Ecological Field Monitoring Protocols Manual

Using the Ecological Monitoring System Australia

Condition Module – PROCEDURE ONLY

Citation

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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 2

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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, Kate Matthews, 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, Hoy Hai Huy 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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Main front cover photograph: Wandoo National Park, Western Australia.

Version control

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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
2	20 August 2024	Improved paragraph text throughout; moved tree stump measurements to the Coarse Woody Debris Module.

1 Condition attributes protocol

1.1 Field collection

1.1.1 Pre-requisites

Pre-requisites for completing this protocol:

- The plot must be established using the Plot Layout and Selection Module prior to conducting the Condition attributes protocol.

1.1.2 Time requirements

Survey activity time estimates will vary depending on the number of trees to be measured, the optional fields that are measured, and the density of vegetation to traverse. As a general guide, to collect the condition attributes of this protocol:

- Allow 1–2 hours for survey planning.
- Allow 20–40 minutes for plot set-up and laying tape-measures (assuming the plot has been previously set-up using the Plot Selection and Layout Module).
- Allow 1–3 hours to complete the survey.
- Refer to the mandatory and optional complementary modules for the time requirements for each protocol that is being completed as part of the condition monitoring.

1.1.3 Personnel requirements

Number of personnel and skills:

- The Condition attributes protocol is best completed with two personnel. This enables one person to complete the required measurements (DBH, tree height, leaf litter depth, etc.) and the other to record the data directly into the Monitor app simultaneously. The second person may also assist with taking measurements.
- A third person can improve data collection workflow during the tree survey by measuring the tree height whilst DBH is being measured.
- Personnel should be familiar with and experienced in identifying growth stages and life stages of tree species.
- Personnel should be familiar with and experienced in identifying the characteristic features of tree health, including but not limited to insect damage, human-induced damage and the presence of mistletoe.
- Personnel should be familiar with and experienced in identifying traits specific to tree species and how to distinguish different species from one another. If personnel are not confident, time should be dedicated to practising, using field reference guides, and seeking advice prior to conducting this protocol.
- Personnel must be familiar with the use of a diameter tape and/or a 5–10 m tape measure as well as with the use of a rangefinder and binoculars.
- The Condition Module does not involve interference with vegetation 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.

1.1.4 Equipment

General:

- Mobile device with the Monitor app installed
- GNSS device capable of achieving <30 cm accuracy (e.g. Trimble® R1 or DA2), hand-held GPS, or device built-in GPS (least preferred)
- 100 m tape measure
- Diameter tape or equivalent
- Rangefinder or equivalent.

Optional:

- Tent pegs
- Clothes pegs
- Flagging tape
- Chalk
- Pocket tape measure
- 30 cm ruler with leaf litter attachment.

1.1.5 Instructions and procedures

1. Ensure the Plot Selection and Layout Module has been completed to mark out the plot boundary, the sub-plot boundary and to define the current plot and visit in the Monitor app.
2. Select the Condition Module and then the Condition attributes protocol.
3. Select *plot size* using the drop-down (100 x 100 m or 40 x 40 m).
4. Select the *DBH instrument* (diameter tape, tape measure, tree caliper) and *height instrument* (rangefinder, clinometer, other).
5. Save the survey set-up component. The *time* and *date* will be automatically recorded. Update if required.

