Private Native Forestry Code of Practice Guideline No. 5

Techniques for Measuring Stand Basal Area

Introduction

This document provides a guide to the measurement of stand basal area. The Private Native Forestry Code of Practice (the Code) uses the concept of basal area to set disturbance thresholds, or retention limits for single tree selection and thinning operations in private native forests. Basal area is a forest measurement that can help forest owners estimate tree volumes, and understand and manage stand density and competition.

It is the responsibility of landowners and forestry contractors and operators to comply with the Code.

For the purpose of this guideline, and for use in accordance with the Code, there are some important definitions which include the following.

- **Tree basal area:** the cross-sectional area of a tree trunk measured at breast height over bark. It can be thought of as the surface area of a cut stump at a height of 1.3 m (Figure 1).
- **Stand:** an area of forest that can be identified and mapped according to broad forest type and height class as listed in section 3.1 of the Code (section 3.2 in the Code for Cypress and Western Hardwood Forests).
- **Stand basal area:** the sum of the basal area of all live trees in a stand, is usually expressed in square metres per hectare (m^2/ha).

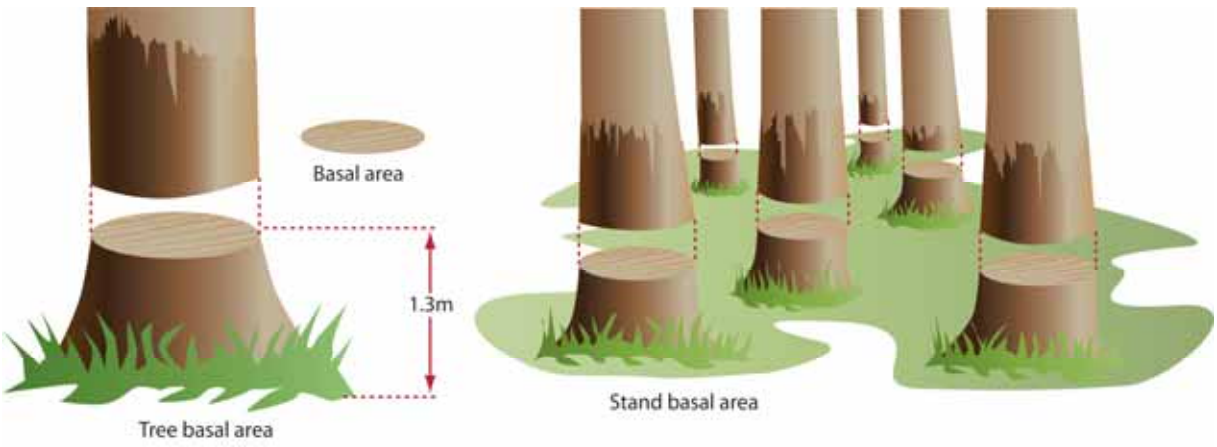


Figure 1: Tree basal area and stand basal area

Methods

Stand basal area can be measured by two methods: angle count sampling or fixed area plot measurement.

Angle count sampling

This method of sampling allows unbiased estimates of stand basal area to be made very quickly without the need to individually measure each tree stem or to set out a fixed sample plot area. A sweep of an area of the forest is made from a sampling point using a relascope, dendrometer or wedge prisms.

Note: Angle count sampling is the method that is described in this guideline for everyday use with the Code.

Fixed area plot measurement

This method involves:

1 the measurement of the diameter of all trees in a set area; one-tenth hectare plots are normal forestry practice (for example 50 m x 20 m)

2 calculating the basal area of each tree in the plot

3 calculating the total basal area.

Fixed area plot measurement should be used where a more definitive measurement than can be obtained from angle count sampling is required. It may be used by officers of the Department of Environment, Climate Change and Water (DECCW) where there is any doubt about compliance with the stand basal area requirements of the Code.

Note: This method may be required for basal area measurement in riparian buffer zones under section 4.4(2) of the Code. See 'Measuring stand basal area in riparian buffer zones' on page 7.

Complying with the Code

Under the Code, minimum stand basal areas have been set for single tree selection and thinning operations below which the stand basal area cannot be reduced. This helps to ensure that an adequate forest structure is maintained for the long term.

Stand basal area will need to be assessed:

- prior to a forestry operation to ensure that there is sufficient existing basal area to conduct the forestry operation in compliance with the Code
- during any forestry operation to ensure continuing compliance with the Code.

