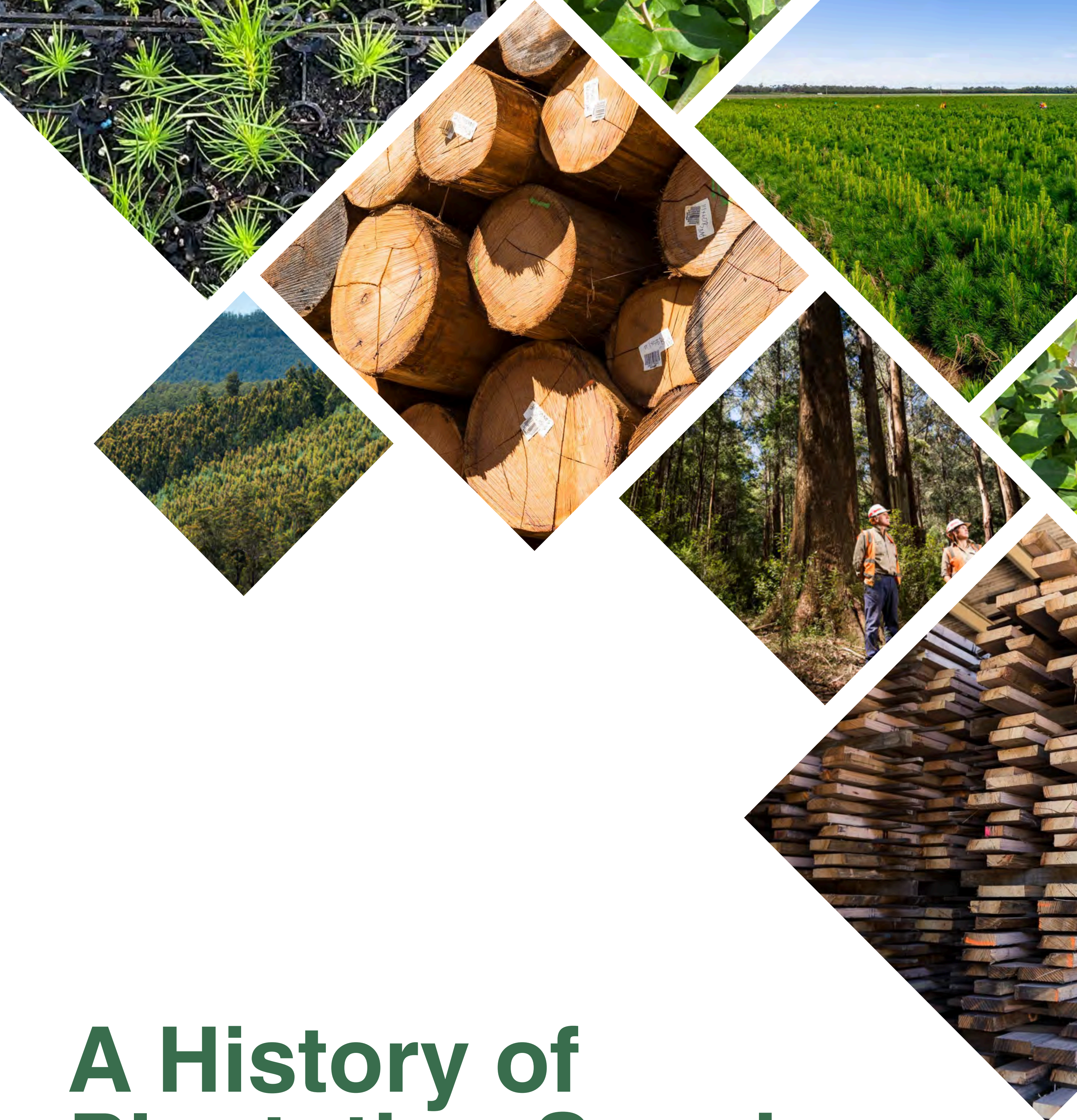

A History of Plantation Species in Gippsland

Prepared by Sylva Systems Pty Ltd.

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Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ACIAR	Australian Centre for International Agricultural Research
APM	Australian Paper Manufactures Limited
APMF	APM Forestry Pty Limited
APP	Australian Paper Plantations
ATO	Australian Taxation Office
ATSC	Australian Tree Seed Centre
ALRTIG	Australian Low Rainfall Tree Improvement Group
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCC	Department of Climate Change
DEECA	The Department of Energy, Environment and Climate Action
DELWP	Department of Environment, Land, Water and Planning
DNRE	Department of Natural Resources and Environment
FCV	Forests Commission, Victoria
GAN	Gippsland Agroforestry Network
GFD	Gippsland Field Days
GFP	Gippsland Farm Plantations Inc.
GIS	Geographic information system
GPF	Gippsland Private Forestry Inc.
ha	Hectare
HVP	HVP Plantations
LGA	Local Government Area
MAI	Mean annual increment
MIS	Managed investment schemes
NAP	National Afforestation Program
NPI	National Plantation Inventory
PSP	Permanent sample plot
RPC	Regional Plantation Committee
RPCs	Regional Plantation Committees
RTA	Radial Timber Australia
SEC	State Electricity Commission
SED	Small end diameter
SF	State forest
SFNSW	State Forests, NSW.
SSO	Seedling seed orchard
VFC	Victorian Forests Commission
VPC	Victorian Plantations Corporation

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Summary and recommendations

A summary

To support an understanding of the current status of a range of tree species for wood production in Gippsland, this report has made use of published information (e.g. peer reviewed papers), grey literature (e.g. accessible current and historic company reports) and personal insights (e.g. to identify reports to seek and specific company information).

Selection of the species of tree to establish in a plantation is the most fundamental decision required by a plantation manager, an investor or a farmer. A prudent party will seek to plant *the right tree in the right place* and a definition of 'right' is linked to the intent; a *laissez faire* approach is unadvisable. The intent of the trees planted must be defined to assist in decision making. Indeed, where the species of tree selected is to form part of a commercial enterprise, the Australian Taxation Office takes an interest and provides definitions linked to the taxation treatment of a tree planting; tree farming, as shelterbelts, a landcare operation or as carbon sink forests. Tree farming must have the intent to grow and sell outputs only as logs for a profit and planting of current commercial species with active markets can support this intent. In Gippsland *Pinus radiata*, *P. pinaster*, *Eucalyptus globulus*, *E. nitens* and *E. regnans* are the only species that have been fully commercialised through to supply of logs into active markets. While a range of other species are close to this point, they remain yet to compete a full rotation harvest and ongoing sales.

The plantation estate in the State of Victoria commenced development prior to Federation with hardwood and softwood species trialled. The intent was to provide resources with a specific focus on softwood species given a general lack of suitable natural forest softwoods. Very quickly, *P. radiata* was identified as the preferred species from a wide range tested and was included in operational plantings. At harvest, the alternative softwood species were replaced with this preferred species. While there were initial trials of a range of eucalypt species in plantations, a focus on hardwood plantations occurred more in the mid-1900s. This resulted in the Victorian estate being dominated by a single softwood species supported by research and genetic improvement. Public and private estates of *P. radiata* were developed.

Development of the Gippsland hardwood estate effectively commenced with an intent to undertake afforestation of the Strzelecki Ranges, which had been deforested for agriculture. Agriculture generally failed in that area and the farmers walked-off their land. Government and then private interests acquired the land and undertook the works, with *E. regnans* as a preferred species, with *P. radiata* planted on more exposed sites. In another case, a significant area of natural forest was destroyed by successive wildfires in 1926, 1932 and 1939 with the tree cover (the natural forest) lost. Initial attempts to reforest failed until more intensive silviculture (i.e. plantation establishment) was applied. In both cases, species choice was supported by research and Gippsland markets, defined wood type requirements.

The species planted in Gippsland plantations have come and gone in some cases; *P. pinaster* planted on poor quality sands replaced by *P. radiata* supported by improved genetics and silviculture, a short experiment with Poplars, *E. regnans* replaced by *E. nitens* and *E. globulus*. The *E. globulus* estate saw a rise and fall, with some plantations established on cleared agricultural land not replanted at harvest. Over this period, *P. radiata* remained the main species in commercial plantations. Guided by Victorian Government and company support programmes, there was a focus by small-scale growers on a core of commercial species in Gippsland as evident in the species by year planted data up to the mid-1980s. In the mid-1980s, there was a change with a plethora of other species planted by small-scale growers. This period corresponds with cessation of some Government support programmes which had a focus on a small number of commercial species. More recent promotion of trees into farming by parties without a link to a market, has again, broadened the number of species encouraged to be planted but with a lack of supporting information. Commencing in the early 2000s, a boutique plantation manager with a focus on durable and appearance grade timber species, selected a small cohort of species to develop. This was supported by research and a focus on the market. Species matching to site was a focus, and again, with experience, some species have come and gone by replacement with alternatives. A focus remains on a narrow range of eucalypt species.

Trials and demonstration plantings in Gippsland have been an ongoing activity (see Table 1). A significant series of species and provenance trials were established by private industry and Victorian Government agencies across 12 sites from 1986 to 1989. The trials included 36 eucalypt species with 140 seedlots. The trials were well managed and generated robust information on species performance at around age 10 to 12 years. This is a foundation to guide species selection by rainfall and soil type. The trials covered a range of sites, but excluding the Red Gum Plains (the area between Sale and Bairnsdale) which had proven unattractive for plantations at that time. A series of trials were established from 1999 in this area, including a species trial focussed on species more likely to cope with the environment and the routine fully commercial species at that time (*P. radiata*, *E. globulus* and *E. nitens*). While it unfortunate that this set of trials did not have continuous management nor adequate assessment, in general, *E. globulus* was the best performing species. A range of other trials were established at the same time and documented outcomes have not been identified. There have been a number of demonstration planting in Gippsland to showcase species to the community. The oldest is at the Lardner Park Field Days site with a succession of plantings and a range of species. While a useful visual resource, a lack of adequate records makes it difficult to provide quantitative based recommendations. Demonstration plantings in the Red Gum Plains area were undertaken in the early 2000s and based on satellite imagery, they remain in place. No records beyond initial establishment have been identified.

With an intent to harvest, regional tree productivity is a required tool to assist with species selection. There have been four regional land assessments for plantations since 1999; curiously later studies did not reference previous studies. These studies generated regional productivity mapping and applied analysis to determine the area of potential plantations. This included potential based on the value of plantation returns compared to agriculture, a focus on productivity driven by geology and rainfall, net mill door returns and suitability defined in qualitative terms. While useful, it is the potential performance of a species on a specific unit of land that will drive a decision to plant or not. Plantations managers have developed propriety productivity modelling tools to assist in this intent and there are publicly available tools which have been published.

Table 1: A summary of the trials and demonstration plantings identified in Gippsland.

Year		Title	Intent	Location	Snapshot
1983-85	Trial	The 150th Anniversary trials		Neerim South	Included 3 species.
1986-89	Trial	APM Forests & Govt trials	Species and provenance trial	12 sites across Gippsland.	Included 36 eucalypt species with 140 seedlots.
1996	Trial	East Gippsland Water trials	Irrigated and dryland species trial	Bairnsdale	Included *Corymbia maculata*, *E. saligna*, *E. botryoides* and *E. globulus*.
1999	Trial	Red Gum Plains Trial series	Species and provenance trial	Red Gum Plains area	Included 32 species of known provenance.
1999	Trial		Best bet management trial	Red Gum Plains area	Included 9 species on a short and long rotation, with and without thinning.
1999	Trial		Alternative silviculture trial	Red Gum Plains area	Pairing of 8 species for out-row thinning for firewood.
1999	Trial		A spacing trial	Red Gum Plains area	Stocking rates of 600, 900 and 1,200 stems/ha with *E. globulus* and *P. radiata*.
2006	Trial	Species and provenance trial			Included 4 species of interest in Gippsland with known provenances; *C. maculata*, *E. muellerana*, *E. botryoides* and *E. saligna*.
1978	Demonstration	Lardner Park Field Days	A range of species and management		An eclectic mix of species and management with a number of years of planting.
1999	Demonstration	Bairnsdale Aerodrome	A range of species		A range of 30 species of known provenances
2003&04	Demonstration	Indigenous species demonstration plantings	A range of species		Included 7 species planted on 6 sites

Beginning with the end in mind, wood properties are a fundamental consideration with species selection. The ability to sell the logs grown will depend on whether they are of a wood required by a target market. For example, while pulpwood can be regarded as a by- or fall-down product by some, the process of pulping and therefore the market is very specific as to species. A current export woodchip operation in Geelong part supplied by Gippsland, has a preference for *E. globulus* and *E. nitens*; it can take other eucalypt species subject to meeting quality requirements. For sawn timber production, utility of the resulting boards can be defined quantitatively by wood type (softwood or hardwood), density, hardness, strength, durability and sapwood susceptibility to Lyctid borer. Reliance on information on wood properties for natural forest trees as a guide to species is problematic. A plantation grown tree of the same species is likely to reach a target log 'size' in a shorter period. With the number of sapwood rings on the outer edge of a log set at around five, this means that the percent of log volume that is sapwood will increase, changing the absolute and relative log properties. This has implications, particularly in regard to sawn timber for appearance grade markets, as Australian Standard (AS 5604-2005) for Lyctid susceptible species prohibits inclusion of any sapwood in boards.

In conclusion, Gippsland has a long history of tree species planted with dynamic introductions and replacement informed by performance (e.g. growth) and market requirements. In general, a lack of market focus has resulted in a wide range of species of unknown performance nor a ready market; a summary is presented in Figure 1.

