Australian Government
Department of Agriculture
ABARES

Australian ground cover reference sites database 2014: User guide for PostGIS

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September 2014

Summary

Ground cover is the amount of living and dead vegetation in contact with the soil surface. Spatially explicit monthly ground cover data are needed to improve modelling and monitoring of wind and water erosion, soil carbon and soil acidification.

The Ground cover monitoring for Australia project has delivered a remotely sensed ground cover product describing green or photosynthetic vegetation, non-green or non-photosynthetic vegetation and bare soil. The project has also delivered a national network of sensor independent ground reference sites to validate this product. The reference site data were collected by relevant state and territory agencies. The project was funded by the Department of Agriculture and coordinated by its Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) in partnership with the CSIRO and state and territory agencies.

The ground cover reference sites database contains the data collected from the national network of ground cover reference sites. The data includes site descriptions and associated field measurements of fractional ground cover. Data were collected across Australia from July 2010 to June 2014 at field sites under grazing and broadacre cropping land uses according to nationally agreed standards (Muir et al. 2011). The database is an update from the 2013 version and now contains published field observations current as at August 2014. This includes information from additional sites and corrects identified errors. The database now contains 507 observations from 486 unique sites across Australia. The data are being used to calibrate, validate and improve vegetation fractional cover products derived from remote sensing, in particular the satellite sensors MODIS and Landsat. The data are being used to improve the national MODIS-derived product of Guerschman et al. (2009, 2012, 2014).

The ground cover reference sites database has been developed using open source software—the object-relational database PostgreSQL with PostGIS to support geographic objects. This enables the database to be displayed spatially by site location within geographical information systems. The data is published through the Terrestrial Ecosystem Research Network (TERN) National Computational Infrastructure (https://rs.nci.org.au/u39/public/html/index.shtml), Australian Ecological Knowledge and Observation System (AEKOS) Data Portal (http://www.aekos.org.au/home), and Soils to Satellites website (http://www.soils2satellites.org.au).

Contents

Introduction

A national remotely sensed fractional cover product is necessary to monitor ground cover levels. Ground cover is a key input to wind and water erosion modelling to predict rates of soil loss, and to monitor the impact of different management practices on ground cover levels and soil erosion risk. It also has applications for managing agricultural assets. Ground cover is defined as the non-woody vegetation and litter covering the soil surface and can be monitored using remote sensing. At a national workshop in November 2009 the MODIS-derived vegetation fractional cover product of Guerschman et al. (2009) was selected for national monitoring of ground cover (Stewart et al. 2011). The workshop also identified the need for a national network of ground cover reference sites to calibrate, validate and improve the accuracy of ground cover estimates. To meet this objective, national standards were developed to collect field measurements of ground cover and to describe sites, with all states and the Northern Territory receiving training in their use (Muir et al. 2011).

The national network of ground cover reference sites commenced in July 2010 and was funded to June 2014. Information from 596 field sites (643 observations) has been delivered as part of the Ground cover monitoring for Australia project. This work was funded by the Department of Agriculture and coordinated by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) in partnership with the CSIRO and state agencies. Details of the project outputs to June 2013 are described in Stewart et al. (2014). The data was collected by the following state agencies:

- New South Wales Office of Environment and Heritage,
- Northern Territory Department of Land Resource Management,
- Queensland Department of Science, Information Technology, Innovation and the Arts,
- South Australian Department of Environment, Water and Natural Resources,
- Tasmanian Department of Primary Industries, Parks, Water and Environment,
- Victorian Department of Environment and Primary Industries, and the
- Western Australian Department of Agriculture and Food.

The updated reference sites database now contains 507 observations from 486 unique sites. This adds 43 observations and 26 sites to the database published in 2013.

The data were collected in the field and entered into two Microsoft Excel spreadsheets—the site description form and the transect form—and provided to ABARES with digital site photographs. These photos were included in the ground cover reference sites database.

The ground cover reference sites database conforms to the methods described in Muir et al. (2011). Choice of site locations was informed by a sampling strategy (Malthus et al. 2013) and sampling protocols (Stewart et al. 2012; Stewart et al. 2013). Sites were preferentially located in areas dominated by non-woody vegetation with tree canopy cover less than 20 per cent under grazing or broadacre cropping land uses. Areas with tree cover greater than 20 per cent (based on Montreal Process Implementation Group for Australia 2008), and non-agricultural land uses such as urban, conservation or indigenous land uses (based on ABARES 2011) were avoided where possible. The majority of sites are located in the rangelands. Data collection in 2014 targeted Interim Biogeographic Regionalisation for Australia (IBRA) regions with few sites.

In developing the database, users requested that it be created using open source software and have the ability to display site data within a geographical information system (GIS). PostGIS was chosen as it enables the object-relational database PostgreSQL to serve the site data spatially by site location, and to query the data using SQL functions. The SQL functions section of this user guide provides some examples. The user guide is an update to a previous version released in 2013 (Rickards et al. 2013).

The appendices of this user guide describe other field observations made available to ABARES as at August 2014 for the validation of remotely sensed fractional cover. This is an additional 1207 field observations from 773 unique sites. These additional observations have not been publically released, or have been collected using slightly different methods such as the TERN AusPlots (rangelands) method.

Observations in the database

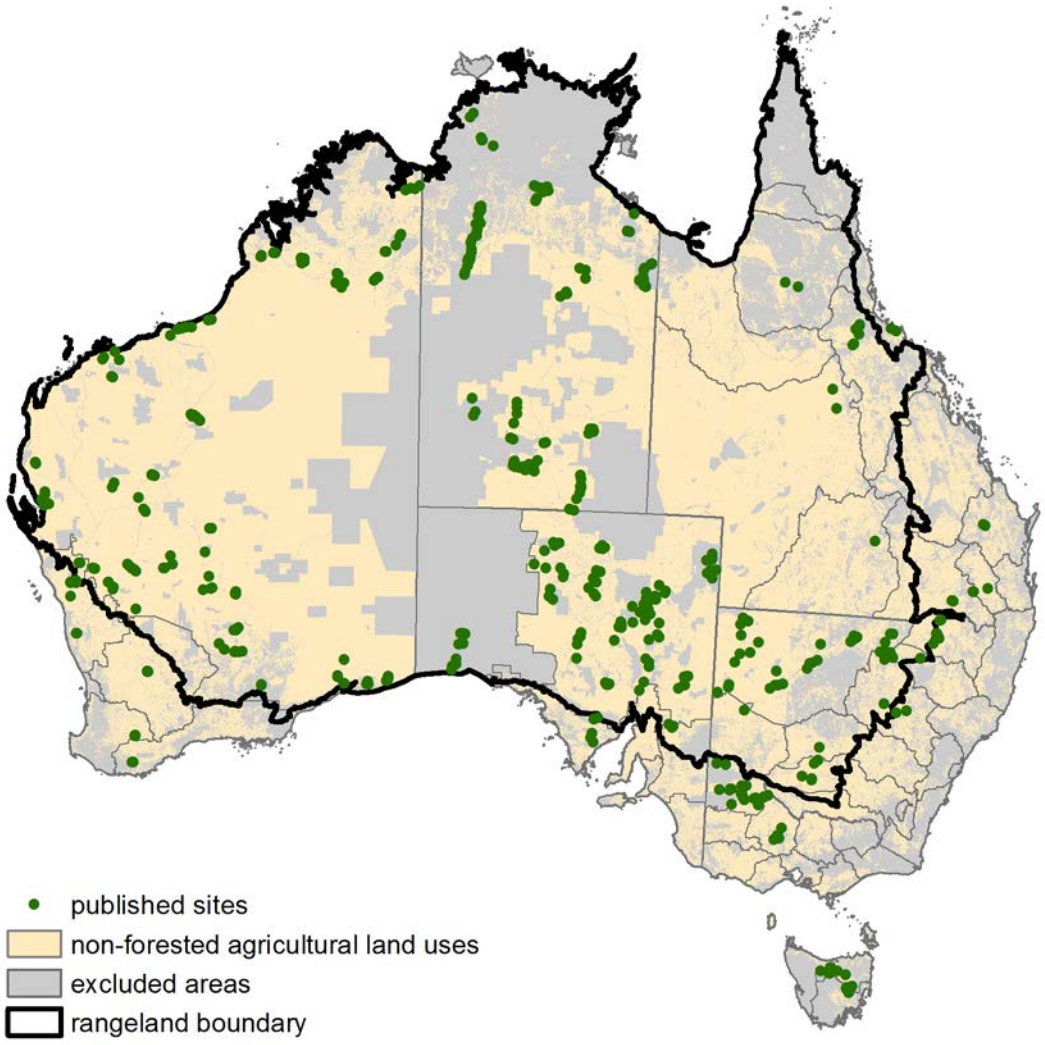
This field site database contains 507 observations from 486 unique sites across Australia. The database does not contain all 643 observations collected under the Ground cover monitoring for Australia project because some project partners requested that field observations on private land not be published due to confidentiality. The total number of observations collected by each state is shown in Table 1. The locations of the publishable sites in the database are shown in Map 1.

