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Ecosystem Research Infrastructure

Ecological Field Monitoring Protocols Manual

Using the Ecological Monitoring System Australia

Basal Area Module – PROCEDURE ONLY

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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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Main front cover photograph: Spring Gully Conservation Park, South 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	20 November 2025	First published version

1 DBH 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 DBH protocol.
- Undertake the Floristics Module to ensure consistency with flora species identifications/assigned field names.

1.1.2 Time requirements

Survey activity time will vary depending on the options chosen, the density of vegetation to traverse, the number of trees to measure and the number and experience of personnel. As a general guide:

- 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 1–4 hours to complete the Enhanced protocol.
- Allow 0.5–2 hours to complete the Standard protocol.

1.1.3 Personnel requirements

Number of personnel and skills:

- Basal area DBH measurements are best conducted with two personnel, one taking measurements and one recording data directly into the Monitor app.
- The surveyor making observations should be familiar with, and experienced in, species identification and differentiating between species.
- Basal area DBH measurements do not involve interference with vegetation or wildlife. Therefore, scientific permits and wildlife ethics approvals are unlikely to be required but always check with the local authority. Access permissions are required.

1.1.4 Equipment

General:

- Mobile device (tablet/phone) with the Monitor app pre-loaded
- GNSS receiver capable of achieving <30 cm accuracy (e.g. Trimble® R1 or DA2), hand-held GPS, or device built-in GPS (least preferred)
- Diameter tape, measuring tape or tree calipers
- Measuring pole with 1.3 m clearly marked or 5−10 m tape measure
- Chalk
- Step ladder (for measuring buttressed trees).

Additional equipment required:

- 4 x 100 m tape measures or pegs/flagging tape to mark the sub-plot boundary (when completing the Standard protocol)
- 10 x 100 m tape measures (or ca. 40 coloured survey pins) to divide the plot into smaller units for ease of sampling (when completing the Enhanced protocol).

1.1.5 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. Survey area is determined by the protocol being undertaken:
    - If completing the Standard DBH protocol use the transects laid out for the Cover Module to delineate the 40 x 40 m sub-plot, between the N/S2 and N/S4, and E/W2 and E/W4 point-intercept transects (see Figure 1). This 40 x 40 m sub-plot will be the survey area.
    - If completing the Enhanced DBH protocol and the plot contains dense trees, tall shrubs and/or mallee, use the transects laid out for the Cover Module to partition the plot into smaller units. Alternatively, use coloured survey pins. The 100 x 100 m plot will be the survey area.
3. Open the Monitor app and navigate to the Basal Area Module and then the DBH protocol.
4. Select the relevant *plot size* for the project. Steps 5–13 are the same whether completing the Enhanced or Standard DBH protocol.
5. Select the *DBH instrument* you are using to measure DBH, either a diameter tape, tape measure or tree caliper.
6. Move through the plot section by section, systematically searching for trees, tall shrubs and mallee greater than 2 m in height and with a DBH ≥10 cm (or 5 cm for mallee and mulga dominated sites).
7. For each tree encountered, record:
    - The *floristics voucher* (i.e. the field name recorded for the species in the Floristics Module). If the tree is dead, leave the *floristics voucher* field blank and flag the tree as 'dead'.
    - If the tree is multi-stemmed, check the box:
        - The app will display stem labels (Stem 1, Stem 2, Stem 3, etc.).
        - Add additional stems by selecting the add button and complete step 8 for each individual stem.
    - If the tree is buttressed, check the box:
        - The app will require the input of the diameter and POM of the tree at its reach point (the highest point you can reach - approximately 2.2 m) and the diameter and POM of the tree at 50 cm above the buttress. If you cannot measure 50 cm above the buttress, leave the field blank, it will be recorded 'not collected'.
8. For each tree/stem, then locate the 1.3 m point of measurement (POM) (see note below) and:
    - Clear any moss, loose bark or other material that may distort the measurement and measure the diameter of the tree at the POM.
        - If using a diameter tape, measure the diameter of the tree (in centimetres) by pulling the diameter tape around the trunk or stem at the POM perpendicular to the main axis of the trunk or stem.
        - If using a 5–10 m measuring tape, record the circumference of the trunk or stem (in centimetres) at the POM. The app will automatically calculate and display the diameter measurement in the DBH field.
        - If using a tree caliper, close the caliper around the trunk or stem at the POM so that it is perpendicular to the main axis of the trunk or stem, rather than parallel to the ground (this provides an accurate measurement of leaning trees). Record the diameter in centimetres.
        - If when using the tree caliper to measure, the trunk or stem is an ellipse shape, check the *ellipse* checkbox and record a second diameter measurement at a 90° angle to the first diameter measurement to account for the ellipse. The app will automatically calculate the square root of the product of the two diameters to determine the measure of trunk or stem diameter and display the diameter measurement in the *calculated DBH* field.
    - Note: use the 1.3 m POM, or suitable POM for problem trees (see Figure 3).
9. Date and time will be automatically recorded. Update if required and save the observation.
10. Once measured, mark the tree or stem with chalk to avoid remeasuring.