		Region	
		Current	Novel
Tree species	Current	**More of the same: current plantation zones** The same species as grown and supplied into existing supply chains / markets. • Current: *E. globulus*, *E. nitens* & *P. radiata.* • Superseded: *E. regnans* & *P. pinaster.*	**New horizons: dryer areas of Gippsland** A proven commercial and accepted species is grown in a new location. • Fully commercial: None through to final harvest and routine resource supply • Wood properties proven: None. • Improved genetics available: Perhaps not site specific? • Growth insights: For *E. globulus*, *E. nitens* & *P. radiata.* • Site: An understanding of the impact of site soils for these species.
	Novel	**A new kid on the block**: new species A new species in a region. Will require alternative supply chains and markets where cannot supply into existing markets. Markets for thinning are critical. • Fully commercial: None through to final harvest and routine resource supply. • Wood properties: Not proven. • Improved genetics: Some proprietary owned under development. • Form: Issues with tree form for *E. botryoides* & *E. bosistoana* are noted. • Productivity: Species with potential; *E. bosistoana*, *E. botryoides*, E. cladocalyx, *E. muellerana*, *E. sieberi* & *C. maculata*.	**A blue sky pioneer: dryer areas of Gippsland** A new species in a new region with nil or limited species experience nor current local processing capacity. • Fully commercial: None through to final harvest and routine resource supply. • Wood properties: Not proven. • Improved genetics: Some proprietary owned under development. • Form: Issues with tree form for *E. botryoides* & *E. bosistoana* are noted. • Productivity: Species with potential; *E. benthamii*, *E. botryoides*, *E. muellerana*, *E. smithii* & *C. maculata*.

Figure 1: A species experience by location matrix which defines requirements for current and new species in current and new locations as a summary of the species status in Gippsland.

Recommendations

Based on this review, the following are recommendations to consider in support of plantations in Gippsland.

Part A: Ongoing management of trials and demonstration plantings.

- Site management: There is a need to facilitate professional management of the cohort of trials and demonstration plantings scattered across Gippsland. Many of these sites have been developed by investment of public funds and remain 'lost'.
- Sunset clauses: Any development of trials and demonstration planting should be guided by an intent to capture all information to a professional standard and that this information must be made available at the end of a period of responsibility by a party. This should be defined in any legal agreements as a 'sunset clause'.

Part B: An information base.

- A regional plan: A Gippsland-wide plan is required to focus plantation development. This should include development of business cases for the species planted or proposed to be planted, with a focus on markets and performance. A key point is to work towards a commercial scale 'critical-mass' estate for a narrow range of species rather than the current *laissez faire* and unstructured approach. This should be informed by species performance, wood properties and potential products. While a grower would have the option to plant any species, this approach would make species selection informed and targeted.
- Advice: All advice to growers must be evidence based and transparent as to the true stage of development of a novel species in Gippsland. This can be supported by the cohort of available information and insights. Logically, advice would be linked to a regional plan for a species or range of species.
- Mapping and assessment: There are a number of important demonstration plantings and trials in Gippsland. The current owners of the sites should be contacted to commence a process of salvaging of insights and lessons. These sites should be mapped (e.g. making use of remote sensing and on-ground approaches), the current state documented and reviewed. If appropriate, an inventory programme should be undertaken.
- Wood properties: Given the fundamental importance of wood properties and the presence of a range of species at an older age (a longer rotation), non-destructive and destructive wood sampling should be undertaken. This would provide invaluable advice towards species commercialisation; for example, the width of hardwood sapwood rings. The approach should be similar to that undertaken by the Department of Primary Industries and Regions, South Australia, with the Green Triangle Forest Industry Hub.
- Processing and products: The age of many of the trees in trials and demonstration planting provides an opportunity to process sample logs to explore recovery rates and product potential.
- Productivity mapping: A publicly accessible land-productivity tool should be developed. This can be presented on a public-access GIS platform and should be underpinned by process-based models of productivity. The approach should be similar to that undertaken by the Department of Primary Industries and Regions, South Australia, with the Green Triangle Forest Industry Hub.

Introduction

Species selection

The history of the Victorian plantation estate is presented in Appendix 1 and to assist in understanding the commercial status of a species, the steps towards commercialisation are presented in Appendix 2. Given the focus on tree species, Appendix 3 presents the nomenclature of the species considered in this report. In regard to species details (e.g. scientific name), these are based on Boland *et al.* (1984) and Bootle (1996).

Species choice is a fundamental decision defining potential future outcomes in regard to yield, products and markets, and therefore grower returns. This is central to any discussion of the future of plantation development in Gippsland. While local experience is critical, it is possible to consider species opportunities based on other regions and match the biophysical requirements of a species; that is, the climate required. A range of authors provide guidance to species selection. For example, Brown and Hall (1968, Table 10.1) present a list of 101 of the most important species for use on farms in southern Australia at that time. Reference guides can be climate zone specific (e.g. for northern Australia, Hearne, 1975; for dry country, Hall *et al.*, 1972, p.270-282), for a specific state (e.g. for South Australia, Boomsma, 1975, p.131-154; for Victoria, Race, 1993, p.120-122, Table 1&2) or a locality within a state (e.g. north-east Victoria, Washusen & Reid, 1996, p.109-140). Other guides are silent on species options and offer guides to a general regime (e.g. Abel, 1997, p.10).

Key definitions

The issue of species has broad implications. Species planted is important in regard to primary production status from a taxation perspective (Jenkin, 2023, p.85&86). The Australian Taxation Office (ATO) considers that trees planted for amenity are not part of primary production whereas trees planted as shelterbelts are, as these benefit a farming enterprise. The definitions of tree growing systems as applied by the ATO are presented in Box 1 and these are fundament to the financial treatment of a tree planting. A forest operation is a form of primary production and has the intent to harvest the trees grown and sell the resulting logs for a profit. Activities are organised and run in a business-like way, including actively maintaining the trees with an objective to improve tree growth (ATO, 2022, p.1). Forestry operations include growing, harvesting and haulage to the place of first processing (provided that this is on behalf of a grower), but specifically excludes onsite processing into woodchips. By this requirement, forest operations are limited to growing and recovery of logs for sale to another party. The intent to harvest and maintain the planted trees can be documented in a business plan for a tree growing enterprise and in silvicultural management plans. The intent to harvest can be underpinned by selection of local commercial plantation species with current and active markets.

The definition of a plantation is an important consideration. There is a general segmentation of planted trees into plantations and trees into farming, and the Victorian Government, in the Code of Practice for Timber Production 2022 (DELWP, 2022), provides definitions (see Box 2). There is no Code regulation covering agroforestry, and small plantations or woodlots, of 5 ha or less (DELWP, 2022, p.26&27). An implication is that timber can be legally harvested and sold on a small-scale basis potentially without official documentation. The National Plantation Inventory (NPI) reports on the Australian planted forest estate and segments the areas into plantations and farm forestry (see Box 2).

Box 1: A breakdown of the classification of tree growing activities from an ATO perspective.		
Activity	Description	Reference
Tree farming (forestry operations)	*'To be carrying on a tree farming business, you must intend to harvest the trees to sell at a profit. Your activities must be organised and run in a business-like way. This, amongst other things, requires you to actively maintain the trees. It does not apply to:* • *trees planted for other purposes, such as to provide protection (shelterbelts), for carbon sequestration or horticulture* • *participants in forestry managed investment schemes.'*	ATO (2023a, p.1)
Shelterbelts	*'A shelterbelt is a line of trees or shrubs planted to protect an area from fierce weather. Shelterbelts can be used to:* • *protect crops and livestock* • *improve biodiversity* • *prevent or fight land degradation – for example, soil erosion or degradation of vegetation.'*	ATO (2021, p.1)
Landcare operations	*'Landcare operations help protect and contribute to the conservation and long-term sustainable growth of land-used for growing crops or grazing farmland – but is not focused on conserving natural water resources. A landcare operation is something you do to:* • *remove animal pests from the land* • *remove or destroy plant growth that is harmful to the land* • *prevent or combat degradation to the land (e.g. soil erosion).'*	ATO (2023b, p.1)
Riparian maintenance	*'Riparian maintenance is something you do to stabilise and protect the banks and land next to creeks, streams and other waterways. These works can include:* • *fencing* • *revegetation* • *off-stream stock watering* • *weed and pest management.'*	ATO (2023b, p.1)
Carbon sink forests	*'Carbon sink forests are established for the primary and principal purpose of carbon sequestration. Carbon sequestration is the process by which trees absorb carbon dioxide from the atmosphere for greenhouse gas abatement.'*	ATO (2019)

A softwood or a hardwood

An important aspect of utilisation of the wood grown in plantations in Gippsland is an understanding the difference in wood properties of a softwood and a hardwood species. A species is either a softwood or a hardwood, and this is an absolute attribute that does not change regardless of management. The differences between a hardwood and softwood part defines the end-use of the wood grown and links to the intent of establishing a specific species. There are biological and end-use differences and Box 3 presents the main attributes for plantation grown trees.

This report

Supporting the expansion of the Gippsland plantation estate can be informed by current and past plantation experience (see Appendix 1: The history of plantations in Victoria). The following document explores the Gippsland plantation species experience with a focus on species planted and productivity. It has been prepared based on published and grey literature, the search for which was informed by significant experience in the region. To support placing the status of species into perspective and a framework to present outcomes, Appendix 2: Species domestication and commercialization presents the process of commercialisation of a species from a natural forest tree, to a commercially proven plantation species; recall the importance of commercial status to the taxation treatment of a plantation enterprise.

Box 2: The definitions applied by the Victorian Code of Practice for Timber Production 2022 and the NPI.			
Term		Narrative	Reference
'agroforestry'		*'Means the simultaneous and substantial production of forest and other agricultural products from the same land unit (defined in the Victoria Planning Provisions).*	DELWP (2022, p.7)
'plantation'		*'Means managed stands of trees of either native or exotic species, planted or sown primarily for timber production purposes'*	DELWP (2022, p.17)
Plantations	*'Industrial plantations'*	*'The term 'industrial plantations' has been introduced into this report to differentiate between traditional large plantation growers reported in previous NPI reports, and farm forestry growers that are now also being reported. The collection and reporting of industrial plantation data is the province of the NPI. Information collected on industrial plantations focuses on growers who manage a combined total estate of greater than 1,000 hectares. This may include joint ventures where one partner is a large grower. However, industrial companies with plantation estates smaller than 1,000 hectares are also included.'*	Wood *et al.* (2001, p.6)
	Plantation	*'An intensively managed stand of trees of native or exotic (that is introduced) species established by the regular placement of seedlings or seeds, usually to produce timber. The NPI currently does not collect data on plantations established primarily to produce eucalyptus oil, sandalwood oil, bioenergy, carbon or other non-timber products or services.'*	Legg et al. (2021, p.74)
		'Intensively managed stand of trees of either native or exotic species, created by the regular placement of seedlings or seeds usually planted at the same time and usually of the same species.'	Daian *et al.*, (2022, p.vii)
	'Commercial plantation'	*'Area of hardwood or softwood plantations managed commercially to supply logs to wood-processing industries for the manufacture of wood products, with estates usually exceeding 1,000 hectares. Commercial plantations are reported through Australia's National Plantation Inventory.'*	Daian *et al.*, (2022, p.vi)
Farm forestry	*'Farm forestry'*	*'The term 'farm forestry', as used in this report, applies to plantations that are owned outright by individuals with total plantation estates less than 1,000 hectares. This is generally considered the small grower sector and is consistent with the operating guidelines for data collection and reporting under the NFFI. This definition does not include other recognised elements of farm forestry such as private native forest management, and joint ventures and annuity schemes. A broader assessment of farm forestry, including the extent of plantations established through joint ventures or leasehold arrangements, is reported at the national level.'*	Wood *et al.* (2001, p.6)
		'Establishment or management of planted trees, usually in rows and which meet the definition of forest, with timber production as a primary management intent, on individual private landholdings with a total area of plantings usually less than 1,000 hectares. Also referred to as farm forestry plantations.'	Daian *et al.* (2022, p.vi)

Box 3: A summary of the two broad types of trees for planting in a plantation.

Attributes	Softwoods	Hardwoods
Reproduction	Plants producing cones (e.g. *P. radiata*).	Plants producing flowers (e.g. *E. globulus*).
Wood basic density	*P. radiata* basic density of 404 kg/m^3 (age 10 y) to 485 kg/m^3 (age 30 - 40 y).	Plantation grown *E. globulus* basic density of 482 to 547 kg/m^3.
Carbon storage	For Victorian and NSW *P. radiata* 0.84 t/m^3 CO_2-e (at age 30 y).	For Western Australian *E. globulus* 1.05 t/m^3 CO_2-e (at age 10 y).
Paper making	Long fibres give paper strength (e.g. tissue paper).	Short fibres give paper a smooth surface (e.g. photocopy paper).
Reconstituted products	Wood based panels made from thinnings and clearfall logs.	Wood based panels.
Saw and veneer logs	Roundwood harvested for timber framing materials through to furniture.	Natural forest sourced roundwood harvested for framing materials through to furniture. Emerging use of plantation grown resources.
Bio-energy (by combustion)	A calorific value of 21 MJ/kg for oven-dry softwood.	A calorific value of 19 MJ/kg for oven-dry eucalypt wood.

- Wood density: From Ilic *et al.* (2003) and Sylva Systems Pty Ltd data sets of published information.
- Carbon storage: Calculated based on DCC (2008, p. 57) assuming a basic density of 440 kg/m^3 and 550 kg/m^3 for *P. radiata* pine and *E. globulus* respectively. A carbon in dry wood ratio of 52% was applied with an assumed ratio of 3.67 CO_2:C.
- Bio-energy (by combustion): Bio-energy includes firewood, the use of residues in boilers and purpose grown trees. See Bootle (1996, p.209) for data.

