

Monitoring ground cover: an online tool for Australian regions

Report prepared for the Australian Government Department of Agriculture and Water Resources

Juan P. Guerschman, John Leys, Pablo Rozas Larraondo, Mats Henrikson, Matt Paget, Michael Hill and Michele Barson

September 2018



Citation:

Juan P. Guerschman¹, John F. Leys², Pablo Rozas Larraondo³, Mats Henrikson⁴, Matt Paget¹, Michael Hill^{1,5} and Michele Barson⁶. Monitoring ground cover: an online tool for Australian regions. Report prepared for the Australian Government Department of Agriculture and Water Resources. CSIRO, Australia

1. CSIRO Land and Water
2. NSW Office of Environment and Heritage
3. National Computational Infrastructure, Australian National University
4. Data61, CSIRO
5. Department of Earth System Science and Policy, University of North Dakota, USA
6. Sustainable Agriculture, Fisheries and Forestry Division, Department of Agriculture and Water Resources.

Cover image:

Sharp contrast in ground cover across a fence caused by differences in grazing management. Marma Station, NSW. Photo by John Leys, April 2018.

Table of contents

Table of contents	2
List of Figures	3
Acknowledgments	4
Executive summary	5
Introduction	7
Remote sensing of vegetation cover	9
Data products	9
Web services and access	13
Using RaPP Map to understand total vegetation change cover reporting	15
Discussion	17
Future developments	17
Training for NRM regions	18
RaPP Map tool improvements	18
Improvements in satellite imagery	18
Routine delivery of lateral cover data	19
Antecedent rainfall effects on vegetation cover	19
Conclusions	21
Abbreviations and acronyms	22
Glossary	23
References	24
Appendix A User Manual for RaPP Map	27
What is included in this tutorial?	27
Getting started	27
Add and remove existing data layers to the map viewer	28
Select an image from the calendar	31
Where can I see the date of the imagery in the map view?	31

Compare two images using a split screen slider	33
What does the split screen slider do?	33
How to use the split screen slider	33
How to turn off the split screen slider	33
View a time series for a region	34
What does the time series chart show?	38
What does the ground cover time series tell me?	38
Troubleshoot common problems	38
I don't see a map	38
Find more help	39

List of Figures

Figure 1: Risk ranking for wind erosion in Australia's agricultural areas	8
Figure 2: The significance of hillslope erosion for Australia's natural resource management regions	9
Figure 3: Vegetation cover classes as measured in the field (from Muir et al	11
Figure 4: Grazing management effects on cover levels (photo John Leys)	11
Figure 5: Screen capture of the seasonal Landsat fractional cover for the summer of 2018 (left) and the monthly MODIS fractional cover for January 2018 (right)	13
Figure 6: Map of Australia showing the calibration and validation sites for the MODIS fractional cover product	14
Figure 7: Screen capture of the RaPP Map (https://map	15
Figure 8: Screen capture of an output for the fractional cover and rainfall data in the Western NRM region of NSW	17
Figure 9: Vegetation cover in a MODIS pixel centred near Cubba, NSW (-31	20
Figure 10: 0: Relationship between total vegetation cover in March and the accumulated rainfall from the preceding 26 months	21

Acknowledgments

This project is supported through funding from the Australian Government's National Landcare Program and the CSIRO. We thank Dr Craig Strong and students of the Australian National University for testing RaPP Map and providing feedback on how to compare different land uses and climatic regions. The Local Land Service Murray, Riverina and Western regions for evaluating the tool and its outputs and for suggestions on how the tool could be modified to help answer local and regional questions related to Natural Resource Management. Jasmine Howorth from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) provided invaluable help in improving the Appendix. The Office of Environment and Heritage DustWatch team, especially Stephan Heidenreich, for assessing the tool's application in DustWatch reporting. We are also grateful to the people and agencies who undertook the vegetation measurements in the field to provide the information needed to calibrate remotely sensed data. The Office of Environment and Heritage DustWatch project, in conjunction with the Australian National University and the Local Land Service Murray, Riverina and Western regions in New South Wales, have all helped guide the development of the tool. Their testing and feedback has helped improve the tool and the user experience.

Executive summary

Programs funded through the Australian Government's National Heritage Trust have invested substantially in improving natural resources management since 2001. The agricultural components of these programs have focused on improving soil condition by encouraging adoption of land management practices that reduce the risk of soil loss through wind and water erosion, manage soil acidification and improve the carbon content of soil.

The use of satellites to remotely sense ground cover can contribute to monitoring of wind and water erosion. Recent advancements in remote sensing have led to the production of a fractional cover data set which enables the classification of total vegetation cover into three cover types: photosynthetic (green) vegetation (PV), non-photosynthetic (brown or dead) vegetation (NPV) and bare soil (BS). Previously only PV could be identified but it was not possible to discriminate NPV from BS.

This report presents the results of a project aimed at delivering public online access to the monthly MODIS fractional cover data (2001-present). The online tool helps regional natural resource management organisations: 1) view and report on ground cover change for their regions, 2) plot time-series of average ground cover for an area, and 3) understand if the ground cover level is normal. The tool can also be used by industries and policy makers to inform them of ground cover change.

The Australian reporting tool (<https://map.geo-rapp.org/#australia>) updated monthly is part of a global online dataset and tool for vegetation cover developed by CSIRO. The tool, called Rangeland and Pasture Productivity Map (RaPP Map), is a major advancement in the monitoring of ground cover. It provides ready access and the ability to query very large datasets by users without remote sensing or GIS experience. RaPP Map complements other Australian initiatives such as VegMachine© (vegmachine.net) and FarmMap4D Spatial Hub (farmmap4d.com.au), which deliver higher spatial resolution (30 metre) but lower temporal resolution (3 monthly seasonal compilations) of ground cover data to end users.

The MODIS fractional cover data sets have been used by the New South Wales Office of Environment and Heritage DustWatch program since 2012 to monitor and report on ground cover change for inland regions in south eastern Australia at risk of wind erosion. The ground cover data will also provide the basis for Department of Agriculture and Water Resources' reporting on improvements in resource condition at the national level, and to identify whether National Landcare Program funding is having an impact on the condition of the soil resource.

Future developments proposed include: training for natural resource management (NRM) regions in the use of the RaPP Map tool, improvements in the tool, replacing MODIS-derived products with higher spatial resolution Landsat and Sentinel products, introduction of a lateral cover product for improved monitoring of wind erosion risk, and explore whether the effects of antecedent rainfall on vegetation cover levels can assist in the separation between rainfall and anthropogenic (land management) effects on vegetation cover.

The report includes an Appendix with a step-by-step guide to using the RaPP Map tool to visualise and interrogate vegetation cover and related environmental data.

Introduction

Programs funded through the Australian Government's National Heritage Trust have invested substantially in improving natural resources management since 2001. The agricultural components of these programs have focused on improving soil condition by encouraging adoption of land management practices that reduce the risk of soil loss through wind and water erosion, manage soil acidification and improve the carbon content of soil.

Around 204 million hectares of Australia's agricultural land (principally the grazed rangelands (93 percent) and some adjacent drier cropping lands (7 percent, see Figure 1) have a moderate to high risk of wind erosion and subsequent removal of topsoil and nutrients (carbon, nitrogen and phosphorus) which are needed to underpin agricultural production (Leys et al. 2017). The rangelands provide around 330 million hectares of mainly native pasture for the grazing industry, which in 2015-16 contributed an estimated \$5.6 billion (10 percent) to the gross value of agricultural production¹.

Wind erosion can also have significant off site impacts. The broader community is affected by wind erosion which causes dust emissions that travel downwind. When dust concentration is high, such as in a dust storm, air quality is reduced in urban areas which may be thousands of kilometres away from the land the dust blew from. There are also substantial cleanup costs, respiratory health impacts and interruptions to economic activity such as closing of airports and building sites. One major dust storm cost the New South Wales' economy \$299 million (Tozer and Leys 2013).

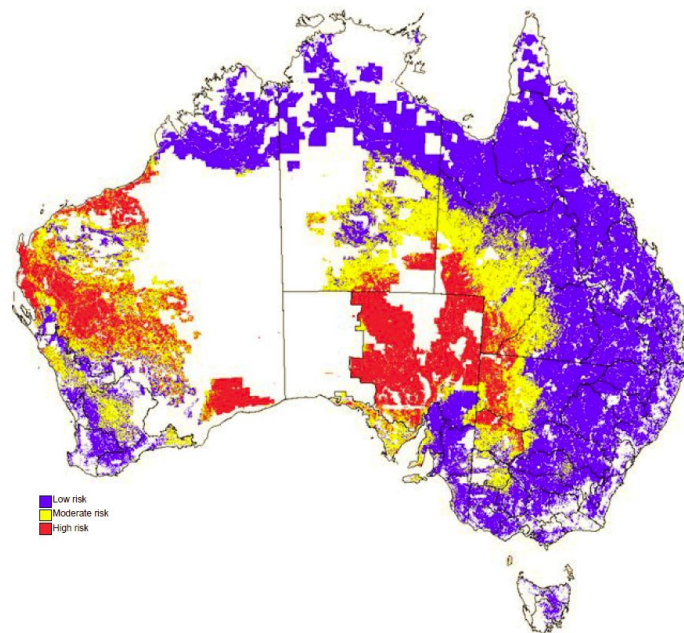


Figure 1: Risk ranking for wind erosion in Australia's agricultural areas. Boundaries for states and territories and natural resource management regions are shown, white = non-agricultural land. From Leys et al. (2017).

A number of rangelands and cropping regions are also at risk of hillslope erosion by water which results in soil loss and elevated concentrations of nutrients and sediment in downstream waters,

with subsequent impacts on water quality for aquatic and some marine environments, stock water and human uses.

This loss of soil, nutrients and potential land productivity is occurring at a rate which may only be perceptible over decades, but is much greater than rates of soil formation, and also results in a net rundown of the soil resource (McKenzie et al. 2017). The hectares of agricultural land at risk of hillslope erosion have yet to be quantified, but the problem is widespread (Figure 2).

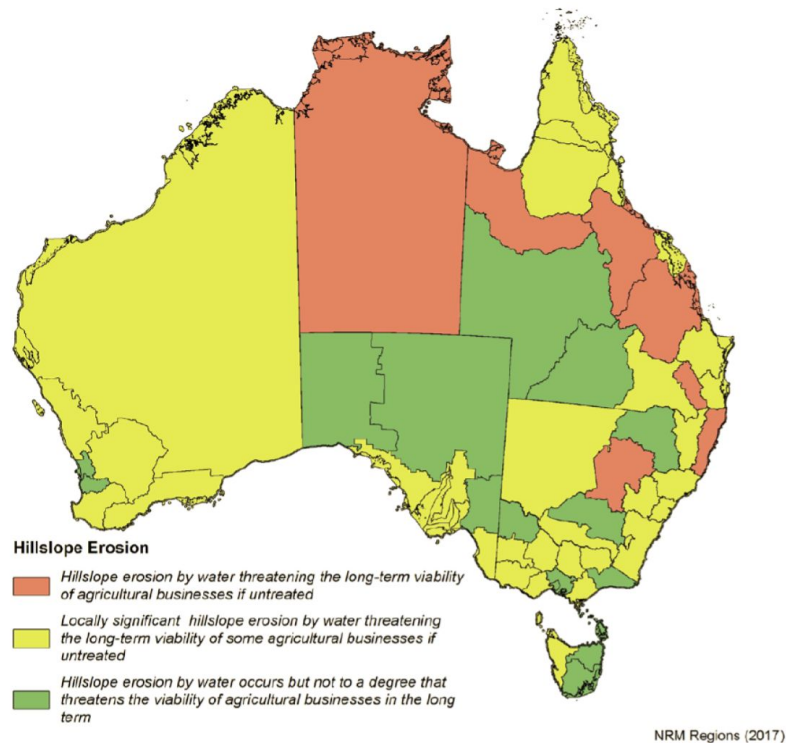


Figure 2: The significance of hillslope erosion for Australia’s natural resource management regions. Note that while having low rankings, the risk of hillslope erosion is accelerating in Queensland’s Southern Gulf and Cape York regions due to land use intensification. Source: McKenzie et al. (2017).

Substantial National Landcare Program funding has been provided to regional NRM organisations to facilitate the adoption of practices to reduce soil loss through wind and water erosion.

