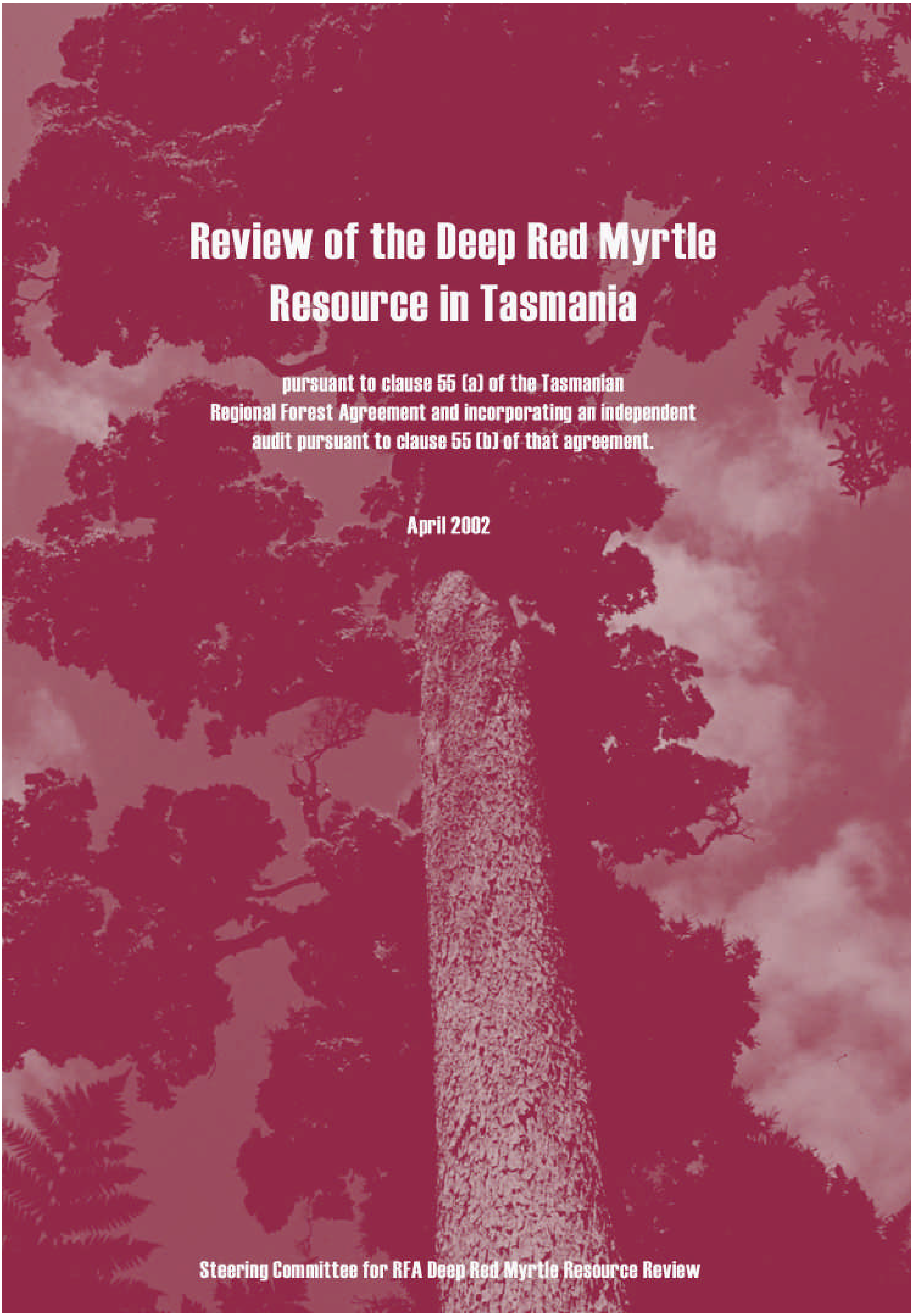


Review of the Deep Red Myrtle Resource in Tasmania

pursuant to clause 55 (a) of the Tasmanian Regional Forest Agreement and incorporating an independent audit pursuant to clause 55 (b) of that agreement.

April 2002

Steering Committee for RFA Deep Red Myrtle Resource Review

STEERING COMMITTEE

Dr Hans Drielsma, Forestry Tasmania, (Chair)
Paul Smith, Forestry Tasmania
Mike Peterson, Forestry Tasmania
Ian Whyte, Forest Industries Association of Tasmania
Glen Britton, Forest Industries Association of Tasmania

PRINCIPAL INVESTIGATOR AND AUTHOR

Dr Bob Mesibov

INDEPENDENT AUDIT (Appendix 9)

Ian S Ferguson,
Professor of Forest Science,
University of Melbourne.

This report has been independently audited by an auditor, Professor I.S Ferguson, jointly agreed by the Tasmanian and Commonwealth Governments, pursuant to clause 55(b) of the Tasmanian Regional Forest Agreement. The audit report forms Appendix 9 of this document. The recommendations of the audit have been incorporated into this final report.

Contents

Executive summary

Overview

The 1997 Regional Forest Agreement required Tasmania to review the volume, quality and economic accessibility of its deep red myrtle (DRM) resource. This report explains how the DRM resource was reviewed and details the results.

Deep redness is a timber characteristic which only becomes apparent after a myrtle has been felled. DRM volume cannot be directly estimated. For the purposes of the resource review we used forest type, forest age and geology as indicators of where DRM can be found. Specifically, we defined *DRM-rich forest* as tall myrtle forest, mainly mature, growing on soils derived from igneous bedrock. Because DRM is mainly found in older trees, a rough estimator of DRM sawlog volume is the volume of category 4 logs (high-quality, $\geq$75 cm mid-diameter) from DRM-rich forest.

Now and in the future, DRM is obtained either from the selective logging of DRM-rich forest managed specifically for ongoing sustainable yields of myrtle sawlog (herein referred to as STM operations) or as arisings in eucalypt or blackwood forest management (herein referred to as non-STM operations). While this review has focussed on STM operations, it has taken account of all potential sources of supply from public forest.

During the remaining 16 years of the Regional Forest Agreement period, an estimated 39 700 m^3 of category 4 myrtle sawlog could be recovered from STM operations in 76 DRM-rich forest coupes outside the Savage River Pipeline Corridor. The 76 coupes are located in 27 clusters, each served by a small network of existing or proposed logging roads. The estimated mill-door cost for sawlog and optional logs in the 27 clusters ranges from $82 to $148 per cubic metre of sawmill deliveries (category 4, utility and optional logs).

Sensitivity analysis shows that mill-door cost is strongly dependent on volume estimates and stumpage. Volume estimates were based on actual recoveries from selective logging but are likely to be optimistic, indicating that the calculated mill-door costs are conservative. No industry-agreed threshold is available to determine the proportion of the resource which is ‘economically accessible’, and it is possible that some of the 76 coupes might not be economically harvested.

Optimistically, selective logging of all 76 coupes could generate ca. 2480 m^3/yr of category 4 myrtle sawlog over the remaining 16 years of the RFA period. Another ca. 640 m^3/yr currently arises from non-STM operations (extensive forestry and plantation clearing). The 3120 m^3/yr total is considerably less than the 4500 m^3/yr target for DRM proposed in the Tasmanian Forests and Forest Industry Strategy and noted in RFA clause 55. The shortfall is expected to be considerably greater because:

- Mature myrtle in the 76 coupes is progressively dying from myrtle wilt, a fungal disease. A proportion of the coupes will become unsuitable for selective logging over the next 16 years due to loss of seedtrees for rainforest regeneration.
- The high-quality myrtle sawlog volume available from non-STM harvesting will decline rapidly in coming years as plantation targets are met and as logging and regeneration of native eucalypt forest moves to sites increasingly less likely to carry sound, red myrtle in the understorey.

In response to recommendations of an external auditor, an approximate 90% confidence interval on the resource estimate of 39,700 m^3 has been calculated as 16,693 m^3 or 42% of the estimate. The probability of the target harvest of 4,500 m^3 /year over 16 years of the RFA period being achievable is less than 0.2% or in terms of odds, is 446 to one (Appendix 10)

Selective logging for myrtle within the Savage River Pipeline Corridor would not be expected to make available more than another 55 000 m^3 of category 4 myrtle sawlog from DRM-rich forest. Cutting at 4500 m^3/yr, the category 4 myrtle sawlog harvest from DRM-rich forest from both inside and outside the Corridor would exhaust the identified resource in less than 25 years. Sustainable supply of DRM would require a re-setting of the current yield target.

Details: Defining and locating the available DRM resource

Deep redness in myrtle is mainly seen in large-diameter logs from tall, mature rainforest growing on fertile sites. The cause of deep redness is unknown, and it is not possible to assess forest for DRM without risking stand death from myrtle wilt disease. Forest type and geology were therefore used as indicators in the DRM resource review. All patches of tall rainforest growing over igneous bedrock in Tasmania were located using GIS methods. Of the public land total of 61 488 ha of DRM-rich forest, 26 481 ha are in formal reserves and another 12 820 ha are in informally reserved patches of State forest.

DRM-rich forest which is both available and potentially suitable for selective logging during the RFA period is found in 239 production forest coupes in State forest. Of these, 62 coupes (5637 ha) of DRM-rich forest are within the Savage River Pipeline Corridor and 177 coupes (9820 ha) are outside the Corridor.

Each of the 177 non-Corridor coupes was inspected to determine its silvicultural suitability for selective logging during the RFA period. Only 76 of the 177 were found to be suitable. Most of the rejected coupes have too low a stocking of mature myrtle to permit selective logging with retention of seedtrees for regeneration. The 76 non-Corridor coupes contain 4658 ha of DRM-rich forest, which is 7.6% of the public land total.

Details: Estimating yields and costs

Sawlog recovery was estimated using harvest yields from recently logged, comparable coupes. Each of the 76 coupes was categorised as ‘good mature,’ ‘poor mature', ‘regrowth-rich’ or ‘salvage’. The corresponding yields of myrtle sawlog were estimated to be 18, 9, 5 and 2.5 m^3/ha, respectively (separate yields for category 4 and utility grade sawlog were also calculated). An operational area for each coupe was determined by drawing a likely logging boundary on aerial photographs overlaid (using GIS) with contour and drainage information. The total operational area is *ca*. 4420 ha.

The 76 coupes were grouped into 27 clusters by road access. Assuming that all coupes within a cluster would be logged, mill-door cost for myrtle sawlog plus optional (‘outspec’) logs was estimated for each cluster. Input costs were for roading, logging, cartage, road toll and stumpage. Cluster costs ranged from $82 to $148/$m^3$ of sawmill deliveries (category 4, utility and optional logs), with a volume-weighted cluster average of $103/$m^3$.

Not enough selective logging has been done in recent years to permit calculation of the expected coupe-to-coupe variation in yield within the four ‘quality’ categories. Mill-door cost variation was examined by adjusting input costs separately and together for a spatially clustered subset of the 76 coupes. Mill-door cost is much more sensitive to stumpage than to roading, logging, cartage or road toll cost, and is even more sensitive to recovered volume. The combined effects are considerable: a modest increase of 25% in roading, logging and carting costs together with a 25% drop in estimated volume results in a 54% jump in mill-door cost, from $102 to $157 per cubic metre of logs delivered.

1. Introduction

The Savage River Pipeline Corridor (Fig. 1.1) is a *ca*. 20 000 ha block of State forest in northwest Tasmania. It is called a 'corridor' because through the forest runs a pipeline used to carry iron ore slurry from a mine at Savage River to a pelletising plant on the north coast at Port Latta. A service road parallels the pipeline.

The Pipeline Corridor also contains *ca*. 12 300 ha of myrtle-dominated rainforest, almost entirely undisturbed. Myrtle (*Nothofagus cunninghamii*) is the most widespread and abundant tree species in Tasmanian rainforest. On most sites the timber is straw to pale pink in colour, but 'deep red myrtle' occurs in some areas, notably on the basalt soil neighbouring the Savage River Pipeline Road. Deep red myrtle (DRM) is preferred by veneer and sawnwood buyers and attracts a premium price.

In the 1997 Tasmanian Regional Forest Agreement (RFA), the Commonwealth of Australia requested and the State of Tasmania agreed that logging in the Corridor would be postponed for five years (RFA clause 54). Clause 55 continued:

> *'The Parties agree that:*
>
> *a) during the first 4 years of this Agreement, the State will review its resource estimates for deep red myrtle available for supply to the furniture and craft industries, in terms of volume, quality and economic accessibility, and will publish a report of the findings; and*
>
> *b) the State will arrange for the review described at (a) above to be independently audited by an auditor agreed to by the Parties, and for a report by that auditor to be published;*
>
> *c) the further management of the Savage River Pipeline will be considered by the State prior to the first five yearly review of this Agreement in the light of the report and audit described at sub-clauses (a) and (b) above; and*
>
> *d) if the resource review and audit confirm the availability, outside the Savage River Pipeline corridor, of adequate resource of acceptable quality and economic accessibility, to maintain a supply of at least 4,500 cubic metres per year of deep red myrtle, for the remainder of the term of the Agreement, then harvesting and associated roading within the area will be further postponed for that period; and*
>
> *e) in the alternative, the area will be further considered by the State to ensure the availability of deep red myrtle for the period.'*

The DRM resource review has been carried out by Forestry Tasmania (FT). Dr Bob Mesibov was the project officer, with supervision by a steering committee consisting of Dr Hans Drielsma (General Manager, Forest Management; FT), Paul Smith (Regional Forester, North; FT), Ian Whyte (Chief Executive, Forest Industries Association of Tasmania Ltd), Glenn Britton (Managing Director, Britton Bros. P/L) and Mike Peterson (Senior Forester (Special Species Timber); FT).

The review was complicated by the fact that DRM volume cannot be directly estimated. As explained in section 3 and Appendix 1, deep redness is a timber characteristic which only becomes apparent after a myrtle has been felled. For the purposes of the resource review, we used forest type, forest age and geology as indicators of where DRM can be found. Specifically, we defined *DRM-rich forest* as tall myrtle forest, mainly mature[1], growing on soils derived from igneous bedrock. Because DRM is mainly found in older trees, a rough estimator of DRM sawlog volume is the volume of category 4 logs (high-quality, $\geq$75 cm mid-diameter) from DRM-rich forest. The relationship between this estimator and the 4500 m^3/yr figure cited in RFA clause 55 is discussed in section 9.

---

[1] In this report we use "mature rainforest" on "mature myrtle forest" to mean myrtle-dominated rainforest containing trees large enough to yield category 4 myrtle sawlogs, ie trees with a breast height diameter of at least 75cm.

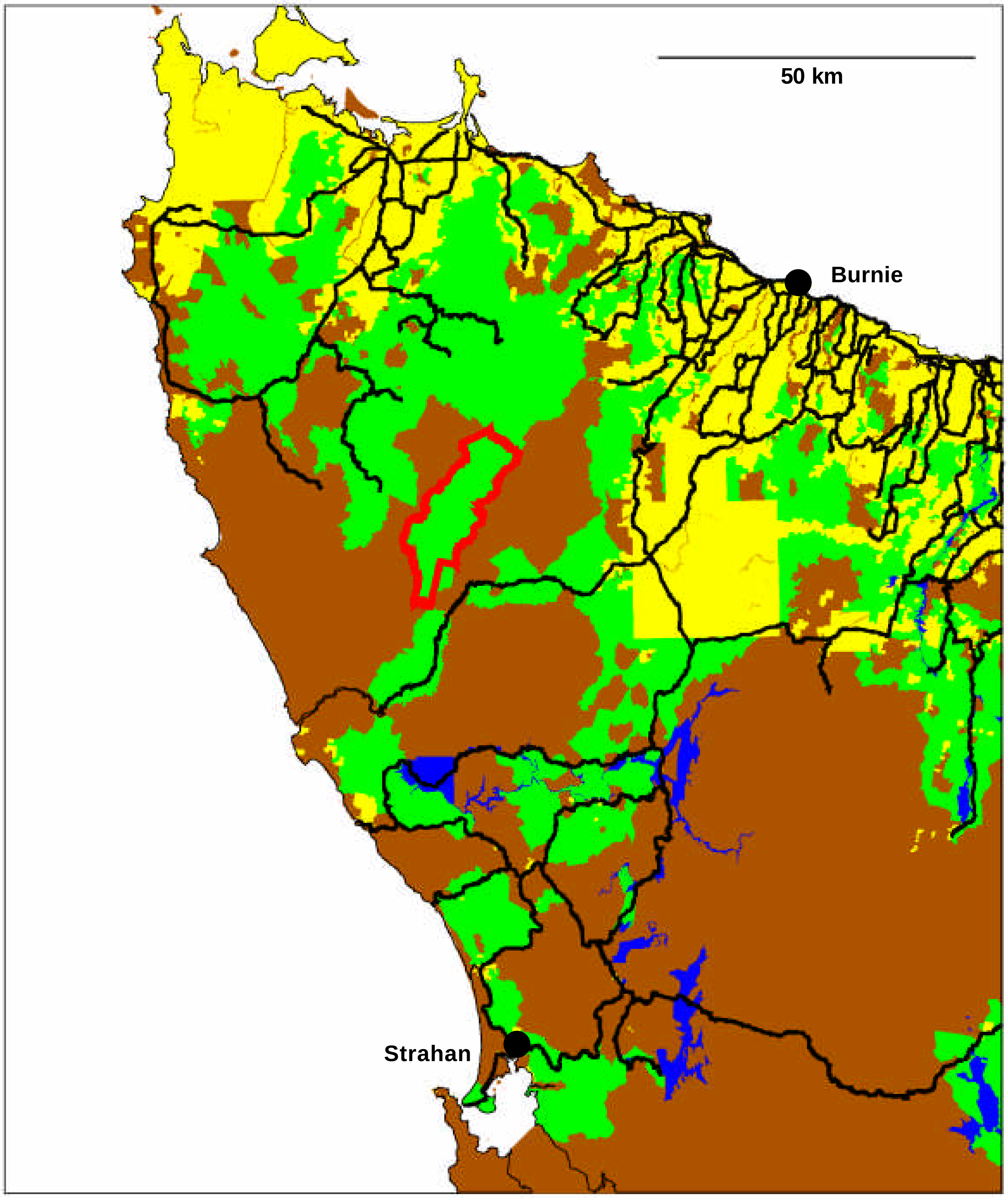
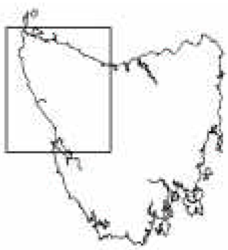


Fig. 1.1. Land tenure in northwest Tasmania showing reserves (brown – includes minor areas of other public land), State forest (green) private land (yellow), lakes and land vested in the Hydro-Electric Commission (blue) and main roads (black). The Savage River Pipeline Corridor is the red-bordered area of State forest.



2. How this report is organised

We aimed in the resource review to answer the following question: *How much deep red myrtle is available for supply to the furniture and craft industries from areas outside the Pipeline Corridor, and at what cost is it available?*

What we did first was to locate all patches of DRM-rich forest within State forest coupes in Tasmania. The identification of coupes containing at least 10 ha of DRM-rich forest was done using GIS methods and is detailed below in section 4, **Locating the couped DRM resource**. Coupe boundaries are drawn by forest planners to exclude riparian reserves, very steep slopes, biodiversity corridors and other special features. State forest outside coupes is currently unavailable for logging and is not included in harvest planning, whether for selective rainforest logging, eucalypt logging or plantation development. In section 4 we also provide information about DRM-rich forest in State forest outside coupes, and on other land tenures.

Note that we excluded DRM-rich forest on private land from the resource review. We did so because the relevant clauses of the RFA (54 and 55) appear in the 'Public Land' section of the Agreement, and the understood intent of the RFA clauses was to refer to public land. The State cannot plan sawlog supply from private forest: the timing and nature of timber sales from private forest are legally the prerogative of the forest owners.

Not all of the DRM-rich forest within State forest coupes is available or suitable for logging within the RFA period. In **Defining the couped DRM resource for the RFA period** (section 5) we show how we developed a preliminary short list of coupes which were both available and potentially suitable for logging in the RFA period from 1997 to 2017.

The short-listed coupes were then inspected to identify the area within each coupe which could be selectively logged for myrtle. **Evaluating DRM-rich coupes** (section 6) explains how the inspections were carried out, and why some coupes were dropped from the list. The remaining coupes make up the 'final set' for estimating the DRM resource.

Estimating DRM recovery (section 7) details the method we used to predict how much myrtle sawlog would arise from selective logging of the final set of coupes.

Costing the DRM harvest (section 8) gives realistic mill-door costs for myrtle sawlog. Costing is based on a simple protocol which ties each coupe in the final set to a particular road network. This section offers a menu of practical logging scenarios, with a price for each.

In the **Conclusion and discussion** (section 9) we answer the question above and comment on the answer.

