Standardised vegetation survey and monitoring data across the Australian rangelands from TERN AusPlots

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Abstract. Robust ecosystem monitoring to report on condition and trajectory in rangelands requires precise and objective measurements of indicators linked to climate and disturbance regimes. TERN AusPlots provides systematic monitoring data at continental scale, enabling comparisons of metrics like vegetation cover and structure or species diversity. Here we present the first collated AusPlots dataset and overview the sampling of environments (e.g. a rainfall gradient of 129–1437 mm Mean Annual Precipitation) and vegetation. Over 3,000 vascular plant taxa in 22 major vegetation types including savanna, eucalypt woodland, chenopod shrubland and grassland have been recorded in these 442 field plots. The core field module of AusPlots is a point intercept survey, which records substrate, plant species, growth form and height at each of 1010 intercepts located along 10 transects arranged in a grid within 1 ha plots. Comprehensive plant species diversity is also recorded through systematic vouchering and formal identification, making the data robust to identification error and taxonomic change. Standardised and quantitative data combined with open access data publication via AEKOS, plus a broad spatial scope, make this a useful dataset for applications such as analysis of vegetation cover (by species, growth form or fractional cover) and species composition modelling. The data are already being used to validate remotely sensed information, including fractional cover products and estimates of tree and forest cover in drylands based on visual interpretation of satellite imagery. Data are available in raw as well as more processed or summarised formats.

The AusPlots data story

Rangeland and desert ecosystems are heterogeneous and dynamic, driven by both natural and human influences. The diversity, structure and condition of vegetation in the Australian rangelands is expected to change in relation to climate variability and change, grazing and fire regimes, salinity and presence of invasive species (Wardle et al. 2013). In order to track these changes and to provide reliable information for decision-makers and environmental reporting, we need a systematic means to record, compare and monitor key attributes of vegetation and soil that relate to ecosystem function and health and that are likely to respond to land use and climate drivers (Sparrow et al 2014).

TERN AusPlots provides site-based data on vegetation condition in the rangelands that incorporates traditional survey techniques, such as flora species inventories, as well as newer technological approaches, such as 3D photo-points and soil metabarcoding (White et al. 2012). The photo-point method takes panoramas from three points using a 360-degree sweep of overlapping photographs, which can be analysed to measure 3D vegetation structure. Soil metabarcoding is an emerging technique that can identify soil microbial communities and the diversity of their functional genes by sequencing environmental DNA from dried topsoil samples. The application of the well-described AusPlots method minimises subjective interpretation and allows continental scale comparisons because methods and data delivery are standardised across jurisdictions (White et al. 2012). Samples are archived for later re-use and field data collected on a tablet, transferred through a staging database and ultimately published open access through the TERN AEKOS data portal (www.aekos.org.au; Tokmakoff et al. 2016). Data are also available from the 'Soils to Satellites' portal (http://soils2sat.ala.org.au).

A core component of the AusPlots vegetation survey is an objective point-intercept method that records plant species, growth form, height and substrate at 1,010 points within one hectare plots. Point-intercepts provide robust estimates of cover by plant species or growth-form that can be used as abundance weights for species in compositional analysis (Baruch et al. 2015). The precise estimation of cover can also be used to compare communities that are floristically distinct via patterns of species' relative abundance (Fig. 1), an attribute of plant communities that may be a useful indicator relating to climate and disturbance regimes. Rank species abundance can be assessed visually in Whittaker plots, or modelled using the Pareto, log-normal or other distributions, where models can be compared by plotting and comparison of coefficients (Guerin et al. 2017).

The AusPlots dataset continues to grow, surpassing 500 plots throughout Australia (TERN AusPlots 2013; Fig. 2). The first 442 plots were compiled to compare measures of vegetation cover and diversity and assess sampling of continental environmental gradients (Guerin et al. 2016; Guerin et al. 2017). These sites span a mean annual rainfall gradient of 129–1437 mm over mediterranean, desert and monsoonal climate regions. Over 3,000 vascular plant taxa were recorded in 22 major vegetation types including savanna, eucalypt woodland, chenopod shrubland and grassland. Ideally, plots will be resampled every 5–10 years.