The early Victorian plantation estate

Summary

Development of the Australian and Victorian plantation estate (commencing prior to Federation) was motivate by a need for timber resources, particularly softwoods. This was driven by an abundance of native forest hardwoods and a lack of extensive native forest softwoods. The intent of the early estate also included provision of bark for tanning. Experience with species of interest commenced with botanical garden collections; for example, *Pinus radiata* (Radiata pine) was planted in the Sydney Botanic Gardens in 1857 and by 1858, in the Melbourne Botanic Gardens. While a broad range of softwood species were tested in trials and over full rotations, *P. radiata* became the dominant softwood species in south-eastern of Australia. Indeed, by 1891 it was noted that *P. radiata* was widely distributed across the colony of Victoria. Reflecting an intent of a suitable resource, wood properties of softwoods were tested. It is useful to note that research on softwood species options continued into the mid-1900's. With an intent of afforestation of the Strzelecki Ranges, a range of eucalypt and softwoods species were tested in that region resulting in *P. radiata* and *Eucalyptus regnans* (Mountain ash) as the preferred species. Following expanding settlement, species trials and demonstration plantings were undertaken in the Mallee and Wimmera, with a focus on species utility. Overall, the species selection process commenced with the nature of the target wood attributes and then explored and eliminated species options. Review of species operational outcomes formed part of the process. The importance of demonstration plantings was noted as a strategy to raise awareness and communicate species options and outcomes.

Introduction

The importance and process of species selection can be informed by consideration of the path followed during the initiation and development of the plantation estate in Australia and Victoria (commencing prior to Federation). This section of the report makes use of a range of historic documents and sources to provide a snap-shot of the process to highlight the key insights and attributes.

Development of Australia's plantation estate

The introduction of softwoods

Plantation development in the Commonwealth of Australia was a national objective in support of overall forest management and resource security (Box 4). The nature of natural softwood (see Baker and Smith, 1910; Baker and Smith, 1924) and hardwood (see Baker, 1919) species were well documented. Developing Australia's plantation estate focused on addressing a general lack of native coniferous wood (Rule, 1967, p.106). The first documented importation of *P. radiata* planting materials occurred in 1857 with a single specimen received for planting in the Sydney Botanic Gardens (Rule, 1967, p.116). Fielding (1957, p.15) provides further insights on the introduction of *P. radiata* and concluded that it was not known when the first introductions occurred. The first record of the species in Australia was in an 1857 'Report of the Director' of the Sydney Botanic Gardens listing plants and seed received in 1857 via the vessel Duncan Dunbar. It is possible that the species arrived in Melbourne via the same vessel as the Melbourne Botanic Gardens reported the species as a plant growing in 1858 (in the 'Report of the Government Botanist to Parliament, 1858' by Baron Ferdinand von Mueller). An 1891 note by von Mueller stated that the species was *'most extensively distributed through the Colony of Victoria and also some other parts of Australia since 1859….'* (Fielding, 1957, p.15). Development of the first plantations of *P. radiata* occurred in 1876 in South Australia (Rule, 1967, p.118) with the first log processed in 1903 into 28 apple cases (Lewis, 1975, p.24). In NSW with a focus was on tannin bark production, the first experimental plantings in 1882 by the Forestry Branch were of acacia species along a railway reserve and with the first *P. radiata* plantation planted between 1883 and 1885 (Grant, 1989, p.147 to 150).

Box 4: A statement in the Official Year Book of the Commonwealth of Australia, for the period 1901 to 1914 (Knibbs, 1915, p.379).
*'**1. Objects.**—Economic forestry, aiming at the conservation of forestal wealth by safeguarding forests against inconsiderate destruction, and by the suitable re-afforestation of denuded areas, is essential to the preservation of industries dependent upon an adequate supply of timber, and to the perpetuation of a necessary form of national wealth. Though in Australia large areas of virgin forests still remain, the inroads made by timber-getters, by agriculturists, and by pastoralists—who have destroyed large areas by 'ring-barking'—are considerable ; and it is not unlikely that climatological changes are caused thereby. It is stated that beneficial consequences follow on the planting of trees on denuded lands, or along eroding coasts, and that a forest covering tends to beneficially regulate the effects of rainfall.* *Successful planting of exotics in various parts of the Commonwealth has demonstrated that the Australian climate is suitable for the cultivation of a large number of the most valuable and beautiful of the world's timber trees.'*

A focus on softwood plantations

Softwood plantations were regarded as an option for sites not suited to agriculture to provide great benefit to the nation. Many *Pinus* species where known to grow satisfactorily on relatively poor sandy soils with mean annual rainfall of less than 730 mm/y. Simpfendorfer (1966, p.10) suggested a potential ability of *P. radiata* to capture and condense wet fog in its natural environment to supplement rainfall. Citing Johnson (1964), Simpfendorfer (1966, p.10) noted that the needle structure can absorb moisture from dew or fog, which explained the survival of *P. radiata* in a rainfall zone noted as marginal for Southern Australia. On such sites, eucalypt species had low productivity, whereas softwoods had higher productivity. The priority of softwoods over eucalypts was driven by productivity noting that the main softwood species grown in Australia at that time matured within 40 years, whereas the better types of eucalypts require double that length of time (Carver, 1958, p.976). A consistent theme is species selection based on an intended product outcome. In support of plantation species selection, the timber properties of 21 species were reported on in 1922 after testing at an Adelaide University laboratory; the species included plantation grown *P. radiata*, *P. pinaster* (Maritime pine) and *P. canariensis* (Canary Island pine) (Chapman, 1922, p.3).

In 1906, the national plantation estate was 7,787 ha (Knibbs, 1908, p.379) composed of a wide range of species on a state by state basis. After 50 years (as at 30th June, 1957), the total net area of Commonwealth and State softwood plantations was 140,330 ha and the privately softwood estate was c.39,660 ha. The hardwood estate (mainly eucalyptus spp.) was c.12,140 ha (Carver, 1958, p.974).

The early Victorian estate

Motivations for species planted

The species selected for planting in plantations had a specific purpose of providing softwood resources. The Victorian Forests Commission (VFC) noted in 1928 a threat of serious shortages *'in the world's supplies of coniferous timbers in the near future'* (Anon, 1928b, p.55&56). The commencement of plantations in Victoria was in response to concerns for domestic resource security as follows (Carron, 1990, p.12). *'The first stimulus to the establishment of plantations in Australia arose from the discovery and mining of gold in Victoria in the 1850s. The large-scale destructive cutting of forests to meet the voracious demands of a rapidly expanding population and a frenetic mining industry prompted an otherwise unlikely troika of the Surveyor General, the Assistant Commissioner of Lands and Survey and the Secretary for Mines to strongly recommend in 1865 that the Government establish plantations of indigenous and exotic species. ......Twenty years after the first nursery was* *established at Mount Macedon in 1872, there were 1,000 hectares of plantations fed by nurseries at Creswick, Havelock, Gunbower Island and the You Yangs, mainly of hardwoods but with increasing use of radiata pine which had shown sufficient promise for commercial planting to begin in the Macedon area in 1880.'*

For species selection, a market demand focus was combined with growth performance (rapid early growth), immunity from disease, 'hardy habit' and the limiting factors of climate and soil in the areas available for planting, noting that *'very few species fulfil the required conditions'* (Anon, 1928b, p.55&56). Species selection considered indigenous species. Ferguson (1957, p.22) noted that '*[o]f the two indigenous coniferous genera Callitris and podocarpus, the latter is of no commercial importance and the former contributes in a very minor degree to the timber economy of the state. It was decided at an early stage that this deficiency would have to be rectified by the establishment of plantations of suitable species, and the earliest plantings on an experimental scale were undertaken about 1880.*' Algar (1988, p.210) suggested that the first commercial plantation was of *P. radiata*, followed by two other plantations intended to provide work for unemployed miners due to a decline in gold production and to rehabilitate sluiced areas in the Ovens Valley. The suitability of *P. radiata* was confirmed in later plantings with some failures in coastal areas.

Early hardwood species considered

An 1890 account of species with potential for plantation development in Victoria (Conservator of Forests, 1890, p.12&13) noted; *'Of the 170 species of eucalyptus scientifically described, probably 70 would be found of sufficient cultural importance to warrant planting for industrial purposes, and it is also quite within the bounds of possibility that some 20 or 30 more might be improved by cultivation. It will thus be seen that we have no reason to doubt our capacity for raising or cultivating eucalypts for mining or other purposes when we have so large a range to select from.'* A short list of 13 species suitable for planting for both mining and industrial pursuits was presented at that time (Conservator of Forests, 1890, p.12&13). Table 2 presents a list of these species and documents the other species noted as part of the early plantation estate development.

Species of potential and trials

General trials

Based on outcomes, commercial plantations in 1928 were noted as dominated by a limited number of proven species suited to Victorian soils and climate as a result of trials which commenced c. 40 years previously (Anon, 1928b, p.55). These species are presented in Table 2. As a risk-management strategy, parallel with proven species, the need for species diversity was noted in 1928. This included the VFC continuing with trials of exotic species (Table 2) (Anon, 1928b, p.56). Some species showed zone promise; for example, *Pseudotsuga menziesii* (Dougals fir) and *Picea sitchensis* (Sitka Spruce) in the Ovens Valley, Macedon, and Aire Valley districts (Anon, 1928a, p.38). An important point is the time over the species were 'proven'; based on trials (Anon, 1928b, p.55) or operational plantings at age 45 years (Anon, 1928a, p.38). In 1928 it was concluded that *'almost without exception, an outstanding feature of the plantations has been the consistently successful growth of P. insignis [P. radiata]'* (Anon, 1928a, p.37) with a site specific recommendation to plant of *P. pinaster* in maritime regions (Anon, 1928a, p.38). Ferguson (1965, p.22) concluded that *'From observations of subsequent growth, it has now been determined that the only species worth persevering with so far as extensive planting is concerned is Pinus radiata which has proved itself adaptable to all sites available, makes rapid growth, is hardy and produces a good quality general utility limber. Many of the areas originally planted with other conifers are now being converted to Pinus radiata.'* Examples of species replaced by *P. radiata* at clearfall after 20 to 30 years-experience included in 1933; *Abies alba* (Silver fir), *Calocedrus decurrens* (Californian incense cedar), *Sequoia gigantea* (Giant sequoia) and *Tsuga heterophylla* (Western hemlock), and in 1934, *Chamaecyparis lawsoniana* (Lawson's cypress) (FCV, 1957, p.9-23). While a focus remained on *P. radiata*, the commercial species planted in Victoria in 1957 included *P. sitchensis*, *P. nigra* (Austrian pine), *P. pinaster*, *P. ponderosa* (Western yellow pine), *P. menziesii (*FCV, 1957, p.9-23). Trials of softwood species continued in Victoria and identified a range of species (Table 2) *'considered worthy of trial plantings on a commercial scale'* (Ferguson, 1965, p.22).

Specific sites

A need to consider the full range of intent of the trees planted (e.g. for production of timber or as shelterbelts) as well as site suitability was noted by Ferguson (1945, p.13) who advised making use of *'an examination of established trees growing in the neighbourhood*'. The need for an evidence based species selection was reiterated with a focus on proven and reliable species for a specific site. The search for suitable species expanded in response to development of new regional settlements. There was a specific focus on trees suited to dryer conditions in the Mallee and Wimmera, with a purpose of providing shade and shelter trees, and timber for general farm requirements. Native hardwood species plantations were established to demonstrate the comparative value of different species in the area and in 1928 that there were over 1,200 ha established (Anon, 1928b, p.60). This highlights the importance of demonstration plantings as a tool to communicate species potential.

Experiments to determine the most suitable species for afforestation (after deforestation for agriculture) of the Strzelecki Ranges in Gippsland commenced in 1944. The softwoods included *Araucaria cunninghamii* (Hoop pine), *P. sitchensis* and *P. menziesii*, and *P. radiata.* The eucalypts included were *E. regnans*, *E. globulus* (Blue gum), *E. sieberi* (Silvertop), *E. delegatensis* (Alpine ash), *E. viminalis* (Manna gum) and *E. muellerana* (Yellow stringy bark). Consistent with broader state-wide outcomes *P. radiata* was the most suitable softwood, and *E. regnans* as the most suitable eucalypt (Noble, 1976, p.37).

Operational plantations

A target softwood estate of c.72,800 – 80,900 ha, planting of c.2,000 ha/y with an average rotation of c. 35 years, was set and in 1928, the target had not been met but it was noted that the '*the programme is steadily extended from year to year'* (Anon, 1928a, p.34). At this time, the VFC softwood plantations were located *'over a widely divergent series of climatic and soil conditions'* (Anon, 1928a, p.34); see Box 5. Other developments included a novel plantation estate developed with the assistance of the VFC; the State School Endowment Plantation Scheme inaugurated in 1923 under the auspices of the Education Department (Anon, 1928b, p.56).

Box 5: A snap shot of the 1928 plantation estate in Victoria (based on Anon, 1928a, p.34).	
Node	Narrative
Ovens Valley District	A high altitude and rainfall zone with c. 8,000 ha in 1928 and expanding at 280 ha/y.
The Anglesea area	A coastal region of comparatively low rainfall and poor soils with 14,200 ha expanding at 400 ha/y.
Aire Valley	In 1928 a plantation node of 4,050 ha was noted to be developed.
Other nodes	Ballarat (ex-mining sites), Mount Difficult (on sandy flats in the Grampians), Creswick, Waarre (includes the Heytesbury plains) and Macedon.

Table 2: A snapshot of the commercial and alternative species planted; note that current species names are used rather than the species names at the time reported.