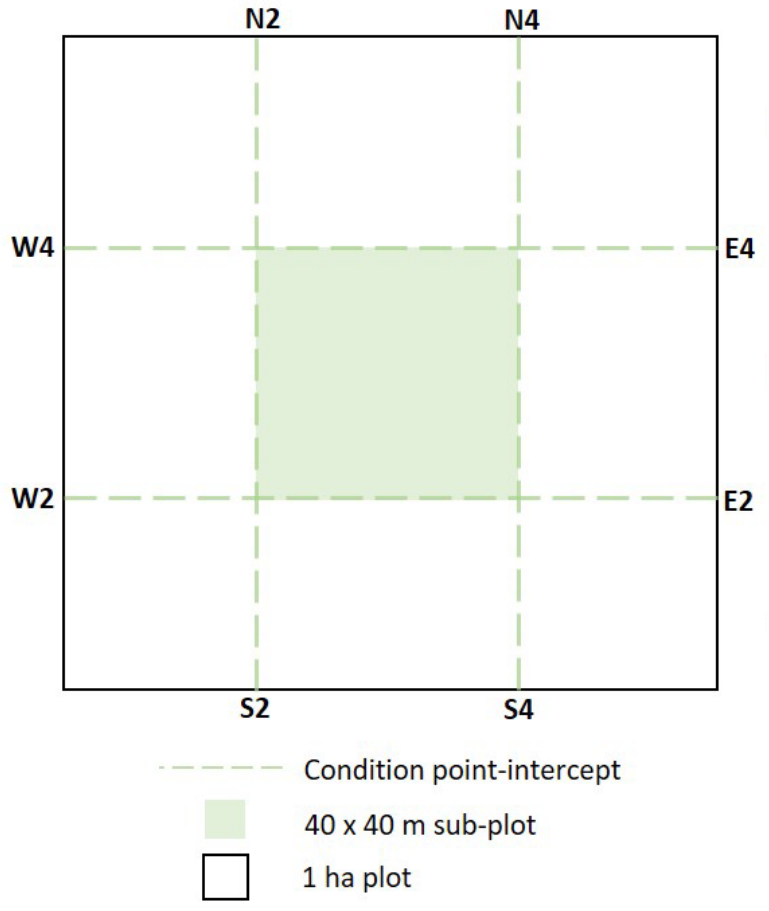

Figure 1. Plot layouts for the 100 x 100 m core plot 40 x 40 m sub-plot.

6. Systematically traverse the survey area searching for perennial species with a DBH ≥10 cm and height >2 m (hereby referred to as 'tree'). For mallee and mulga systems, record all individuals with a DBH ≥5 cm.
7. For each tree encountered, select *add tree* and record:
   - If the tree is a *mallee* or *mulga.*

- If the tree is *dead*. When dead is selected, completion of the growth stage and reproductive life stage fields is not required.
- If the tree is dead and partially downed, select the *partially downed tree* check-box.
- The *floristics voucher.*
- The *growth stage* of the tree (recruiting, resprouting mature, senescent, dead) Refer to Table 2 and Figure 2 for more information. If resprouting, indicate if *basal* or *epicormic* (both can be selected).
- The *life stage*, refer to Table 3 for more information. If *flowering*, record the *intensity* (percentage of the canopy in flower).
- The *height* (m) of the tree using a rangefinder or equivalent.
- The *DBH* (cm) and *POM* (m). See the Basal Area Module for measurement instructions, including for multi-stemmed and buttressed trees.
- *Tree health*, including:
    - The percentage of *canopy cover* present versus dieback. Use the *South Australian Bushland Assessment Manual* (Native Vegetation Council 2020) to assist with the determination.
    - Crown damage, including the *incidence* and *severity* of discoloured, necrotic and missing foliage.
        - Enter the *type of damage* into the description column, followed by *incidence* and *severity* values (see Appendix 1). The product will be automatically calculated. Use the add row button to add additional damage or crown portion measures (Appendix 1).
    - The number of *mistletoes alive* and *mistletoes dead*. If no number is recorded, the app will automatically populate the field with 0.
    - Add any *hollows* and record:
        - The *size* (cm) of the hollow.
        - The *direction* (°) of the hollow opening.
        - The *height* (m) of the hollow.
    - The presence of *deep cracks* or *crevices* present using the check-box.
    - The presence of *abnormal growth* using the check-box.
    - If the *tree bark is loose* using the check-box.
    - The presence of *insect bores* using the check-box.
    - The *incidence* and *severity* of insect damage on the foliage.
        - Select the *damage type* (gall, lerp, scale, blistering, skeletonization), followed by *incidence* and *severity* values). Use the *South Australian Bushland Condition Monitoring Manual* (Milne et al. 2008) or similar to assist with determination (examples available in Appendix 2).
    - Any *human induced damage* (lopping, logging, ringbarking, poisoning) or input a custom value present.
    - Any obvious signs of any other *abiotic stressors* or *biotic stressors*.

