processing and data storage, and three new ASD spectrometers. There are also plans to purchase a terrestrial laser scanner.

WORKSHOP

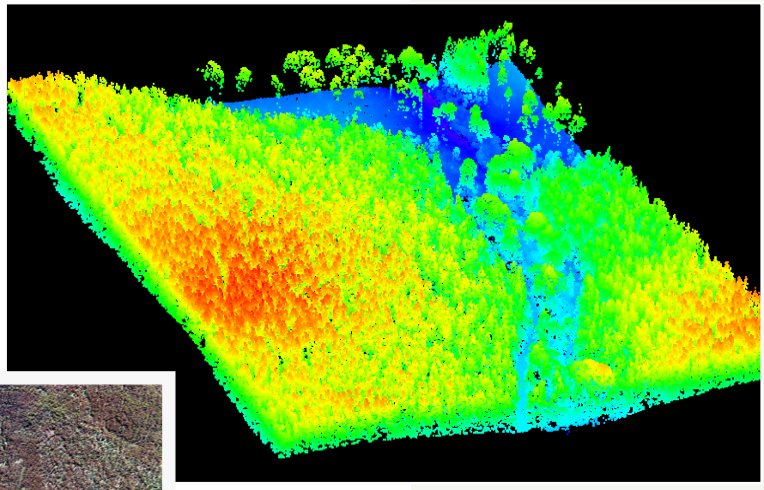
National Workshop on Radiometric Correction of Medium-Resolution, Long-term Satellite-image Archives

Hosted at The University of Queensland, Brisbane 2010

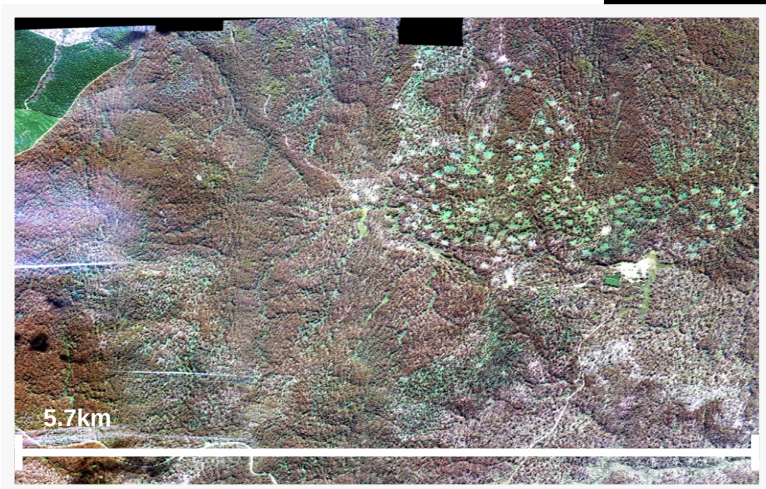
The objective for the workshop was to develop a nationally consistent approach for the radiometric correction of moderate spatial resolution (10-60m) satellite imagery for use by TERN Auscover in delivering a publicly accessible and fully corrected moderate spatial resolution, multi-spectral data archive.

This work has progressed since the workshop with CSIRO, GeoScience Australia, and the JRSRP currently processing 90 Landsat scenes for testing of the Bidirectional Reflectance Distribution Function (BRDF) and atmospheric correction techniques used. The processed images will be validated and compared and a workshop will be organised for Nov/Dec 2011 for the groups to assess and discuss the outcome.

Tumbarumba is located in south west NSW, close to the VIC border.

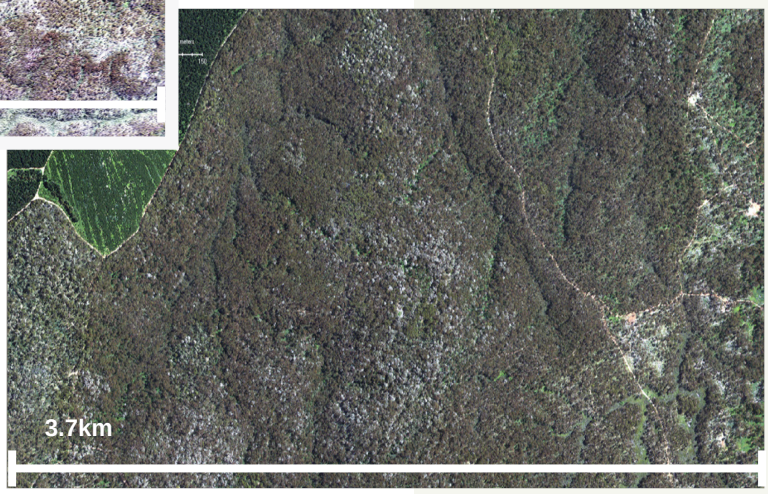


LiDAR - Tumbarumba image represent 1 km2



Hymap - Tumbarumba

WorldView 2 - Tumbarumba



FUTURE

Planned Research Activities for 2011 - 2012

The research plan for Auscover over the next year are extensive and varied. Some of the Brisbane nodes planned activities include:

