

Forests Service

NATIVE FOREST SILVICULTURE GUIDELINE No. 12

**TREATMENT OF
NON-MERCHANTABLE TREES**

**Department of Natural Resources and Environment
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NATIVE FOREST SILVICULTURE GUIDELINE NO. 12

This Guideline describes procedures for planning and conducting the treatment of non-merchantable trees during and following harvesting of eucalypt forests in Victorian State forests. The effects of retained trees on regrowth development are summarised, and specifications for desirable retained basal areas are given. Treatment categories, methods and costs are also covered.

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1 INTRODUCTION

All silvicultural operations in Victorian native State forests are carried out according to the principles of ecological sustainable forest management (ESFM). These principles cover issues such as soil and water quality, fauna and flora, and landscape and cultural/historic values and are set out in the Code of Forest Practices for Timber Production (NRE 1996), Regional Forest Agreements and Forest Management Plans. ESFM is management that is designed to ensure that natural ecological processes and components of the forest will be maintained in the long term.

Silviculture, which involves the management of forest establishment, composition and growth, is thus a fundamental element of ESFM where timber harvesting and regeneration is practised. This Guideline is one of a series produced to explain and document good silvicultural practices for Victorian native State forests, incorporating the results of both research and field experience.

1.1 AIM OF GUIDELINE

The aim of this Guideline is to provide information on the effects and treatment of non-merchantable trees to assist in planning and carrying out harvesting, regeneration and post-regeneration treatments.

1.2 WHY TREAT NON-MERCHANTABLE TREES?

Due to frequent damaging fires, fungal/insect attack and selective logging, a proportion of eucalypt trees in State forests are defective in various ways, making them non-merchantable. Many of these should be removed during or soon after timber harvesting so that regeneration and young, growing trees have the best chance to survive and grow without excessive competition for light, moisture and nutrients. The competitive effects of non-merchantable trees will reduce the growth rate of the young forest by a significant amount.

Non-merchantable trees are those:

- not currently suitable for commercial harvesting, and
- not required for regeneration or habitat purposes.

Historically, non-merchantable trees have been known by a variety of names and definitions, including; 'overwood'¹, 'culls'² or 'potentially merchantable'³. Each term has a specific connotation but the general term 'non-merchantable' will be used in this Guideline.

1 'Overwood' is a collective term used to describe mature trees growing on a site which also carries regeneration or regrowth.

2 A 'cull' is a tree of merchantable size but which has no current commercial value for timber production.

3 A 'potentially merchantable' tree is a tree which currently has no commercial value, but which with changing market conditions or increased size may, in the future, be merchantable.

Non-merchantable trees often occupy a large amount of the site, yet are growing little or no merchantable timber, so that the overall commercial site productivity is lower than it could be. The objective in treating non-merchantable trees is to reduce the density of non-productive overwood, to levels at which regeneration and the subsequent growth of the stand is not unduly inhibited. To maximise the commercial returns from a regenerating stand, the regrowth should be able to utilise more than 90% of the site's growth potential.

Situations where removal of non-merchantable trees should be considered include:

- *Regrowth stands with a high proportion of cull overwood.* Removal of the non-merchantable trees in this situation is usually called 'timber stand improvement'.
- *Mature forest being harvested where there is a significant cull component.* Here, cull removal is best done in conjunction with the harvesting operation.
- *Forests selectively harvested many years previously, with little or no advanced regrowth or regeneration and with a significant cull component.*

2 EFFECTS OF RETAINED TREES⁴

Retained overwood trees affect the growth of the regenerating forest by competing for and utilising some of the available plant growth resources—light, soil nutrients and moisture. The effect of this competition is summarised below. Further information is included in **Appendix 1**.

2.1 ZONE OF INFLUENCE

The 'zone of influence' is the area surrounding an individual tree which contributes resources to that tree's development and growth, and therefore depletes (influences) the resources available to any other (regrowth) stems in that zone. The simplest example of the zone of influence is demonstrated by the low density or absence of regeneration directly below the crown of a tree. Within crown projection of all eucalypts, the number of surviving seedlings *decreases* markedly closer to the trunk (Florence 1996), even though they may have germinated from seedfall, the quantity of which is known to *increase* along that continuum (Campbell *et al.* 1990, Bassett 1996). For some eucalypts (e.g. *Eucalyptus camaldulensis*) there is commonly no surviving regeneration within crown projection, (Opie 1969, Dexter 1978).

However, the boundary of crown extent does not necessarily define the zone. The zone of influence of a tree may be more accurately defined as the total area over which the tree obtains, or competes for, site resources.

A number of studies have been conducted to define a suppressive zone of influence for some eucalypt species (Incoll 1979, Rotheram 1983, Kellas *et al.* 1998 and Bi & Jurskis 1997). Similar trends were obtained in all studies, with the exception of Incoll (1979), who recorded the greatest zone of influence with an average radius of 4 to 6 crown radii around the subject tree *E. sieberi*, (see Fig 1.). In contrast, Opie (1969) indicated the radius of this zone in *E. camaldulensis* as 2.1 crown radii, *i.e.* substantially smaller.