The key to controlling soil erosion is the maintenance of protective cover on the soil surface, the ground cover. Ground cover comprises the vegetation, leaf litter, biological crusts and stone in contact with the soil surface. If ground cover is not maintained, wind and hillslope erosion can occur, reducing soil depth and fertility, and its moisture holding capacity and aggregate stability. Previous research has identified that ground cover levels greater than 50 percent are needed to reduce soil losses through wind erosion (Leys 1991), and that 70 percent ground cover is needed to protect against soil loss via hillslope erosion (Lang 1979).

A national workshop (Leys et al. 2009) identified that satellite remote sensing of ground cover could contribute to the monitoring of wind and water erosion. Recent developments in remote sensing have enabled three ground cover types to be identified: photosynthetic vegetation (PV), non-photosynthetic vegetation (NPV) and bare soil (BS). Together they are known as fractional

cover. The inclusion of NPV or dry vegetation into the assessment is a major advance. Previously only PV vegetation, identified from normalised difference vegetation index (NDVI) was reported (Lu et al 2003) causing a major underestimation of ground cover and overestimation of erosion rates. The sum of PV and NPV is total vegetation cover (TVC) and provides the data needed to monitor and report on changes in ground cover.

In treeless vegetation types such as grasslands, TVC and ground cover are equivalent. On the other extreme, in dense forests with closed canopies, ground cover cannot be observed by optical remote sensing such as MODIS or Landsat. In mixed tree-grass systems such as savannas, woodlands and shrublands, the trees obscure the understory layer (the ground cover) and therefore the total vegetation cover may be equal or higher than ground cover. As a rule of thumb, the TVC can be assumed to be a good estimator of ground cover when tree cover is lower than 20%.

This project has contributed to CSIRO's development of a global online dataset and tool for seasonally updated, 500 metre resolution, MODIS-derived vegetation cover, the Rangeland and Pasture Productivity Map (RaPP Map <https://map.geo-rapp.org/>, and produced a customised version for Australian reporting <https://map.geo-rapp.org/#australia>) which is updated monthly.

This Australian reporting site delivers public online access to the monthly MODIS fractional cover data (2000-present). The main product displayed is the total vegetation cover (TVC). A simple tool is available to help regional NRM organisations: 1) view and report on ground cover change for their regions, 2) plot time-series of average ground cover for an area, and 3) understand if the ground cover level is normal. The tool can also be used by industries and policy makers to inform them on ground cover change.

Remote sensing of vegetation cover

Data products

Remote sensing has been used for tracking changes in TVC (i.e. PV plus NPV) for Australian rangelands since the 1980s. Recent developments in remote sensing (Guerschman et al. 2009; 2015; Guerschman and Hill 2018) resolve the fractions of TVC into PV, NPV and BS, enabling the separation and reporting of green, dead and bare components of cover. The reporting of the dead fraction has led to a major improvement in erosion modelling and monitoring. Previously only green cover was used (Lu et al 2003) which underestimated the amount of ground cover protecting the soil from erosion.

Fractional cover refers to the fraction of an area (usually a pixel for the purposes of remote sensing) that is covered by a specific cover type such as green vegetation (PV), dead vegetation (NPV) (i.e. stubble, senescent herbage, leaf litter) and bare soil/rock (BS) (Stewart et al. 2009). The term integrates all layers of vegetation, including the understorey (grasses, forbs, rocks, cryptogams) and, if present, the midstorey (shrubs) and overstorey (trees) (Figure 3).

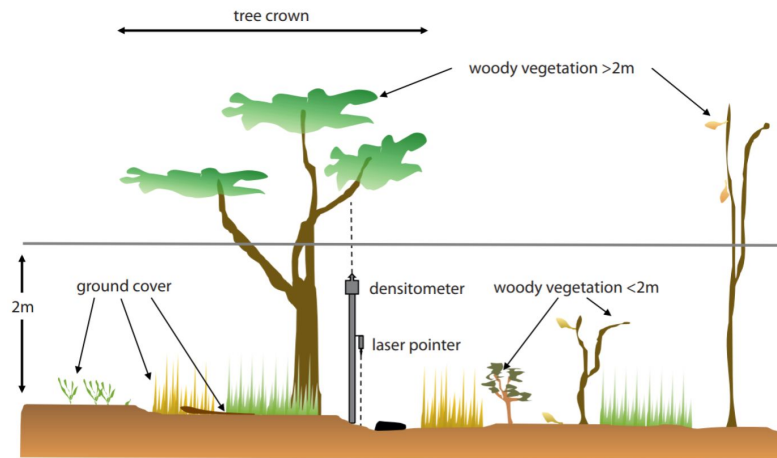


Figure 3: Vegetation cover classes as measured in the field (from Muir et al. 2011).

The total vegetation cover is comprised of woody and non-woody components. Woody trees and large shrubs change slowly; except when fire occurs or land clearing is undertaken. The non-woody ground cover such as crops, grass, forbs and chenopod-type shrubs may change monthly, making this component a good indicator of land management performance. TVC is closely linked to the soil erosion potential. The higher the TVC levels, generally the lower the risk of losing soil by wind or water erosion. This is the message promoted through soil conservation extension (Leys et al. 2009) (Figure 4).



Figure 4: Grazing management effects on cover levels (photo John Leys).

The range of satellite derived fractional cover products developed by CSIRO and by the Queensland Department of Science, Information Technology and Innovation (QDSITI, now known as the Department of Environment and Science) are shown in Table 1. These complementary products have different spatial and temporal resolutions, time spans and coverage.

Table 1: Summary of the characteristics of fractional cover and derived products available for Australia

	Landsat Fractional Cover	Sentinel Fractional Cover	MODIS Fractional Cover
Spatial resolution	30 metres	10 metres	500 metres
Temporal repetition	Seasonal (3 months)	Seasonal (3 months)	1: 8-day 2: monthly
Time span	1990-present	2016-present	2000-present (*)
Coverage	Australia	Australia (only Qld, NT and NSW)	Global
Latency (frequency and timing of updates)	Within a week of the end of the season	Within a week of the end of the season	8-day: A week after the end of the 8-day period Monthly: A week after the last 8-day period of the month
Derived products	Ground Cover (cover under trees) (#) Total ground cover (green + non-green ground cover) Seasonal deciles		Total cover (PV and NPV fractions) Ground Cover (cover under trees) (#) Monthly anomalies Monthly deciles
Access to data	http://auscover.org.au/purl/landsat-seasonal-fractional-cover	http://data.auscover.org.au/xwiki/bin/view/Product+pages/Sentinel-2+Seasonal+Fractional+Cover	http://www.auscover.org.au/purl/modis-fractional-cover-csiro And http://dap.nci.org.au/thredds/remoteCatalogService?catalog=http://dapds00.nci.org.au/thredds/catalog/u39/public/prep/modis-fc/v310/catalog.xml
References	Scarth et al. 2010		Guerschman et al. 2009, 2015; Guerschman and Hill 2018

(*): in the last MODIS reflectance data update (collection 6) data for the year 2000 have some problems in band 7, the fractional cover product for 2000 will be produced when the issue is resolved. (#) As per methods in Trevithick et al. (2014).

Figure 5 shows examples of the Landsat and the MODIS fractional cover products, demonstrating the differences in spatial resolution.

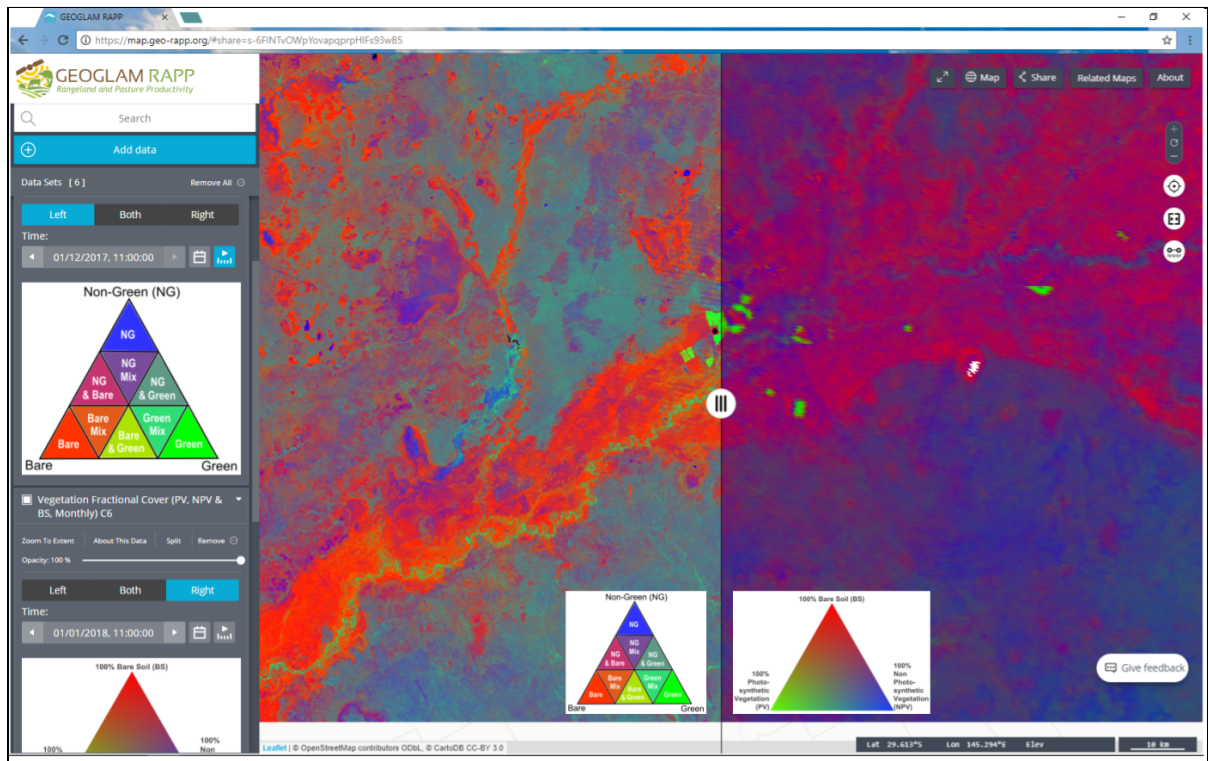


Figure 5: Screen capture of the seasonal Landsat fractional cover for the summer of 2018 (left) and the monthly MODIS fractional cover for January 2018 (right). Note that the two products have a slightly different colour enhancement, and the two legends have been superimposed on each side of the figure. Link to the RAPP Map tool with the view as in this figure in <https://map.geo-rapp.org/#share=s-6FINTvOWpYovapqprpHfS93wB5>

The Landsat and the MODIS-derived fractional cover products have been developed and tested using a collection of ~1700 field measurements collected using the “SLATS transect” method (Guerschman et al 2015). The MODIS Fractional Cover product has recently been recalibrated and enhanced using the most up to date version of the SLATS transects dataset (3022 sites, provided by Rebecca Trevithick on August 13th 2017, see Figure 6), and data from the MODIS collection 6 (Schaaf and Wang 2015). The results of this updated have been documented by Guerschman and Hill (2018).

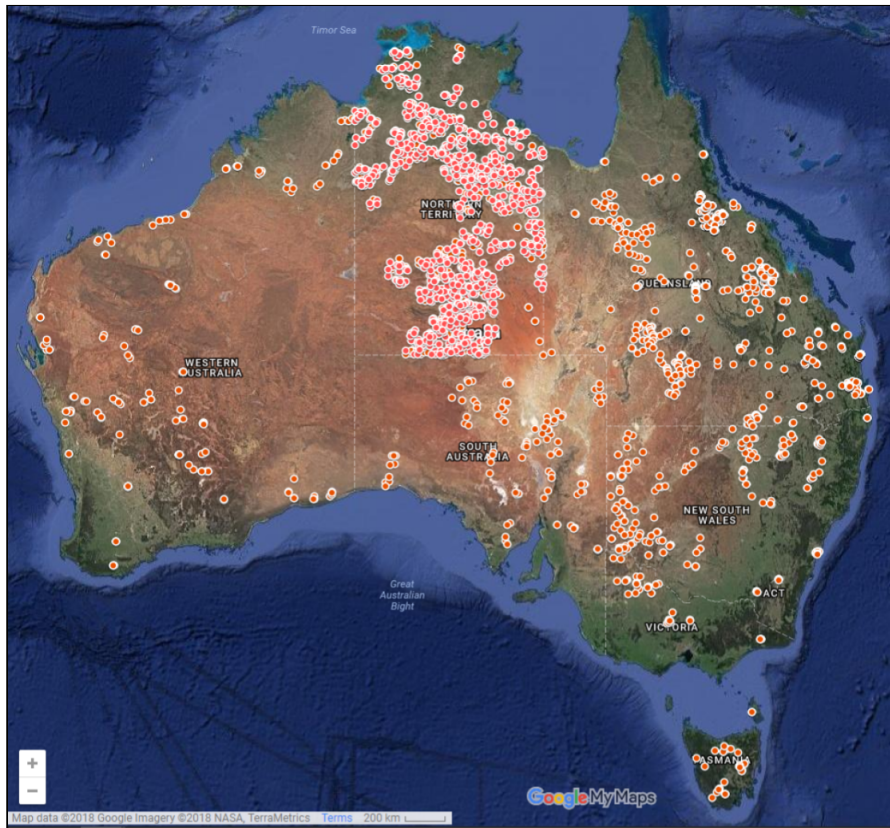


Figure 6: Map of Australia showing the calibration and validation sites for the MODIS fractional cover product. Adapted from Guerschman and Hill (2018).