As background to the resource review, we present in the next section a general overview of myrtle logging and myrtle sawlog quality in Tasmania, **Myrtle timber production**.

3. Myrtle timber production

3.1. Myrtle timber and the nature of DRM

Seasoned myrtle timber is hard and strong with a smooth, durable finish. Myrtle was a well-known 'cabinet wood' or ornamental timber in the 19th and early 20th centuries, and its hard-wearing properties made it popular for dance floors. After World War 1, myrtle production increased to supply the expanding markets for boot lasts and shoe heels, broom handles, brush backs, furniture, wall panelling, stairs, flooring and decking. Today myrtle is used for furniture, flooring, joinery and craftwood. Myrtle veneer has been cut from selected logs since the early 1940s and is bonded to particle board and plywood for use in furniture and wall panelling.

Myrtle sawlogs vary greatly in the quality of the wood they contain, and especially in colour. For more than a century the timber industry has distinguished 'red' from 'white' myrtle (Appendix 1), but these two classes have been imposed on a continuous variation in colour from straw-brown to blood-red. 'Deep red myrtle' (DRM) is only a name for timber at the darker end of the red myrtle range (Fig. 3.1). Nevertheless, it has long been recognised that myrtle colour correlates with wood properties: the deeper the red, the heavier and harder the timber, and the longer to air-dry. 'Deep redness' is a signal to the sawmiller that special care needs to be taken in seasoning, and to the wood user that machining will not be easy. 'Deep redness' is also a selling feature. For many years Burnie Timber marketed its myrtle under the name 'Australian Cherry'.

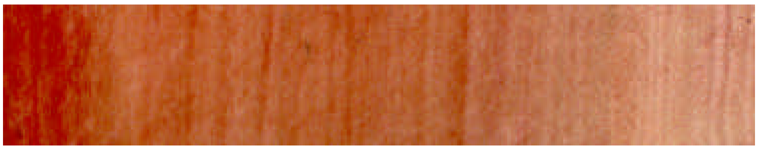


Fig. 3.1. Myrtle colour varies within a single log. This section of myrtle veneer, shown here approximately life-size, is deep red at the left-hand end and pale pink on the right.

The causes of variation in myrtle colour are unknown, but deep redness is believed to be associated with fungal infection (Appendix 1). The long-term experience of loggers and sawmillers is that DRM in Tasmania is largely restricted to highly fertile soils. In the Northwest, DRM is particularly common on sites underlain by Tertiary basalt. It is also well-known that heartwood redness deepens and increases in extent (occupies more of the cross-sectional area of the log) as a myrtle gets older.

3.2. Sawlog production

Myrtle sawlog production from public land in Tasmania peaked at more than 20 000 m^3/yr in the 1950s (Fig. 3.2). Over the past five years (1995/96 to 1999/2000) public land production has averaged *ca*. 1800 m^3/yr. Small volumes of myrtle sawlog have also come from private land in recent years, mainly from the Surrey Hills block in northwest Tasmania now owned by Gunns Pty Ltd.

To be graded as sawlog, myrtle logs have to meet certain form- and defect-based criteria. Myrtle sawlogs greater than or equal to 75 cm in mid-diameter are 'category 4', while 'utility' myrtle sawlogs are less than 75 cm. Over the past five years the volume ratio of category 4 to utility myrtle sawlogs was 0.88 to 1.

The sawmilling industry also buys myrtle logs which do not meet sawlog specifications because they are too bumpy, bendy, twisted, grooved, rotted or otherwise defective. Production of these 'outspec' logs has grown in recent years and reached *ca*. 1600 m^3 in 1999/2000 (Fig. 3.3).

At the time of writing, the stumpages paid for category 4, utility and outspec myrtle logs from public land were \$60, \$30 and \$15 per cubic metre, respectively.

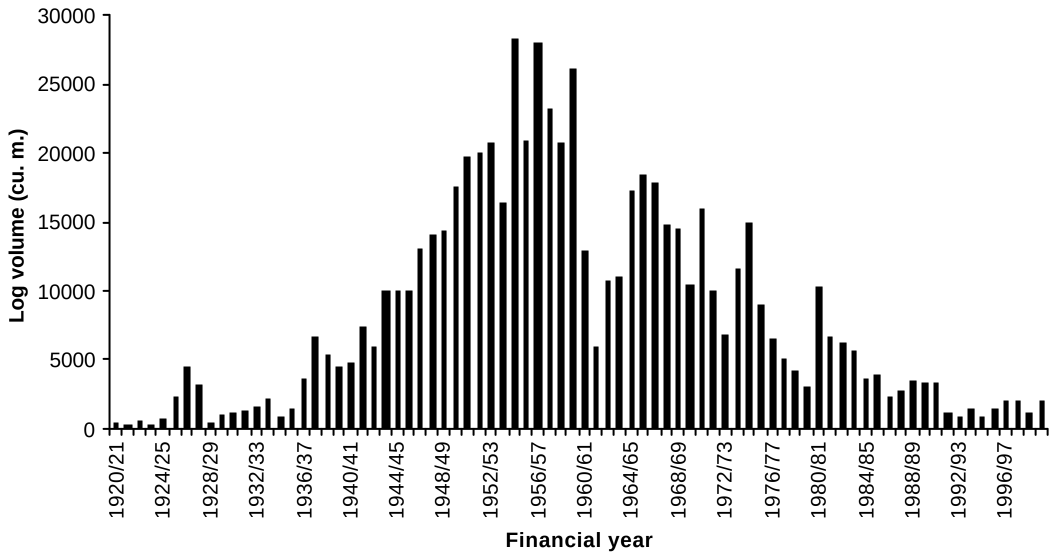


Fig. 3.2. Myrtle sawlog volume from public land in Tasmania, 1920/21 to 1999/2000. Data from Forestry Tasmania sales records and from Forestry Commission and Forestry Department Annual Reports.

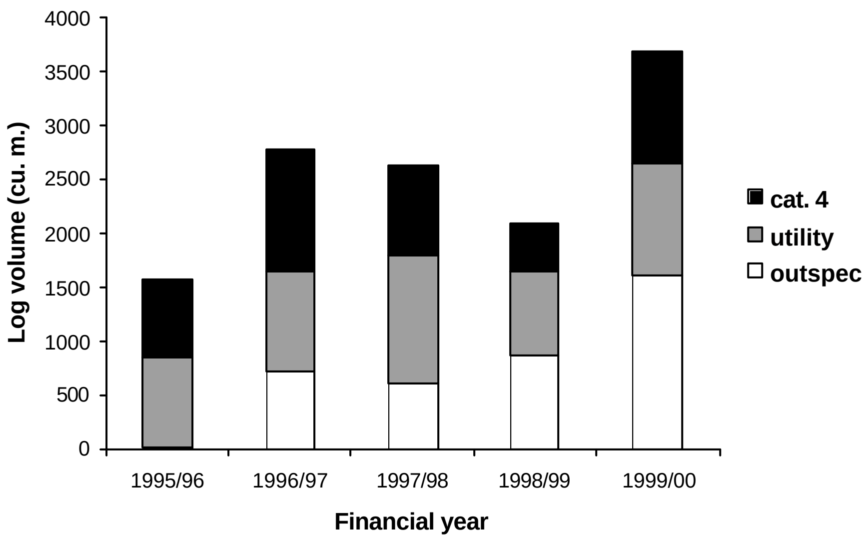


Fig. 3.3. Myrtle sawlog and outspec volumes from public land in Tasmania, 1995/96 to 1999/2000. Data from Forestry Tasmania sales records.

3.3. Sawlog sources

Myrtle sawlogs come from selective operations in mature rainforest, from clearfelling and regeneration of mixed eucalypt forest (mature eucalypt over rainforest), from clearing of native forest for plantation development and from selective logging for blackwood in northwest Tasmania and for Huon pine on the West Coast. Selective logging for myrtle is called ‘STM logging’ by Forestry Tasmania planners because the coupes selectively harvested are formally designated ‘STM’ (Special Timbers Management) in Forestry Tasmania’s coupe databases. Other myrtle sources are here called ‘non-STM’, although a few of the coupes involved (such as those from which Huon pine is harvested) may also be STM. Figure 3.4 shows that STM logging has generated most of the larger-diameter sawlog volume over the past five years.

These larger diameter logs are the ones most likely to contain DRM (see above, section 3.1) and are also more likely to have larger volumes of heartwood free of rotten core, which is common in myrtle on all sites. Selective logging of mature rainforest in STM coupes is thus a more reliable source of DRM than non-STM logging.

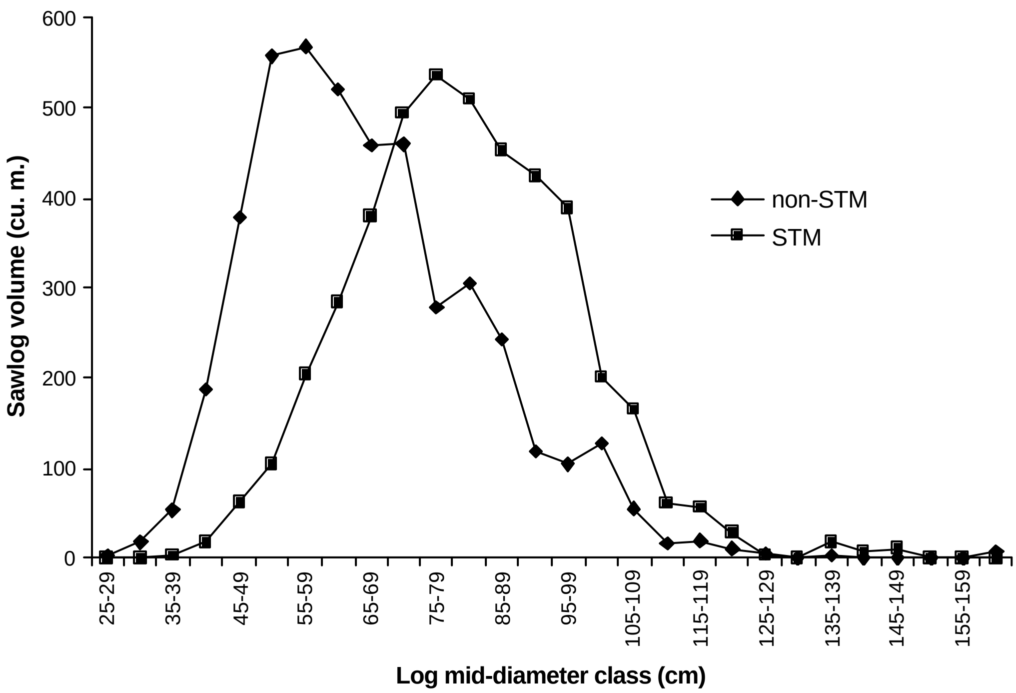


Fig. 3.4. Diameter profiles for myrtle sawlog volume from STM and non-STM logging on public land in Tasmania, 1995/96 to 1999/2000. Data from Forestry Tasmania sales records.

3.4. The nature and future of STM logging

Silvicultural prescriptions for selective logging of rainforest (Forestry Tasmania 1998) are based on research trials carried out in the 1970s and 1980s. The trials demonstrated that myrtle forest on fertile sites can be readily regenerated after logging (Fig. 3.5). Myrtle seedtrees are left standing at an even spacing and non-sawlog trees (myrtle and other species) are retained wherever possible to provide seed and shelter for regeneration. All patches of existing regeneration and regrowth are also retained, as they represent many valuable years of seedling establishment and growth.

STM logging for myrtle is thus a relatively low-impact operation aimed at recovering sawlogs and regenerating rainforest. Nevertheless, selective rainforest logging also generates pulpwood in the form of headlogs in sawlog trees and ‘duds’, i.e. myrtles which look like sawlog trees when standing but which are found when felled to have excessive levels of internal decay. In silvicultural trials on fertile sites in the 1980s, pulpwood was deliberately harvested to increase the overall yield of forest produce, and an average of 3.3 tonnes of myrtle pulpwood were produced per cubic metre of sawlog. In recent years, STM logging has been more selective and now generates about 2.3 tonnes per cubic metre of sawlog, or about 1.1 tonnes of myrtle pulpwood for every cubic metre of total sawmill input (sawlog plus outspec).

Non-STM logging over the past five years yielded 4500 m^3 of myrtle sawlog, compared with 4409 m^3 from selective logging. Analysis of the non-STM sources (Table 3.1) shows that much of the myrtle arose from clearing of previously cut-over rainforest and mixed eucalypt forest for plantation development. Conversion of native forest to plantation increased several years ago in Tasmania as part of the RFA plan to rapidly expand the State’s plantation estate and replace the wood resource represented by expanded conservation reserves. As plantation land targets are met in coming years, this source of non-STM myrtle sawlog will become insignificant. Almost all the remaining non-STM volume came from mature mixed eucalypt forest which was regenerated to native forest after logging. Forestry Tasmania planners expect that the area of mature eucalypt forest with a myrtle-rich understorey which remains available for logging will decline substantially in coming years.

Table 3.1. Myrtle sawlog from non-STM operations on public land in Tasmania, 1995/96 to 1999/2000. Data from Forestry Tasmania sales records, not adjusted for small rounding errors.

	Sawlog volume (cu. m.)		
	Log mid-diameter class (cm)		
Type of operation	**<75**	**≥75**	**Total**
Plantation development	1564	488	2053
Native forest logging/regeneration	1400	478	1878
Plantation + logging/regeneration*	57	25	82
Other**	182	305	487
Total	3204	1296	4500

*Coupes logged and subsequently divided into plantation and native forest regeneration.
**Almost entirely from clearing of a mine site near Savage River in 1999/2000.

In the short term, non-STM sources will continue to supply a substantial but unpredictable volume of myrtle sawlog to the sawmilling industry. The DRM-rich component of this supply will come from the very limited areas of cut-over rainforest being converted to plantation on the most fertile sites. In contrast, much of the mature eucalypt forest which remains available for logging is on lower-fertility sites and is unlikely to yield DRM. Thus the only continuing supply of DRM-rich sawlog in future will be from selective logging of mature rainforest in STM coupes on fertile sites. It is this supply which the present review considers in detail.

Fig. 3.5 This rainforest stand south of the Arthur River was harvested to an overstorey retention prescription where at least 30 healthy trees were retained per ha. Additional mechanical disturbance was used, above that resulting from harvesting, so that at least 50% of the area had a mineral earth seedbed for new regeneration.

4. Locating the couped DRM resource

4.1 Forest typing by GIS

Over the years, Forestry Tasmania has invested considerable effort in defining and classifying rainforest on aerial photographs (Hickey *et al.* 1993). Photo-interpretation (P.I.) maps of vegetation types now cover the whole State and include all rainforest patches down to 3 ha in extent. However, classifying rainforest by height and vegetation sub-type from aerial photographs has proved to be very difficult, and rainforest is now broadly typed as either

M+ Usually taller than 25 m, with a sparse understorey which often includes manferns (*Dicksonia antarctica*), usually growing on more fertile sites; or

M- From 8 m to usually less than 25 m, with a dense understorey which mingles with The canopy trees resulting in a fine-textured appearance on aerial photographs, usually growing on sites of low to moderate fertility.

We have based the DRM resource review on P.I. types which include M+ or MR (myrtle regrowth, but excluding 'MR' associated with 'M-' type).[1] The map opposite (Fig. 4.1) shows all the GIS polygons mapped by Forestry Tasmania which include the selected P.I. types and which are at least 1 ha. The mapping comprises 294 different P.I. types (Appendix 2) and covers 200 771 ha in total. For simplicity's sake the 294 types are classed in this report as

OK largely undisturbed mature M+
E largely undisturbed mature eucalypt with M+ understorey (no MR)
MR largely undisturbed mature M+ with MR, or 'pure' MR
FCD fire-damaged, cut-over or dead and dying M+ forest or eucalypt over M+

A breakdown of the P.I. type data by scale and date of photography is given below (Table 4.1). Although the P.I. type data set was current in April 2001, more than half the selected area was typed from photographs taken before 1986. Since then, a considerable area of M+ forest on private land has been cleared for plantation, but the private land P.I. typing has not been updated by Forestry Tasmania (see also discussion of tenure, below).

Table 4.1. P.I. type data used in the DRM resource review.

Photo scale	Photo year	No. of polygons	Area (ha)
1:10000	1994	2	48
1:15000	1977	40	909
	1979	1005	19298
1:20000	1977	79	2113
	1978	42	2579
	1980	240	10388
	1981	19	459
	1984	1060	54942
	1985	299	20219
	1986	361	12340
	1988	272	13931
	1989	339	13552
	1990	87	1559
	1991	148	3087
	1992	119	3471
	1993	195	5129
	1998	273	16130
	1999	24	531
1:42000	1984	9	738
	1985	1	192
	1986	65	4323
	1988	120	8279
	1989	66	6048
(uncertain)		7	506
Total		4872	200771

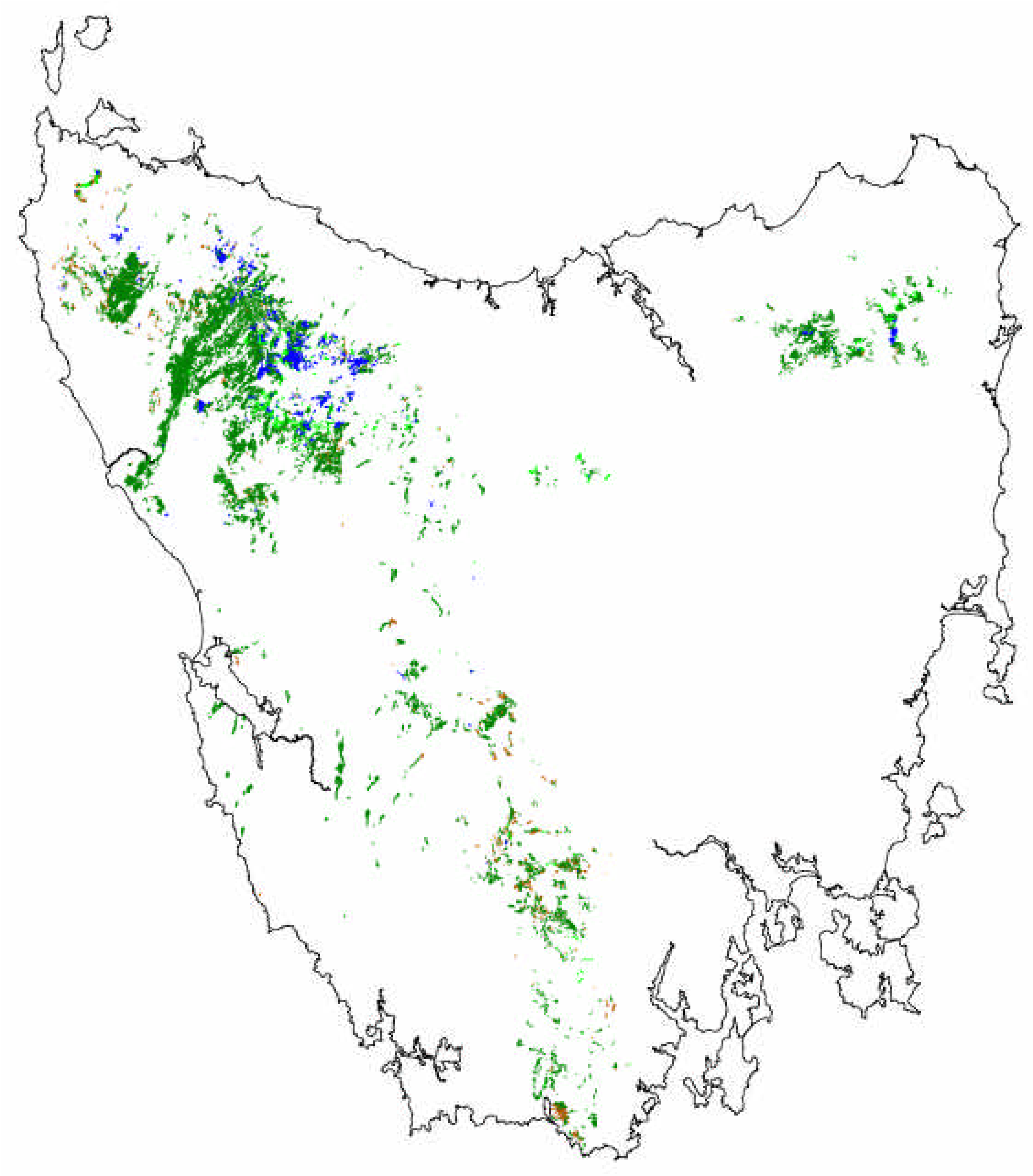


Fig. 4.1. Distribution of OK (dark green), E (brown), MR (light green) and FCD (blue) P.I. types.

[1] The evidence that M-types exclude high-quality myrtle forest can be found in Hickey et al (1993), where the earlier P.I. types included in M- are listed, and in Walker & Candy (1983), which reviews ground-truthing of the earlier P.I. types.