Year	Scientific name	Common name	Sites	Basis	Reference
1890	*E. capitellata*	Stringy-bark	Victoria	Potential at that time	Conservator of Forests, (1890, p.12&13)
	E. cladocalyx	Sugar-gum	Victoria	Potential at that time	Conservator of Forests (1890, p.12&13)
	E. globulus	Blue gum	Victoria	Potential at that time	Conservator of Forests (1890, p.12&13)
	E. leucoxylon	Iron bark	Victoria	Potential at that time	Conservator of Forests (1890, p.12&13)
	E. macrorhyncha	Stringy-bark	Victoria	Potential at that time	Conservator of Forests, (1890, p.12&13)
	E. marginata	Jarrah or Redgum	Victoria	Potential at that time	Conservator of Forests, (1890, p.12&13)
	E. muellerana	Yellow stringybark	Victoria	Potential at that time	Conservator of Forests, (1890, p.12&13)
	E. obliqua	Stringy-bark (common)	Victoria	Potential at that time	Conservator of Forests, (1890, p.12&13)
	E. polyanthemos	Red Box (Victoria),	Victoria	Potential at that time	Conservator of Forests (1890, p.12&13)
	E. rostrata	Redgum	Victoria	Potential at that time	Conservator of Forests (1890, p.12&13)
	E. siderophloia	Iron bark	Victoria	Potential at that time	Conservator of Forests (1890, p.12&13)
	E. sideroxylon	Iron bark	Victoria	Potential at that time	Conservator of Forests (1890, p.12&13)
	E. viminalis	Manna or white gum	Victoria	Potential at that time	Conservator of Forests (1890, p.12&13)
1928	*Araucaria cunninghamii*	Norfolk Island pine	Victoria	Alternative	Anon (1928b, p.56)
	E. cornuta	Yate	Mallee / Wimmera	Demonstration	Anon (1928b, p.60)
	E. botryoides	Mahogany gum	Mallee / Wimmera	Demonstration	Anon (1928b, p.60)
	E. citriodora	Lemon scented gum	Mallee / Wimmera	Demonstration	Anon (1928b, p.60)
	E. cladocalyx	Sugar gum	Mallee / Wimmera	Demonstration	Anon (1928b, p.60)
	E. globulus	Blue gum	Mallee / Wimmera	Demonstration	Anon (1928b, p.60)
	E. leucoxylon	White Ironbark	Mallee / Wimmera	Demonstration	Anon (1928b, p.60)
	E. marginata	Jarrah	Mallee / Wimmera	Demonstration	Anon (1928b, p.60)
	E. sideroxylon	Red Ironbark	Mallee / Wimmera	Demonstration	Anon (1928b, p.60)
	P. radiata	Monterey pine	Victoria	Commercial at that time	Anon (1928b, p.55)
	P. nigra	Corsican pine	Victoria	Commercial at that time	Anon (1928a, p.38); Anon (1928b, p.55)
	P. pinaster	Maritime or Cluster Pine	Victoria	Commercial at that time	Anon (1928b, p.55)
	P. ponderosa	Western yellow or Bull Pine	Victoria	Commercial at that time	Anon (1928a, p.38); Anon (1928b, p.55)

Year	Scientific name	Common name	Sites	Basis	Reference
	P. canariensis	Canary Island Pine	Victoria	Commercial at that time	Anon (1928b, p.55)
	Poplars		Victoria	Alternative	Anon (1928b, p.56)
	Pseudotsuga menziesii	Douglas Fir or Oregon	Victoria	Commercial at that time	Anon (1928b, p.55)
	Quercus suber	Cork Oak	Victoria	Alternative	Anon (1928b, p.56)
	Willows		Victoria	Alternative	Anon (1928b, p.56)
1933	*Abies alba*	Silver fir	Victoria	Commercial at that time	FCV (1957, p.9-23)
	Calocedrus decurrens	Incense cedar	Victoria	Superseded by P. radiata	FCV (1957, p.9-23)
	Sequoiadendron gigantea		Victoria	Superseded by P. radiata	FCV (1957, p.9-23)
	Tsuga heterophylla	Western Hemlock	Victoria	Superseded by P. radiata	FCV (1957, p.9-23)
	Chamaecyparis lawsoniana	Lawson’s cypress	Victoria	Superseded by P. radiata	FCV (1957, p.9-23)
1944	*A. cunninghamii*	Hoop pine	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	E. delegatensis	Alpine ash	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	E. globulus	Blue gum	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	E. muellerana	Yellow stringy bark	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	E. regnans	Mountain ash	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	E. sieberi	Silvertop	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	E. viminalis	Manna gum	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	P. radiata	Radiata pine	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	Picea sitchensis	Sitka spruce	Strzelecki Ranges	Experimental	Noble (1976, p.37)
	P. menziesii	Douglas fir	Strzelecki Ranges	Experimental	Noble (1976, p.37)
1957	*P. nigra*	Corsican pine	Victoria	Commercial at that time	FCV (1957, p.9-23)
	P. pinaster	Maritime or Cluster Pine	Victoria	Commercial at that time	FCV (1957, p.9-23)
	P. ponderosa	Western yellow or Bull Pine	Victoria	Commercial at that time	FCV (1957, p.9-23)
	P. radiata		Victoria	Commercial at that time	FCV (1957, p.9-23)
	P. sitchensis		Victoria	Commercial at that time	FCV (1957, p.9-23)
	P. menziesii		Victoria	Commercial at that time	FCV (1957, p.9-23)
1965	*P. canariensis*	Canary Island pine	Victoria	Experimental	Ferguson (1965, p.22)

Year	Scientific name	Common name	Sites	Basis	Reference
	P. muricata D. Don	Prickle pine	Victoria	Experimental	Ferguson (1965, p.22)
	P. nigra var. laricio	Corsican pine	Victoria	Experimental	Ferguson (1965, p.22)
	P. pinaster	Maritime pine	Victoria	Experimental	Ferguson (1965, p.22)
	P. ponderosa	Western yellow pine	Victoria	Experimental	Ferguson (1965, p.22)
	P. radiata	Radiata pine	Victoria	Experimental	Ferguson (1965, p.22)
	P. sitchensis	Sitka Spruce	Victoria	Experimental	Ferguson (1965, p.22)
	P. menziesii	Douglas fir	Victoria	Experimental	Ferguson (1965, p.22)
	Sequoia sempervirens	Redwood	Victoria	Experimental	Ferguson (1965, p.22)
1971	*E. bicostata*		Gippsland	Experimental	Cromer (1971)
	E. bicostata X E. viminalis	A natural hybrid	Gippsland	Experimental	Cromer (1971)
	E. delegatensis	Alpine ash	Gippsland	Experimental	Cromer (1971)
	E. fastigata	Brown barrel	Gippsland	Experimental	Cromer (1971)
	E. globulus	Southern blue gum	Gippsland	Experimental	Cromer (1971)
	E. quadrangulate	White-topped box	Gippsland	Experimental	Cromer (1971)
	E. nitens	Shining gum	Gippsland	Experimental	Cromer (1971)
	E. regnans	Mountain ash	Gippsland	Experimental	Cromer (1971)
	E. viminalis	Manna gum	Gippsland	Experimental	Cromer (1971)
1972	*E. delegatensis*	Alpine ash	Toorongo Plateau	Experimental pre operations	McKimm & Flinn (1979, p.118)
	E. globulus sub sp. bicostata	Blue gum	Toorongo Plateau	Experimental pre operations	McKimm & Flinn (1979, p.118)
	E. nitens	Shining gum	Toorongo Plateau	Experimental pre operations	McKimm & Flinn (1979, p.118)
	E. regnans	Mountain ash	Toorongo Plateau	Experimental pre operations	McKimm & Flinn (1979, p.118)

The Victorian and Gippsland plantation estate

Summary

Reporting of the national plantation estate has been continuous since federation (the 1909 estate was 4,298 ha). The current reporting framework is the NPI which provides valuable data in support of industry. To place plantations in Gippsland into perspective, the Gippsland land-base (4.62 million ha) includes 23.8% as agriculture and 2.3 % as plantations. This agricultural land-use is dominated by improved pasture, with irrigated land accounting for 11.2% of the agricultural land. The Victorian plantation estate has had a focus on *P. radiata* as the main softwood and indeed species planted. This contrasts with the hardwood estate which had an initial narrow range of commercial species planted, to a wide range of un-proven species planted. The change in species planted has been driven by experience resulting in species replacement (e.g. *E. regnans* replaced by *E. globulus*; *P. pinaster* replace by *P. radiata*), the threat of pests and diseases (*E. botryoides*), or a market change (poplars). A renaissance of interest in hardwoods has seen a different range of species planted. Where species are promoted by an industry / processor linked party, the range of species is focused on end-use and site matching. Currently, there are five species that have been grown, harvested and processed on a routine basis; *E. globulus*, *E. nitens* and *P. radiata* as current species and *E. regnans* and *P. pinaster* as species that have been replaced.

Introduction

The NPI reporting of plantation area by zone commenced in 1997 noting that the 1994 Australian estate was 1,042,600 ha (NFI, 1997, p.10). However, reporting on the national and state plantation estate has been a continuous endeavour. The Official Year Book of the Commonwealth of Australia published in 1909 reflected the period of 1901 to 1908 and reported the area of plantations in Victoria for 1909 as 4,298 ha (Knibbs, 1909, p.468). The 1939-40 Victorian Year Book reported that by 1939 there were 17,869 ha of plantations with *P. radiata* as the dominant species (Gawler, 1941, p.450). Reporting evolved with publication of the Quarterly Forest Products Statistics by the Australian Bureau of Agricultural and Resource Economics (ABARE) (e.g. see ABARE, 1993) which later evolved into the Australian Forest Product Statistics (e.g. ABARE, 2000) and then into the Australian Forest and Wood Products Statistics (e.g. ABARE, 2001). Plantations established primarily to produce eucalypt oil, sandalwood oil, bioenergy, carbon or other non-timber products are not currently recorded by the NPI (ABARES, 2016, p.44). This continuous reporting is an important record of the National and Victorian estate, and this section presents collated insights from published and un-published sources to place the Victorian and Gippsland plantation estate into perspective.

The Gippsland land-base

To place consideration of the Gippsland plantation estate into perspective, Figure 2 presents the Gippsland land-base by Local Government Area (LGA) and a high-level segmentation into ‘other’, ‘agriculture’ and ‘plantations’ for 2019. The total area of land (excluding water bodies) in Gippsland was reported as 4.5 million ha with agriculture and plantations occupying 22.0% and 2.4% respectively. A breakdown of the agriculture and plantation land-use area is presented in Figure 3. The area of non-native pasture (e.g. improved pasture) is the dominant land-use, with the area of softwood and hardwood plantations as a minor component. Irrigation of land is an important land-use (10% of the agricultural land) with intensive agriculture, including horticulture (e.g. vegetable growing) and grazing (e.g. dairy) activities undertaken.

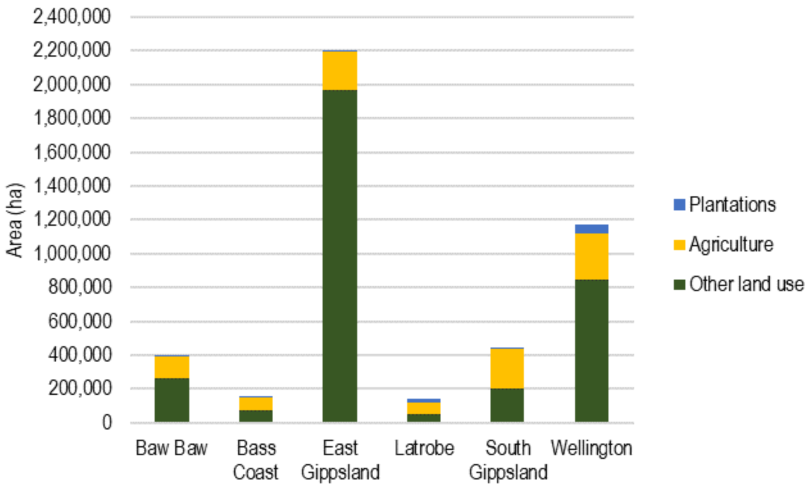

Figure 2: Land-use in Gippsland by LGA (based on DELWP, 2020).

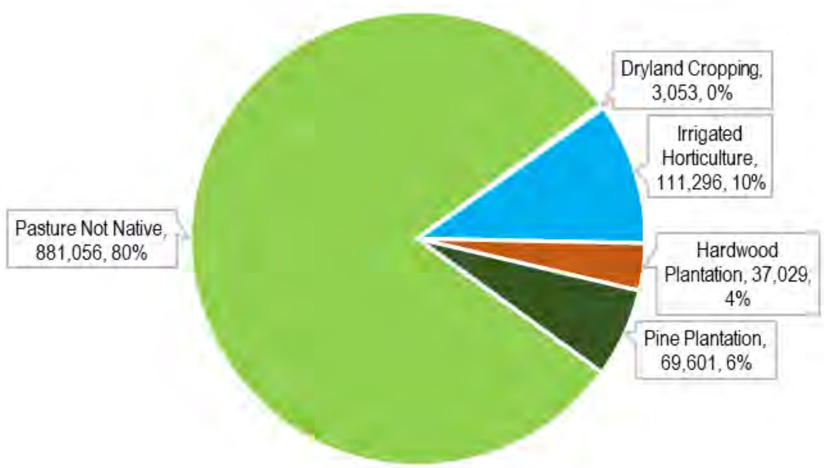

Figure 3: A breakdown of the agricultural land-use in Gippsland (based on DELWP, 2020).

To assist in understanding the spatial arrangement of the different land-uses in Gippsland, Figure 4 presents a breakdown of land-use area by LGA. To place the importance of each land-use into perspective, Figure 5 presents this breakdown on a relative basis for each LGA. Across all LGAs, improved pasture is the dominant agricultural land-use, with the zones of irrigation mostly in East Gippsland and Wellington LGAs. The plantation estate is concentrated in Latrobe and Wellington LGAs.

