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VICTORIA, AUSTRALIA**

**Native Forest Silviculture Guideline No.10**

*This Guideline\* describes the recommended procedures for planning and conducting stocking surveys in native State forests (whether sown or planted) in Victoria. It covers uneven-aged stands as well as even-aged stands. Appendices include a review of regeneration survey methods and standards, procedures for germination monitoring, the preferred technique for establishment of survey grids, and details on using and making basal area gauges.*

**TITLE:** **EUCALYPT STOCKING SURVEYS**

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\* This Guideline replaces Sections 4.4.4 – 4.4.6 of CFL Departmental Instruction 01-20-0141-1 (1989), Forests Commission Operational Information No. 11, (1976), and relevant sections of SSP Technical Report No.6 (1991)

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# 1. INTRODUCTION

## 1.1 PURPOSE OF GUIDELINE

The future of native State forests designated for timber production, and the benefits they provide to our community, depends on successful regeneration<sup>1</sup> following harvesting. Stocking surveys provide an objective measure of the success of regeneration operations and can be a useful tool for refinement and improvement of on-line planning and operations.

Stocking surveys are the means by which the distribution and density of seedlings (even-aged silviculture) or all components of the forest (uneven-aged silviculture), are measured at a given time after harvesting and regeneration treatment.

*The purpose of this Guideline is to describe survey methods and define standards for eucalypt stocking following harvesting for wood production, and following reforestation<sup>2</sup>. It places an emphasis on:*

- defining the objectives of a stocking assessment program
- carrying out survey procedures with a high degree of uniformity and accuracy
- recording and evaluating performance

This Guideline provides the recommended procedures for stocking surveys as required under the Departmental Instructions 'Planning for Harvesting and Regeneration of Native Forests using Even-aged / Uneven-aged Silviculture' (DNRE, 1997 a&b).

*As a basis for preparing this Guideline, a review of even-aged regeneration survey methods and standards was undertaken by the Centre for Forest Tree Technology. **Appendix I** is a shortened version of this review.*

## 1.2 OBJECTIVES OF STOCKING SURVEYS

The primary objective of stocking surveys for Victorian native forests is:

- to meet the requirement to demonstrate that the forest is adequately stocked as required by the Code of Forest Practices (Section 2.2.4)(DNRE, 1996)

Secondary objectives are:

- to identify and delineate areas requiring rehabilitation or overwood treatment
- to evaluate and provide feedback for improvement of regeneration techniques

The stocking survey procedures proposed are designed to meet the above objectives for eucalypt-dominated forests managed for wood production using both even-aged and uneven-aged (mixed age) silvicultural systems.

Table 1 sets out details of survey methods and standards recommended for each management system.

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<sup>1</sup> *Regeneration* - the renewal or re-establishment of a forest crop (by sowing or planting) following harvesting. Also refers to the new crop itself.

<sup>2</sup> *Reforestation* - the establishment of a stand of trees (by planting or sowing) on previously cleared or scrub-covered land. (In Section 2, wherever 'regeneration' is mentioned, 'reforestation is also implied.)



**Table 1. Summary of recommended survey methods and standards by stand type and component**

STAND TYPE	SURVEY METHOD	SURVEY GRID SIZE <i>(intensive survey)</i>	COMPONENT	PLOT TYPE (radius)	DESCRIPTION OF ACCEPTABLE STEM			MINIMUM STOCKING STANDARDS <i>(see text also)</i>	
					Height (approx.)	DBHOB (approx.)	Form, etc.	Plot	Coupe*
Even-aged	Stocked plot	80 m x 20 m <i>(40 m x 20 m)</i>	Regeneration (seedling/coppice)	fixed area (2.27 m)	0.4–3 m	N/A	likely to survive & keep growing (also see p.7)	1 acceptable stem	≥65% of plots (≥55%)*
		80 m x 30 m <i>(40 m x 30 m)</i>	Sapling	fixed area (3.57 m)	3–15 m	5–15 cm	good form, little defect, potential sawlog tree	1 acceptable stem	≥65% of plots (≥55%)*
	Triangulation	N/A <i>(50 m x 20 m)</i>	Regeneration (seedling/coppice)	variable-sized triangle (all stems within 5 m of point)	0.4–3 m	N/A	as above	1000 stem/ha	≥65% of plots (≥55%)*
		80 m x 30 m <i>(40 m x 30 m)</i>	Sapling	variable-sized triangle (all stems within 8 m of point)	3–15 m	5–15 cm	as above	600 sph (4-8yrs) 400 sph (9-12yrs)	≥65% of plots (≥55%)*
Uneven-aged	Stocked plot	Coupe size: >200 ha – 250 m x 100 m 100 – 200 ha – 150 m x 100 m <100 ha – 100 x 50 m (for intensive surveys, halve the distance between the transects)	Regeneration (if coppice)	fixed area (2.27 m) fixed area (3.57 m)	0.4–3 m	N/A	likely to survive & keep growing (also see p.7)	1 acceptable stem	≥70% (60%)* of plots stocked with regen/saplings and/or poles or larger trees
			Sapling	fixed area (3.57 m) plus BA sweep	3–15 m	5–15 cm	good form, little defect, potential sawlog tree		
			Pole	BA sweep	>15 m	15–45 cm	good form, potential sawlog tree	>30% of RBA*	
			Mature	BA sweep	>20 m	>45 cm	meets sawlog specifications		
			Mature (non-merch)	BA sweep	>20 m	>45 cm	non-merch. due to poor form or defect, or habitat tree		

\* % acceptable if an intensive survey is used

+ RBA = Reference Basal Area

N/A = not applicable

\* In addition, no discrete area of 1 or 2 ha must be unstocked



## 2. SURVEYS IN EVEN-AGED STANDS

### 2.1 CHOICE OF SURVEY METHOD

The stocking survey process for sites or forest types managed under even-aged silvicultural systems (i.e. clearfelling, seed-tree and shelterwood) is based on an evaluation of regeneration operations and monitoring of conditions known to contribute to regeneration failure. Planted areas, e.g. some reforestation sites, being even-aged, are also covered by this procedure.

Figure 1 illustrates the process which should be followed to assess the stocking on sites managed using even-aged silvicultural systems.<sup>3</sup>

After satisfactory seed supply, an evaluation should be made of the risk of failure of germination or of high seedling mortality. This should be based on local experience and should reflect the proportion of coupes which fail in that district due to factors other than seed supply and seedbed. Consider factors such as: aspect, frost severity, weed invasion or browsing. For example, HEMS coupes, especially those on southerly aspects, would be relatively high risk.

On coupes identified as subject to a moderate to high risk of failure (>30% risk), a **Preliminary Seedling Survey (PSS)** should be undertaken while receptive seedbed is still available. The PSS is described in Section 2.2. On some coupes it may be appropriate to determine whether sufficient seedling establishment has taken place (e.g. via slash seed) to stock the site without further treatment. In these cases, a PSS may be carried out, 6–12 months after harvesting. The result of the PSS help managers to make appropriate and timely decisions about possible follow-up treatments.

Before the site can be declared regenerated, **all sites require an Established Seedling Survey (ESS)** whether or not a PSS has been carried out. This survey is done directly on sites which are identified as having a low risk of failure, and is described in Section 2.3. An Intensive ESS is suggested where the standard ESS shows marginal stocking. The higher sampling rate gives a better estimate of actual stocking, thus allowing a lower acceptable standard.