4.2. Geology by GIS

We also used GIS to define the distribution of igneous bedrock in Tasmania (excluding King Island and the Furneaux Group). Figure 4.2 shows the distribution of **Tb** (Tertiary basalt) and **Oi** (other igneous) according to a spatial data set provided by Mineral Resources Tasmania in late 1998. Geology polygons less than 1 ha were deleted from the data set. Table 4.2 describes each of the selected rock types and gives the area as shown in Fig. 4.2.

Table 4.2. Igneous rock types for the DRM resource review.

Code	Class	Area (ha)	Description
Cba	Oi	2070	Cambrian; boninitic lavas
Cbb	Oi	478	Cambrian; low-Ti tholeiitic and boninitic lavas
Cbt	Oi	2168	Cambrian; low-Ti tholeiitic lavas
Cbtg	Oi	349	Cambrian; gabbroic rocks associated with low-Ti lavas
Ccb	Oi	82	Cambrian; basalt
Cd	Oi	11716	Cambrian; dominantly Middle Cambrian sedimentary and volcanic sequences
Cda	Oi	7389	Cambrian; dominantly andesitic volcanics and intrusives
Cdb	Oi	3725	Cambrian; dominantly shoshonitic, basaltic to andesitic volcanics
Cdl	Oi	203	Cambrian; dolerite of probable Cambrian age
Cdtl	Oi	1440	Cambrian; felsic lavas within Tyndall Group
Cdv	Oi	26098	Cambrian; dominantly felsic to intermediate volcanic rocks
Cdvt	Oi	12927	Cambrian; upper, dominantly volcanoclastic sequences of Tyndall Group
Cg	Oi	878	Cambrian; coarse-grained basic rocks
Cgr	Oi	4589	Cambrian; granite
Cqf	Oi	15685	Cambrian; quartz-feldspar porphyry - dominantly intrusive
Ct	Oi	425	Cambrian; tonalite and associated rocks
Cwb	Oi	4992	Cambrian; basalt
Cwmb	Oi	4105	Cambrian; basalt of the Mainwaring River area
COb	Oi	30	Cambrian-Ordovician; vesicular, chlorite-carbonate-altered basalt
COd	Oi	62	Cambrian-Ordovician; sills of subophitic dolerite
Dd	Oi	969	Devonian; dolerite dykes
Dg	Oi	748	Devonian; undifferentiated granitic rocks
Dga	Oi	81623	Devonian; undifferentiated alkali-feldspar granite/granite/adamellite
Dgaa	Oi	85137	Devonian; dominantly adamellite/granite and associated dykes
Dgaas	Oi	13608	Devonian; dominantly adamellite/granite (S-type)
Dgaf	Oi	9467	Devonian; alkali-feldspar granite
Dgafs	Oi	19484	Devonian; dominantly alkaili-feldspar granite (S-type)
Dgas	Oi	22266	Devonian; undifferentiated alkali-feldspar granite/granite/adamellite (S-type)
Dgd	Oi	171	Devonian; dominantly diorite
Dgn	Oi	30935	Devonian; dominantly granodiorite / adamellite
Dgr	Oi	66502	Devonian; dominantly granodiorite
DI	Oi	19	Devonian; lamprophyre dykes and bodies
Dp	Oi	8428	Devonian; acid pyroclastics
Jb	Oi	676	Jurassic; basalt with minor mudstone
Jd	Oi	1449291	Jurassic; dolerite
Ka	Oi	37	Cretaceous; appinite
Ks	Oi	345	Cretaceous; syenite
Ld	Oi	2379	Precambrian; mafic and felsic dykes
Lg	Oi	8265	Precambrian; granite (Bass Strait only)
Lob	Oi	97	Precambrian; basalt
Lsb	Oi	12977	Precambrian; tholeiitic basalt
Lvb	Oi	713	Precambrian; tholeiitic basalts
Tb	Tb	403856	Tertiary; basalt

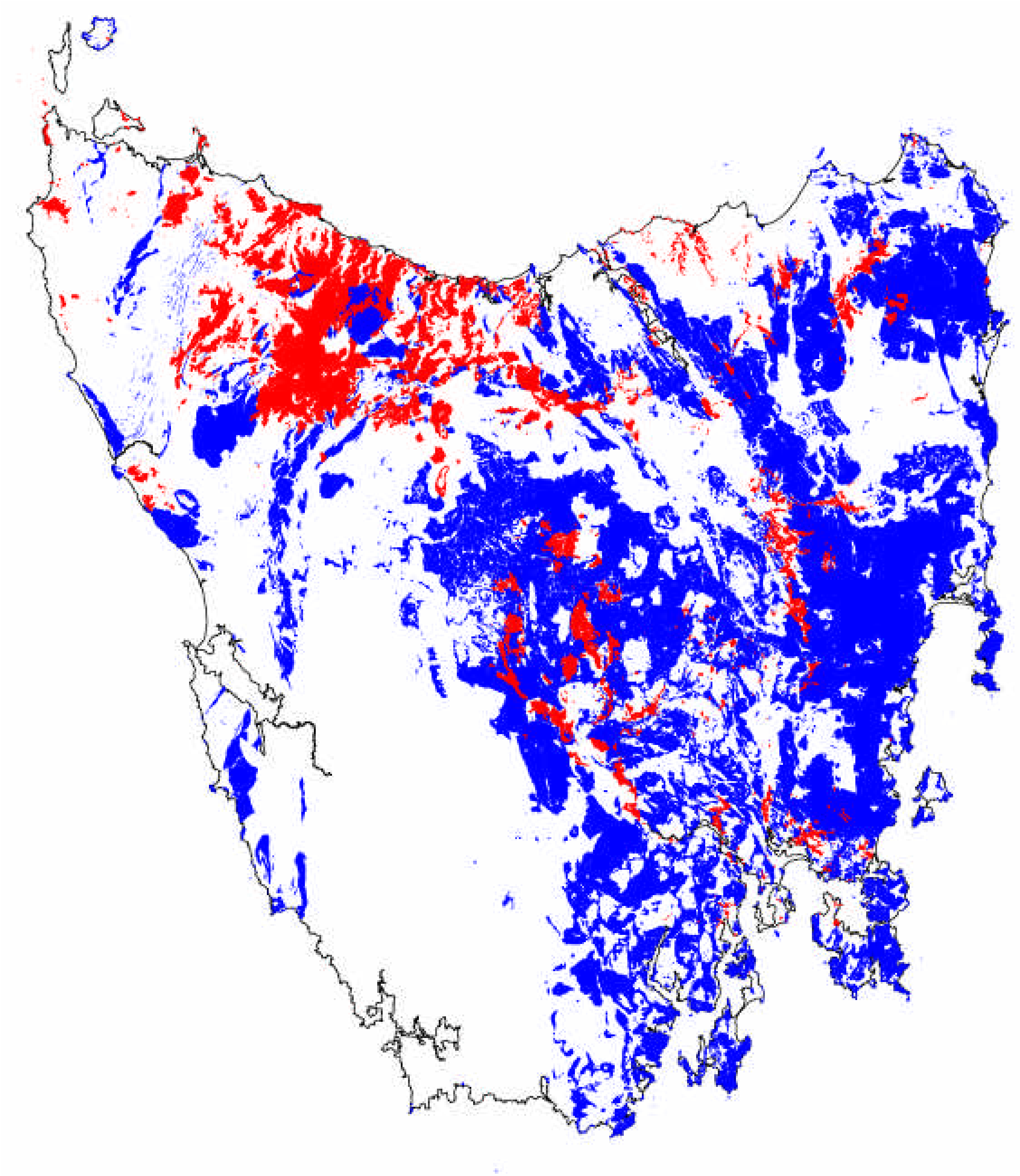


Fig. 4.2. Distribution of Tertiary basalt (red) and other igneous bedrocks (blue).

4.3. DRM-rich forest and its tenure

The map opposite (Fig. 4.3) shows the distribution of DRM-rich forest as we define it: forest where M+ and MR types are growing over igneous bedrock. Ignoring GIS polygons less than 1 ha, the total area of this forest in Tasmania is 76 242 ha. Table 4.3 breaks down this area by current tenure, geology and P.I. class. (Note that the private land category is out of date; see discussion of P.I. data, above.)

Table 4.3. Classification of DRM-rich forest by tenure, geology and P.I. class. Totals have not been adjusted for small rounding errors.

	Area (ha)								
Tenure	**Tb OK**	**E**	**MR**	**FCD**	**Oi OK**	**E**	**MR**	**FCD**	**Total**
Private	5052	371	2101	5767	723	171	337	234	14755
Public									
State forest	15914	384	1792	2352	11857	1180	716	749	34943
Reserve	6991	116	276	945	16175	889	466	623	26481
HEC*	1	0	0	0	10	0	0	0	11
Lake**	0	0	0	0	6	0	0	0	6
Unallocated	30	0	3	0	7	0	7	0	47
Total public	22937	500	2071	3297	28054	2068	1189	1372	61488
Grand total	27989	871	4172	9064	28776	2239	1526	1606	76242

*Land vested in the Hydro-Electric Commission.
**Forest flooded since P.I. typing.

Just over two-fifths of the DRM-rich forest on public land (26 481 out of 61 488 ha) is formally reserved. Appendix 3 shows how this forest is distributed through 59 public land reserves. Of the 34 943 ha in State forest, 12 820 ha (37%) is outside planned coupes and is classed as shown below (Table 4.4). Together with the formally reserved land, these informally reserved patches of State forest raise the area of DRM-rich forest on public land which is not available for logging to 39 301 ha, or 64% of the public land total.

Table 4.4. Classification of DRM-rich forest outside planned coupes by geology and P.I. class. Totals have not been adjusted for small rounding errors.

	Area (ha)								
Class	**Tb OK**	**E**	**MR**	**FCD**	**Oi OK**	**E**	**MR**	**FCD**	**Total**
Inaccessible	5	0	0	0	191	3	10	0	210
MDC*	1329	24	97	147	1573	118	153	60	3501
Non-commercial	133	0	170	66	238	17	84	2	711
Not loggable	109	0	4	2	339	9	24	44	530
Rainforest**	670	18	490	247	1474	7	50	71	3027
Regen problems***	58	0	62	9	60	26	17	0	233
Streamside reserve	279	1	41	34	883	20	23	44	1325
Too steep	681	10	50	108	1766	34	126	216	2991
Uneconomic	39	2	0	0	138	3	9	37	228
Total	3303	56	914	613	6728	237	496	474	12820

*Management Decision Classification; excluded for special management of non-production values.
**Small patches of rainforest adjoining production coupes and some larger blocks set aside for other reasons.
***Not loggable because regeneration would be difficult.

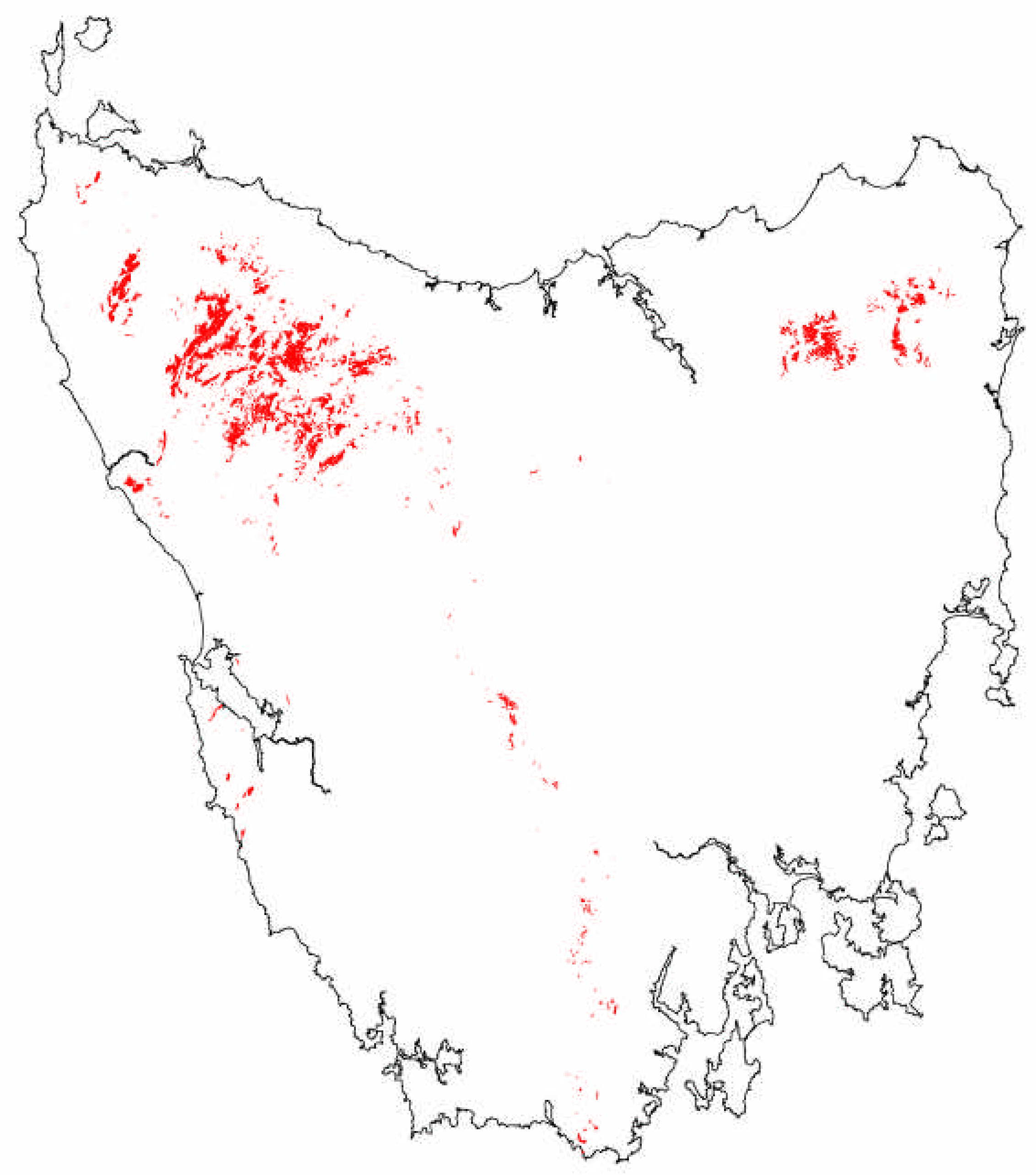


Fig. 4.3. Distribution of DRM-rich forest (red).

4.4. DRM-rich forest in production forest coupes

Of the DRM-rich forest within State forest coupes, about 250 ha consists of tiny fragments less than 1 ha in extent. Ignoring these fragments, the gross area of DRM-rich forest within production coupes in State forest is 21 869 ha. Table 4.5 shows how this couped area is distributed among Tasmania's five Forest Districts. For the purposes of the DRM resource review we regard 10 ha as the lower limit for practical management of DRM-rich forest. (See section 9.2. These areas may yield small volumes of myrtle sawlog during non-STM harvests.) Applying this rule, the total within-coupe area of DRM-rich forest drops 5.6% to 20 652 ha (Table 4.5). This area is distributed as shown in Fig. 4.4. In the following section we progressively discount this figure to find the coupes which are both available and potentially suitable for selective logging during the RFA period.

Table 4.5. Summary of DRM-rich forest area within production forest coupes.

	Gross area		**Coupes with $\geq$10 ha of DRM-rich forest**	
District	**No. of coupes**	**DRM-rich forest (ha)**	**No. of coupes**	**DRM-rich forest (ha)**
Bass	219	3149	101	2673
Derwent	62	608	23	477
Huon	34	350	11	265
Mersey	21	192	7	145
Murchison	397	17570	289	17092
Total	733	21869	431	20652

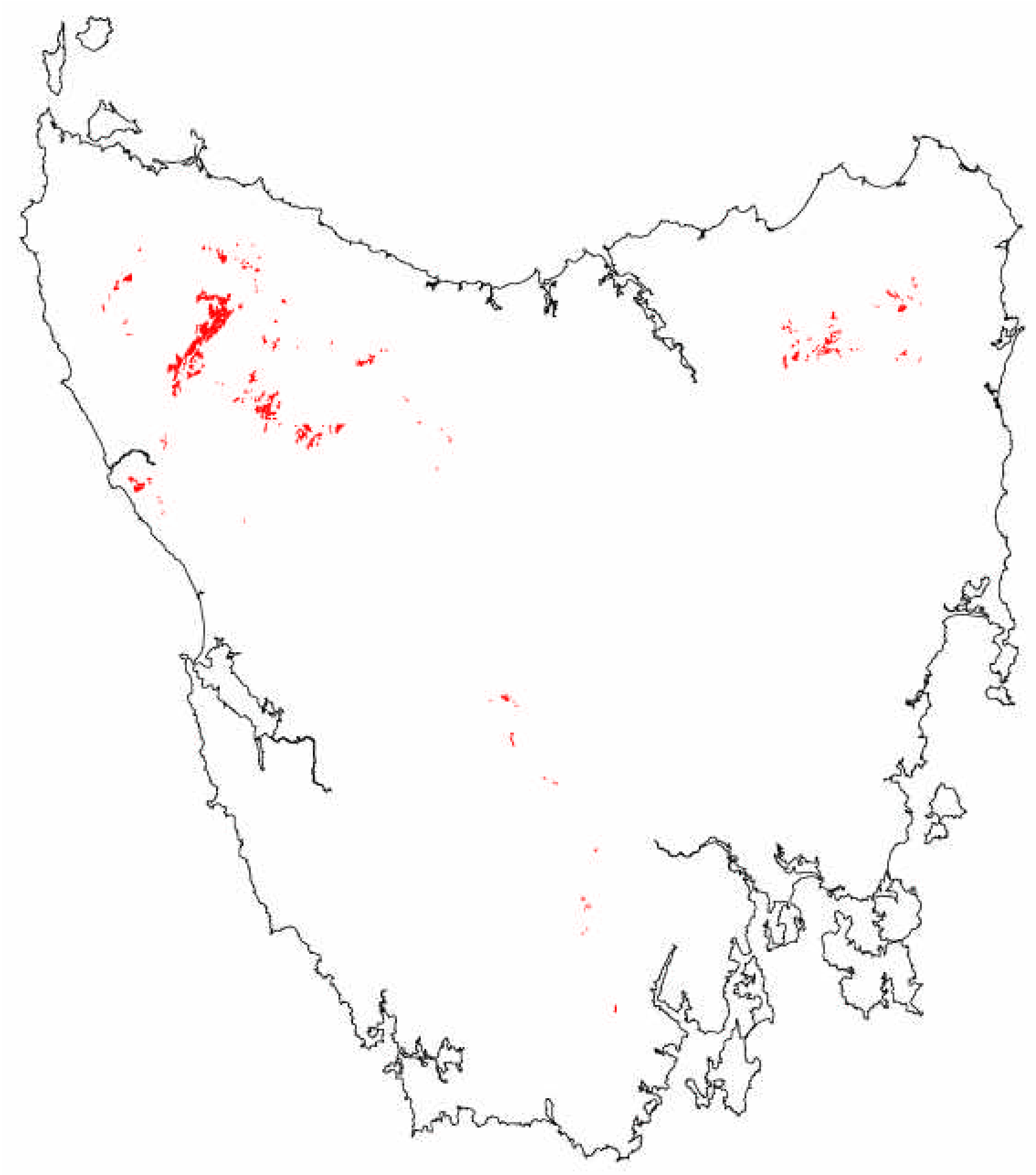


Fig. 4.4. Distribution of DRM-rich forest (red) within State forest coupes which contain at least 10 ha of DRM-rich forest.

5. Defining the couped DRM resource for the RFA period

5.1. Not all coupes are available

In the previous section we identified 20 652 ha of DRM-rich forest in 431 production forest coupes in State forest. To be available and potentially suitable for selective logging during the RFA period, a coupe containing DRM-rich forest has to meet three criteria:

1) the coupe is not being managed for eucalypt production or plantation forestry,
2) the coupe contains at least 10 ha of potentially loggable P.I. types, and
3) the topography and spatial distribution of potentially loggable P.I. types within the coupe allow for practical logging.

In what follows we discuss each of these criteria and its consequences for estimating the DRM resource.

5.2. Eucalypt production and plantation forestry

Using information current in April 2001, we excluded 132 of the 431 coupes because Forestry Tasmania planners have earmarked the coupes for plantation development or extensive forestry (harvest and regeneration of native eucalypt forest). When selecting native forest coupes for conversion to plantation, planners have followed Forestry Tasmania guidelines which require undisturbed rainforest patches over 10 ha to be retained wherever possible as informal reserves. (An example of an informal reserve is *ca.* 20 ha of M+ forest on Tertiary basalt in the recently logged coupe DP021C, in Murchison Forest District.) Rainforest patches within extensive forestry coupes will either be converted to eucalypt (when small) or retained as informal reserves (when large). Table 5.1 gives a breakdown of the 3244 ha of DRM-rich forest in the 132 excluded coupes. The potential significance of the DRM resource excluded by this discount is evaluated in section 9.2 (below).