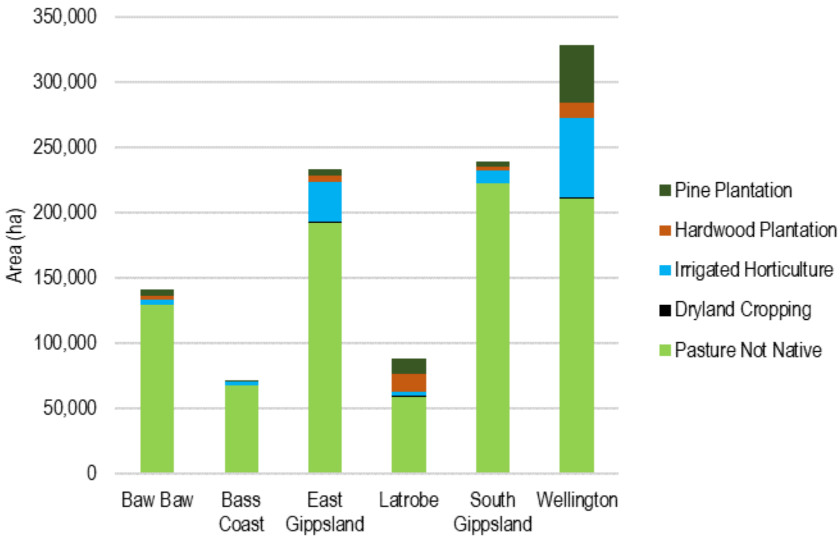

Figure 4: A breakdown of the agricultural land-use in Gippsland by LGA (based on DELWP, 2020).

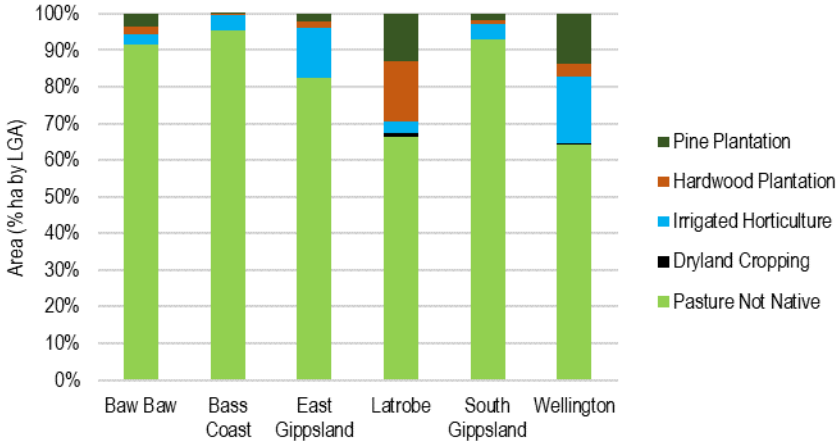

Figure 5: A percentage break-down of land-use presented in Figure 4.

The Victorian plantation estate

The total estate over time

The plantation estate in Victoria, segmented into softwoods and hardwoods, is presented in Figure 6. The softwood estate dominated by *P. radiata,* has remained relatively stable compared to the *E. globulus* dominated hardwood estate. The development of the *E. globulus* estate accelerated from the 1990s driven by managed investment schemes (MIS). To explore this development, Figure 7 presents the year-to-year change in area. The annual establishment rate of the hardwood estate peaked in the late 1990s, and declined thereafter, with a period of deforestation from 2012/13.

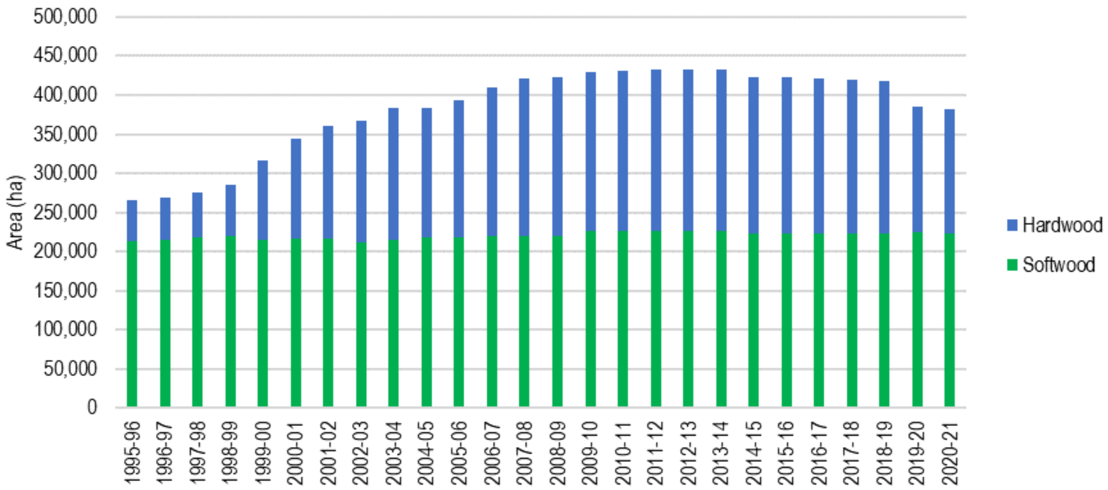

Figure 6: The Victorian plantation estate segmented into softwoods and hardwoods (based on ABARES, 2022 dataset)

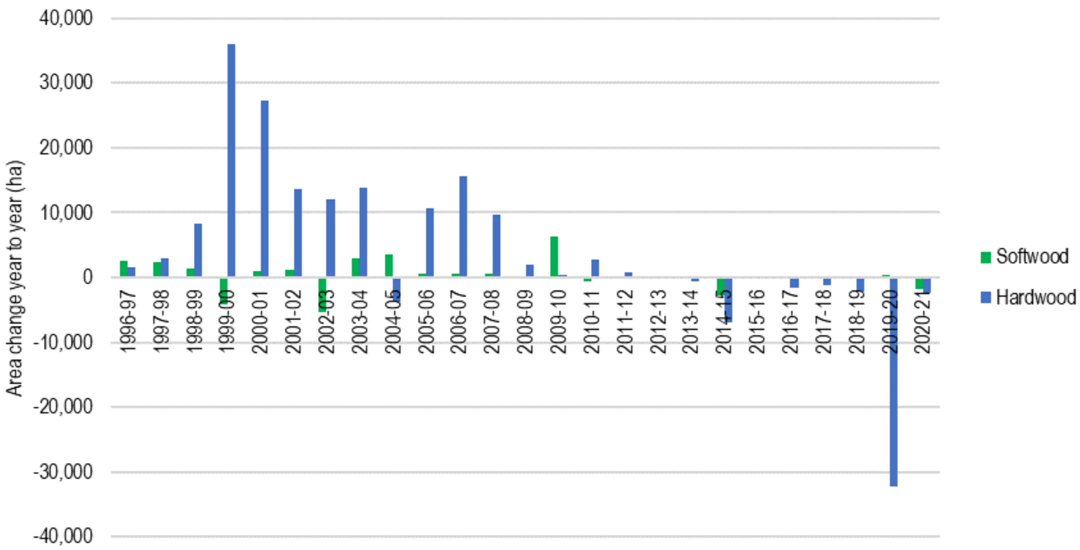

Figure 7: A summary of the year to year change in the Victorian plantation estate, segmented into softwoods and hardwoods (based on the ABARES, 2022 dataset).

The Victorian estate by species; the pre-1996 estate

Species is an important consideration and Figure 8 for softwoods and Figure 9 for hardwoods, presents a break-down of the pre-1996 Victorian estate. The softwood estate was stable at c.212,000 ha and was dominated by *P. radiata*. Early plantings of *P. pinaster* were encouraged by increased use of this species in other maritime regions of Australia (Anon, 1928a, p.38). It was strategically planted on poor-quality sites in Western Australia, South Australia and Victoria, which were considered not suited to *P. radiata* due to sandy soils and lower rainfall. The species was established in Gippsland in the 1960s and 1970s on infertile sands (Cameron, *et al.*, 2004, p.20). With the exception of Western Australia, *P. pinaster* plantations have been replaced with *P. radiata* at harvest due to growth performance and the higher resin content of *P. pinaster* logs creating issues with sawing. This replacement has been facilitated by an improved understanding of the site requirements of *P. radiata,* silviculture and genetic improvement.

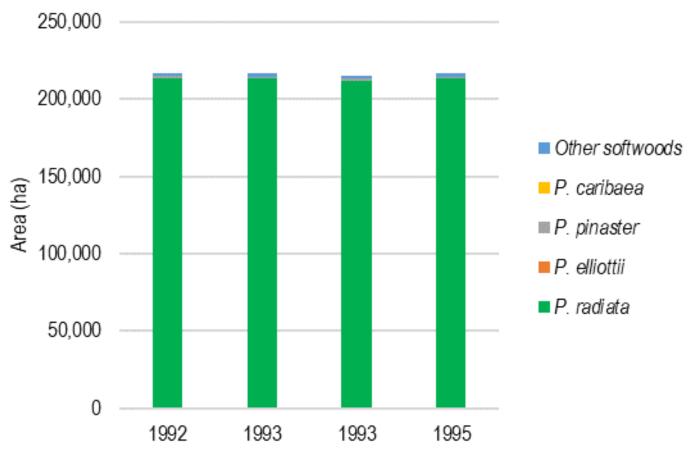

Figure 8: The species planted by area in the Victorian softwood plantation estate (based on ABARES, 1993, p.48; 1994, p.51; 1995, p.57; 1996, p.58).

Figure 9 presents the pre-1996 hardwood estate species in Victoria. The data was non-specific as to the species of eucalypt planted and included reference to poplars. A poplar (*Poplus nigra* and *Poplus deltoides;* Wilson & Wilson, 1976a, p.77&79) plantation estate was developed in the 1950s and 1960s (Wilson, & Wilson, 1976b, p.62-63). The trees were harvested to recover logs for processing into match splints, displacing imported products (Wilson & Wilson, 1976b, p.62-63). Indeed the largest poplar growers in Australian in 1976 were match manufacturing companies via specific entities; Brymay Forests Pty Ltd and F.M. Forests Pty Ltd. An estate of c.1,020 ha in 1976 was split between Grafton, NSW and Cobrawonga, Victoria (Wilson & Wilson, 1976b, p.62-63). Poplars required good quality soils with adequate water and intensive management to produce a good stem (Wilson, & Wilson, 1976a, p.77&79). Poplar plantations have been used to assist with effluent disposal; there was a 4 ha trial site at Dutson Downs in Gippsland in 1976 (Wilson & Wilson, 1976b, p.62-63). While the industry was stated to generally discourage private growers, poplars were part of the Victoria Government Farm Forestry Loan Scheme (Semmens, 1977, p.185 - 187; McCarthy, 1977, p.83&84). Poplar rust (Marssonina leaf spot disease) hit in 1972 impacting tree productivity (Wilson & Wilson, 1976a, p.77&79). Tree breeding and hybrids were used to reduce the impact of disease (Wilson, & Wilson, 1976b, p.62-63) however, with a cessation of local match production, this species was of less interest.

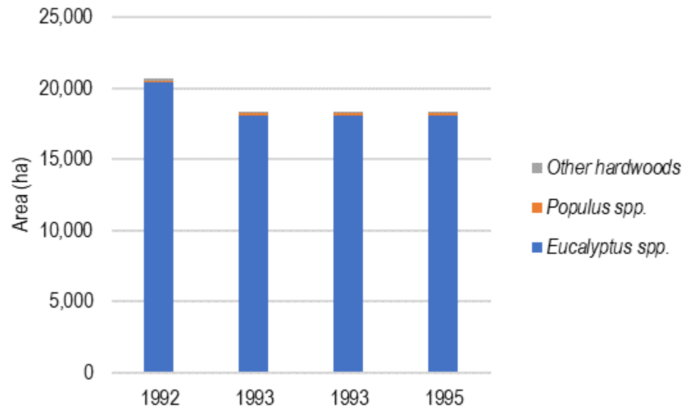

Figure 9: The species planted by area in the Victorian hardwood plantation estate (based on ABARES, 1993, p.48; 1994, p.51; 1995, p.57; 1996, p.58).

The Central Gippsland plantation estate

The current plantation estate

The NPI reports by region and Gippsland is covered by the Central Gippsland and East Gippsland - Bombala zones. The map of the East Gippsland - Bombala zone indicates that the majority of the *P. radiata* estate is located in NSW and 2,900 ha of *E.*

nitens, is mostly located in East Gippsland. A total of 80,483 ha of plantations were in place in Gippsland in 2021 (the Central Gippsland estate and the hardwood component of East Gippsland - Bombala). Figure 10 presents a species breakdown for the Central Gippsland zone.

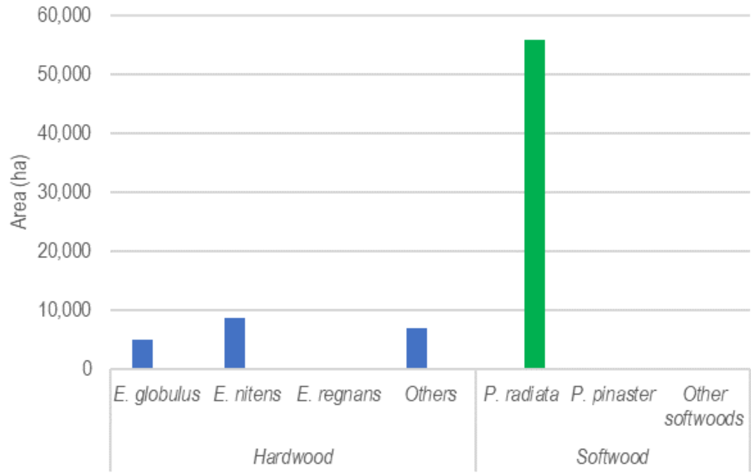

Figure 10: The Central Gippsland zone plantation species profile by area as at 2021 (based on ABARES, 2022, DATASET).

