The Statewide Landcover and Trees Study (SLATS) - Monitoring Land Cover Change and Greenhouse Gas Emissions in Queensland.

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Background

Prior to the commencement of the Statewide Landcover and Trees Study (SLATS) project the National Greenhouse Gas Inventory [1] estimated that land clearing for agriculture and pastoralism accounted for 24% of the total national greenhouse gas emissions on a carbon dioxide equivalent basis. The size of this source in comparison to others has focussed attention on land clearing as a major contributor to Australia's total greenhouse gas emissions.

In the State of Queensland, this attention is particularly strong because this State was identified as having the highest source of emissions as a result of tree clearing. Queensland is one of the last States to clear its land for agriculture and pastoralism, the southern Australian States having completed the bulk of their land development decades ago. Most of this clearing for pastoralism occurs in woodland areas to increase pasture productivity, although continued population growth is increasing the demand for urban land which is resulting in forest clearing in coastal and southeast Queensland.

Estimates of tree clearing in Queensland, based on surveys of clearing contractors, herbicide sales and other sources, fluctuated wildly from 200,000 - 1,000,000 hectares per year, depending on the position being argued. This large variation in quoted figures was a source of contention and hampered informed public debate.

The Queensland Department of Primary Industries (QDPI) estimated that the rate of carbon storage due to regrowth of trees, forest thickening and growth of woody weeds would more than balance the release of greenhouse gases through clearing. QDPI theorised that the land use and forestry sector may be a net sink for greenhouse gases in Queensland [2].

In response to the lack of quantitative information the Queensland Government established the SLATS project.

Description

SLATS aims to improve the greenhouse gas inventory for the land use and forestry sector in Queensland and to provide information for review of vegetation management policies in Queensland. In order to determine project priorities, the uncertainties involved in calculation of greenhouse gas emission were evaluated [3]. The resulting program set out to address the largest of these uncertainties. Key components of the SLATS project are:

- The development of a satellite based monitoring system using Landsat Thematic Mapper (TM) satellite imagery for 1988, 1991, 1995 and 1997 to detect change in woody vegetation cover across the entire State;
- An analysis of clearing in Queensland based on Landsat Multi Spectral Scanner (MSS) satellite imagery for 1972, 1980 and 1984 to provide improved estimates of regrowth area cleared and historical clearing rates;

- Mapping the extent of woodlands in Queensland by conducting a detailed baseline landcover survey using 1991 TM satellite imagery;
- Establishment of permanent vegetation monitoring sites to assess woodland thickening trends across the State;
- Assessment of the impacts of tree clearing and woodland regrowth on Queensland's greenhouse emissions;
- Extension of the broadscale and local tree clearing guidelines covering leasehold land in Queensland;
- Production and distribution of products for vegetation management planning and policy including reports, satellite image maps and digital products to government, land holders, other industry and the general public.

The SLATS team has developed a high quality, consistent set of image processing procedures which has evolved over the course of the project. Most of these procedures have now been automated and standardised into documented macros and scripts to minimise errors, although considerable visual editing is still performed by trained professionals to ensure accurate results. These procedures are all documented on the SLATS local Intranet Web pages and are under continuous addition, upgrade and development.

The project utilises a huge amount of data to monitor change. There are seven temporal data sets each of 88 Landsat scenes covering the State over the period 1972 – 1997. Two Cray SV1 supercomputers® coupled with a Storage Technology 4410® robotic tape library with two Timberline® tape drives (800 megabyte capacity uncompressed) and two Redwood® tape drives (50 gigabyte capacity uncompressed) are used to store and retrieve the satellite imagery, derived products and other modelling data. The potential storage capacity of the tape library is 280 terabytes.

Methods

Imagery must undergo several pre-processing steps prior to use in change detection and mapping procedures. All imagery was purchased from the Australian Centre for Remote Sensing (ACRES) pre-processed to level 5. Radiometric calibration, geometric correction and image registration are the main image pre-processing steps undertaken by the group on the SLATS data.

A semi-automated technique for change detection has been developed using band reflectance differences and a Normalised Difference Vegetation Index (NDVI) differencing methodology. This technique is used to provide change detection classifications between data sets held over the various time spans following image pre-processing.

After field data has been collected a detailed baseline landcover classification is done using the 1991 TM imagery. This involves the development of wooded / non-wooded masks, foliage projective cover (overstory and shrub) and tree basal area layers. Full descriptions of these methods are held on the SLATS web site (http://www.dnr.qld.gov.au/slats) where various papers outlining SLATS methodologies are available.

Field validation of remote sensing analysis is an essential part of the SLATS methodology [4] and involves approximately 70,000 kilometres of travel throughout the State each year. Each scenes is ground truthed:

- to verify vegetation change classification accuracy;
- to measure differential GPS ground control points;
- to collect vegetation site data for calibration and classification validation purposes;
- by liaising with local Queensland Department of Natural Resources (QDNR) officers and landholders.