Table 5.1. Classification of DRM-rich forest in coupes not available for selective logging. **OK** totals are misleading in cases where ground inspection has found evidence of earlier logging in the coupes concerned. Totals have not been adjusted for small rounding errors.

	Area (ha)									
	Tb				Oi					
District	**OK**	**E**	**MR**	**FCD**	**OK**	**E**	**MR**	**FCD**	**Total**	**No. of coupes**
Bass	0	0	0	0	1281	54	51	0	1386	64
Derwent	0	0	0	0	70	309	0	0	380	18
Huon	0	0	0	0	0	0	0	0	0	0
Mersey	55	27	0	6	27	0	0	0	115	6
Murchison	264	157	117	364	186	159	3	114	1363	44
Grand total	319	183	117	369	1565	523	54	113	3244	132

5.3. Area of potentially loggable P.I. types

We excluded another 28 coupes because they contain less than 10 ha of potentially loggable P.I. types (**OK** and **E**) , which we regard as the minimum for practical logging. ‘Non-loggable’ DRM-rich forest contains myrtle regrowth or is P.I.-typed as fire-damaged, cut-over or dead and dying. These types are left unlogged to conserve myrtle regeneration for future logging. Although **MR** types such as M+.MR2 can be logged if care is taken to avoid damage to regrowth, the difficulty of such logging increases considerably with **MR** proportion. We take the position that a coupe rich in **MR** is only worth logging if it contains at least 10 ha of **OK** and **E** types as well. (The one exception is BO206A, which has been operationally combined with an adjoining coupe, BO217A.) Table 5.2 summarises type classes for the 1071 ha of DRM-rich forest in the 28 excluded coupes.

Table 5.2. Classification of DRM-rich forest in coupes with less than 10 ha of loggable P.I. types. Totals have not been adjusted for small rounding errors.

	Area (ha)									
	Tb				**Oi**					**No. of**
District	**OK**	**E**	**MR**	**FCD**	**OK**	**E**	**MR**	**FCD**	**Total**	**coupes**
Bass	0	0	0	0	0	0	17	0	17	1
Derwent	0	0	0	0	0	0	0	0	0	0
Huon	0	0	0	0	0	0	0	0	0	0
Mersey	0	0	0	0	0	0	0	0	0	0
Murchison	45	0	216	683	28	0	26	56	1054	27
Total	45	0	216	683	28	0	43	56	1071	28

5.4. Topography and spatial distribution

We looked at the distribution of DRM-rich forest within coupes and excluded another 32 coupes, either because the 10 ha or more of **OK** or **E** types within the coupes are in small, scattered patches or restricted to coupe edges (typically close to streams), because the coupe is surrounded by clearfall eucalypt coupes or because the ground is too steep for selective logging. (Cable logging of steep ground is only feasible for clearfelling; selective cable logging would unacceptably damage retained trees.) Table 5.3 gives a breakdown of the 877 ha of DRM-rich forest in the 32 excluded coupes.

Table 5.3. Classification of DRM-rich forest in coupes unsuitable for topographic or spatial reasons. Totals have not been adjusted for small rounding errors.

	Area (ha)									
	Tb				**Oi**					**No. of**
District	**OK**	**E**	**MR**	**FCD**	**OK**	**E**	**MR**	**FCD**	**Total**	**coupes**
Bass	0	0	0	0	571	26	15	0	612	17
Derwent	0	0	0	0	57	40	0	0	98	5
Huon	0	0	0	0	99	27	0	0	126	7
Mersey	0	0	0	0	0	0	0	0	0	0
Murchison	0	0	0	0	38	3	0	0	41	3
Total	0	0	0	0	766	96	15	0	877	32

In summary, we examined the list of 431 production forest coupes containing at least 10 ha of DRM-rich forest. We excluded 192 of the coupes (25% of the DRM-rich forest area) because for management or practical reasons the coupes are either unavailable or unsuitable for selective logging during the RFA period. The 192 excluded coupes are listed in Appendix 4. The exclusions and their significance are further discussed in section 9.

6. Evaluating DRM-rich coupes

As described in preceding sections, we identified a ‘short list’ of 239 production forest coupes in State forest which are both available and potentially suitable for selective logging. As shown in Table 6.1, more than 90% of the DRM-rich forest in these coupes is in Murchison Forest District in northwest Tasmania (see also Fig. 4.4), and about one-third of the available and potentially suitable DRM-rich forest is within the Savage River Pipeline Corridor.

Table 6.1. Classification of DRM-rich forest in short-listed coupes. Totals have not been adjusted for small rounding errors.

	Area (ha)									
District	**Tb OK**	**E**	**MR**	**FCD**	**Oi OK**	**E**	**MR**	**FCD**	**Total**	**No. of coupes**
Bass	194	0	28	0	404	0	20	12	658	19
Derwent	0	0	0	0	0	0	0	0	0	0
Huon	0	0	0	0	48	92	0	0	140	4
Mersey	29	0	0	0	0	0	0	0	29	1
Murchison										
outside Corridor	6433	72	445	569	1276	80	46	76	8993	153
inside Corridor	5375	56	30	0	176	0	0	0	5637	62
Total	12030	128	503	569	1903	171	66	88	15457	239

The next step in reviewing the DRM resource was a coupe-by-coupe evaluation of the DRM-rich forest in the 177 coupes outside the Corridor. An exhaustive approach of this kind is justified because the total forest area involved is not large, and because RFA project funding has made possible a close study of a particularly valuable timber resource.

In Murchison District, evaluating suitability amounted to a ground-truthing of the GIS selection process. We also checked to see whether mature myrtle stocking was high enough to allow sufficient live seedtrees to be retained for subsequent regeneration. The silvicultural prescriptions for selective logging of M+ forest (Forestry Tasmania 1998) specify that at least 15 stems per hectare in the retained overstorey be healthy, evenly spaced myrtles. As noted below, we found that canopy death (from myrtle wilt disease) has greatly reduced the stocking of mature myrtle in many areas. Low-stocked coupes cannot be selectively logged. Although small volumes of myrtle sawlog could be harvested from such coupes, the logging would not leave enough seedtrees for natural regeneration of myrtle.

Coupe evaluation was based on a set of decision rules (Table 6.2), and inspections were carried out on the ground where feasible. Coupes in more remote areas were inspected from a helicopter or fixed-wing aircraft. A number of the coupes, especially among those inspected by air, appeared to be only marginally suitable. For the purposes of the resource review, these coupes are assumed to be suitable for selective logging. Evaluation of coupes in Forest Districts other than Murchison was largely based on advice from local Forestry Tasmania planners.

A minor complication was that some of the short-listed coupes were logged during the resource review, or had been logged since the last P.I. typing update. We treat these coupes as unsuitable. In other words, our final DRM resource estimates are based on coupes available and suitable from mid-2001, i.e. for the last 16 years of the RFA period.

The results of the coupe evaluation are summarised in Tables 6.3 and 6.4 with coupe details presented in Appendices 4 and 5. Only 76 of the 177 non-Corridor coupes were found to be suitable for selective logging. These 76 coupes are the ‘final set’ discussed in the remaining sections of this report. The most important reason for rejection was low mature stocking, typically because a high proportion of canopy trees had died from myrtle wilt in recent years, particularly in northwest Tasmania. Further information on the incidence and spread of myrtle wilt can be found in Appendix 7.

Table 6.2. Decision rules for coupe evaluation. 'Callidendrous', 'thamnic' and 'implicate' are the three broad structural classes in Tasmanian rainforest (Jarman, Kantvilas & Brown 1991).

1. Forest type of DRM-rich patches within coupe

   Myrtle/sassafras/manfern ± small amounts of leatherwood or horizontal…..……...………………..go to 2
   (callidendrous or tall thamnic rainforest; M+ forest)
   Myrtle/sassafras/leatherwood/horizontal…………………………………………………………...REJECT
   (short thamnic or implicate rainforest; M- forest)

2. Mature tree stocking of DRM-rich patches

   High enough to allow selective logging, keeping sufficient healthy seedtrees………………………go to 3
   (often: old, even-aged stand)
   Low, but with high stocking of younger myrtle……………………………………………..…….go to 3
   (often: lightly logged for myrtle in the past)
   Low, with low stocking of younger myrtle…..……………………..………….………………...REJECT
   (often: recent, massive dieback from myrtle wilt)

3. Mature tree patchiness

   Well-stocked patches cover more than 10 ha and aren't widely scattered…..………….…...…...…...go to 4
   Only small or widely scattered patches of suitable mature trees ……………….…..…..…..……..REJECT

4. Mature tree quality (by ground inspection only)

   Reasonable stocking of good-form, relatively defect-free stems……………….……………SUITABLE
   Very few good-form, relatively defect-free stems…………………………………...………......REJECT

Table 6.3. Coupe evaluation results by Forest District, excluding the Pipeline Corridor. 'Area' is area of DRM-rich forest.

	Final set		**Unsuitable**		**Total**	
District	**Coupes**	**Area (ha)**	**Coupes**	**Area (ha)**	**Coupes**	**Area (ha)**
Bass	2	93	17	565	19	658
Huon	-	-	4	140	4	140
Mersey	-	-	1	29	1	29
Murchison	74	4565	79	4428	153	8993
Total	76	4658	101	5162	177	9820

Table 6.4. Reasons for unsuitability of short-listed coupes for selective logging.

	No. of coupes
Recently logged	8
Wrong forest type	6
Mostly wrong forest type and mature stocking too low	23
Good mature stocking too low	53
Good mature too patchy	10
Research control area	1
Total	101

7. Estimating DRM recovery

7.1. Method

For a number of reasons, forest assessors have been unable to make reliable estimates of myrtle sawlog volumes in Tasmanian rainforest (Appendix 6). We have therefore based our estimates of recoverable myrtle sawlog volume in the final set of coupes (see previous section) on actual logging yields from similar coupes.

First, we estimated the loggable area of DRM-rich forest in each unlogged coupe by drawing a likely harvest boundary (using GIS tools) on the digital version of a recent aerial photograph. The boundary usually enclosed an area smaller than that defined by P.I. type and geology, because we excluded steep terrain, the neighbourhoods of major streams, small patches of non-M+ vegetation and patches of trees recently dead from myrtle wilt. Some area was gained, however, when patches of apparently good-quality M+ forest just outside the GIS-based geological boundary were included. On average, loggable area was not very different from the GIS-based estimate of DRM-rich forest area, excluding **FCD** types. Appendix 8 illustrates loggable area estimation for a typical coupe.

The second step in estimating recovery was to match each unlogged coupe to an already logged one. When the resource review began it was our hope that a substantial number of DRM-rich forest coupes could be selectively logged in the 1998/99, 1999/2000 and 2000/01 summers. This sample of coupes was to contain a variety of forest ages and structures and would be geographically well-dispersed.

Unfortunately, only four coupes were sampled during the review, all from the same general area in northwest Tasmania. It was particularly disappointing that road access problems prevented logging of sample coupes near the Savage River Pipeline Road, since Pipeline Road coupes (i.e., outside the Pipeline Corridor) make up two-thirds of the final set. Of the four harvests during the review, two (BO109B and BO201B) had been started earlier and were completed in 1999/2000, one (WH017B) was stopped at the half-way point in 1999/2000 when the contractor judged the remaining half of the coupe to be uneconomic to log, and the fourth (BO206A/217A) began in mid-summer 2000/01 and will be finished in the 2001/02 summer.

In total, seven previously unlogged coupes have been selectively logged for myrtle in recent years (Table 7.1). For each of the seven we estimated the area actually cut-over from a ground survey of logging tracks or from post-logging aerial photographs. We then calculated the recovery per hectare of category 4 and utility myrtle sawlogs, myrtle outspec logs and myrtle pulpwood.

Table 7.1 also presents recovery data from silvicultural trials close to the Savage River Pipeline Road and north of the Pipeline Corridor. Recoveries from the trials of sawlog $\geq$75 cm mid-diameter (current category 4) were comparable to those from the better coupes of the last few years, but recoveries of smaller sawlogs (current utility) were much higher. The difference is largely due to the more selective nature of recent logging. Loggers now focus on the larger stems richer in DRM, and smaller stems that were taken in the 1980s are now left to provide additional seed and shelter for regeneration.

Using the limited data available we have classed DRM-rich forest coupes as shown in Table 7.2 (p. 26). We recognise that the logged coupe sample is small and that it does not adequately represent the full range of elevations, soils and forest structures in the final set. However, we are confident that the ‘good mature' class sets a credible upper bound. Table 7.1 indicates that selective logging of DRM-rich forest is unlikely to yield more than 15 m^3/ha of category 4 myrtle sawlog.

Table 7.1. Myrtle recoveries from recent STM logging and 1980s trials. Figures are m^3/ha for category 4 sawlog (**c4**), utility sawlog (**U**) and outspec (**O**), and t/ha for pulpwood (**Pwd**). In all cases ‘category 4’ and ‘utility’ refer to myrtle sawlogs with mid-diameters $\geq$75 and <75 cm, respectively. Sawlog totals have not been adjusted for small rounding errors.

		Volumes (m^3/ha; Pwd t/ha)								
		Sawlog			Other					
Coupe	**Seasons**	**c4**	**U**	**c4+U**	**O**	**Pwd**	**Location**	**Approx. elev. (m)**	**Geology**	**Forest**
STM logging:										
BO109B*	1995/96, 1996/97 1997/98, 1999/00	13	4	17	12	-	4.5 km SW of Cradle Mountain turnoff on Murchison Highway, NW Tasmania	640	Tb	Dense, even-aged mature
BO201A	1995/96, 1996/97	12	5	17	3	-	8.5 km E of Cradle Mountain turnoff on Murchison Highway, NW Tasmania	770	Tb	Dense, even-aged mature
BO201B	1997/98 , 1998/99, 1999/00	13	5	18	21	35	8.5 km E of Cradle Mountain turnoff on Murchison Highway, NW Tasmania	770	Tb	Dense, even-aged mature
BO206A/217A	2000/01 (unfinished)	4	1	5	6	60	6 km E of Cradle Mountain turnoff on Murchison Highway, NW Tasmania	720	Oi	Mainly dense, even-aged older regrowth
NW006C/D	1997/98	0	1	1	0	0	5 km W of Wilson Road turnoff on Heemskirk Road, W Tasmania	120	Tb	Moderately stocked, poor-form mature
OO068A	1995/96	2	4	6	3	na	3 km W of Viney Road turnoff on Murchison Highway, NW Tasmania	550	Tb	Moderately stocked mature patches of older regrowth
WH017B**	1999/00	2	1	4	7	11	6 km S of Waratah, NW Tasmania	620	Tb	Moderately stocked mature but many large gaps from wilt
Silvicultural trials:*										
MB069B	1981/82	?	?	61	2	44	Just W of Pipeline Road, NW Tasmania	460	Tb	Well-stocked, multi-aged mature
RD018B	1985/86	10	50	60	3	234	3.5 km W of Pipeline Road, NW Tasmania	410	Tb	Mainly dense, even-aged older regrowth
RD023B (part)	1983/84	14	20	34	1	97	2 km W of Pipeline Road, NW Tasmania	430	Tb	Well-stocked, multi-aged mature
RD023B (part)	1984/85	17	10	27	1	159	2 km W of Pipeline Road, NW Tasmania	430	Tb	Well-stocked, multi-aged mature
RD025B	1982/83	15	26	41	0	157	2 km W of Pipeline Road, NW Tasmania	400	Tb	Well-stocked, multi-aged mature

*No pulpwood taken early in operation; later pulp recovery was 1.2 t **Pwd**/m^3 of **c4**+**U**+**O**.
**Only half of this coupe was tracked and logged, the contractor rejecting the other half as uneconomic to log. The area base for recovery is the whole coupe, not just the logged half.
***Some of the 1980s **c4** and **U** would be **O** under current specifications; 1980s **O** was ‘dry and defective’.

Table 7.2. Recovery classes for unlogged DRM-rich forest coupes. Abbreviations and units as in Table 7.1.

	Volumes (m^3/ha; Pwd t/ha)					
	Sawlog			Other		
Class	**c4**	**U**	**c4+U**	**O**	**P**	**Source**
Good mature	13	5	18	12	36	**c4**, **U**, **O** are average of BO109B, BO201A and BO201B; **P** is 1.1 x (**c4**+**U**+**O**)
Poor mature	6.5	2.5	9	6	18	Arbitrarily, half of 'good mature'
Regrowth-rich	3	2	5	4	30	Average of BO206A/217A and OO068A
Salvage	1	1	2.5	3.5	5.5	Average of NW006C/D and WH017B

We assigned the 76 coupes in the final set (see section 6, above) to the classes in Table 7.2 as follows:

Good mature: coupes well-stocked with mature trees.
Poor mature: the default class for coupes not clearly in any of the other three classes.
Regrowth-rich: coupes with a substantial proportion of **MR** types and coupes found to be regrowth-rich on inspection.
Salvage: coupes with small, well-stocked patches of mature trees in a poorly stocked surround; typically, coupes badly affected by myrtle wilt but with patches carrying adequate numbers of seedtrees.

Assignments are shown in Appendix 5, and Table 7.3 summarises the classification. The total estimated recoverable volumes in the 76 coupes are ca. 39 700 m^3 of category 4 sawlog and ca. 15 700 m^3 of utility sawlog; see section 8 for more details.

In response to recommendations of an external audit of the review, Appendix 10 estimates an approximate confidence interval around this resource estimate.

Table 7.3. Number of coupes in the final set by recovery class and Forest District.

District	Good mature	Poor mature	Salvage	Regrowth-rich	Total
Bass	-	1	-	1	2
Murchison	32	30	8	4	74
Total	32	31	8	5	76

7.2. Selective logging of other rainforest coupes

Recovery data are available for selective logging of three other rainforest coupes in Murchison Forest District. SU010E and SU014H (logged 1996/97) contain no DRM-rich forest. The per-hectare yields of category 4 and utility myrtle sawlog from these coupes were approximately 0.6 m^3, 1.5 m^3 and 0 m^3, 0.5 m^3 respectively. The third coupe, BO214A, was short-listed (see section 5) but rejected when myrtle stocking and quality were found in a ground inspection to be poor. Selective logging, principally for celery-top pine, began in BO214A in the 2001 summer. The category 4 and utility yields to date for myrtle have been approximately 0.6 and 0.2 m^3/ha, respectively. These results validate the decision, early in the resource review, to estimate myrtle sawlog yields only from good-quality DRM-rich forest. Other mature rainforest can be selectively logged, but the myrtle sawlog yields can be more than an order of magnitude smaller, and the likelihood of the sawlogs containing DRM is very much lower.

8. Costing the DRM harvest

8.1. Method

Clause 55a of the 1997 Tasmanian RFA requires that the State review the DRM resource in terms of its ‘economic accessibility’. The measure of ‘economic accessibility’ chosen for this review is ‘dollars per cubic metre at mill door’.

We used a simple protocol for estimating mill-door cost. The 76 coupes in the final set were divided into 27 clusters, each served by a separate road or road network which feeds into a major trunk road. We assume that if any coupes in a cluster are logged, all will be. This assumption represents a change from the costing procedure outlined in the *Overview of the Deep Red Myrtle Project* released earlier (Forestry Tasmania 1999). With up to 14 coupes in a single cluster, the number of possible logging options would be far too large for each to be independently costed, and as shown in Appendix 7 of the *Overview*, the differences in mill-door cost for options within a cluster would generally be small.

For each coupe in each cluster, we calculated total stumpage and logging cost payable by industry for the mix of myrtle logs (category 4 and utility sawlog, outspec logs) predicted as in section 7, above. A single on-truck cost per m^3 of log was used, in line with current industry practice. The logging cost covers equipment floating, tracking, sawlog tree falling, ‘dud’ falling, snigging, landing work and loading.

Roading cost was calculated from road plans devised for each cluster and from estimates of construction costs. New arterial roads within clusters were assumed to be class 4 road standard if longer than 1 km, otherwise all roading was assumed to be summer-use dirt tracks. It was assumed that the only costs incurred in using the Savage River Pipeline Road were a per-kilometre repair cost at the end of each logging season and a one-off cost for temporary crossings of the pipeline. It has not yet been decided whether logging roads used for one-off myrtle logging will be decommissioned and rehabilitated after use. We assume that decommissioning, if it occurs, is outside the scope of costing for access.

Cartage distance from each cluster was calculated from an approximate ‘midpoint’ on coupe roading within the cluster to the nearest appropriate sawmill. In the case of Murchison Forest District, which has two principal myrtle processors, the destination is a hypothetical sawmill which is the average distance to the two principal sawmills, weighted by current volume allocation. The cartage rate was assumed to be per tonne-km and is based on 1 m^3 of log weighing 1.1 tonnes.