The MODIS fractional cover dataset has been chosen to establish a national monitoring capability. This dataset has two key features which make it particularly suitable for reporting regional scale TVC change: 1) a high temporal frequency - 2 daily overpasses giving 60 scenes per month which ensures a mostly cloud-free monthly composite, and 2) a short latency -the data is available shortly after the overpass, and for composites, shortly after the end of the compositing period. The disadvantage of the MODIS data is its pixel size of 500 metres. In landscapes where TVC changes over smaller distances such as farm land in Victoria, cover components are mixed and the likelihood of measuring higher and lower TCV levels decreases.

Web services and access

Fractional cover data has traditionally been delivered to users via ftp or other similar portals. This is very useful when users want to download data for analyses such as calculating areal summaries, looking at trends, combining with other data sources such as climate and so on. The difficulty is that these analyses need technical capacity in remote sensing data processing and Geographical Information Systems (GIS).

The RaPP Map tool for Australia (<https://map.geo-rapp.org/#australia> Figure 7) has been designed to simplify the reviewing and reporting of regional, state and national TVC change.

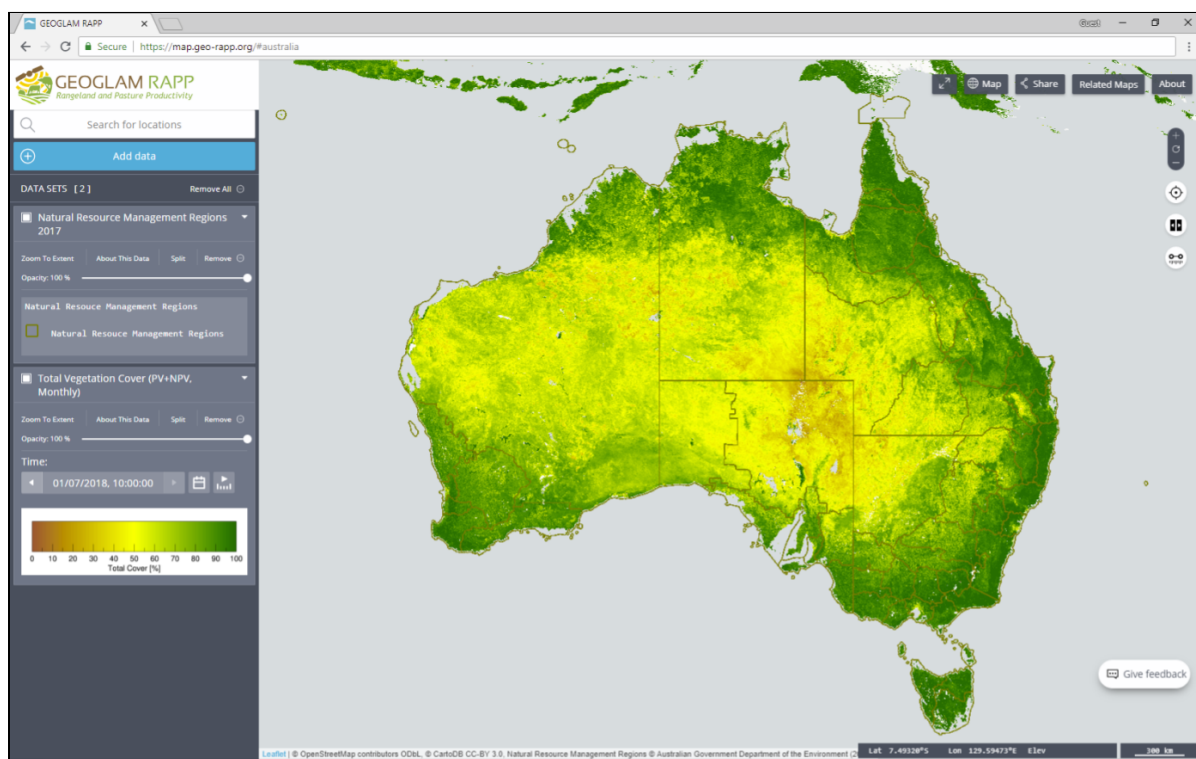


Figure 7: Screen capture of the RaPP Map (<https://map.geo-rapp.org/#australia>) landing page.

The RaPP Map tool (Table 2) contains:

1. Time-series layers for the MODIS and Landsat fractional cover datasets and several derived data product such as anomalies and deciles. The MODIS layers provide coarse spatial resolution (500 metre pixels) information updated every eight days and monthly. The Landsat layers provide high spatial resolution (30 metre pixels) information but are only updated seasonally. Landsat is good for property scale analysis over long time periods at seasonal time steps. MODIS data is good for monthly regional scale analysis, reporting and tactical decision making.
2. Climate data to assist with interpretation of cover trends. The global CHIRPS dataset is currently displayed (Funk et al 2015). CHIRPS will be replaced by Bureau of Meteorology data once licensing arrangements are finalised.
3. Land use and land cover information to assist with interpretation of the remotely sensed images.
4. Digital boundaries for commonly used reporting areas. Additional boundaries can be added by the user (using shapefiles or kml formats) or can be requested by the user and added to the tool.

Many of the available layers, particularly the land use/land cover and the boundaries can be displayed in the map and used for extracting statistics from the time-series of TVC data, as explained in Section 2.3. The user can also add her own layers, either from the web (if they are available as Web Map Service (WMS)) or add vector layers stored locally in the user's computer. These layers can be visually inspected and also used to extract time-series data from the fractional cover dataset (see below). Appendix A provides a step-by-step guide for using the tool for Australia.

Table 2: List of available layers in RaPP Map as of September 2018

Layer type	Layer name	Custodian
Remote sensing time-series	MODIS Fractional Cover: Monthly: <ul style="list-style-type: none"> Fractional Cover (PV, NPV and BS) Total Vegetation Cover (PV+NPV) Total Veg Cover anomalies Total Veg Cover deciles 8-day: <ul style="list-style-type: none"> Fractional Cover (PV, NPV and BS) Total Vegetation Cover (PV+NPV) 	CSIRO
	Landsat (Australia only): <ul style="list-style-type: none"> Landsat Fractional Cover: Seasonal fractional cover (green, non-green, bare) Seasonal Persistent Green Cover 	Joint Remote Sensing Research Project (JRSRP)
Climate	Rainfall Totals Rainfall Anomalies, monthly	Climate Hazards Group, UC Santa Barbara
Land Use and Land Cover	Catchment Scale Land Use 2017 - Australian Collaborative Land Use and Management Program (ACLUMP) Australian land use at the national scale, 2010 to 2011. Extent of all forms of vegetation across Australia	Australian Bureau of Agricultural and Resource Economics and Sciences
	Ramsar Wetlands of Australia Interim Biogeographic Regionalisation for Australia (IBRA) version 7.0 Regions Interim Biogeographic Regionalisation for Australia (IBRA) version 7.0 Subregions Collaborative Australian Protected Areas Database (CAPAD) Observed major vegetation subgroups, from Australia's NVIS database	Australian Government Department of the Environment
	Physiographic Regions of Australia Generalised map of soil orders for Australia (ASRIS).	CSIRO
	Vegetation height and structure	Joint Remote Sensing Research Project (JRSRP)
Boundaries	Australian Rangelands Natural Resource Management Regions 2017	Australian Government Department of the Environment
	Local Government Areas 2016 Mesh Blocks 2011 Suburbs (SSC) 2016 Statistical area level (SA1, SA2, SA3 and SA4)	Australian Government Bureau of Statistics
	River Regions	Australian Government Bureau of Meteorology

Using RaPP Map to understand total vegetation change cover reporting

The RaPP Map tool can be used to: 1) visualise the type of ground cover (whether green, dead vegetation or bare) in a region, 2) visualise total ground cover (green plus dead) for any month from February 2000 to current month as maps (Figure 8), and 3) look at trends in the mean TVC (green

plus dead) for any area. The results are displayed on the screen as a chart, and the user can also download the data as a .csv file. Figure 8 shows the TVC for July 2018 and a time-series of the average TVC for the Western NRM region in NSW. The outputs can be displayed on the screen and downloaded into a spreadsheet for further analyses. At the time of publishing, the tool **can NOT be used to set ground cover targets**. This is because ground cover targets are expressed as the user defined percentage area of a polygon (say 80 per cent) that is achieving protection from wind erosion (requiring greater than 50 per cent cover) or water erosion (requiring greater than 70 per cent cover).

A further explanation on the steps to obtain the various outputs are provided in Appendix A.

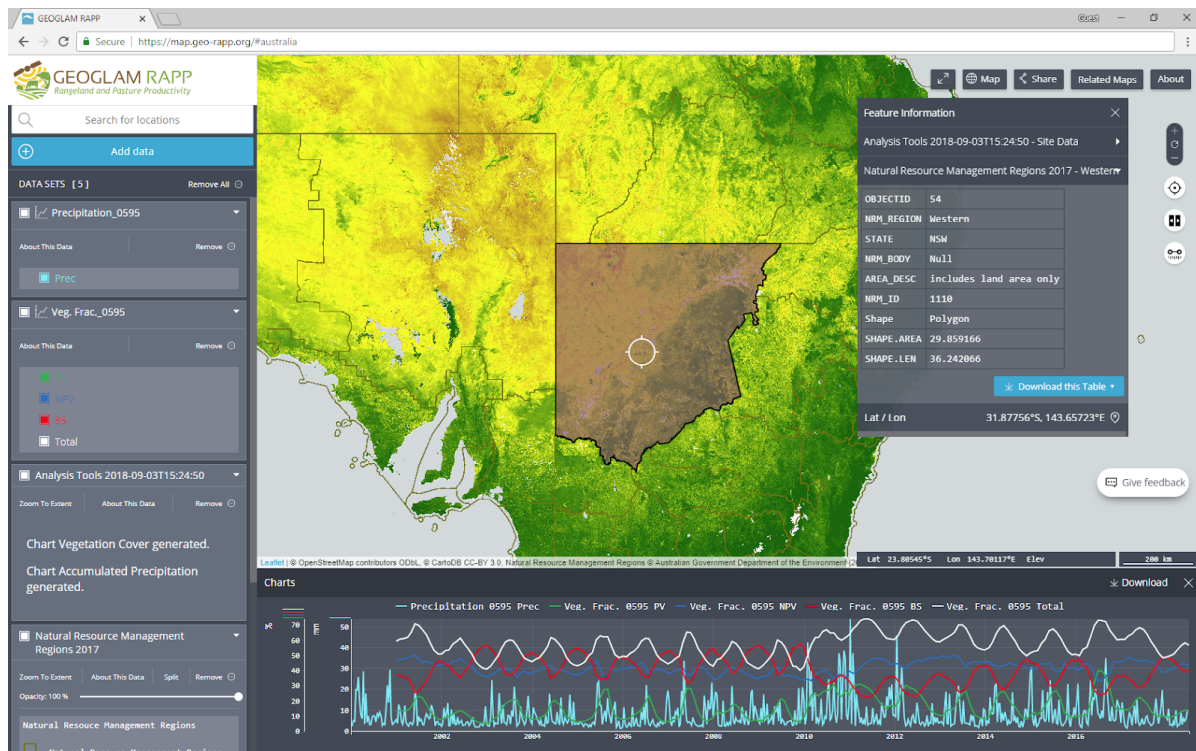


Figure 8: Screen capture of an output for the fractional cover and rainfall data in the Western NRM region of NSW. The green, blue, white and red lines in the bottom chart show the median value in the region for photosynthetic vegetation (PV), non-photosynthetic vegetation (NPV), total vegetation (PV+NPV) and bare soil (BS) respectively. The light blue line shows mean rainfall in the region. The data in the chart can be downloaded for further analysis using the download button

The RaPP Map user tool has been developed by CSIRO’s Data61 National Map team. The handling of time-series is supported by CSIRO, AusCover (www.auscover.org.au) and the National Computational Infrastructure (NCI). The GSKY system developed for this project by the NCI, serves the MODIS layers as maps (Web Mapping Service, WMS) and queries of data over time (Web Processing Service, WPS) (see Larraondo et al 2017a and 2017b). GSKY has recently been adopted by Geoscience Australia’s Digital Earth Australia initiative to provide advanced data services.