Applications

The precise, quantitative open access data available and the continental sampling coverage make AusPlots useful for many applications including vegetation ordination, species composition modelling that can make use of systematically recorded absences, and mapping of key functional attributes. For example, 'fractional cover', the proportion of bare ground, 'green' photosynthetically active vegetation and 'brown' non-photosynthetically active vegetation, can be calculated from AusPlots by processing point-intercepts (Fig. 3). Fractional cover can be used to compare functional responses to disturbance or climatic variation and to validate remotely sensed products.

AusPlots were used to estimate measurement error in an assessment by Bastin et al. (2017) of forest cover across the global drylands. Bastin et al. (2017) used visual interpretation of Very High Resolution satellite imagery through the CollectEarth software to map forest cover as part of the Global Drylands Assessment, coordinated by the Food and Agriculture Organization of the United Nations. Tree cover estimates were compared between satellite image interpretation and field-based point-intercept data at AusPlots sites, as were the proportion of sites that were classified as forest based on a standard definition of greater than 10% cover of trees over 5 m high. Comparison with AusPlots showed that the error rate was acceptably low, with differences in classification typically occurring when tree cover was close to the 10% cut off. The root-mean-square difference in tree cover estimates between CollectEarth and AusPlots was 8% (Fig. 4). While this suggests CollectEarth is a valid method of mapping tree cover, the AusPlots field truthing provided crucial information on measurement error that is carried into further calculations, such as the area of land covered by drylands forest. The global dataset compiled by Bastin et al. (2017) that was validated by AusPlots showed that forests covered 40–47% more land in global drylands than previously mapped, including a high proportion of closed canopy forest. These previously unmapped forests were enough to increase the global estimate for cover of all forests by a whopping 9%.

Baruch et al. (2015) used 351 AusPlots to assess rangelands floristic and structural diversity. Vegetation clusters representing floristically similar plots in Mediterranean, Savanna and Desert systems were described by species richness, diversity and vegetation structure. They used ordination techniques to relate floristic composition in plots to environmental variables, finding that aridity, rainfall, temperature, seasonality, soil nitrogen and pH were the most related to composition. With sufficient sampling, this approach on AusPlots data could contribute to a next-generation classification system for Australian rangelands vegetation communities. The standardised method of Auplots along with robust measures of cover for species and growth-forms enables such comparisons of communities across Australia.

Conclusions

AusPlots is a successfully established method for standardised, objective ecological surveillance monitoring. Open access data are available from over 500 sampling sites (raw data) and processed static data are currently available for 442 sites that include site information and extracted environmental data, compiled detailed information on species and growth-forms within each plot, and a processed species cover against sites matrix for ecological analysis. The raw and processed data are useful for applications in vegetation science, species distribution modelling and environmental reporting.