Road toll (per m^3) payable to Forestry Tasmania was calculated as full toll where existing Forestry Tasmania roads are used to access the cluster, and as the half-rate ‘network toll’ where new roads are needed.

The sum of stumpage, logging, roading, cartage and road toll is mill-door cost. For commercial reasons, the component costs are not shown here but are made available as required to the external auditor reviewing this report (RFA clause 55b).

Note that the use of currently applicable costs in this review has the primary aim of determining relative mill-door costs for different components of the resource, and does not represent any express or implied basis on which logs may or will be supplied by Forestry Tasmania. Actual mill-door costs in future are matters for commercial contract negotiation.

8.2. Results

Table 8.1 lists the 27 clusters together with their estimated volumes and mill-door costs (coupe assignments to clusters are given in Appendix 5). ‘Economic accessibility’ varies by nearly a factor of two over the 27 clusters, from \$82 per M^3 of sawmill input to \$148 per M^3, and roughly half the total myrtle sawlog volume (category 4 plus utility) is in clusters whose mill-door cost is more than $100/m^3$. The clusters can be arranged by cumulative average cost into three groups as shown in Table 8.2.

Table 8.1. Mill-door costs for individual clusters of DRM-rich forest coupes in the final set. Volumes are total myrtle log volumes expected if all coupes in the cluster are logged; **c4** = category 4 sawlog, **U** = utility sawlog, **O** = outspec log. **Cost** is mill-door cost per m^3 of **c4**+**U**+**O**. The average cost for all 27 clusters, $103/m^3$, is weighted by total volume (**c4**+**U**+**O**).

Cluster	No. of coupes	Volumes (m^3) c4	U	O	Estimated mill-door cost ($/m^3$)
Cradle Link 1	1	159	106	212	82
Heemskirk 1	1	110	42	102	110
Moorina 1	1	90	60	120	136
Murchison 1	1	292	112	270	101
Murchison 2	4	410	210	598	100
Murchison 3	2	311	127	318	90
Murchison 4	1	351	135	324	130
Pipeline 0	1	130	50	120	148
Pipeline 1	9	4207	1635	3908	99
Pipeline 2	1	1144	440	1056	83
Pipeline 3	2	2405	925	2220	94
Pipeline 4	4	2457	945	2268	99
Pipeline 5	1	715	275	660	91
Pipeline 6	1	559	215	516	82
Pipeline 7	1	754	290	696	96
Pipeline 8	14	7638	2938	7050	111
Pipeline 9	3	1885	725	1740	100
Pipeline 10	4	5466	2102	5046	95
Pipeline 11	10	6877	2645	6348	109
Pipeline 12	1	306	118	282	93
Pipeline 13	1	429	165	396	117
Procters 1	3	1638	630	1512	123
Rattler 1	1	332	128	306	95
Que 1	3	380	225	600	91
Waratah 1	2	208	148	338	111
Waratah 2	2	219	219	766	143
Waratah 3	1	273	105	252	92
Total	76	39745	15715	38024	103

Table 8.2. Cost groupings of the clusters in Table 8.1.

Average cost	Cost range	Clusters	Total volumes (m^3) c4	U	O
<$85	$82 - $83	Cradle Link 1; Pipeline 2, 6	1862	761	1784
<$95	$82 - $109	above plus Murchison 1, 2, 3; Pipeline 1, 3, 4, 5, 7, 9, 10, 11, 12; Que 1; Rattler 1; Waratah 3	28932	11328	27296
<$105	$82 - $148	all clusters	39745	15715	38024

8.3. Sensitivities

Mill-door costs were calculated using a spreadsheet containing 28 adjustable, independent variables (volume, 12 variables; stumpage, 3; logging, 1; roading, 8; cartage, 1; destination, 1; road toll, 2). It would be impractical to test the sensitivity of mill-door cost for all 27 clusters to variation in each of the 28 adjustable values. Instead we focussed on the Pipeline Road clusters taken as a group, and examined the effects of a range of cost increases and of variation in volume estimates.

The results are shown in Tables 8.3 and 8.4. Average mill-door cost for the 14 clusters increases least rapidly with road toll and fastest with stumpage (Table 8.3). However, mill-door cost is far more sensitive to volume estimates than to component costs (Table 8.4). Even a doubling of stumpage does not increase mill-door cost as much as a 30% shortfall in the log volume delivered to the sawmill. The combined effects are considerable: a modest increase of 25% in roading, logging and carting costs together with a 25% drop in estimated volume results in a 54% jump in mill-door cost, from \$102 to \$157 per m^3 of logs delivered.

Table 8.3. Sensitivity of mill-door cost to separate increases in component costs. Cost figures show average mill-door cost of all log deliveries (category 4, utility and optional myrtle logs) from Pipeline coupes.

	Estimated mill-door cost (\$/m^3)				
Percent increase	**Increase in: Stumpage**	**Roading**	**Logging**	**Cartage**	**Road toll**
0	102	102	102	102	102
20	109	106	108	105	103
40	117	111	113	107	103
60	124	115	119	110	104
80	132	119	124	112	104
100	139	123	130	115	105

Table 8.4. Sensitivity of mill-door cost to variation in total estimated total log volume (category 4, utility and optional myrtle) for Pipeline coupes.

Percent of estimate	**Estimated mill-door cost (\$/m^3)**
50	204
60	170
70	146
80	128
90	113
100	102
110	93
120	85
130	78
140	73
150	68

9. Conclusion and discussion

9.1. An overview of the short-term DRM resource

How much deep red myrtle is available for supply to the furniture and craft industries from areas outside the Pipeline Corridor, and at what cost is it available?

There are 76 DRM-rich forest coupes in 27 coupe clusters which could be selectively logged for DRM during the remaining 16 years of the RFA period. If all 76 coupes were selectively logged, the total yield of category 4 myrtle sawlog (the log class most likely to contain DRM) would be ca. 39 700 m^3 and the estimated average mill-door cost would be about $100 per cubic metre of all log grades (category 4, utility and optional) (Table 8.1). The average yearly harvest would be ca. 2480 m^3. Another ca. 640 m^3/yr of category 4 myrtle sawlog currently arises from other logging operations around Tasmania (Table 3.1). Adding the two totals together gives 3120 m^3/yr, which is considerably less than the 4500 m^3/yr targeted in the RFA.

Furthermore, the predicted recovery from selective rainforest logging is almost certainly an overestimate, because continuing loss of mature overstorey to myrtle wilt (see Appendix 7) will render substantial areas of DRM-rich forest unsuitable for logging through lack of sufficient seedtrees.

The ca. 640 m^3/yr of category 4 myrtle arising from non-STM harvesting operations is also expected to decline as area targets for plantation conversion (including degraded rainforest sites) are met in the next few years. Most of the remaining 'non-selective' myrtle sawlog will come from understorey logging of eucalypt forest on sites unlikely to yield DRM.

Although ca. 2480 m^3/yr of category 4 myrtle sawlog is estimated to be available from selective logging, not all of it is necessarily economically accessible. The average mill-door cost of about $100/$m^3$ disguises the variability in estimated costs between coupes as a result of standing volume and access cost variations (Table 8.1). There is no explicit industry-defined maximum mill-door cost, which will be determined by mill processing costs and market prices for myrtle timber over time.

It is not possible to quantify the uncertainties noted above. We are confident, however, that the summary figures in Table 8.1 set a realistic upper bound on the DRM resource referred to in RFA clause 55.

9.2. Excluded volumes

In sections 4 and 5 we excluded DRM-rich forest from the resource picture for a variety of forest management reasons. What do these exclusions amount to in myrtle sawlog volume? The answer varies from exclusion to exclusion, and it is important to understand that it is not possible to convert *area* of excluded DRM-rich forest to myrtle sawlog *volume* without knowing much more about both the forest patches involved and what might happen to them.

For example, we can derive a very rough estimator for sawlog volume (category 4 plus utility) per hectare by dividing the estimated total volume from the 27 coupe clusters by the estimated operational area in those clusters. The result is 12.5 m^3/ha. This figure, however, only applies to selective logging of high-quality forest. Some of the excluded patches could not be selectively logged (in conjunction with other operations) because they lack sufficient seedtrees for subsequent regeneration, because the myrtle in the patches is highly defective or because the patches occur on 'unloggable' ground (too steep, too close to streams, etc.). Other patches will be clearfelled in conjunction with plantation establishment. Although clearfelling would yield more sawlog than would selective logging in the same patch of forest, the patches to be cleared in conjunction with plantation establishment very rarely contain high-quality sawlogs: the great majority of these patches have been selectively cut-over in the past. Finally, many of the excluded patches are likely to be subject to Forestry Tasmania's rainforest policy, which generates informal reserves within individual coupes by setting aside undisturbed rainforest patches larger than 10 ha. In eucalypt production coupes, these patches are generally unavailable for selective logging because such an operation puts the patches at risk during regeneration burning.

What follows is an estimation procedure that deals with these unknowns by making several broad assumptions:

Small areas. Table 4.5 excludes 1217 ha of DRM-rich forest because the coupes concerned each have less than 10 ha of such forest. Of the 1217 ha, 1060 ha are **OK** and **E** P.I. types. Table 5.2 excludes another 1071 ha because the coupes concerned each have less than 10 ha of **OK** and **E** P.I. types. The total of such types in these coupes is 113 ha. Small-area exclusions of suitable types are thus 1060 + 113 = 1173 ha. Table 5.3 discounts the available area (at that point in the analysis) by *ca*. 5% mainly for topographic reasons. Applying this loggability discount, the loggable area of the 1173 ha is *ca*. 1110 ha. The evaluation procedure in section 6 discounted the total area of available DRM-rich forest by approximately half (Table 6.3). Applying this evaluation discount, the small-area total is 555 ha. If all this area of scattered small patches could be selectively logged to yield 12.5 m^3/ha, the total myrtle sawlog yield is estimated to be *ca*. 6900 m^3. The category 4 proportion is unknown.

Production forestry. Table 5.1 excludes 2590 ha of **OK** and **E** P.I. types because the patches concerned are in coupes to be managed for extensive eucalypt forestry or plantation. Current planning assumes that about one third of this area will be converted to plantation, but under planning guidelines the larger, least disturbed (by selective logging) rainforest patches will be left unlogged. If we apply the 'salvage' recovery estimate from Table 7.2 of 2.5 m^3/ha to the conversion area of ca. 863 ha, then ca. 2160 of myrtle sawlog could be recovered during conversion. If we apply loggability and evaluation discounts (above) to the remaining ca. 1723 ha, then 1723 ha x 0.95 x 0.5 x 12.5 m^3/ha or *ca.* 10230 m^3 of myrtle sawlog could be supplied from patches in extensive eucalypt coupes, for a total of ca. 12 390 m3 of myrtle sawlog. Again, the category 4 proportion of this volume is unknown.

We are confident that the exclusions in sections 4 and 5 are reasonable ones, because we believe that only a small proportion of the 19 290 m^3 of myrtle sawlog estimated to be present in small-area and production forestry exclusions would be economically recoverable. Recovered volumes from production forest coupes will become part of the 'non-STM supply of ca. 900 m^3/yr, of which less than 30% is in the larger logs likely to contain DRM (Table 3.1).

9.3. The Pipeline Corridor resource

Rainforest in the Pipeline Corridor was not studied as carefully in the resource review as non-Corridor forest, because RFA clause 55d did not make this the focus of the study (section 1). Nevertheless, if we assume that the 62 Corridor coupes containing DRM-rich forest (Table 6.1) have the same average recoveries as the Pipeline Road coupes outside the Corridor, then another *ca*. 55 000 m^3 of category 4 myrtle sawlog could be available from selective logging, at an estimated minimum cost of \$125/m^3 (Table 9.1). The cost is high because roads to Corridor coupes would need to be considerably longer than those to non-Corridor coupes further north along the Pipeline Road.

Table 9.1. Estimated approximate volumes (m^3) of myrtle sawlog available from DRM-rich forest in the 27 non-Corridor coupe clusters identified in section 8, and extrapolated volume estimates for Corridor coupes (see text for explanation).

	Volume (m^3)			**Estimated**
	Category 4 (≥75 cm)	**Utility (<75 cm)**	**Total sawlog**	**mill-door cost (\$/m^3)**
non-Corridor	39700	15700	55400	105
Corridor	55000	20000	75000	125

The Corridor volumes in Table 9.1 are likely to be optimistic. Inspection of Corridor coupes from the air and on aerial photographs has shown that large areas typed as M+ forest (tall, better sawlog quality) in the Corridor are actually M- (short, low sawlog quality). Further, the concerns about myrtle wilt noted above (section 9.1) apply to the Corridor as well as to the non-Corridor resource. The *ca.* 95 000 m^3 of category 4 myrtle sawlog nominally available from both sources (Table 9.1) would allow the RFA target of 4500 m^3/yr of DRM to be reached during the RFA period, but at that rate of cut, all myrtle sawlog from suitable, DRM-rich, couped forest in Tasmania would be cut out in 2030.

References

Chattaway, M.M. (1952) The sapwood-heartwood transition. *Australian Forestry* 16(1): 25-34.

Davis, S.R. (1998) *A Multistage Resource Inventory of Temperate Rainforest in NW Tasmania*. (Draft internal Forestry Tasmania report)

Forestry Tasmania. (1998) *Rainforest Silviculture. Native Forest Silviculture Technical Bulletin No. 9.*

Forestry Tasmania. (1999) *Overview of the Deep Red Myrtle Project*. (Released May 2000, available on the Forestry Tasmania website, **www.forestrytas.com.au**.)

Hickey, J. Davis, S., Wardman, R. and Harris, J. (1993) How much rainforest is in Tasmania? A better answer to a difficult question. *Tasforests* 5: 13-24.

Jarman, S.J., Kantvilas, G. and Brown, M.J. (1991) *Floristic and Ecological Studies in Tasmanian Rainforest. Tasmanian NRCP Report No. 3*. Forestry Commission, Tasmania and Department of the Arts, Sport, the Environment, Tourism and Territories, Canberra.

Kile, G.A., Packham, J.M. and Elliott, H.J. (1989) Myrtle wilt and its possible management in association with human disturbance of rainforest in Tasmania. *New Zealand Journal of Forest Science* 19: 256-264.

Montgomery, P.J. (1985) *A Critical Examination of Inventory in Rainforest in Northwest Tasmania with Emphasis on the Assessment of Inner Stem Defect*. Unpublished Graduate Diploma of Science report, Australian National University.

Packham, J.M. (1991) *Myrtle Wilt. Tasmanian NRCP Report No. 2.* Department of Parks, Wildlife and Heritage, Tasmania and Department of the Arts, Sport, the Environment, Tourism and Territories, Canberra.

Packham, J.M. (1994) *Studies on Myrtle Wilt*. Unpublished PhD thesis, University of Tasmania.

Stone, M.G. (1998) Forest-type mapping by photo-interpretation: A multi-purpose base for Tasmania's forest management. *Tasforests* 10: 15-32.

Walker, B.B. and Candy, S. (1983) Investigating methods of assessing rainforest in Tasmania; pp. 7-33 in *Tasmanian Rainforest: Recent Research Results*. Forest Ecology Research Fund, Hobart.

Appendix 1. More on deep red myrtle

'Red' myrtle has long been recognised as a special timber by sawmillers and wood buyers:

> *There are two varieties of Tasmanian myrtle, the red and the white. The wood of the red variety is mostly bright pink in colour, and often beautifully marked. It is close-grained and tough. It is an attractive, sound, mild-working wood, easily seasoned, and is capable of a high polish…The Light Myrtle is a variety of the same species, not as close-grained as the dark nor of so high a specific gravity. In colour the wood is a brownish grey…*
>
> Lewin, D.W. (1906)
> *The Eucalypti Hardwood Timbers of Tasmania and the Tasmanian Ornamental and Softwood Timbers.*
> Gray Brothers, Hobart (pp. 51-52)

> *…as a first step, myrtle might be sorted into the two classes commonly recognised in the trade as "white" myrtle and "red" myrtle, and each class dried separately. Such a method of classification has been adopted in the later tests made at the laboratory, the classes being more fully described as follows:—*
>
> "White" Myrtle.—*Straw coloured to pale pink and comparatively soft.*
> "Red" Myrtle.—*Pink to red or red-brown and comparatively hard.*
>
> Greenhill, W.L. and Thomas, A.J. (1937)
> *A Guide to the Seasoning of Australian Timbers. Part 2.*
> *Division of Forest Products Technical Paper No. 22*. C.S.I.R., Melbourne (p. 31)

The cause of redness in myrtle is unknown. Nearly the full range of myrtle timber colour can sometimes be found in a single, even-aged stand. Deep red myrtle (DRM) is relatively common on highly fertile soils, but even 'good red myrtle country' on Tertiary basalt can carry older stands of trees with straw- to pink-coloured heartwood. In cross-section, most DRM logs show only partial 'deep-reddening' of heartwood. Completely deep red logs, with only a narrow ring of light-coloured sapwood, are extremely rare.

A specimen of red myrtle heartwood was closely studied by M. Margaret Chattaway (1952). She obtained a section from a Tasmanian tree, about 350 years old, which was 105 cm in diameter at 3 m from the ground. The heartwood margin was very irregular and the heartwood proper was filled with fungal hyphae. Chattaway regarded it as '*probable that the heartwood in this log…was of pathological origin. This is supported by the zone lines that can be traced in the wood…and by the irregular outline of the heartwood. Other large logs of "red" myrtle beech were seen in the felling area. In every one the outline of the red heartwood showed similar marked irregularities.*'

So far as we are aware, the association of myrtle redness with fungal invasion has not been further studied. It seems unlikely that a 'reddening' fungus could also be responsible for the extensive decay which is common in both 'red' and 'white' myrtle, because DRM logs are often sound to the core.

Appendix 2. P.I. types

Classification of P.I. types ('NewPItype' on the Forestry Tasmania corporate GIS cover) as **OK**, **E**, **MR** and **FCD**, and the total area of each in hectares. For an explanation see **Locating the DRM resource**, above. For more information about P.I. types, see Stone (1998).