⁴ Section 2 and Appendix 1 have been predominantly drawn from Bassett & White (1999), "Review of the Impact of Retained Overwood Trees on Stand Productivity".

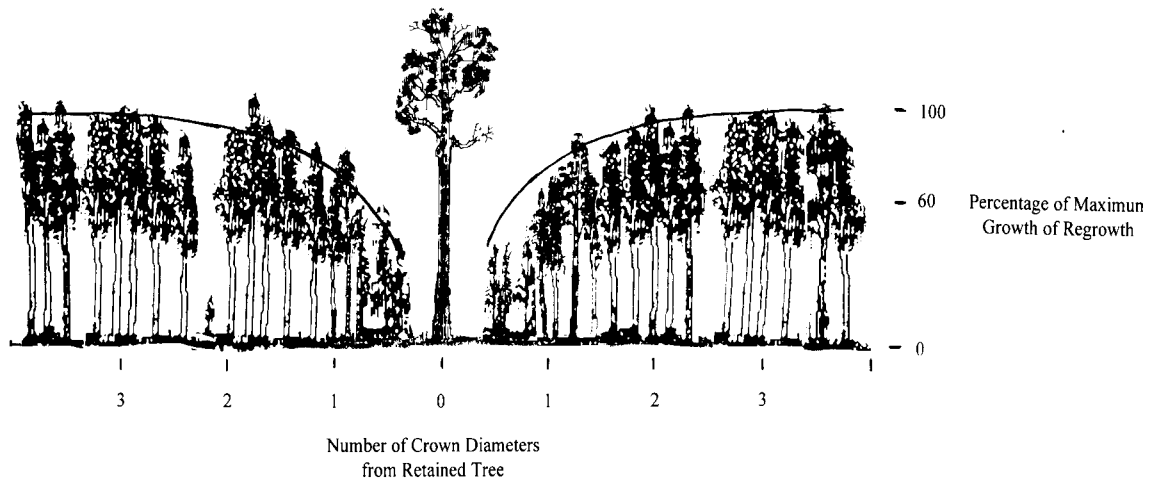


Figure 1. The effect of a retained overwood tree on the growth of *E. sieberi* (silvertop) regrowth – adapted from Incoll (1979)

Note that the effect on volume will be even greater because overwood competition reduces both the height and basal area growth of the regrowth. The competitive effect of overwood trees of different sizes should also be considered. Table 1 below shows the number of trees of different sizes which have the same total basal area as one tree of 100 cm DBHOB.

Table 1. Comparison of basal areas of trees of different sizes

Tree DBHOB (cm)	Tree basal area (m ²)	Number of trees	Total basal area (m ²)
100	0.79	1	0.79
70	0.38	2	0.77
50	0.20	4	0.79
35	0.10	8	0.77
25	0.05	16	0.79
17.5	0.02	32	0.77

Clumping retained overwood may have benefits, including more effective use of habitat trees (Loyn 1985). The impact of overwood on regeneration and regrowth may be reduced by clumping retained trees, effectively reducing the spread of zone of influence. Bi & Jurskis (1997) demonstrated this effect in *E. fastigata* when study trees were clumped with neighbouring regrowth on one side only. However, in drier forest types where competition for soil moisture is high this may not be a factor.

2.2 RETAINED TREES IN A MIXED AGE STAND

From a total stand perspective, commercially non-productive trees contribute to overall productivity and will respond in the same manner as productive trees. However, from an economic perspective, any site productivity being utilised by these non-commercial trees will be to the detriment of those trees of commercial value.

In mixed age stands, the proportion of the stand occupied by each tree is inversely proportional to the number and size of trees present on the site. For a range of stockings within the zone of maximum growth, Table 2 illustrates the percentage of commercial stem volume lost due to the presence of a non-commercial tree, using the assumption that tree volume is directly proportional to basal area.

Table 2. Percentage of volume loss per hectare due to the retention of a single tree of a particular diameter for various stand stocking (BA) levels.

Retained tree		Production loss (%) for a given stand BA			
Diameter (cm)	Basal Area (m ² /tree)	50 m ² /ha	40 m ² /ha	25 m ² /ha	15 m ² /ha
50	0.20	0.4	0.5	0.8	1.3
75	0.44	0.9	1.1	1.8	2.9
100	0.79	1.6	2.0	3.2	5.3
125	1.23	2.5	3.1	4.9	8.2
150	1.77	3.5	4.4	7.2	11.8
200	3.14	6.3	7.9	12.6	21.0

If the non-commercial stems are in the dominant class and the commercial or potentially commercial stems are in a lower canopy class then the impact of the retained trees on the merchantable growth may be under-estimated by Table 2.