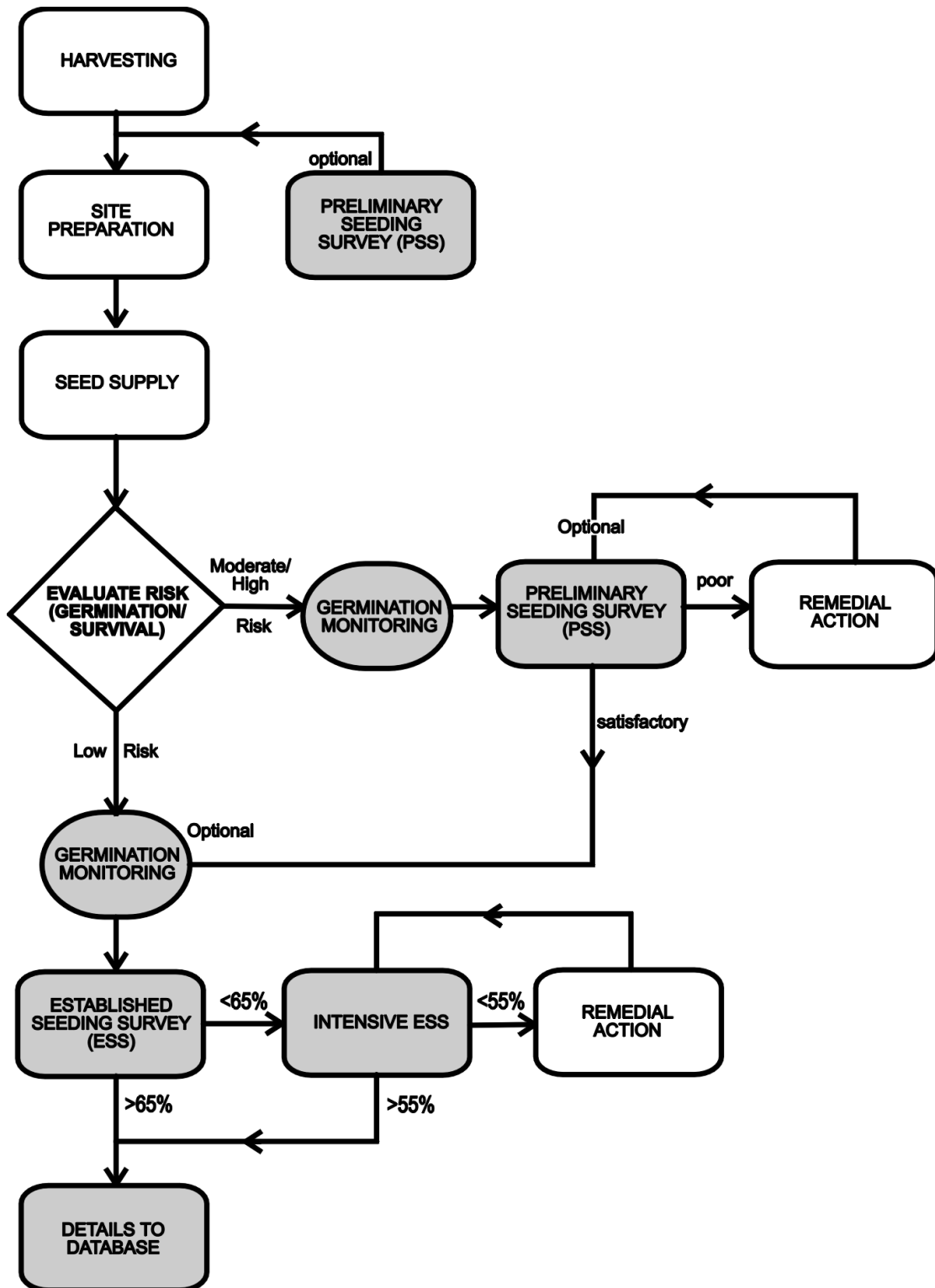
Although not shown in Figure 1, situations may also arise where it is necessary to determine the stocking of sapling stands, e.g. following overwood removal in dual-aged stands, timber stand improvement, thinning operations, etc. Details of Sapling Survey procedures are given in Section 2.4.

**Germination and survival monitoring** (described in detail in **Appendix 2**), is desirable, as shown in Figure 1, for all coupes, but is particularly valuable on higher risk sites. It involves setting up small plots soon after sowing or seedfall and regularly counting seedling germination and mortality. As with the PSS, the results assist timely and appropriate decision-making.

Preliminary Seedling Surveys and germination monitoring are not mandatory.

<sup>3</sup> Note that where the harvesting is in the form of a thinning operation in even-aged stands, no regeneration action is required ( see *Code*, Section 2.2.1). In these cases, post-thinning assessment must be carried out according to procedures detailed in NFS Guideline 13 or 14 (*Thinning of Ash / Mixed Species Regrowth*).

Figure 1 Regeneration monitoring and intervention process for even-aged stands. (Shaded actions are covered in this Guideline)



## 2.2 PRELIMINARY SEEDLING SURVEY (PSS)

### 2.2.1 Objectives

This type of survey is carried out on a coupe in one of two situations, as follows:

- prior to any specific site preparation treatment, and sowing/planting. This is to indicate if the site is likely to become stocked without any extra site treatment/sowing.<sup>4</sup>
- after site preparation and sowing/planting, on sites that are identified as having a moderate to high risk of failure. This is useful in order to decide if early remedial action is needed.

It is not a mandatory survey, but it has particular value in the latter situation.

### 2.2.2 Survey technique

The recommended technique is the stocked plot method. (See Section 2.3, ESS.)

### 2.2.3 Timing

The PSS is usually carried out within 9–12 months of site preparation/sowing (or within 6–12 months of the completion of harvesting, where adequate stocking may be achieved with no extra site preparation. As this is before seedlings could be considered 'established', a follow-up ESS will be required whether or not any remedial treatment is undertaken.

### 2.2.4 Field procedure

The procedure is almost exactly the same as for the ESS. For example, the survey grid is 80 m x 20 m and plot radius is 2.27 m.

The criteria for acceptable seedlings are described in Section 2.3.4 and a seedbed assessment is made. However, there is no need to count seedlings as described for the ESS.

### 2.2.5 Compilation and evaluation

Follow the procedure as for the ESS.

### 2.2.6 Standards

As the PSS is not mandatory, the standards set out below are for guidance only. The minimum standard is:

- 65% of plots on potentially productive area should be stocked; and
- no discrete area greater than 1 ha should be unstocked.

If unstocked areas of 1 ha or greater are designated for re-treatment and the overall percentage of stocking is less than 65%, the Adjusted Stocking may be used. If the adjusted stocking is less than 65%, a more intensive survey may be considered.

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<sup>4</sup> For example, seed from slash or seed trees may have germinated on a disturbed soil seedbed created by logging machinery. If sites do not need extra site preparation and/or sowing, considerable savings can be made.

### **2.2.7 Intensive survey**

If the stocking of the site, allowing for discrete understocked areas, does not meet the minimum standards, or if discrete areas within the surveyed area are classified as understocked, a further more intensive stocking survey of the entire coupe, or just the designated understocked area, may be undertaken. (See Section 2.3.7 for procedures.)

However, such a survey is likely to have more value after an Established Seedling Survey (see Figure 1).

### **2.2.8 Documentation**

The Survey Summary details should be transferred to Part B of the Forest Coupe Plan and the full Summary sheet attached to Part B.

## **2.3 ESTABLISHED SEEDLING SURVEY (ESS)**

### **2.3.1 Objectives**

The objectives of the ESS are to:

- assess the distribution (and density) of seedlings/coppice which have high potential for survival and good future growth
- identify gaps that may need remedial regeneration treatment

### **2.3.2 Survey technique**

*An ESS must be undertaken for each coupe treated to produce regeneration.*

The recommended ESS technique is the stocked plot method, which has been found to be a reliable, robust and cost-efficient technique when used in conjunction with accurate mapping (see **Appendix 1**). However, being a sampling technique, it has associated errors which must be kept within acceptable limits by strict adherence to unbiased plot selection and delineation of the plot boundaries.

