Supplementary Material – S1

Additional figures S1-S5: *AusPlots* locations in relation to the rangelands, bioregional boundaries, major vegetation groups and agroclimatic zones. Schema of the *AusPlots* dataflow system.

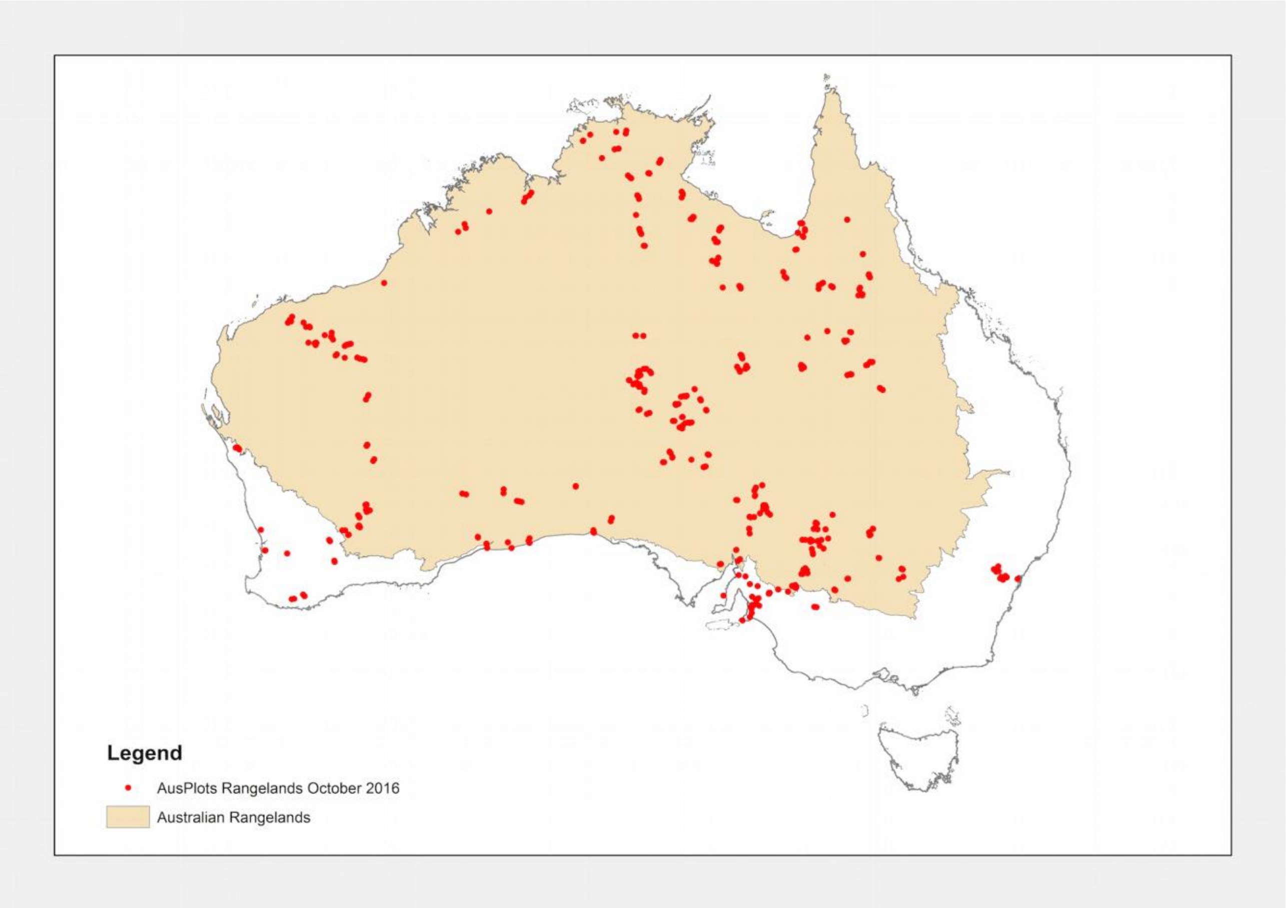

Fig. S1. *AusPlots* site locations in the context of the Australian rangelands boundary.