3 IDENTIFYING TREATMENT REQUIREMENTS

3.1 FOREST PLANNING

3.1.1 Forest management zone objectives

The future timber yield of a stand which has been regenerated following harvesting will vary depending on the management objectives adopted for the coupe.⁵ Where timber production is a major objective for a particular forest management zone, the achievement of that objective will require that the basal area of non-merchantable trees is reduced to the levels given in this Guideline, subject to consideration of retained habitat requirements as required by the Code of Forest Practices (section 2.3.6) (NRE, 1996).

In forest management zones where timber production is not the major objective, the basal area of non-merchantable trees retained to meet other forest management goals should be identified and the sustainable yield of sawlogs and other timber products reduced accordingly.

3.1.2 Wood utilisation planning

⁵ The Forest Management Plan prepared for a Forest Management Area divides the forest area into management zones, each of which may have different primary management objectives.

The potential habitat value of many non-merchantable trees means that programs to treat these trees need to be appropriately assessed. Wood Utilisation Plans and Regional Forest Management Prescriptions provide an effective vehicle for this purpose.

As required in the Coupe Planning Procedures, the standing eucalypt basal area of all coupes should be measured prior to harvesting to assist in the evaluation of the proportion of the stand which will be removed commercially during the harvesting operation and that which will require non-commercial treatment. These pre-harvesting measurements will enable the identification of the size range and species of tree requiring treatment and will help to select an appropriate method. In addition, for cost-efficiency, the basal area of potential/actual habitat trees and seed trees could be assessed at the same time.

It is at this point that decisions can be made regarding which coupes, if any, should be scheduled to produce any marketable residual wood from the 'non-merchantable' component. This process may reduce the amount of non-merchantable material and assist in the regeneration process.

3.1.3 Coupe planning

It is essential that harvesting contractors understand their obligations (at the time of signing a Coupe Plan) in relation to how non-merchantable trees are to be treated. The contractor should also be aware of the residual basal area target to be achieved and the mechanism for payment (if any). *Trees to be retained for seed or habitat purposes must be clearly marked.* Figure 2 shows a coupe where numbers of trees have been retained for various purposes.

Note that all coupe regeneration operations should be undertaken with the objective of maintaining local genetic pools and species mixes—according to section 2.2.3 of the Code of Forest Practices (NRE, 1996).



Figure 2. Retained trees (for seed, habitat and landscape values) after the first cut on a shelterwood coupe – Wombat State Forest.

3.2 SPECIFICATIONS FOR RETAINED BASAL AREA

In State forest in Victoria the acceptable total retained basal area (BA) after harvesting of merchantable trees will vary depending on specific habitat tree prescriptions, and whether the stand is:

- in the regeneration phase, or
- in the growing phase of its life cycle.

Relatively high densities of non-merchantable trees are tolerable during the regeneration and early growth phase of a stand's life as they may contribute seed or provide shelter. However after this period, significant growth losses in the new stand will occur unless the densities are reduced.

For **even-aged silvicultural systems**, acceptable live retained BAs (including habitat trees) will depend on the system being implemented, as follows:

- **Clear-felling:** the retained BA should generally not exceed **3 m²/ha**.
- **Seed tree:** the retained BA will be determined by the diameter of stems retained as seed trees (spacing a maximum of 2 x tree height apart) and should generally fall in the range **3–5 m²/ha**.
- **Shelterwood:** the retained BA following the first cut should be in the range **9–11 m²/ha**. A higher residual BA will result in the favouring of shade-tolerant species such as *E. radiata* over shade-intolerant species such as *E. obliqua*. Following the second cut, the residual BA should generally not exceed **3 m²/ha**.

Actual BAs that are acceptable will vary slightly with species, aspect, height and diameter of the retained trees. Consideration needs to be given to the number and distribution of habitat trees and their effect on regeneration and growth. *Where habitat retention requirements may require retention of BAs in excess of the guidelines above, consideration should be given to clumping retained habitat, or retention adjacent to coupe boundaries.*

In **selection harvesting**, gaps are created in which seedling or coppice regeneration occurs. The 'overwood' for this regeneration may be patches of regrowth, sub-merchantable trees, mature merchantable trees or culls. Gaps of 30–50 m diameter are required in order to release adjoining pre-existing advance growth and/or to allow new regeneration to establish and develop. In addition to the removal of the merchantable trees, non-merchantable trees need to be treated to create a suitable gap.

In selection harvesting, if the basal area of non-merchantable trees is greater than 5–7% of the 'Reference Basal Area' ⁶, the commercial potential productivity of the site is likely to be adversely affected and treatment of the overwood should be considered. At residual basal areas exceeding 15 m²/ha, little or no effective regeneration can be expected to establish.

4 TREATMENT CATEGORIES

The appropriate treatment of non-merchantable trees will depend on:

- the age of the stand,
- the proportion of merchantable to non-merchantable trees, and
- the size, species and number of non-merchantable trees.