If evaluation of the regeneration operation has indicated a good probability of success (see Figure 1), an ESS should be the only survey required.

### **2.3.3 Timing**

*The timing of the ESS will vary, but it must be carried out between **18 and 30 months** after the regeneration establishment treatment i.e. sowing/seedfall/planting.*

The survey should be carried out when site colonisation has stabilised and the competitive status of eucalypts and competing species has been established. Local experience, forest type and seedbed conditions will dictate this, but this point is normally reached at about 2 years following regeneration treatment.

The survey must be timed to leave no doubt that the site is regenerated with a high probability of seedling survival and further growth. For example, on sites where there is a risk of damage due to browsing, the seedlings stocking the site should be greater than 60 cm in height before they can be considered established, and thus the ESS should not be undertaken until the regenerating seedlings have had an opportunity to achieve this. On heavy bracken sites, the ESS should also be delayed if seedlings are not clear of the bracken.

### 2.3.4 Field procedure

Record Sheets needed for this survey are given in **Appendix 4**. They consist of Field Survey Sheets, a Stocking Survey Map Sheet and a Stocking Survey Summary Sheet. (Consider the use of waterproof paper for the field sheets.)

- In the “Species Required” section of the Field Survey Sheet, enter the species listed as present on the coupe in Part A of the Forest Coupe Plan or known to be present on the site prior to disturbance.
- Transfer or attach an accurate map of the area to be surveyed to the Stocking Survey Map Sheet.
- Establish a systematic grid over the area (see **Appendix 3** for this procedure). Locate parallel transects 80 m apart at right angles to the long axis of the coupe, or to the main snig track orientation. Locate plots at 20 m intervals along the transects.
- Assess a minimum of 30 plots within each coupe (or each cell if the area is stratified). If the standard transect layout will result in less than 30 plots (e.g. if the coupe/cell is less than ~5 ha), reduce the distance between transects until there are enough transects to give 30 plots.
- Locate the first transect starting point and the location of the first plot on this transect in an unbiased manner. Clearly mark the start and end of each transect. This will assist any later more intensive surveys, rehabilitation or infill planting work carried out on the basis of the survey. Make notes of features which will aid accurate re-location of the transects.
- As each plot is reached, mark the plot centre prior to assessment of each plot. A pigtail pin is suitable for plot centre location. Each plot consists of a circle of radius 2.27 m (~16 m<sup>2</sup>). A suitable measuring staff (stick) must be carried to ensure accurate plot delineation.
- Search the plot for acceptable seedlings using the 2.27 m staff centred on the plot marker.

An acceptable seedling must meet the following criteria:

- ♦ *Species*: native to that forest type (See Code of Forest Practices (DNRE 1996)).
- ♦ *Vigour*: must have a healthy, vigorous growing tip. If damage has occurred to the growing tip, the surveyor must judge, based on local knowledge and experience, whether the plant is likely to recover apical dominance.
- ♦ *Origin*: seedlings, lignotubers, and coppice (of all species) are acceptable. For coppice, the base of the stem must be within 20 cm of ground level, and likely to remain attached to the stump.
- ♦ *Stem damage*: must be free of severe damage to the cambium (e.g. frost kill, insect attack, or rubbing on logging slash) and have a clear path for future growth.
- ♦ *Height and competitive position*: at least 40 cm tall, and should be above any competing understorey. Healthy seedlings in an intermediate position may be tallied where field experience has demonstrated that they will outgrow their competitors. Suppressed seedlings, where understorey, grass or bracken competition is strong, should not be included.

- If the plot contains at least one acceptable seedling it is classified as stocked and entered as such (**S**) on the Field Sheet. Care should be taken to ensure that seedlings close to the boundary of the plot actually are in the plot. This is easily done by laying the plot staff on the ground between the centre pin and the seedling base. If the centre of the seedling base is inside the plot it is counted 'in'. (Error due to seedlings just outside the plot boundary being counted as 'in' is very common and can severely bias the outcome of the survey.)
- Count the number of acceptable seedlings within the plot, up to a maximum of 5. If more than 5 are present, an estimate should be made. Enter the number counted or estimated in the "No. of Seedlings" column<sup>5</sup>.
- Record the species of acceptable seedlings present on the plot.
- If no acceptable seedling can be located, the plot is classified as unstocked (**✕**). The following procedure should then be followed:

If the plot has the potential to support eucalypt growth, either in its present state or with extra site preparation, a seedbed assessment should be made:

- The plot is classified as receptive (**R**) if at least 50% of the area is uncompacted, exposed mineral earth or ashbed.
- If less than 50% of the plot is receptive, the reason should be recorded as either:
  - soil compacted or damaged in some other way (**D**);
  - colonised by non-eucalypts (**C**); or
  - covered by slash/litter/debris (**L**);and noted in the 'Comments' section of the survey sheet. These will be useful in determining further action if necessary.

If the plot has no potential, in its present state, for successful eucalypt establishment and growth, or is reserved from further seedbed preparation, it should be classed as non-productive (**N**) and the reasons noted in the 'Comments' section. Examples of non-productive areas include major rock outcrops, internal roading (excluding snig tracks), filter strips, retained understorey 'islands', and permanently saturated zones.

- In some seed tree or shelterwood coupes it is useful to record overwood basal area. In these cases, use a 1 or 2 factor gauge to do a BA count every third plot.
- Note any evidence of seedling damage due to browsing or insects/fungi in or around the plot in the 'Comments' section. This should include an estimate of the severity of the damage or infestation, and the species responsible.<sup>6</sup>

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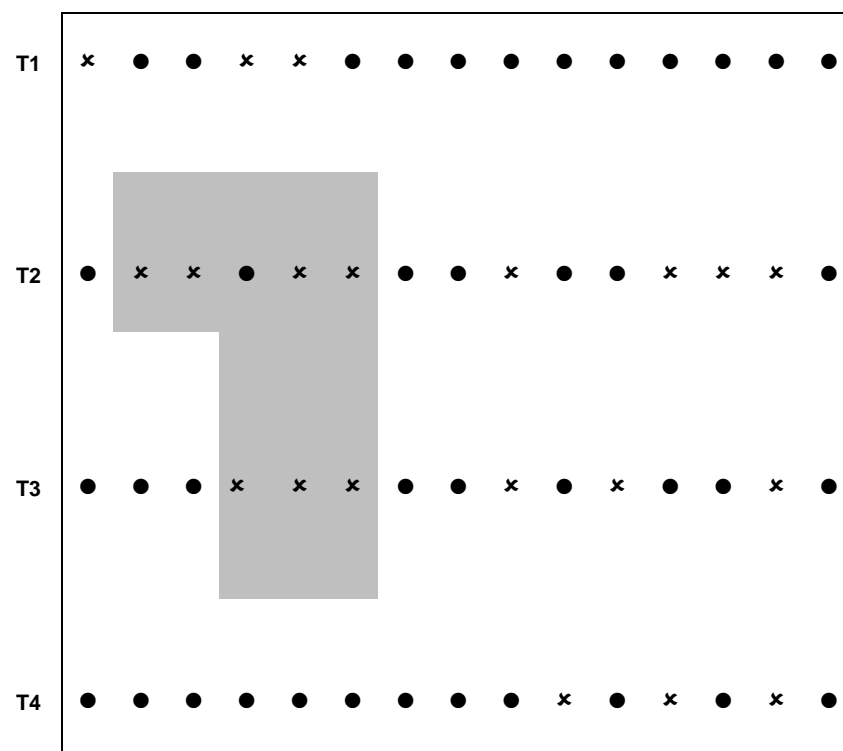
<sup>5</sup> Seedling density is not used as a stocking standard. However, it is valuable information and can be used in evaluation of regeneration techniques (e.g. sowing rates), and standards, and in helping to decide if a stand could be pre-commercially thinned in later years. Recording plot densities in this way is a cost-effective step in the evaluation process. See also Section 2.3.9.

