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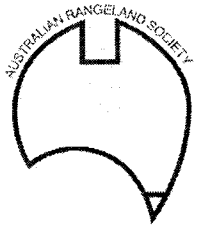

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WOOLGROWERS WITH REMOTE CONTROL
NEW TOOLS FOR WHOLE OF PROPERTY MANAGEMENT

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ABSTRACT
With the support of funding from the Land, Water & Wool program, we worked with woolgrowers in north eastern South Australia to adapt MODIS-derived images of cover into products useful for monitoring and managing vegetation at paddock and property scale. Products included maps of fractional cover scaled to the interests of individual producers, maps simplified to three classes of cover and time-trace summaries of average cover by land type for particular paddocks. We report project results and steps still required to progress this technology to a workable system that can assist property-level management of natural resources.

INTRODUCTION
Monitoring data to inform appropriate adaptive management decisions is critical in complex environments (Rempel *et al.* 2004). This is particularly the case for pastoral land use in the rangelands. The requirements for wool producers to monitor are largely self-evident and could include:

1. their need to manage in a highly variable environment;
2. the requirement to preserve the health of the natural resource base so that its function and future productive potential is not impaired; and
3. proactively working with the wool industry to develop tools that assist in guaranteeing environmentally safe production.

Pastoralists in the first instance probably base paddock stocking decisions largely on the quantity and quality of forage available for the class of stock being run. To a greater or lesser degree, they also use indicators of longer term change such as composition (or perhaps density or diversity) of palatable species (particularly perennials), the balance between pasture and woody species, and soil indicators (surface cover, erosion etc). Their monitoring may be either formal (at fixed locations, photos supplemented by recorded observations) or largely informal (observations on water runs, diary notes, photos at points of interest etc) and may be complemented by the results of an agency monitoring program. Observations are largely ground-based although managers who fly obtain an additional aerial perspective.

Some agency monitoring programs have capitalised on the complete and regular coverage provided by some forms of satellite-based remote sensing and their image archives. However there has been limited access by pastoralists to this technology to date. The main impediments have been cost and difficulty in accessing data, and then lack of suitable methods (mainly software tools) to transform data into useful information products. The availability of free MODIS imagery via the internet, improved communication services in some parts of the rangelands together with the rapidly increasing power of personal computers and the expanding range of freeware products mean that this technology is now within the reach of land managers.

We obtained funding from the Land, Water & Wool program that assisted us to work with eight woolgrower families in north eastern South Australia to test whether remote sensing products that allowed more comprehensive and precise assessments of vegetation cover could assist their grazing management. Specific objectives were to build effective relationships with woolgrowers; provide images and graphs of cover through time at paddock scale; develop and test software tools to automate the creation of these products; and, dependent on progress to this point, test options for delivering and displaying products through a web-like interface.

INITIAL WORKSHOPS

During initial workshops with woolgrowers in late March 2005 to introduce the project, participants were sceptical that they would use information derived from satellite data to make decisions about their current grazing management practices (e.g. number of sheep in each paddock and the time over which these flock sizes were maintained in the paddock). However all producers saw value in satellite-derived maps of cover as a way of complementing current methods used to monitor their land and vegetation. Most woolgrowers also said that they would appreciate current information being placed against historical context ("knowing where I am now compared to where I have come from"). The existence of a substantial archive of satellite imagery (dating back 30+ years) meant this request was achievable. Encouragingly, all woolgrower families were keen to participate in the project.

To meet the request for historical context, we provided:

1. Time traces of average values of the Normalised Difference Vegetation Index (NDVI), stratified by land type, for the project area (8,213 sq km) for the period 1981-2003. NDVI values, which indicate vegetation greenness and to some extent cover, were derived from Advanced Very High Resolution Radiometer data and showed a decreasing trend since the mid 1990s, i.e. declining seasonal quality. Recent years have some of the lowest NDVI values in the 20+ year record.
2. Digital Landsat images (11 image dates) from the Australian Greenhouse Office archive for each station for the period 1972-2002 (see http: //www.ga.gov.au/acres/prod_ser/agosuite.jsp). We also provided freeware image viewing software (Open EV), documented instructions and some tuition on its use while visiting woolgrower families.

PRODUCT DEVELOPMENT AND DELIVERY

MODIS Imagery

MODIS is the MODerate resolution Imaging Spectro-radiometer and is carried on the Terra and Aqua satellites, first launched in 1999. The data are free and can be downloaded as various image products from either the US or the Australian Centre for Remote Sensing (see http://www.ga.gov.au/acres/prod_ser/modisprice.jsp). We used the MOD13Q1 image product, obtained from the CSIRO Land & Water archive for the period 2000-2004 and downloaded during 2005 from the US web-site data pool (ftp site e0dps01u.ecs.nasa.gov). MOD13Q1 is a 16-day cloud-free composite product with a pixel size of approximately 230-m. Images were reprojected to the Australian Map Grid and the visible red band (0.6-0.7 μm) of each image combined to provide a total of 113 image dates. The visible red band, when appropriately scaled, provided a simple and reasonably robust index of vegetation cover for the region most of the time. When moisture appeared to be present, cover values spiked to produce falsely high values with these anomalies occurring most frequently in winter. These anomalies were caused either by changed reflectance properties of a moist soil surface or increased water vapour in the atmosphere. Due to our emphasis on tailoring products for, and building relationships with, woolgrowers we elected to minimise this difficulty by removing problem images from the time-series comparison rather than find a technical solution.