Generally, one of the following categories of treatment will apply:

4.1 TREATMENT AT THE TIME OF HARVESTING (or immediately following)

4.1.1 Numerous and large trees

In these stands, the only feasible treatment is to fall the non-merchantable trees. Pushing with machinery in these stands is generally too expensive and dangerous. Herbicide injection may not be cost-effective due to very thick bark, e.g. *E. sieberi* and *E. obliqua* or deep fissuring making treatment difficult. Falling will result in large accumulations of additional fuel, which could help to improve a burnt seedbed.

In these stands it is important to decide whether harvesting at this time is appropriate, or whether it should be delayed pending the development of alternative markets for the non-merchantable trees.

4.1.2 Few and large trees

In these stands falling, treatment by injection with herbicide, or sap-ringing are acceptable alternatives. Choice of method will depend on the availability of fallers, contractors or Departmental resources.

4.1.3 Numerous and small trees

Pushing by machinery is an efficient method for these stands, although falling may be used where fallers are available and machinery access is restricted. Where falling is employed, herbicide treatment of stumps may be necessary to reduce future competition from coppice.

Small trees are frequently killed, or severely damaged, during the regeneration burn. A follow-up stem injection treatment of the surviving trees is a cost-effective approach.

⁶ RBA – The basal area of a healthy mature stand of the species, which has developed from dense regeneration in the locality being considered (Dignan and Fagg 1997). For example, 35 m²/ha in medium site quality mixed species in the Heywood State forest.

Timber industry operators may be best situated to use a combined method, particularly where contractors have both fallers and machinery available.

4.2 TREATMENT FOLLOWING THE ESTABLISHMENT OF REGENERATION/REGROWTH

Where seed trees are non-merchantable, stem injection or sap-ringing are generally the best methods, as falling would damage the seedling regeneration. However, falling may be considered where the stand is young and dense and some loss, by crushing, would not greatly affect overall stocking levels.

Note that *previously* non-merchantable seed trees left in coupes harvested and regenerated 10–15 years ago may, with the changes in utilisation standards or markets, be currently merchantable. If so, careful falling and extraction (to protect established regrowth) may be carried out, provided that the prescribed density of habitat trees is retained on such coupes. Whether or not the overwood is harvested or treated in such situations, the operation can be termed *Timber Stand Improvement*.

For procedures on the removal of non-merchantable stems in even-aged regrowth (pre-commercial thinning), refer to *NFS Guideline No. 14* (Sebire and Fagg 1997).

5 TREATMENT METHODS AND COSTS

Operational and administrative details of several treatment methods are described below. Table 3 gives indicative costs. Where a combined method is to be applied, this must clearly be identified prior to harvesting and the cost components clearly separated.

5.1 FALLING

Trees, not harvested or required for habitat, seed or other purposes, may be removed by hand falling with chainsaws in one of the following ways.

5.1.1 By logging contractor during harvesting

This is the preferred method where falling only is applied. This method minimises the risks associated with falling, as the faller is trained, skilled, and can fall the non-merchantable trees at convenient times during the harvesting period. This method will normally lead to increased volumes of timber (up to 10% additional) being harvested, as trees of marginal quality are felled and converted to logs if found to be merchantable.

5.1.2 By NRE resources following harvesting

This method may be appropriate in circumstances where the falling costs are offset by other Departmental requirements, e.g. the need to train and maintain crew work skills, or where resources such as additional fire suppression employees are not fully committed during summer.

This method is generally less efficient as falling in an already harvested coupe requires greater care due to the hazard involved with crown-damaged trees and any trees producing merchantable timber are unlikely to be harvested.

5.1.3 By private contractor following harvesting

It may be necessary to engage private contractors should logging contractors or Departmental resources not be available, but the complexities of operating in a coupe after completion of harvesting generally make this method more expensive.

The clear preference is for the harvesting contractors to perform this work as part of the harvesting operation. This provides the best option to maximise timber utilisation, efficiently manage coupes, utilise skilled operators and minimise the safety hazards associated with post-harvesting treatments.

An analysis of 'time and motion' study data collected from the falling of approximately 2300 trees during the establishment of the Silvicultural Systems Project at Cabbage Tree Creek in 1990 showed that *the average time to fall a square metre of tree basal area was almost constant over the full range of tree diameters* i.e. 4–5 m² of basal area per hour spent on the job, i.e. all time involved in tree selection, falling, saw maintenance and delay time. However, there was significant variation in the time taken to fall different trees of the same size.

5.2 PUSHING

Pushing by bulldozer is the preferred method where the non-merchantable trees are numerous, e.g. more than 50/ha, and small, e.g. less than 60 cm DBHOB. Pushing is quick, efficient, provides almost complete control of coppice compared with falling and provides additional fuel for regeneration burning. The operation may be carried out during or following routine harvesting by the same groups referred to above.