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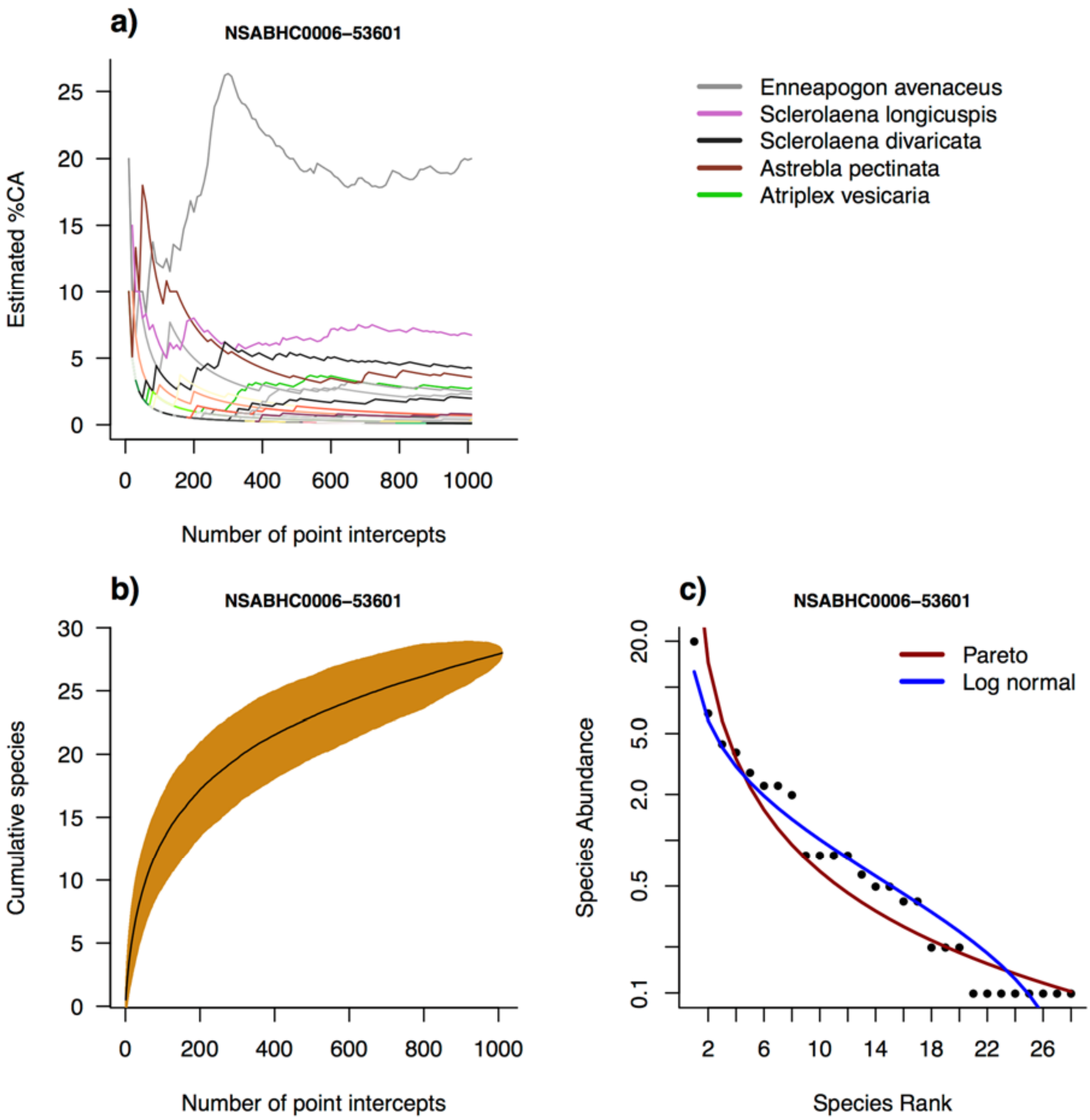

Fig. 1. Example of vegetation sampling for AusPlots site NSABH0006-53601 (Guerin et al. 2017)**:** (a) Cumulative cover abundance (%CA) for species with point-intercepts. Cover estimates stabilise with point-intercept sampling, which means they are robust for repetition and comparison. The five most abundant species recorded are labelled; (b) Species accumulation curve with point-intercepts; (c) Rank Abundance Distribution shown as a Whittaker plot with fitted Pareto and Log-normal models to quantify the shape of the distribution, which can be used to compare floristically distinct plant communities and has potential as an ecological indicator.