<sup>6</sup> Little is currently known about the frequency, severity and distribution of insect and fungal pathogens of regenerating eucalypts. Seedling Surveys have the potential to be a cost-effective method of gathering ancillary information and providing early identification of pathogen outbreaks.

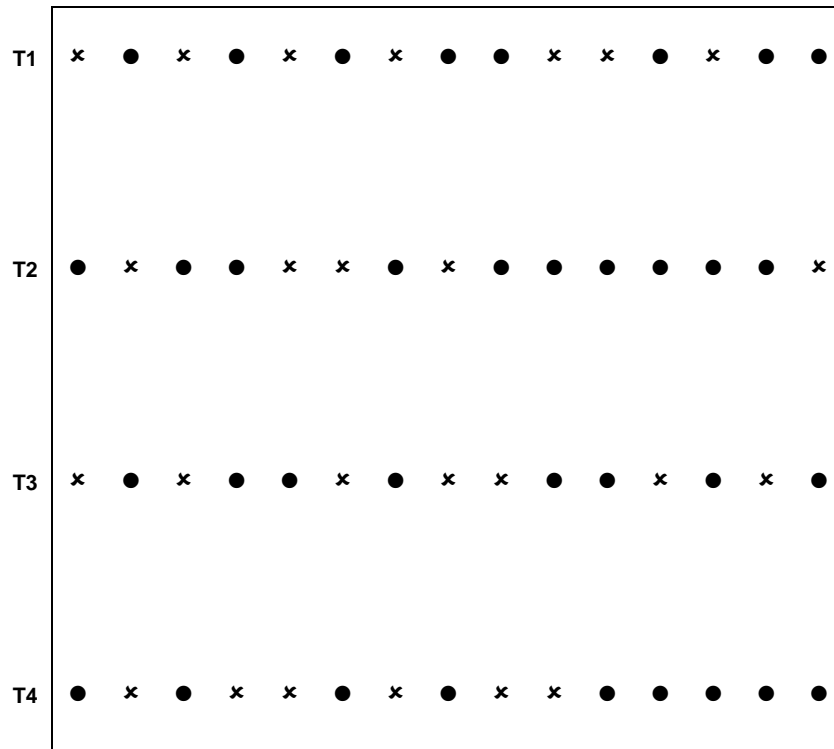
### 2.3.5 Compilation and evaluation

- On completion of the survey, transcribe the results from the Field Survey Sheet to the Stocking Survey Map Sheet as accurately as possible. Accurately draw the transects and plots on the map and show the stocking status for each plot.
- Enter the number of plots in each category for each transect in the right hand columns of the map sheet and calculate the total number of plots in each category. **Appendix 4** shows an example of completed Survey Field Sheets and a completed Stocking Survey Map.
- Examine the map for areas dominated by unstocked plots. A group or sequence of **6** plots represents an area of about 1 ha:
- Search adjacent transects for sequences of unstocked plots. A single stocked plot with two unstocked plots on each side (i.e. 4 unstocked plots out of 5), on the same transect, can be considered unstocked for the purposes of delineating understocked areas. At least 3 unstocked plots must be in a line for adjacent transects to be included as unstocked. Examples of mapped plot sequences representing understocked areas are given in Figures 2 and 3.

**Figure 2. Example of a mapped area which is more than 65% stocked, but with a discrete unstocked area (shaded) represented by 8 plots, or ~ 1.3 ha (stocked = ●; unstocked = x, T = Transect)**



**Figure 3. Example of an area which is less than 65% stocked (~58%), but with no discrete unstocked areas greater than 1 ha (stocked = ●; unstocked = x).**



- Enter the column totals in the Sample Points Summary at the bottom of the sheet. The total number of plots in all designated understocked areas should also be entered.
- If understocked areas are designated within the surveyed area, the number of plots in each category excluding those within the understocked area must be noted so that the percentage of stocked plots can be calculated for the remainder of the site.

Transfer the species composition results from the Field Sheet, and the summary of results from the Stocking Survey Map sheet to the Stocking Survey Summary sheet (**Appendix 4**).

Carry out the following calculations:

*Percentage of area productive:*

$$\frac{\text{total no. of plots (T)} - \text{no. of unproductive plots (N)}}{\text{total no. of plots (T)}} \times 100$$

*Percentage of productive area stocked:*

$$\frac{\text{no. of stocked plots (S)}}{\text{total no. of plots (T)} - \text{no. of unproductive plots (N)}} \times 100$$

*If unstocked areas within the surveyed area are designated for re-treatment and will clearly be re-treated within 3 years, the stocking estimate of the remaining area may be adjusted accordingly. The number of sample points in each category should be recalculated (excluding **all** points in the designated unstocked area) and entered in the 'Adjusted' section of the Stocking Survey Summary sheet. All the above calculations should be carried out using the adjusted figures; e.g. the Adjusted percentage of productive area stocked should be calculated using the formula:*

*Adjusted percentage of productive area stocked:*

$$\frac{\text{no. of stocked plots (S adjusted)}}{\text{total no. of plots (T adjusted) - no. of unproductive plots (N adjusted)}} \times 100$$

(See worked example in **Appendix 4.**)

To estimate the percentage of receptive seedbed available, calculate, *for the understocked area only*:

$$\frac{\text{No. of receptive unstocked plots}}{\text{No. of unstocked plots}} \times 100$$

If this percentage is less than 65% supplementary seedbed preparation will be needed if any remedial sowing is to result in a satisfactory stocking level, ie.  $\geq 65\%$

### **2.3.6 Standards**

Regeneration standards aim to ensure that the site has an adequate distribution of high quality seedlings, of appropriate species, to result in full site occupation early in the rotation.

- **Stocking**

The minimum standard<sup>7</sup> is:

- **65%** of plots on potentially productive area must be stocked for the standard survey (**55%** for an intensive survey - see Section 2.3.7), and
- no discrete area greater than **1 ha** should be unstocked.

If unstocked areas of 1 ha or greater are designated for re-treatment, and the overall stocking is less than 65%, the Adjusted Stocking percentage may be used. If the adjusted stocking is less than 65%, a more intensive survey should then be considered before undertaking re-treatment (see Section 2.3.7). If this survey shows a stocking of 55% or greater (and there are no unstocked areas greater than 1 ha) the coupe is satisfactory.

<sup>7</sup> These standards are the subject of research and may be altered as we improve our knowledge of stand dynamics from seedlings through saplings to the mature trees.

- **Species composition**

The minimum standard<sup>8</sup> is:

- at least 10 acceptable seedlings (or coppice) of those eucalypt species present on the site, prior to harvesting or other disturbance, must be present on the regenerated site.

If enough acceptable individuals of each required species have not been observed in the course of the survey, a reasonable search should be carried out. Failure to locate 10 seedlings should be recorded in Part B of the Forest Coupe Plan.

### 2.3.7 Intensive survey

If the stocking of the site, allowing for discrete understocked areas, does not meet the minimum standards (for example, see Figure 3), or if discrete areas within the surveyed area are classified as understocked, a further stocking survey of the entire coupe, or the designated understocked area, may be considered. This may be either a stocked plot survey with a closer transect spacing, or a triangulation survey.

- *If re-surveying is carried out to double check that the area is unstocked, the stocked plot method should be used. Transect spacing should be 40 m, with plots at 20 m and at least 30 points sampled. If the transects for the Established Seedling Survey have been marked, then placing extra transects half-way between them will enable the results from both surveys to be combined (this will save on the extra work needed). Results should be evaluated as for the ESS, except that the minimum stocking standard is 55%, rather than 65%. (See Appendix 1 (p.41) for an explanation of the mathematics.)*
- *If the survey is carried out to determine seedling requirements for infill planting of seedlings, the triangulation method should be used as it provides a better density estimate in sparse stands (see **Appendix 5**). Transect spacing should be a maximum of 50 m with plots at 20 m, and at least 20 points sampled.*

For areas clearly identified as understocked, refer to NFS Guidelines No. 6 (*Site Preparation*), No. 8 (*Sowing and Seedfall*) and No. 9 (*Eucalypt Planting*) for re-treatment options. The intensive survey will provide valuable information to help determine the most appropriate action.