Some attachments to the machinery used may improve the results:

- Tree pushers will increase the maximum tree diameter which can be removed, improve safety particularly with large trees, and leads to improved mechanical efficiency of the operation due to the greater leverage.
- Rippers will allow anchoring tree roots to be cut.

5.3 HERBICIDE TREATMENT

Herbicide is generally applied by stem injection using one of three methods. All methods require the herbicide to be placed *into the sapwood* to allow effective uptake. Placement of the herbicide within 1–15 seconds of making the cut or hole is recommended.

- Basal spear
This method involves the use of a heavy spear (~ 4.5 kg when loaded) operated by driving the chisel end into the base of the tree to make a notch about 2 cm into the wood (see Fig. 3). The handle of the spear is pumped to deliver herbicide from the shaft of the spear to the tree via a hole in the chisel blade.

- Nick and squirt

This method involves the notching of the tree at waist height with an axe and injecting herbicide from a backpack (purchased or modified so that herbicide supply tube enters pack *at the top*) via a spot gun into the notch (see Fig. 4). A cut-down axe (see **Appendix 2**) may assist in cutting through the bark of thick-barked species. A special 1 kg axe, with grooves, is also available – see Section 8.

- Drilling

The use of a petrol-engine driven power drill, instead of an axe, will allow for easier and more thorough penetration of thick-barked species and will create a large enough reservoir to hold the required dose of herbicide.



Figure 3
Stem injection with basal spear



Figure 4
Stem injection by 'nick and squirt' using a 'spot gun' and a back-pack

In all methods, repeated cuts/drills, with centres 13 or 25 cm apart are made downwards at a 45 ° angle through the bark and partly into the sapwood, around the circumference of the tree. The chemical used is either *glyphosate* or a *triclopyr/picloram* mixture developed and registered particularly for tree control. See Section 8 for details on the suppliers and costs of the equipment and chemicals.

The advantages of stem injection, compared to falling or pushing, are:

- The ability to control the time of seedfall to maximise regeneration success (if seedfall is required) (Ryan 1997b).
- The elimination of falling damage to growing stock in selectively harvested or thinned stands.
- The provision of some shading/shelter by the dead overwood.
- Standing dead trees can provide significant habitat value.
- Generally cheaper than other techniques.

The long term fire hazard created with dead standing trees is a disadvantage of this type of treatment.

The cost-effectiveness of herbicide treatment is influenced by:

- Bark thickness. Difficulty and cost increase with increasing bark thickness. Bark thicker than 5 cm reduces the effectiveness of the tools used for stem injection except for the drill.
- Coupe access. Understorey development generally makes stand access more costly in the period 3 to 20 years after harvesting.
- Season. The effectiveness of the method varies with season of treatment. Autumn and winter are the most effective (Fagg *et al.* 1990), but other seasons are satisfactory. Avoid injection when rain is forecast or stems are wet as this has the potential to dilute or wash out the herbicide.
- Herbicide cost and rate.

Research in East Gippsland (Lutze 1998) indicates that glyphosate is effective:

- with cut, or drill hole, spacings between 13 and 25 cm.
- at an increasing volume per cut with increasing DBHOB of the tree (see Table 3) to ensure dose rates of approximately 40 g/m² of basal area.

Other early observations from this research are that:

- treatment rates of 3–4 m² basal area per hour are possible.
- increased mortality of trees is obtained when thick-barked species, e.g. *E. sieberi*, are drilled instead of axe notched because of better penetration of herbicide.

Operators need to observe the appropriate occupational health and safety measures when handling and using stem injection chemicals.

5.4 SAP-RINGING

Sap-ringing is the complete removal of a band of sapwood from around the girth of a tree by chainsaw and/or axe. The sapwood must be totally removed from a band 5–10 cm wide to be effective (see Fig. 5). This method may be used in preference to stem injection because it avoids the use of chemicals and the quality of the work can be easily checked. However it is usually more expensive, per tree or per hectare, because of the additional time required for this treatment.

Ring-barking is different to sap-ringing, in that only the bark is removed. This is cheaper than sap-ringing but often results in trees with fluted trunks surviving. In addition, ring-barked trees may take up to 9–10 months to die. For these reasons it is not recommended.

These methods have similar advantages and disadvantages as stem injection. The major safety issues relate to the use of sharp tools (chainsaw and axe) in slash or understorey scrub.



