Ecological Field Monitoring Protocols Manual

Using the Ecological Monitoring System Australia

Plot Description Module

tern Ecosystem Research Infrastructure

NCRIS National Research Infrastructure for Australia An Australian Government Initiative

Australian Government
Department of Climate Change, Energy, the Environment and Water

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Version

Readers are advised that all modules of the Ecological Field Monitoring Protocols Manual regularly undergo revision. Readers should check the website tern.org.au/emsa-protocols-manual/ to ensure they are viewing the current version.

Version 1

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Acknowledgements and contributors

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Key components of this module were developed, written, and field tested by the TERN Ecosystem Surveillance team based at The University of Adelaide. Additional to the authors, the following team members made contributions to the project: Ellen Kilpatrick, Mark Laws, Kate Matthews, Tamara Potter, Rhys Morgan, David Peacock, and Carly Steen. Technical components, including the development of the accompanying app, were developed by the team led by Andrew Tokmakoff, including Luke Derby, Matthew Barty, Jin Zhou, Ho Hai Hoy Vo, Walid Al Naim, Muhummad Khan, and Michael Doroch. Aspects of the protocols that have been built on by this project are the result of the extensive and ongoing body of work conducted by the TERN Ecosystem Surveillance team, as part of TERN's field-based ecosystem monitoring program. A full list of team members who have contributed is available on the TERN eSupport Services website.

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The information contained in this document comprises information and instructions for implementing ecological monitoring field surveys. The reader is advised that TERN has made best efforts to ensure instructions are comprehensive enough to fulfil the tasks required to the standards required at the time of publication. All field surveys must be carefully planned to ensure the safety of personnel is paramount and that the required scientific permits and wildlife licences are obtained from the appropriate jurisdictions and conditions strictly adhered to. Such requirements may go above and beyond those listed in this manual. TERN, including the project personnel, are excluded from all liability to any person for the consequences, including but not limited to all losses, damages, costs, expenses, and any other compensation arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

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Main front cover photograph: Mount Remarkable, South Australia

Version control

Readers are advised that all modules of the Ecological Field Monitoring Protocols Manual regularly undergo revision. Readers should check the website tern.org.au/emsa-protocols-manual/ to ensure they are viewing the current version.

The version history of this module is identified below. The version history of the Ecological Field Monitoring Protocols Manual, the methods and data implications, both historical, current and future interpretations of data, are available from the TERN website. Enquiries should be directed to tern@adelaide.edu.au.

Version	Date	Version update overview
1	21 July 2023	First published version

About the Ecological Field Monitoring Protocols Manual

This module is one of many that form the *Ecological Field Monitoring Protocols Manual* using the *Ecological Monitoring System Australia* (EMSA), available at tern.org.au/emsa-protocols-manual/. EMSA has been developed by the Terrestrial Ecosystem Research Network (TERN) in collaboration with the Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW) to support the National Landcare Program (NLP). The protocols included in the modules build on previous work by numerous ecologists throughout the country (acknowledged in the text) and have been refined with the help of Australia's natural resource management (NRM) community. They provide users with a clear set of protocols to measure and monitor most Australian ecosystems quantitatively and repeatably to enable the reliable quantification of environmental change.

The system addresses many limitations evident in previous NRM programs that have made this change quantification difficult. These included measuring or estimating environmental occurrences with disparate and often incompatible methods, particularly over a range of geographic scales, along with previous inefficiencies in data provision and analysis. The EMSA protocols presented in the modules provide clear and proven methods (built upon previous method/s where appropriate) to accurately measure environmental change for many variables of interest in Australian terrestrial environments. The modules are supported by a toolset to collect and deliver data to the Australian Government's Biodiversity Data Repository, which will see various management, policy and research outcomes informed by the data collected.

The current set of 24 modules is not an exhaustive list, and TERN and DCCEEW may develop additional modules in the future as gaps are identified. We intend these modules and the supporting Monitor app to be widely accessible, with little assumed knowledge, using methods that NRM practitioners and ecologists can easily adopt. To support the uptake of the protocols, we are also developing a series of education and guidance materials and an in-person training course. We anticipate that users outside of the NLP may be interested in utilising these protocols. The team plans to make a version available in the near future that will be independent of the NRM project management system - the monitoring, evaluation, reporting and improvement tool (MERIT), to enable that widespread use.

We acknowledge, value and respect the experiences, perspectives and cultures of Indigenous Australians. We recognise the importance of combining Indigenous and western environmental knowledge systems to improve ecological monitoring in Australia. The EMSA protocols are designed to be implemented alongside First Nations protocols, procedures and policies, and we look forward to working in partnership with Indigenous land managers on future versions of these protocols.