- New field and airborne campaigns, some of which will be in Queensland. Sites for consideration in Queensland include Robson Creek, Cape Tribulation and Injune.
- The continuation of calibration and validation activities within AusCover and the development of protocols and metadata for obtaining, processing and storing data used for calibration and validation activities.
- Contributions to the development of field data protocols and field and image metadata generation for field and airborne campaigns throughout Australia.

External Collaboration's

We continue to foster partnerships and collaboration between academic sectors, and all levels of government. In 2010 and 2011 we welcomed to the program the Terrestrial Ecosystem Research Network (TERN) Auscover (Brisbane Node) and the Victorian Department of Sustainability and Environment. Because remote sensing research has a national spread we see our program growing to include agencies all across Australia, we actively encourage this incentive.

We are currently working with Landcare Research NZ on the development of radiometric and atmospheric correction methods for medium resolution imagery and with The University of Trier, Germany for research into improved cover algorithms based on spectral mixture analysis.

And, in collaboration with colleagues from Aberystwyth University, drawing on field data provided by the Queensland Herbarium, considerable work has been completed on determining the effect of soil moisture on Synthetic Aperture Radar (SAR) backscatter leading to the production of preliminary statewide biomass maps.

We have also assisted Aberystwyth University in the development of the Sorted Pulse Data Library (www.spdlib.org and www.spdpointsviewer.sourceforce.net).

"Scientific publications produced by the program help ensure that the science of the program and in turn the remote sensing analysis done by OEH is high quality science."
- Tim Danaher

The University of Queensland has maintained strong links with CSIRO Land and Water as well as commercial remote sensing operations such as Geoimage and Hyvista, while, DERM has previously partnered with the New South Wales Office of Environment and Heritage as well as Geoscience Australia. These relationships provide a balance between organisations with an interest in research and those with an interest in the application of that research.

Tim Danaher, the manger of the Remote Sensing Unit at the NSW Ofice of Environment and Heritage commented on the programs benefits to his organisation:

"The program research has enabled the implementation of operational systems within OEH. These include the provision and implementation software systems for pre-processing of satellite systems and for mapping and monitoring woody vegetation extent using Landsat and SPOT imagery.

The ongoing research has and will continue to provide improvements for the next round of SPOT change mapping in particular.

The program has provided training in software tools which has helped develop the research capacity within OEH.

Scientific publications produced by the program help ensure that the science of the program and in turn the remote sensing analysis done by OEH is high quality science."

Andrew Mellor, the Senior Project Officer of Remote Sensing at Victoria's Department of Sustainability and Environment said;

"As a member of the Joint Remote Sensing Research Program, the Victorian Department of Sustainability and Environment (DSE) is able to collaborate with remote sensing experts and draw on the consortium's collective knowledge and expertise to support its state-wide sustainable forest management monitoring and

Below: Terrestrial LiDAR intensity image of savanna woodland near C

Above, from left to right: Sel Counter, Robert Denham, Tim Danaher and John Armston

reporting activities and legislative requirements."

Peter Scarth, principal research scientist at the Remote Sensing Centre in the Qld Department of Environment and Resource Management, commented:

"The Queensland state government undertakes state-wide mapping and monitoring using information derived from satellite image data. This information is required to inform policy decisions, assist in regulation and compliance with legislation, and assist land-holders and non-government organisations in land management.

The program has greatly assisted in the research and development needed for validated operational applications through the sharing of knowledge, data and procedures between the members. It has led to improved operational versions of the surface reflectance product, woody vegetation extent, fractional cover and the procedures needed to validate these products."

harters Towers.

> "The program has greatly assisted in the research and development needed for validated operational applications through the sharing of knowledge, data and procedures between the members.