Customised Images of Fractional Cover

During station visits (September-December 2005), we worked with family members to produce tailored images of cover using a laptop computer. Areas with dense woody cover were usually highlighted and then removed from further analysis. Remaining areas were then mapped using a ramped colour display stretched according to relative cover present (between bare ground and highest cover, excluding dense woody vegetation). Printed colour maps of cover for suitable image dates through 2005 based on the relevant station display were subsequently supplied to each woolgrower family, in December 2005 and March 2006.

In workshop discussions, project participants agreed that image displays scaled to show cover differences at paddock or station scale (Fig. 1) were most relevant to managing their vegetation resource. They were less interested in a benchmarking approach where cover in focus paddocks or across a station would be compared with regional performance for each image date. In this example (Fig. 1), scaling cover to the range present in the paddock shows more detail than scaling to the property or region. Scaling by property in turn shows a little more detail than that for the region.

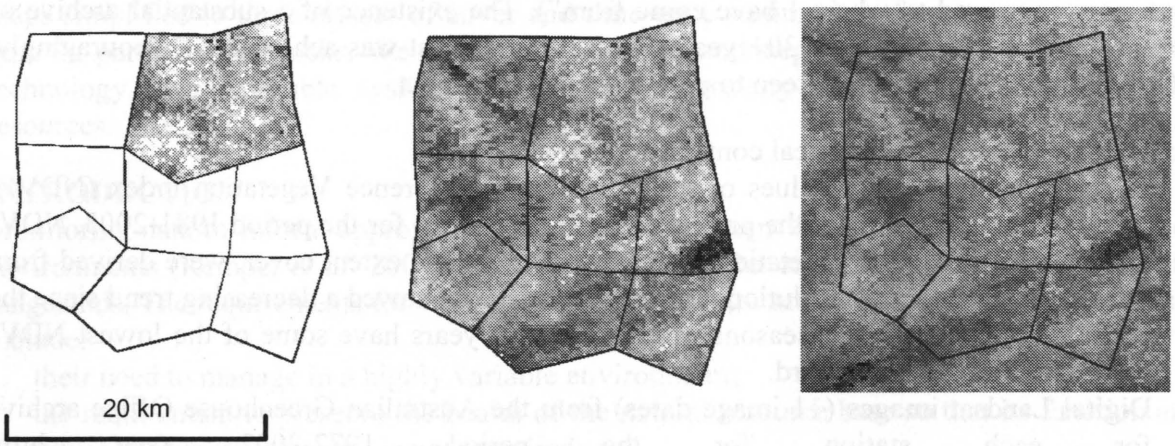

Figure 1: Cover index derived from the visible red band of MODIS imagery for 23rd April 2005 scaled to the cover range of a paddock (left panel), property (centre panel) and project area (right panel). Increasing brightness indicates decreasing cover

Time Traces of Cover

Multi-temporal images of vegetation cover for each station were summarised as time traces of average cover across land types within paddocks. These time traces can be viewed either as a continuous record for the duration of MODIS imagery or as a year-on-year record. At the final evaluation workshops, woolgrowers considered both display types useful. For the year-on-year option, average cover levels in a paddock for all years of available data are plotted on a calendar-year basis (i.e. January to December). Average cover values for the current year can be emphasised for comparison against previous years and it may also be useful to show the accumulating average of cover levels in previous years.

Managing Grazing for Different Cover Classes

Cover values can be presented to show changes in categories (such as low, medium, high). The spatial distribution of these classes and their changing pattern over time may assist woolgrowers to manage cover against preset targets. We acknowledge that managing grazing pressure and its distribution in paddocks is vastly more complex than briefly described here. However, the positive response of most woolgrowers to demonstrated products encourages us that this product-type is a useful way of presenting MODIS-derived information about cover.

PRODUCT EVALUATION

We held two workshops with woolgrower families in March 2006 to formally evaluate products and establish the level of support for expanding the project should suitable funding become available. The first workshop was with woolgrower families in the project area and the second involved a new group from neighbouring stations who had not been directly involved in the project, although some were aware of it. Participants in both workshops provided positive feedback about products developed during the project. Producers were more interested in longer term interpretation of cover change ("where am I now compared with where have I been?") although their consensus was that products also have some value in tracking shorter term (seasonal) changes in cover (i.e. to assist decisions about current stocking). As indicated earlier, participants in both groups thought that products emphasising cover differences at paddock and/or property scale were more useful than comparing (benchmarking) their place against regional cover levels, but that regional comparison had value too. All were enthusiastic for the project to continue across an expanded area (possibly multiple regions in different states) and with increased focus on product delivery and uptake by users.

FURTHER DEVELOPMENT

To truly deliver on the potential of MODIS imagery as a monitoring tool for woolgrowers (and pastoralists generally), we need to provide robust software that forms the interface between standardised imagery and those information products desired by managers. This might work through a web-based subscription service where eligible producers download the latest available images for just their station via password protection. Images would be processed to a consistent index of cover by a commercial supplier. Menu-driven software installed on the family computer would then allow user-specified choices about type of scaled cover display (paddock, station, property), options for infrastructure overlay (fences, tracks, waterpoints etc) to assist interpretation, and associated time-trace summaries for selected paddocks (continuous, year-on-year). There are a number of technical challenges to establishing such a service and obviously the economic feasibility of this delivery model needs to be established. Also, significantly, training and ongoing technical support that allows producers to fully utilise such a service is paramount to its success.

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