The protocols detailed here are freely available for widespread use by acknowledging their source. The protocols will be refined over time, so we encourage you to download the latest version before using them. We look forward to continuously improving these protocols in the same way as we utilise an adaptive management framework on the environments we monitor. We know that the data collected and supported by this program will enable analyses in novel ways and at previously impossible scales. We thank you for joining us on that journey and look forward to working with you to implement the EMSA system to benefit all Australians.

We also welcome you to provide feedback to tern@adelaide.edu.au

Ben Sparrow
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1 Module overview

1.1 Available protocols

The Plot Description Module includes two protocols to describe a core monitoring plot:

1. Enhanced protocol – used to describe the landform, land surface and vegetation of a plot when it is established (i.e. first visit).
2. Standard protocol – used to describe the vegetation of an established plot that has previously been described using the enhanced protocol (i.e. revisit).

The protocols use standardised methods and terminologies that align with national guidelines for surveying land and vegetation, including the Australian Soil and Land Survey Field Handbook (also known as the Yellow Book; NCST 2009), Guidelines for Surveying Soil and Land Resources (also known as the Blue Book; McKenzie *et al.* 2008), and the Native Vegetation Information System (NVIS) Australian Vegetation Attribute Manual (NVIS Technical Working Group 2017).

1.2 Relationships to other modules

1.2.1 Mandatory related modules

Complete before the Plot Description Module

- Plot Selection and Layout Module – the plot must be established and marked out to ensure the surveyor remains within the plot boundaries while describing the plot.

1.2.2 Optional complementary related modules

- Floristics Module – a physical description of the plot is required to place the floristic data in context with the surrounding landform, land surface and vegetation. Growth forms and field names assigned in the Floristics Module can help to determine the structural formation and are required for consistent naming in plant species life-stage and mass flowering event data, respectively.
- Cover Module – plant species height and cover data recorded in the Cover Module can inform structural formation selection in the Plot Description Module and be used to classify the vegetation association of the plot using the NVIS to complement the vegetation information obtained in the Plot Description Module.
- Photopoints Module – panoramic photos taken from the centre of the plot in the Photopoints Module provide a visual representation of the plot and the features described in the Plot Description Module.
- Condition Module – condition attribute data (tree health, leaf litter depth, etc.) recorded in the Condition Module complement the vegetation information obtained in the Plot Description Module and may contribute to a more detailed description of the plot.

2 Introduction and background

The Plot Description Module records basic physical information about a plot, including landform, slope and aspect, lithology, disturbance, fire history and vegetation type. The information collected aligns with national guidelines from the Australian Soil and Land Survey Field Handbook (also known as the Yellow Book; NCST 2009), Guidelines for Surveying Soil and Land Resources (also known as the Blue Book; McKenzie *et al.* 2008) and the NVIS Australian Vegetation Attribute Manual (NVIS Technical Working Group 2017), as well as a number of state and territory guidelines.

A plot is considered an area of land representative of the landform, vegetation and land surfaces present within a sampling unit (NCST 2009). Plot locations are generally determined by a two-step process, which involves a desktop assessment to define areas of interest, followed by a field assessment to select final plot locations based on areas with a consistent vegetation community, slope, relief and soil (Michaels 2006; White *et al.* 2012; Eyre *et al.* 2015; Freeman *et al.* 2015). As a standard, plots are 100 x 100 m (1 ha) in size, but in some cases plot shape may need to be altered to align with landscape features such as a dunecrest or watercourse (White *et al.* 2012). The Ecological Monitoring System Australia protocols currently do not support other plot shapes but are expected to in the future.

2.1 Key definitions and terminology

Table 1. Key definitions and terminology relevant to the Plot Description Module.