The change of species in the hardwood plantation estate

To understand hardwood species dynamics in Gippsland, a range of datasets was explored. Details of the hardwood species planted in Gippsland are presented in Figure 11 on an absolute basis and in Figure 12 on a relative basis. Figure 13 presents plantings by species in five-year periods. The rise and fall of the hardwood species planted is evident. The NPI (1997, p.41) noted that since 1990, *E. globulus* had replaced *E. regnans* as the main hardwood species planted; *E. regnans* was a core species and with harvest, it was not replanted. While the *E. globulus* estate initially increased with plantings on cleared agricultural land, it has deceased as on harvest in some areas, it has not been replanted. The *E. nitens* estate has increased and a cohort of unidentified by species plantations exists. While the data indicates an uplift in area of the unidentified species, this is most likely due to a capture of broader data, rather than due to planting activity.

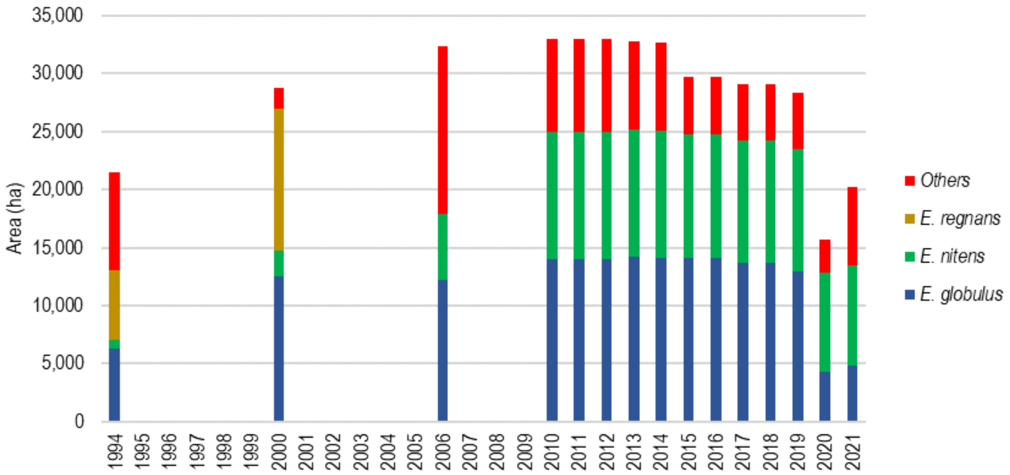

Figure 11: The Central Gippsland zone hardwood plantation estate by species (based on Wood *et al.*, 2001, p.96; Parsons *et al.*, 2006, p.9; Gavran & Parsons, 2011, p.6; Gavran, 2012, p.9; Gavran, 2013, p.12; Gavran, 2014, p.9; Gavran, 2015, p.11; ABARES, 2016, p.9; Downham & Gavran, 2017, p.8; Downham & Gavran, 2018, p.9; Downham & Gavran, 2019, p.11; Downham & Gavran, 2020, p.11; Legg *et al.*, 2021, p.23 to 67; ABARES, 2022, datasets).

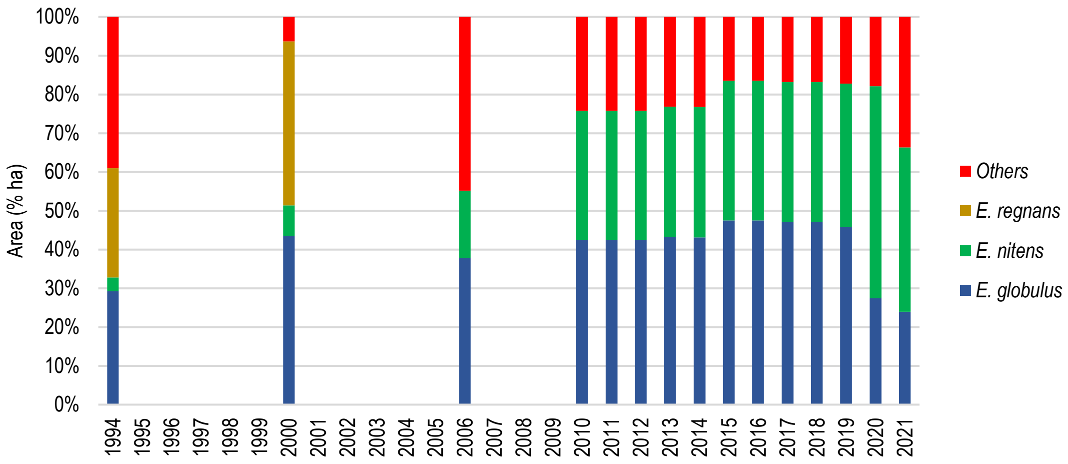

Figure 12: The data presented in Figure 11 on a percentage by species for each year.

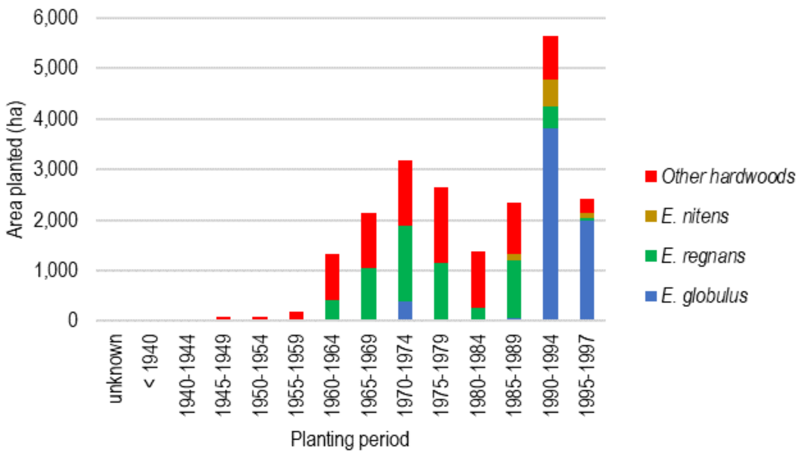

Figure 13: The hardwood species planted in the Central Gippsland plantation estate pre-1997 (NPI, 1997, p.42).

The change of species for the softwood plantation estate

Details of the softwood species planted post-1994 in Gippsland are presented in Figure 14 on an absolute basis and in Figure 15 on a relative basis. Figure 16 presents the planting of the estate by species in five-year periods. The softwood estate was relatively stable until recent losses due to bushfire events. Overall, the species planted has been stable and focussed on *P. radiata*.

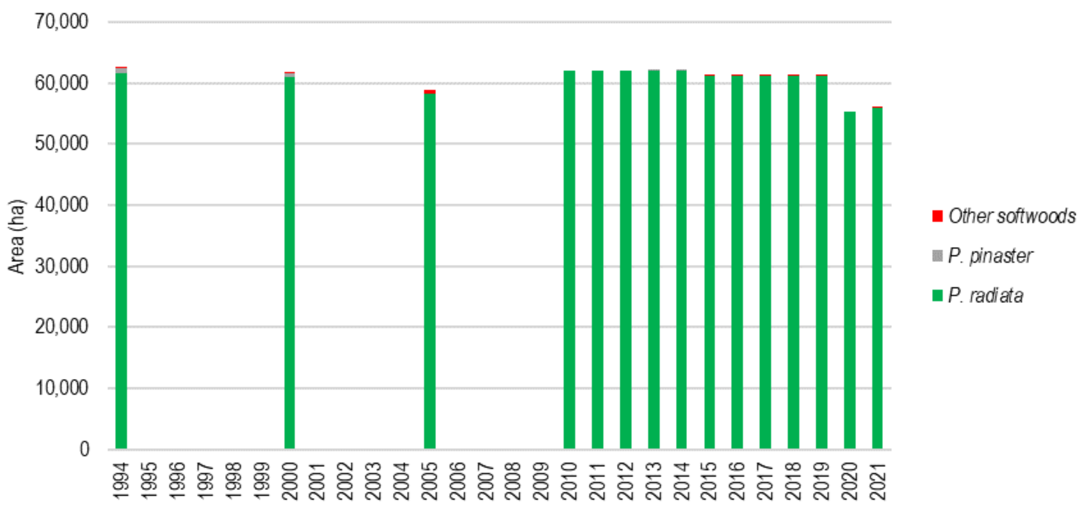

Figure 14: The Central Gippsland zone softwood plantation estate by species (based on Wood *et al*., 2001, p.96; Parsons *et al*., 2006, p.9; Gavran & Parsons, 2011, p.6; Gavran, 2012, p.9; Gavran, 2013, p.12; Gavran, 2014, p.9; Gavran, 2015, p.11; ABARES, 2016, p.9; Downham & Gavran, 2017, p.8; Downham & Gavran, 2018, p.9; Downham & Gavran, 2019, p.11; Downham & Gavran, 2020, p.11; Legg *et al*., 2021, p.23 to 67; ABARES, 2022, datasets).

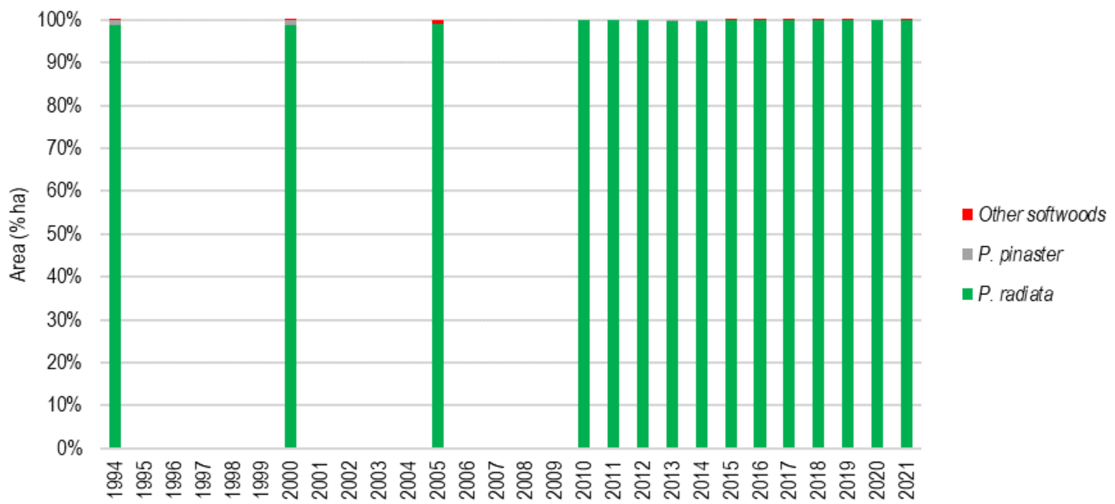

Figure 15: The data presented in Figure 14 on a percentage by species for each year.

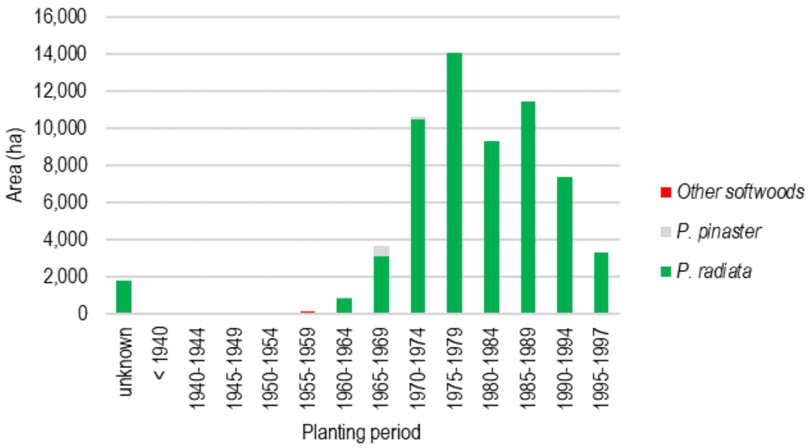

Figure 16: The softwood species planted in the Central Gippsland plantation estate pre-1997 (NPI, 1997, p.42).

Data on species planted to identify the 'other species'

A 2005 statewide survey of private growers

A 2005 survey of private growers in Victoria identified the species planted (Jenkin, 2005). The dataset was reduced to only include survey respondents from Gippsland and the results are presented in Figure 17. A trend evident was a narrow focus on a small number of commercial species in Gippsland at that time until the mid-1980s; *P. radiata*, *E. regnans* and *E. globulus*. After that period, a wider range of species were planted. Figure 18 presents the same data excluding *P. radiata* and *E. globulus* to highlight the other species planted; this included a broad range of un-proven species.

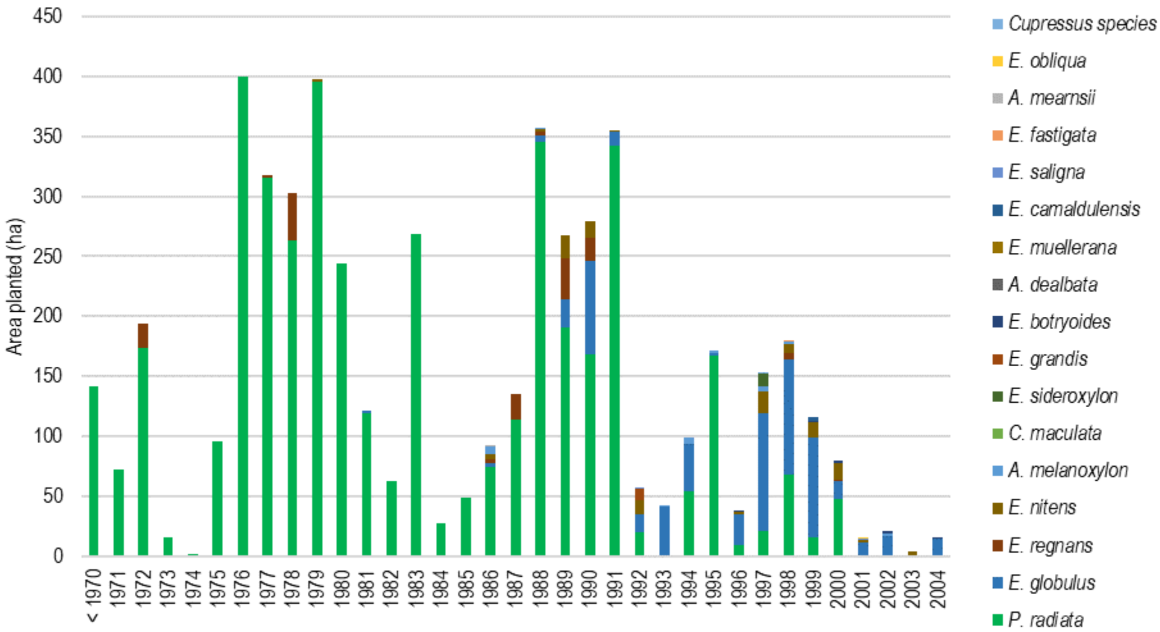

Figure 17: Results of a 2005 survey of private growers in Victoria noting the area of species planted by year (Jenkin, 2005).