OK	K.M+.	5
OK	K/2.M+.	4
OK	M.	17
OK	M.E-3f.	7
OK	M+.	125267
OK	M+.dd E2F.	59
OK	M+.E+3f.	1175
OK	M+.E1f & dd(F).	848
OK	M+.E1f.	1530
OK	M+.E2(P).	1726
OK	M+.E2f & dd(F).	342
OK	M+.E2f.	19876
OK	M+.E-3f.	13
OK	M+.K.	114
OK	M+.K.E2f.	16
OK	M+.om E2f & dd(F).	23
OK	M+.Tb.	2491
OK	M+.Tb.E2f.	790
OK	M+.Tc.Tb.	117
OK	M+.Tk.	315
OK	M+.Ts.	34
OK	M+.Tw.	1239
OK	M+.Tw.dd E2F.	53
OK	M+.Tw.E+3f & dd(F).	4
OK	M+.Tw.E+3f.	25
OK	M+.Tw.E2f.	780
OK	M+.Vz.	10
OK	M+.W.	7
OK	M+/+3.	94
OK	M+/2.	76
OK	M+/2.Tw.	91
OK	om E1c.M+.	53
OK	om E1d & dd(D).M+.	15
OK	om E1d.M+.	8
OK	om E2b.M+.ER.	21
OK	om E2c & dd(F).M+.	15
OK	om E2c.M+.	36
OK	om E2d & dd(F).M+.	23
OK	om E2d.M+.	8
OK	om M+.	84
OK	om M+.E1f & dd(F).	11
OK	S.W.M.	10
OK	Tb.M+.	31
OK	Tc.Tb.M+.	22
OK	Ts.M+.	77
OK	Tw.M+.	61
OK	Tw.M+.E2f.	41
OK	W.M.S.	77
E	E+3a.M+.	7
E	E+3b.ER.M+.	10
E	E+3b.M+.	320
E	E+3c.M.	76
E	E+3c.M+.	272
E	E+3d.ER1f.dd M+.	15
E	E+3d.ER3(P).M+.	102
E	E+3d.M+.	840
E	E1b.M+.	263
E	E1c & dd(F).M+.	97
E	E1c.ER3f.M+.	20
E	E1c.M+.	1673
E	E1d & dd(F).M+.	115
E	E1d.M+.	1090
E	E2(P).M+.	79
E	E2a.M+.	4
E	E2b.M+.	2401
E	E2c.ER3d.M+.	14
E	E2c.ER3f.M+.	33
E	E2c.M+.	3417
E	E2c.Tw.M+.	13
E	E2d & dd(D).M+.	36
E	E2d & dd(F).M+.	82
E	E2d.ER3d.M+.	39
E	E2d.ER3f.M+.	27
E	E2d.ER4d.M+.	45
E	E2d.M.	4
E	E2d.M+.	6517
E	E2d.M+.ER2(P).	31
E	E2d.M+.Tb.	26
E	E2d.M+.Tw.	25
E	E2d.Tw.M+.	20
E	E-3c.M+.	14
E	E-3d.M+.	52
E	E3f.M+.Tw.	7
E	E4c.M+.	2
E	E4d.M+.	3
E	ER3(P).M+.E2f.	59
E	ER3b/+3.M+.	3
E	ER3b/2.M+.	2
E	ER3d/2.M+.	7
E	ER3f/+3.M+.Tw.	12
E	ER3f/2.M+.	32
E	ER5b/2.M+.	72
MR	E+3b.Mr2.S.	18
MR	E+3c.Mr2.	48
MR	E+3c.Mr2.S.	7
MR	E+3c.Mr2.T.	6
MR	E+3d.ER3f.Mr2.T.	8
MR	E+3d.ER3f.Mr2/M+.	9
MR	E+3d.M+.Mr2.	13
MR	E+3d.Mr.	7
MR	E+3d.Mr1.	33
MR	E+3d.Mr1/M+.	39
MR	E+3d.Mr2.	47
MR	E+3d.Mr2.M+.	14
MR	E+3d.Mr2.S.	20
MR	E+3d.Mr2/M+.	8
MR	E+3d.S.Mr2.	12
MR	E+3d.T.Mr2.	6
MR	E1b.Mr2.	7
MR	E1d.ER4f.S.Mr2.	15
MR	E1d.Mr2.S.	33
MR	E1d.Mr2/M+.	28
MR	E1d.S.Mr2.	10
MR	E1d.S.T.Mr2.	7
MR	E2b.M+.Mr1.	36
MR	E2b.M+.Mr2.	26

MR	E2b.M+.Mr2.Tb.	63
MR	E2b.Mr2.	13
MR	E2b.Mr2.S.	19
MR	E2b.Mr2/M+.ER.	17
MR	E2b.S.Mr2.	53
MR	E2c.ER3f.Mr1/M+.	12
MR	E2c.M+.Mr2.	42
MR	E2c.Mr1/M+.	10
MR	E2c.Mr2.	10
MR	E2c.Mr2.M+.	10
MR	E2c.Mr2/M+.	48
MR	E2d.ER2d.Mr1/M+.	33
MR	E2d.ER3d.Mr2.	8
MR	E2d.M+.Mr2.	98
MR	E2d.Mr1.	43
MR	E2d.Mr1.M+.	42
MR	E2d.Mr1/M+.	61
MR	E2d.Mr2.	48
MR	E2d.Mr2.S.	7
MR	E2d.Mr2/M+.	6
MR	E2d.S.Mr2.	12
MR	E2d.T.Mr2.	9
MR	E-3d.dd S.Mr2.	13
MR	E-3d.ER2d.S.Mr2.	7
MR	E-3d.Mr2.	7
MR	E-3d.S.Mr2.	17
MR	E4d.S.Mr2.	4
MR	ER2c/2.Mr1.	13
MR	ER2d/+3.T.Mr1/M+.	7
MR	ER2f/+3.S.Mr.	11
MR	ER3(P)/2.Mr2.	6
MR	ER3d/+3.Mr2.	10
MR	ER3d/+3.Mr2/M+.	9
MR	ER3d/2.Mr2.	8
MR	ER3d/2.Mr2.S.	8
MR	K.Mr2.	10
MR	K.T.Mr2.	9
MR	M(72:94)N/X.	22
MR	M(80)N/X.	4
MR	M(81)N/X.	8
MR	M(82)N/X.	4
MR	M(84)N/X.	32
MR	M(86)N/X.	9
MR	M(88)N/X.	29
MR	M(94)N/X.	26
MR	M+.Mr1.	194
MR	M+.Mr1.E2f.	10
MR	M+.Mr2.	2638
MR	M+.Mr2.E1f.	25
MR	M+.Mr2.E2f.	576
MR	M+.Mr2.K.	18
MR	M+.Mr2.Tb.	36
MR	Mr.	9
MR	Mr1.	48
MR	Mr1.E2f.	6
MR	Mr1.M+.	204
MR	Mr1.M+.Tw.	9
MR	Mr1/M+.	286
MR	Mr2.	958
MR	Mr2.dd E+3F.	9
MR	Mr2.E+3f.	11
MR	Mr2.E2f.	8
MR	Mr2.K.	4
MR	Mr2.M+.	628
MR	Mr2.M+.E2f.	27
MR	Mr2.M+.Tb.	9
MR	Mr2.S.	157
MR	Mr2.S.E+3f.	4
MR	Mr2.S.E2f.	10
MR	Mr2.S.T.	38
MR	Mr2.S.T.E2f.	59
MR	Mr2.S.T/2.	5
MR	Mr2.S.Tw.	12
MR	Mr2.T.	124
MR	Mr2.T.E2f.	5
MR	Mr2.T.S.	74
MR	Mr2.Tw.S.E2f.	48
MR	Mr2.Vz.	10
MR	Mr2/2.S.	4
MR	Mr2/M+.	1025
MR	S.Mr.	2
MR	S.Mr1.	21
MR	S.Mr2.	362
MR	S.Mr2.dd E4F.	25
MR	S.Mr2.E+3f.	38
MR	S.Mr2.E2f.	31
MR	S.Mr2.T.	198
MR	S.Mr2.Wr.dd E4F.	25
MR	S.T.Mr2.	125
MR	T.Mr1/M+.	14
MR	T.Mr2.	46
MR	T.Mr2.S.	93
MR	T.S.Mr2.	7
MR	Tw.S.Mr2.	4
FCD	co dd E2D.Mr2.S.	9
FCD	co dd E2D.S.Mr2.	10
FCD	co dd M+.K.	101
FCD	co dd M+.Tk.	13
FCD	co E(66)2d.E2f.Mr1/M+.	13
FCD	co E(66)2d.Mr1/M+.E2f.	5
FCD	co E+3b.Mr2.S.	12
FCD	co E+3c.ER3f.Mr1.	35
FCD	co E+3c.Mr2.S.	10
FCD	co E+3d.ER3d.Mr2.	17
FCD	co E+3d.M+.	10
FCD	co E+3d.Mr1.	97
FCD	co E1(P).M+.Tb.	44
FCD	co E1c.M+.	181
FCD	co E1d.M+.	108
FCD	co E2b.M+.	36
FCD	co E2c.M+.	77
FCD	co E2d.ER1f.M+.	21
FCD	co E2d.ER2d.Mr2.	44
FCD	co E2d.ER4f.Mr1.	13
FCD	co E2d.M+.	298
FCD	co E2d.Mr2.	6
FCD	co E2d.Mr2.W.	7
FCD	co E2d.Mr2/M+.	48
FCD	co E2d.W.Mr2.	31
FCD	co E-3c.ER2d.Mr2.	16
FCD	co ER1d/+3.Mr2.	23
FCD	co ER2c/+3.Mr2.	31
FCD	co ER2d/+3.M+.	29
FCD	co ER2d/+3.Mr1.	17
FCD	co ER2d/2.M+.	28
FCD	co ER2f/2.Mr2/M+.	18
FCD	co ER4f/2.M+.	12
FCD	co fd M+.	24
FCD	co fd M+.E2f.	9
FCD	co K.M+.	29
FCD	co M.	5
FCD	co M+.	7324
FCD	co M+.dd E+3F.	8
FCD	co M+.E1f.	9

FCD	co M+.E2f.	1325
FCD	co M+.K.	146
FCD	co M+.Mr1.	530
FCD	co M+.Mr1.Tw.	82
FCD	co M+.Mr2.	1729
FCD	co M+.Mr2.E2f.	165
FCD	co M+.Mr2.K.	72
FCD	co M+.Mr2.W.	17
FCD	co M+.Tb.	40
FCD	co M+.Tb.E2f.	66
FCD	co M+.W.	32
FCD	co M+/2.	9
FCD	co Mr1.E2f.	9
FCD	co Mr1.M+.	138
FCD	co Mr1/M+.	101
FCD	co Mr2.E2f.	11
FCD	co Mr2.M+.	68
FCD	co Mr2.M+.K.	8
FCD	co Mr2.S.Tw.E2f.	14
FCD	co Mr2.W.	5
FCD	co Mr2/M+.	89
FCD	co om E1c.M+.	206
FCD	co W.M+.	27
FCD	dd E+3D.Mr1.	8
FCD	dd E2D.M+.	40
FCD	dd E-3D.S.Mr2.	18
FCD	dd M.	3
FCD	dd M.S.	12
FCD	dd M+.	971
FCD	dd M+.fd E2f.	8
FCD	dd M+.K.	9
FCD	dd M+.S.	31
FCD	fd E+3c.Mr.S.	25
FCD	fd E+3d.ER1f.dd M+.	27
FCD	fd E2d.dd M+.	7
FCD	fd E2d.fd M+.	31
FCD	fd E-3b.Mr2.	12
FCD	fd E4d.Mr2.S.	15
FCD	fd M.	5
FCD	fd M+.	262
FCD	fd M+.fd Mr1.	14
FCD	fd Mr2.M+.	14
FCD	S.dd M.	34
FCD	S.K.dd M.	119

Appendix 3. Formally reserved DRM-rich forest

Classification of DRM-rich forest in 49 formal reserves. Minor patches are scattered through 10 other formal reserves which each contain between one and 10 ha of DRM-rich forest. All figures are hectares. Totals have not been adjusted for minor rounding errors.

Reserve type	Reserve name	Tb OK	E	MR	FCD	Oi OK	E	MR	FCD	Total
Forest Reserve	Arthur River	35	0	0	5	5	0	0	0	44
Forest Reserve	Balfour Track	0	0	0	0	30	3	0	0	32
Forest Reserve	Black Creek	0	0	0	0	13	0	0	0	13
Forest Reserve	Blue Tier	70	0	0	0	827	0	109	0	1006
Forest Reserve	Bond Tier	0	0	0	0	0	35	0	0	35
National Park	Cradle Mt - Lake St Clair	0	0	0	0	357	53	0	0	410
Forest Reserve	Deep Gully	650	38	8	157	54	0	13	19	937
Forest Reserve	Dip Falls	4	0	0	13	0	0	0	0	17
Forest Reserve	Dip River	20	38	0	36	0	0	0	0	95
Nature Recreation Area	Donaldson River	97	4	0	0	33	12	0	0	146
Forest Reserve	Dove River	0	0	15	0	48	0	0	0	63
Forest Reserve	Frome	0	0	0	0	82	25	0	0	107
Conservation Area	Granite Tor	188	0	0	0	427	103	0	0	718
Conservation Area	Great Western Tiers	0	0	0	0	0	0	36	0	36
National Park	Hartz Mountains	0	0	0	0	41	1	0	0	43
Forest Reserve	Hatfield River	9	0	3	0	0	0	0	0	12
State Reserve	Hellyer Gorge	575	0	66	486	0	0	0	0	1126
Regional Reserve	Leven Canyon	0	0	0	0	57	0	0	0	57
Forest Reserve	Mackintosh	0	0	0	0	28	0	0	0	28
Forest Reserve	Maggs Mountain	29	0	0	0	0	0	0	0	29
Forest Reserve	Meander	0	0	0	0	0	0	25	0	25
Regional Reserve	Meredith Range	224	0	42	0	2913	5	33	32	3248
Regional Reserve	Mt Dundas	0	0	0	0	93	0	0	0	93
Forest Reserve	Mt Kershaw	0	0	0	0	25	0	0	0	25
Forest Reserve	Mt Maurice	0	0	0	0	1941	45	0	135	2122
Forest Reserve	Mt Victoria	2	0	1	2	554	42	80	412	1043
Forest Reserve	Paradise Plains	0	0	0	0	63	0	0	0	63
Forest Reserve	Pruana	470	5	54	135	70	0	0	0	733
Forest Reserve	Quamby Bluff	0	0	0	0	0	0	73	0	73
Nature Recreation Area	Reynolds Falls	132	0	0	0	861	43	20	0	1056
Forest Reserve	Ringarooma River	0	0	0	0	102	3	0	0	105
State Reserve	Roger River	0	0	0	0	112	4	0	0	115
State Reserve	St Columba Falls	0	0	0	0	23	0	11	0	34
National Park	Savage River	2868	20	53	110	73	0	0	0	3124
Regional Reserve	Savage River	1541	1	0	0	1457	155	0	0	3154
Forest Reserve	South Esk	0	0	0	0	172	0	0	0	172
National Park	South West	0	0	0	0	429	120	13	0	562
Conservation Area	South West	0	0	0	0	967	0	0	0	967
Forest Reserve	Sumac	22	0	0	0	2510	103	0	0	2634
Regional Reserve	Tikkawoppa Plateau	4	11	0	0	2	0	0	0	17
Forest Reserve	Tombstone Creek	0	0	0	0	44	6	0	0	50
Forest Reserve	Trowutta	0	0	0	0	1104	30	0	12	1145
Conservation Area	Vale of Belvoir	10	0	20	0	2	0	45	0	76
National Park	Walls of Jerusalem	0	0	0	0	238	0	4	12	254
Regional Reserve	West Coast Range	0	0	0	0	48	0	0	0	48
National Park	Wild Rivers	0	0	0	0	342	94	0	0	436
State Reserve	Yellow Creek	0	0	0	0	10	0	0	0	10
Scenery Reserve	(Weldborough Pass)	40	0	0	0	12	0	0	0	52
River Reserve	?	0	0	16	0	12	0	0	0	31
(minor patches)	(10 various)	1	0	0	2	16	7	6	1	33
Total		6991	116	276	945	16175	889	466	623	26481

Appendix 4. Excluded and rejected coupes

Coupes excluded when defining the couped DRM resource for the RFA period:

To be managed for production forestry:

Bass Forest District: BS101A, BS101B, BS101C, BS102C, BS103H, BS103I, BS107L, BS108J, CC133B, CC151A, CC155B, CC154A, CC154B, CC155C, CC156B, CC157D, CC157E, CC157F, CD102B, CD106A, CD106B, CD106D, CD112E, CD115B, CD115C, CD118A, CD118B, CD118C, EV035A, EV109D, FL104A, FL104C, FL104D, FL104G, FL122F, GC128A, MO122C, MO145A, RR107A, RR108A, RR114C, RR114D, RR124D, RR124E, RR126A, RR127A, RR127B, RR127C, RR128B, RR129A, RR131A, RR131B, RR132A, RR132C, RR133C, RR136A, SF155B, SF157A, SF158D, SF161G, SF164A, SF166B, SF167B, SF169D.
Derwent Forest District: CO010E, CO010G, CO011A, CO011B, CO011C, CO023B, CO023D, CO023F, CO023G, CO027C, RP034C, RP034G, RP036H, TN061A, WW054A, WW054D, WW059A, WW059B.
Mersey Forest District: GA101X, GA106A, GA106X, GA119V, part of MI017D, MI018A.
Murchison Forest District: BO115C, BO209C, DP017B, DP021C, DP023D, FD035A, FD041C, GR005D, HE007D, HL044A, KA026A, LG007A, LG007F, ME017A, ML055F, ML058B, NH011A, NH028A, OO068B, PU008A, PU027B, PU027D, PU037A, PU038A, PU040D, PU041I, PU042C, PU043F, PW012C, WH016D, RD024A, SU020A, SU020B, SU022B, SU022C, SU023A, SU024A, SU034B, SU037A, SU055A, WH012D, WH014A, WH017A, WH027A.

Containing less than 10 ha of potentially loggable P.I. types:

Bass Forest District: CC150A.
Murchison Forest District: BO101B, BO103A, BO104A, BO106A, BO109C, BO205A, BO218A, BO239A, BO251A, DP019F, LG023A, LG024A, LG024B, LG024C, LG025A, ML017A, NH005A, NH009B, NH018E, NH018F, RD018B, WH001A, WH001B, WH001C, WH016F, WH016G, WH016H.

Potentially loggable P.I. types on ground too steep for conventional logging:

Bass Forest District: CD114K, CD116D, CD117B, CD117C, CD117E, MO117E, RR106A, RR129B, RR129C, RR129D, RR130A, RR138A, RR151A, RR159C, RR161A, RR162B.
Derwent Forest District: CO020D, CO023A, WW058E.
Huon Forest District: BB016H, KD028A, RU008F, RU008G.
Murchison Forest District: ML022A, ML031A.

Potentially loggable P.I. types mainly along coupe edges:

Bass Forest District: MO118A.
Derwent Forest District: CO010I.
Huon Forest District: DN017D, RU012F.
Murchison Forest District: BF012C.

Potentially loggable P.I. types only small, scattered patches:

Huon Forest District: RU008E.

Potentially loggable P.I. types tightly bounded by clearfall eucalypt forest:

Derwent Forest District: CO023I.

Coupes rejected on evaluation:

Recently logged:

Murchison Forest District: BO109B, BO201A, BO201B, NH019H, NW006C, NW006D, OO068A, WH017B.

Wrong forest type:

Bass Forest District: MO145D.
Huon Forest District: RU012E, RU012G.
Murchison Forest District: FR039A, SU035E, WH004B.

Mostly wrong forest type and mature stocking too low:

Bass Forest District: RR155A.
Murchison Forest District: BF002B, BF004E, BF005C, BO250A, ML023A, ML068A, ML068D, NW007D, NW007E, SU019A, SU019B, SU019C, SU055B, WD006A, WD006B, WD013A, WD015A, WH001D, WH001E.

Good mature stocking too low:

Bass Forest District: CC147B, CC147C, CC148A, CC148B, CC148C, CC148D, CD110A, CD112I, CD117D, CD118H, FL122E.
Huon Forest District: AR004C, KD026B.
Murchison Forest District: BF012A, BF012B, BO100C, BO100D, BO101A, BO114A, BO202A, BO214A, BO240B, BO244B, FY002D, FY002E, FY014E, HE011A, HK011A, LG011P, LG013B, LG014A, LG014B, LG014D, LG023B, ML021A, ML032A, NH019D, NH019I, NW003D, NW006A, NW006B, NW006E, NW007A, NW007B, NW008B, PW018M, WD014A, WH002A, WH016E, WH017C, WH019A, WH026A, WH028C.

Good mature stocking too patchy:

Bass Forest District: BS106A, RR101C, RS144D, SF166C.
Mersey Forest District: MI007D.
Murchison Forest District: FY002F, MD001C, NW008A, WH001G, WH001H.

Research control area:

Murchison Forest District: SU017A.

Appendix 5. Final list of coupes

Coupes by cluster, with estimated DRM-rich forest (D) and estimated operational areas (O) (both in ha) and recovery class. Note that one Pipeline coupe (FY035D) has been split and two (MB068C and MB068E) combined for operational reasons.

Cluster	Coupe	D	O	Recovery class
Cradle Link 1	B0206A/271A	40	80	regrowth-rich
Heemskirk 1	NW003B	17	17	poor mature
Moorina 1	MO123B	42	30	regrowth-rich
Murchison 1	BO114B	26	45	poor mature
Murchison 2	BO213A	73	50	salvage
	BO213B	33	15	salvage
	BO244A	38	20	salvage
	BO244C	45	50	poor mature
Murchison 3	BO250B	37	46	poor mature
	BO251B	15	12	salvage
Murchison 4	RN002C	14	54	poor mature
Pipeline 0	MB068A	14	10	good mature
Pipeline 1	RD018C	59	43	good mature
	RD019A	105	62	good mature
	RD019B	13	20	regrowth-rich
	RD023B	31	12	poor mature
	RD023C	59	53	good mature
	RD023D	85	79	good mature
	RD024C	45	38	poor mature
	RD025B	30	18	poor mature
	RD025C	60	48	good mature
Pipeline 2	RD022A	80	88	good mature
Pipeline 3	MB067A	101	110	good mature
	MB067B	68	75	good mature
Pipeline 4	MB066A	12	14	poor mature
	MB067C	118	102	poor mature
	MB068D	78	68	good mature
	MB068F	63	63	good mature
Pipeline 5	MB068C,E	75	55	good mature
Pipeline 6	MB069A	44	43	good mature
Pipeline 7	MB069B	72	58	good mature
Pipeline 8	FY014A	40	33	poor mature
	FY014B	31	27	poor mature
	FY014C	42	37	poor mature
	FY014D	49	38	poor mature
	FY018A	114	122	good mature
	FY029A	54	46	good mature
	FY030A	92	71	good mature
	FY031A	24	31	poor mature
	FY031B	71	64	good mature
	FY033A	41	30	good mature
	FY033B	44	31	good mature
	FY034A	58	48	good mature
	FY034B	75	58	good mature
	FY034C	87	69	poor mature
Pipeline 9	FY033C	55	42	good mature
	FY033E	74	90	good mature
	FY033F	30	26	poor mature
Pipeline 10	FY033D	122	113	good mature
	FY035D (north)(part of 139)		90	good mature
	FY035E	78	75	poor mature
	FY035G	154	180	good mature
Pipeline 11	FY027B	23	18	poor mature
	FY027C	58	88	poor mature
	FY027D	171	160	poor mature
	FY035A	122	107	poor mature
	FY035B	54	55	good mature

	FY035C	135	117	good mature
	FY035D (south)(part of 139)		30	good mature
	FY036A	66	51	poor mature
	FY055C	104	79	good mature
	FY055D	46	36	good mature
Pipeline 12	FY055A	52	47	poor mature
Pipeline 13	FY055B	77	66	poor mature
Procters 1	NW011A	52	113	poor mature
	NW011D	29	32	poor mature
	NW011E	105	107	poor mature
Que 1	BO102A	40	80	salvage
	BO109A	20	30	poor mature
	BO109D	35	35	regrowth-rich
Rattler 1	FL122D	51	51	poor mature
Waratah 1	WH001F	143	60	regrowth-rich
	WH018A	44	28	salvage
Waratah 2	WH020B	53	122	salvage
	WH021A	15	97	salvage
Waratah 3	MD003A	42	42	poor mature

Appendix 6. Rainforest assessments and their problems

Rainforest is notoriously hard to assess for myrtle sawlog. One source of difficulty is defect:

> *'Studies have shown that it is almost impossible to estimate ocularly the degree of defect in standing myrtle trees. An apparently sound myrtle may be shown to be almost entirely rotted when felled. Conversely, a myrtle which from ocular assessment would be judged to be rotten, can be shown to be sound when felled. A study of the ability of forest assessors to predict internal defect reliably from external appearance, showed that experience is of little value and a blind guess was as good as the considered opinion of an experienced assessor in most cases (FORTECH, 1982).'*
>
> P.J. Montgomery (1985; p. 5)

Another stumbling block is sampling strategy. If the forest is treated as a single, uniform type for assessment, the between-sample variation is enormous. To reduce the variation, the forest needs to be stratified in some way and the strata sampled separately. If the strata each represent more or less uniform forest, the between-sample variability should be more acceptable.