For the purpose of this guideline, the minimum stand basal areas in the Code *will be applied as an average* over the *relevant operational area* of a forestry operation. This will require a number of representative measurements to be taken across the area so that an average can be calculated. This allows a reasonable degree of silvicultural flexibility and practicality in planning forest operations.

The relevant operational area of a forestry operation is defined as follows:

- for *current forestry operations*: those parts of the stand within the area described in the current Forest Operation Plan where the current forestry operation has already been implemented – see section 2.1(5)(a)(i)

- for *previously completed forestry operations*: those parts of the stand where forestry operations have previously been conducted under the Code – see section 2.1(5)(a)(i).

While the stand basal area provisions of the Code are applied as an average, there are limits to this principle.

- Averaging can only occur within contiguous forest areas. Isolated patches or physically separate areas of forest must be treated individually.
- No more than half of the sampling points in the relevant operational area can be below the minimum limits.

Note: Calculations undertaken during a harvesting operation to ensure that the average stand basal area complies with the Code cannot include areas outside the Forest Operations Plan boundary or areas within the Forest Operations Plan boundary that are yet to be harvested.

It is important that everyone involved with any single tree selection or thinning operation understands the minimum basal area requirements of section 3.1 of the Code (section 3.2 of the Code for Cypress and Western Hardwood Forests) and this guideline. This may include landowners, forest contractors and forestry consultants.

To comply with the Code, this procedure must be followed:

- Classify the proposed area for single tree selection or thinning into broad forest types and map on the Forest Operation Plan.
- Classify each broad forest type into two height classes of less than 25 metres or greater than 25 metres, and map or note on the Forest Operation Plan.
- Comply with the relevant minimum stand basal area.

Note: The first two points above do not apply to the river red gum broad forest type.

While not required by the Code, it is beneficial to mark the boundaries of the above areas on the ground prior to commencing forest operations.

Angle count sampling

Instruments

Stand basal area can be measured using a variety of instruments, ranging from the sophisticated and expensive which can be obtained from forestry equipment suppliers, through to simple home-made devices. These instruments are referred to as relascopes or dendrometers, and there are a number of versions. Glass wedge prisms can also be used.

The simpler instruments are hand-held gauges with sights which are held at a pre-determined distance from the operator's eye. There is a mathematical relationship between the width of the sight of the instrument and the distance from the eye which is known as the basal area factor (BAF). Most relascopes and dendrometers have a BAF of 1, 2 or 4; generally using a BAF of 2 is a good starting point.

Bottle-opener dendrometer

A bottle-opener dendrometer combines BAFs of 1, 2 and 4 and can be obtained from forestry equipment suppliers. It is flat and fits comfortably in a pocket. It has an attached cord so that the distance at which it is held from the eye is constant (Figure 2).

Rod relascope

Unlike a bottle-opener dendrometer, each rod relascope measures a single BAF; a set of rod relascopes to measure various BAFs can be easily made from metal (Figure 3). Instructions for constructing a rod relascope are given in the Appendix.

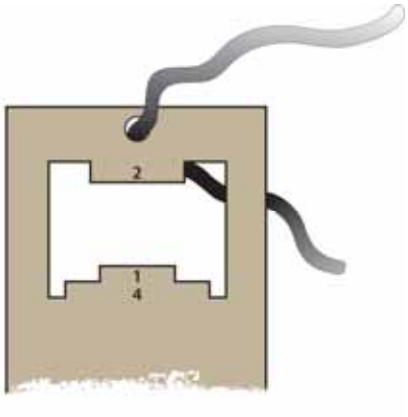


Figure 2: Bottle-opener dendrometer

Figure 3: A rod relascope

Method

Angle count sampling requires a sweep of an area of forest from a set sampling point within the forest stand. A sweep is where the operator stands in one spot and turns through 360° sighting each tree with a relascope or dendrometer. A number of sweeps throughout the forest stand will be required.

When using a relascope or dendrometer the cord (which must be kept taut) or rod is held against the operator's cheek just below the eye. If using an instrument with multiple BAFs only use one BAF per sweep (Figure 4). To assess a tree that is partially or fully hidden behind other trees or undergrowth, move sideways until the tree is fully in view. Move back to the sweep centre before assessing the next tree. Trees under 10 cm in diameter at breast height and dead trees should not be counted.

