Australian Government
Department of Climate Change and Energy Efficiency

THE LAND SECTOR IN THE NATIONAL INVENTORY — OVERVIEW

Australian National Greenhouse Accounts

National Inventory

In Australia, the land sector contributes about 25% of total-human induced greenhouse gas emissions to the annual national inventory through activities such as crop production and land clearing. The removal of carbon dioxide from the atmosphere by forests and other vegetation also provides an important carbon sink.

Australia's forests extend over 106 million hectares. Only a relatively small portion of these forests are managed for commercial timber so that, when Australia's national inventory was first being developed, there were few measurements available on the amount of biomass in the forests and little monitoring of forest cover change.

It was not economically feasible or logistically practical to address these data gaps over such a large area with the use of direct emissions estimation methods alone e.g. field sampling or lidar sensors. Given these circumstances, the design of Australia's national inventory system for the land sector relies heavily on the application of 25 metre grid resolution satellite data to assess land use change and use of a modelling framework, the Full Carbon Accounting Model or *FullCAM,* to estimate the biomass of vegetation on lands across Australia, the carbon stored in above and belowground vegetation and soil and emissions resulting from land use and management activities.

The priority for the development of the system so far has been to support the estimation of emissions from land use change, which is a key category for Australia in terms of both total level and trend terms. In future, the development of the system will be aimed increasingly at the enhancement of the estimation processes for other sources and sinks in the land sector, like croplands and grazing lands requiring the development of new measurement protocols, the acquisition of new datasets and the implementation of new estimation techniques.

Land Cover Change

Satellite images from the Landsat program — a series of Earth observing satellite missions jointly managed by NASA and the U.S. Geological Survey — are processed each year to monitor Australia-wide land cover change. ***National coverages of Landsat satellite data at a resolution of 25m across nineteen time epochs from 1972 to 2010 have been assembled and analysed.***

The application of a consistent dataset over a time series dating back to 1972 is important as the effects on greenhouse gas emissions from land cover change are typically long lasting. Emissions and removals from current activities will also be affected by site history — for example, a current deforestation event will likely generate fewer emissions if the forest cleared is secondary forest (regrowth after previous clearing) rather than a primary forest.

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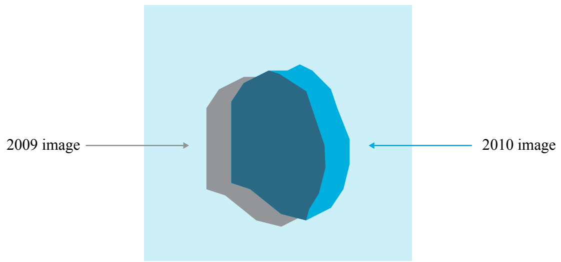
Changes on the land from one year to the next are identified from raw satellite data processed largely by private companies under close supervision by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The first step is to select the Landsat images from the archive held by Geoscience Australia, that provide the best view of the landscape for the purpose of distinguishing different land uses and identifying forests. Images are selected to minimise cloud cover and seasonal "green flushes" which can make it harder to distinguish forests from other vegetation. Images taken in different years are then spatially aligned so that identified land use changes are not simply the result of a "frame shift" of one image compared to another as illustrated in Figure 1. Once the data is spatially aligned, it must also be spectrally calibrated to avoid errors rising from differences in surface reflectance (brightness) at the time the image was captured in one year compared to another.

Figure 1:

Spatial alignment of satellite data is necessary to minimise accounting error.



Finally thresholds are used to assign a probability of forest cover to each pixel based on an index which discriminates between forest cover and non-forest cover. Reference indices are established through the use of air photographs, ground data and very high resolution satellite data, which are compared with Landsat images of the same area at the same time to ensure that interpretations of the those images are correct. The final product is a Continental Landsat Mosaic (Figure 2), and maps identifying forest extent (Figure 3) and change (i.e. regrowth & deforestation) compared to the previous year. Forest extent data for the period from 1972 to 2000 have been independently verified by a team of experts from the Geospatial Science Initiative of RMIT University, using high resolution aerial photographs and Ikonas satellite imagery for nearly 1000 sites across Australia (Figure 2). This verification process is currently being repeated for more recent data, for the period 2000 to 2011 by researchers from the Cooperative Research Centre for Spatial Information(CRC SI).

Figure 2:

Continental Mosaic of LandSat images. High resolution Ikonos images at nearly 1000 sites (yellow dots) are used to train and verify Landsat data classification.

Source: *National Inventory Report 2009*, vol 2, p 42.