Discussion

The RaPP Map tool is a major advancement in the monitoring of TVC. It provides ready access and the ability to query very large datasets (the global MODIS fractional cover dataset is 1.6 Terabytes, and the Australian Landsat seasonal fractional cover is 8.8 Terabytes) to users without remote sensing or GIS experience.

The RaPP Map tool complements other Australian initiatives -VegMachine© (vegmachine.net) and FarmMap4D Spatial Hub (farmmap4d.com.au)- which deliver higher spatial resolution seasonal (3 monthly compilations) of ground cover data to end users. VegMachine© provides access to Landsat and Sentinel fractional cover data products. Users can select a region of interest and retrieve time-series data, or compare cover average TVC values for two regions over time. FarmMap4D Spatial Hub is a commercial service aimed at property level management and is available by subscription (AUD 300 per year for the standard service). It uses the same web services as VegMachine© to show time-series data from the Landsat fractional cover product, and provides property managers with a tool to assess, monitor and manage property infrastructure.

The MODIS fractional cover data sets have been used by the New South Wales Office of Environment and Heritage DustWatch program

(<http://www.environment.nsw.gov.au/topics/land-and-soil/soil-degradation/wind-erosion/community-dustwatch>) since 2012 to monitor and report on ground cover change for inland regions in south eastern Australia at risk of wind erosion. This work has helped NRM regions:

- understand the dynamic nature of ground cover and the relative impacts of climate and land management
- how land use affects trends in ground cover
- identify locations at risk of wind erosion (e.g. areas with less than 50 percent cover) and assess their suitability for investment
- establish regional or subregional targets for ground cover improvement
- report on the impact of investment on ground cover.

The MODIS fractional cover data has also been used in wind and water erosion modelling and for biodiversity condition assessments undertaken by the New South Wales Office of Environment and Heritage.

The MODIS fractional cover data will also provide the basis for Department of Agriculture and Water Resources' reporting on improvements in resource condition at the national level, and to identify whether National Landcare Program funding is having an impact on soil condition at regional level.

Future developments

This section outlines the proposed developments and improvements to the tools and services described in this report.

Training for NRM regions

The current on line tool does not yet provide data in the correct form to use for target setting. The National Landcare Program is proposing to provide training in the use of the online tool to regions funded through the Program to reduce soil loss through wind or hillslope erosion. Workshops will be run with regional staff to familiarise them with the tool and the nature of ground cover change in their region, and to guide NRM organisations through a process to set their own regionally relevant target.

Establishing ground cover targets is part of the monitoring, evaluation and reporting process. Targets enhance NRM outcomes by helping people measure if projects are achieving their outcomes, including the extent to which local projects are influencing ground cover management at the district and regional level. While the concept of target setting is simple, the practice is not so simple, as targets should be SMART -Specific, Measurable, Attainable, Relevant and Timely-.

The RAPP Map tool will be upgraded to provide access to data that can be used to set targets and undertake on-going monitoring. The training will use the concept of “improving on area protected from erosion”. Average ground cover within a region will **not** be used, as this gives perverse outcomes. For example if a hypothetical region has as 100 per cent bare in one half and 100 per cent cover in the other half the consequences for soil erosion are very different to the case where the entire area has 50 per cent ground cover.

RaPP Map tool improvements

A number of features suggested by users will be improved or added to the RAPP Map tool. These include:

- Ensuring the data are routinely updated each month
- Incorporating the capacity to report areas above target (see next section) to enable users to retrieve reports for any area and any time period
- Better labelling of results returned from the analysis tools – replacing random numbers assigned to time-series so user can more readily distinguish between polygons when results for more than one area are retrieved
- Removal of the restriction of the size of the polygon (currently around 4.4 million km²) for which data can be retrieved
- Replacing the global rainfall data set with interpolated data from the Bureau of Meteorology (awaiting licensing agreement)
- Including additional data layers for the tool and in reporting, including fire occurrence and scars, surface roughness (Chappell et al 2018), plus others that may be requested by users.

Improvements in satellite imagery

The MODIS sensors used for producing the vegetation fractional cover product are quickly approaching their end of life. Arrangements will be made to replace these -possibly with a combination of data from the Landsat and Sentinel 2 sensors. The aim is to provide users with a high

temporal and high spatial resolution dataset to overcome the main individual drawbacks of Landsat and MODIS data product (e.g. Emelyanova et al 2013, Hilker et al 2009).

Routine delivery of lateral cover data

Fractional cover is a measure of ground cover when looking down vertically from the satellite. Fractional cover has been correlated to wind erosion rates, with 50 percent fractional cover being sufficient to control wind erosion (Leys 1999). However, wind erosion is more closely correlated with lateral cover, because wind erosion can happen below tall canopies and between ground cover elements. Fractional cover does not capture the effects of surface roughness created by objects projected into the airstream. Chappell et al (2018), present a measure of lateral cover which is derived from MODIS albedo data. Surface roughness can also be used to infer cover type, e.g. forest, annual grassland, perennial grassland. If a lateral cover dataset was made available, it would provide be a better measure than fractional cover for setting targets and monitoring wind erosion risk.

Antecedent rainfall effects on vegetation cover

Research has been initiated on the effects of antecedent (stored) rainfall on TVC levels. One of the main environmental drivers of vegetation growth is rainfall. Years with higher rainfall lead to higher vegetation growth and vice-versa. It is also evident that the vegetation growth response is delayed from the rainfall event, and that in many cases there is a period of rainfall accumulation before a response is observed (Andela et al 2013, Evans and Geerken 2004). There is anecdotal evidence that in rangeland systems vegetation cover responds (growing or decaying) to the rainfall accumulated over long periods (for example 2-3 years). There are many factors affecting this including the depth to the groundwater table, the particular terrain characteristics and the vegetation type. The idea was to explore, for every “pixel” in the rangelands, how much of the temporal variability in vegetation cover could be explained by the rainfall accumulated in the antecedent period, and also, the length of the period which maximises the predictive capacity of rainfall to explain TVC.

This idea is illustrated for a location in Cubba, NSW (-31.393, 145.461). Figure 9 shows the dynamics of TVC in that location. In March 2018 the TVC is lower than that month’s average, but not the lowest March as it was lower in March 2003 and 2005.

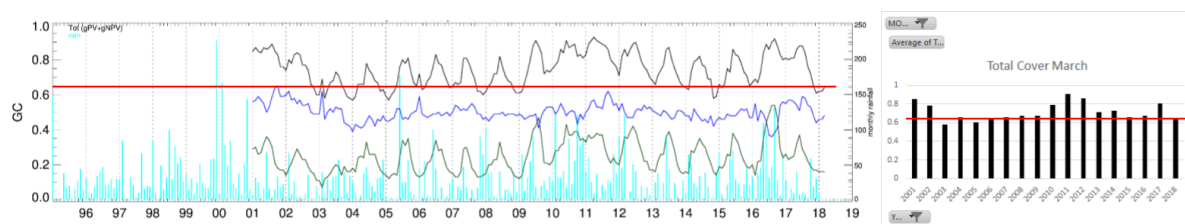


Figure 9: Vegetation cover in a MODIS pixel centred near Cubba, NSW (-31.393, 145.461). The left panel shows the monthly green vegetation cover (green line), non-green vegetation cover (blue line) total vegetation cover (black line) and the monthly rainfall (cyan bars). The right hand diagram shows the total vegetation cover in March for each year. The red horizontal lines show the total vegetation cover in March 2018 for reference.

However, when the vegetation cover for all the months of March are plotted as a function of the accumulated rainfall in the preceding 26 months (2 years and 2 months) the value for March 2018 is

much lower than would be expected from the linear relationship between the two variables (Figure 10).

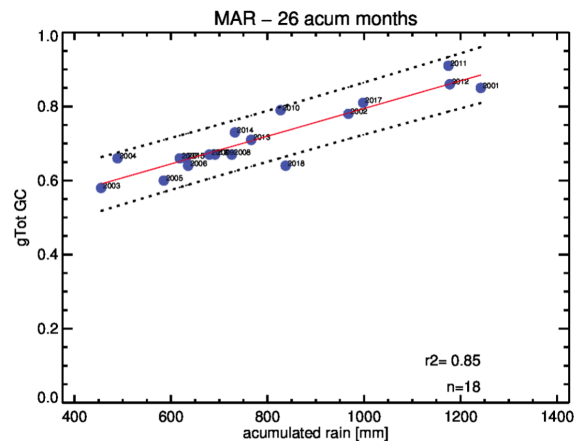


Figure 10: Relationship between total vegetation cover in March and the accumulated rainfall from the preceding 26 months. The red line is the line of best fit and the dotted lines show the 95% confidence interval for the prediction.

The cause of this anomaly cannot be inferred from Figure 10, but as the vegetation cover in March 2018 is much lower than would be expected given the amount of rainfall accumulated in the previous 26 months this suggests some disturbance has occurred in that pixel. Possible explanations are: fire, changed grazing intensity or management or some other human-induced change.

A system could be built to apply this approach to all pixels. Each month the observed vegetation cover would be compared to the expected cover based on the antecedent rainfall. When the observed value is much lower than the expected (like in the Cubba example), an 'alarm', or flag, could be issued for further exploration. This would serve as an early warning detection of negative anomalies potentially attributed to changes in grazing management or other human-related causes.

Conclusions

The MODIS fractional cover data (2000-present) is a valuable resource which contributes to monitoring wind and water erosion. We have developed an online tool to facilitate access and use of these large remote sensing datasets. This simple tool can be used to help regional natural NRM organisations report on ground cover change for their regions, and to provide information to industries and policy makers on ground cover change for reporting purposes. Users do not need specialist knowledge of GIS or remote sensing. With training and access to TVC data for the area above a threshold, say 70 per cent, then targets can be set to monitor land management outcomes

This tool can help to understand the dynamic nature of ground cover (represented here by TVC), if the levels are normal compared to the previous recorded months. It can help to identify locations at risk of wind and water erosion and establish regional or subregional targets for ground cover improvement.

Future developments include specific training for NRM regions in the use of the tool and training in how to set ground cover targets. There is also opportunity to improve the tool following user consultation, and a comprehensive study of the dependency of ground cover on antecedent rainfall to provide a predictive tool to assess likely areas of disturbances, including changes in land management.

Abbreviations and acronyms

BS	Bare soil
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CSIRO	Commonwealth Scientific and Industrial Research Organisation
GEOGLAM	Group on Earth Observations Global Agricultural Monitoring initiative
GIS	Geographical Information System
kml	Keyhole Markup Language
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalised Difference Vegetation Index
NPV	Non-photosynthetic vegetation
NRM	Natural Resource Management
PV	Photosynthetic vegetation
RAPP	Rangeland and Pasture Productivity
SLATS	Statewide Landcover and Trees Study
WMS	Web Map Service
WPS	Web Processing Service

Glossary

Fractional cover	The percentage or fraction of an area (usually a pixel for the purpose of remote sensing) covered by the specific cover types of green or photosynthetic vegetation (PV), non-photosynthetic vegetation (NPV) such as stubble, senescent herbage and leaf litter, and bare soil or rock. Areas that have been burnt resulting in ash or blackened soil are considered a bare soil cover type
Ground cover	Any non-woody plant cover, both photosynthetic and non-photosynthetic, near the soil surface including vegetative litter (Murphy & Lodge 2002). Using remote sensing, ground cover is derived from fractional cover by excluding woody vegetation. Stones in contact with the soil are not included in estimates of remotely sensed ground cover as they cannot be reliably distinguished from the underlying soil.
Rangelands	In Australia, encompasses tropical woodlands and savannas in the far north; vast treeless grassy plains (downs country) across the mid-north; hummock grasslands (spinifex), mulga woodlands and shrublands through the mid-latitudes; and saltbush and bluebush shrublands that fringe the agricultural areas and Great Australian Bight in the south. Seasonal rainfall changes from summer-dominant (monsoonal) in the north to winter-dominant in the south. Soils are characteristically infertile. Distinctly characterised by great climate variability and the dominating influence of short growing seasons (Bastin et al. 2008).
Remote sensing	The process of obtaining information on vegetation attributes from a distance. Remote sensing records the reflected surface electromagnetic radiation of the vegetation cover and bare soil
Soil erosion	The displacement of the upper layer of soil caused by the dynamic activity of erosive agents, particularly water and wind
Vegetation cover	The percentage or fraction of an area covered by any vegetation (both photosynthetic (PV) and non-photosynthetic (NPV)) including all vegetation layers: understory, mid-storey and overstorey (see Figure 3). It is equivalent to the sum of the PV and NPV components of fractional cover.