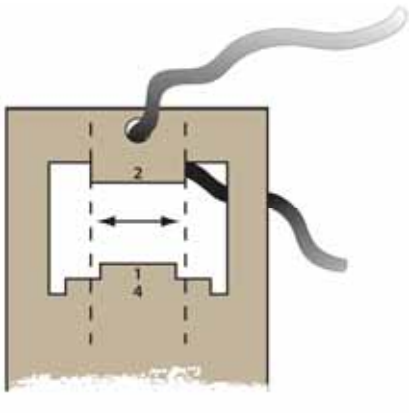


Figure 4: Dendrometer sight with a BAF of 2

The angle count sampling method is described as follows:

Step 1: Select the sampling point where the angle count sweep is to be taken.

Step 2: While ensuring that the eye remains over the sampling point, complete a 360° sweep around that point. Aim the sight of the instrument at the stem of each tree at breast height and count trees as follows (Figure 5):

- If the stem of the tree is wider than the instrument sight, the tree is 'in' and assigned a count of 1.
- If the stem of the tree matches the width of the instrument sight, the tree is deemed to be borderline and is assigned a count of ½.
- If the stem of the tree is narrower than the instrument sight, the tree is deemed to be 'out' and is not counted.
- Tally the number of counts as you conduct the sweep.

Step 3: Calculate the stand basal area (m^2/ha) by multiplying the tally for the sweep by the BAF used.

There is no set area covered by an angle count sweep. Trees will appear either in, equal to or out according to their diameter, the distance from the sighting point and the BAF of the instrument being used. It is important to select a BAF that is suitable for the forest being assessed. To obtain the best accuracy, the aim should be to have a tally of approximately 10 to 12 trees per sweep. This may mean using a higher or lower BAF instrument.

Note: It is a good idea to occasionally check your accuracy using this method by calculating the basal area at the same site using the fixed plot method.

The existing stand basal area prior to a forestry operation must be entered on the Forest Operation Plan.

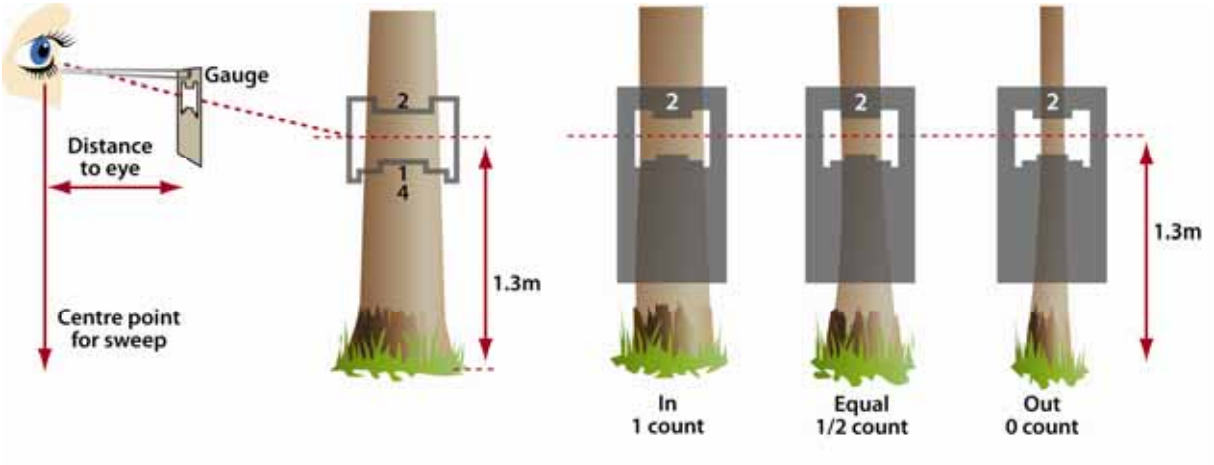


Figure 5: Assessing trees which are in, equal, and out for a BAF of 2

Tips to remember:

- View each tree at breast height (1.3 m above ground).
- The operator's eye must remain over the centre point of the sweep during the whole sweep.
- View at right angles to the stem of leaning trees. If the stem of the tree is not upright, hold the instrument at a tilt (Figure 6).
- View trees hidden by undergrowth or other stems by moving to the side.
- Use an instrument BAF that counts 10 to 12 trees for each 360° sweep.
- Include all living trees with a diameter greater than 10 cm at breast height.