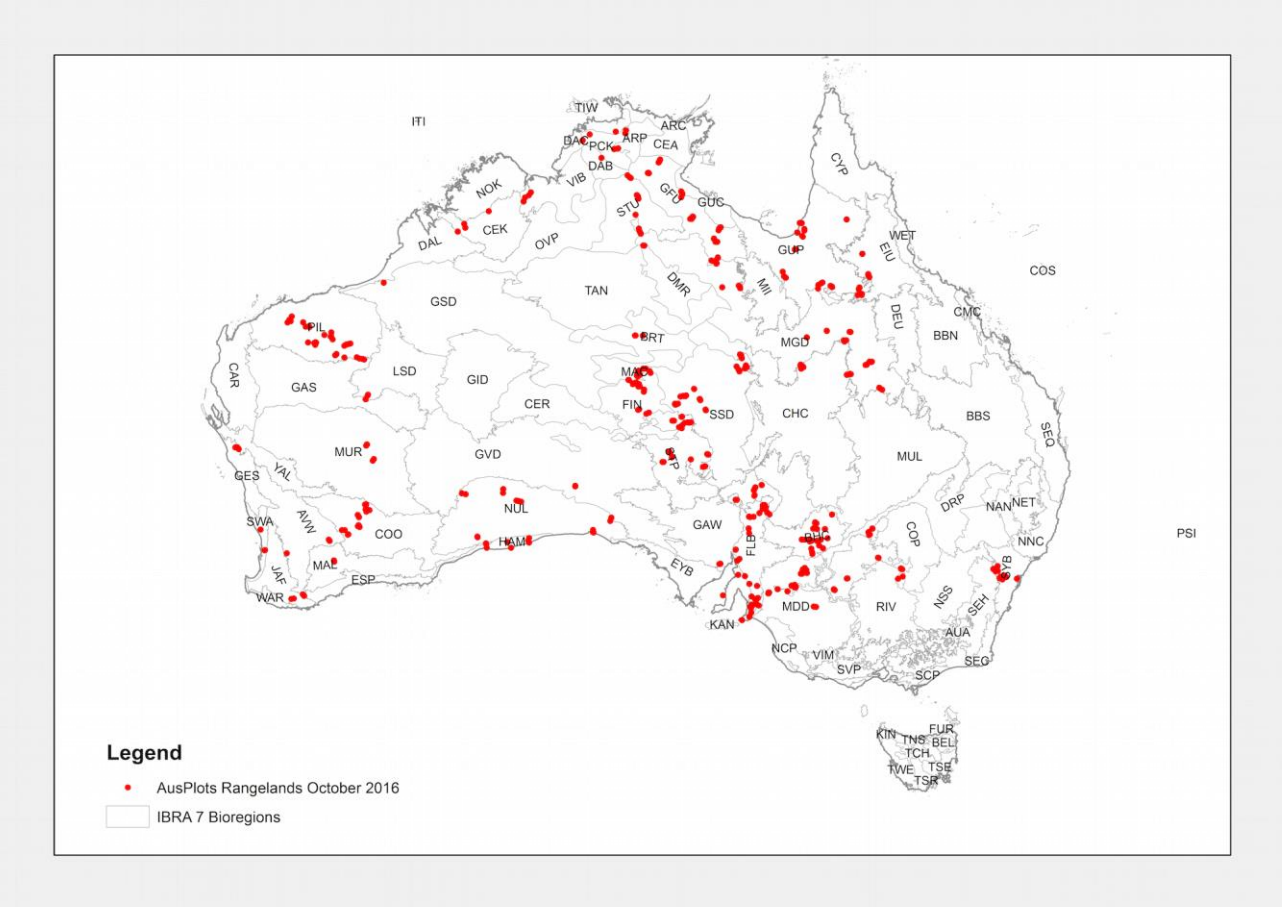

Fig. S2. *AusPlots* site locations in the context of the Australian bioregional boundaries (Interim Bioregionalisation of Australia v7).