### 2.3.8 Seedling density

Mean density figures in the regeneration stage (no. of seedlings/ha) can be difficult to interpret because of 'clumpiness'. However, some estimates may be useful for local evaluation of regeneration operations and subsequent conditions relating to germination and establishment. If an estimate is required, the following methodology should be used:

For each plot, add 1 to the plot density and take the natural logarithm of the result. Calculate the mean value of the natural logarithm for all plots in the survey area (C25 in example on p.13), then take the exponent of the mean and subtract 1 (C26, p.13). Multiply the result by 618 ( $10\,000\text{ m}^2 \div 16\text{ m}^2$ ). This is an approximation of the seedling density per hectare of the survey area.

<sup>8</sup> This is a draft standard which will be the subject of research and review.

This calculation can be done quickly using a computer spreadsheet (see below). The density per plot figure from this calculation is 1.4. This results in a density of 865 acceptable seedlings per hectare.

*Example of seedling density calculation using an EXCEL spreadsheet.*

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<b>1</b>	Plot No	Plot Density	Ln(Density+1)	EXCEL formula in column "C"
<b>2</b>	1	1	0.69	= ln(B2 + 1)
<b>3</b>	2	5	1.79	= ln(B3 + 1)
<b>4</b>	3	0	0.00	= ln(B4 + 1)
<b>5</b>	4	0	0.00	= ln(B5 + 1)
<b>6</b>	5	2	1.10	= ln(B6 + 1)
<b>7</b>	6	2	1.10	= ln(B7 + 1)
<b>8</b>	7	11	2.48	= ln(B8 + 1)
<b>9</b>	8	9	2.30	= ln(B9 + 1)
<b>10</b>	9	2	1.10	= ln(B10 + 1)
<b>11</b>	10	1	0.69	= ln(B11 + 1)
<b>12</b>	11	1	0.69	= ln(B12 + 1)
<b>13</b>	12	1	0.69	= ln(B13 + 1)
<b>14</b>	13	0	0.00	= ln(B14 + 1)
<b>15</b>	14	1	0.69	= ln(B15 + 1)
<b>16</b>	15	1	0.69	= ln(B16 + 1)
<b>17</b>	16	3	1.39	= ln(B17 + 1)
<b>18</b>	17	3	1.39	= ln(B18 + 1)
<b>19</b>	18	2	1.10	= ln(B19 + 1)
<b>20</b>	19	1	0.69	= ln(B20 + 1)
<b>21</b>	20	0	0.00	= ln(B22 + 1)
<b>22</b>	21	0	0.00	= ln(B23 + 1)
<b>23</b>	22	1	0.69	= ln(B24 + 1)
<b>24</b>				
<b>25</b>	Average of column C		0.88	=average(c2:c23)
<b>26</b>	Exponent of "0.88", then subtract 1		1.40	=exp(c25)-1
<b>27</b>	No. or seedlings/ha		865	=C26 x 618

For the triangulation method (intensive survey only), coupe seedling density should also be calculated using logarithms, to reduce the size of the bias caused by a few heavily stocked plots.

Give unstocked plots a value of 0, then use the appropriate method for 'stocked plots', except that the average plot density is also the average coupe density.

### 2.3.9 Documentation

The Stocking Survey Summary details should be transferred to Part B (Silvicultural Planning and Recording) of the Forest Coupe Plan and the full summary sheet attached to Part B.

The Field Survey Sheets, the Stocking Survey Map and recommended action should also be filed with the Coupe Plan.

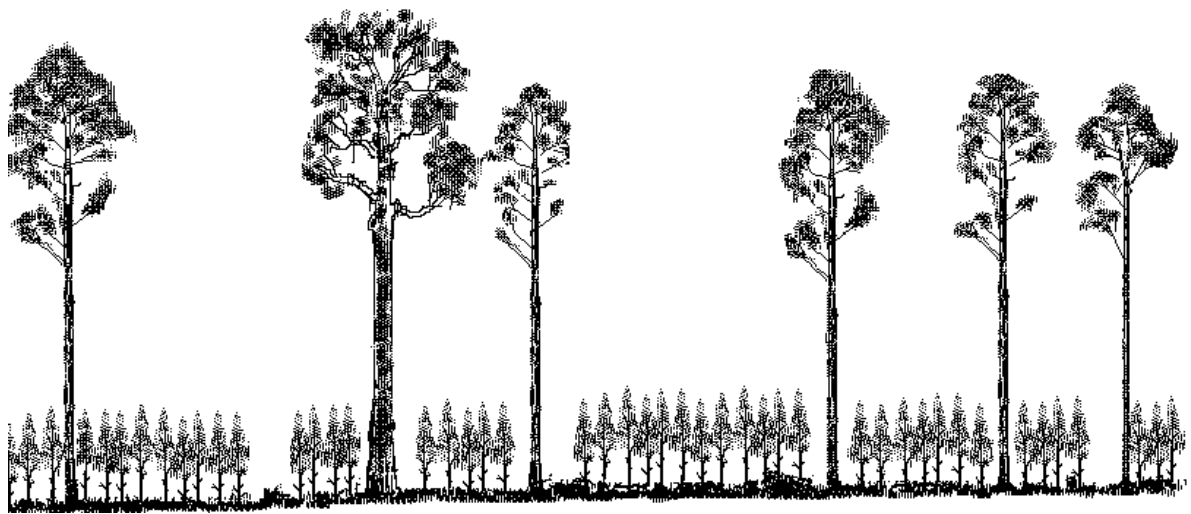
## 2.4 SAPLING SURVEY

'Sapling' is defined as the growth stage between 'seedlings' and 'poles'. Saplings are generally 4-10 years old and may be up to 15 m in height (Table 1). Sapling surveys may need to be undertaken:

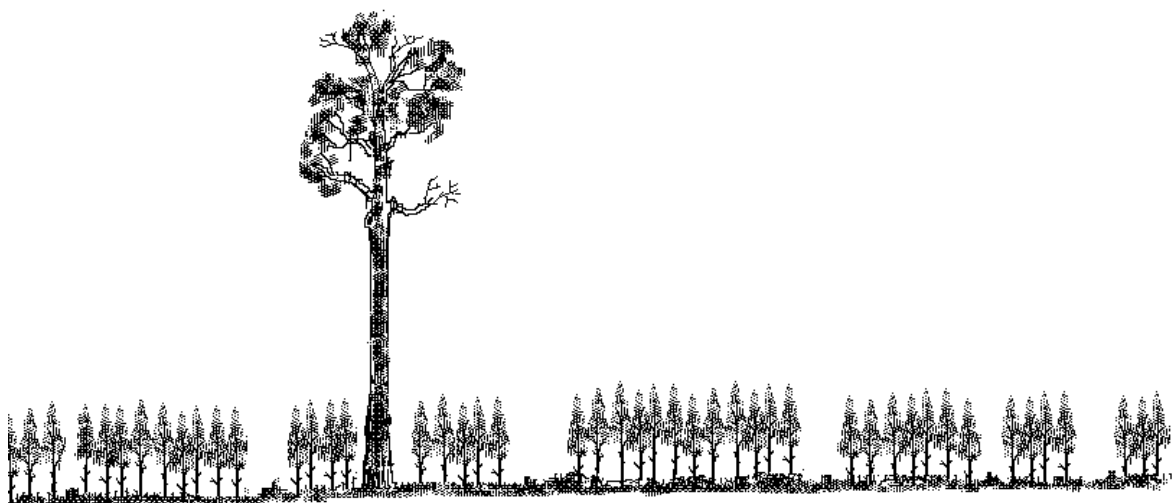
- where even-aged stands have not had an Established Seedling Survey, for whatever reason,
- where overwood removal in a dual-aged stand leaves a generally even-aged sapling stand, e.g. in shelterwood or timber stand improvement (TSI) operations.