Figure 5. Overwood treatment by sap-ringing – Heywood

Table 3. Indicative costs for different treatment methods of non-merchantable overwood

Treatment method	Description	Indicative cost per m² BA treated	Source of cost
Felling	Contractor chainsaw felling	\$6 (at time of harvesting) \$10 (following harvesting)	Departmental cull falling rates (1999) Contract falling rate (1997)
Pushing	Bulldozer pushing	\$12	Orbost (1996)
Herbicide glyphosate 360 g/L ai e.g. Roundup	25 cm spacing centres; axe, drill or basal spear Application rates: 0–30 cm DBHOB 4 mL/cut 31–60 cm DBHOB-6 mL/cut 61–80 cm DBHOB-8 mL/cut 81–100 cm DBHOB-10 mL/cut >100 cm DBHOB-12 mL/cut	\$9+ (\$13+ for 13 cm spacing)	Lutze (1998).
picloram+ triclopyr e.g. Tordon TCH	25 cm spacing centres; axe, drill or basal spear 2 mL per notch *	n/a	
Sap-ringing	Complete removal of sapwood in 5–10 cm wide band by chainsaw and axe	\$12 \$14	Cann River contract (1995). Lutze (1998).

* Always follow the chemical label instructions closely. Do not use chemicals 'off-label' unless such use has been discussed with the Chemical Standards Branch to determine if such 'off-label' use is permissible.

+ Cost of labour plus chemical used.

6 METHODS OF PAYMENT

There are several payment options available:

- **Payment per hour**

This option is applicable for falling and herbicide treatment, as well as pushing.

- **Payment per tree**

This option is currently only applicable for falling of non-merchantable trees. The currently approved schedule of rates (as at March 1990) is listed in **Appendix 3**. This method could also be used for herbicide treatment or sap-ringing following the development of an appropriate schedule of rates.

- **Payment per hectare**

This method requires that the area of each coupe is accurately measured and a payment rate is negotiated. This option is applicable to falling and pushing, as well as herbicide treatment (see above). The rate of payment should be set using a tendering process.

- **Payment per coupe**

Public tenders may be called, or a price negotiated, for the felling or other suitable treatment of overwood on specified areas. Overwood treatment may be conducted concurrently with or following harvesting depending on whether or not the successful tenderer is also the harvesting contractor. This option is applicable to overwood removal by falling, pushing or herbicide treatment.

The following method is based on the assumption that there is always a proportion of the stand that is non-merchantable, and that removal of these trees will be silviculturally beneficial.

- **Payment per cubic metre of merchantable logs**

The volume on which the contractor is paid is determined through the Logsales accounting system while the rate should be agreed prior to commencement. The schedule of rates on which payment is made may take the following factors into account:

- location, e.g. District
- rate per m³ may decrease as merchantable yield per ha increases
- a yield, above which no payments are made, e.g. 100 m³/ha total product
- the volume basis for the schedule, e.g. C+ sawlog, D+ sawlog, total product (sawlog plus residual roundwood)

This option is applicable to overwood removal by falling or pushing and is recommended for use where clear felled or seed tree coupes are managed individually by the Department. (An example of this method of payment is the cull payments made under the Departmental harvesting contract operating in Tambo FMA.)

7 MONITORING

Post-harvesting monitoring of basal area is a key element for successful regeneration and growth of forests after harvesting.

Where a retained basal area level is specified on the Coupe Plan, the Operator Completion Certificate should only be issued when the retained basal area has been measured and is at or below the specified level. See **Appendix 4** for a field method of measuring basal area following harvesting. This method recognises the normal low density of retained trees, the operational difficulty of collecting the minimum 15 measurements, and the safety issues when traversing harvested coupes.

In seed tree systems it may be necessary to monitor basal area immediately after harvesting. During stocking surveys, basal area may also be measured – see NFS Guideline No. 10.

8 EQUIPMENT AND SUGGESTED SUPPLIERS

<p>‘CMB Tree Spear’</p> <p>CMB Engineering, 58 Oliver Street, Inverell, NSW. 2360 (02) 6722 1525</p> <p>Cost: \$240 (w/o sales tax, Jul. ‘99)</p>	<p>‘Phillips Model 74’ automatic vaccinator, 5 mL</p> <p>Local rural supplies traders.</p> <p>Cost: \$60 (w/o sales tax, Feb. ‘97)</p>	<p>‘Monsanto Bi-active’ Roundup Herbicide</p> <p>E.E. Muir & Sons P/ L 542 Footscray Road Footscray, Vic. 3011 (03) 9687 6836</p> <p>Cost: \$133 / 20 L (w/o sales tax, Jul. ‘99)</p>
<p>‘Dow Elanco Tordon TCH’ Herbicide</p> <p>Iama Victoria Pty. Ltd. 29 Beverage Drive Tullamarine, Vic. 3043 (03) 9335 1911</p> <p>Cost: \$420 / 20 L (w/o sales tax, Jul. ‘99)</p>	<p>‘Tanaka Model TCD/262/R’ reversing drill with ‘Irwin’ 19 mm self-cleaning bit</p> <p>Various chainsaw suppliers</p> <p>Cost: \$725 with 2 drill bits (Mar. ‘99)</p>	<p>Axes – ‘Injection Axe’</p> <p>Keech Castings Australia Pty. Ltd. 7 Woodbine Crt. Wantirna South, Vic. 3152 (03) 9801 5961</p> <p>Cost: 1kg. \$19 ea. w/o handle (w/o sales tax, May ‘99)</p>

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Wendy Havard prepared the final version for publication.