Table 1 Number of observations in each state

		Observations	
State	**Total**	**Published**	**Unpublished**
New South Wales	91	58	33
Northern Territory	118	103	15
Queensland	30	28	2
South Australia	109	97	12
Tasmania	25	25	-
Victoria*	119	45	74
Western Australia	151	151	-
Total	**643**	**507**	**136**

Note: Data from unpublished sites may be acquired for specific research projects at the discretion of the relevant state agency. *Of the 119 observations collected by the Victorian Department of Environment and Primary Industries, 48 were directly funded through the Ground cover monitoring for Australia project

Map 1 Location of sites in the database as at August 2014



Source: ABARES 2014

Database design

The ground cover reference sites database has been created using the open source software PostGIS (http://postgis.refractions.net/) and is available as a pg-dump SQL file. It can be loaded into PostGIS by running the pg-dump file. Running this file will create and populate five 'tables' and three 'views' (schema shown in Figure 1). Tables contain static data. Views calculate values from the tables and automatically update when new data is entered into the tables.

A description of each table and view are given in Table 2. The attributes contained in each table are provided in Tables 3 to 12. Each site visit is assigned a 'unique_obs' code of 'longitude_latitude_date' to join or relate all tables. Each table also contains a 'primary key' which is unique for each data entry at a site. For attributes with a single data entry, such as in the site description table (Table 5), the 'primary key' is the 'unique_obs' code. For attributes with multiple data entries, such as in the raw transect data table (Table 3) with 200-300 points per site, the 'primary key' is either a new field or a combination of existing fields.

Figure 1 Schema of PostGIS database

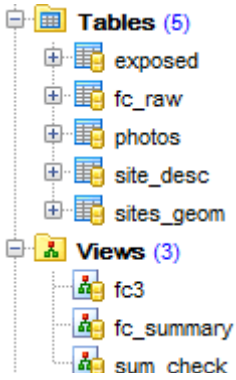


Table 2 Tables and views in the ground cover reference site database

Name	Content for each site	Type	Attributes
exposed	Exposed ground cover fractions; bare, non-green (NPV) and green (PV) of sites	Table	Table 11
fc_raw	Raw data for each point along the transect layout (200 or 300 observations)	Table	Table 3
photos	An index of 7 or 5 photographs taken along the transect layout	Table	Table 4
site_desc	Other information describing the site such as land use, vegetation species, soil surface condition, soil colour etc	Table	Table 5-7
sites_geom	Location in latitude and longitude	Table(geom)	Table 8
fc3	Totals for the ground layer fractions green (PV), non-green (NPV) and BS (bare) fractions and ground cover (PV + NPV) (%)	View	Table 10
fc_summary	Totals for each cover category (%)	View	Table 9
sum_check	Total cover to identify errors (%)	View	Table 12

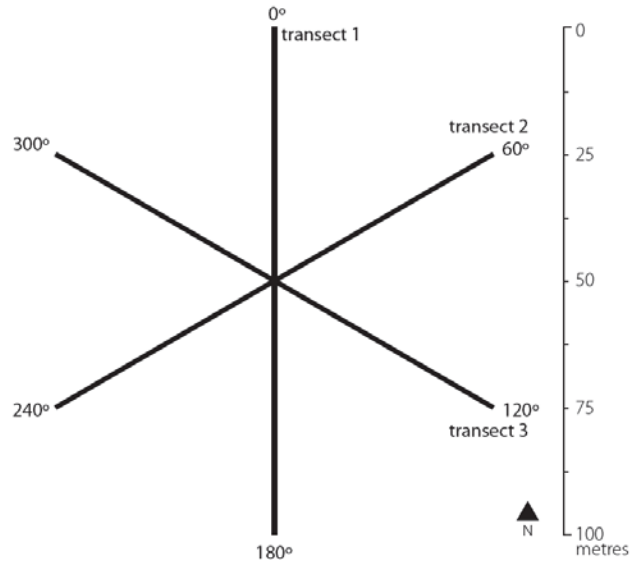
Note: PV—photosynthetic vegetation; NPV—non-photosynthetic vegetation; BS—bare soil

Field collection protocols

The field collection protocol code from the site_desc table in the PostGIS database (Table 5) identifies the layout of the field transects and the attributes collected at the site. The data collected through the Ground cover monitoring for Australia project uses two transect layouts developed by Queensland Department of Science, Information Technology, Innovation and the Arts (Muir et al. 2011). Fractional ground cover data collected prior to this project used the same transect layouts but slightly different attributes. TERN AusPlots sites use a more intensive transect layout to collect fractional ground cover data as described at Appendix B. The different transect layouts described by the protocols below are all suitable for improving MODIS and Landsat fractional cover algorithms. The protocols have been assigned a code, beginning with P1 for Protocol 1. Each protocol is described below.

P1: The star-shaped transect method developed for the Queensland Statewide Land And Trees Survey (SLATS) has been used to measure vegetation in natural or pastoral environments (Figure 2). Three hundred points are measured using the star-shaped transect method as described in Muir et al. (2011).

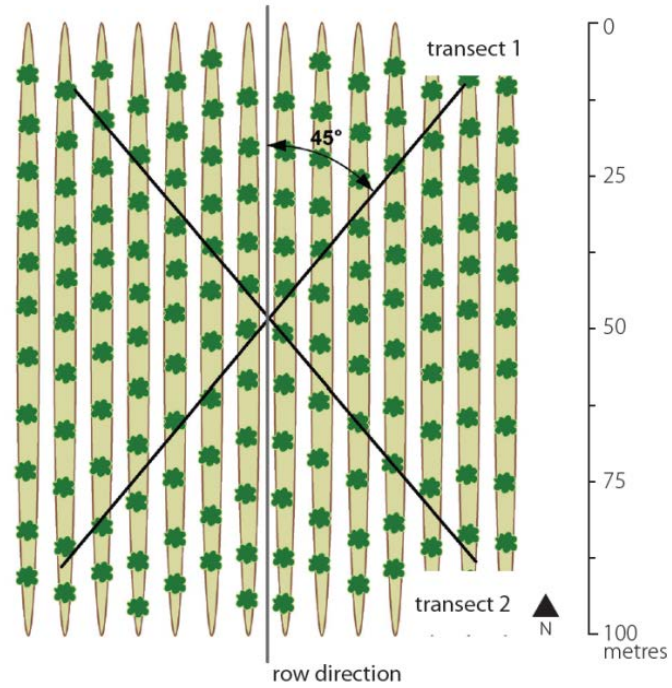
Figure 2 P1 transect layout for natural or pastoral environments



Source: Muir et al. (2011)

P2: The cross transect method has been adapted from the SLATS star-transect method as a simplified method for vegetation in rows, such as crops (Figure 3). Two hundred points are measured using the cross-shaped transect method as described in Muir et al. (2011).

Figure 3 P2 transect layout for vegetation in rows, such as agricultural crops



Source: Muir et al. (2011)

Raw transect data

The fc_raw table (Table 3) contains multiple measurements taken at each site of the presence or absence of ground cover, woody vegetation less than two metres (midstorey) and woody vegetation greater than 2 metres (overstorey). For most sites a total of 300 observations of the vegetation at the site are taken, with one measurement taken every metre along three 100 metre transects arranged in a star-shape (P1) (Figure 2). Where vegetation is in rows, as for cropping, the pattern of cover is more uniform and the method has been simplified to a total of 200 observations recorded along two 100 metre transects oriented 45 degrees off-row (P2) (Figure 3) as described in the section above.

Measurements are recorded as a '1'. Only one feature type (i.e. green leaf, dry leaf etc) is recorded for each observation category (stratum), except where the measurement for woody vegetation greater than two metres is within a live tree crown, in this case two measurements are recorded, 'in crown' (field name: 'oic') as well as the canopy element intercepted.

Table 3 Attributes of fc_raw table

Field name	Description	Data type	Values allowed	Strata
point	Transect measurement	Integer	1–300	All
cr	Soil crust	Integer	0, 1	Ground
ds	Disturbed soil	Integer	0, 1	Ground
rk	Rock	Integer	0, 1	Ground
gr	Green leaf non-woody vegetation	Integer	0, 1	Ground
dr	Dry leaf non-woody vegetation	Integer	0, 1	Ground
li	Litter	Integer	0, 1	Ground
cy	Cryptogam	Integer	0, 1	Ground
mg	Green leaf woody vegetation <2m	Integer	0, 1	Mid
md	Dry leaf woody vegetation <2m	Integer	0, 1	Mid
mb	Branch <2m	Integer	0, 1	Mid
oic	In crown for live woody vegetation >2m	Integer	0, 1	Over
og	Green leaf woody vegetation >2m	Integer	0, 1	Over
od	Dry leaf woody vegetation >2m	Integer	0, 1	Over
ob	Branch >2m	Integer	0, 1	Over
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters	All
g_total	Only one observation for ground cover (cr+ds+rk+gr+dr+li+cy) is permitted at each point	Integer	1	Ground
m_total	Zero or one observations of woody vegetation <2m (mg+md+mb) are permitted at each point	Integer	0, 1	Mid
o_total	Zero, one or two observations of woody vegetation >2m (oic+og+od+ob) are permitted at each point.	Integer	0, 1, 2	Over
all_total	Number of strata for each transect point (g_total+m_total+o_total)	Integer	1, 2, 3, 4	All

Note: Primary key = unique_obs, point. Non-woody vegetative cover, such as grasses, has no height restriction; dry leaf is senescent or dead vegetation attached to a plant or the ground; litter is unattached dead vegetation; cryptogam is a biological crust on the soil surface; in crown is the vertically projected perimeter of all foliage and branches of the plant and is recorded for live trees only. Latitude and longitude are given in decimal degrees.