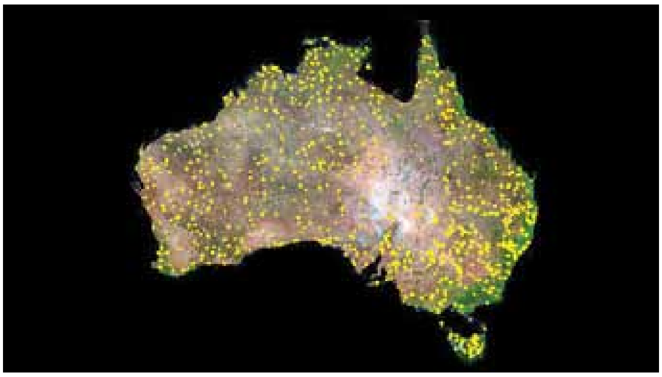
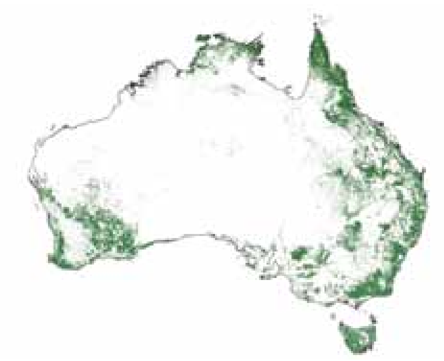


Figure 3:

Forest extent in Australia 2009.

Source: *National Inventory Report 2009*, vol 2, p 11.



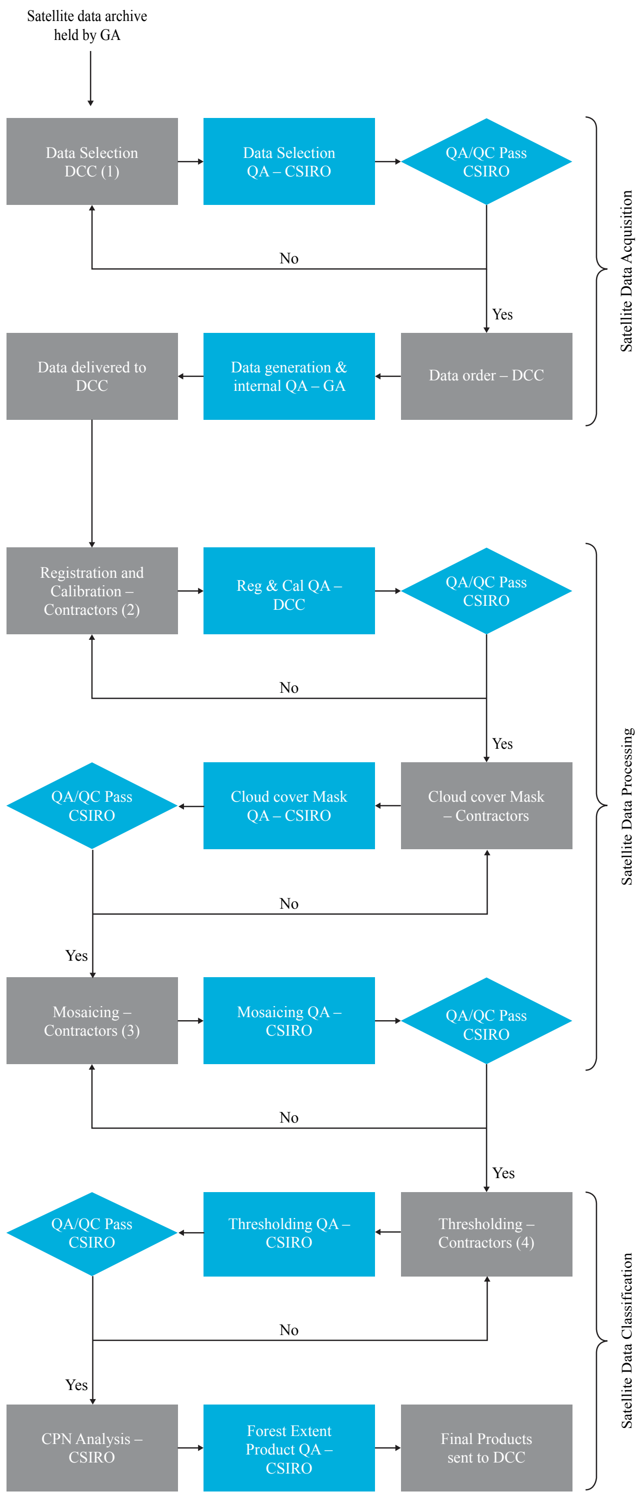
Attribution of Change

The high resolution spatial assessment across the continent identifies land cover change resulting from many causes. For policy purposes it is necessary to distinguish between natural and human-induced land use change. Forest harvesting and dieback during drought periods may cause forest loss but do not necessarily result in the conversion of forest land to a different permanent use. The remote sensing data is cross-checked with fine scale images and national land use databases to identify and separate areas of temporary forest loss from changes that can be attributed to forest conversion.