References

- Andela, N., Liu, Y.Y., van Dijk, A.I.J.M., de Jeu, R.A.M., McVicar, T.R., 2013. Global changes in dryland vegetation dynamics (1988–2008) assessed by satellite remote sensing: comparing a new passive microwave vegetation density record with reflective greenness data. *Biogeosciences* 10, 6657–6676. [doi:10.5194/bg-10-6657-2013](https://doi.org/10.5194/bg-10-6657-2013)
- Bastin G and the ACRIS Management Committee, 2008. *Rangelands 2008 - Taking the Pulse*, Rangelands. Canberra. Retrieved from <http://www.environment.gov.au/system/files/resources/a8015c25-4aa2-4833-ad9c-e98d09e2ab52/files/rangelands08-pulse.pdf>
- Chappell, A., Webb, N.P., Guerschman, J.P., Thomas, D.T., Mata, G., Handcock, R.N., Leys, J.F., Butler, H.J., 2018. Improving ground cover monitoring for wind erosion assessment using MODIS BRDF parameters. *Remote Sens. Environ.* 204, 756–768. [doi:10.1016/j.rse.2017.09.026](https://doi.org/10.1016/j.rse.2017.09.026)
- Chappell, A.; Webb, N.P.; Guerschman, J.P.; Thomas, D.T.; Mata, G.; Handcock, R.N.; Leys, J.F.; Butler, H.J. Improving ground cover monitoring for wind erosion assessment using MODIS BRDF parameters. *Remote Sensing of Environment* 2018, 204, 756-768. [doi:10.1016/j.rse.2017.09.026](https://doi.org/10.1016/j.rse.2017.09.026)
- Emelyanova, I. V, McVicar, T.R., Van Niel, T.G., Li, L.T., van Dijk, A.I.J.M., 2013. Assessing the accuracy of blending Landsat–MODIS surface reflectances in two landscapes with contrasting spatial and temporal dynamics: A framework for algorithm selection. *Remote Sens. Environ.* 133, 193–209. [doi:10.1016/j.rse.2013.02.007](https://doi.org/10.1016/j.rse.2013.02.007)
- Evans, J., Geerken, R., 2004. Discrimination between climate and human-induced dryland degradation. *J. Arid Environ.* 57, 535–554. [doi:10.1016/S0140-1963\(03\)00121-6](https://doi.org/10.1016/S0140-1963(03)00121-6)
- Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., Shukla, S., Husak, G., Rowland, J., Harrison, L., Hoell, A., Michaelsen, J., 2015. The climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes. *Sci. Data* 2, 150066. [doi:10.1038/sdata.2015.66](https://doi.org/10.1038/sdata.2015.66)
- Guerschman, J.P., Hill, M.J., Renzullo, L.J., Barrett, D.J., Marks, A.S., Botha, E.J., 2009. Estimating fractional cover of photosynthetic vegetation, non-photosynthetic vegetation and bare soil in the Australian tropical savanna region upscaling the EO-1 Hyperion and MODIS sensors. *Remote Sens. Environ.* 113, 928–945. [doi:10.1016/j.rse.2009.01.006](https://doi.org/10.1016/j.rse.2009.01.006)
- Guerschman, J.P., Scarth, P.F., McVicar, T.R., Renzullo, L.J., Malthus, T.J., Stewart, J.B., Rickards, J.E., Trevithick, R., 2015. Assessing the effects of site heterogeneity and soil properties when unmixing photosynthetic vegetation, non-photosynthetic vegetation and bare soil fractions from Landsat and MODIS data. *Remote Sens. Environ.* 161, 12–26. [doi:10.1016/j.rse.2015.01.021](https://doi.org/10.1016/j.rse.2015.01.021)
- Guerschman, J.P., Hill, M.J., 2018. Calibration and validation of the Australian fractional cover product for MODIS collection 6. *Remote Sens. Lett.* 9, 696–705. [doi:10.1080/2150704X.2018.1465611](https://doi.org/10.1080/2150704X.2018.1465611)

- Hilker, T., Wulder, M.A., Coops, N.C., Seitz, N., White, J.C., Gao, F., Masek, J.G., Stenhouse, G., 2009. Generation of dense time series synthetic Landsat data through data blending with MODIS using a spatial and temporal adaptive reflectance fusion model. *Remote Sens. Environ.* 113, 1988–1999. [doi:10.1016/J.RSE.2009.05.011](https://doi.org/10.1016/J.RSE.2009.05.011)
- Lang, R.D., 1979. The effect of ground cover on surface runoff from experimental plots [soil erosion]. *J. Soil Conserv. Serv. New South Wales* 34, 108–114.
- Larraondo, P.R., Pringle, S., Antony, J., Evans, B., 2017a. GSKY: A scalable, distributed geospatial data-server, in: *Proceedings of the Academic Research Stream at the Annual Conference Locate, Research@ Locate*. pp. 7–12. http://ceur-ws.org/Vol-1913/RL17_paper_14.
- Larraondo, P.R., Pringle, S., Guo, J., Antony, J., Evans, B., 2017b. GSio: A programmatic interface for delivering Big Earth data-as-a-service. *Big Earth Data* 1–18. [doi:10.1080/20964471.2017.1397898](https://doi.org/10.1080/20964471.2017.1397898)
- Leys, J.F., 1991. Towards a better model of the effect of prostrate vegetation cover on wind erosion. *Vegetatio* 91, 49–58. [doi:10.1007/BF00036047](https://doi.org/10.1007/BF00036047)
- Leys, J.F., 1999. Wind erosion on agricultural land, in: Goudie, A.S., Livingston, I., Stokes, S. (Eds.), *Aeolian Environments, Sediments and Landforms*. John Wiley and Sons, England, pp. 143-166.
- Leys, J., Smith, J., MacRae, C., Rickards, J., Yang, X., Randall, L., Hairsine, P., Dixon, J., McTainsh, G., 2009. Improving the capacity to monitor wind and water erosion: a review. Department of Agriculture, Fisheries and Forestry, Canberra. Available from <http://nrmonline.nrm.gov.au/catalog/mql:2243>
- Leys, J., Chappell, A., Mewett, J., Barson, M., 2017. Wind Erosion Assessment for National Landcare Program, NSW Office of Environment and Heritage, Australia. Sydney. <http://www.agriculture.gov.au/SiteCollectionDocuments/ag-food/wind-erosion-assessment.pdf>
- Lu, H.; Raupach, M.R.; McVicar, T.R.; Barrett, D.J. Decomposition of vegetation cover into woody and herbaceous components using AVHRR NDVI time series. *Remote Sensing of Environment* 2003, 86, 1-18.
- McKenzie, N.J., Hairsine, P.B., Gregory, L.J., Austin, J., Baldock, J., Webb, M., Mewett, J., Cresswell, H.P., Welti, N., Thomas, M., 2017. Priorities for improving soil condition across Australia’s agricultural landscapes. Canberra. [doi:10.4225/08/59e4f3adc09ac](https://doi.org/10.4225/08/59e4f3adc09ac)
- Muir, J., Schmidt, M., Tindall, D., Trevithick, R., Scarth, P., Stewart, J., 2011. Field measurement of fractional ground cover: a technical handbook supporting ground cover monitoring for Australia. Canberra. Available from http://data.daff.gov.au/data/warehouse/pe_hbgcm9abl107701/HndbkGrndCovMontring2011_1.0.0_HR.pdf
- Murphy, S.R., Lodge, G.M., 2002. Ground cover in temperate native perennial grass pastures. I. A comparison of four estimation methods. *Rangel. J.* 24, 288. [doi:10.1071/RJ02016](https://doi.org/10.1071/RJ02016)

Scarath, P., Roder, A., Schmidt, M., 2010. Tracking grazing pressure and climate interaction--the role of Landsat fractional cover in time series analysis, in: Proceedings of the 15th Australasian Remote Sensing and Photogrammetry Conference. Alice Springs, Australia. [doi:10.6084/m9.figshare.94250](https://doi.org/10.6084/m9.figshare.94250)

Schaaf, C., Wang, Z., 2015. MCD43A4 MODIS/Terra+Aqua BRDF/Albedo Nadir BRDF Adjusted Ref Daily L3 Global - 500m V006 [Data set]. NASA EOSDIS Land Processes DAAC, USGS Earth Resources Observation and Science (EROS) Center. [doi:10.5067/MODIS/MCD43A4.006](https://doi.org/10.5067/MODIS/MCD43A4.006)

Stewart, J.B., Rickards, J.E., Bordas, V.M., Randall, L.A., Thackway, R.M., 2009. Ground cover monitoring for Australia—establishing a coordinated approach to ground cover mapping. Workshop proceedings, ABARES, Canberra, Australia. Canberra. http://data.daff.gov.au/data/warehouse/pe_abares99001799/Groundcover_mapping-workshop_poc_11.pdf

Teng, H., Viscarra Rossel, R.A., Shi, Z., Behrens, T., Chappell, A., Bui, E., 2016. Assimilating satellite imagery and visible–near infrared spectroscopy to model and map soil loss by water erosion in Australia. *Environ. Model. Softw.* 77, 156–167. [doi:10.1016/j.envsoft.2015.11.024](https://doi.org/10.1016/j.envsoft.2015.11.024)

Tozer, P., Leys, J., 2013. Dust storms – what do they really cost? *Rangel. J.* 35, 131–142. [doi:10.1071/RJ12085](https://doi.org/10.1071/RJ12085)

Trevithick, R., Scarath, P., Tindall, D., Denham, R., Flood, N., 2014. Cover under trees: RP64G Synthesis Report. Brisbane. Available from <https://publications.qld.gov.au/dataset/ad30c88c-185d-4d9a-9971-69968f958a70/resource/350aefd-ff8f-4876-a12f-7eb8d4e6f991/download/coverundertreesreportrp64gfinal.pdf>

Appendix A User Manual for RaPP Map

What is included in this tutorial?

The online Rangeland and Pasture Productivity Map (RaPP Map) can be used to assess vegetation cover and ground cover in areas with tree cover lower than 20 per cent.

The tutorial will show how to use some of the functions available in RaPP Map as at August 2018.

This tutorial works with the following data:

- vegetation fractional cover: Total Vegetation Cover (PV+NPV, Monthly).
 - Total vegetation cover is the sum of the green or photosynthetic vegetation (PV) and brown or non- photosynthetic vegetation (NPV).
 - Total vegetation cover can be interpreted as ground cover in areas with tree cover lower than 20 per cent.
- Natural Resource Management regions 2017. These administrative boundaries are found in the Australia tab, Boundaries folder.

To get more help while using the software click *About* and *Help* and *FAQ* in the top right of the screen or go to <https://map.geo-rapp.org/help/help.html>. Help will be updated as the RaPP Map tool is developed.

This tutorial will focus on comparison and exploration of cover trends, rather than reporting on cover or setting ground cover targets.

You will learn how to:

- Open RaPP Map # Australia
- Find tools on the interface
- Add and remove existing data from the map viewer.
- Select an image from the calendar
- Compare two images using a split screen slider
- View a time series for a region
- Troubleshoot common problems

Getting started

1. Open the tool
 - a. Go to <https://map.geo-rapp.org/#australia>
 - b. Accept the disclaimer by clicking Continue. The screen will show as at Figure A1.

