

A national approach to map management practices that improve soil condition

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Abstract

The Australian Collaborative Land Use and Management Program (ACLUMP) has identified the mapping of ground cover using remote sensing as a key tool for monitoring adoption of sustainable farming practices. Ground cover can be used as an indicator of soil condition. ACLUMP has been working towards the establishment of national standards for reporting of land management practices, field measurement of fractional cover, and selection of appropriate remotely sensed products such as fractional cover and land cover to monitor and interpret ground cover levels over time. Focus has been on the more intensively managed agricultural areas under cropping and modified grazing land uses. These ACLUMP activities are informing State and Australian Governments' natural resource monitoring programs and are linked to other initiatives such as the Terrestrial Ecosystem Research Network (TERN) providing nationally consistent time-series datasets underpinned by a network of observational sites.

Key Words

Ground cover, remote sensing, erosion, agriculture, soil carbon.

Introduction

Ground cover provides the protective layer of living and decaying plant material covering the soil surface. Ground cover limits erosion and improves the water infiltration and organic matter content of soil. Ground cover is a sub-component of land cover and can be used to infer land management practices and in particular practices impacting on soil condition.

Management and changes in management are critical for Australian agriculture to increase its productive capacity and resilience to changing climate patterns. The Australian Government through its Caring for our Country initiative has recognised the importance of recording information about ground cover especially with regards to its sustainable farm practices targets which includes practices related to soil condition (DEWHA and DAFF 2009). Under Caring for our Country, practices related to maximum ground cover levels are encouraged such as: reduced tillage; stubble retention; careful timing of, or where feasible, avoidance of long cultivated fallow for cropping areas; careful management of stocking rates and; increasing the proportion of perennial vegetation in pastures for grazing areas.

The Australian Collaborative Land Use and Management Program (ACLUMP), a consortium of State and Federal agencies under the auspices of the National Committee for Land Use and Management Information (NCLUMI), is developing nationally consistent land management practice mapping based on characteristic patterns of ground cover maintenance in agricultural systems (NCLUMI 2009). These ACLUMP activities will support the information obtained through the Australian Bureau of Statistics' Agricultural Resource Management Survey (ABS 2009) funded under Caring for our Country.

ACLUMP have selected remote sensing as the tool to measure ground cover over large spatial extents. A fractional cover time-series product of ground cover levels where bare soil, photosynthetic and non-photosynthetic vegetation can be distinguished is favoured for monitoring land management practices that impact on ground cover (Leys *et al.* 2009; Stewart and Rickards 2010). Currently, there are no methods developed that have been designed or calibrated for the range of intensive agricultural systems (i.e. cropping and improved pastures) in Australia (Schmidt *et al.* 2010b).

Methods

Leys *et al.* (2009) reported on ground cover measurement techniques developed for Australia that are suitable for erosion modelling. Schmidt *et al.* (2010b) compared these satellite-based ground cover time-series products and assessed their accuracy and utility for monitoring ground cover levels in selected intensive agricultural areas. To calibrate and validate ground cover levels estimated from satellite imagery a

network of national reference sites are required. Field sampling methods for collection of calibration data were also trialled by Schmidt *et al.* (2010b).

The States and the Northern Territory through ACLUMP have compiled calendars of operations indicating the timing of typical management practices for the major cropping and improved pasture land uses occurring in a natural resource management (NRM) region or sub-region. The calendars of operations are based on expert opinion and provide an overarching context for interpretation of the satellite imagery for ground cover maintenance. They will also assist with the location and number of ground cover reference sites and supplement the results of the Australian Bureau of Statistics' Agricultural Resource Management Survey 2007-08.

The ACLUMP State and Northern Territory partners also undertook an assessment of existing monitoring sites that collect information on ground cover and/or land management practices for their suitability as reference sites for calibrating and/or validating remote sensing products and in particular fractional cover. Methods of ground cover collection were compared with a modified discrete point transect sampling which measures the bare soil, photosynthetic and non-photosynthetic vegetation fractions of ground cover as described in Schmidt *et al.* (2010a). This method is used in Queensland's and now New South Wales' statewide landuse and trees study (SLATS) programs. It has been proposed that this method be adopted nationally as a consistent approach for measuring fractional cover in the field (Stewart and Rickards 2010).

Results and discussion

Half of all Australian agricultural businesses are engaged in cropping activities and these enterprises collectively cover 8 % of the area under agriculture (ABS 2009). Over the last 12 years the adoption of some key practices that improve soil condition and minimise erosion risk has increased. Stubble retention in 2008 was undertaken on 58 % of the stubble treated area (up from 31 % in 2001 and 22 % in 1996). This represents 43 % of agricultural businesses undertaking stubble treatment (27 % in 2001). No tillage (apart from the actual sowing operation) occurred on 57 % of the land prepared for crops (38 % in 2001 and 21 % in 1996), accounting for 53 % of agricultural businesses preparing land for crops (35 % in 2001). Further breakdown of these trends to State and NRM regions can be used to target where to invest to change management practices.

Figure 1 shows the timing of typical management practices for dryland wheat for some NRM regions. These calendars will determine when to visit a region to measure ground cover fractions for a particular crop and the likely sequence of practices. For calibration of fractional cover, site visits should coincide with the satellite overpass. Site visits should at least occur at times of minimum and maximum cover (e.g. March-May and November-December in the case of Western Australia). Consideration of climatic conditions will determine when a farmer is likely to implement a particular practice within the available window of opportunity.

