VegMachine - putting pastoralists in the picture.

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Australia's rangelands are the extensive arid and semi-arid grazing lands that cover approximately 70% of the Australian continent. They are characterised by low and generally variable rainfall, low productivity and a sparse population. They support a number of industries including mining and tourism, but pastoralism is the primary land use.

In some areas, the rangelands have a history of biological decline (Noble 1997), with erosion, loss of perennial native grasses and incursion of woody vegetation commonly reported in the scientific and lay literature. Despite our historic awareness of these trends, the establishment of systems to measure and monitor degradation, has presented numerous problems. The size and accessibility of Australia's rangeland often mitigates development of extensive monitoring programs. So, too, securing on-going commitment from Government agencies to fund rangeland monitoring activities have led to either abandonment or a scaled-down approach in some instances (Graetz *et al.* 1986; Holm 1993). While a multiplicity of monitoring schemes have been developed for landholders at the property scale, and some have received promising initial uptake, relatively few have been maintained for more than a few years on any property without at least some agency support (Pic+kup *et al.* 1998). But, ironically, such property level monitoring tools can contribute significantly to local decisions about stock, infrastructure and sustainability.

Research in recent decades has shown the value of satellites for monitoring change in rangelands (Wallace *et al*. 2004), especially in terms of tree and ground cover. While steadily improving, use of satellite data as a monitoring tool has been limited by the cost of the imagery, and the equipment and expertise needed to extract useful information from it. A project now under way in the northern rangelands of Australia is attempting to circumvent many of the problems through a monitoring system that allows property managers to use long-term satellite image sequences to quickly and inexpensively track changes in land cover on their properties.

The VegMachine Project

The VegMachine project was commenced to realise the benefits of satellite based monitoring for pastoral producers. Key to its design are the ideas that monitoring should address a range of management questions and incorporate pastoralists' detailed knowledge of their properties. This requires a flexible capacity to interrogate images and time traces, to overlay local management data, and to display ground photographs.

VegMachine is funded by Meat & Livestock Australia (MLA) to 2006. It includes as partners Northern Territory Department of Infrastructure Planning and Environment, Queensland Department of Primary Industries and Fisheries, and CSIRO Mathematical and Information Sciences. The extension project areas are multi-jurisdictional, covering the Victoria River District-East Kimberley (NT-WA), Barkly Tableland (NT), and the Quilpie area of south west Queensland. Consequently, the VegMachine project is well positioned to assess differences in pastoral land management across rangeland with regard to environment, climate and grazing history, as well as differences in extension agencies and their relationships with land managers.

The VegMachine project consists of three major components:
1. A software package for display and interrogation of the monitoring data and products. The software is stand-alone and provided free to participants in the project. The software has been designed by CSIRO to accommodate any form of georeferenced data, including near real-time MODIS, high resolution Quickbird and aerial photography as well as topographical maps and property plans in catering for any level of sophistication by the user (Peel 2004). Design is compatible with a web-based system, but present delivery to producers is on CD-ROM;
2. Image processing and preparation of data products for local producer use; and,
3. A 'two-way' extension project to test use of the software and data in the producer environment, and to ensure that software and data meet the requirements of users in terms of functionality, content and ease of use.

Core functions of the software are the display of images (various dates, as well as maps, photomosaics, etc) with the capacity to zoom, roam and to overlay vector files, and the display of 'trend summary' images which highlight temporal changes over a selected period. Simple 'two-date' images which indicate areas of differing cover between years are also of interest to producers. In addition, images can be queried to produce graphical plots of time trends for selected points or areas. These plots identify the timing and magnitude of changes in terms of the cover index. Comparisons of paddock or site trends with regional or reference-site trends from a library are also possible. A split-screen 'geolinked' format has been chosen to enable image comparison and reference to the temporal plots. Other interactive tools assist with measurement and location on image display. Monitoring site locations and photo-points can be overlaid, and site photos viewed in 'pop-up' windows (Figure 1). Local users or data providers can easily add photos, vectors and images (in supported formats) to the data.