Term	Description
Aspect	Identifies the downslope direction (orientation) of the slope. The reading is taken looking down the slope. Due north is recorded as 360 degrees. Aspect can only have a value of 1 to 360 degrees. A value of 0 indicates that there is no slope.
Coarse fragment lithology	Dominant lithology of any surface stones or rocks (e.g. calcrete/limestone, sandstone or quartz).
Coarse fragment size	Size of any surface stones or rocks in millimetres.
Homogeneity measure	Record of the visual estimate (in metres) of the shortest distance from the survey point to a vegetation association different to the one being sampled. Provides an indication of how far the association being sampled extends beyond the plot.
Landform element	Landform elements have a dimension of approximately 40 m but can vary from a few metres to 100 m. A landform element is described by the following attributes – slope, morphological type, dimensions, geomorphological activity and geomorphological agent. Landform elements make up a mosaic within landform patterns. There are approximately 80 different landform elements that occur in Australia including dunecrests and hillslopes (Appendix A – Landform Element Summary).
Landform pattern	Landform patterns have dimensions of approximately 600 m and are based on the following attributes – relief, slope (most common), stream channel occurrence, geomorphological attributes and component landform elements. Landform patterns generally have longer histories than landform elements. There are approximately 40 different landform patterns that occur in Australia including sand plains and hills (Appendix A– Landform Pattern Summary).
Modal slope	The most common class of slope occurring in a landform pattern.
NVIS	National Vegetation Information System – a comprehensive data system that provides information on the extent and distribution of vegetation types across Australia and defines how vegetation associations should be classified. The NVIS is hierarchical and different levels in the classification provide a description of the vegetation from class to sub-association that can be directly related to spatially defined areas.
Outcrop lithology	Dominant lithology of the outcrop (any area of exposed rock that is assumed to be continuous with the underlying bedrock).
Plot	The specific survey area where information is collected (generally 100 x 100 m; 1 ha). Final plot location is determined in the field, with preference given to homogeneous areas representative of the broader sampling unit, with consistent vegetation, slope, relief and soil.
Relief	The difference in elevation between the high and low points of a land surface.
Slope	The rise or fall of the land surface, which is measured in degrees using a clinometer. Slope should be measured over a distance of at least 20 m to reduce influence of any microrelief changes.
Structural formation	Vegetation classification that aligns with NVIS and is based on growth form, height, and cover (see Appendix 2).

2.2 Rationale

The use of standardised terminology for the collection of plot information ensures plots are described in a consistent manner across projects and locations, and this facilitates the development of comprehensive datasets that can be used more widely (NCST 2009). Collecting consistent information regarding the physical environment of plots can improve understanding of interactions between the environment and vegetation, capture important information about the landform being surveyed and allow plot summary data to be compared between different sites and across projects (Heard and Channon 1997; Brocklehurst *et al.* 2007; NCST 2009).

Landform information is generally collected using landform pattern and landform element components. The key determinants of landform pattern are relief, stream occurrence, lithology and soil, while slope, aspect and the position along the slope (toposequence) are key determinants of landform element (Heard and Channon 1997; McKenzie *et al.* 2008; NCST 2009). There are approximately 40 landform patterns defined for Australia and approximately 80 landform elements (NCST 2009). A variety of land surface attributes are also measured for each plot, including slope, aspect, outcrop lithology and coarse fragments lithology, size and abundance. Slope and aspect record the degree and orientation of the slope respectively (Heard and Channon 1997). Outcrop lithology and coarse fragments lithology provide an indication of the dominant surface rock types (Heard and Channon 1997; Brocklehurst *et al.* 2007; McKenzie *et al.* 2008).

Vegetation structural formation is a standardised terminology that integrates growth form, height and cover within each stratum (see Appendix 2), and is therefore used to provide a relatively user-friendly description of the dominant growth form, cover and height within the plot (NVIS Technical Working Group 2017). A homogeneity measure (an estimate of the shortest distance from the survey point to the boundary of the vegetation association) is collected to assist with vegetation classification and mapping (see the Vegetation Mapping Module; Sparrow *et al.* 2020).

Supporting information, including growth stage, life stage, disturbance and fire history at the plot provides an indication of the reliability of the vegetation data in terms of species diversity and the abundance of seasonal vegetation (which depends on preceding rainfall and other weather conditions), and helps document other pressures on the vegetation such as grazing (Heard and Channon 1997; Brocklehurst et al. 2007; McKenzie et al. 2008; Casson et al. 2009). Collecting this descriptive information provides context for the analysis of data collected using a variety of other methods at the plot level.

3 Enhanced protocol

3.1 Field collection

3.1.1 Pre-requisites

Pre-requisites for completing this protocol:

- Become familiar with the standard terminology and definitions in the Yellow Book and NVIS Australian Vegetation Attribute Manual.

3.1.2 Time requirements

Survey time requirements will vary depending on the experience of personnel and their familiarity with the landform, land surface and vegetation of the project area. As a general guide:

- Allow 15–45 minutes to collect and record the information.

3.1.3 Personnel requirements

Number of personnel and skills:

- One person is required to complete the Plot Description Module.
- Personnel should be familiar with definitions of landform, land surface and vegetation attributes, including but not limited to landform patterns and elements, lithology, vegetation growth stages and vegetation structural formation. Reference material, including the Yellow Book is recommended.
- Personnel should be familiar with and experienced in identifying major vegetation groups and the growth stage of a system. If personnel are not confident, time should be dedicated to practising, using field reference guides, and seeking advice prior to conducting this protocol.
- The Plot Description Module does not involve interference with vegetation (no sampling is required), or wildlife. Therefore, scientific permits and wildlife ethics approvals are unlikely to be required but always check with your local authority. Access permissions will likely be required.