8. If there is leaf litter present at the base of the tree:
    - Record the *direction from tree* (°) and *distance from tree* (m) that the litter depth will be recorded. These parameters should remain consistent for each tree surveyed where possible.
    - Create a small clearing in the litter and remove any coarse material then place the flat end of the leaf litter measurement tool on the soil surface. Slide the disc component down until it contacts the leaf litter surface. Apply light pressure to the disc and use the screw to tighten it into position. Read and record the *litter depth* (mm) where the top of the disc intersects the ruler. Instructions for building the tool can be found in the supplementary document Leaf litter tool instructions.
    - If there is no leaf litter present, select no litter using the check-box.
    - Replace any litter or woody debris moved during the process.

9. Add *photo* of the tree.
10. Use the *comments* field for any additional remarks.
11. Select *save* when all attributes have been recorded for the tree.
12. Mark the tree with coloured chalk or equivalent to avoid unintentional remeasuring.
13. Repeat steps 7–12 for each eligible tree encountered in the survey area.
14. Select *complete* to when all trees within the survey area have been recorded.

Table 1. Description of growth stage classes.

Growth stage	Description
Recruiting	*Trees:* From the juvenile and sapling stages to well-developed individuals with a crown of small branches, but below maximum height for a stand, crown exhibits apical dominance – approx. 0-30 years
	Shrubs: Juvenile stage, shrub has not reached maximum height, apical dominance
Resprouting	*Trees and Shrubs:* Woody perennial which is resprouting after significant loss of foliage. Resprouting can occur from the trunk or branches (epicormic) or from the base (basal).
Mature	*Trees:* Tree has reached maximum height and crown has reached full lateral development although branch thickening can occur. Apical dominance lost – approx. 30-80 years
	Shrubs: Shrub has reached maximum height, crown has reached full lateral development
Senescent	*Trees:* Crown form contracting and becoming 'stag headed' decrease in crown diameter and crown leaf area. Distorted branches and burls common – approx. >80 years
	Shrubs: Crown form contracting and decrease in crown diameter and crown leaf area. Dead branches more common – approx. >80 years
Dead	*Trees:* Dead individuals in all stages – from presence of tertiary branches and bark to no remaining crown structure and absence of bark
	Shrubs: Dead individuals in all stages

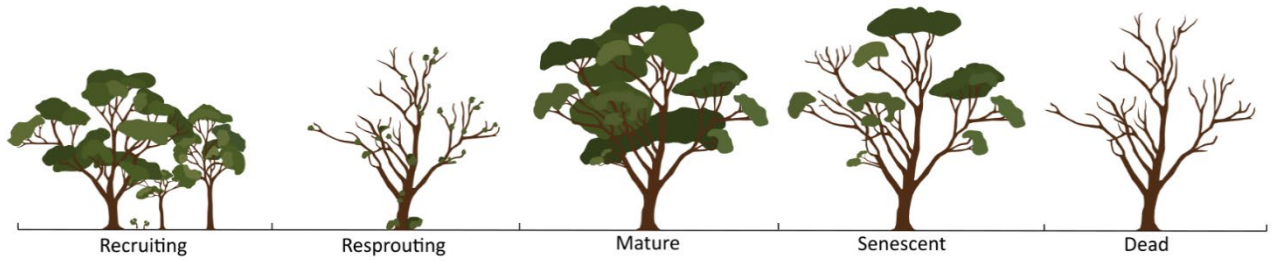

Figure 2. Growth stage visual representation examples.

Table 2. Life-stage classes.

Adapted from (Heard and Channon 1997). Seedling, sapling and juvenile cannot be selected within this module. To record the presence of seedlings, saplings and juveniles, complete the Recruitment Module.

Life stage	Description
Seedling	*Trees:* individuals <2 cm DBH. *Shrubs*: <5cm height.
Sapling	*Trees:* individuals <2 m in height and ~2-10 cm DBH. *Shrubs:* has not reached maximum height, apical dominance.
Buds	Plants have buds formed in varying stages of development for flowering.
Flowers	Plants are in flower.