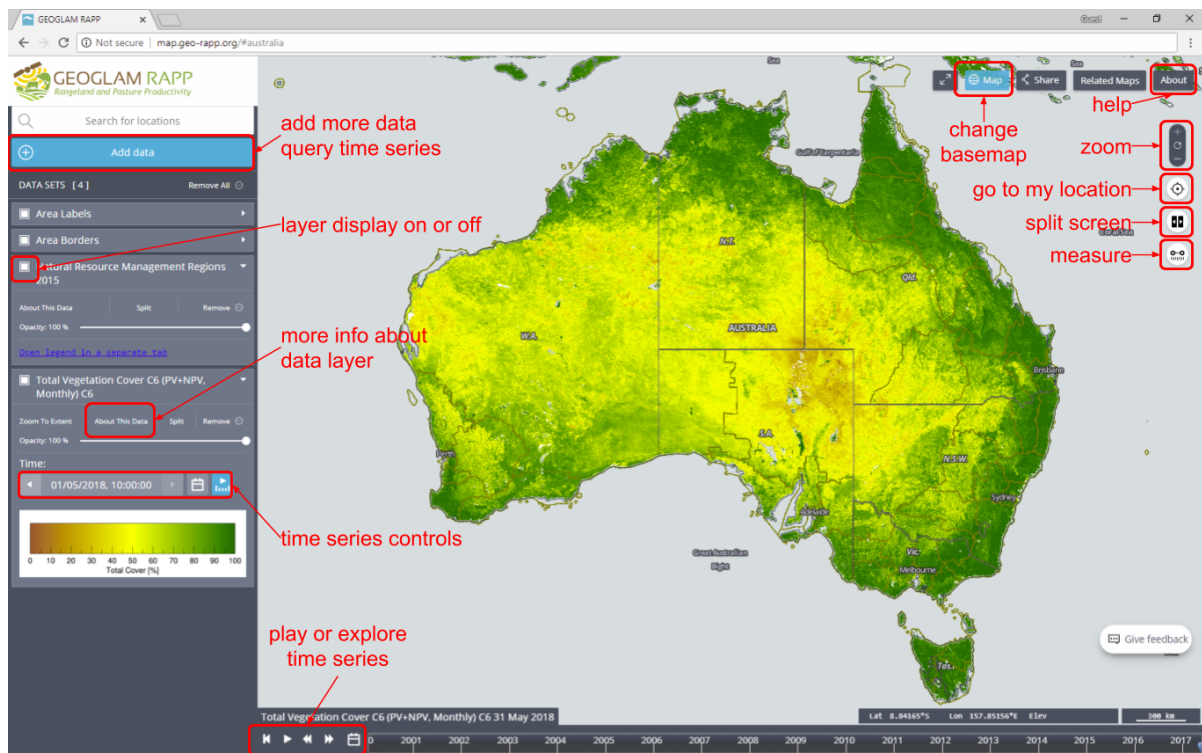


Figure A1 Tools on the RaPP Map Interface.

Note: The image shows the RaPP Map interface displaying Total Vegetation Cover (PV+NPV) Monthly and 2017 Natural Resource Management Regions. This is the default view. Tools available for use are labelled.

Add and remove existing data layers to the map viewer

1. Click Add data
2. The Add data window shown at Figure A2 will appear. This window includes five tabs:
 - a. Global: Data available for the world
 - b. Australia: Data available for Australia (MODIS data from the Global tab are repeated here)
 - c. Analysis tools: Allows you to produce a graph of the vegetation fractional cover for a point or polygon
 - d. Regional reports: Prepared reports of vegetation cover over time for each Australian NRM and LGA Region.
 - e. My Data: Add own data, either local (from user's computer) or Web data

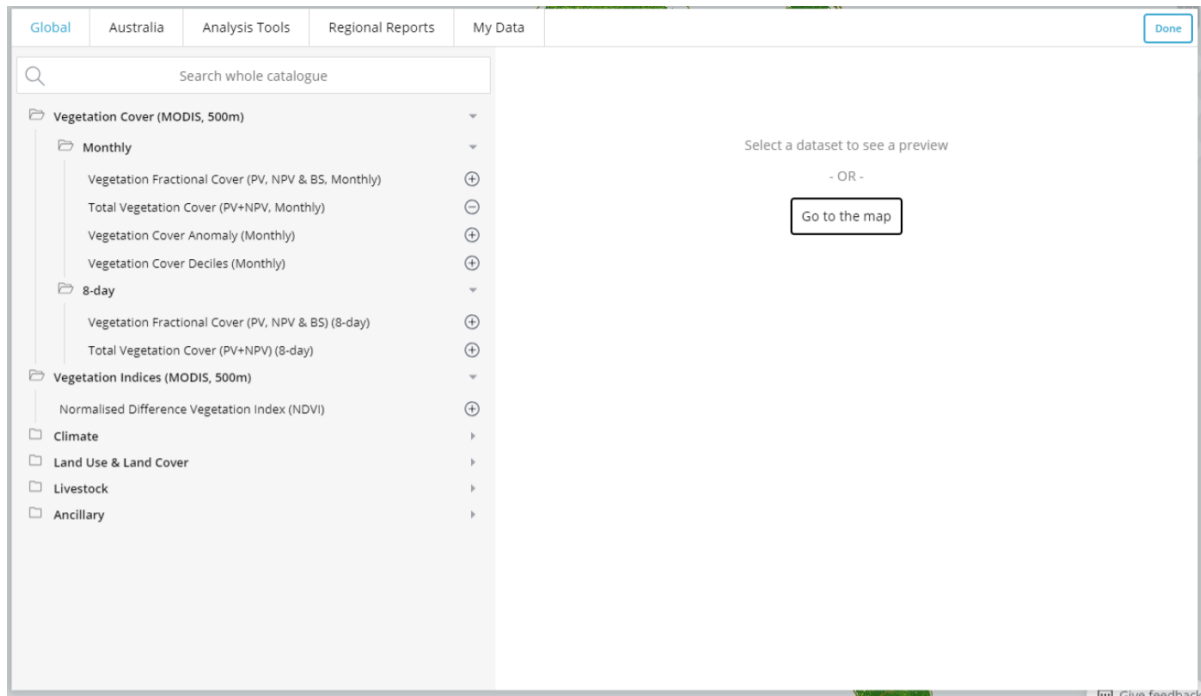


Figure A2: Add data window, global tab.

Note: The image shows the Add data window with Total Vegetation Cover (PV+NPV) Monthly selected from the Global tab. ⊕ symbols indicate data layers which can be added to the map. ⊖ symbols indicate data layers which are already displayed on the map and can be removed. Clicking Done in the top right will close the window.

3. Expand the folders to view data layers which are grouped by theme. For example climate and boundaries.
4. Add a data layer to the map from the Add data window by either:
 - a. Click the ⊕ button beside the layer of interest (see Figure A3), or
 - b. Click the layer name to view the metadata for the layer and click *Add to the map* in the top right of the window.

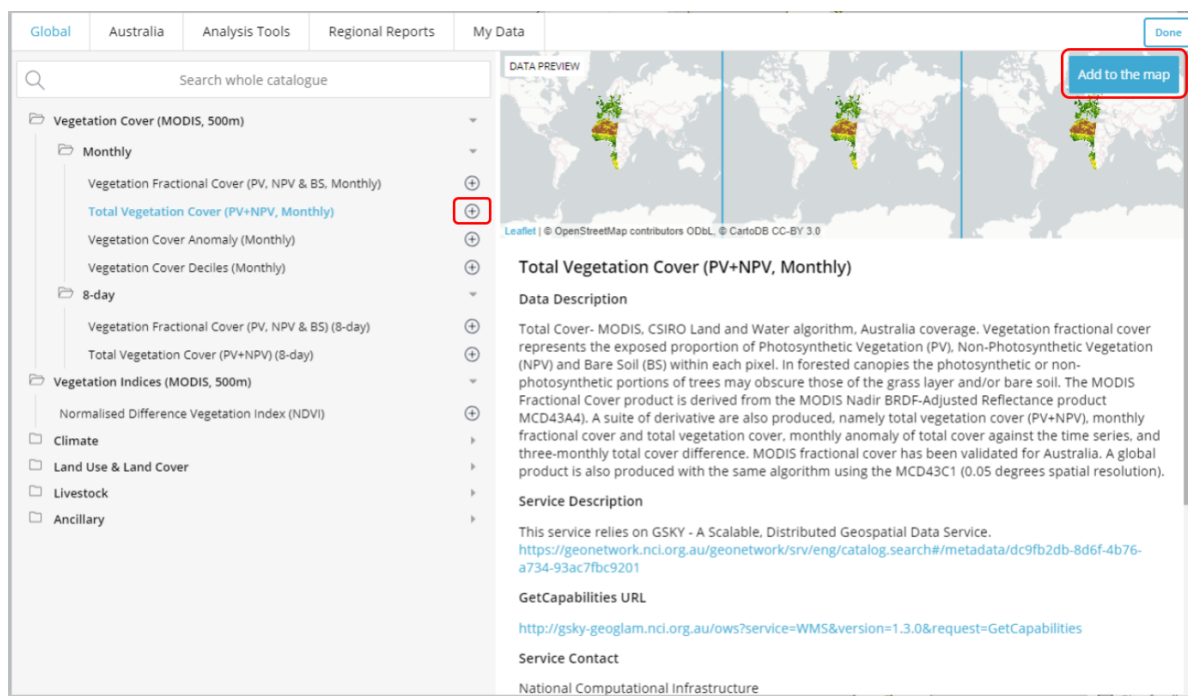


Figure A3: Options to add a data layer to the map view

Note: The image shows the Add data window with Total Vegetation Cover (PV+NPV) Monthly selected from the Global tab.

5. Remove a single data layer or multiple layers from the map (see Figure A4) by either:
 - a. Click the Remove ⊖ button beside the layer in the left hand interface panel, or
 - b. Open the Add data window then:
 - i. click the ⊖ button beside the layer (or layers) that you don't wish to display, and then Done in the top right of the window, or
 - ii. Click the layer names to view the metadata for the layer and click Remove from the map then Done in the top right of the window.
6. For this exercise ensure that Total Vegetation Cover (PV+NPV, Monthly) and Natural Resource management regions are shown on the map and the legends for these layers can be seen on the left hand side of the interface panel.

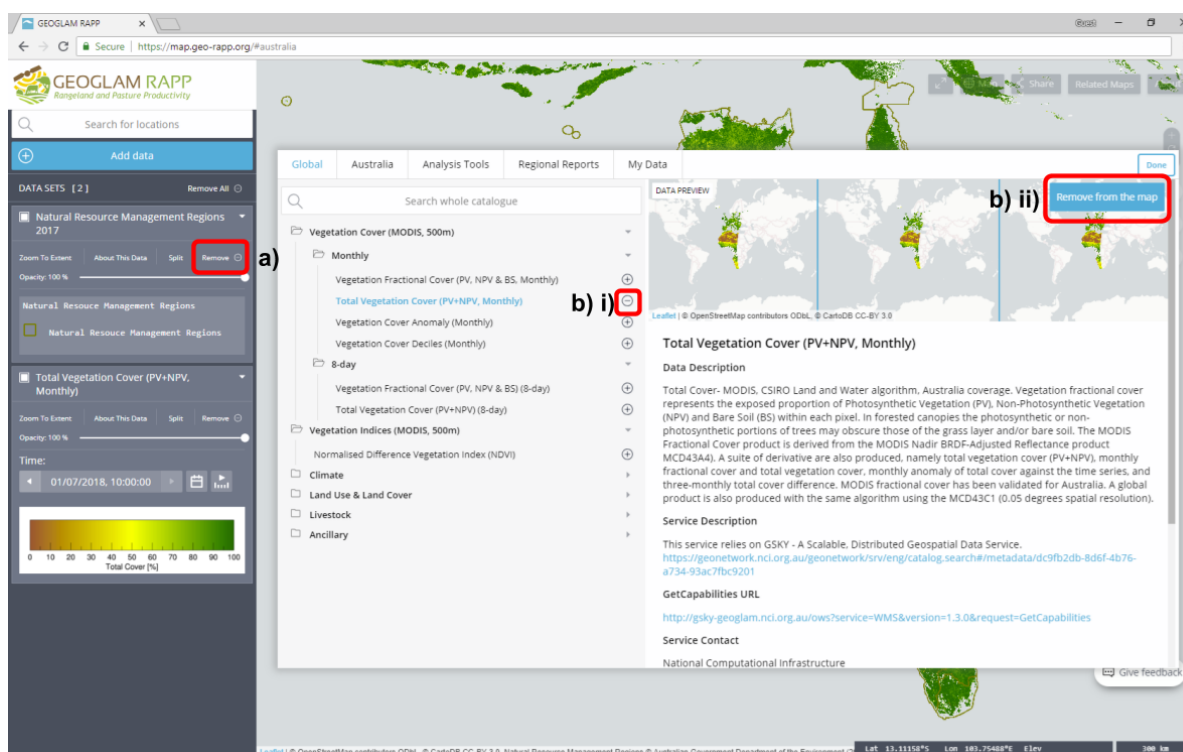


Figure A4: Options to remove data layers from the map view

Note: The image shows options for removing data from the map view. a) shows the remove button in the left hand interface, b) i) shows the remove button in the List of Data layers from the Add data window and b) ii) shows the Remove from Map button which displays when viewing metadata for a layer in the Add data window.