Photographs

Digital photographs are taken at each site. All images are taken from the transect centre, with the first pointing directly down (G) and the others along each transect line (L) starting at north and

working around in a clockwise direction. Five photos are taken when the site has vegetation in rows (cropping) and seven photos at each site in natural or pastoral environments. The number of photos taken reflects the field collection protocol adopted—P2 or two transects for vegetation in rows (Figure 3) and P1 or three transects for natural or pastoral environments (Figure 2). The photos table (Table 4) stores the details of the digital photographs.

Table 4 Attributes of photos table

Field name	Description	Data type	Values allowed
code	Primary key (unique_obs, name)	Text	35 characters
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters
site_name	Name of the site e.g. Vic1001	Text	20 characters
state	State abbreviation e.g. NSW	Text	3 characters
crop	Site cropped or not	Text	Yes, No
name	G1=centre down, L1=1st , L2=2nd , L3=3rd, L4=4th, L5=5th, L6=6th	Text	G1, L1, L2, L3, L4, L5 , L6
transect	Which transect the image shows	Integer	1, 2, 3
direction	Site orientation in degrees	Integer	0-360
cardinal_direction	Direction text	Text	10 characters

Note: At sites with vegetation in rows (cropping) only 5 photos were taken (G1, …, L4). Site photos can be viewed on the TERN AEKOS data portal (http://www.aekos.org.au/home).

Site description

The site description details are saved in the table site_desc. In this user guide the site_desc attributes are presented in three tables corresponding to the three sections of the site description form used by the field operator to enter the data. Table 5 contains the basic site description attributes, Table 6 contains the vegetation description attributes and Table 7 contains the land surface attributes. Some site_desc table attributes—basic soil colours and soil moisture (Table 7)—have been calculated from the collected data.

Table 5 Attributes of site_desc table: basic site description

Field name	Description	Data type	Values allowed
publish	Consent for public release of data (if 'No': not published)	Text	Yes, No
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters
site_name	Name of the site e.g. Vic1001	Text	20 characters
state	State abbreviation e.g. NSW	Text	3 characters
loc_desc	Landform or nearby landmarks e.g. towns or roads – UNPUBLISHED	Text	255 characters
site_desc	Details of land use, management or recent natural events	Text	255 characters
date_collect	Date site completed as year, month, day	Integer	yyyymmdd
time	Time site started in 24 hour time	Time 5	hh:mm
purpose	Purpose of data collection	Text	Ground cover monitoring
protocol	Code describing the transect layout and attributes collected	Text	P1, P2, P3, P4, P5
revisit	If site has been observed previously using the same protocol	Text	Yes, No
zone	Zone as per MGA94 or UTM	Integer	49–56
datum	Coordinate system, WGS94 or GDA94	Text	6 characters
obs_collect	Person who made the transect readings – UNPUBLISHED	Text	20 characters
obs_log	Person who recorded the transect readings - UNPUBLISHED	Text	20 characters
east_c	Transect centre easting	Real	
north_c	Transect centre northing	Real	
diff_gps	Whether a differential GPS was used for a more accurate location	Text	Yes, No
bear_t1,2,3	Bearing of transect 1, 2 and 3 in degrees	Integer	0–360
slope	Slope of site in per cent	Integer	0–100
aspect	Horizontal direction in which the slope faces in degrees	Integer	0–360
landuse	ALUM v7 tertiary class	Text	50 characters
alumv7	ALUM v7 tertiary code, no decimals e.g. 331	Integer	100–663
commod	Commodity name	Text	20 characters
crop	Site cropped or not	Text	Yes, No
management	The current management phase for the vegetation present, including litter (interpreted with growth stage)	Text	Abandoned, Baled, Burnt, Cultivated, Grazed, Incorporated, Mulched, Sprayed, Standing/none, Other
growth	Growth phase for the majority of plants observed	Text	Establishment, Immature/growing, Mature, Senescence/residue, None
spectra	Whether field spectra collected	Text	Yes, No

Note: See field protocols section for descriptions of protocols. ALUM v7 is the Australian Land Use and Management Classification (www.daff.gov.au/abares/aclump). Unpublished data (see description: 'UNPUBLISHED') has been excluded from the dataset.

Table 6 Attributes of site_desc table: vegetation description

Field name	Description	Data type	Values allowed
biomass	Estimate of standing non-woody ground cover biomass (kg/ha)	Real	
biomass_method	Method used to estimate biomass density	Text	Visual, Photo standards, Visual and photo standards, Quantitative
grass_m	Average non-woody vegetation height (m)	Real	
fire	Recent or severe fire	Text	0 - No evidence, 1 - Minor burn (<5% site or >3 years), 2 - Recent/major burn (>5% site or <3 years)
perm_veg	Percentage of perennial grass cover	Text	0-5%, 6-25%, 26-50%, 51-75%, 76-100%
overstorey	Average woody vegetation height (m)	Real	
veg1st_o, 2nd, 3rd	Dominant 3 species by biomass for woody vegetation >2m	Text	55 characters
veg1stpc_o, 2nd, 3rd	Occurrence by biomass of the 3 dominant woody vegetation >2m species (%)	Real	0–100.00
veg1st_m, 2nd, 3rd	Dominant 3 species by biomass for woody vegetation <2m	Text	55 characters
veg1stpc_m, 2nd, 3rd	Occurrence by biomass of the 3 dominant woody vegetation <2m species (%)	Real	0–100.00
veg1st_g, 2nd, 3rd	Dominant 3 species by biomass for the non-woody ground layer	Text	55 characters
veg1stpc_g	Occurrence by biomass of the 3 dominant non-woody species (%)	Real	0–100.00
prism1, 2, 3, 4, 5, 6, 7	Prism factor used for tree basal area at each of 7 points on the transects	Real	
live1, 2 ,3 ,4 ,5 , 6, 7	Number of live trees inside area at each of 7 points on the transect	Integer	
dead1,2,3,4,5,6,7	Number of dead trees inside area at each of 7 points on the transect	Integer	
conv1, 2, 3, 4, 5, 6, 7	Converted (prism x live)	Real	
total_live	Average (live) tree basal area (total conv / 7) (m^2/ha)	Real	

Table 7 Attributes of site_desc table: land surface

Field name	Description	Data type	Values allowed
erosion	State of erosion	Text	N - None, A - Active, S - Stabilised, P – Partly stabilised
wind_erosion	Wind erosion severity	Text	0 - None, 1 - Minor, 2 - Moderate, 3 - Severe, 4 - Very severe
scald_erosion	Scald erosion by water and/or wind severity	Text	0 - None, 1 - Minor (<5% of site), 2 - Moderate (5-50% of site), 3 - Severe (>50% of site)
sheet_erosion	Sheet erosion by water severity	Text	0 - None, 1 - Minor, 2 - Moderate, 3 - Severe
rill_erosion	Rill erosion by water severity	Text	0 - None, 1 - Minor (occasional), 2 - Moderate (common), 3 - Severe (corrugated)
gully_erosion	Gully erosion by water severity	Text	0 - None, 1 - Minor (isolated), 2 - Moderate (restricted to drainage lines), 3 - Severe (branch away from primary drainage lines)
deposits	Deposited materials	Text	Sand (<2mm), Gravel (2-60mm), Stones (>60mm)
amount	Abundance of deposited material	Text	0 - None, 1 - Very few (<2%), 2 - Few (2-10%), 3 - Common (10-20%), 4 - Many (20-50%), 5 - Abundant (50-90%), 6 - Very abundant (>90%)
micro_relief	Surface smoothness, mounds, depressions, furrows	Text	0 - Smooth (<3 mm variation), D - Depressions, M - Mounds, C - Cropping rows/furrows
vertical_m	Interval between base and crest (m)	Integer	
horizontal_m	Horizontal distance between crests (m)	Integer	
s_cond1, 2, 3	Surface condition when dry	Text	G - Cracking, M - Self-mulching, L - Loose, S - Soft, F - Firm, H - Hard setting, C - Surface crust, X - Surface flake, Y - Cryptogam surface, T - Trampled, P - Poached, R - Recently cultivated, Z - Saline, O - Other
s_stngth	Surface soil strength	Text	0 - Loose, 1 - Very weak, 2 - Weak, 3 - Firm, 4 - Very firm, 5 - Strong, 6 - Very strong, 7 - Rigid
s_cracks	Surface cracks	Text	1 – Fine (<5 mm), 2 – Medium (5-10 mm), 3 – Coarse (10-20 mm), 4 - Very coarse (20-50 mm), 5 - Extremely coarse (>50 mm)
disturb1, 2, 3	Biotic agents causing soil surface relief disturbance (up to 3 agents)	Text	NH - Horses, NS - Sheep, NC - Cows, NG - Goats, NP - Pigs, NM - Macropod, NL - Camel, NR - Rabbits, H - Human, B - Bird, T - Termite, A - Ant, V - Vegetation, O - Other
crust_d/w_h	Dry and wet soil crust colour (Munsell hue)	Text	
crust_d/w_v	Dry and wet soil crust colour (Munsell value)	Integer	
crust_d/w_c	Dry and wet soil crust colour (Munsell chroma)	Integer	
dist_d/w_h	Dry and wet disturbed soil colour (Munsell hue)	Text	
dist_d/w_v	Dry and wet disturbed soil colour (Munsell value)	Integer	
dist_d/w_c	Dry and wet disturbed soil colour (Munsell chroma)	Integer	
crypto	Cryptogam cover (%)	Text	None, <2%, 2-10%, 10-20%, 20-50%, 50-90%, >90%
crypto_mc	Cryptogam colour (Munsell hue, value, chroma)	Text	50 characters e.g. 5YR 3/2
crypto_bc	Cryptogam colour (basic colour)	Text	50 characters
crypto_w_d	Cryptogam wet or dry	Text	Wet, Dry
rock1st, 2nd, 3rd_h	First three dominant rock cover readings (Munsell hue)	Text	