Stratification using aerial photos has been less than successful, as explained by Hickey *et al.* (1993) and in more detail by Walker and Candy (1983). Height estimates are strongly dependent on the photo-interpreter's experience with rainforest and on mean dominant height of the stand being examined. When three different P.I. stratification systems were carefully tested for their effectiveness in predicting total merchantable wood volume, one of the three *'was found to be of no use and the* [other two] *systems were little better'* (Walker & Candy 1983, p. 31).

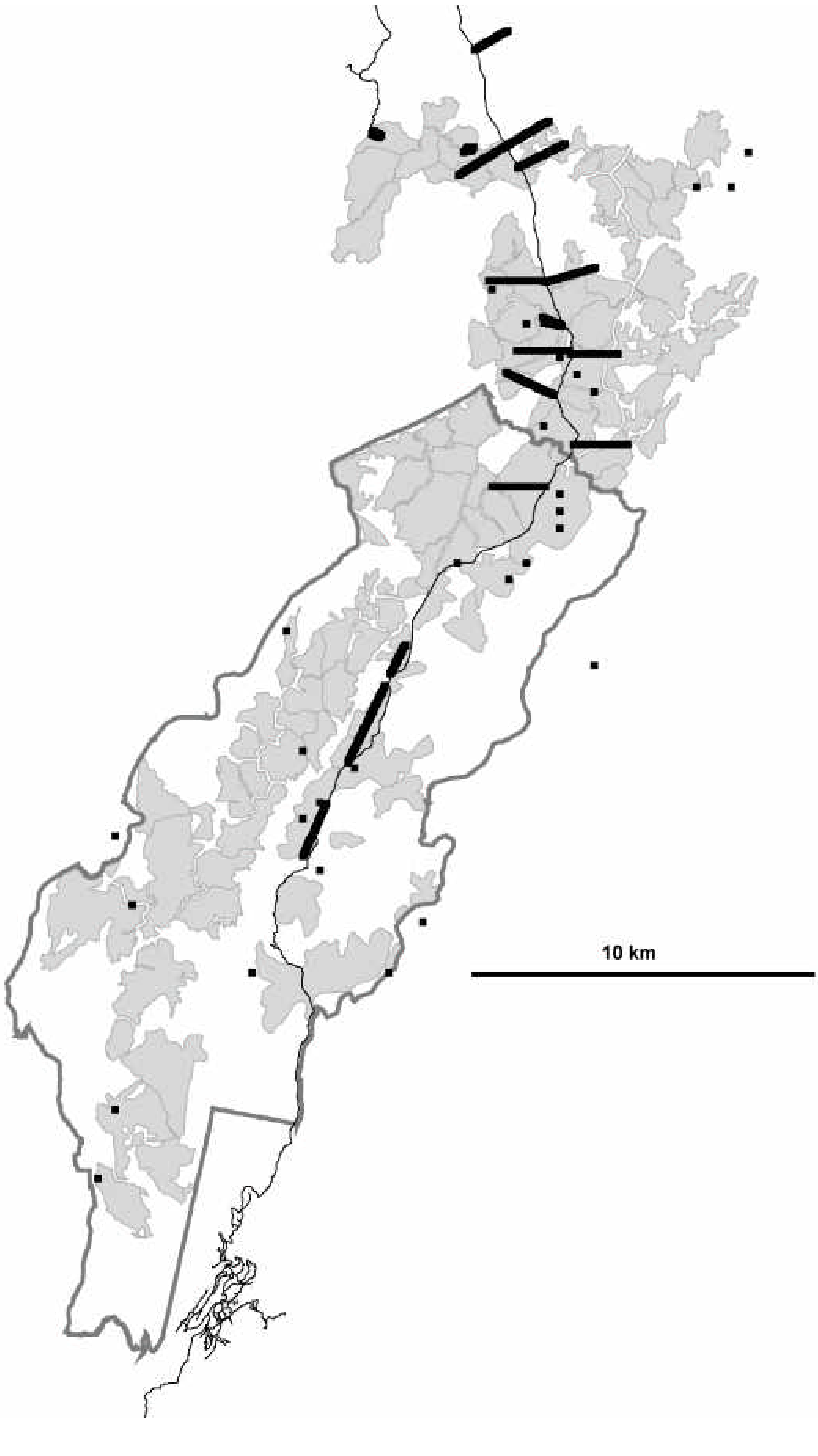
Even management level (fine-scale) sawlog assessments can be unreliable. Five such assessments were reviewed during the DRM resource study. All were in logging or planting trials in M+ forest on basalt near the Savage River Pipeline Road. Actual sawlog recoveries ranged from 38 to 68% of pre-logging estimates, despite the fact that in each trial the loggers were free to harvest all apparent sawlog.

In an attempt to improve the accuracy and reduce the variability of volume estimates, Forestry Tasmania (then the Forestry Commission) undertook a helicopter-assisted assessment of tall rainforest on basalt in the Northwest during the 1984/85 and 1985/86 summers (Davis 1998). The multi-stage sampling procedure, designed by a biometrician, investigated only the 'M+' P.I. stratum. The results of the first summer's assessment (37 plots) were discouraging, with 95% confidence limits on myrtle sawlog volume (corrected for defect) at ±143% of the mean value. The second summer's 36 plots seem to have been located in a more productive forest. Combined results for the two summers showed a 45% increase in mean sawlog volume and a drop in the 95% confidence limits to ±24%.

As part of the DRM resource review, all available assessment results were compiled for rainforest along the Pipeline Road. The map on the next page shows the southern half of the Pipeline Road, with coupes in light grey and the 'Pipeline Corridor' marked with a dark grey boundary. The 29 isolated black squares are plots from the 1984-1986 multi-stage assessment. Black lines and blotches are stripline assessments using the Mature Forest Inventory (MFI) system.

The 672 assessed plots are as follows:

Project 30 (February 1974). 155 MFI subplots, 0.08 ha each.
Project 116 (May 1975 to January 1976). 268 MFI subplots, 0.08 ha; 35 MFI subplots, 0.04 ha.
Project 40, area 3 (January and February 1976). 129 MFI subplots, 0.04 ha.
Prelogging 1980 (July 1980). 29 MFI subplots, 0.08 ha; 1 MFI subplot, 0.018 ha.
Prelogging 1982 (November 1982). 10 MFI subplots, 0.08 ha; 1 MFI subplot, 0.07 ha.
Prelogging 1986 (January 1986). 15 MFI subplots, 0.04 ha.
Multi-stage Inventory (1984/85 and 1985/86 summers). 29 special plots, 0.2 ha.


10 km

Assessment results and other information were taken from original plot sheets. The location of strip 12 in Project 116 (35 x 0.04 ha subplots) is currently undetermined. Strip 12 data are used in some analyses below but strip 12 does not appear on the accompanying map.

As is obvious from the map, the 672 Pipeline plots do not sample the Pipeline rainforest in an unbiased manner. For this reason, summary statistics from the plots can only be indicative, and hypothesis testing would not be soundly based. Nevertheless, it was worth looking 'globally' at the data set in search of patterns of interest for the DRM resource review, since the most frequently sampled forest was M+ on basalt.

The key resource for this project, category 4 myrtle sawlog, comes from live myrtles with dbhob $\geq$75 cm, referred to here for convenience as 'big myrtle'. Big myrtles were recorded on four out of every five Pipeline plots. The average basal area of big myrtle on the 672 plots was 37 m^2/ha. The variation around this figure with aspect (Table 1) is considerably less than the variation within a given aspect class, suggesting that big myrtle may be more or less evenly distributed across the terrain where it was found.

Table 1. Aspect and big myrtle. 'BA' is mean basal area (m^2/ha) of live myrtle $\geq$75 cm dbhob.

Aspect	BA	No. of plots
N	31	18
NE	32	44
E	40	75
SE	24	33
S	32	14
SW	38	49
W	38	91
NW	31	38
Flat	34	206

Note, however, the relatively low value in Table 1 for a SE aspect. The 33 SE plots had an average slope of 34%, and big myrtle may be less common on steeper slopes (Table 2).

Table 2. Slope and big myrtle. 'BA' is mean basal area (m^2/ha) of live myrtle $\geq$75 cm dbhob.

Slope (%)	BA	No. of plots
5 or less	37	305
6 to 29	36	186
30 or more	21	74

Horizontal (*Anodopetalum biglandulosum*) is sometimes regarded as an indicator of M- forest. Assessors usually recorded the presence or absence of understorey and ground layer horizontal on full-sized 0.4 ha or 0.2 ha MFI plots, rather than on subplots. If we assume that these results apply to all subplots within a plot, big myrtle seems to occur more or less uniformly in and out of horizontal (Table 3). This result accords with experience in coupe evaluation (section 6, above): horizontal was frequently seen in tall myrtle/sassafras/manfern forest in the Pipeline area.

Table 3. Horizontal and big myrtle. 'BA' is mean basal area (m^2/ha) of live myrtle $\geq$75 cm dbhob.

In understorey?	BA	No. of plots
No	38	321
Yes	35	290

In ground layer?	BA	No. of plots
No	43	177
Yes	34	378

The 'global' result for dead myrtle is particularly interesting. Assessors recorded the condition of mature myrtle crowns on almost all plots, usually unambiguously: ('*A moderate stocking of* *predominantly myrtle of fair form & quality. Crowns vigorous but unbalanced. Large trees o/m. Some dead trees*.' (Project 116, plot 47)) Assuming again that full-plot comments apply to subplots, the assessment data suggest that live myrtle occurrence may be 'globally' independent of the presence of dead myrtle (Table 4).

Table 4. Dead crowns and myrtle occurrence. 'BA' is live basal area (m^2/ha) and 'stocking' is in stems per hectare.

	Myrtle BA:				**Myrtle stocking**
Dead crowns?	**<45 cm**	**<75 cm**	**≥75 cm**	**all**	**≥75 cm**
No (321 plots)	2.3	10.5	35	45	32
Yes (318 plots)	2.2	9.0	39	48	33

Another set of 'global' results concerns myrtle crown height, which was estimated by assessors to the nearest metre (nearest five feet in Project 30). Crown height reaches a plateau at roughly 80-89 cm diameter (Fig. 1).

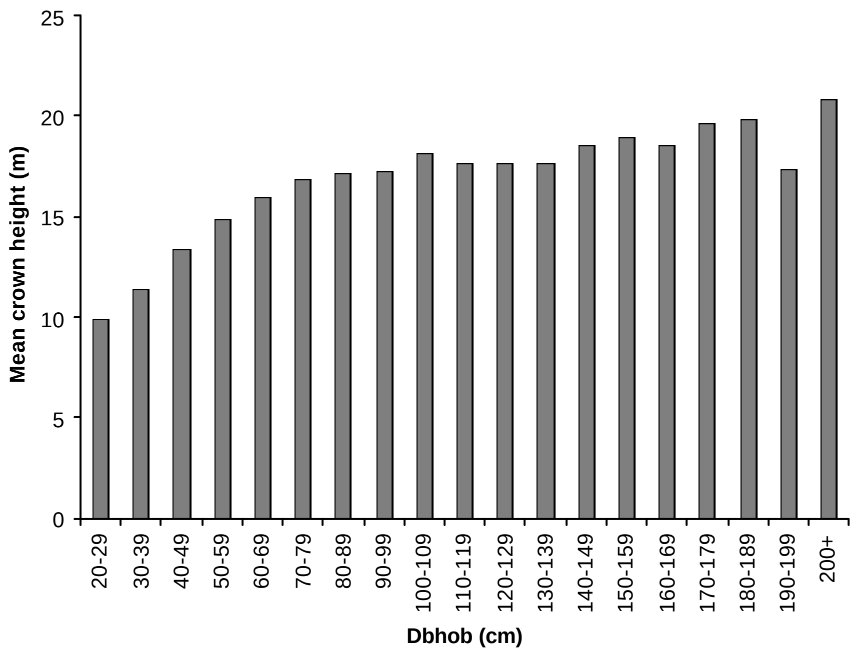


Fig. 1. Mean crown height for 10 cm dbhob classes of all live myrtles on the 672 Pipeline plots.

The frequency distribution of *plot* mean crown height is the same for plots with and without leatherwood, but is shifted to lower heights on plots without sassafras relative to plots with sassafras (Fig. 2, next page). The explanation seems to be the one suggested in Fig. 1: plots without sassafras were richer in smaller, shorter myrtle (Table 5).

Table 5. Small myrtle occurrence and presence/absence of leatherwood and sassafras. 'BA' is live basal area (m^2/ha).

	Myrtle BA:		
Leatherwood?	**<45 cm**	**<75 cm**	**No. of plots**
No	2.1	9.2	421
Yes	2.7	11.8	251
Sassafras?			
No	3.5	13.5	197
Yes	1.9	8.7	475

The crown height data are a little surprising. A well-known result from rainforest assessments is that sites with leatherwood tend to have lower merchantable myrtle volumes than sites with sassafras. If crown height distributions are unaffected by leatherwood or sassafras (allowing for the myrtle size effect), the difference in volume must be largely due to a difference in basal area. As shown in Fig. 3, this is the case. Plots with leatherwood have generally lower myrtle basal areas than plots without leatherwood, and plots with sassafras have generally higher myrtle basal areas than plots without sassafras.

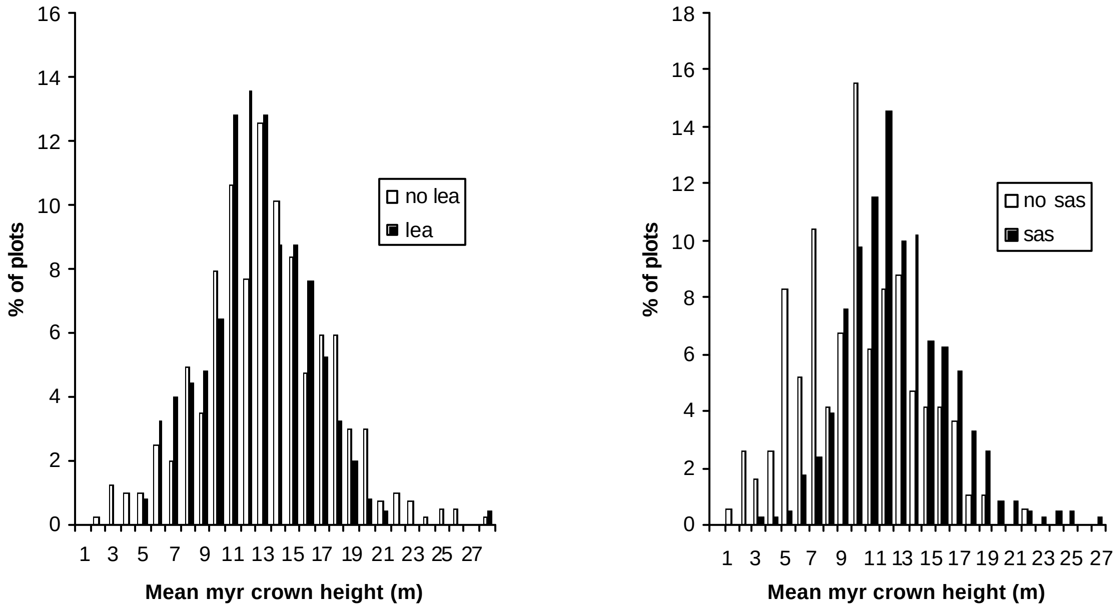


Fig. 2. Plot means of live myrtle crown height with leatherwood (251 plots) and without (421 plots), and with sassafras (475 plots) and without (197 plots).

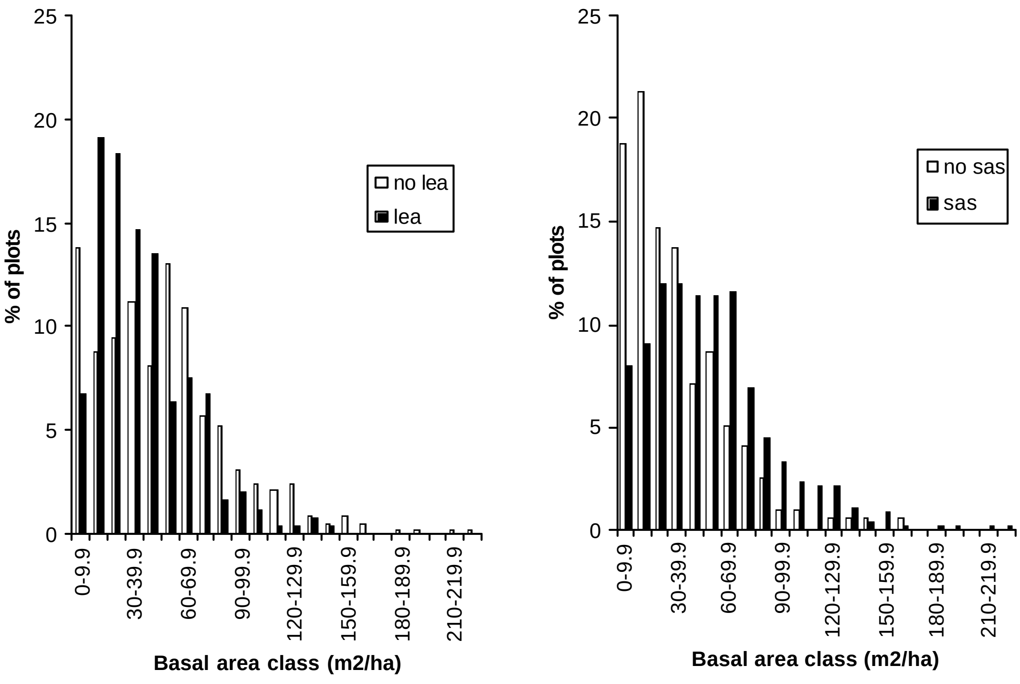


Fig. 3. Live myrtle basal area with leatherwood (251 plots) and without (421 plots), and with sassafras (475 plots) and without (197 plots).

Appendix 7. Myrtle wilt

'Myrtle wilt' is a disease caused by the pathogenic fungus *Chalara australis*. The nature, epidemiology and history of the disease in Tasmania were comprehensively reviewed by Jill Packham in an unpublished PhD thesis (Packham 1994), from which much of the following summary information has been taken. More easily accessible but preliminary accounts are those of Kile *et al.* (1989) and Packham (1991).

C. australis is known to enter individual myrtles either through fresh wounds on standing trees or through root grafts with neighbouring myrtles. Mature trees are more likely to be infected than regrowth. Infected trees generally die within three years. A rapid browning and loss of foliage is followed by loss of twigs and small branches. Dead trees can remain standing for many years and often acquire a covering of grey lichens on persistent limbs. An early sign of infection is attack on stems by the pinhole borer *Platypus subgranosus*. Attack generally follows infection, i.e. the beetle does not carry the disease from tree to tree. Logs from wilted myrtles are unsuitable for sawing due to brown staining of heartwood.

Myrtle wilt occurs throughout the range of myrtle in Tasmania, even in the most remote, least disturbed stands. Packham (1994) estimated that the average annual myrtle mortality due to wilt is 0.61%. There is no clear evidence for a sudden, major increase in the incidence of myrtle wilt in recent decades, but there is clear evidence that mechanical disturbance (e.g., from roading and selective logging disturbance) has substantially increased the incidence of wilt in particular areas. The most susceptible stands are in tall M+ forest on high-fertility sites.