11. Repeat steps 7–10 for every tree within the plot or sub-plot.
12. When all trees have been measured, queue the collection for submission.

1.1.6 Additional guidelines

Taking measurements

- It may be beneficial to undertake this module while the transects for the point-intercept measures in the Cover Module (5 N/S and 5 E/W; see Figure 1) are laid out. The transects can help to partition the plot into more manageable units that can be surveyed systematically. Alternatively, use coloured survey pins to divide the plot. This will be particularly helpful in dense plots.
- When recording a new tree using the *add tree* button, ensure that the app operator is standing as near to the tree as possible as the tree location is recorded with this action.
- Chalk that is light coloured such as pink and purple show up best when marking trees.
- Clearly mark the measuring pole at 1.3 m to easily locate the POM.
- If a measuring pole is not available, use the normal side of the diameter tape (i.e. the side of the tape with 1 cm increments) or a regular measuring tape to locate the POM. Mark the tape at 1.3 m to easily locate the POM.
- Loose litter and debris at the base of the tree should be brushed aside before determining the POM.
- The rule set to determine if a tree is in or out of the plot is illustrated in Figure 4. A tree is in the plot if more than 50% of the base of the trunk is within the plot.
- A rigid tape measure is accurate for measuring the circumference of smaller trees (~50 cm DBH) and where there is loose bark.
- For mallee or mulga trees that branch into multiple stems below 1.3 m it is recommended to take diameter measurements at 30 cm from the ground or if branching lower than this at 10 cm and record the POM as such.

Solutions to problem trees

The solutions to measuring DBH for problem trees are illustrated in Figure 3.

- Trees on a slope (Figure 3a), 1.3 m should be measured on the uphill side of the tree.
- Leaning trees (Figure 3c) should be measured on the inside of the lean, starting at the ground next to the base of the tree.
- Multi-stemmed trees (Figure 3d and e) are treated as single trees with multiple stems (Stem 1, 2, 3, etc.). A single DBH is recorded if the tree branches above 1.3 m (d), otherwise, each individual stem is measured (e).
- Mallee or mulga (Figure 3f) that branch very close to the ground should be measured at 30 cm or if branching lower than this, 10 cm and POM recorded accordingly.
- Deformed trees (Figure 3g and h) should be measured either above or below 1.3 m and the POM recorded.
- Buttressed trees (Figure 3i) are a significant source of error in repeat tree measurements and require careful attention in the field. Buttressed trees are measured at 1.3 m, at the highest point you can reach (e.g. approximately 2.2 m) and 50 cm above the top of the buttress. Every effort must be made for both the 1.3 m and the highest point you can reach during initial surveys.
- Dead trees in a baseline survey are flagged as *dead,* and all other attributes are measured as normal.

- The soft texture of tree fern trunks is not conducive to DBH measurements and therefore, tree ferns are not measured for diameter.