Table 7 (cont.) Attributes of site_desc table: land surface

Field name	Description	Data type	Values allowed
rock1st, 2nd, 3rd_v	Rock colour for dominant 3 (Munsell value)	Integer	
rock1st, 2nd, 3rd_c	Rock colour for dominant 3 (Munsell chroma)	Integer	
rock_lag	Abundance of rocks/lag (%)	Text	0 - None, 1 - Very few (<2% of site), 2 - Few (2-10% of site), 3 - Common (10-20% of site), 4 - Many (20-50% of site), 5 - Abundant (50-90% of site), 6 - Very abundant (>90% of site)
rock_lag_s	Average fragment size	Text	Fine gravelly (2-6 mm), Medium gravelly (6-20 mm), Coarse gravelly (20-60 mm), Cobbly (60-200 mm), Stony (200-600 mm), Boulders (60-2000 mm), Large boulders (>2000 mm)
soilclr1_cd	Basic colour for dry soil crust	Text	Yellow, Red, Brown, Black, Grey
soilclr2_dd	Basic colour for dry disturbed soil	Text	Yellow, Red, Brown, Black, Grey
soilclr3_cw	Basic colour for wet soil crust	Text	Yellow, Red, Brown, Black, Grey
soilclr4_dw	Basic colour for wet disturbed soil	Text	Yellow, Red, Brown, Black, Grey
soil_col_max	Most represented soil colour	Text	Yellow, Red, Brown, Black, Grey, Null
wet_dry	Whether a dry soil colour was given	Text	Dry, Null, Wet

Note: Soil and rock/lag colour are recorded using the Munsell Soil Color Charts (1994). Basic soil colour is derived from the Munsell Soil Color Charts according to the colour classes of the Australian Soil Classification (Isbell 2002) (www.clw.csiro.au/aclep/asc_re_on_line/soilcocl.htm). Most represented soil colour is determined from the frequency of transect observations for soil crust and disturbed soil from fc_raw (Table 3). The soil surface is assumed to have been wet when visited if there is no dry soil colour recorded.

Site locations

The x, y coordinates of the field locations are saved in the sites_geom table (Table 8). This table contains geometries to enable the field locations to be shown and queried spatially in geographic information system programs such as QGIS.

Table 8 Attributes of sites_geom table

Field name	Description	Data type	Values allowed
site_name	Name of the site e.g. Vic1001	Text	20 characters
state	State abbreviations e.g. NSW	Text	5 characters
latitude	Latitude	Real	
longitude	Longitude	Real	
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters
geom	Point geometry (latitude, longitude in WGS84)	Point location	

Cover summaries

Views are automatically updated as data is added or changed in the other tables. The views fc_summary (Table 9) and fc3 (Table 10) calculate fractions for the ground layer from the raw transect values in fc_raw (Table 3). Other views could be produced to calculate total vegetation cover including the woody vegetation components (such as view sum_check; Table 12).

The view fc_summary (Table 9) calculates the percent cover for each cover type directly from the 200 or 300 transect observations (points) recorded in the table fc_raw.

Table 9 Attributes of fc_summary view

Field name	Description	Data type	Values allowed
crust	Soil crust (%) = (sum cr / no. points) x 100	Real	0–100.00
dist	Disturbed soil (%) = (sum ds / no. points) x 100	Real	0–100.00
rock	Rock (%) = (sum rk / no. points) x 100	Real	0–100.00
green	Green leaf non-woody vegetation (%) = (sum gr / no. points) x 100	Real	0–100.00
dry	Dry leaf non-woody vegetation (%) = (sum dr / no. points) x 100	Real	0–100.00
litter	Litter (%) = (sum li / no. points) x 100	Real	0–100.00
crypto	Cryptogam (%) = (sum cy / no. points) x 100	Real	0–100.00
mid_g	Green leaf woody vegetation <2m (%) = (sum mg / no. points) x 100	Real	0–100.00
mid_d	Dry leaf woody vegetation <2m (%) = (sum md / no. points) x 100	Real	0–100.00
mid_b	Branch <2m (%) = (sum mb/ no. points) x 100	Real	0–100.00
in_crown	In live tree crown (%) = (sum oic/ no. points) x 100	Real	0–100.00
over_g	Green leaf woody vegetation >2m (%) = (sum og/ no. points) x 100	Real	0–100.00
over_d	Dry leaf woody vegetation >2m (%) = (sum od / no. points) x 100	Real	0–100.00
over_b	Branch >2m (%) = (sum ob / no. points) x 100	Real	0–100.00
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters

Cover fractions

The view fc3 (Table 10) calculates the three ground cover fractions by adding the field calculated in the view fc_summary (Table 9).

Table 10 Attributes of fc3 view

Field name	Description	Data type	Values allowed
bare	Bare soil (BS) (%) = (crust + dist + rock + crypto)	Real	0–100.00
green	Photosynthetic non-woody vegetation (PV) (%) = green	Real	0–100.00
brown	Non-photosynthetic non-woody vegetation (NPV)(%) = dry + litter	Real	0–100.00
cover	Non-woody ground cover (PV + NPV) (%) = green + brown	Real	0–100.00
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters

Exposed cover fractions

The table exposed (Table 11) presents the three cover fractions calculated from all vegetation strata – ground, mid, and overstorey. Exposed cover is the first cover seen when looking down on the transect point and estimates the view seen by the satellite. Exposed cover differs from the fc3 calculated cover as fc3 presents the ground cover by calculating the cover fractions only for non woody vegetation, bare soil and litter and excludes woody vegetation <2m and woody vegetation >2m (Table 10). The calculation of exposed cover is currently completed in Microsoft Excel however this table could be improved by calculating exposed cover as a view so it automatically updates as new observations are added.

Table 11 Attributes of exposed table

Field name	Description	Data type	Values allowed
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters
ex_bare	Exposed bare soil (BS)(%) = (crust + dist + rock + crypto) where no mid or overstorey	Real	0–100.00
ex_brown	Exposed non-green or non-photosynthetic vegetation (NPV) (%) = ob, od, mb, md, dry or litter	Real	0–100.00
ex_green	Exposed green or photosynthetic vegetation (PV) (%) = og, mg or green	Real	0–100.00
points	Number of point intercept observations	Integer	0-300

The exposed cover is calculated for each transect point. A pivot table is then used to calculate the percentage exposed cover for the site. For each transect point the exposed cover is the overstorey cover fraction, unless there is no overstorey fraction then it is the midstorey fraction, unless there is no midstorey, then it is the ground cover fraction. The overstorey and midstorey are calculated as green, brown, or absent using the following calculations:

mid = IF(mid green mg=1,"green", IF(mid dry md=1, "brown", IF(mid branch mb=1, "brown", 0)))
over =IF(over green og=1,"green", IF(over dry od=1, "brown", IF(over branch ob=1, "brown", 0)))

The ground cover is calculated as green, brown or bare using the following calculation:

ground=IF(crust =1,"bare", IF(disturbed=1,"bare", IF(rock=1,"bare",
IF(green=1,"green",IF(dry=1,"brown",IF(litter=1,"brown",IF(crypto=1,"bare",0)))))))

The exposed cover for the point is calculated as:

exposed=IF(over="green", "green",IF(over="brown","brown",IF(mid="green",
"green",IF(mid="brown","brown", ground))))

Checking the data

The view sum_check (Table 12) calculates the cover fraction percentages for each site at the ground layer, woody vegetation <2m layer (midstorey) and woody vegetation >2m layer (overstorey). The ground layer percentage should equal 100 percent as a fraction is recorded at each transect intercept (observation). The woody vegetation <2m (midstorey) and woody vegetation >2m (overstorey) layers do not have values collected at every transect intercept. When woody vegetation >2m is encountered in a live tree crown two values are recorded. 'In crown' indicates that the transect falls in an area of live tree canopy, and the second value recorded describes the cover

fraction encountered. Overstorey transect intercepts in sites with live tree canopy present may add up to 200. Sites suitable for collecting ground cover information are however chosen based on less than 20 per cent foliage projective cover and therefore the overstorey intercepts should be less than 100.