3.1.4 Equipment

- Mobile device pre-loaded with the Monitor app
- Yellow Book (and/or soil and landform reference charts)
- NVIS Australian Vegetation Attribute Manual (and/or vegetation reference charts)
- Compass (or a suitable app)
- Clinometer (or a suitable app)
- Rangefinder (or suitable app/equipment).

3.1.5 Instructions and procedures

1. Ensure the Plot Selection and Layout Module has been completed to mark out the plot boundary and define the current plot and visit in the Monitor app.
2. Select the Plot Description Module and then the Enhanced protocol.
3. Considering the entire 1 ha plot, complete all landform and land surface fields using the Yellow Book, Appendix 1 and app info buttons for reference:
    - *Slope (degrees)* – measure the slope in degrees using a clinometer, compass or suitable app. The number recorded should be between 0° (level) and 90°.
    - *slope (class)* – automatically generated from a list of eight values when *slope (degrees)* is entered (refer to Appendix 1 for further explanation on how this is calculated).

- *aspect* – measure the downslope direction (orientation) of the slope if it is uniform across the plot using a compass or suitable app. The number recorded should be between 0° (level) and 360° (due north). Otherwise, select if the slope is not uniform across the plot select.
- *relief* – select the category that describes the difference in elevation between the high and low points of the land surface from the drop-down list.
- *modal slope* – select the most common class of slope occurring in the landform pattern from the drop-down list.
- *landform pattern* – select from the drop-down list.
- *landform element* – select from the drop-down list.
- *outcrop lithology* – select the lithology type from the drop-down list if confident. If not confident, record either metamorphic, sedimentary or igneous (optional field).
- *coarse fragments lithology* – select the two most common lithology *types* from the drop-down list if confident. If not confident, record either metamorphic, sedimentary or igneous. Record the *size* and *abundance* from drop-down list (optional field).
- *nearest infrastructure* (to the plot) – select from the drop-down list. If other, record the type of infrastructure in the comments (optional field).
- *land-use history* – select from the drop-down list (optional field). See the Australian Land Use and Management classification system (ABARES 2016).

4. Considering the entire 1 ha plot, complete all vegetation fields using the Yellow Book, Appendix 2 and app info buttons for reference:
   - *growth stage* – select from the drop-down list (early regeneration, advanced regeneration, mixed age, mature phase, senescent phase).
   - *fire history* – select if known and enter the *year* of the most recent burn.
   - *structural formation* – select from the drop-down list. Determine using the growth form, height and cover of the tallest dominant stratum (Appendix 2).
   - *homogeneity measure* – record the distance in metres from the plot centre to the nearest edge of the vegetation association you're sampling. If too far to determine, record the distance that the vegetation association can still be seen (maximum 1000 m).
   - *plant species life-stage* – record up to 10 plant species that are at an important life-stage at the time of the survey (budding, flowering, immature fruit, mature fruit, recently shed). If flowering is selected, select if there is a *mass flowering event* across the plot. Recommended if not undertaking the Floristics Module during the current visit (optional field).
   - *site disturbance* – select from the drop-down list.
   - *impact of introduced plant species* – record notes on any impacts observed. Recommended if not undertaking the Cover Module during the current visit (optional field).
5. Record any additional information about the physical features of the plot in the comments (optional field).
6. Complete the Enhanced protocol when all landform and land surface and vegetation fields have been recorded.
7. Check the summary of the data and mark it ready for submission to return to the module selection screen.

3.1.6 Additional guidelines

Landform and land surface

- Lithology information can be sourced from relevant spatial datasets for the region. This information should be reviewed before the field survey and a copy taken to the field to assist with the lithology classification.

- Contour maps and spatial imagery can assist in determining outcrop lithology if it is difficult to determine within the field.