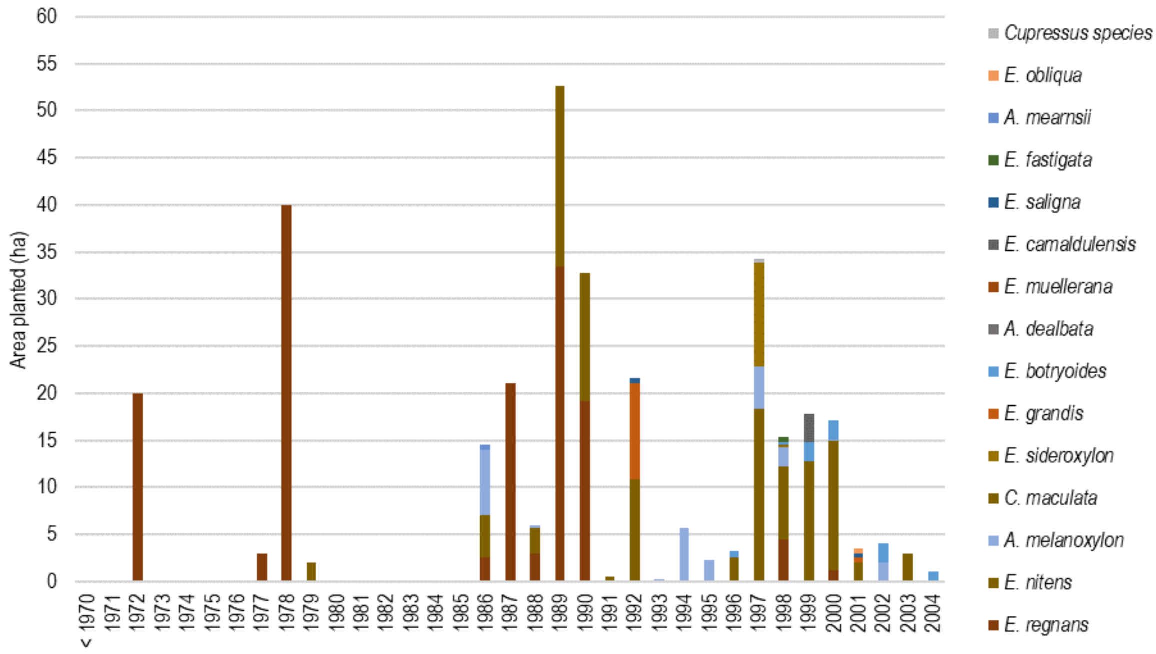

Figure 18: Results of a 2005 survey of private growers in Victoria noting the area of species planted by year; excluding *P. radiata* and *E. globulus* plantings (Jenkin, 2005).

The Heartwood Unlimited estate

Heartwood Unlimited is a Gippsland based boutique plantation manager, managing plantations on behalf of investors, with a focus on durable hardwood species. The basis of the selection of the species planted is for their premium timber quality, high demand and rapid growth. The company has progressed species selection to the point where there is confidence in species by site matching. In regard to growing conditions, the species are noted as *'suited to a specific climate range and certain soil types'* for sites that receive rainfall in excess of 600 mm/y.[1] While actual experience has provided a short list of species for sites with greater than 750 mm/y rainfall, there is less confidence for sites with less than 750 mm/y rainfall and where frost is not an issue. A process of review has resulted in removal of species from the preferred species list and a focus on species that have demonstrated greater potential. For example, *E. botryoides* is no longer planted on higher rainfall sites due to tree form and insect predation issues. However, for frost risk sites and with rainfall below 750 mm/y, *E. botryoides* is the only robust durable species. Figure 19 presents the Gippsland estate managed by Heartwood Unlimited by species and planting year, which includes an area of *E. globulus* planted for VicForests. Figure 20 presents the estate excluding the *E. globulus* stands to highlight the other species planted; the area of the other species under management is 1,113 ha. The rise (e.g. of *Corymbia maculata*) and fall of species (e.g. of *E. botryoides*) is evident. Figure 21 presents the estate data on a percentage by species for each planting year to highlight the species mix proportions. A narrow range of species is evident, reflecting a focus on developing of a specific resource.

[1] https://heartwoodplantations.com.au/species accessed on the 16/04/2024.

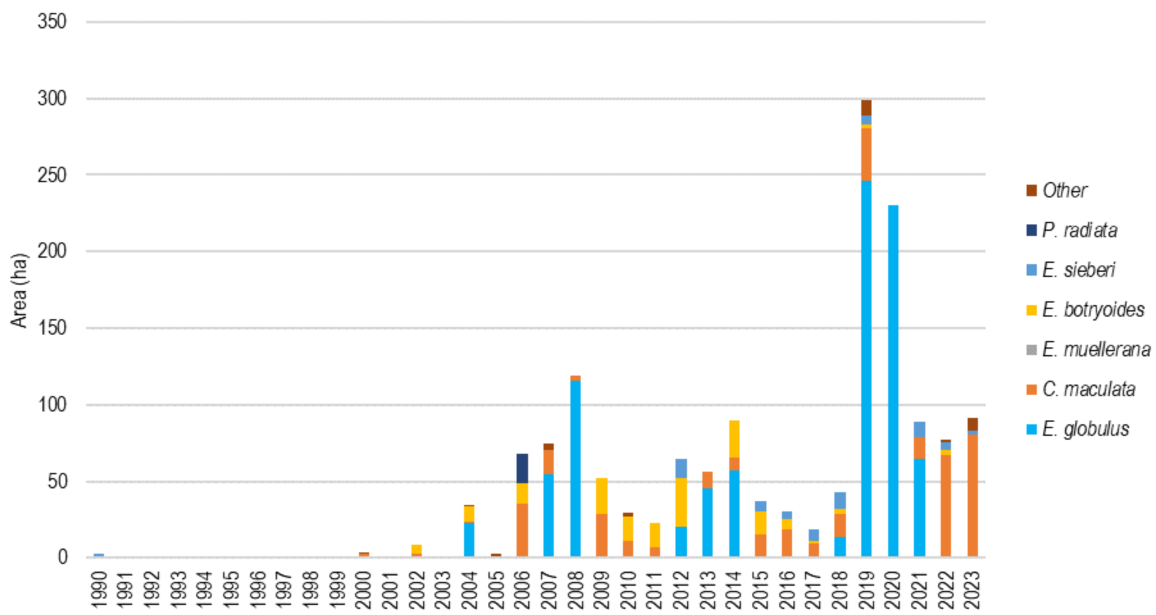

Figure 19: A break-down of the Heartwood Unlimited managed Gippsland estate by year established (Lambert, *pers. comm.*).

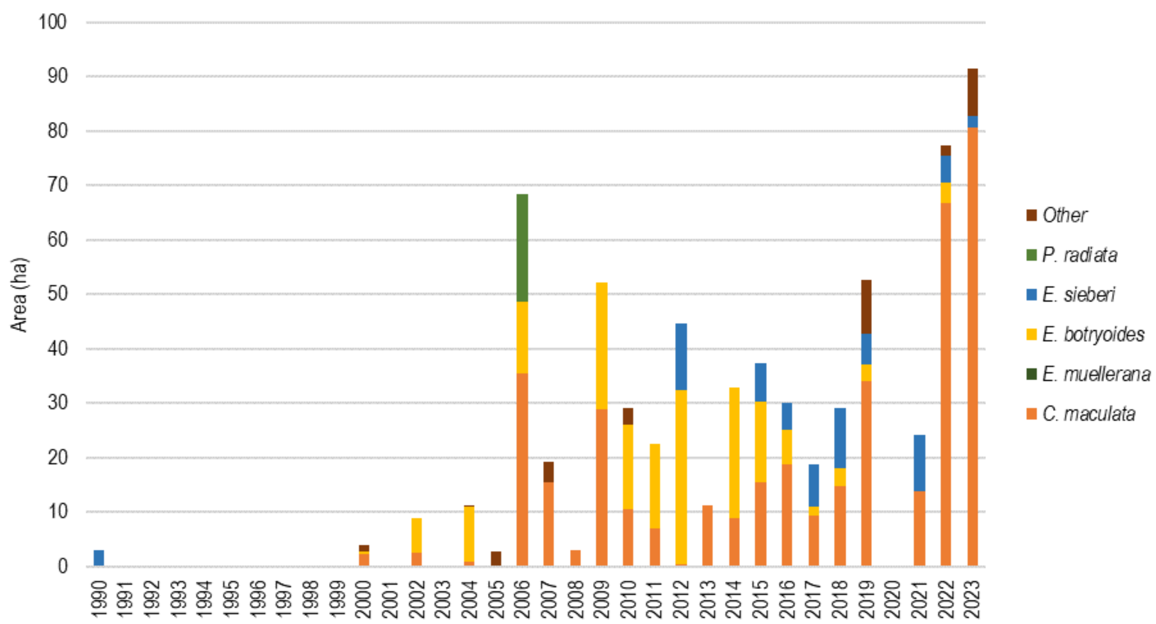

Figure 20: A break-down of the Heartwood Unlimited managed Gippsland estate by year established, excluding the *E. globulus* estate (Lambert, *pers. comm.*).

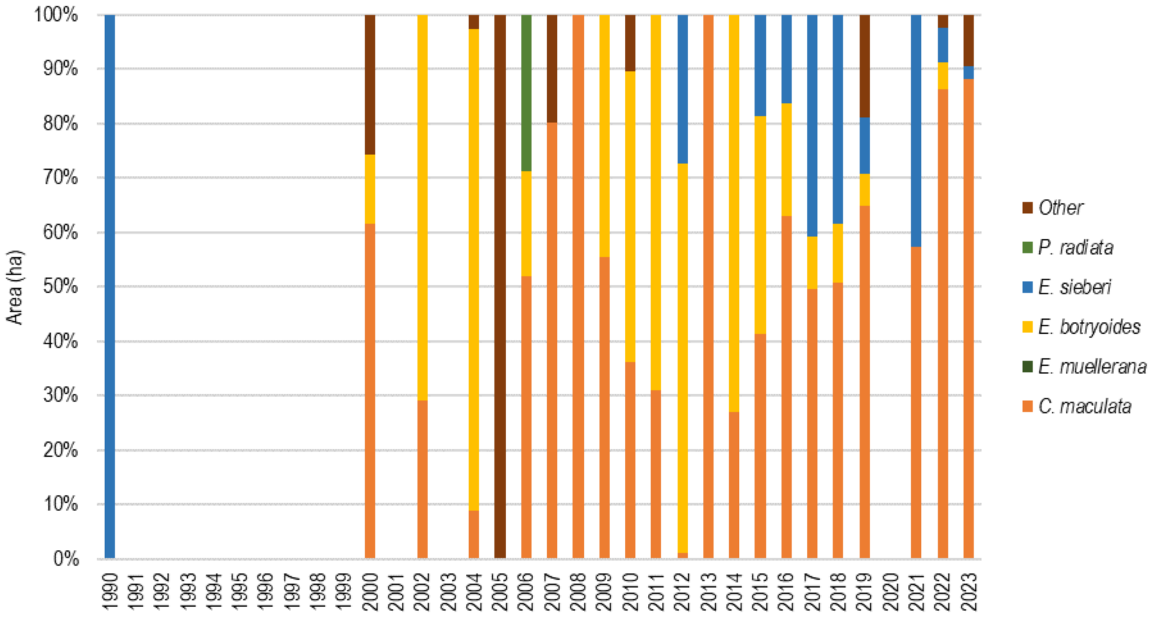

Figure 21: A break-down of the Heartwood Unlimited managed Gippsland estate by year established; excluding the *E. globulus* estate (Lambert, *pers. comm.*). This is the data presented in Figure 20 on a percentage species area for each planting year.

Figure 22 present the Heartwood Unlimited estate for Gippsland on a current age basis (as at 2024) and the cumulative area planted up to each age. The estate has 50% of the area planted at 8 years of age or younger, which indicates the time remaining for the estate to commence production and the realisation of species performance for wood production.