Table 12 Attributes of sum_check view

Field name	Description	Data type	Values allowed
unique_obs	Site identifier (longitude_latitude_date)	Text	00000000_0000000_yyyymmdd 32 characters
ground	Intercepts with a value for ground layer (%)	Real	100.00
mid	Intercepts with a value for woody vegetation <2m (%)	Real	0–100.00
over	Intercepts with a value for woody vegetation >2m (%)	Real	0–200.00
total	Sum of all observations (%) (ground + mid + over)	Real	100.00–400.00

SQL functions

Querying the database

Example SQL functions to query the PostGIS field database (table name, field name or threshold values can be changed as desired):

- Select all raw transect points for a particular site (change table name or field as desired)
  SELECT *FROM fc_raw WHERE "unique_obs" = '14885344_3205411_20101125';
- Select only some columns from a table
  SELECT photos.code,photos.crop FROM photos;
- Select sites with bare (crust, disturbed, rock, crypto) greater than 40 per cent
  SELECT * FROM fc3 WHERE (cast(bare as double precision)>40);
- Select sites with bare excluding crypto (crust, disturbed, rock) greater than 40 per cent
  SELECT * FROM fc_sum WHERE (cast (dist as double precision)+cast(cr as double precision)+cast(rock as double precision)>40);
- Select site name and collection date for sites with active erosion
  SELECT erosion,site_name,date_collect,time FROM site_desc WHERE erosion LIKE ('A%');
- Join two tables on unique_obs and select all bare, brown and green fractions and site name and collection date and time for sites with active erosion
  SELECT fc3.*, site_desc.erosion, site_desc.site_name, site_desc.date_collect, site_desc.time FROM fc3,site_desc WHERE erosion LIKE ('A%') AND fc3.unique_obs=site_desc.unique_obs;
- Summarise data by a column (number of sites per state)
  SELECT state, COUNT(*) FROM site_desc GROUP BY state;
- Select metrics and summarise by a column (bare—maximum, minimum, average by state)

SELECT state, MAX(bare), MIN(bare), AVG(bare) FROM site_desc, fc3 WHERE site_desc.unique_obs=fc3.unique_obs GROUP BY state;

- Summarise data by 2 columns (states, cropping)
  SELECT state, crop, COUNT(*) FROM site_desc GROUP BY state, crop ORDER BY 1, 2;

Manipulating the database

Example SQL functions to manipulate the PostGIS field database:

- Create a copy of an existing table
  CREATE TABLE fc_raw_backup AS SELECT * FROM fc_raw;
  INSERT into gcov_pub.fc_raw SELECT * from gcov.fc_raw;

- Change a column name
  ALTER TABLE photos RENAME COLUMN direction TO dir;

- Insert a row of values into a table
  1. landsat table
     INSERT INTO landsat VALUES
     ('13426837_2887273_20110416_1','13426837_2887273_20110416','1','LT51010802011085ASA00.tar.gz','0');

  2. photos table
     INSERT INTO photos (code,unique_obs,site_name,state,crop,name,transect,direction)
     VALUES
     ('10000000_1000000_20110101_g1','10000000_1000000_20110101','sitename','NSW','n','g1','00','00');

- Delete a row from a table
  DELETE FROM photos WHERE code='10000000_1000000_20110101_g1';ALTER TABLE photos DROP ROW yel

- Delete column (a whole table can also be dropped)
  ALTER TABLE table_name DROP COLUMN column_name

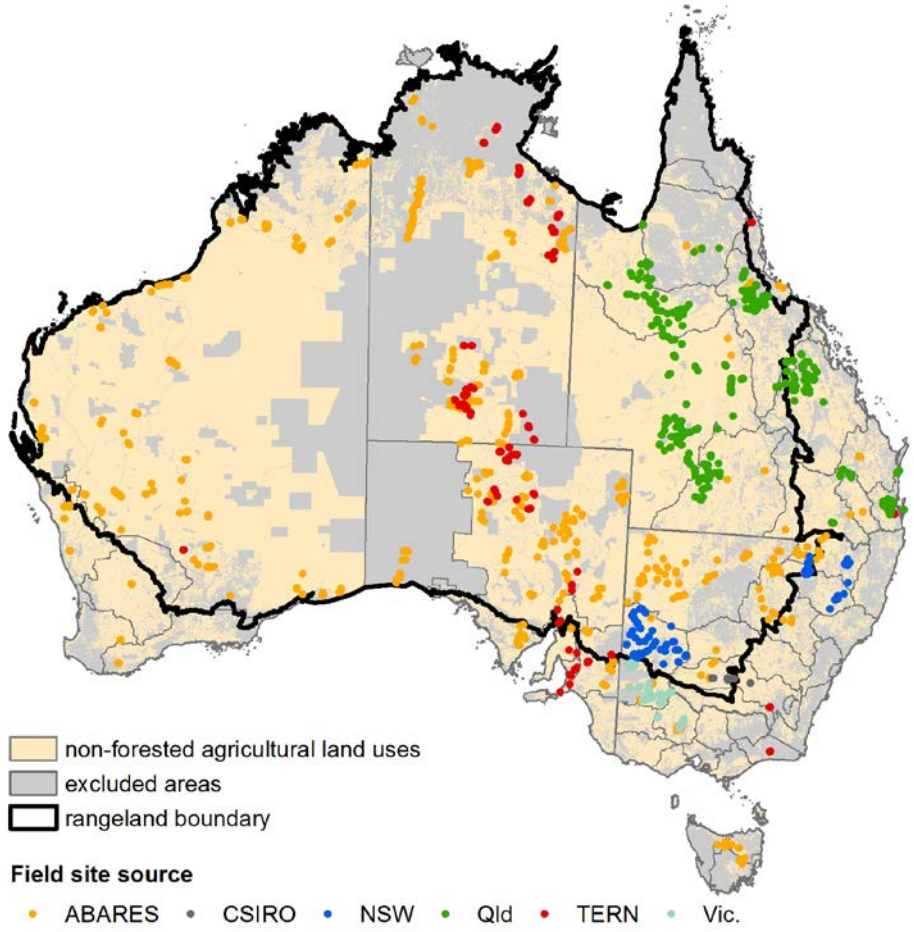
- Delete from a table based on an attribute in another table
  DELETE from gcov_pub.fc_raw WHERE unique_obs in (select unique_obs from gcov.site_desc where publish = 'No');

- Update data in a column based on an existing attribute
  1. Replace an existing value with a new one
     UPDATE exposed set "unique_obs" = '12172062_3086876_20101013' where "unique_obs" = '12172062_3086876_20101213';
  2. Add a new geometry location
     UPDATE sites_geom set geom = geomfromtext('Point (-36.836742 143.96555)' ,4326) where site_name = 'vic002';

Appendix A. Other fractional cover reference site data

The Australian ground cover reference sites database, as described in this user guide, contains only published data. Field observations of fractional cover which are unpublished or collected outside of the Ground cover monitoring for Australia project are also available to calibrate and validate fractional cover products derived from the Landsat and MODIS satellites. Appendix A describes the larger database of all 1714 observations from 1259 unique sites provided to ABARES as at August 2014. Map A1 shows the breakdown of these field sites by provider. Table A1 gives the total number of sites collected for the Ground cover monitoring for Australia project and by other sources. Table A2 provides the organisation and date of collection for site data delivered under the Ground cover monitoring for Australia project, while Table A2 gives the same information for the additional site data available for validation.

Map A1 Ground cover sites in the database (as at August 2014)



Note: Sources of sites data are: ABARES funded by Department of Agriculture through the Ground cover monitoring for Australia project; CSIRO Commonwealth Scientific and Industrial Research Organisation; NSW Lower Murray-Darling and Namoi Catchment Management Authorities; Qld Queensland Remote Sensing Centre; TERN Terrestrial Ecosystem Research Network AusCover Supersites and AusPlots (rangelands) sites; Vic. Victorian Department of Environment and Primary Industries.