Measuring slope using a clinometer

- Measure slope from the most representative point within the plot.
- If slope is measured down the slope, aspect can be recorded from the same position.
- Slope incline or decline can be measured but it should always be recorded as a positive value.
- If a clinometer is not available, slope can be measured with a compass (some compasses are also fitted with a clinometer) or a suitable app (e.g. Simple Inclinometer, Inclinometer).
- Using a clinometer, stand so you are facing directly up or down the slope. If there is no slope, the measurement is 0.
- Keep both eyes open and align the clinometer cross hairs with the target point in the distance. To minimise the influence of micro-relief on the slope reading, the slope measurement should be taken across a distance of at least 20 m.
- The clinometer should be angled so a consistent height above the ground is maintained (i.e. measure eye level of another field member standing at least 20 m away or an object that is approximately the same height above the ground as eye level).
- Two scales appear through the clinometer lens (degrees and percent). Record slope in degrees.
- Slope class information can help determine landform element.
- Theil Sen estimator can be used to calculate slope if surveyors are familiar with this method.

Recording aspect using a compass

- Aspect is the direction in degrees that a slope faces, measured in the downslope direction.
- Stand so you are facing directly down the middle of the slope and record the compass bearing (1–360°).
- If there is no slope, then the aspect will be 0. If you are facing due north then the reading will be 360°.

Vegetation

- Completion of the Floristics Module and Cover Module can assist in correctly determining the structural formation within the plot. If these modules are being undertaken, it is recommended that they are completed prior to undertaking the Plot Description Module.
- Structural formation is determined using the growth form, cover characteristics and height range of the tallest dominant stratum in the plot (see Appendix 2).

Homogeneity measure

- The homogeneity measure is defined as a record of the visual estimate (in metres) of the shortest distance from the plot centre to a vegetation association different to the one that you are sampling in (White et al. 2012).
- Where there is uncertainty in estimating the homogeneity measure, be conservative in estimating the distance (it is better to underestimate the distance to ensure homogeneity).
- Where it is not possible to directly observe the distance to a different association (e.g. goes over dune crest), estimate the furthest distance that you are sure is within the same association (i.e. as far as you can still see the vegetation association from the point you are standing). If working in large homogeneous areas, existing field mapping and use of the vehicle odometer may assist with this.

3.2 Post-field survey tasks

3.2.1 Sample curation

No samples are collected directly as part of this module. However, plant specimen vouchers collected in the Floristics Module will be used to verify assigned field names used in the plant species life-stage and mass flowering event fields in this module.

4 Standard protocol

4.1 Field collection

4.1.1 Pre-requisites

Pre-requisites for completing this protocol:

- The Enhanced plot description protocol must have been completed upon the first visit to the plot. The Standard protocol is only applicable for plot revisits.
- Become familiar with the standard terminology and definitions in the Yellow Book and NVIS Australian Vegetation Attribute Manual.

4.1.2 Time requirements

Survey activity time estimates will vary depending on the experience of the personnel, their familiarity with the project area and the degree of change to vegetation within the project area. As a general guide:

- Allow 15–30 minutes to collect and record the required information.

4.1.3 Personnel requirements

Number of personnel and skills:

- One person is required to complete the Plot Description Module.
- Personnel should be familiar with and experienced in identifying major vegetation groups and the growth stage of a system. If personnel are not confident, time should be dedicated to practising, using field reference guides, and seeking advice prior to conducting this protocol.
- The Plot Description Module does not involve interference with vegetation (no sampling is required) or wildlife. Therefore, scientific permits and wildlife ethics approvals are unlikely to be required but always check with your local authority. Access permissions will likely be required.

4.1.4 Equipment

- Mobile device pre-loaded with the Monitor app and a mapping or field GIS app
- Yellow Book and/or soil and landform reference charts
- NVIS Australian Vegetation Attribute Manual and/or vegetation reference charts
- Compass (or suitable app)
- Clinometer (or suitable app)
- Rangefinder (or suitable app/equipment)

4.1.5 Instructions and procedures

1. Ensure the Plot Selection and Layout Module has been completed to mark out the plot boundary and define the current plot and visit in the Monitor app.
2. Select *Plot Description Module > Standard protocol*
3. Select the *reason for the revist* (phenological event, seasonal change, major disturbance, climatic event, ongoing monitoring, other).
4. The information previously recorded for the plot can be viewed by selecting *past records*.
5. Considering the entire 1 ha plot, complete all vegetation fields using the Yellow Book, Appendix 2 and app info buttons for reference:
    - *growth stage* – select from the drop-down list (early regeneration, advanced regeneration, mixed age, mature phase, senescent phase).

- *fire history* – select if known and enter the *year* of the most recent burn.
- *structural formation* – select from the drop-down list. Determine using the growth form, height and cover of the tallest dominant stratum (Appendix 2).
- *homogeneity measure* – record the distance in metres from the plot centre to the nearest edge of the vegetation association you're sampling. If too far to determine, record the distance that the vegetation association can still be seen (maximum 1000 m).
- *plant species life-stage* – record up to 10 plant species that are at an important life-stage at the time of the survey (budding, flowering, immature fruit, mature fruit, recently shed). If flowering is selected, select if there is a *mass flowering event* across the plot. Recommended if not undertaking the Floristics Module during the current visit (optional field).
- *site disturbance* – select from the drop-down list.
- *impact of introduced plant species* – record notes on any impacts observed. Recommended if not undertaking the Cover Module during the current visit (optional field).