The flowchart in Figure 4 provides an overview of the sequence of steps required to process the satellite imagery including the role of DCCEE, Geoscience Australia, CSIRO and industry partners. Quality assurance procedures are taken at every stage before proceeding to the next step.

Figure 4:

Land Sector Annual Emissions Estimation — QA/QC Procedures for Remote Sensing and GIS



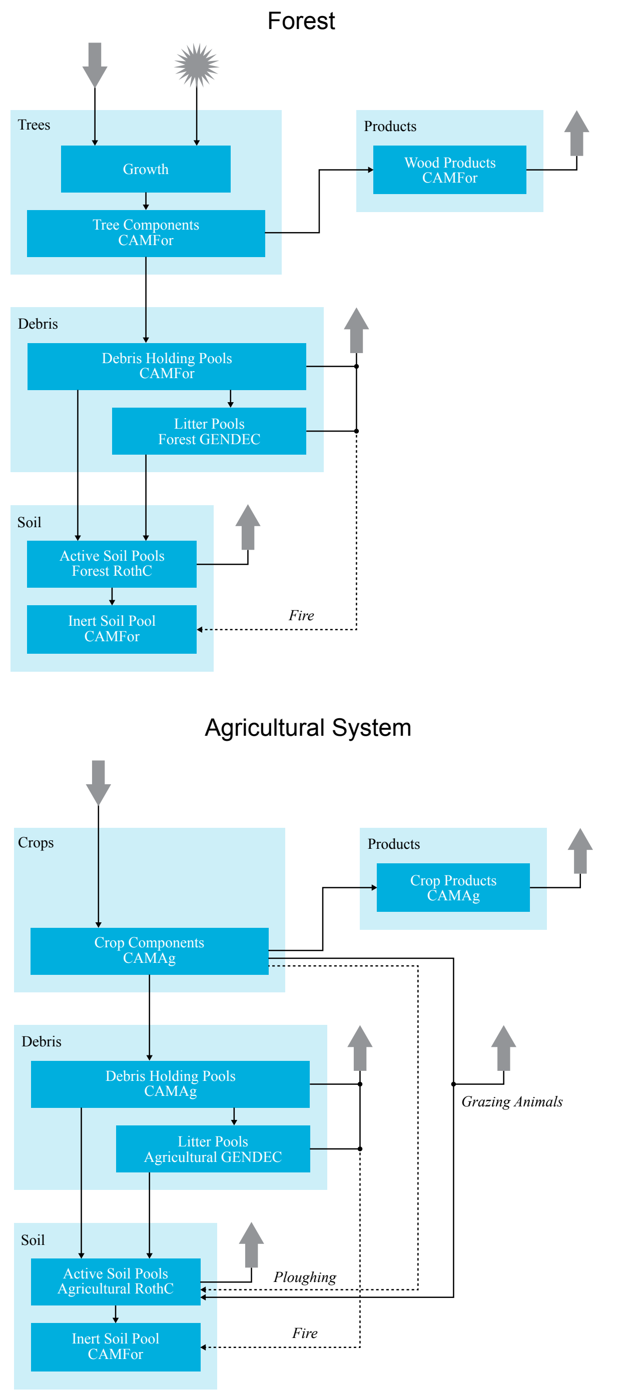
Model Framework

The modelling framework for estimation of emissions from the land sector is provided by *FullCAM (Figure 5)*. *FullCAM* has components that deal with both the biological and management processes which affect carbon pools and the transfers between pools in forest and agricultural systems. The exchanges of carbon, loss and uptake between the terrestrial biological system and the atmosphere are accounted for in the full/closed cycle mass balance model which includes all biomass, litter and soil pools.

Figure 5:

The *FullCAM* model pool structure.

Source: *National Inventory Report 2009*, vol 2, p 50.