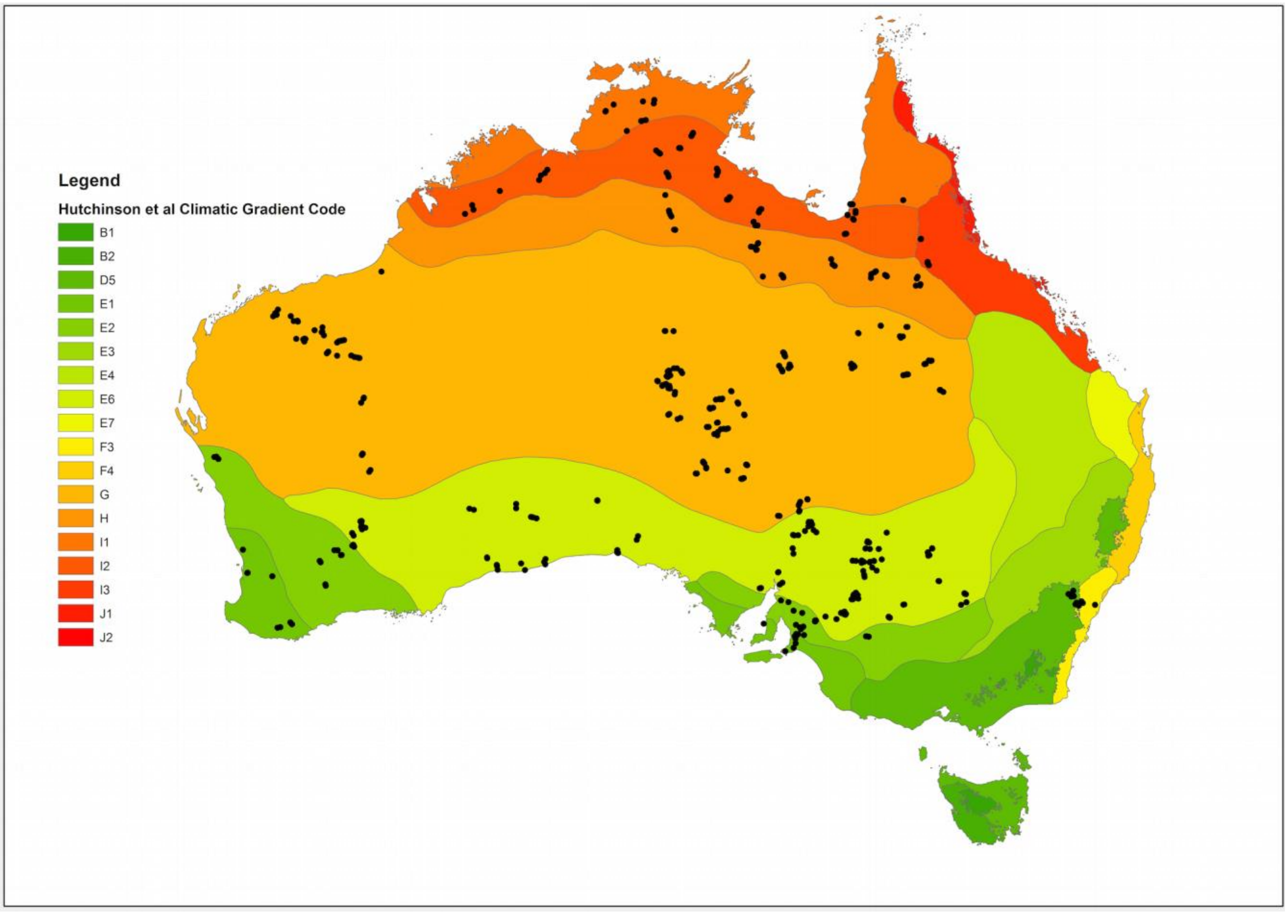

Fig. S3. *AusPlots* site locations in the context of Hutchinson's agroclimatic zones.