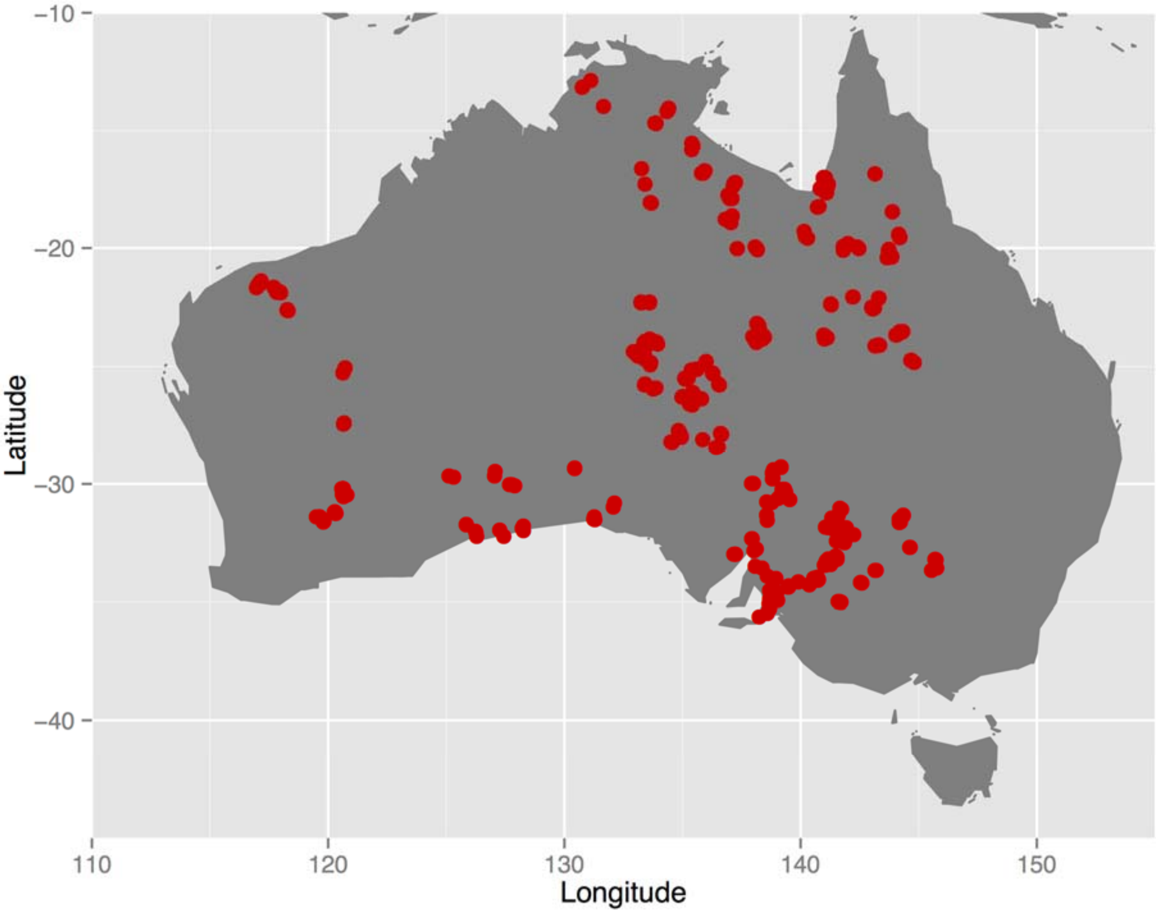

Fig. 2. Location of the 442 AusPlots across Australia compiled by Guerin et al. (2017).