Select an image from the calendar

The RaPP Map contains a time series of images derived from satellites. For example Total Vegetation Cover (PV+NPV, Monthly) contains monthly images from February 2001 until July 2018. This time series will be updated as more imagery becomes available.

To choose an image to view in the map you can choose one of three options (Figure A5), either:

1. Click the calendar icon in the left hand interface panel,
 - a. The select a year window shows the number of images available in each year as blue lines. Scroll down using the mouse or right hand scroll bar to see more recent images.
 - b. Select your year of interest by clicking anywhere in that row
 - c. Select an image by clicking the image date from the list (Figure A6)
 - d. Your selected image will show in the map view
2. Use the calendar icon at the bottom of the screen, (follow the steps at 1) or
3. Use the slider on the bottom of the screen, or

Where can I see the date of the imagery in the map view?

The date of the imagery for each layer is shown in the left hand interface panel next to the calendar view. The date of the imagery of the active layer is also shown above the slider at the bottom of the screen (Figure A5).

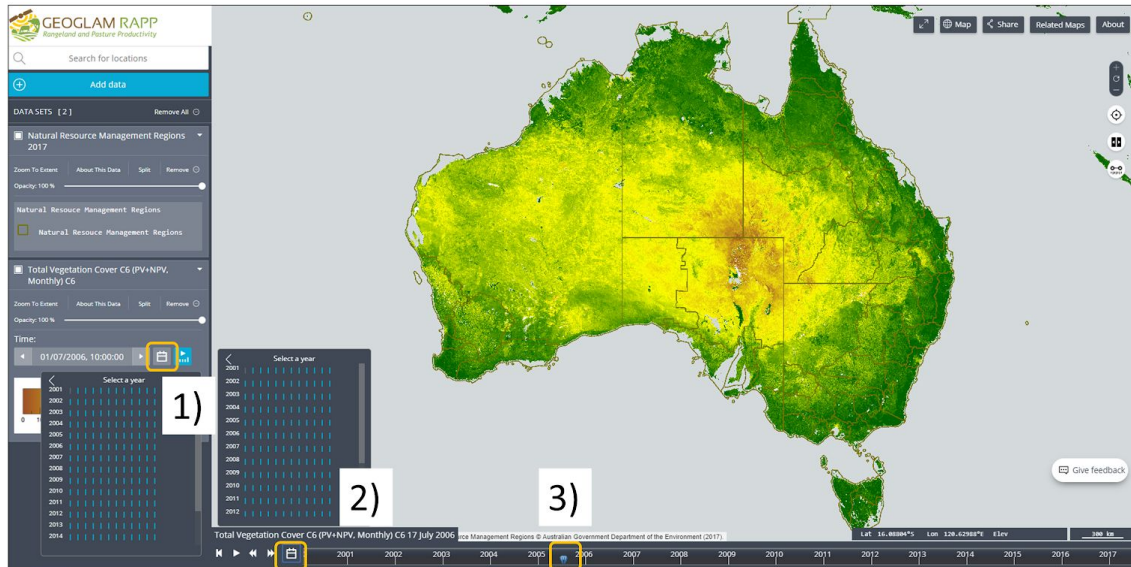


Figure A5: Options for selecting an image from the calendar

Note: The image shows the locations of the calendar icons and sliders for selecting an image from the time series. 1) calendar icon in the left hand interface panel open to select an imagery year 2) calendar icon at the bottom of the map open to select a imagery year for the data layer currently active in the map window 3) the slider bar.

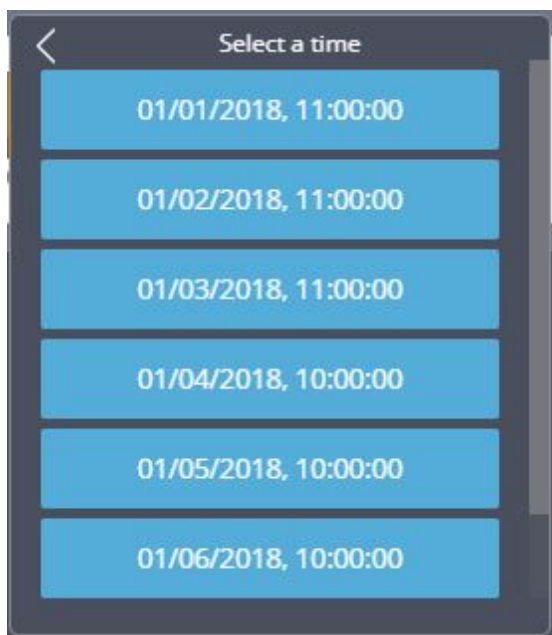


Figure A6: Available images for 2018 shown in the Select a time window

Compare two images using a split screen slider

What does the split screen slider do?

You can compare two images using the split screen slider. The split screen tool slider allows you to have a different image on the right and left of the RaPP Map view and slide the divider left and right to see locations covered by one image and then the other.

You can use the split screen to compare different dates of imagery and or different imagery products. In this example we will compare imagery for two different dates.

How to use the split screen slider

1. Activate the split screen slider by either:
 - a. Click the *Split* button in the left hand interface panel for any of the data layers open in the map view. This will duplicate the imagery on both left and right of the split. This option is better for comparing imagery for different dates from the same data layer.
 - b. Click the *Toggle splitter control* on the right hand side of the map view (Figure A1. and Figure A7). This will turn the splitter on, but not duplicate the active data layer. This option is better for comparing images from different data layers.
2. Assign images to left, right or both sides of the splitter
 - a. Once split screen is active the options Left, Right and Both will be shown for every data layer in the left hand interface panel (Figure A8). Use these buttons to assign a layer to left and right of the splitter.
3. Compare images
 - a. Use the mouse to grab the splitter icon and drag left and right to switch between the two chosen images

How to turn off the split screen slider

Remove the split screen slider by clicking the *Toggle splitter control* again (Figure A7).



Figure A7: Toggle splitter control

To compare a total vegetation layer with the anomaly layer for the same date

1. Click "Split" on the Total Vegetation Cover layer. The layer is duplicated and one is shown on the left and the other on the right (Figure A8)
2. Select different dates in each layer
3. Drag the toggle splitter (in the middle of the screen) left or right to expose the Total Vegetation Cover in each date.

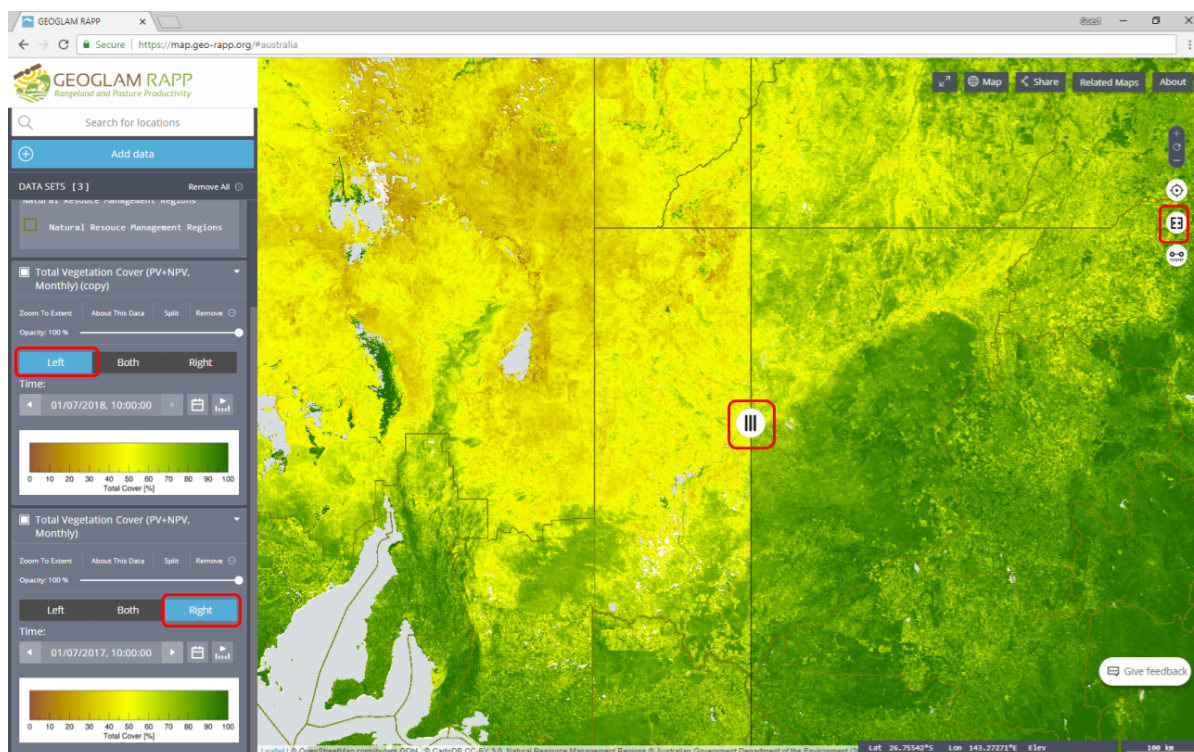


Figure A8: Toggle split option, showing total vegetation cover in July 2017 (left) and in July 2018 (right).

View a time series for a region

A time series of vegetation cover and rainfall for a region shows variation in vegetation cover between seasons and across years. This can provide a picture of the vegetation responding to temperature, rainfall and land management.

Average cover is different to area achieving total cover for wind and water erosion protection. As such this tool is intended for comparison and exploration of cover trends, rather than reporting on cover or setting ground cover targets.

You can view a time series for:

- A point: a point will represent a single pixel of the imagery. At the moment this option is only available for MODIS pixels, then the size of the pixel will be 500 metres. A time series from a pixel may be useful for portion of a farm or property.
- An existing polygon: boundaries for several regions are included in RaPP Map such as Natural Resource Management Regions, Local Government Areas, and Statistical Regions
- Your own polygon: you can draw a polygon on the map or upload a polygon and use for extracting a time-series.

These instructions will show changes in **average** total vegetation cover and rainfall for a polygon, for example a Natural Resource Management (NRM) Region.

1. Go to the *Add data window* – Figure A2.
2. Click the *Analysis Tools* tab and the *Analysis Tools* option
3. Choose *Existing polygon* – Figure A9. (Other options are *Point* (single pixel), a *Polygon* (user draws a polygon adding vertices by clicking on the map)

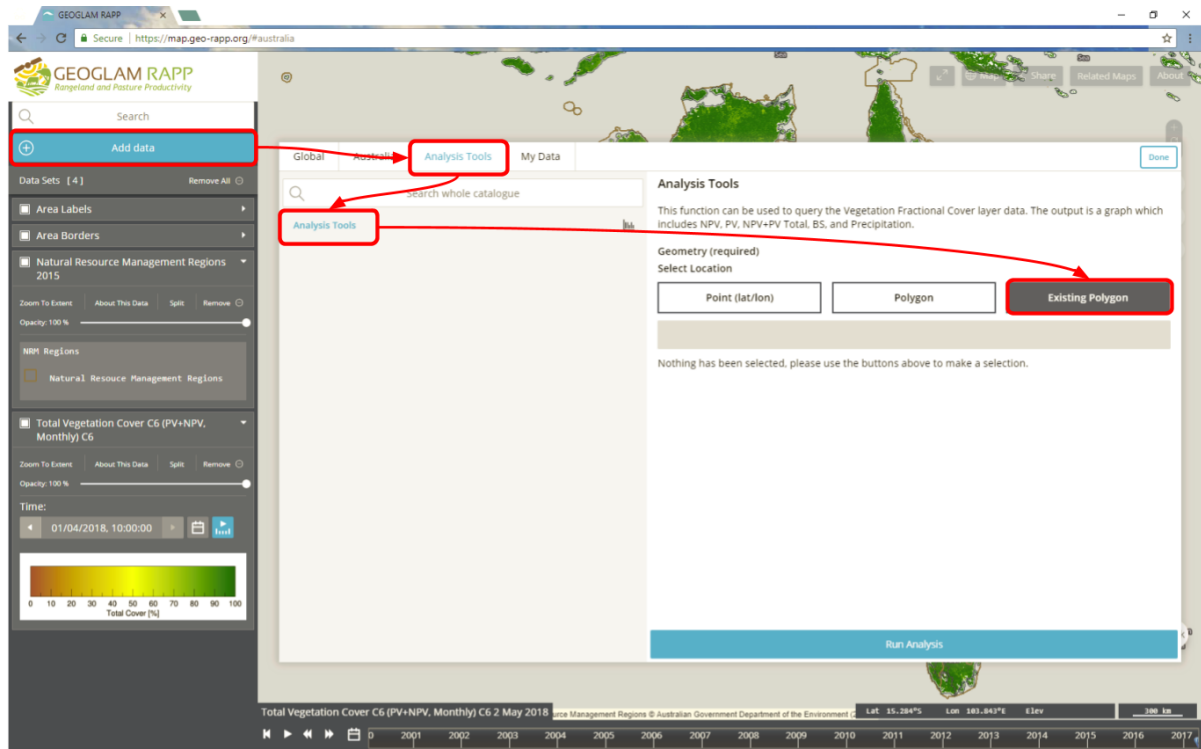


Figure A9: Select fractional cover analysis for an existing polygon

4. The Select existing polygon window will open. Note that clicking *Cancel* will return to the Analysis tools tab to select a different option.
5. Ensure that the Natural Resource Management (NRM) Regions are displayed on the map
 - a. To turn on or off regions check the box on the left hand navigation panel (Figure A1).
6. Click on an NRM region
 - a. Select existing polygon by clicking with the mouse
 - b. In this case click on the Western New South Wales Natural Resource Management (NRM) region (see Figure A10).