Figure 4 illustrates a sapling stand resulting from overwood removal in a mixed-aged stand.

Sapling surveys are not mandatory, except where an ESS has not been undertaken.



**Figure 4(a) Dual-aged stand prior to overwood removal.**



**Figure 4(b) Even-aged stand following overwood removal.**

### 2.4.1 Objectives

The objectives of the survey are:

- to determine whether the site is adequately stocked
- to identify areas requiring remedial treatment

### 2.4.2 Survey technique

The primary survey method recommended is the stocked plot method as used for Established Seedling Surveys. The triangular tessellation survey described in **Appendix 5** is also suitable for sapling stands. It is more time-consuming but gives better estimates of stem density and should be used where this information is required.

### 2.4.3 Field procedure

The procedures used for the Sapling Survey and the ESS are similar so that the details described in Section 2.3.4 should be followed, with the following changes:

- *Timing:*  
If the survey is to be carried out following some form of stand alteration, such as overwood removal, it should be done as soon as possible so that, if necessary, advantage can be taken of any identified receptive seedbed resulting from the disturbance. If the survey is simply being carried out to ascertain the stocking status of an existing stand there are no specific timing requirements.

- *Plot size and grid spacing:*  
Plots of 3.57 m radius (~ 40 m<sup>2</sup>) should be surveyed at intervals of 30 m on parallel transects 80 m apart. One acceptable sapling renders a plot 'stocked'.

Due to the larger plot sizes, it may be impracticable to carry a survey staff to delineate the plot. In this case the distance from the plot centre to the nearest acceptable sapling should be measured by tape. If it is equal to or less than 3.57 m then the plot is stocked.

- *Definition of acceptable saplings:*  
'Acceptable' saplings must be capable of developing into high quality trees with sawlog potential. They should:
  - ♦ be of an acceptable species for that area and forest type;
  - ♦ be of an acceptable size (3–15 m) and not be suppressed;
  - ♦ be free of obvious stem defect; and
  - ♦ have a vigorous, healthy crown.

### 2.4.4 Compilation and evaluation

The procedure as described for the ESS should be followed. (Section 2.3.5)

#### **2.4.5 Standards**

A minimum of **65%** of plots on the potentially productive area must be stocked, (**55%** for an intensive survey) and no discrete area greater than **1 ha** should be unstocked.

Observation of at least 10 saplings of each required species (anywhere on the surveyed area) is needed.

#### **2.4.6 Intensive survey**

If the stocking of the site, allowing for discrete understocked areas, does not meet the minimum standards or if discrete areas within the surveyed area are classified as understocked, a further stocking survey of the entire coupe, or the designated understocked area, may be considered. This may be either a stocked plot survey with a closer transect spacing, or a triangulation survey.

*If a re-surveying is carried out to double check that the area is unstocked, the stocked plot method should be used.* Transect spacing should be 40 m, with plots at 30 m and at least 30 points sampled. If the earlier transects have been marked, then placing extra transects half-way between them will enable the results from both surveys to be combined (this will save on the extra work needed). Results should be evaluated as for the ESS, except that the minimum stocking standard is 55%, rather than 65%. (See **Appendix 1** (p.41) for an explanation of the mathematics.)

If the survey is carried out to determine actual density of stems, the triangulation method should be used as it provides a better density estimate in sparse stands (see **Appendix 5**). Plot frequency should be as for stocked plots.

#### **2.4.7 Sapling density**

For the stocked plot method use the technique outlined in Section 2.3.8, but multiply the average plot density by 250 (10 000 ÷ plot area (m<sup>2</sup>))

For the triangulation method, coupe seedling density should also be calculated using logarithms to reduce the size of the bias caused by a few heavily stocked plots.

Give unstocked plots a value of 0 then use the appropriate method for 'stocked plots', except that the average plot density is also the average coupe density.

#### **2.4.8 Documentation**

Transfer the Stocking Survey Summary details to Part B of the Forest Coupe Plan.

The Field Sheets, the Stocking Survey Map and recommended action should also be filed with the Coupe Plan.

### **3. SURVEYS IN UNEVEN-AGED STANDS**

#### **3.1 OBJECTIVES**

The objectives of stocking surveys in forest stands managed as mixed age or uneven-aged<sup>9</sup> vary with the forest type and the silvicultural objectives. However, generally, the surveys:

- determine whether the stand is in a potentially productive condition following selection harvesting;
- evaluate the outcome of any regeneration treatment;
- identify any areas requiring remedial treatment; and
- provide information on appropriate remedial treatment, if needed.

### 3.2 COUPE PLANNING

To reduce the amount of plot work that this survey system entails, coupe size should be no greater than necessary. For example, selection harvesting may actually take place only in a discrete part (perhaps 80 ha) of a potentially very large (> 200 ha) area.

Accordingly, define the coupe, in the planning stage, as the expected area to be harvested. However, if the harvesting has been (or will be) evenly distributed over a large area, then all of that area must be surveyed.

The pre-harvesting Coupe Reconnaissance which may be carried out under the Coupe Planning procedures (NRE, 1997b) should assist in identifying where harvesting will actually take place and thus keep coupe sizes to the minimum necessary.

### 3.3 COMPONENTS OF UNEVEN-AGED STANDS

Uneven-aged stands are composed of some or all of the following components (or growth stages) (as defined in Table 1, p 2):

- **regeneration** – seedlings, lignotubers, or coppice  
*height < 3 m*
- **saplings** – small trees of good form. May also be termed 'advance growth'. These usually develop in gaps in the forest canopy and will, on release, develop into potentially productive trees.  
*height 3–15 m*  
*DBHOB 5–15 cm*
- **poles** – trees with the potential to grow into merchantable trees (but may already be merchantable for certain products). (The upper DBHOB limit is made equal to the lower merchantable (sawlog) stem limit.)  
*height >15 m*  
*DBHOB 15–45 cm*
- **mature trees (merch.)** – trees having reached mature age and size, and which contain saleable timber  
*height >20 m*  
*DBHOB > 45 cm*
- **mature/overmature trees (non-merch.)** – trees having reached or exceeded maturity, and which do not contain saleable timber. Some may have been retained as 'habitat trees'. Also may be termed 'cull' trees.  
*height >20 m*  
*DBHOB > 45 cm*

<sup>9</sup> Forests in which more than one age class contributes to the growing stock following utilisation, or in which the period between harvests is less than the nominal rotation.

### 3.4 SURVEY TECHNIQUE

#### 3.4.1 Background theory

In an uneven-aged native forest, each of the components has a different distribution pattern. For instance, as the stand ages, the spatial pattern of the trees tends towards a natural random distribution (known as a Poisson distribution), particularly when the site is fully utilised. The closer to the Poisson pattern the stand gets, the more useful is density (e.g. no. of stems/ha) in describing the stand. Conversely, in regeneration, because of its usual 'clumpiness', density may be of little use in predicting future site occupation, so that distribution of regeneration over the site (stocked plots) is a more useful parameter. (See **Appendix 1.**)

The survey must be carried out over the full coupe area at a sampling intensity to adequately sample each component. A grid based on parallel transects is used to ensure that the entire area is sampled.