Immature fruit	Immature fruits not shedding seed.
Mature	Fruit fruits ripe and/or shedding seed.
Recently shed	Plants are in a non-reproductive phase which show signs of having shed seeds or fruits within the last 12 months.
Dead/dormant	Indicates above-ground material only is dead and includes plant species that may still have dormant below-ground organs (eg orchids, lilies etc.).
Vegetative	Only refers to plants in a non-reproductive phase ie. no flowers, buds or unshed seed.
Regenerating	Woody perennial which is resprouting after significant loss of foliage.

Table 3. Factors affecting vegetation health to be recorded in the field.

Health factor		Description
Canopy health	Canopy cover	The percentage of foliage present within the canopy relative to a local reference tree.
	Crown damage index (CDI)	An index based on the incidence and severity of discoloured, necrotic or missing foliage [Stone 2003].
Mistletoe		Aerial plant parasite which can be identified by its different foliage from host plant. Number of mistletoes present to be recorded.
Hollow		Cavity that has formed within the trunk or branch of a tree. Number, direction and position recorded.
Human induced damage		Any physical harm caused by human activity. Presence or absence recorded.
Insect damage		The incidence and severity of galls, skeletonization, lerps, blistering and scale on foliage.
Trunk condition		The presence of hollows, cracks, crevices, loose bark and insect bores on the tree trunk.

1.1.6 Additional guidelines

General

- Partitioning the sub-plot into more manageable units using existing Cover point-intercept transect tapes, additional tapes and/or coloured survey pins is highly recommended, particularly in dense systems.
- Plot boundaries should be marked out according to the existing method described in the Plot Selection and Layout Module.
- Assessment across the plot is used to document signs of pest fauna, record fire scar height, and document age class structure, growth and life-stages, and health of the perennial species present.
- Assessment of fire extent and severity is undertaken in the Fire Module (which is carried out within the Cover Module). If a condition survey is to be undertaken, ensure that the fire option has been activated in the Cover Module.

Tree survey

- A tree is considered in the plot if than 50% of the base of the trunk is within the plot (Figure 3).
- Tree height can be estimated using a forestry rangefinder for rapid and accurate height measurements. The person entering the data into the Monitor app can carry the rangefinder on a lanyard over their shoulder and record tree height when required.
- Where a rangefinder is not available, tree height can be estimated using the following methods:
  - Clinometer and tape (Department of Environment and Climate Change 2007)
  - Mobile phone applications

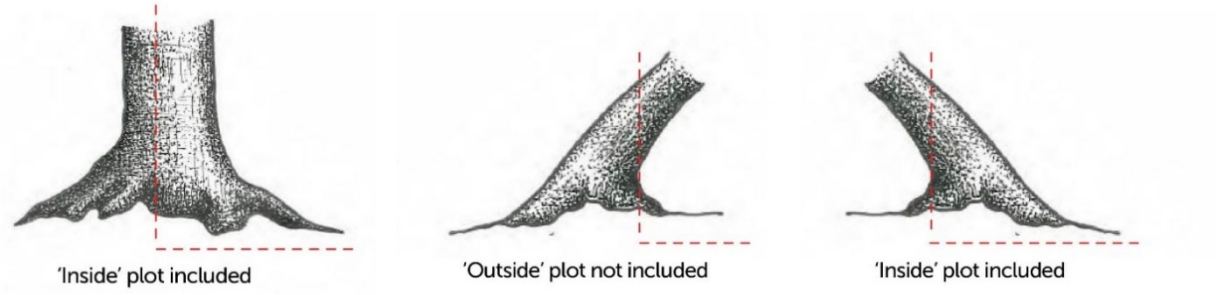

Figure 3: Rule set to determine if a tree is in or out of the plot

adapted from Wood et al. (2015).