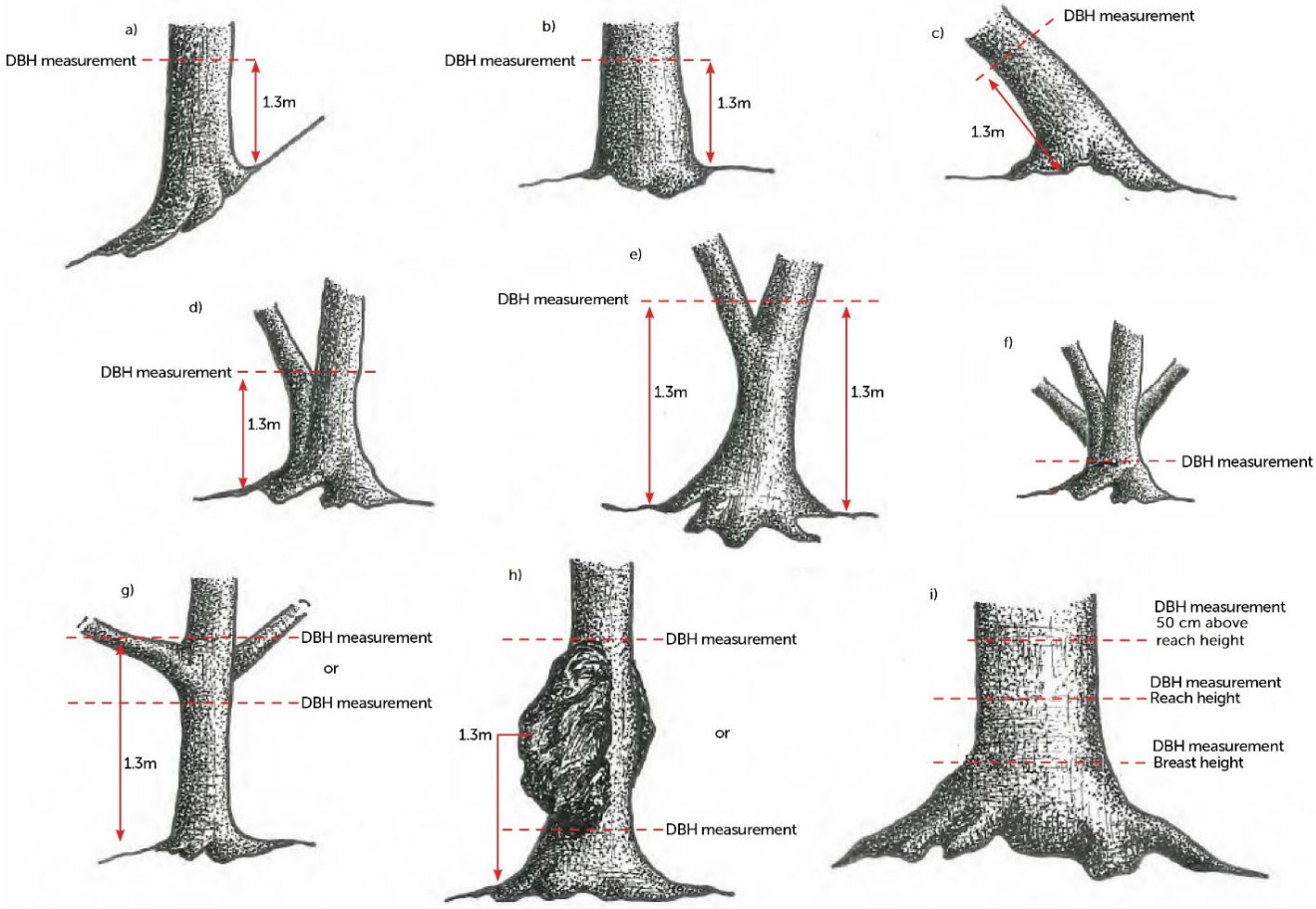

Figure 1. Solutions to measuring DBH for problem trees. Adapted from: Wood et al. (2015): a) trees on a slope, b) straightforward tree, c) leaning tree, d) and e) multi-stemmed trees, f) mallee/mulga, g) and h) deformed trees and i) buttressed trees.