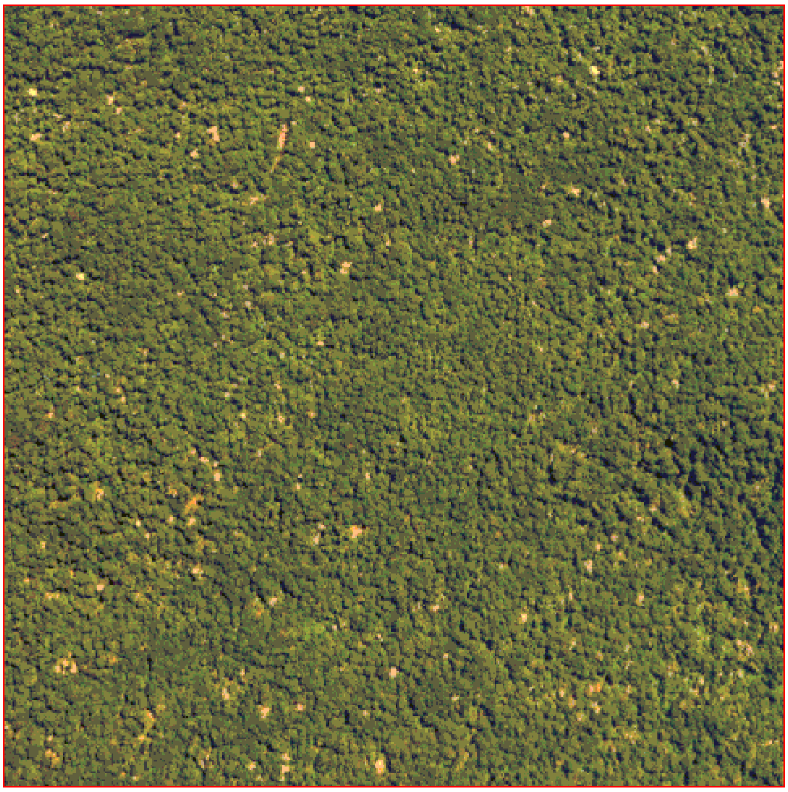
Myrtle-dominated rainforest affected by wilt regenerates to myrtle-dominated rainforest. *'Thus in undisturbed Tasmanian forests, the loss of all mature myrtles due to the disease is not anticipated. However, where continuously high levels of myrtle wilt are experienced, the loss of the largest myrtle size classes can be expected'* (Packham 1994, p. 200).

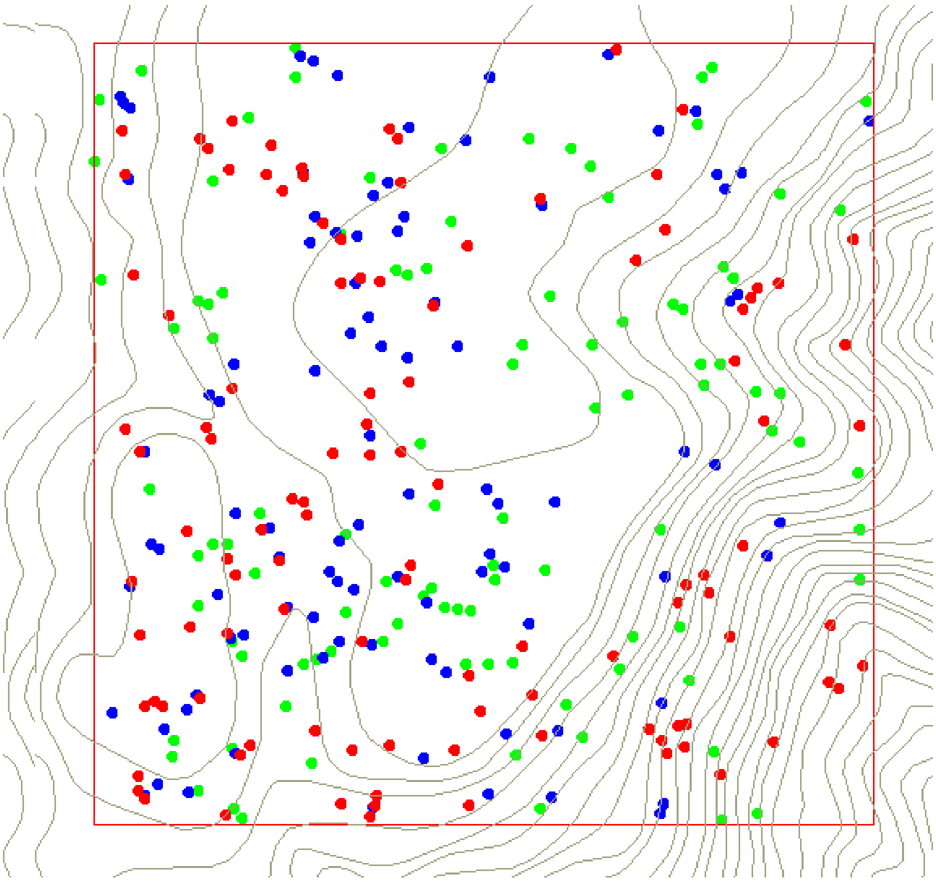
As part of the DRM resource review, the incidence of myrtle wilt was studied in an undisturbed block of M+ rainforest south of the Cradle Mountain Link Road, using colour aerial photographs from the 1978/79, 1984/85 and 1996/97 summers. The 1996/97 image was imported into GIS, then registered and rectified (placed and 'rubber-sheeted' so that all parts of the image were correctly located in the landscape). The 1978/79 and 1984/85 images were then registered and rectified using the 1996/97 image as a reference. The result is a set of three images in GIS with almost exactly the same spatial location: a given tree in the 1978/79 image is no more than a few metres from its location in the 1996/97 image.

A one kilometre-square study area was chosen in a fairly uniform portion of the photographed rainforest. The study area is shown opposite (top) as it appears in the 1978/79 image. Using a stereoscope, dead and dying tree crowns were identified on the original 1978/79 photos and marked on the digital image using GIS tools. (Dead and dying crowns are readily identified by colour and shape.) There are 109 such marks on the 1978/79 image. It was not possible to distinguish tree species, or to decide if a mark represents a small-crowned single tree or a portion of the crown of a large-crowned tree, but the great majority of marks are likely to represent individual mature myrtles.

The marking procedure was repeated on the 1984/85 image (97 marks) and the 1996/97 image (102 marks). The three sets of dead-and-dying-crown marks are shown in the lower illustration, opposite. 1978/79 is red, 1984/85 is blue and 1996/97 is green. Gray lines are 10 m elevation contours and the red box is the one kilometre study square.

The rainforest through which the disease spread over the 18-year period was not uniformly stocked with myrtle, and wilt cannot be assumed to be the only cause of death. It seems clear, however, that trees died at considerable distances from earlier patches of death. The practical implication for forest management is that wilt incidence is well spread in space and time. Myrtle wilt makes coupes unsuitable for selective logging through the progressive loss of potential seedtrees over the *whole* of the coupe.





Appendix 8. Estimating operational area

The illustrated example is the cluster 'Waratah 1' (Appendix 5). Waratah 1 consists of the two coupes WH018A and WH001F and is located about 8 km southwest of the township of Waratah in northwest Tasmania. The figure opposite has a recent aerial photograph of the coupes as its base.

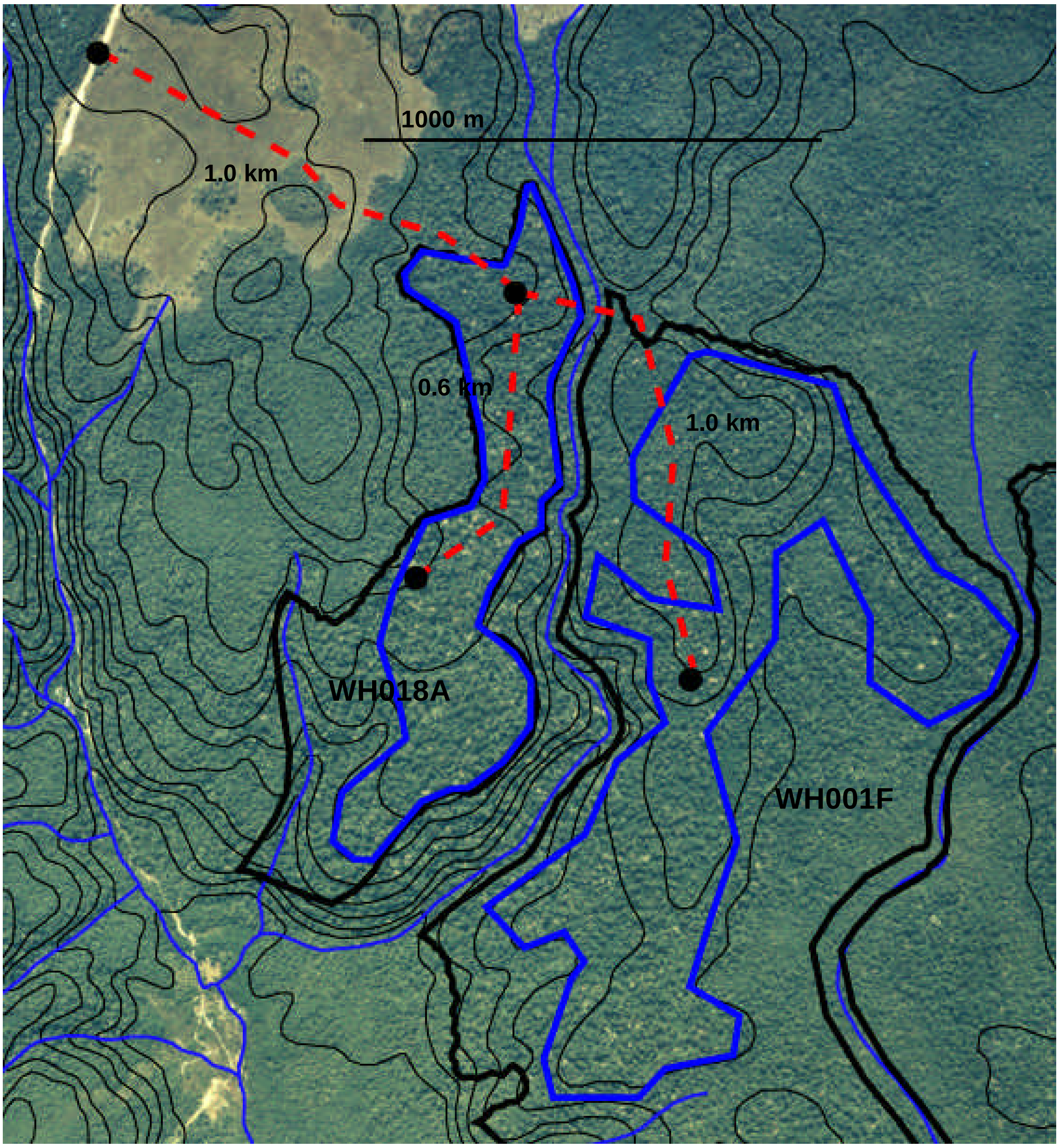
The two coupes were inspected from a helicopter in 2000, and WH018A and its surrounds were inspected on the ground in 1998 (section 6). Neither coupe has previously been logged, but WH018A is crossed by an overgrown bulldozer track associated with mining exploration on nearby Wombat Creek. Basalt soil in both coupes carries tall mature myrtle over an understorey of sassafras and manfern (high-quality M+ forest). Off basalt the rainforest is shorter with a dense understorey of leatherwood, horizontal and native plum (M- forest). The M+ forest was formerly well stocked but has lost a substantial portion of its mature overstorey due to death from myrtle wilt.

In the figure, coupe boundaries are shown as thick black lines, 10 m elevation contours are thin black lines and streams are thin blue lines. The thick blue line in each coupe is a proposed operational boundary based on coupe inspection and stereoscopic examination of recent aerial photographs.

According to the GIS analysis of P.I. types and geology, WH001F has 80 ha of M+ (mature myrtle P.I. type) and 63 ha of M+.MR2 (mature myrtle over tall myrtle regrowth) on Tertiary basalt, or a total of 143 ha of DRM-rich forest. The 60 ha within the operational boundary captures the tallest of the M+ and avoids the 'regrowth', which during the helicopter inspection appeared to be M- forest on poorly drained ground.

WH018A was analysed as having 29 ha of M+ on Tertiary basalt and 15 ha of M+ on Devonian granite (44 ha of DRM-rich forest). The rainforest on granite is in fact M- , and the 28 ha within the operational boundary includes all the taller rainforest on basalt.

The dotted red lines in the figure are proposed summer-only logging tracks and locations are based on ground inspection of access possibilities. The starting point is 0.7 km south along a mining track from the Waratah Road. The only roading cost considered for the cluster Waratah 1 (section 8) is for the 2.6 km of dirt track to the mid-coupe endpoints. Although the distance from the WH001F endpoint (furthest landing) to the south end of the operational area is *ca*. 1 km, building a longer track to reduce snig distance would not be economical due to the low volume to be harvested in this portion of the coupe.


1000 m
1.0 km
0.6 km
1.0 km
WH018A
WH001F

Appendix 9

Report of Audit of Deep Red Myrtle Project
Professor Ian S Ferguson

1. Introduction

The Tasmanian Government, through the RFA Implementation group, commissioned this report. In brief the task involved an independent audit of the draft report dated 1 November 2001 entitled Deep Red Myrtle Resource by Dr Bob Mesibov.

It was preceded by a draft workplan by Dr Bob Mesibov on which I was previously asked to comment. Where appropriate, the comments were incorporated in a reviewed workplan, which was then implemented by Dr Mesibov.

The audit involved reading the report and a one-day visit to Burnie and to the field with Dr Mesibov, followed up by the writing up of this report.

2. Scope

The Deep Red Myrtle Resource report is a detailed and well-documented study of the likely location and volumes available for harvesting of deep red myrtle in Tasmania.

There are two primary sources of data - those on the areas likely to contain deep myrtle at volumes that might be economically harvested under current conditions and costs, and those of the average volumes of deep red myrtle by log class within the aggregate area so identified.

3. Areas

The difficulties in identifying commercially viable red myrtle (both deep red and other) coupes are formidable, because of the difficulty in identifying stands of mature red myrtle trees that are lacking in damage and rot and are of sufficient size. This study has circumvented those difficulties by using an initial stratification of M+ and MR API types that has been well proven by earlier line plot sampling. These patches were then further examined to eliminate areas not available under the Code of Forest Practice, and those less than 1 ha in size and too small too harvest.

There is ample evidence for not including M- types. There is also evidence that the use of 1:42000 photos for part of the area did not cause a reduction in the extent to the high-yielding type as a result of the scale of the photos. I am satisfied that this interpretation was conservative in the sense of including **more** M+ than was correct, rather than less. The M- type, on the other hand, contains very little if any myrtle sawlog. In any event, the M- areas seem to be concentrated around the pipeline corridor and hence are not critical to this evaluation. **I recommend that the evidence on these matters be incorporated by way of footnotes and/or appendices.**

4. Volumes/ha

Some seven recently harvested coupes were used to estimate the average volume/ha of deep red myrtle actually sold from them The areas involved has been delineated on air photos in the earlier work and these coupes were then checked in the field by compass and chain survey. While the checks tallied well in most cases, those for one coupe were influenced by the withdrawal of the contractor on the basis that the remaining volume was insufficient to sustain the operation. Since this happens on a haphazard but significant basis in other logging, the total area involved was included in the estimation of volume/ha.

The seven samples were then classified according to their condition relative to the strata that could be identified from the aerial photography. Three fell in the 'Good mature' class, two each in the 'Regrowth rich' and 'Salvage' classes, but none fell in the 'Poor mature' class. Subjective estimates of the average volume/ha for the first three were made based on the (?simple) average volumes/ha in the class. The report subjectively interpolated the value to be attributed to the 'Poor mature' class as being half that of the 'Good mature' class. This constitutes a major weakness in the estimate because this class represents nearly half (Table 7.3) of the potentially loggable coupes and therefore the argument of possible bias by the researcher might reasonably be raised. This constitutes a serious potential source of bias: much more so than the subjective estimates for the three other classes that are at least close to (but not identical with), the average volumes/ha from the logged coupe outcomes. I do not believe that the argument of bias has substance. Nevertheless, there are ways of addressing it that should be pursued.

I recommend that the volumes/ha in the three classes for which there are samples be set equal to their area-weighted averages volumes/ha - to avoid any minor element of personal subjectivity in them. Then, for the 'Poor mature' class, take the two extremes - that 'Poor mature' is identical in volume/ha to 'Good mature' or that it is equal to 'Regrowth Rich' and recast the aggregate volumes for these two alternatives. This would also enable calculation of area-weighted standard errors for each class (or amalgamated class) and an overall aggregate standard error and sampling error to be established for each alternative, with accompanying statements of probabilities or odds in relation to the critical question.

The purist will rightly point out that the seven coupes do not represent a random or stratified random sample but this is an objection that tempers the entire report. It is the best and only sample we have and the sampling error of the weighted volume/ha estimates would at least provide some guidance as to the degree of dispersion of values. This sampling error is bound to be very large.

I therefore recommend that the outcomes be re-stated in terms of the approximate probabilities or odds pertaining to the mean value and bounds, rather than giving them the appearance of an absolute certainty.

For example, one could state that there is only 1 in ?? chance that the average volume is sufficiently high to meet the required annual yield.

5. Overview

This report provides a very useful and careful analysis of the resource. The points enumerated above are not likely to change the final outcome. Nevertheless, implementation of the recommendation regarding the final estimates would ensure that it is as free as possible from any allegation of personal subjectivity. I commend the principal author and the committee on the study.

Professor Ian Ferguson
21/02/2002

APPENDIX 10

Deep Red Myrtle Project – Addendum
Dr Steve Candy, Forestry Tasmania

1. Summary

As recommended in Professor Ferguson's Audit Report (21/2/02), section 4 - Volumes per Hectare, an area-weighted estimate of the total resource volume of Cat 4 sawlogs was calculated.

The standard error of this estimate was calculated as described below. The usual textbook calculation for stratified sampling was modified to incorporate the uncertainty in the stratum means for the poor mature and salvage strata. This is also described below.

The estimate for the total resource was 39 745 m^3. The standard error of estimate was 5 132 m^3 and an approximate 95% confidence interval is 16 693 m^3 or 42% of the estimate. The probability of the target harvest of 4 500 m^3 /yr over 16 years of the RFA period being achievable is less than 0.2% or in terms of odds is 446 to one.

2. *Statistical Methods*

Statistical analysis of recovered sawlog volumes from Table 7.1 of the report ; 'Review of the Deep Red Myrtle Resource in Tasmania' by Dr. R. Mesibov.

- As suggested in Prof. Ferguson's audit report, estimates of mean c4 volume per hectare and total volume for the resource as a whole were calculated using the formula for stratified sampling with statistical weights being the area of each stratum in the resource. Using the areas of the potential coupes the total area was 4423 ha. Using the c4 column in Table 7.1 as samples of size 3,0,2,2 coupes in each of the 4 strata identified in Table 7.2 the stratified, weighted estimate of the total resource was 39, 026 m^3 and the per hectare volume was 8.823 m^3/ha. The total resource estimate is slightly different (cf: Table 8.1) to the Report due to rounding of the per hectare means in Table 7.2 whereas here rounding was carried out on the total resource estimate.

- An estimate of the standard error of the stratified/weighted per hectare c4 volume estimate was obtained by calculating a pooled within-stratum variance using ANOVA in GenStat. Applying stratum weights and giving the unsampled 'Poor Mature' stratum the same variance as the 'Mature' stratum the standard error of estimate was calculated as 0.39 m^3/ha or 4.4% of the estimate. With only 3 residual degrees of freedom a 95% confidence interval is approximately +/-14%.

- To account for the extra uncertainty in the resource estimate of c4 volume, above that due to sample variation, due to (a) the lack of any sample coupes for the 'Poor

Mature'stratum and (b) the incomplete logging of coupe WH017B, the pooled variance for the 'Poor Mature' and 'Salvage' strata was augmented by adding an extra variance term specific to these two strata. The extra variance component for the 'Poor Mature' stratum was calculated so that the 95% coverage of a normal distribution corresponded to the range between the 'Good Mature' and 'Regrowth-Rich' stratum means in Table 7.2. Similarly the corresponding range of 1 m^3/ha to 2 m^3/ha (=double the value for the half of the coupe that was logged) for coupe WH017B was used to determine the extra variance term which was then divided by two to reflect the fact that two coupes were 'sampled' in the 'Salvage' stratum.

- Resource level statistics were then obtained using the augmented standard errors and the t-distribution. The resulting statistics for the per hectare volume of c4 logs were a standard error of 1.16 m^3/ha or 13.2% of the estimate, and a 95% confidence interval of approximately +/-42%.