Source*:* ABARES

Table A1. Total number of sites and observations

Source	Number of sites (observations)			
	Total	Rangelands	Intensive land use zone	Cropping
Ground cover monitoring for Australia	596 (643)	437 (441)	159 (202)	156
Other sources	422 (631)	277 (355)	145 (276)	0
Total	**1259 (1714)**	**935 (1169)**	**324 (545)**	**156**

Table A2. Number of sites and observations collected though the Ground cover monitoring for Australia project

		Data collected		Number of sites (observations)			
State	Source	Year	Month	Total	Rangelands	Intensive land use zone	Cropping
NSW	Training	2010	Nov	5	0	5	1
	OEH	2011	April, June, July	44	41	3	7
		2012	April, Aug, Oct	42	39	3	6
NT	Training	2011	May	5	5	0	2
	LRM	2011	Aug–Oct	36	36	0	0
		2012	Feb–Aug	68	68	0	0
		2014	May	9	9	0	0
Qld	DSITIA	2011	June–Sept, Nov	16 (17)	4	12 (13)	3
		2012	April–June, Oct	9 (13)	9 (13)	0	0
SA	Training	2010	July	6	4	2	2
	DEWNR	2011	April, May	39	34	5	7
		2012	March, April, Nov, Dec	55	48	7	8
		2014	May	9	9	0	0
Tas.	Training	2011	March, April	4	0	4	1
	DPIPWE	2011	Dec	2	0	2	0
		2012	June, Dec	18	0	18	12
		2013	Feb	1	0	1	0
Vic.	Training	2011	March	5	0	5	2
	DEPI	2012	Jan, Feb	22	0	22 (23)	15
	*	2012	Jan, Feb, April, May	15 (30)	0	15(30)	13 (23)
		2013	Jan	19	0	19 (20)	14 (15)
	*	2014	Jan, Feb, April, May	16 (41)	0	16 (41)	16 (40)
WA	Training	2010	Oct	9	6	3	3
	DAF	2011	May, July–Oct	50	43	7	7
		2012	June–Sept, Nov	83	73	10	2
		2014	June	9	9	0	0
			Total	**596 (643)**	**437 (441)**	**159 (202)**	**121 (156)**

Note: OEH NSW Office of Environment and Heritage; LRM NT Department of Land Resource Management; DSITIA Queensland Department of Science, Information Technology, Innovation and the Arts; DEWNR South Australian Department of Environment, Water and Natural Resources; DEPI. Victorian Department of Environment and Primary Industries (*71 extra observations were funded by DEPI); DAF Western Australian Department of Agriculture and Food. Source: ABARES

Table A3. Number of sites and observations collected by other sources

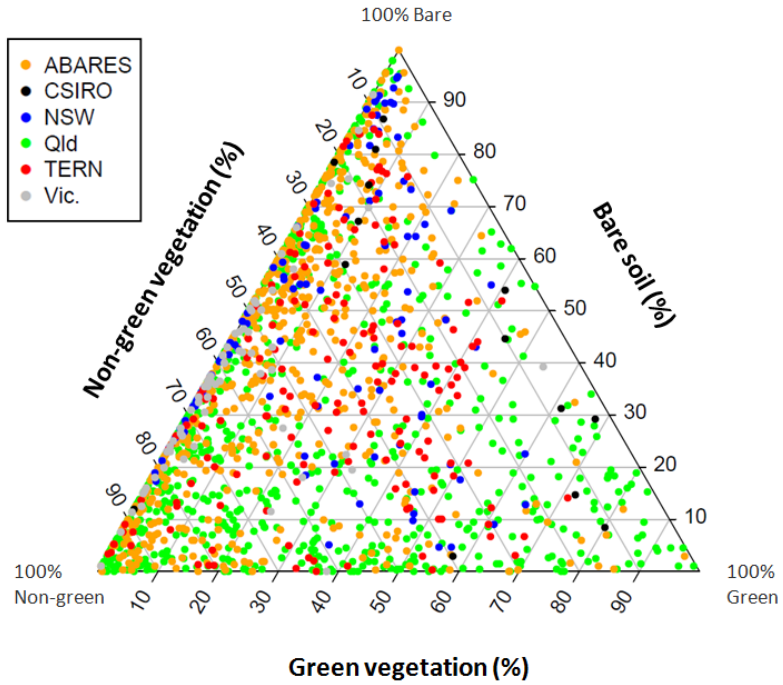
		Data collected		Number of sites (observations)			
Source	**State**	**Year**	**Month**	**Total**	**Rangelands**	**Intensive land use zone**	**Cropping**
RSC	Qld	1997	Feb, Sept, Oct	36 (53)	35 (51)	1 (2)	n/a
		1998	Feb	2 (50)	2 (48)	0 (2)	n/a
		2002	July, October	73	73	0	n/a
		2003	April	65	65	0	n/a
		2004	May, April, Oct, Nov, Dec	55 (94)	46 (78)	9 (16)	n/a
		2005	Jan, March, April, May, Aug–Nov	10 (105)	0 (58)	10 (47)	n/a
		2006	Feb, April–June, Aug–Oct	53 (105)	4 (35)	49 (70)	n/a
		2007	May	7	0	7	n/a
		2008	June, July, Oct–Dec	39 (66)	31 (52)	8 (14)	n/a
		2009	April, May, July–Oct	45 (55)	32 (34)	13 (21)	n/a
		2010	Feb–Dec	11 (61)	0	11 (61)	n/a
		2011	May–Dec	3 (46)	3 (5)	0 (41)	n/a
		2012	Jan, Feb	4 (9)	0	4 (9)	n/a
CMAs	NSW	2009	April, May	32	32	0	n/a
		2011	March–June	17 (37)	17 (37)	0	n/a
		2012	March–June	39	18	21	n/a
CSIRO	NSW	2010	Aug–Oct	13 (14)	12 (13)	1	n/a
AusCover	NSW	2010	Nov	1	0	1	0
	NSW	2011	Jan	4	0	4	0
	SA	2012	Jan, Feb	6	6	0	0
	Vic.	2012	April	5	0	5	n/a
	WA	2012	May	8	8	0	n/a
	Qld	2013	Jan, Feb	8	0	8	n/a
AusPlots	NT	2011	Sept–Dec	22	22	0	0
	NT	2012	Jan–Sept	57 (58)	57 (58)	0	0
	SA	2011	June	5	0	5	0
	SA	2012	June–Nov	43	35	8	0
			Total	**422 (631)**	**277 (355)**	**145 (276)**	**0**

Note: RSC Queensland Remote Sensing Centre; CMAs NSW Catchment Management Authorities; CSIRO Commonwealth Scientific and Industrial Research Organisation; Terrestrial Ecosystem Research Network AusCover Supersites and AusPlots (rangelands) sites.
Source: ABARES

Fractional cover observations

From the field observations of fractional ground cover the three fractions; bare soil, non-green (or non-photosynthetic) vegetation, and green (photosynthetic) vegetation can be calculated. The distribution of the fractional ground cover observations are shown in Figure A1. This tri-plot shows the spread of observations across the possible cover fractions. There are fewer observations with low (<10%) non-green vegetation in conjunction with high (>90%) bare soil, however this is likely to be a naturally rare combination.

Figure A1 Distribution of green vegetation, non-green vegetation and bare soil ground cover fractions across the field observations

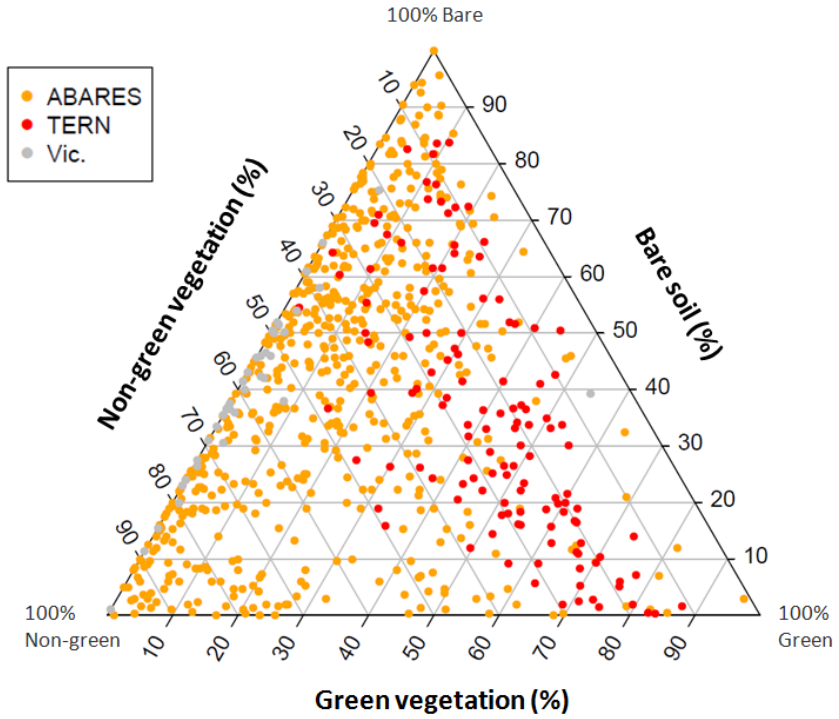


Note: Colours represent data source: ABARES funded by Department of Agriculture through the Ground cover monitoring for Australia project; CSIRO Commonwealth Scientific and Industrial Research Organisation; NSW New South Wales Lower Murray-Darling and Namoi Catchment Management Authorities; Qld Queensland Remote Sensing Centre; TERN Terrestrial Ecosystem Research Network AusCover Supersites and AusPlots (rangelands) sites; Vic. Victorian Department of Environment and Primary Industries. Number of observations is 1714.