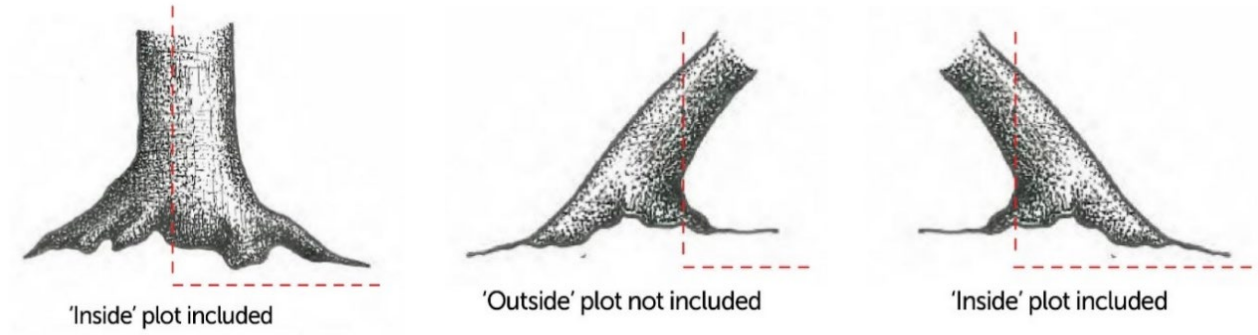

Figure 2. Rule set to determine if a tree is in or out of the plot (adapted from Wood *et al.* (2015).

1.2 Post-field survey tasks

1.2.1 Sample curation

The DBH protocol does not collect samples. There are no curation requirements.

2 Basal wedge protocol

2.1 Field collection

2.1.1 Pre-requisites

Pre-requisites for completing this protocol:

- The plot must be established using the Plot Layout and Selection Module prior to conducting the DBH protocol.
- Undertake the Floristics Module to ensure consistency with flora species identifications/assigned field names.

2.1.2 Time requirements

Survey activity time will vary depending on the options chosen, the density of vegetation to traverse, the number of trees to measure and the number and experience of personnel. As a general guide:

- Allow 30 minutes to complete the basal wedge survey per plot.

2.1.3 Personnel requirements

Number of personnel and skills:

- Basal wedge sweeps may be conducted by a single observer and the observations can be recorded directly into the Monitor app.
- The surveyor making observations should be familiar with, and experienced in, species identification and differentiating between species.
- Basal wedge sweeps do not involve interference with vegetation or wildlife. Therefore, scientific permits and wildlife ethics approvals are unlikely to be required but always check with the local authority. Access permissions are required.

2.1.4 Equipment

- Mobile device (tablet/phone) with the Monitor app pre-loaded
- TERN Basal Wedge (Figure 2) with attached string knotted at precisely 50 cm from the wedge.

2.1.5 Instructions and procedures

1. Ensure the Plot Selection and Layout Module has been completed to mark out the plot (including the centre point and north, south, east and west point sampling locations) and define the current plot and visit in the Monitor app.
2. Open the Monitor app and navigate to the Basal Area Module and then the Basal wedge protocol.
3. Stand at one of the nine basal wedge sampling locations (see Figure 1) and select the location from the drop-down list (Appendix 2). It does not matter which order the sampling locations are surveyed.
4. Hold the end knot of the 50 cm length of string attached to the wedge on your cheek below one eye – close the other eye. Hold the wedge so that the string is taut (see Figure 5).
5. Determine if the use of the basal wedge is warranted at the plot (i.e. are there sufficient trunks or stems of trees, tall shrubs or mallee that are large enough to obtain a score of seven or more from 'in' and 'borderline' trees for any species). If there are not sufficient trees to sample then the Enhanced or Standard DBH protocols are recommended to complete basal area measurements.
6. For each species, establish which Basal Area Factor (BAF; 0.1, 0.25, 0.5, 0.75, 1 and 2) to use. This is determined by selecting a BAF and undertaking a brief sweep around the point sampling location to determine if the selected BAF will sample seven or more 'in' trees (see Additional guidelines below for rules on counting 'in' and 'borderline' trees) for the sampling location. Ideally, aim to achieve the minimum seven 'in' trees with the largest aperture width.