6. Record any additional information about the physical features of the plot in the comments (optional field).
7. Complete the Standard protocol when all vegetation fields have been recorded.
8. Check the summary of the data and mark it ready for submission to return to the module selection screen.

4.1.6 Additional guidelines

Vegetation

- Completion of the Floristics Module and Cover Module can assist in correctly determining the structural formation within the plot. If these modules are being undertaken, it is recommended that they are completed prior to undertaking the Plot Description Module.
- Structural formation is determined using the growth form, cover characteristics and height range of the tallest dominant stratum in the plot (see Appendix 2).

Homogeneity measure

- The homogeneity measure is defined as a record of the visual estimate (in metres) of the shortest distance from the plot centre to a vegetation association different to the one that you are sampling in (White et al. 2012).
- Where there is uncertainty in estimating the homogeneity measure, be conservative in estimating the distance (it is better to underestimate the distance to ensure homogeneity).
- Where it is not possible to directly observe the distance to a different association (e.g. goes over dune crest), estimate the furthest distance that you are sure is within the same association (i.e. as far as you can still see the vegetation association from the point you are standing). If working in large homogeneous areas, existing field mapping and use of the vehicle odometer may assist with this.

4.2 Post-field survey tasks

4.2.1 Sample curation

No samples are collected directly as part of this module. However, plant specimen vouchers collected in the Floristics Module will be used to verify assigned field names used in the plant species life-stage and mass flowering event fields in this module.

5 Data submission

Data from the Plot Description Module is collected in the field using the Monitor app. Data entry is completed in the app, photos are taken using the app (or later linked if taken on other devices), and voucher barcodes are scanned in the app to link voucher numbers to the unique data. All data is checked for correctness and completeness in the app before it is submitted.

Once all data is finalised and marked as complete, the data is submitted from the Monitor app to the staging server by an explicit user action. If the device is offline at the time, the data will be pushed as soon as it is reconnected to a network (i.e. either back in mobile phone range or a wi-fi network). Once data reaches the staging server it is prepared in an export interface for delivery to the Biodiversity Data Repository. DCCEEW is then responsible for managing the data. In the future, it is anticipated that data curation tools will be made available to project personnel.

6 Data use and reason for collection

6.1 Data use to date

To date, standardised plot description information collected as part of TERN's Ecosystem Surveillance monitoring program has been used by the CSIRO for a project focused on producing site level ecological condition assessments. Information from 21 sites has been used, in combination with associated site photographs, to build a library of site condition observations across Australia and to support the development of the CSIRO-DEE Habitat Condition Assessment System (CSIRO 2021).

6.2 Future use of the data

Standardised plot description information, including landform and vegetation information, can be used to inform program summary statistics information, including the number of surveys undertaken, the location of surveys and the ecosystems in which surveys are undertaken. Information may also be used to assess drivers of vegetation type across the landscape and interactions between vegetation and the physical environment. This information can also feed into national databases, including NVIS and contribute to state or national spatial datasets.

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8 Appendices

Appendix 1. Landform and land surface resources

Landform pattern

Slope and associated landform patterns

Slope classes and associated landform patterns. Adapted from information in the Yellow Book (NCST 2009).

Slope class	Code	Degrees	Percent	Associated Landform Pattern Types
Level	LE	0–0°35′	0–1	Plains, sheet-flood fan, pediplain, peneplain, alluvial plain, flood plain, meander plain, bar plain, covered plain, anastomotic plain, stagnant alluvial plain, terrace, tidal flat, made land, playa plain.
Very gently inclined	VG	0°36′–1°45′	2–3	Pediments, alluvial fan, sand plain.
Gently inclined	GE	1°46′–5°45′	4–10	Rises, beach ridge plain, dunefield, lava plain, coral reef.
Moderately inclined	MO	5°46′–18°	11–32	Low hills, karst, meteor crater.
Steep	ST	18–30°	33–56	Hills
Very steep	VS	30–45°	57–100	Mountains, escarpment, volcano, caldera.
Precipitous	PR	45–72°	101–300	Rare in Australia.
Cliffed	CL	>72°	>301	Rare in Australia.