Expected benefits and current challenges

This approach to on-property monitoring offers a number of advantages, some of which have been difficult to capture in previous monitoring systems. Firstly, the system is designed for ease of use. Extension staff can train producers to use the software and interpret data products in less than two hours. Monitoring is computer based and does not require in-paddock vegetation and soil measurements. Only limited ongoing support from extension staff is required, primarily to update imagery.

Secondly, the system provides a flexible approach to rangeland monitoring, both in terms of information delivery and monitoring goals. VegMachine can incorporate multiple image types and display cover change in a variety of formats according to the user's preferences. The approach being taken so far has been to support as wide a range of producer goals as possible, resulting in a surprising variety of uses for the system (Table 1), and demonstrating the potential of the system to meet a variety of monitoring needs.

Table 1: Recorded examples of how producers are using VegMachine on properties in Qld, NT and WA, and the outcomes of their work so far.

Property	Producer's interest	Outcome
1	Understand the historical impacts of stock placement decisions and the validity of recent changes in stock placement.	VegMachine confirmed manager's suspicion that flood-out country has been steadily declining and so supported recent decisions to adjust stock numbers there.
2	Monitor tree and ground cover changes as part of the property's Environmental Management System.	VegMachine has been written into the property EMS to be used annually to monitor changes in tree and ground cover and subsequently guide stocking levels.
3	Place new fences and waters to maximise the potential of each land type and prevent overgrazing of sweeter country.	Single large paddock ($150km^2$) was split on the basis of land types using VegMachine to determine fence positioning.
4	Test the sustainability of cell grazing on highly productive grassland country after conversion from a single paddock / single water design.	VegMachine analysis of each cell showed that cover levels were maintained despite a productivity increase of 200%.
5	Quickly learn about property layout, and changes in cover after recently acquiring a property.	Manager was able to view property in VegMachine, and quickly appraise healthy and poor areas, distribution of different land types and placement of fence, road and water infrastructure.

Thirdly, producers come to the project with a substantial data set ready for interpretation. This means participants don't have to wait for useful data to accrue over time, and so can gain immediate returns from the system. This should improve the likelihood that participants will continue to use the system.

Finally, VegMachine relies on the producers to perform their own analyses, effectively making them the information provider for their property. Judgements of improvement or decline are therefore provided from within the enterprise. This empowers producers to perform rigorous analyses, avoids much potential for conflict because assessments are not imposed by outside interests, and may leave a clearer path for producers to act on their analyses.

Two substantial challenges are being addressed within the project. The first is ensuring that software meets producer needs, and the second is that cover indices used within the software accurately reflect cover change.

Extension officers have tested successive versions of the software with selected pastoralists in Northern Territory and Queensland. Feedback from this process has led to improvements in functionality and in ease of use for producers. In addition, new management-relevant image products have been identified and produced for properties. While the current phase of software development is now complete, extension staff are still working with producers to identify future software improvements and develop alternative data products.

Cover indices for much of the Northern Territory / Western Australia area of the project have already been developed and tested (Karfs 2002). In Queensland, producers have begun using experimental tree and ground cover indices developed by the Queensland Department of Natural Resources and Mines. These indices have been tested extensively across large parts of Queensland (Armston *et al.* 2002), and as well as using these indices in their monitoring, participants will provide feedback on the performance of the indices at property level. VegMachine extension staff are also conducting independent on-ground soil and vegetation monitoring to further test and validate locally used cover indices.

Summary

Rangeland monitoring has traditionally presented a number of problems for land managers, and these have greatly impeded the assessment of resource condition and trends, particularly at the property scale. VegMachine is a novel and efficient attempt to overcome many of these difficulties by providing pastoralists with resources to assess changes on their land using satellite data in a user friendly format. Producer responses have been positive. Participants are using the package to address a range of issues on their properties. They are also contributing valuable information for development of VegMachine while providing feedback on the effectiveness of the project outputs.