Appendix 1

(Adapted from Bassett and White (1999)).

INFLUENCE OF RETAINED TREES ON SURROUNDING REGROWTH

Incoll (1979) indicates that the retention an average of 5 equally spaced *E. sieberi* overwood trees per hectare will reduce the growth of the regrowth to 80% of its potential over approximately 20 years. Assuming a crown diameter:DBHOB ratio of 15 and trees of approximately 70 cm DBHOB, this equates to an overwood basal area of 2 m²/ha.

Overwood stem diameter, as an estimator of the zone of influence, is a simpler measure to apply than the more accurate crown radius. While a universal relationship between overwood stem diameter and volume loss on trees within the zone of influence cannot be developed, Table 1 presents specific results from two studies which attempted to estimate losses.

Operationally, the results from Incoll could be considered to *represent worst case growth losses for mixed species* and other forests with a 'reference basal area' of about 45 m²/ha. For up to 5 trees per hectare, he postulates that the effect will be additive. However the other studies (Rotheram 1983, Kellas *et al* 1998, and Bi and Jurskis 1997) probably provide more realistic estimates of overwood suppression for eucalypts. They indicate an average zone of influence of radius equal to 1.7–3.0 crown radii. When multiple overwood stems are retained, the subsequent affected area and growth and stocking losses can be significant.

Table 1. Percentage (%) of regrowth volume loss per hectare due to the presence of overwood trees, based on Incoll (1979) and Rotheram (1983). CD = crown diameter, Est. CD = estimated crown diameter, Est. ZOI = estimated zone of influence (radius from stem in metres).

Overwood characteristics				Regrowth volume loss/ha/retained tree			
DBHOB (cm)	BA (m ² /ha)	CD (m)	Est. ^a CD (m)	<i>E. sieberi</i> Incoll (1979) (%)	Est. ZOI (m)	<i>E. diversicolor</i> Rotheram (1983) (%)	Est. ZOI (m)
^a 50	0.20	7.5		1.9	23		
75	0.44		11	4.4	33	1.2	11
100	0.79		15	7.8	45	3.4	15
150	1.77		22			7.6	22

^a Derived assuming a CD:DBHOB ratio of 15 (Jacobs 1955).

Results of research in Victoria and Tasmania that analysed seedling growth at three years under a variety of overwood levels in either lowland sclerophyll forest or *E. regnans* (mountain ash) forests are shown in Table 2. Growth losses were comparable between all studies, including both height *and* diameter increment losses. The magnitude of this increased with increasing retained basal area, supporting the theory that zones of influence are additive due to their overlap under higher basal area retention (Incoll 1979).

Table 2. Effect of retained overwood on dominant seedling growth at age 3 years since site preparation, compared with clearfell for: (1) lowland sclerophyll forest, East Gippsland (Faunt et al. in prep); (2) *E. regnans* mixed forest, Southern Tasmania (Bassett et al. in prep); and (3) *E. regnans* wet sclerophyll forest, Central Highlands (Dignan et al. 1998).

Retained overwood (percentage of total basal area) (%)	Height loss (%)		Volume loss (%)
	(1) mixed species	(2) <i>E. regnans</i>	(3) <i>E. regnans</i>
10	13	16	15
30	55	na	45
50	67	68	65
100	82	*74	96

*regrowth below single tree selection gaps; thus only an approximation of 100%

Dignan *et al.* (1998) and Bassett *et. al.* (in prep) both found that of all growth parameters, stem diameter increment was most affected by competition and contributed to significant early volume loss.