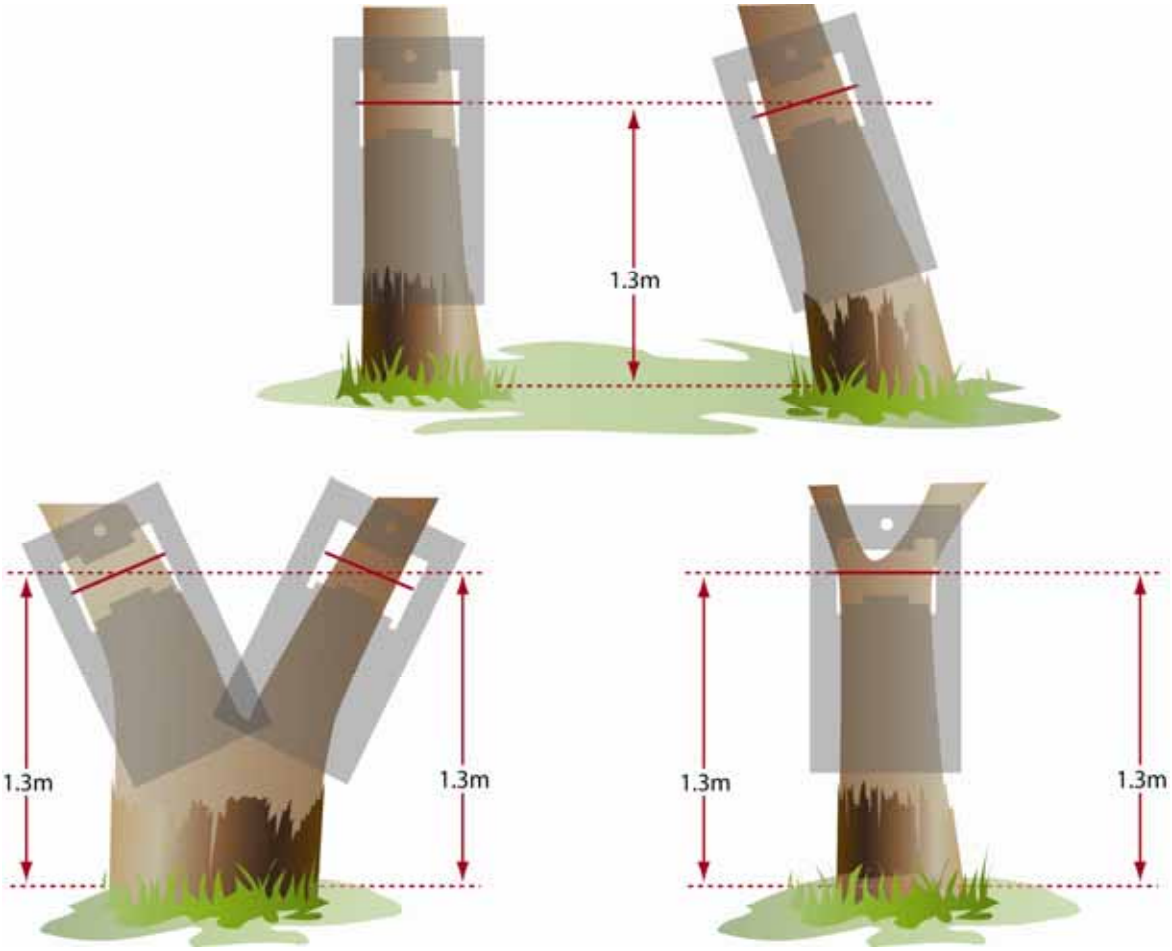


Figure 6: Measuring tree stems

Determining the number of sweeps

It will usually be necessary to conduct a number of sweeps across the current operational area in order to obtain a reasonable and accurate average measurement of the stand basal area.

There is no set rule as to how many sweeps should be made, but the results will be more accurate as the number of sweeps increases. A guide for native forest stands is 10 sweeps for any area up to 30 hectares, and up to at least 30 sweeps for larger stand areas. The greater the variability of basal area throughout the stand, the greater the number of sweeps that should be conducted.

Note: You should conduct at least enough sweeps to ensure that you are confident of compliance with the Code.

There are a number of considerations when selecting sampling points.

- Sweeps should be located at random and not overlap with other sweeps.
- Sweeps should sample a range of topography and not be conducted within or near canopy openings, roads, tracks or log dumps.
- Although within the general operational area, natural openings (not created by current or past forestry operations) in the forest should be avoided.

- Sweeps must not include areas of forest that may not be felled under the Code, for example old growth forest, rainforest and riparian exclusion zones.
- All readings should be at least 30 m from the edge of the timbered area. This may mean that the angle count method may not be suitable for small patches of forest.