Land-use history

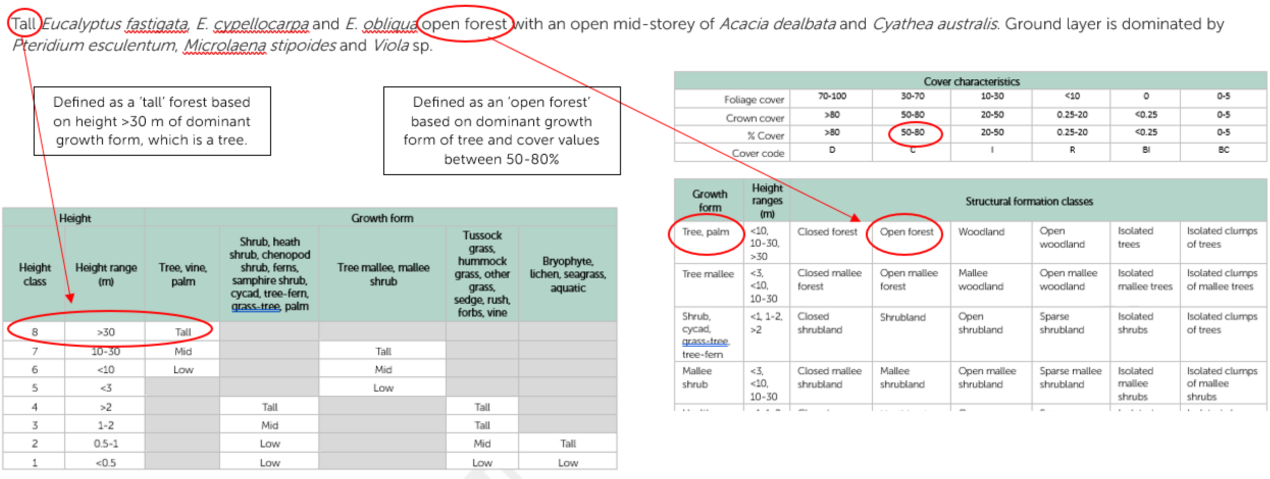
Land-use history categories according to the ALUM version 8 classification system (ABARES 2016).

Tertiary code	Tertiary name
1.1.0	**Nature conservation**
1.1.1	Strict nature reserves
1.1.2	Wilderness area
1.1.3	National park
1.1.4	Natural feature protection
1.1.5	Habitat/species management area
1.1.6	Protected landscape
1.1.7	Other conserved area
1.2.0	**Managed resource protection**
1.2.1	Biodiversity
1.2.2	Surface water supply
1.2.3	Groundwater
1.2.4	Landscape
1.2.5	Traditional Indigenous uses
1.3.0	**Other minimal use**
1.3.1	Defence land - natural areas
1.3.2	Stock route
1.3.3	Residual native cover
1.3.4	Rehabilitation
2.1.0	Grazing native vegetation
2.2.0	Production native forests
3.1.0	Plantation forests
3.2.0	Grazing modified pastures

Structural formation

To determine the appropriate structural formation asses the height and cover of the tallest dominant stratum. Use the growth forms and height class table below, in association with the vegetation structural formation table.

Using NVIS classes



Growth forms and heights

Height classes for specific growth forms defined for the NVIS. Sourced from page 34 of NVIS (NVIS Technical Working Group 2017).

Height		Growth form				
Height class	Height range (m)	Tree, vine, palm	Shrub, heath shrub, chenopod shrub, ferns, samphire shrub, cycad, tree-fern, grass-tree, palm	Tree mallee, mallee shrub	Tussock grass, hummock grass, other grass, sedge, rush, forbs, vine	Bryophyte, lichen, seagrass, aquatic
8	>30	Tall				
7	10-30	Mid		Tall		
6	<10	Low		Mid		
5	<3			Low		
4	>2		Tall		Tall	
3	1-2		Mid		Tall	
2	0.5-1		Low		Mid	Tall
1	<0.5		Low		Low	Low

Vegetation structural formation

NVIS growth form and structural formation classes (NVIS Technical Working Group 2017).