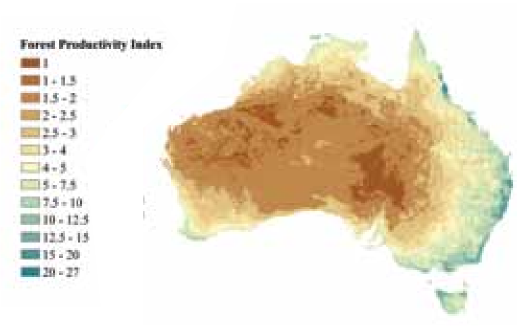
Spatial Application of *FullCAM*

The fundamental analytic unit of *FullCAM* is the land cover change grid (25 m x 25 m) derived from the satellite remote sensing program. The first time a land clearing event is detected for a pixel from one satellite image to the next, in the time series dating back to 1972, the modelling of that pixel commences. The pre-clearing biomass for forest at a specific pixel is modelled from site productivity taken from the *Forest Productivity Index* (Figure 6).

Figure 6:

Forest Productivity Index—a spatially explicit representation of the variation in conditions that promote plant growth e.g. soil quality, water availability, frost extent, across Australia.

Source: *National Inventory Report 2009*, vol 2, p 63.



Not all forest areas are in a 'mature' state, so the remote sensing of land cover change is used to identify disturbance history back to 1972 and, therefore, forest age. The forest growth model component of *FullCAM* is used to estimate the amount of biomass on such lands using information on the initial biomass for the location, forest age and data on climatic conditions experienced since regrowth commenced.

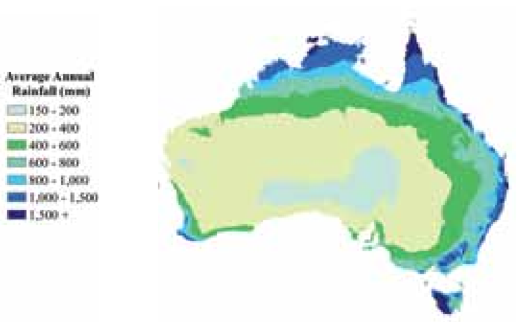
Data from the Bureau of Meteorology for rainfall, minimum and maximum temperature, evaporation and solar radiation are processed each year by researchers at the Australian National University to generate monthly climate surfaces (maps) at 1 km resolution (Figure 7).

Following a clearing event, the subsequent land use (e.g., crop or pasture type) and management practices (e.g., tillage, use of fire and grazing intensity) will also impact significantly upon ongoing emissions from that land. The Landsat mosaic is combined with non-spatial data from Australia's National Forest Inventory and from the land use mapping program of the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) to assign a land use type to each area of Australia (Figure 8).

Figure 7:

Average annual rainfall — an example of climate inputs to *Fullcam* (examples shown as annual averages of monthly input data).

Source: *National Inventory Report 2009*, vol 2, p 76-78



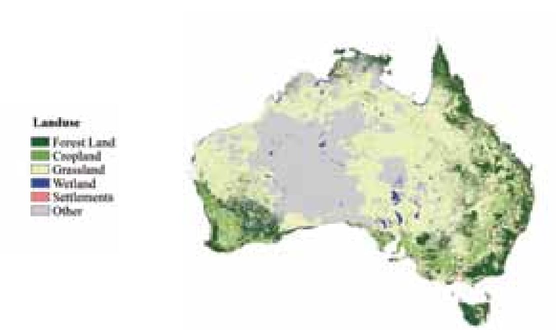
FullCAM also accounts for lagged emissions in any given year that result from a land clearing event in previous years. These lagged emissions are associated with the decay of dead organic matter and the release of soil carbon over time.

Change in soil carbon is derived from mapped soil units that provide pre-disturbance carbon (organic) content, clay content and soil type, allowing the application of *FullCAM*, along with site history and land use management data, to model change in soil carbon at each pixel.

Figure 8:

Land use in Australia 2009.

Source: *National Inventory Report 2009*, vol 2, p 9.



Review and Quality Assurance

Land sector emissions, along with those from all other sectors, are published annually in *Australia's National Inventory Report* which is posted on the DCCEE website and submitted to the UNFCCC. After submission, the Inventory is reviewed by a panel of international experts. The review report is published on the UNFCCC website.

In order to improve the accuracy and reduce uncertainties associated with emissions estimates, the data, methodologies and models used by *FullCAM* are under a process of continual review and update. In 2011, Australia and New Zealand conducted a mutual review of each other's inventory systems and provided feedback on areas for potential improvement. Working groups of experts are also regularly convened to review the emissions estimation methodologies and models for a particular land sector activity, and provide advice on updating these, if new research or technical data are available that may make a demonstrable difference to the accuracy of emissions estimates. For example the CSIRO is currently engaged to undertake field measurements of above and below ground biomass for environmental plantings in Australia as well as to support the development of direct measurement protocols. Biomass models, and the implementation of soil carbon models, are also currently under review.

Need more information? *http://www.climatechange.gov.au/emissions*