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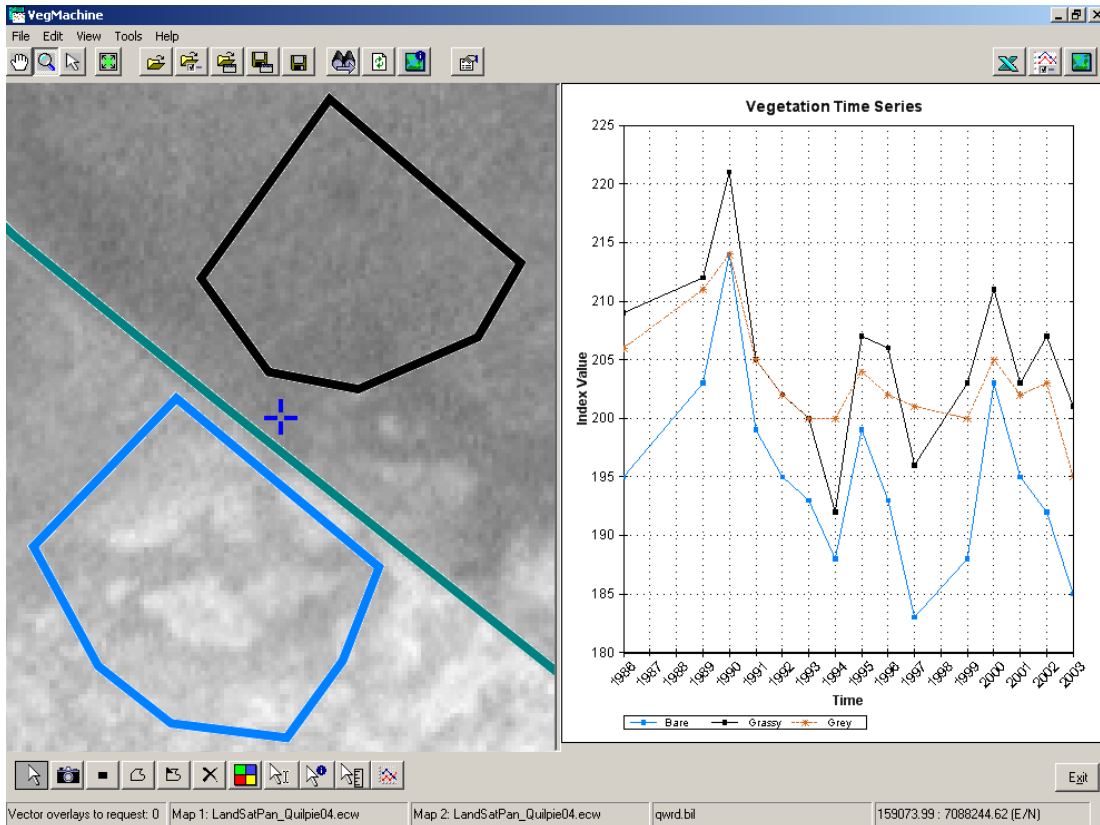
Figure 1: A screen shot of the VegMachine software at work. Two windows are visible. The left window depicts a section of stock route northwest of Quilpie. The line dissecting this window NW/SE is a raised bitumen road that prevents the natural flow of water from north to south and results in more Mitchell grass cover north of the road. Vectors are drawn on either side of the road to highlight sites of interest and VegMachine produces a time series for the amount of cover inside each plotted area (right window).

Several trends are visible in the time series window. More vegetation cover north of the road (black line) and less vegetation cover south of the road (blue line) is evident in the time series, concurring with local conditions. Lower and higher levels of cover correspond with drier (1991-94, 2001-03) and wetter (1989, 1990 and 2000) years respectively, and so also correspond with seasonal conditions. VegMachine also provides a time series for average cover in this land type (brown line), and in most years, the site north of the road has above average ground cover while the site south of the road cover has below the local average for this land type. Producers can use this and other functionality in the software to answer important questions about cover trends on their property.