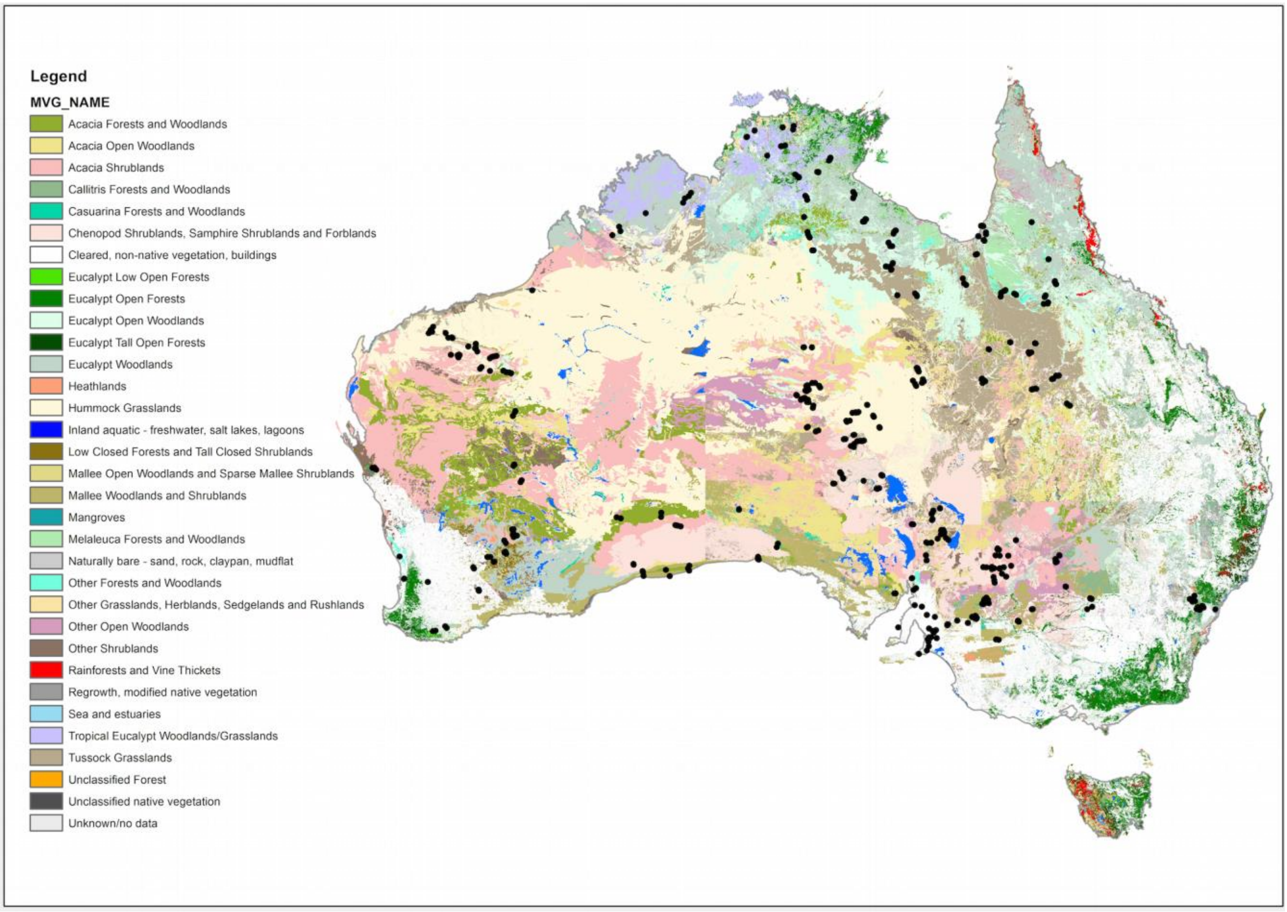

Fig. S4. *AusPlots* site locations in the context of Major Vegetation Groups.