7. Once you have selected the appropriate BAF for a species, rotate through a complete 360° sweep and, looking through the eye above the string, count the number of stems or trunks of each species at breast height, that are wider than the aperture of the chosen BAF as 'in', and the exact width of the aperture as 'borderline' (i.e. half count).
8. Record the *floristics voucher* (i.e. the field name recorded for the species in the Floristics Module). Species that cannot be easily distinguished from one another may be combined for the basal wedge count. In this case, check the *group species* box and select all relevant floristics vouchers. This is only applicable if they are of the same genus and growth form (e.g. mallee).
9. Record the BAF used (from the drop-down list; see Appendix 1), and the tally of 'in' and 'borderline' trees for that particular species/group.
10. Date and time will be automatically recorded. Update if required and then save the observation.
11. Repeat steps 6–10 for the remaining species at the sampling location using the blue + button.
12. Select the *finish sampling location* button to return to the sampling location selection screen.
13. Repeat steps 3–12 at each remaining sampling location.
14. When basal area has been recorded for each species at each sampling location, queue the collection for submission.

Figure 3. Surveyor correctly holding the end of the TERN Basal Wedge string on the cheekbone below the eye and holding the wedge at full length with the string taut.

'in' (+1) 'borderline' (+0.5) 'out' (0)

Figure 4. Examples of how to score trees using the TERN Basal Wedge.

2.1.6 Additional guidelines

Rules to determine 'in' trees

- Examples of how to score trees using the TERN Basal Wedge are illustrated in Figure 6.
- A tree is 'in' when its trunk or stem, at breast height (1.3 m, or the nearest point above if there is a deformity at 1.3 m), is wider than the chosen BAF (Figure 6).
- Species that cannot be easily distinguished from one another may be combined for the basal wedge count but this is only applicable if they are of the same genus and growth form (e.g. in mallee) as the basal area equation will be the same.
- Do not record the data if less than seven 'in' trees for a given BAF are achieved for each species. Data become meaningless with less than seven 'in' trees. Repeat the sweep using a smaller BAF, or if there are less than seven 'in' trees with the smallest BAF (0.1), no data is recorded.
- Where the trunk or stem is exactly the width of the BAF (i.e. 'borderline' tree), add a half count to your tally (Figure 6).
- Select the widest suitable BAF to sample seven 'in' trees for the species. This increases efficiency as it reduces the number of 'in' trees likely. For example, use the '1' BAF to record eight 'in' trees rather than the '0.5' BAF to record 15 'in' trees.
- It is more efficient to use the same BAF for every species at each sampling location. However, this is not always practicable. For example, the '0.5' BAF may be suitable to be used for *species x* at all sampling locations; while the '0.1' BAF may be required for *species y* at all sampling locations, etc.
- For each species, only use one BAF at each sampling location. Do not make separate counts of 'in' trees using different BAFs for the same species.

Solutions to problem trees

- For hidden trees (trees that are partially or fully hidden behind other trees or undergrowth), move sideways until the tree is fully in view, but be sure to maintain the same distance to the tree. Move back to the sampling point before assessing the next tree.
- Buttressed trees should be measured above the buttress.
- For multi-stemmed trees, measure each stem individually and add all 'in' stems to your tally.
- For trees on a slope, the 1.3 m POM should be measured on the uphill side of the tree.
- For leaning trees, hold the basal wedge at a tilt so that the view is at right angles to the trunk or stem.
- Deformed trees should be measured at the nearest point above 1.3 m that is not deformed.
- Dead trees are flagged as *dead* and all other attributes are measured as normal.
- The soft texture of tree fern trunks is not conducive to DBH measurements, and therefore, tree ferns are not measured for diameter.

2.2 Post-field survey tasks

2.2.1 Sample curation

The Basal wedge protocol does not collect samples. There are no curation requirements.

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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