#### 3.4.2 Reference basal area and plot type

The mature (merchantable) and mature (non-merchantable) tree and pole components of the stand are surveyed using basal area. The degree of site occupation or stocking by these components is assessed by comparison with the expected basal area for a fully stocked stand. This varies with forest type and site quality. This stand basal area is referred to as the Reference Basal Area (RBA). Table 2 shows typical RBAs for forest types often managed using uneven-aged silviculture.

**Table 2. Typical Reference Basal Areas (RBA) and Top Heights for some forest types managed using uneven-aged silviculture for a range of site qualities.\***

Forest Type	Site Quality					
	High		Medium		Low	
	Basal area (m <sup>2</sup> /ha)	Top height (m)	Basal area (m <sup>2</sup> /ha)	Top height (m)	Basal area (m <sup>2</sup> /ha)	Top height (m)
<b>Mixed Species</b>						
-Wombat	55	42	44	30	38	22
-Heywood	45	30	34	25	26	20
<b>Box-Ironbark</b>	26	26	20	18	16	14
<b>River Red Gum</b>	40	38	30	26	24	20

\*These figures are given as a guideline only. Local experience should be used to determine an appropriate RBA for any individual site. The figure selected should represent the basal area for that site, when fully stocked.<sup>10</sup>

The sapling component is surveyed using a circular plot of radius 3.57 m (~40 m<sup>2</sup>).

For seedling regeneration a circular plot of radius 2.27 m (16m<sup>2</sup>) is used. Where coppice regeneration is present a plot of radius 3.57 m should be used, because coppice (especially red gum or box-ironbark) is likely to survive to maturity.

Some plots will have only 1 or 2 components in them, and rarely will plots have 4 or 5 components to assess.

<sup>10</sup> *Fully-stocked site*: a site which is supporting the maximum basal area which it is capable of. This basal area will be that of a healthy mature stand which has developed from dense regeneration.

### 3.5 TIMING

The survey should be undertaken **18–36 months after harvesting**. In river red gum areas subject to regular flooding, the survey should be done 18–30 months after the first flood after harvesting. This delay should allow seedlings to have become established (if this component is expected to be significant).

In box-ironbark coupes, where seedling regeneration is likely to be a small component of overall stocking, surveys could be done as soon as 9 months after harvesting.

There are however, circumstances where this survey technique may be appropriate for pre-harvesting surveys, particularly where components may be adequate to productively utilise the site without the need to establish post-harvesting regeneration. Such a survey could be part of the Coupe Reconnaissance on appropriate coupes, although it is not mandatory.<sup>11</sup>

### 3.6 FIELD PROCEDURE

Use the Field Survey Sheets, a Stocking Survey Map Sheet and a Survey Summary Sheet as given in **Appendix 6**.

- Enter the species listed as present on the site in Part A (1) of the Coupe Plan, in the 'Species Required' section. The presence of at least 10 individuals of each species anywhere on the surveyed area should be noted by entering a tick in the appropriate 'present/absent' box.
- Enter the recommended basal area for a fully stocked stand of the site quality and forest type of the area being surveyed in the box labelled RBA (see Table 2).<sup>12</sup>
- Choose a gauge of appropriate Basal Area Factor (BAF)<sup>13</sup> and record this on the sheet.
- Transfer or attach an accurate map of the area to be surveyed to the Stocking Survey Map Sheet, i.e. the mapping is preferably done prior to the survey, so the grid can be appropriately placed.
- Place a systematic grid over the map. (See **Appendix 3** for details.) Locate parallel transects at right angles to the long axis of the coupe, or to the main snig track orientation and locate plots at the following spacings, dependent on coupe size:

<sup>11</sup> Pre-harvesting surveys may be used to:

- determine the most suitable silvicultural system for regeneration of a stand. This is a function of stand composition and management objectives.
- to enable development of a utilisation strategy
- to aid in tree marking for the above
- to aid in yield prediction and wood flow planning

The specific components of the stand which need to be assessed are those which are likely to be still present following utilisation, i.e. pole-stage trees and saplings. Information on the presence of merchantable and mature non-merchantable trees would also be useful.

Survey procedure should be as for the post-harvesting survey, but without the need to search for the regeneration component. Note: If DBHOBs and log lengths are measured for the merchantable trees counted 'in', then their volume/ha can be calculated using the VBAR computer program.

<sup>12</sup> This should be based on local knowledge or data. See Table 2 for assistance, and Silviculture Section can advise if necessary.

<sup>13</sup> The choice of Basal Area Factor (BAF) depends on the likely density of stems. The factor chosen should result in counts between 5 and 12 per sweep. A gauge of BAF 2 is likely to be useful for a post-logging survey, in mixed species and red gum and BAF 1 in box-ironbark.

Coupe Size	Transect spacing	Plot spacing	No. plots/ha
200 ha +	250 m (125 m)	100 m (100 m)*	0.40 (0.08)
100–200 ha	150 m (75 m)	100 m (100 m)*	0.67 (1.33)
<100 ha	100 m (50 m)	50 m (50 m)*	2.00 (4.00)

\*Intensive survey grid (see 3.9)

- In the field, locate the first transect starting point and then locate the first plot on this transect in an unbiased manner.

Clearly flag the start and end of each transect. This will assist any later regeneration work carried out on the basis of the survey results. Make notes of features which will aid relocation of the transects.

- As each plot is reached, mark the plot centre before assessment - a pigtail pin is suitable and convenient.
- Calculate the plot basal area by multiplying the total number of trees tallied by the BAF of the gauge used. Enter this in the 'Total BA column.
- **If the total basal area is greater than 30% of the Reference Basal Area, the plot is stocked** and a tick (✓) is entered in the 'BA Stocking' column. If the plot is not stocked by overwood, enter a cross (✗).
- Even if the plot is stocked by BA, the plot is still assessed for saplings/coppice and seedlings.
- If at least **one** acceptable sapling or coppice (see Table 1) is within 3.57 m, the plot is stocked, and a tick (✓) is entered in the 'Sapling/Coppice' column. A pole or longer tree can also stock this plot if a sapling/coppice is not present. If so, indicate in the 'Comments' section. If there is no acceptable stem within 3.57 m, the sapling/coppice plot is unstocked. Enter a cross (✗).
- Search a standard regeneration plot (2.27 m radius) using a measuring stick for acceptable seedlings<sup>14</sup> (see Table 1). The plot is stocked if it contains at least **one** acceptable seedling, and a tick (✓) is entered in the 'Seedling' column. If the plot does not contain acceptable regeneration enter a cross (✗).
- Conduct a BA sweep of all trees >5 cm DBHOB. Non-merchantable mature trees are recorded separately. The 'in' trees may be put in appropriate DBHOB classes – this is optional. (Note: 'saplings' may also be counted on the fixed area plot.)
- *The sample point is stocked if either the 'BA Stocking' box or the 'Sapling/Coppice', or 'Seedling' boxes contain a tick (✓).*

*Enter 'B' in the 'Stocking Status' column if the point is stocked by BA.*

*Enter 'R' in the 'Stocking Status' column if the plot is **not** stocked by BA but is stocked by sapling/seedling/coppice.*

<sup>14</sup> includes acceptable plants of lignotuberous origin.

- If the point is stocked, continue to the next plot. Use the map and comments column to record any significant understocked areas (>2 ha) between plots. Some deviation from the transect may be needed to check possible gaps.
- If the sample point is not stocked by any of the above components, enter an 'X' in the 'Stocking Status' column, and carry out a seedbed assessment on the 2.27 m radius plot searched for regeneration.

If the plot has no potential, in its present state, for successful eucalypt establishment and growth, or is reserved from further seedbed preparation, it should be classed as non-productive, recorded in the 'Seedbed' column as 'N' and the reasons noted in the 'Comments' section. Examples of possible non-productive areas include rock outcrops, internal roading (not snig tracks), retained landing sites, filter strips and permanently saturated zones such as swampy ground.