DECCW officers check basal area as part of routine audits of compliance with the Code.

Measuring stand basal area in riparian buffer zones

In the Code for Northern NSW, Southern NSW and River Red Gum Forests, riparian buffer zones apply to specified drainage features (riparian buffer zones are not required under the Code for Cypress and Western Hardwood forests). Within these buffer zones additional basal area restrictions apply where only 30% of the pre-harvest basal area can be removed in any 10-year period (section 4.4(2)). This means that basal area within riparian buffer zones may need to be measured separately from the remainder of the harvest area.

Riparian buffer zones vary from 10 to 30 metres in width. Because of this limited width it will not be possible to conduct a full angle count sweep, and therefore alternative basal area measurement methods must be used.

The alternatives are as follows.

- In wide buffer zones (25 and 30 metres) it may be possible to conduct half sweeps (180°) and multiply the result by two to obtain the basal area. To conduct the basal area sweep in these cases, stand on the boundary of the buffer zone and the adjacent riparian exclusion zone.
- In all other cases it will be necessary to conduct a fixed area plot measurement to obtain an accurate result.

Alternative method in river red gum forests

The minimum stand basal area across all river red gum forests is 12 m^2/ha, and therefore an additional method to assist retention of the stand basal area, based on tree spacing, can be used. The maximum tree spacing is given by d/4 x 100 (or ¼ diameter x 100), where d is the over bark tree diameter in centimetres at breast height.

To determine the distance to the next tree of the same diameter that must be retained:

- Measure the over bark diameter of a retained tree at breast height in centimetres. This is best done using a diameter tape.
- Divide the diameter by 4 and then multiple by 100 to express the measurement in metres.

For example, if the diameter of a tree is 60 cm, then d/4 = 15cm. To achieve the minimum basal area of 12 m^2 /ha, another tree of the same diameter must be retained within 15 m from the measured tree (15 cm x 100 = 15 m).

To determine the distance between trees of different diameter, an average of the distance required for each tree diameter can be used. The following table shows the required distance between trees of different diameters.

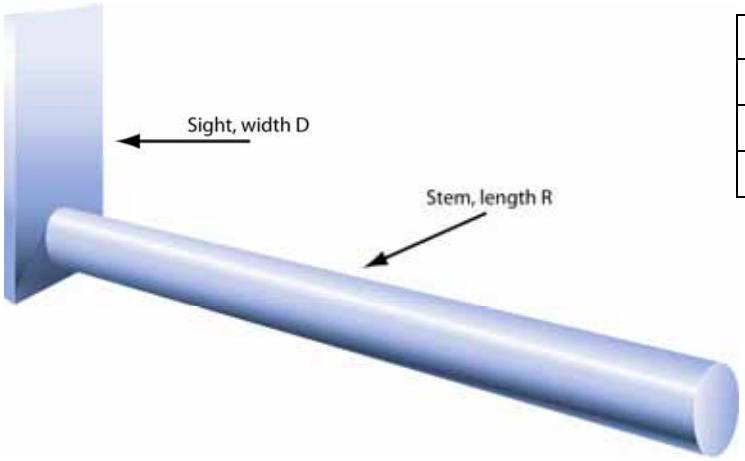
Tree spacing (centre to centre) to average 12 m^2 /ha basal area (to nearest ¼ metre)

Distance between trees (m)										
Tree diameter (cm)	Tree diameter (cm)									
	100	90	80	70	60	50	40	30	20	10
100	25.00									
90	23.75	22.50								
80	22.50	21.25	20.00							
70	21.25	20.00	18.75	17.50						
60	20.00	18.75	17.50	16.25	15.00					
50	18.75	17.50	16.25	15.00	13.75	12.50				
40	17.50	16.25	15.00	13.75	12.50	11.25	10.00			
30	16.25	15.00	13.75	12.50	11.25	10.00	8.75	7.50		
20	15.00	13.75	12.50	11.25	10.00	8.75	7.50	6.25	5.00	
10	13.75	12.50	11.25	10.00	8.75	7.50	6.25	5.00	3.75	2.50

Appendix: Building a rod relascope

The rod relascope can be simply and cheaply constructed from a straight rod with a flat sight attached to the end of the rod at a right angle. The length of the rod and the width of the sight must be to exact specifications to achieve an accurate BAF.

The following table gives measurements for the length of the stem (R) and the width of the sight (D) for three values of BAF.



BAF	R (mm)	D (mm)
1	500	10
2	460	13
4	400	16

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