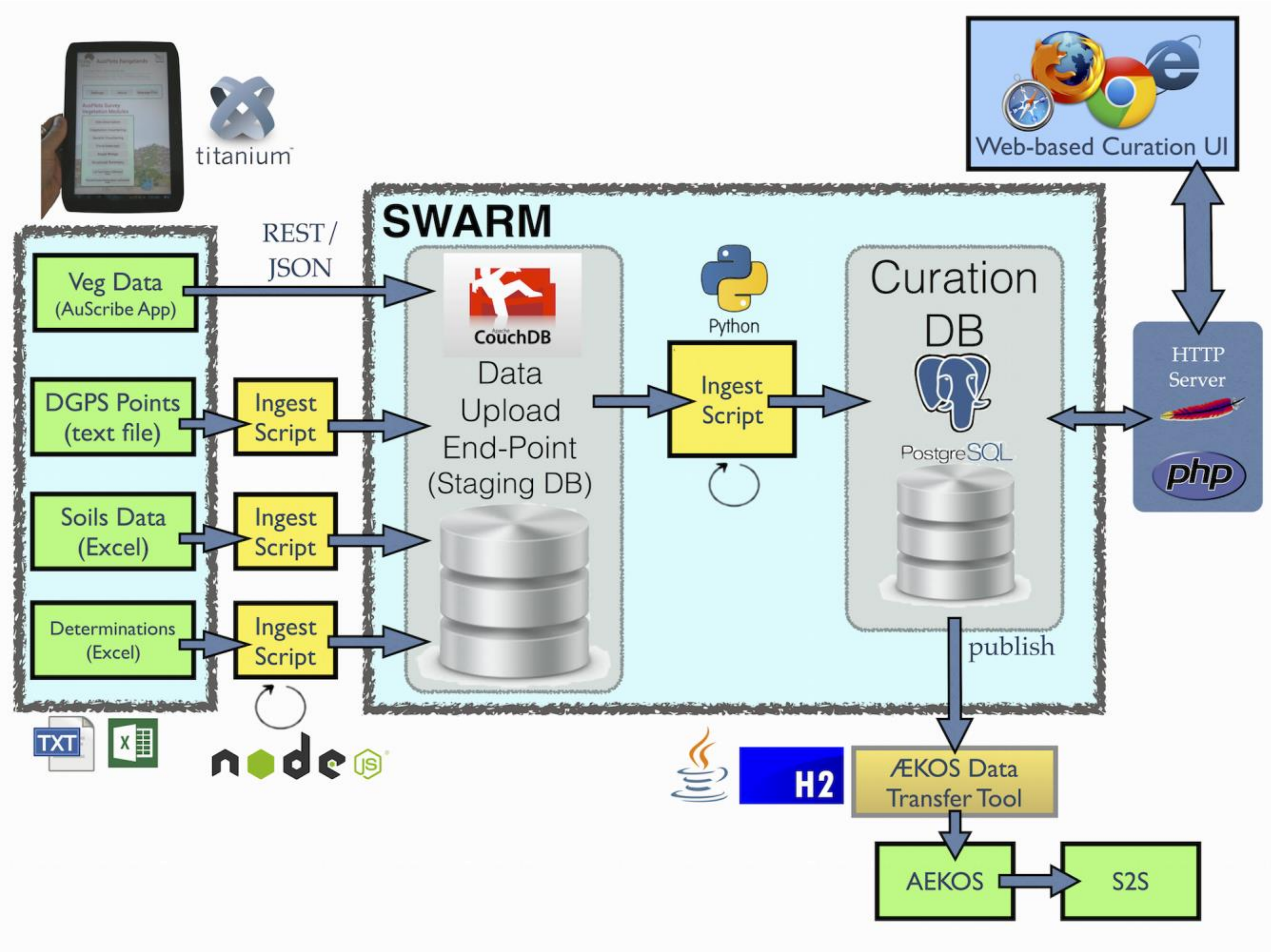

Fig. S5. Schema of the *AusPlots* data system design and workflow, illustrating the flow of data from collection at field monitoring plots to publication. SWARM ingests and integrates a set of *AusPlots* data types that are collected in various data formats. The data are 'pulled together' into a unified relational schema that allows a unified view on the collected *AusPlots* data, thereby facilitating curation (via a web-based tool) and publication via the AEKOS data transfer tool.

Supplementary Material – S2

Additional acknowledgements

TERN Surveillance Monitoring Program would like to acknowledge the following people and organisations for their input to developing the method detailed in this paper, either by contributions at workshops, collaborative research or providing critique on our draft methods.

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Christina MacDonald, Ian Fox, Richard Flitton and Sally O'Neill contributed significantly to method development and creation of the *AusPlots* Program.

Supplementary Material- S3

Box 1. Designing a continental-scale plot network.

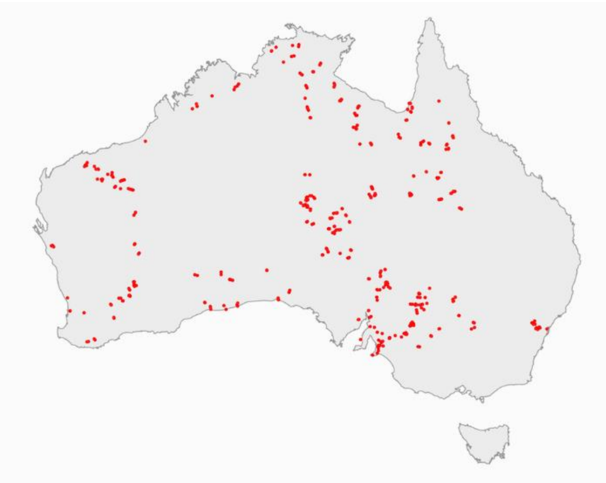
AusPlots Rangelands

A new surveillance monitoring capability, TERN's Ecosystem Surveillance Platform (which includes the former *AusPlots Rangelands program)*, was created by the Australian Terrestrial Ecosystem Research Network (TERN) to address the critical need for a continental-scale network of plots, initially focused on vegetation and soils. The *AusPlots Rangelands* program was designed to establish a baseline and monitoring method to enable quantification of trends in rangeland ecosystems and inform on the effectiveness of management interventions. Information on plant diversity and vegetation structure collected using standardized protocols can inform our understanding of system productivity and sustainable management (Morton *et al.* 2009).

Consultative process

The methodology was developed following three years of negotiations with over 200 scientists, land managers and policy makers from Australian state and federal government agencies, universities and land management groups. Soil protocols were informed by discussion with representatives on the Australian National Committee for Soil and Terrain.