Figure 2(b) shows the cross transect method with the diagonal across the row, trialed for agricultural crops sown in lines, to measure ground cover fractions. This complements the star transect approach currently used for pastoral environments in Queensland (Figure 2(a)). Stewart and Rickards (2010) support adoption of these methods as national protocols for measuring ground cover fractions. Schmidt *et al.* (2010b) recommend testing the cross transect method for a range of crop types and at different stages of the cropping cycle. This method at 1 ha scale should use Landsat (30 m) as an intermediate step if upscaling to MODIS (Moderate Resolution Imaging Spectroradiometer) (500 m) type resolution is required. Spectral signatures of different ground covers are also required for calibrating fractional cover.

Queensland and New South Wales currently collect ground cover measurements using the star transect approach in pastoral environments. Other States use different but often similar approaches in their pastoral monitoring to measure ground cover (e.g. South Australia, Tasmania and Northern Territory). There is some interest in trialing the star transect approach to compare with existing methods (e.g. Northern Territory). Few States have established monitoring sites for the purpose of calibrating or validating remote sensing products. Generally new sites would need to be established and separately funded to meet the requirements for remotely sensed fractional cover and land cover data, particularly in cropping areas.

Assessment of MODIS-based data showed the benefit that increased temporal frequency has for estimating ground cover through the annual cropping cycle. Based on paddock size, the lower spatial resolution of MODIS is not appropriate for monitoring most cropping systems. Fractional cover products are being developed using Landsat within the Queensland Department of Environment and Resource Management, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Geoscience Australia. Low-cost or free access to the Landsat archive would greatly improve the temporal frequency of imagery at an appropriate scale for monitoring ground cover and related practices in cropping and modified pasture land uses. The MODIS fractional cover product of Guerschman *et al.* (2009) needs further calibration covering a range of environments (including pastoral) to improve its estimates. Several hundred calibration sites within each State may be required to achieve a reliable ground cover estimate (T Danaher pers. comm. 2009).

	Month											
State NRM region NRM sub-region	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
New South Wales Murrumbidgee	Graze	Plant tillage) (no							Harvest			stubble
Victoria Wimmera	Cultivate (site prep)		Plant tillage) (min						Harvest and graze stubble		Mulch stubble	
Queensland Maranoa Balone	Stubble left intact		Plant (zero tillage, controlled traffic, opportunity crop)						Harvest	Stubble left intact		
South Australia Eyre Peninsula	Graze	Plant tillage) (no							Harvest			stubble (light-mod)
Western Australia Avon		Cultivate (site prep)		Plant (min tillage)					Harvest			Graze stubble (time based)
Tasmania North Northern Midlands	Harvest and graze stubble (heavily)		Plant tillage) (no						Harvest and graze stubble (heavily)			

Figure 1. Timing of management practices influencing ground cover levels for dryland wheat for selected NRM regions as derived from the calendar of operations. Zero tillage (at sowing < 10 % soil disturbance e.g. disc planters); no tillage (at sowing < 30 % soil disturbance e.g. knife points); minimum tillage (one or two cultivations prior to sowing). In the examples above, a chemical fallow is common (no soil disturbance) or a cultivated fallow in the cases where minimum tillage is used.

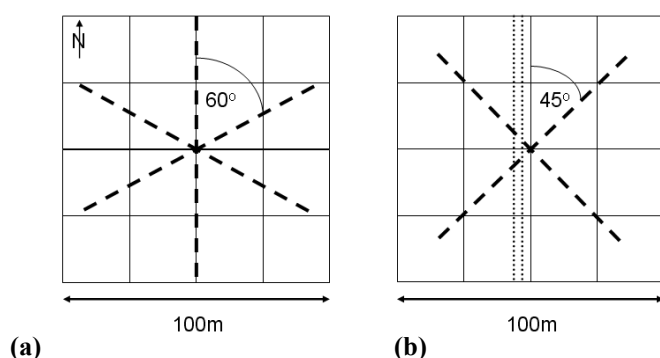


Figure 2. Layout of 100 m transects for measurement of ground cover at 1m intervals under (a) pastoral environments (rangelands and improved pastures) and (b) intensive agricultural systems (cropping) for calibration of Landsat imagery (from Schmidt *et al.* 2010b).

Recommendations

Ground cover information will be used to monitor land management practices and their effects on soil erosion and landscape condition across the continent. Recommendations from Schmidt *et al.* (2010b) and Stewart and Rickards (2010) for national ground cover monitoring include:

- National protocols developed for quantitative field sampling of fractional cover
- A spectral library developed for Australian land cover types that captures the spectral characteristics of each land cover type at various stages of the dynamic cycle
- A network of calibration sites for priority landscapes, land uses and management practices for reliable estimates of fractional cover

- Collaboration and coordination with other initiatives such as the Terrestrial Ecosystem Research Network (TERN), the Australian Collaborative Rangeland Information System (ACRIS) and soil condition monitoring through the National Committee for Soil and Terrain including erosion monitoring (roadside surveys) for remote sensing products (i.e. land cover and fractional cover) and to extend network of reference sites
- A comprehensive, spatially explicit, national database of land management practices is required to complement and inform the remote sensing products (see ACLUMP 2009)
- Access to ancillary data (in particular land cover, land use and climatic data) to put interpretation of fractional cover in context
- New fractional ground cover products using Landsat or sensors at similar resolution developed and implemented across Australia. These products could be augmented with MODIS-based products (e.g. Guerschman *et al.* 2009) to provide the temporal resolution sometimes required to adequately monitor intensive agricultural systems.
- Investigate the influence of climate and land management practices on fractional cover dynamics. De-coupling these effects will help to understand natural and human-induced variability in ground cover levels and provide for more informed policy and natural resource management.

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