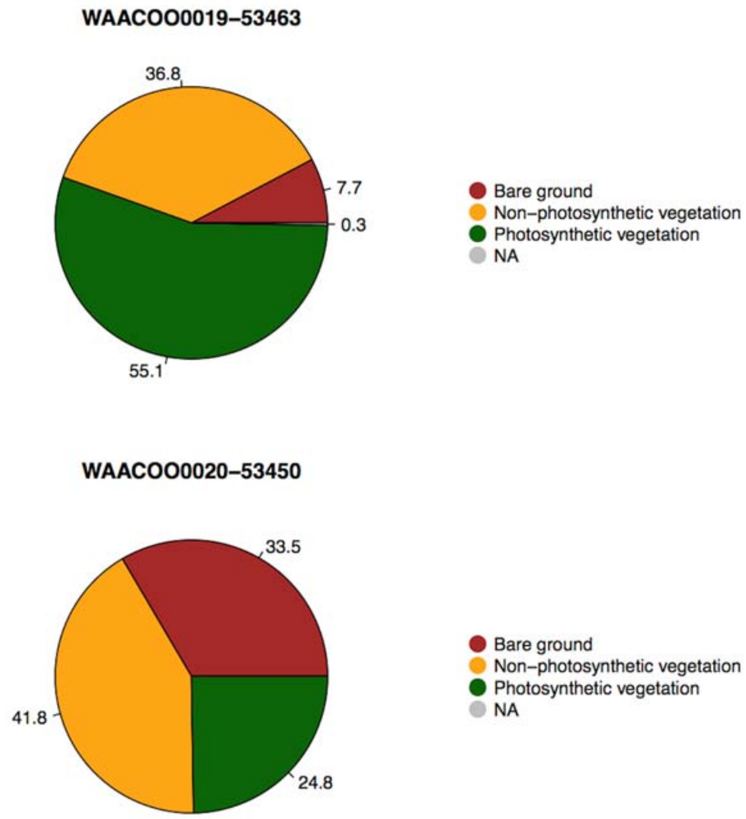

Fig. 3. Example application of TERN AusPlots data to calculating 'fractional cover' (the proportional cover of bare ground versus 'green' photosynthetic and 'brown' non-photosynthetic vegetation) for two AusPlots sites, which can be used to validate remotely sensed products and is a key functional attribute with links to climatic and disturbance regimes.

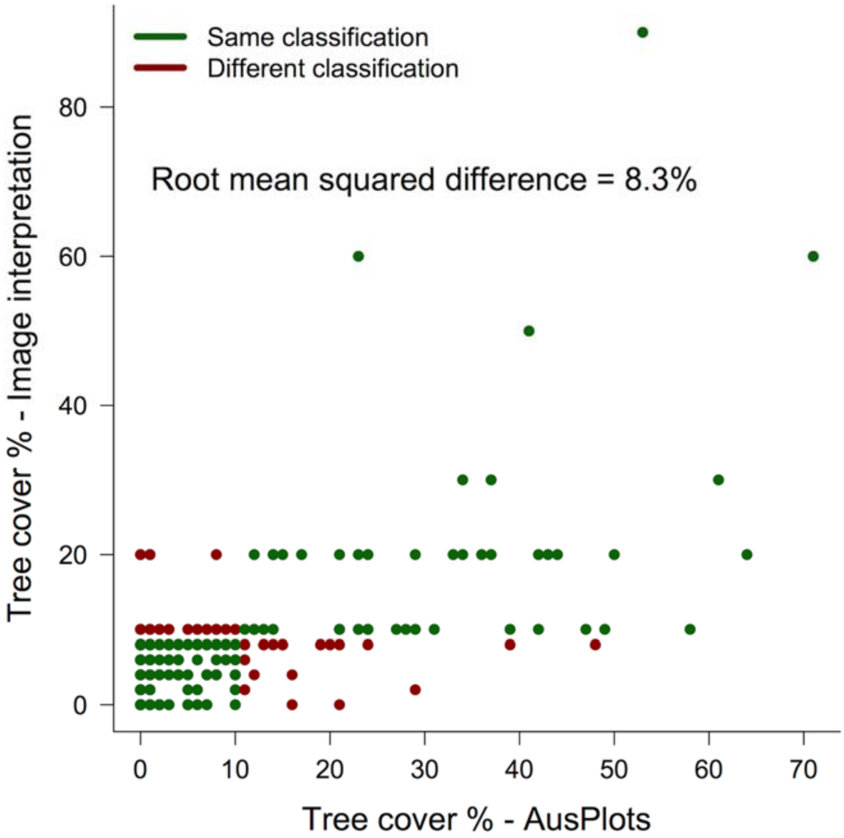

Fig. 4. Application of TERN AusPlots data to an accuracy assessment for tree cover estimates and forest classification from 'CollectEarth' (Very High Resolution satellite image interpretation) as part of the Global Drylands Assessment of the United Nations FAO. Bastin et al. (2017) reported an increase in known forest stands in global drylands of 40-47%, with field validation and assessment of uncertainty from AusPlots.