(a)



(a) Program rollout

AusPlots has established a network of over 550 plots across Australia– the first methodologically consistent biodiversity survey and monitoring program instituted across rangelands jurisdictions (Appendix S1). Floristic data have identified undescribed species and range extensions, evidence that *AusPlots* is filling knowledge gaps. Central field teams establish plots across the continent, complemented by teams from local agencies. Teams comprise three to six personnel that take one-half to two days to complete a plot. Plots are also established by trained third parties who return data to a central database.

Data collection and publication

Vegetation data are recorded directly into the 'AuScribe' mobile tablet application and are subsequently uploaded to the SWARM ('Staging Warehouse for AusPlots Rangelands Monitoring') staging database (Tokmakoff *et al.* 2016; Fig. S5 in Appendix S1). SWARM provides a web-based curation facility which allows for effective and rapid data management prior to site data being published to external data repositories including AEKOS (www.aekos.org.au) . Data are made freely available under creative commons licensing.

Extensions

AusPlots recently developed monitoring protocols for woodlands to bridge the gap between rangelands and forests protocols (Wood *et al.* 2015). Protocols targeting condition and fauna are in development (http://www.ausplots.org).

Program structure

TERN provides ecological research infrastructure in the form of landscape, surveillance and targeted high-intensity monitoring along with advanced data management, delivery and synthesis capability to the Australian ecosystem science community and public, to address pressing environmental issues challenging the nation (Karan *et al.* 2016).

Supplementary Material – S4

Box 2. Guiding principles for the development of a robust surveillance monitoring methodology.

1. Widespread consultation is essential.

Developing a surveillance monitoring framework for a diverse set of habitats builds upon previous learnings and review of methods already employed in individual regions. A model we found successful was to seek input from experts and follow with widespread consultation across the ecosystem science community. Workshops can then be held to refine particular components and reference groups convened to provide peer-review and guidance during development. Stakeholder groups should be regularly updated, engaged to review and refine proposed methods and provide comment on the pragmatic deployment of methods.

2. Providing a robust baseline from which to detect subsequent change.

A fundamental imperative for creating a monitoring method is the generation of a robust baseline against which ecosystem change can be measured and be sensitive enough to detect relatively small changes. Describing methods in detail ensures they can be accurately reproduced by ecologists with access to a manual and field equipment (White *et al.* 2012a). A long-term surveillance monitoring framework needs to be robust to taxonomic change, thus vouchering and long-term archiving of specimens is critical. It is not always possible to anticipate how practitioners will use data (Burton *et al.* 2014; Bayne *et al.* 2015), therefore subjective data should be minimised hence our framework focuses on high quality, objective data supported by physical samples. This approach allows data to be summarised according to users' analytical needs, whilst maintaining underlying raw data for other end-uses. Quantitative data increase temporal and spatial robustness and enhance change detection.

3. Modular design provides flexibility.

Modular sampling allows components to be implemented separately or in concert. Modularity enables different tasks to be assigned to individuals within a field team and flexibility enables greater uptake of data collection by third parties. The only mandatory module is site establishment. A practitioner implementing part of the method can collect data for those modules they require, and exclude others. Selectively collected modular data are published and analysed alongside data of the same type. Some modules have dependencies, such as the point-intercept module relying on completion of vouchering. Modularity permits a wider group of practitioners to implement the method and benefit from data management pathways.

4. Training and coordination are needed for implementation.

Each field team should comprise, as a minimum, a proficient field botanist capable of discriminating between different plant species and a competent soil scientist and a field technician. With more members, field teams are more efficient with teams of six working well. Field training enhances the pool of expertise.

5. Data and sample management protocols are essential.

To ensure efficient workflow from field to database, all samples such as plant vouchers and tissues are assigned a unique barcode label (pre-prepared on archival quality stickers) for subsequent tracking. Barcodes can then be scanned along with field identifications on a field tablet. Barcodes allow a staging data server to perform three key functions; 1) connect samples with plots and visits; 2) track loaned samples; 3) record references to analysis undertaken by users. Barcodes provide a long-term link between a physical sample and data collected at a plot, making the data system resilient to nomenclatural updates.

6. Open data access is a prerequisite for widespread use.

The impact of collected data is maximised if they are made freely and easily available. Ecosystem science has moved rapidly, and data integration from different disciplines, modelling and re-use are as important as new data collection (Reichman *et al.* 2011). These applications benefit from well-described, discoverable and downloadable datasets.