Staff & Students

QLD Department Environment & Resource Management


Christian Witte


Peter Scarth


Neil Flood


John Armston


Rebecca Trevithick


Michael Schmidt

NSW Office of Environment and Heritage


Tim Danaher


Tony Gill


Adrian Fisher

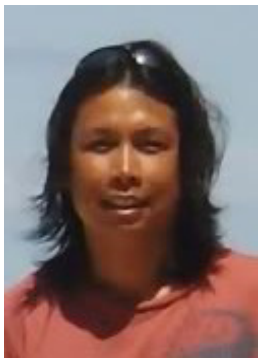
University of Queensland


Stuart Phinn


Kasper Johansen


Chris Roelfsema


Mitchell Lyons


Robert Canto


Johana Speirs

Joanne Edkins

VIC Department of Sustainability and Environment


Andrew Mellor


Andrew Haywood

Financial Statement

Statement of Operating Income and Expenditure. Year ended 30 June 2011.

Income	Note	2008/2009	2009/2010	2010/2011	Total
CSER	1				
DERM	1	349,090.91	166,317.00		515,407.91
OEH	1	450,000.00		280,000.00	730,000.00
DSE	1				
Total Income		**799,090.91**	**166,317.00**	**280,000.00**	**1,245,407.91**
Funds brought forward from previous year		0.00	567,738.50	451,865.75	
Total Funds Available		799,090.91	734,055.50	731,865.75	
Expenditure					
Salaries	2	106,344.85	277,530.02	236,453.40	620,328.27
Consumables	3	200.00	756.61		956.61
Services	4	121,236.37			121,236.37
Equipment					
Travel & Hospitality	5	3,571.19	3,903.12	16,845.15	24,319.46
Total Expenditure		231,352.41	282,189.75	253,298.55	766,840.71
Funds Carried Forward		567,738.50	451,865.75	478,567.20	

Explanatory notes to Statement of Income and Expenditure

1 In-Kind Contributions	2007/2008	2008/2009	2009/2010	2010/2011	Total
CSER	235,320.00	235,320.00	280,320.00	374,820.00	1,125,780.00
DERM	153,017.00	200,140.00	179,877.00	210,706.00	743,740.00
OEH		115,000.00	115,000.00	115,000.00	345,000.00
DSE				76,000.00	76,000.00
Total In-Kind	**388,337.00**	**550,460.00**	**575,197.00**	**776,526.00**	**2,290,520.00**

2 Salaries	2008/2009	2009/2010	2010/2011	Total
DERM	53,172.43	158,907.08	87,716.19	299,795.70
OEH	53,172.43	118,622.94	117,061.99	288,857.36
Total Salaries	**106,344.86**	**277,530.02**	**204,778.18**	**588,653.06**

3 Consumables	2008/2009	2009/2010	2010/2011	Total
DERM	200.00	554.79		754.79
OEH		201.82		201.82
Total Consumables	**200.00**	**756.61**		**956.61**

4 Services	2008/2009	2009/2010	2010/2011	Total
DERM	86,236.37			86,236.37
OEH	35,000.00			35,000.00
Total Services	**121,236.37**			**121,236.37**

5 Travel & Hospitality	2008/2009	2009/2010	2010/2011	Total
DERM	2,495.02	3,024.85	15,543.70	13,263.82
OEH	1,076.17	878.27	1,301.45	3,072.80
Total Travel & Hospitality	**3,571.19**	**3,903.12**	**16,845.15**	**16,336.62**

BRDF	Bidirectional Reflectance Distribution Function.
CSER	The Centre for Spatial Environmental Research in the School of Geography, Planning and Environmental Management at the University of Queensland.
CSIRO	The Commonwealth Scientific and Industrial Research Organisation.
DERM	Queensland Department of Environment and Resource Management.
DSE	Victorian Department of Sustainability and Environment
FPC	Foliage projective cover is the percentage of ground area occup by the vertical projection of foliage.
GDAL	Geospatial data abstraction library. GDAL is a translator library raster geospatial data formats that is released under an X/MIT s Open Source license by the Open Source Geospatial Foundatior
JAXA	The Japanese Space Agency.
Landsat	The Landsat program is a series of Earth-observing satellit missions jointly managed by NASA and the U.S. Geologica Survey.
LiDAR	Light Detection and Ranging (LIDAR) is a technology that utilises lasers to determine the distance to an object or surface.
OEH	New South Wales Office of Environment and Heritage
PPC	Plant Projective Cover.
Python	Python is a computer programming language.
SLATS	Queensland's state-wide land-cover and trees study.
SPOT	SPOT (Système Probatoire d'Observation de la Terre) is a resolution, optical imaging earth observation satellite syst It is run by Spot Image based in Toulouse, France.
TM/ETM	Landsat Thematic Mapper/Enhanced Thematic Mapper
UNSW	University of New South Wales.
USGS	United States Geological Survey.

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