Source: ABARES

Exposed fractional cover could be calculated for 741 of the total 1714 observations where the raw point intercept data was provided to ABARES, rather than just the summarised ground cover fractions. Exposed cover is an estimate of the first cover viewed by the satellite – overstorey when present, midstorey if no overstorey present and ground cover when no mid or overstorey. Exposed cover is shown in Figure A2.

Figure A2 Distribution of green vegetation, non-green vegetation and bare soil exposed cover fractions across the field observations



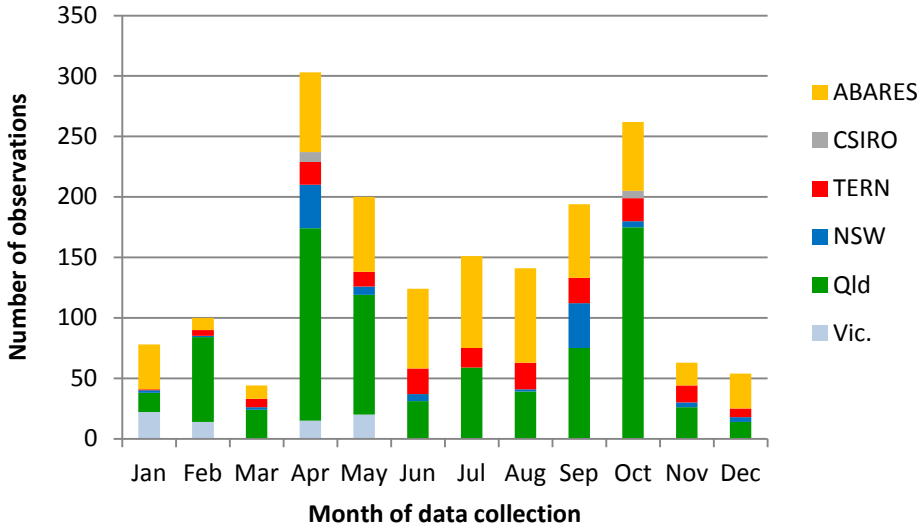
Note: Colours represent data source: ABARES funded by Department of Agriculture through the Ground cover monitoring for Australia project; TERN Terrestrial Ecosystem Research Network; Vic. Victorian Department of Environment and Primary Industries. Number of observations is 741.

Source: ABARES

Data collection

The number of observations collected in each month of the year, and for each year between 1997 and 2014, are shown at Figure A3 and A4. Observations have been collected throughout the year though data collection has tended to occur more during the months of April to October. The ABARES Ground cover monitoring for Australia project began in 2010 with a small number of training sites. The majority of observations were collected in 2011 and 2012. Prior to 2010, field observations were collected by the Queensland Remote Sensing Centre (now within the Department of Science, Information Technology, Innovation and the Arts) and by the New South Wales Lower Murray-Darling Catchment Management Authority.

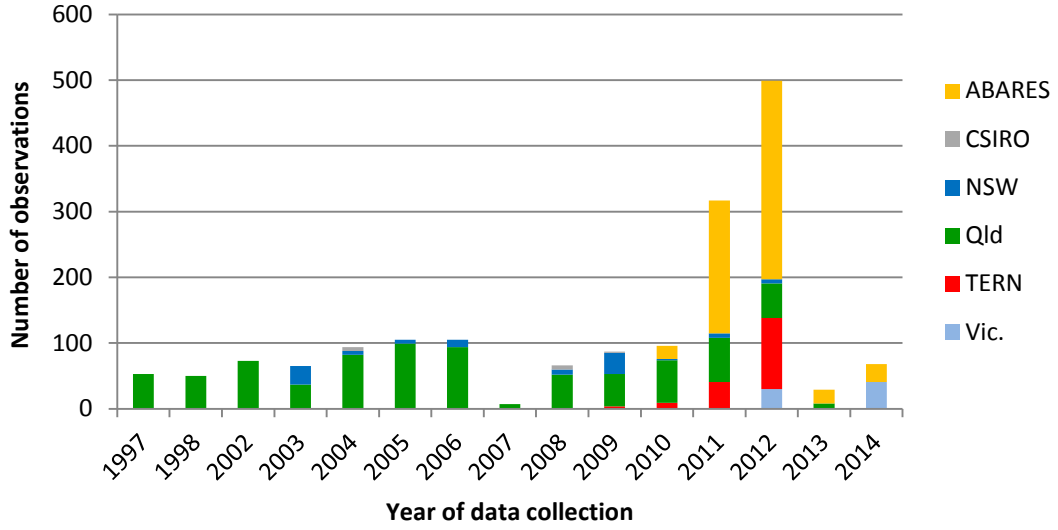
Figure A3. Data collection by month



Note: Colours represent data source: ABARES funded by Department of Agriculture through the Ground cover monitoring for Australia project; CSIRO Commonwealth Scientific and Industrial Research Organisation; NSW Lower Murray-Darling and Namoi Catchment Management Authorities; Qld Queensland Remote Sensing Centre; TERN Terrestrial Ecosystem Research Network AusCover Supersites and AusPlots (rangelands) sites; Vic. Victorian Department of Environment and Primary Industries.

Source: ABARES

Figure A4. Data collection by year



Note: Colours represent data source: ABARES funded by Department of Agriculture through the Ground cover monitoring for Australia project; CSIRO Commonwealth Scientific and Industrial Research Organisation; NSW Lower Murray-Darling and Namoi Catchment Management Authorities; Qld Queensland Remote Sensing Centre; TERN Terrestrial Ecosystem Research Network AusCover Supersites and AusPlots (rangelands) sites; Vic. Victorian Department of Environment and Primary Industries.

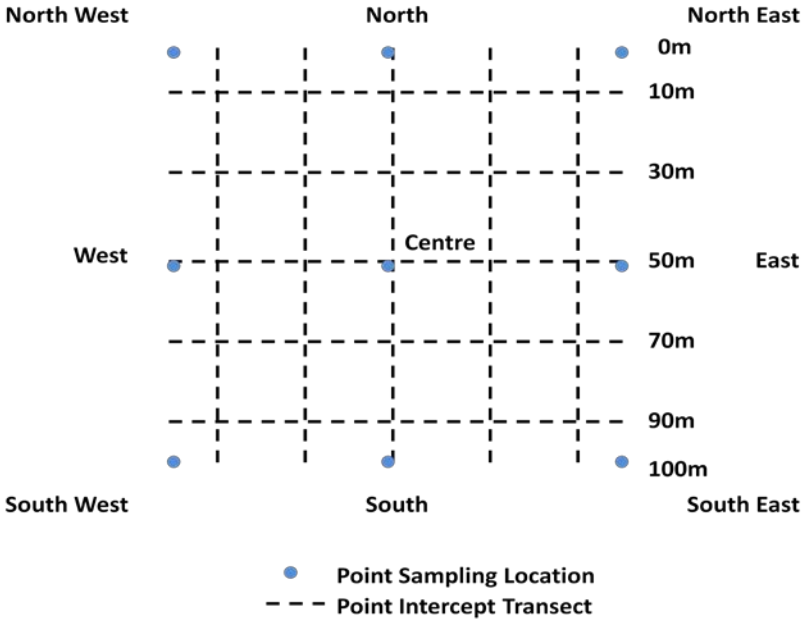
Source: ABARES

Appendix B. Translation of TERN AusPlots fractional cover reference site data

As at June 2014 TERN AusPlots (rangelands) had published data from 129 observations (128 unique sites) on the Soils to Satellite (http://www.soils2satellites.org.au) and AEKOS websites (http://www.portal.aekos.org.au/home). More observational data will be published. Appendix B describes the procedure used to translate the TERN AusPlots (rangelands) point intercept observations into vegetation cover fractions to use in calibration or validation of remotely sensed fractional cover.

The point intercept method adopted by TERN AusPlots (rangelands) includes a 100 metre by 100 metre grid of five north-south transects and five east-west transects resulting in 1010 points (White et. al. 2012) (Figure B1).

Figure B1. TERN AusPlots grid transect layout for rangeland environments



Source: White et al. (2012)

AusPlots (rangelands) transect measurements are different to the Ground cover monitoring for Australia protocol (Muir et al 2011) due to:

1. No separation of crust and disturbed soil—both are combined into bare
2. No distinction between green and dry attached vegetation (or branch)—vegetation is labelled as alive or dead
3. No strata distinction—all vegetation in the intercept is recorded by height rather than a single intercept for each strata of ground, mid and overstorey.

These differences are summarised in Table B1.

Table B1. Cover fractions collected by Ground cover monitoring for Australia and AusPlots (rangelands) protocols

	CRUST	DISTURBED	ROCK	GREEN LEAF	DRY LEAF	LITTER	CRYPTOGAM	<2M GREEN LEAF	<2M DRY LEAF	<2M BRANCH	IN CROWN	>2M GREEN LEAF	>2M DRY LEAF	>2M BRANCH
GCM4A	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0
AusPlots	Bare Y/N		Outcrop gravel rock	Alive / dead + growth form + height		Y/N	Y/N	Alive / dead + growth form + height			In Canopy sky	Alive / dead + growth form + height		

Note: GCM4A Ground cover monitoring for Australia project.