Tree health

Canopy cover

- Canopy cover is assessed as the percentage of foliage missing from the canopy relative to a reference tree.
- Reference trees can be an archetype of a species with optimal foliage (absolute reference tree), or a nearby tree with maximum foliage considering site conditions, altitude, latitude, etc., (local reference) (Dobbertin 2005; Eichhorn and Roskams 2013).
- Local reference trees are generally best, and a suitable tree is one that is presumed to be completely healthy (i.e. stress-free), of the same species, similar age and with maximum foliage (Dobbertin 2005; Thimonier *et al.* 2010; Eichhorn *et al.* 2020).
- Canopy cover is scored in 5% increments, and a healthy tree would have a canopy cover score of 100% (i.e. 0% defoliation or dieback), whereas a tree with 25% dieback would have a canopy score of 75%.
- To estimate percentage canopy, visualise a circle around the outer boundary of the crown. Estimate the proportion of dead crown and the remainder is the proportion of healthy crown cover (Michaels 2006).
- Epicormic shoots below the crown, absent or fallen branches, and lower limbs that do not form part of the canopy are not included in assessable canopy (Michaels 2006; Eichhorn *et al.* 2020).

Crown Damage Index

- The incidence and severity of each type of foliage damage (necrosis, discolouration and defoliation) is also assessed for each tree (Stone *et al.* 2003). Incidence (*I*) is the percentage of leaves in the canopy affected, and severity (*S*) is the percentage of each individual leaf affected. Info buttons will be provided in the app for easy reference.
- Incidence and severity scores for each type of damage are then multiplied together and divided by 100 i.e., (*I* x *S*)/100.
- The results for each are then added to produce an overall Crown Damage Index (CDI).

- Alternatively, the crown can be divided and the incidence and severity across all types of damage can be estimated for each portion and then summed to produce an overall CDI.
- The Crown Damage Index (CDI) is created by visually assessing the incidence (extent of damage over the entire canopy), and severity (percentage of each leaf affected), of missing, damaged and discoloured foliage (Stone *et al.* 2003).
    - There are three types of damage:
        - Defoliation – where entire leaves or parts of leaves are missing (Figure A5.1)
        - Necrosis – presence of dead leaf tissue (Figure A5.2)
        - Discolouration – non-green leaf tissue including yellowing or reddish-purple discolouration, chlorotic spots or margins (Figure A5.2). Natural variation of leaf colour needs to be considered when assessing discolouration, for example *Eucalyptus* leaves can change colour as they develop.

General guidelines for canopy health

- Although assessments of canopy cover and foliage damage are subjective, observer bias can be reduced by having the same observer team for each survey, creating a photo library of local reference trees with typical canopy morphology, and intercalibrating between observers and across surveys (Eichhorn and Roskams 2013).
- It is important to observe each tree from several positions, ideally standing at a distance equal to the height of the tree. An elevated position ensures a better view.
- Where possible take a closer look at branches, leaves and stems for signs as to what may be causing the stress symptoms (e.g. galls and lerps, boreholes etc., are indicative of insect infestation. Appendix 6 provides examples of the types of damage produced by insect and disease). Binoculars are helpful for looking higher into the canopy. Use the comments field to add notes regarding potential causes of damage.

Mistletoe

- Walk around the tree to ensure that all mistletoes are identified and counted correctly.
- Only record living mistletoe.
- Mistletoe abundance generally increases with tree height, diameter and basal area.
- Trees close to a patch edge or another infested individual are more likely to host mistletoe (Ward 2005).

Hollows

- Walk around the tree to ensure that all hollows are identified and counted correctly.

Leaf litter

- Leaf litter is all the plant organic matter above the top layer of the compacted soil, mostly consisting of decaying and dry leaves (Moses *et al.* 2021), but can also include needles, grass, twigs and bark (Wundke *et al.* 2015).
- Leaf litter does not include coarse woody debris or woody debris.
- Push the ruler through the litter until it reaches the soil surface. The soil surface should be firm.
- Measures of litter depth can have low accuracy (Marimon-Junior and Hay 2008), so ensure that the light pressure applied until there is even contact with the litter surface is consistent across sampling locations.
- If leaf litter measurement device is not available, an equivalent can be created with a standard 30 cm ruler and a piece of cardboard. Ensure that the tool used is consistent throughout the survey.
- The same individual should conduct all leaf litter measurements to reduce error.

We at TERN acknowledge 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.

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