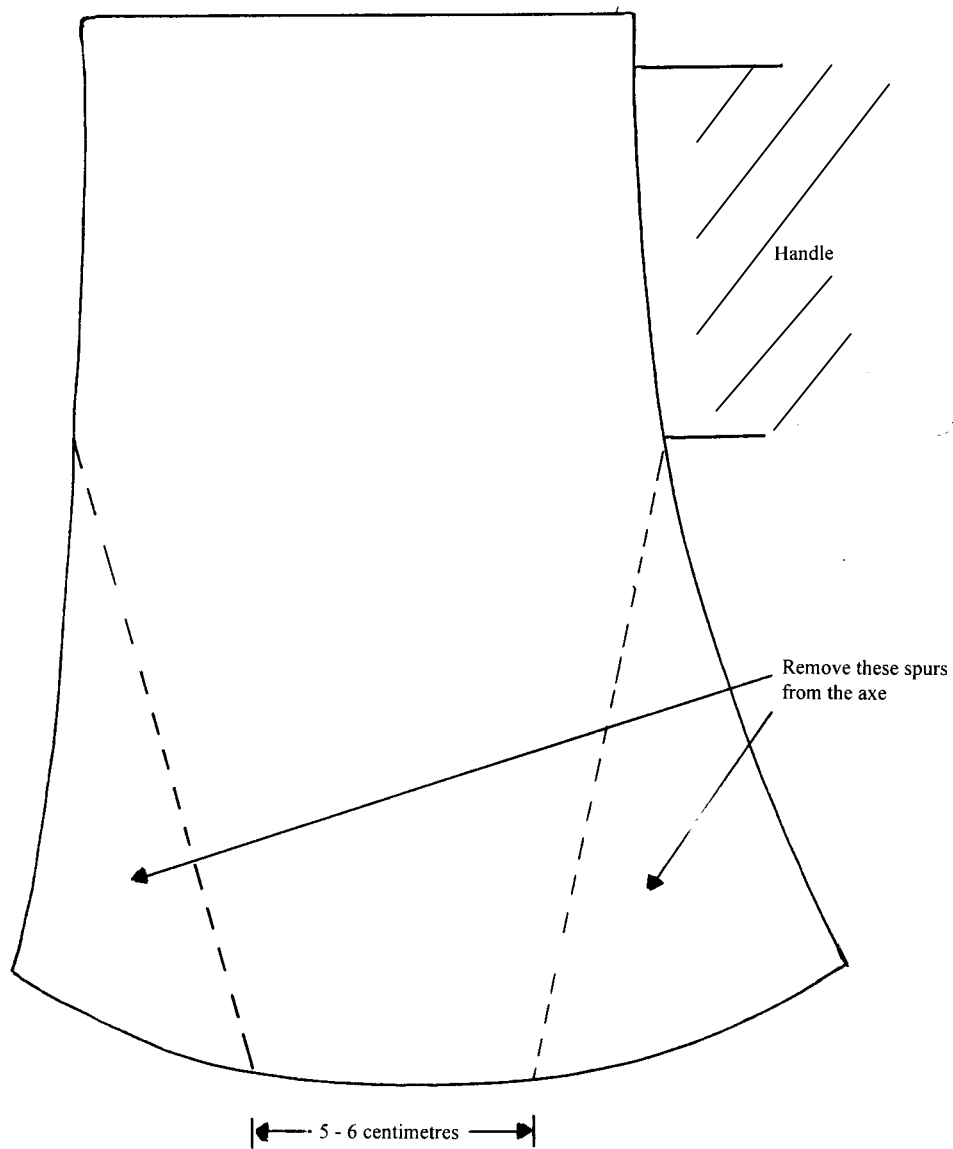
Appendix 2

AXE PROFILE FOR USE IN TREE INJECTION

The following modification (shoulder removal) may be made to a 2 kg axe to allow for easier penetration of the bark of thick-barked eucalypt species.

The modification:

- maintains much of the axe weight, and
- allows the reduced head length to cut more easily into thick bark



Appendix 3

CULL FALLING RATES

Diameter under bark (cm) at stump height	Rate per tree (\$)
<20	0.67
21-30	0.67
31-40	0.67
41-50	0.92
51-60	1.38
61-70	1.93
71-80	2.57
81-90	3.30
91-100	4.12
101-110	5.03
111-120	6.04
121-130	7.13
131-140	8.32
141-150	9.60
151-160	10.97
161-170	12.43
171-180	13.98
181-190	15.62
191-200	17.35

Rates for diameters over 40 cm are based on the formula:

$$\text{Rate (\$)} = \text{diameter (range mid point (cm))}^2 \times 0.0004564$$

Appendix 4

MEASURING BASAL AREA AFTER HARVESTING

The following operational procedure has been developed for measuring retained basal area (BA) on coupes harvested under the clear-felling, seed tree, or shelterwood silvicultural systems. It may be undertaken at the same time as a coupe completion inspection is carried out.

It assumes that there is no bias between location of snig tracks and retained trees and utilises the variable probability sampling method of BA determination.

NB: If BA is not required immediately after harvesting, it can be measured during the systematic stocking surveys which are required 18–30 months after sowing or seedfall.

RECOMMENDED PROCEDURE

- Use a 1 factor BA gauge. (Important, as trees may be widely spaced). See Appendix 7 of NFS Guideline No 10 for details on making and using basal area gauges.
- Use the plot sheet given on p. 23. (See example on p. 22)
- Locate plots at spacings of 50–100 m along randomly selected snig tracks, commencing at a randomly selected distance from a landing.
- Do not include trees (but adjust for any area involved) in the following areas: streamside reserves / retained habitat cluster / wildlife corridors / visual buffers.
- At each plot, count and record the number of 'in' trees, separating out 'habitat' trees, if applicable.
- Locate a maximum of 5 plots along each selected snig track.
- Preferably locate plots along at least 3 snig tracks from each landing.
- Assess a minimum of 15 plots per coupe.
- Record the results as:
 - ◆ average retained BA per hectare,
 - ◆ a map of the retained BA and
 - ◆ identify any areas of excessively high BA which requires treatment.

The following diagram illustrates the suggested method of locating survey points.