A field based woodland monitoring program, run by QDPI Tropical Beef Centre staff in Rockhampton, measure woodland thickening trends across Queensland. Actual field measurements are required as woodland thickening is not measurable using Landsat TM imagery. As part of the SLATS project, QDPI

has extended its permanent on-ground woodland monitoring system, known as TRAPS [5] to include a total of 118 measurement sites. These sites are measured in fine detail using tree bands and callipers. Woodland thickening should not be confused with regrowth after clearing; woodland thickening refers to increases in the woody biomass due to changes in vegetation density from causes such as a reduction in the frequency of fires. Thickening is understood to be occurring across vast areas of Queensland's woodlands. In addition, another 20 sites across the State have been sampled to confirm woodland thickening by analysis of carbon isotope ratios using the $\delta^{13}C$ technique [6]. This technique discriminates between carbon produced by trees with C_3 photosynthetic pathway from carbon produced by C_4 grasses which dominate tropical and sub-tropical areas. This technique uncovers areas where grass dominated plant communities have been replaced by thickening trees and shrubs.

In order to calculate changes in greenhouse gas emissions resulting from clearing, a measurement of the biomass of cleared vegetation is required. There are known relationships between biomass and tree basal area for some species [7, 8], so a combination of the vegetation change mapping and land cover mapping are used to estimate the biomass of cleared vegetation [9].

Results

Vegetation Change Rates

Until recently, clearing rates in Queensland were estimated to range from 200,000 - 1,000,000 hectares per year. SLATS reports have now settled this, by providing 1991 to 1995 clearing rates of 285,000 hectares per year $\pm$ 10%.

Farmers, conservationists, governments and scientists now have factual information when formulating policy and making land management decisions. For the SLATS Interim report [10], a raster of cleared areas was intersected with geographic information system (GIS) overlays of tenure type, biogeographic regions and provinces, catchments, local government areas and native pasture communities. For each polygon the clearing rate (square kilometres per year) and also the clearing rate as a proportion of polygon area per year was calculated. This proportional analysis highlighted significant clearing areas in smaller polygons. Once the 1991 baseline landcover mapping is complete it will be possible to provide clearing as a proportion of the area of 1991 woody vegetation in each polygon. Clearing by vegetation communities will also be calculated once current and pre-European[1] vegetation communities are mapped.

Greenhouse Gases Emissions

An analysis of biomass cleared combining the latest SLATS Landsat TM based change analysis, 1.1 kilometre resolution NOAA satellite imagery, generalised equations for tree basal area [9] and biomass per unit basal area, showed that approximately 20 million tonnes of live trees are cleared each year. Standing dead trees, fallen timber, litter and tree roots are not included in this measurement. These 20 million tonnes of biomass are equivalent to 33 million tonnes of carbon dioxide (CO_2) emissions when timber is burned or eventually decays.

This system over-estimates biomass in areas of regrowth clearing because reliable regrowth mapping is not available at the present time. The historical vegetation analysis using Landsat MSS data will refine this measurement by delineating woody to cleared to woody transitions. Once age of clearing is established estimates of growth can be used to estimate regrowth biomass increments and carbon pools.

The Future

In the three and a half years that SLATS has been in progress there has been a huge demand for the information and products produced. The availability of factual information has moved the debate on land clearing forward with all parties adopting the SLATS figures. Information provided by SLATS has

[1] Australia's vegetation status prior to European settlement.

been used in the development of broadscale tree clearing policies on leasehold land and has prompted the Government to reassess vegetation management policies on other tenures. The project has also provided crucial information for the establishment of Australia's national greenhouse position.

A monitoring system is essential to ensure that Queensland's vegetation retention policies and practices are ecologically sustainable and the biodiversity status of regional ecosystems is maintained. Through a new greenhouse initiative of the Queensland Government, SLATS will continue to be funded for a further three years. Satellite imagery will be used to routinely monitor regions identified as clearing hot spots every two years. The entire State will be analysed every four years. The historical Landsat MSS imagery (1972, 1980 and 1984) will be analysed to provide a better historical context of clearing rates, regrowth age, soil carbon run-down and greenhouse calculations. Woodland thickening trends will continue to be monitored using permanent field monitoring sites. Laser profiling techniques [11] are being investigated as a means of monitoring cover and height of woody vegetation. The new initiative will have a targeted extension program to promote responsible vegetation management practices, the Queensland tree clearing guidelines, tree management planning, the SLATS project and on-farm use of SLATS satellite products across the State.

In conclusion, the SLATS project is providing a solid foundation to implement a fully integrated approach to vegetation management based on appropriate technology, best science and embracing ecologically sustainable development principles.

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