NVIS growth form and structural formation classes (NVIS Technical Working Group 2017). Cover characteristics							
	Foliage cover	70–100	30–70	10–30	<10	0	0–5
	Crown cover	>80	50–80	20–50	0.25–20	<0.25	0–5
	% Cover	>80	50–80	20–50	0.25–20	<0.25	0–5
	Cover code	D	C	I	R	BI	BC
Growth form	Height ranges (m)	Structural formation classes					
Tree, palm	<10, 10–30, >30	Closed forest	Open forest	Woodland	Open woodland	Isolated trees	Isolated clumps of trees
Tree mallee	<3, <10, 10–30	Closed mallee forest	Open mallee forest	Mallee woodland	Open mallee woodland	Isolated mallee trees	Isolated clumps of mallee trees
Shrub, cycad, grass-tree, tree-fern	<1, 1–2, >2	Closed shrubland	Shrubland	Open shrubland	Sparse shrubland	Isolated shrubs	Isolated clumps of trees
Mallee shrub	<3, <10, 10–30	Closed mallee shrubland	Mallee shrubland	Open mallee shrubland	Sparse mallee shrubland	Isolated mallee shrubs	Isolated clumps of mallee shrubs
Health shrub	<1, 1–2, >2	Closed heathland	Heathland	Open heathland	Sparse heathland	Isolated heath shrubs	Isolated clumps of heath shrubs
Chenopod shrub	<1, 1–2, >2	Closed chenopod shrubland	Chenopod shrubland	Open chenopod shrubland	Sparse chenopod shrubland	Isolated chenopod shrubs	Isolated clumps of chenopod shrubs
Samphire shrub	<0.1, >0.5	Closed samphire shrubland	Samphire shrubland	Open samphire shrubland	Sparse samphire shrubland	Isolated samphire shrubland	Isolated clumps of samphire shrubs
Hummock grass	<2, 2	Closed hummock grassland	Hummock grassland	Open hummock grassland	Sparse hummock grassland	Isolated hummock grasses	Isolated clumps of hummock grasses
Tussock grass	<0.5, >0.5	Closed tussock grassland	Tussock grassland	Open tussock grassland	Sparse tussock grassland	Isolated tussock grasses	Isolated clumps of tussock grasses
Other grass	<0.5, >0.5	Closed grassland	Grassland	Open grassland	Sparse grassland	Isolated grasses	Isolated clumps of grasses
Sedge	<0.5, >0.5	Closed sedgeland	Sedgeland	Open sedgeland	Sparse sedgeland	Isolated sedges	Isolated clumps of sedges
Rush	<0.5, >0.5	Closed rushland	Rushland	Open rushland	Sparse rushland	Isolated rushes	Isolated clumps of rushes
Forb	<0.5, >0.5	Closed forbland	Forbland	Open forbland	Sparse forbland	Isolated forbs	Isolated clumps of forbs
Fern	<1, 1–2, >2	Closed fernland	Fernland	Open fernland	Sparse fernland	Isolated ferns	Isolated clumps of ferns
Bryophyte	<0.5	Closed bryophyteland	Bryophyteland	Open bryophyteland	Sparse Bryophyteland	Isolated bryophytes	Isolated clumps of bryophytes

Site disturbance

Disturbance classes adapted from information in the Yellow Book (NCST 2009) unpublished fourth edition (NCST in prep), with the addition of light, medium and high grazing disturbances (AusPlots Rangelands Manual (White et al. 2012).

Code	Description
0	No effective disturbance
1	No effective disturbance except grazing by hoofed animals ▪ 1L = Light grazing ▪ 1M = Medium grazing ▪ 1H = High grazing
2	Limited clearing, for example limited logging
3	Extensive clearing, for example poisoning, ringbarking
4	Complete clearing, pasture, native or improved, but never cultivated
5	Complete clearing, pasture, native or improved, cultivated at some stage
6	Cultivation, rain fed
7	Cultivation, irrigated, past or present
8	Highly disturbed, e.g. quarrying, road words, mining, landfill, urban
9	Regrowth after clearing
10	Significant natural disturbances, e.g. cyclonic impact

As part of its Ecological Monitoring System Australia (EMSA), the Australian Government has partnered with Australia's Terrestrial Ecosystem Research Network (TERN) in the co-design of a suite of ecological monitoring protocols and a data exchange system. The protocols build on TERN's long-established data aggregation systems and well-tested survey protocols.

The primary purpose of the standardised monitoring protocols is to support natural resource management (NRM) programs that benefit the environment, agriculture and communities, as well as making the protocols freely available for use by other environmental land managers and environmental consultants.

The Australian Government and TERN protocols ensure NRM service providers and ecologists collecting field data:

- have ready access to comprehensive instructions for each of the standardised collecting protocol modules
- are able to use mobile-based applications in the field to enter data and images
- and can easily submit and share data.

Data collected from the application of the standardised collecting protocol modules will help evaluate the current NRM program and support research on changes to Australia's ecosystems and biodiversity.

TERN acknowledges the traditional owners and their custodianship of the lands on which TERN operates. We pay our respects to their ancestors and their descendants, who continue cultural and spiritual connections to country.