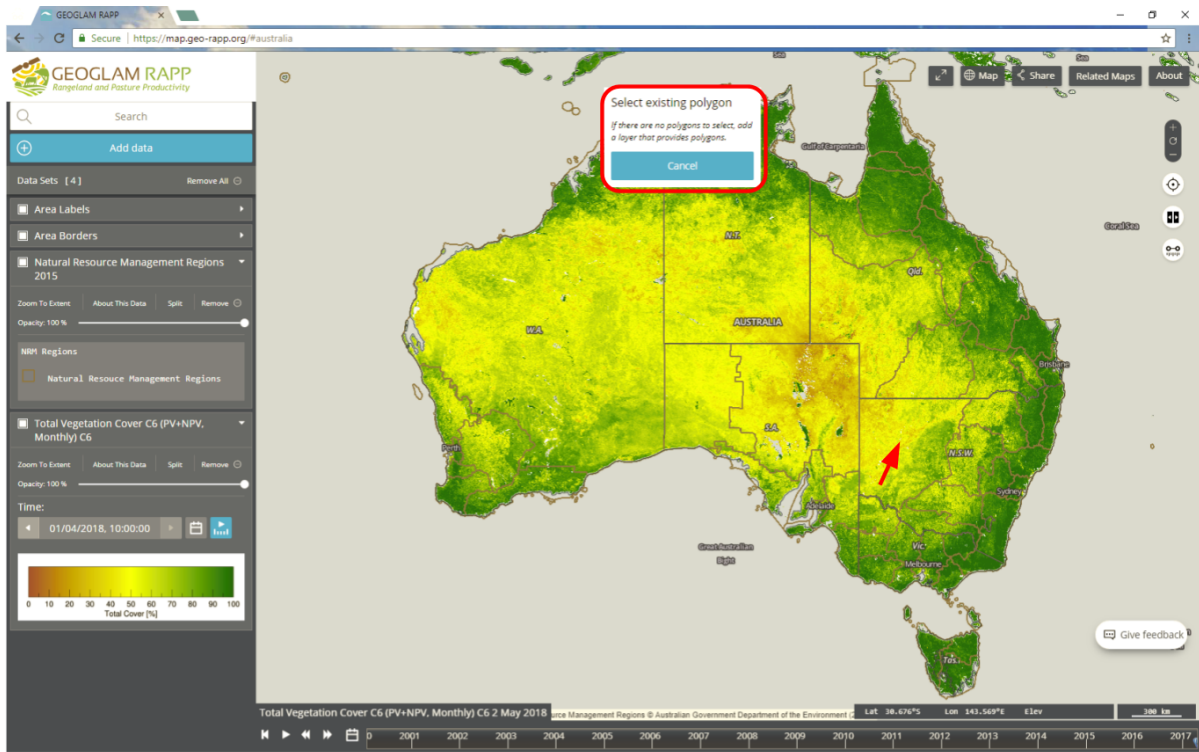


Figure A10: Screen used to select an existing polygon to generate a time series Select existing Western New South Wales region

7. You will return to the Analysis tools tab.
 - a. Your selected region will show in light grey text below the *select location* options (Figure A11)
 - b. Click *Run analysis* at the base of the page

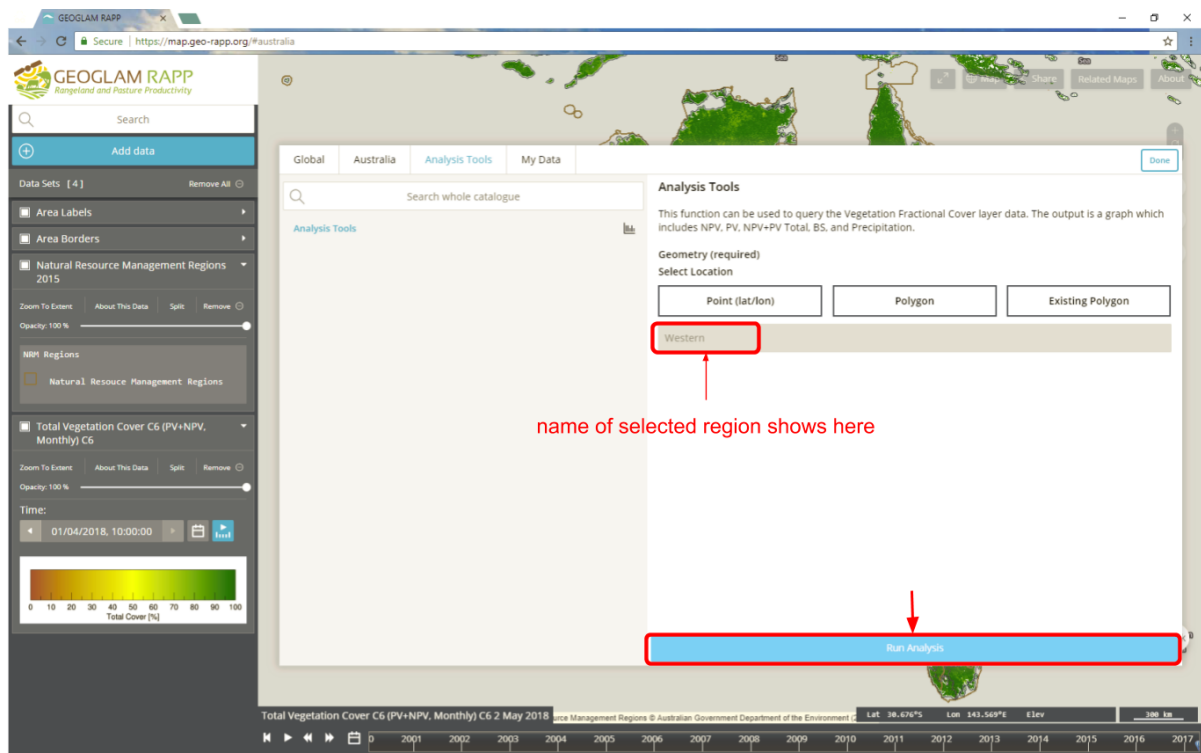


Figure A11: Run analysis

8. Wait for results to load. If the region is large the results may take several (20-30) seconds. Please be patient!
9. View the fractional cover and rainfall time series chart at the bottom right of the screen see Figure A12.
 - a. The 5 time-series are labelled in the legend in the left panel
 - b. Turn each time-series on and off using the left hand panel
 - c. Download these time-series data to a csv file by clicking *Download* at the top right of the chart (Figure A12).
10. To create a time series for another region
 - a. Remove the existing time series by clicking *Remove* in the left hand interface panel
 - b. Repeat Steps 1-9

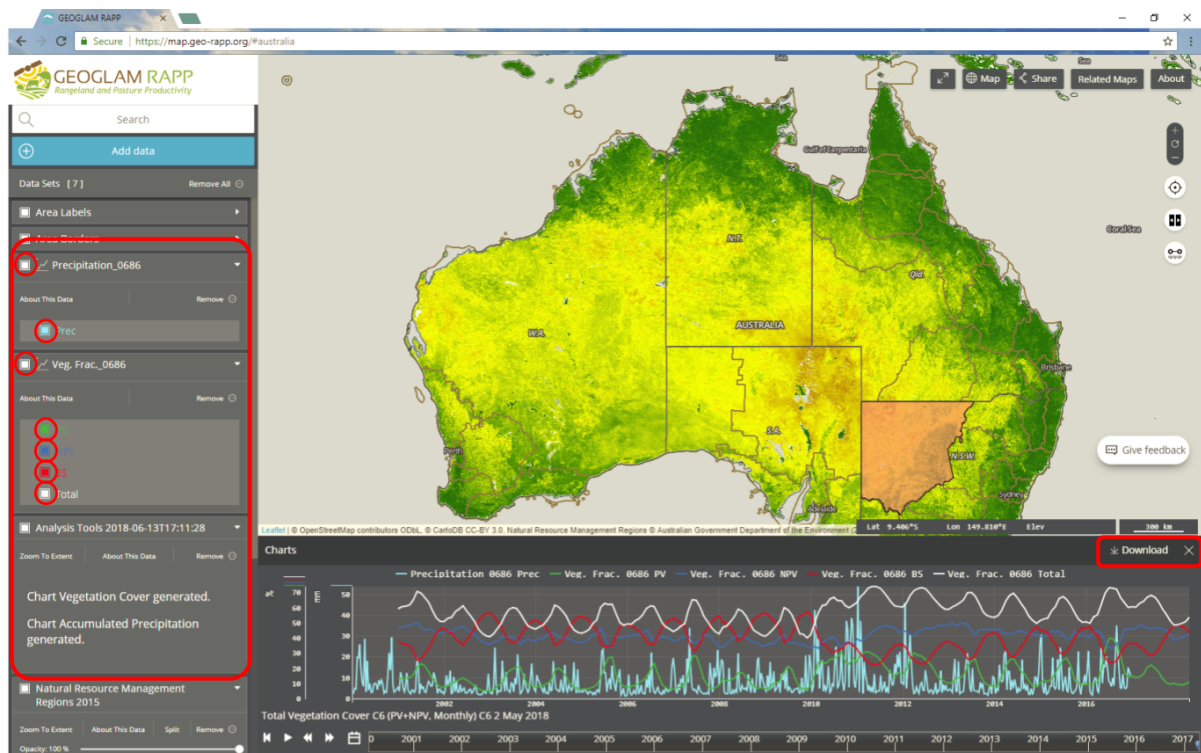


Figure A12: Fractional cover time series results

What does the time series chart show?

Figure A12 shows time-series of vegetation cover and rainfall data for the Western NRM region of NSW (highlighted on the map). The time-series charts mean monthly rainfall and median monthly vegetation cover fractions. These values are calculated from an average (mean) of all the pixels within the region (polygon). The colours lines on the chart are: light blue – rainfall (Precipitation), green – photosynthetic vegetation (PV), blue – non-photosynthetic vegetation (NPV), red – bare soil (BS), and white – total vegetation (PV+NPV).

What does the ground cover time series tell me?

In the example shown there is a clear seasonal variation in total vegetation cover. The highest mean total cover in winter and the lowest cover is in summer. There is a decline in total vegetation cover from 2001 to 2002, a similar seasonal variation until 2010 when the total cover increases. The period of low average cover was likely a result of the millennium drought and you can see the rainfall response from 2010 to 2012.

Looking at the green (PV) cover curve, there is a seasonal variation; however, in some winters, e.g. 2002, 2008 and 2009, there is low average green cover. This suggests a failure of vegetation growth. The dominant cover type in the Western region is dead (NPV) cover, which is fairly uniform (average of 30 to 50%) through the time-series. Bare Soil (BS) tends to be the inverse of green cover

Troubleshoot common problems

I don't see a map

Try changing the Basemap at the top right. 3D basemaps may not work with RaPP Map so try a 2D basemap.

Find more help

To get more help while using the software click *About* and *Help* and *FAQ* in the top right of the screen or go to <https://map.geo-rapp.org/help/help.html>. Help will be updated as the RaPP Map tool is developed.