Source: ABARES derived from Muir et al. (2011) and White et al. (2012).

To derive the exposed and ground cover fractions from the AusPlots (rangelands) data the following steps were applied. Note that "Green" describes green or photosynthetic vegetation and "Brown" describes non-green or non-photosynthetic vegetation including litter, dry leaf or branch.

1. Extract data
   AusPlots tables: studyLocationDetails + studyLocationVisitDetails + pointIntersectVegetationSpecies are linked using a sampling unit ID code e.g. 21503.
   From the pointIntersectVegetationSpecies table extract the following fields for each site:
   a. TRANSECT
   b. POINT
   c. DEAD
   d. GROWTHFORM
   e. HEIGHT
   f. HERBARIUMDETERMINATION
   g. INCANOPYSKY
   h. SUBSTRATE

2. Sort data by TRANSECT, then POINT, then HEIGHT decreasing

3. Insert column TRANSECTPOINT to create a single identifier.
   FORMULA =TRANSECT&"."&POINT

4. Insert column FRACTIONSUBS
   This column determines whether the substrate at each point is bare soil (bare) or non-green vegetation (brown). Brown = litter or coarse woody debris (CWD), Bare = bare, cryptogram, rock, gravel or outcrop, NC = Not collected (substrate not visible under vegetation)
   FORMULA =IF(OR(SUBSTRATE="Litter", SUBSTRATE="CWD"),"Brown", IF(OR(SUBSTRATE="Bare", SUBSTRATE="Crypto", SUBSTRATE ="Rock", SUBSTRATE ="Outcrop", SUBSTRATE ="Gravel"),"Bare", SUBSTRATE))

5. Insert column EXPOSED
   This column calculates the cover fraction for each row. Where there is vegetation the exposed value is the colour of vegetation (green or brown) and where there is no vegetation the exposed value is the substrate fraction (brown or bare).
   FORMULA = IF(AND(GROWTHFORM<>0,DEAD="FALSE",INCANOPYSKY="FALSE"), "Green",IF(AND(GROWTHFORM<>0,DEAD="TRUE",INCANOPYSKY="FALSE"),"Brown", FRACTIONSUBS))
   Explanation: When the vegetation growth form does not equal zero and the vegetation is not dead and it is not in the canopy with sky visible, then the cover fraction is 'Green' (green vegetation). Otherwise if the growth form does not equal zero and it is dead and it is not in the canopy with sky visible then the cover fraction is 'Brown' (non-green vegetation). Otherwise take the substrate fraction.

6. Ignore duplicate rows so only one cover value is provided for the tallest observation for each TRANSECTPOINT.
   Insert a column EXPOSED_IGNORE. If the row has the same identifier (TRANSECTPOINT) as the row above, or if the cover was not collected 'NC', it is labelled 'ignore'.
   FORMULA
   =IF(OR(TRANSECTPOINT=precedingTRANSECTPOINT,EXPOSED="NC"),"Ignore", EXPOSED)

7. Calculate the exposed cover fractions
   Take the sum of each fraction in the EXPOSED_IGNORE column as a percentage of the total number of points excluding the 'ignores'.
   TOTAL=COUNTIF(EXPOSED_IGNORE<> "Ignore")
   SUMBARE=COUNTIF(EXPOSED_IGNORE, "Bare")
   FRACTIONBARE=(SUMBARE/TOTAL)*100

8. Calculate the ground cover fraction
   Add a column GROUND_VEG. This answers 'Y' if GROWTHFORM at each point is a ground cover growth form or 'N' if it is not. Ground cover growth forms are: Hummock grass, Tussock grass, Fern, Forb, Sedge or Vines less than 1m height.
   FORMULA =IF(OR(GROWTHFORM="Hummock grass", GROWTHFORM="Tussock grass", GROWTHFORM="Fern", GROWTHFORM ="Forb", GROWTHFORM ="Sedge", (AND(GROWTHFORM ="Vine",HEIGHT<1))),"Y","N")

9. Add column ROWORDER
   This column indicates the row with the tallest cover for each transect point. This first row is given a value of 1.
   FORMULA =IF(TRANSECTPOINT=precedingTRANSECTPOINT, 1+precedingROWORDER,1)

10. Join TRANSECTPOINT with GROUND_VEG
    This provides an identifier to show if there is ground cover vegetation at each point. For example, E2W2.1Y means there is ground cover vegetation at the row for transect E2W2 point 1.
    FORMULA =TRANSECTPOINT&GROUND_VEG

11. Add column PNT&Y
    This is a reference column for each transect point. This is 'transectpointY'. This is used to look for ground cover vegetation in all other transect points.
    FORMULA =TRANSECTPOINT&"Y"

12. Add column GCPERPOINT
    This column indicates if ground cover vegetation is present at each point by counting Yes values in the column PNT&GC.
    FORMULA =COUNTIF(PNT&GC: PNT&GC,PNT&Y)

13. Add column GCROW
    GCROW determines whether a row contains ground cover vegetation and if it is the first (or tallest) ground cover vegetation recorded at that TRANSECTPOINT. This assigns a value of 0 for non ground cover rows a value of 1 for the first ground cover row for each TRANSECTPOINT and 2 for subsequent rows.
    FORMULA=IF(GROUND_VEG="N",0,IF(COUNTIF(PNT&GCtop:PNT&GCpreceding, PNT&GCcurrent)>0,2,1))
    Explanation: When the row does not contain a ground cover growth form it is given a value of 0. If the count of all rows above which match the current row is greater than 1 give a value of 2. Otherwise the row is the first row that contains a ground cover value and is given a value of 1.

14. Add column TRANSECTPOINT1
    This column copies TRANSECTPOINT for the first (tallest) ground cover at each TRANSECTPOINT and leaves duplicates as 0.
    FORMULA=IF(AND(GCPERPOINT=0, ROWORDER=1),TRANSECTPOINT, IF(GCROW=1,TRANSECTPOINT,0)).
    Explanation: When there is no ground cover vegetation for this transect point, and it is the first row for the transect point, copy the transect point value. If this is the first ground cover growth form for the transect point copy the transect point value. Otherwise the row is a duplicate and is given a value of 0.

15. Add column GC_COLOUR which provides the ground cover fraction.
    If there are no rows for a transect point which have ground cover vegetation it takes the substrate. If the ground cover vegetation is not dead (i.e. dead = FALSE) it is assigned to 'Green' otherwise to 'Brown'.
    FORMULA =IF(GCPERROW=0,FRACTIONSUB,IF(DEAD="FALSE","Green","Brown"))

16. Calculate the ground cover fractions
    Filter to exclude all data where TRANSECTPOINT1 = 0.
    Take the sum of each remaining fraction in the GC_COLOUR column as a percentage of the total number of points.
    TOTAL=COUNTIF(TRANSECTPOINT1<> 0) SUMBARE=COUNTIF(GC_COLOUR, "Bare")
    FRACTIONBARE=(SUMBARE/TOTAL)*100

These rules were developed in discussion with the producers of the remotely sensed fractional cover products and TERN representatives. All TERN AusPlots (rangelands) measurements are likely to underestimate the non-green vegetation fraction as there is no distinction between dry leaf, green leaf and branch. The AusPlots interpretation of growth form into ground cover may also vary to the protocol of Muir et al. (2011). Cover fractions are currently displayed differently on the Soils to Satellite website (http://www.soils2satellites.org.au due to the ABARES calculation including cryptogam in the bare soil fraction as described in Muir et al (2011). Cryptogam can be photosynthetic or non-photosynthetic vegetation and has been included in green fraction of the TERN calculations.

The differences between the TERN AusPlots (field) and AusCover (remotely sensed) cover fractions shown on the Soils to Satellite website are from differences between the date of field data collection and the date of the displayed imagery; which is a single image for Australia (B. Sparrow per comm. 2014). It is expected that imagery closer to the date of field site collection may be displayed in the future.

Acronyms

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AEKOS	Australian Ecological Knowledge and Observation System
ALUM	Australian Land Use and Management classification
CMAs	Catchment Management Authorities
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAF	Western Australian Department of Agriculture and Food
DEPI	Victorian Department of Environment and Primary Industries
DEWNR	South Australian Department of Environment, Water and Natural Resources
DPIPWE	Tasmanian Department of Primary Industries, Parks, Water and Environment
DSITIA	Queensland Department of Science, Information Technology, Innovation and the Arts
GDA94	Geocentric Datum of Australia 1994 grid coordinate system for Australia
GPS	Global Positioning System
LRM	Northern Territory Department of Land Resource Management
MGA94	Map Grid of Australia (standard revised 1994) projection
MODIS	Moderate Resolution Imaging Spectroradiometer
OEH	New South Wales Office of Environment and Heritage
RSC	Remote Sensing Centre (now part of Queensland DSITIA)
SQL	Structured Query Language
TERN	Terrestrial Ecosystem Research Network
UTM	Universal Transverse Mercator projection
WGS84	World Geodetic System (standard revised 1984) projection

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