If the plot has potential to support eucalypt growth, the percentage of receptive seedbed should be estimated. If the percentage of receptive seedbed is 50% or greater the plot is considered receptive and 'RS' should be entered in the 'Seedbed' column. If the seedbed is less than 50% receptive, the reason should be recorded in the 'Seedbed' column as either soil damaged (D), colonised by non-eucalypts (C), or covered by slash/litter/debris (L).

- Any seedling damage due to browsing or insects/fungi in or around the plot should be noted in the 'Comments' section. Record the severity and the species responsible.

### 3.7 COMPILATION AND EVALUATION

On completion of the survey, the results should be accurately transcribed from the Field Sheet to the Stocking Survey Map sheet or an attached map sheet. Where more than one Field Sheet is used, it may be convenient to calculate sub-totals at the end of each sheet.

- Accurately mark the transects and plots on the map and enter the Stocking Status for each plot.
- Enter the number of plots in each category, for each transect, in the right hand columns of the map sheet.
- Calculate the total number of plots in each column.
- Enter the column totals in the Sample Points Summary at the bottom of the sheet. The total number of plots in all designated unstocked areas should also be entered.

**Appendix 6** gives an example of a completed Stocking Survey Map.

The species composition results from the Field Survey Sheet and the summary of results from the Stocking Survey Map sheet should be transferred to the Stocking Survey Summary sheet.

Carry out the following calculations:

*Percentage of area potentially productive:*

$$\frac{(\text{total no. of plots (T)} - \text{no. of non-productive plots (N)})}{\text{total no. of plots (T)}} \times 100$$

*Percentage of productive area stocked:*

$$\frac{\text{no. of stocked plots (S)}}{\text{total no. of plots (T)} - \text{no. of non-productive plots (N)}} \times 100$$

If unstocked areas within the surveyed area are designated for re-treatment, the stocking estimates of the remaining areas may be adjusted accordingly. The number of sample points in each category should be recalculated (excluding **all** points in the designated unstocked area) and entered in the 'Adjusted' section of the Stocking Survey Summary sheet. All the above calculations should be carried out using the adjusted figures; e.g. the Adjusted percentage of productive area stocked should be calculated using the formula:

*Adjusted percentage of productive area stocked:*

$$\frac{\text{no. of stocked plots (S adjusted)}}{\text{total no. of plots (T adjusted)} - \text{no. of unproductive plots (N adjusted)}} \times 100$$

To estimate the percentage of receptive seedbed available, calculate, for the unstocked area only:

$$\frac{\text{no. of receptive unstocked plots}}{\text{no. of unstocked plots}} \times 100$$

If this percentage is less than 70%, supplementary seedbed preparation will be needed if any remedial sowing is to result in a satisfactory stocking level, i.e.  $\geq 70\%$ .

The basal area data collected in this survey will provide valuable information for management of the site. However, the primary concern with basal area in this case is to ensure that the potential for productive development of the stand is not compromised by excessive mature non-merchantable trees.

The column totals for Merchantable and Non-Merchantable 'in' trees should be calculated for each Field Sheet, and the grand totals transferred to the 'Basal Area Summary' in the Stocking Survey Summary sheet. Then the coupe average for the BA categories can be calculated and compared.

If required, the proportion of area stocked by each component or group of components can also be calculated.

### 3.8 STANDARDS

The stocking standards aim to ensure that the site is occupied by components which have the ability to meet wood production management objectives. If wood production is a management objective, The emphasis, therefore, is on ensuring adequate stocking and distribution of productive or potentially productive components.

#### 3.8.1 *Stocking and distribution*

The minimum acceptable stocking standard<sup>15</sup> is:

- **70%** of plots on the productive area must be stocked for the standard survey (**60%** for an intensive survey), and
- no discrete area greater than **2 ha** should be unstocked (if caused by recent harvesting).

This is the primary standard by which coupes will be judged as satisfactorily stocked or not. If unstocked areas of 2 ha or greater are designated for re-treatment and the overall percentage stocking is less than 70%, the Adjusted Stocking may be used. If the adjusted stocking is less than 70%, intensive survey should then be considered (see Section 3.9).

#### 3.8.2 *Species composition*

The minimum standard for eucalypt species composition is that those species present on the site prior to harvesting or other form of disturbance should continue to be present.

The minimum standard is:

- at least 10 acceptable individuals (incl. coppicing stumps) of each species listed, anywhere on the surveyed area, must be present on the coupe.<sup>16</sup>

If enough acceptable individuals of each required species have not been observed in the course of the survey, a reasonable search should be carried out. Failure to locate acceptable stems should be recorded in Part B of the Coupe Plan.

#### 3.8.3 *Non -merchantable tree basal area*

Where wood production is a primary objective, the average stand basal area contained in mature non-merchantable stems (including habitat trees) should not be greater than 5–7 % of the Reference Basal Area (see Section 3.4.2). Higher levels of non-merchantable trees will result in significant loss of site productivity due to regrowth suppression.

<sup>15</sup> These standards are the subject of research and may be altered as we improve our knowledge of stand dynamics from seedlings through saplings to the mature trees.

<sup>16</sup> This is a draft standard which will be the subject of research and review.

### **3.8.4 Merchantable basal area**

A standard for this component is not appropriate in the context of stocking surveys. However, the Basal Area Summary should be useful for planning and evaluation purposes. For example, in the Heywood District, the data is computed using the VBAR Program to calculate volumes and diameter distributions in the stand following utilisation.

## **3.9 INTENSIVE SURVEY**

If the regrowth/regeneration stocking of the site, after adjusting for discrete unstocked areas, is below the 70% standard, or if discrete areas within the surveyed area are classified as unstocked, a further survey of the entire coupe, or the identified unstocked area, may be considered prior to applying remedial treatment. This should be a stocked plot survey with transect spacings as set out in Section 3.6 and at least 20 points sampled. Placing the transects half way between the initial transects will allow the results to be combined to give twice the sampling intensity.

*A minimum standard of 60% of stocked plots is acceptable for intensive surveys.*

An intensive survey of any area proposed to be re-treated will provide valuable information for determining the most appropriate action. Marking of areas to be re-treated should also be done at this time.

## **3.10 OVERWOOD TREATMENT**

If the area surveyed has an overall basal area of non-merchantable overwood of greater than 5–7% of the Reference Basal Area, the potential productivity of the site is likely to be adversely affected.

The Stocking Survey map and comments should be examined for concentrations of plots with non-merchantable overwood levels greater than 5–7% of the RBA. If there are discrete areas present they should be clearly mapped and the overall non-merchantable overwood BA should be re-calculated without the plots within the mapped area/s. If it is still above 5–7% the whole area may be considered for overwood reduction. If the overall non-merchantable overwood BA drops to less than 5–7% on re-calculation, then only the marked area/s need be considered for treatment.

Consult *Native Forest Silviculture Guideline No. 12* for information on the treatment of non-merchantable trees.

## **3.11 DOCUMENTATION**

The Stocking Survey Summary details should be transferred to Part B (Silvicultural Planning and Recording) of the Coupe Plan and is sheet attached to Part B.

The Field Survey Sheets, the Stocking Survey Map and recommended action should also be filed with the Coupe Plan.

**Appendix 6** has an example of a completed Stocking Survey Record.

## 4. REFERENCES AND FURTHER READING

DNRE (1996) Code of Practices for Timber Production, Dept of Natural Resources and Environment, Melb.

DNRE (1997a) Planning for harvesting and regeneration of native forests using even-aged silviculture, Dept. of Natural Resources and Environment, Melb.

DNRE (1997b) Planning for harvesting and regeneration of native forests using uneven-aged silviculture, Dept. of Natural Resources and Environment, Melb.

***For most of the relevant 'Further Reading' documents, see the Reference list at the end of Appendix 1 - 'Review of Regeneration Survey Methods and Standards'.***

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