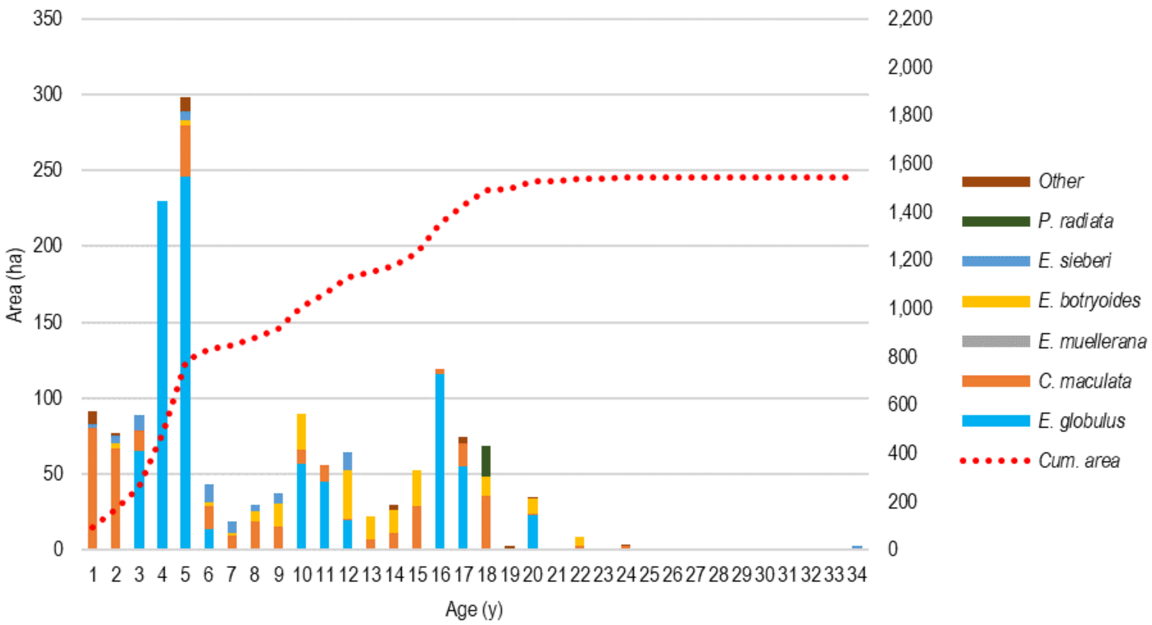

Figure 22: A break-down of the Gippsland estate managed by Heartwood Unlimited by age (Lambert, *pers. comm.*). The cumulative estate area by age is presented.

Commercial operation linked experience

Summary

The Gippsland plantation estate includes a large player with the HVP Plantations estate of 125,000 ha of land with *P. radiata* as the dominant species. The HVP Plantations estate includes the plantations developed by APM Forests. APM Forests was created in 1951 to develop a plantation estate to provide resources to the APM Maryvale pulpmill. The company estate included softwoods and hardwoods with, *P. radiata* as the dominant species. Establishment of eucalypts was in phases with a renaissance of interest in the mid-1980s focussed on *E. regnans* and *E. nitens,* and later *E. globulus,* all matched to site. An area of *E. saligna* was established on land leased from the State Electricity Commission in 1992; this was unsuccessful. Development of the estate was supported by research into species and silviculture, and included a tree improvement programme supported by the CSIRO with a field station in Traralgon. A focus was on wood as a specific resource. Heartwood Unlimited is a boutique plantation management service provider with a focus on development of a hardwood resource for the Radial Timber Australia Pty Limited sawmill at Yarram. The company undertakes research and considers species selection on a holistic basis, with an intent to create a narrow species range resource.

Introduction

The Gippsland plantation estate is dominated by HVP Plantations (HVP) with an area of 125,000 ha of land[2]. The dominant species planted is *P. radiata*. The steps towards the creation of HVP are documented in Appendix 1: The history of plantations in Victoria. HVP Plantation resulted from the initial corporatisation of the Victorian Government plantation assets to create the Victorian Plantation Corporation in 1993, followed by privatisation via the sale of the forward cutting rights (but not the land) to the Hancock Natural Resources Group in 1998 to form Hancock Victorian Plantations. Via a series of transactions, the original APM Forests estate (then Australian Paper Plantations; APP) was sold in 2001 to form Grand Ridge Plantations. In 2011, Grand Ridge Plantations and Hancock Victorian Plantations merged (McCarthy, 2019). This section of the report addresses the development of APM Forests Pty Limited as an integral part of the Gippsland industrial plantation estate and a boutique plantation manager, Heartwood Unlimited.

APM Forests Pty Limited

Development of the paper industry in Victoria

The first paper making mill in Victoria commenced as a start-up in 1868 (the Ramsden Mill or Melbourne Mill) and in 1895 a formal meeting established the Australian Paper Mills Company (Sinclair, 1990, p.11&26). In 1915, Mr. H. E. Surface tested pulping of eucalypt wood in Tasmania for the Tasmania Government and concluded that *'the soda process for pulping our eucalypts was likely to be more successful than grinding the fibres'* (SFD, 1918, p.8). Wood samples of *E. regnans* were tested in Norway for pulp and paper making in 1917, utilising a mechanical or grinding process and the species was found not suitable and inferior to Norwegian spruce pulp (SFD, 1918, p.8). By 1921-22, laboratory analysis had proven *E. regnans* based paper to be suitable and high-grade (FCV, 1922, p.3). A lack of regional markets for thinnings in 1935-36 resulted in consideration of supply of pulpwood and specifically pulpwood from *'mountain forests* [that] *would in no wise prejudice supplies of sawmilling timber or other produce from these forests'* (FCV, 1936, p.4). Pulplogs were *'entirely of timber which at present is waste due*

[2] Information accessed from https://www.hvp.com.au/about-hvp/ accessed on 02/07/2024.

to economic considerations, including cull trees left standing after milling operators have completed logging, heads, offcuts and sawmill waste, and small-sized material removed as thinnings from young regrowth stands' (FCV, 1936, p.4). The FCV and Australian Paper Manufacturers Ltd. (APM), reached an agreement and legislation was enacted to enable supply of pulpwood (e.g. sawmill residues, inferior trees and harvesting residues, and prospective thinnings) from suitable areas of natural forests (FCV, 1937, p.3). The first pulpwood was delivered to the Maryvale site on the 4th October 1937 (Collins *et al.*, undated, p.11). Supply of pulpwood post the major wild fire in 1939 commenced in 1940 (FCV, 1941, p.4) with c.6,000 m^3 supplied in 1941-42 (FCV 1942, p.12&13).

APM Forests Pty Limited

The first plantation developed by APM was in NSW in 1948 with the Gippsland plantation program commencing in the 1950's. APM Forestry Pty Limited was created in 1951 to produce softwood and eucalypt trees as potential resources for the company's pulp and paper operations (Sinclair, 1990, p.95 &171). By 1977, *P. radiata* was a preferred species in Gippsland (Pollock, 1977, p.195&196). The company developed hardwood plantations in Gippsland commencing in the early 1960s. By the early 1980s there was renewed interest in eucalypt plantations with large-scale species and provenance trials established across the estate in 1986 and 1987 (see Duncan *et al.*, 2000). Jenkin (1992, p.29) reported on the species planted in the APM Forests estate. Operational establishment of eucalypt plantations re-commenced in 1987 with *E. regnans* as the primary species (underpinned by seed orchard based planting stock) planted on sites with good quality soils and rainfall greater than 900 mm/y, and by proxy, such sites were generally located above 400 m in elevation and were sheltered. *E. nitens* planting was supported by seed orchard based stock and were planted on more exposed sites with a potential for frost. *E. globulus* (from select local wild provenances) was established on lower elevation and dryer sites (700 to 900 mm/y). All species were regarded as suitable for pulp and paper making. Establishing *E. globulus* plantations expanded in 1992 onto drier sites under a lease arrangement to establish hardwood plantations on land owned by the State Electricity Commission (SEC). Under the lease, land in proximity to the Yallourn open-cut coal mine was not allowed to be planted to *E. globulus* for fire risk reasons. Instead, plantations of *E. saligna* were planted and while initial growth in the first 2 to 4 years looked promising, this species was a failure on these sites.

APM Forests Pty Limited research programme

Development of the APM Forests estate was supported by a comprehensive research programme; indeed, there was a Commonwealth Scientific and Industrial Research Organisation (CSIRO) field station located in Traralgon. Eldridge (1964, p.36) noted that the *'Commonwealth Forestry and Timber Bureau's tree-breeding programme at Traralgon in the Gippsland region of Victoria started in 1958 as a co-operative venture with A.P.M. Forests Pty. Ltd.'* For *E. regnans* the aims were to improve the rate of growth and wood quality, and increase resistance to damage by fire (Eldridge, 1964, p.35). Research into species performance included consideration of wood properties related to the intended markets. For example, research was undertaken into kino vein formation in *E. regnans* due to their adverse effect on the value of wood; kino significantly lowers the quality of pulpwood by reducing the yield of pulp and increasing the consumption of pulping chemicals (Doran, 1975, p.21 citing Gardner & Hillis, 1962; Hillis, 1972), large kino veins can weaken timber used for structural purposes and small kino veins de-grade timber intended for interior joinery and cabinet work (Doran, 1975, p.21 citing Jacobs, 1955). An altitudinal *E. regnans* provenance trial (see Eldridge, 1972) located in the Strzelecki Ranges (1960 - Ashlakoff Block; 1963 - Dumbrell Block) suggested that *'variation in the degree of development of kino veins is influenced more by environmental than genetic factors'* (Doran, 1975, p.21).

Species trials were established with an objective to better understand species options and matching to site. For example, Cromer (1971) reported on a nutrient by species trial established on sites in the Strzelecki Ranges (Jeeralangs) and at Silver Creek (south-east of Morwell). The Silver Creek site was noted as having 1,000 mm/y of rainfall at 90 to 300 m above sea level with undulating topography. The trials included nine species with three provenances for *E. globulus* (see Table 3); it was noted that *E. delegatensis*, *E. nitens* and *E. regnans* as alpine species, were offsite at the Silver Creek site (Cromer, 1971, p.4). The results indicated that at age 3 years and with application of nitrogen and phosphorous, *E. globulus* and *E. regnans* were the better species at Silver Creek and the Jeeralang site respectively (Figure 23). The outcomes of a significant series of trials established in the 1980s are reported later in this document (commencing on page 54).

Table 3: The species included in the trials as reported by Cromer (1971, p.2&3).

Scientific name	Common name	Notes
E. bicostata	Southern blue gum	
E. bicostata X E. viminalis	A natural hybrid	Omitted from the reported outcomes due to adverse impacts during seedling transport resulting in poor survival (Cromer, 1971, p. 3).
E. delegatensis	Alpine ash	
E. fastigata	Brown barrel	
E. globulus	Southern blue gum	Seed sourced from Tasmania, Cabazedos (Spain) and Llanes (Spain) (Cromer, 1971, p. 3).
E. quadrangulate	White-topped box	
E. nitens	Shining gum	Omitted from reported outcomes due to an error in treatments (Cromer, 1971, p.2&3).
E. regnans	Mountain ash	
E. viminalis	Manna gum	

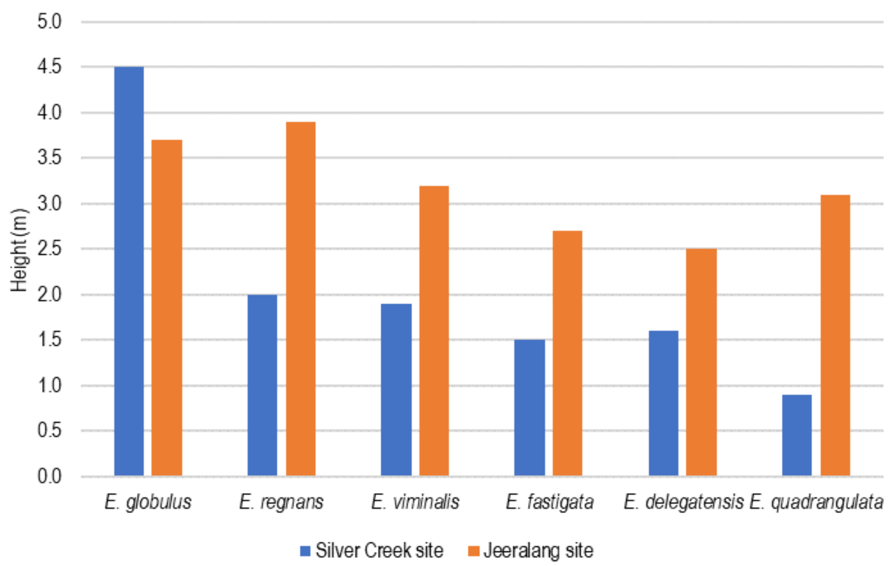

Figure 23: The tree height outcome at age 3 years of a species and nutrient trial for the nitrogen and phosphorous treatments (Cromer, 1971, p.5).

The National Afforestation Programme (1987 to 1992)

The Australian Government established the National Afforestation Program (NAP) in 1987 to stimulate expansion of commercial hardwood timber supply, assist in land rehabilitation and control degradation through afforestation. Nearly $15 million was invested over three years, targeting State and large private industrial growers; it was the first production forestry initiative that directly sought to engage private landholders, but it was not designed to address the needs of non-industrial forest managers (Catton *et al.*, 2004, p.14). The program funded establishing of 6,000 ha of hardwood plantations and supported research on tree productivity (Dargavel, 1995). APM Forests was the recipient of NAP support to facilitate establishment of woodlots of *E. globulus* on cleared agricultural land across Gippsland in the early 1990s (see Figure 24). This resulted in a wide-spread cohort of woodlots which have provided a useful source of performance insights.

Figure 24: An E. globulus woodlot / NAP site near Bairnsdale (Sylva Systems, 05/09/2005).

Heartwood Unlimited: promoting hardwood sawlog plantations

A service provider model

Heartwood Unlimited (and its predecessors) has operated in Victoria since 1995 and is an umbrella group which includes Heartwood Plantations Pty Limited. It is a Gippsland based plantation management service provider (see Box 6) with a focus on developing a hardwood resource for the Radial Timber Australia Pty Limited (RTA) (an integrated sawmill) located at Yarram. The company commenced plantation establishment in Gippsland in 2004. The business model is to develop and manage plantations on behalf of other entities. For example, Heartwood Unlimited was contracted to established second rotation *E. globulus* plantations in the Yallourn North area on behalf of VicForests (Lambert, *pers. comm.*). The company has grown and harvested *E. globulus* for pulpwood and more recently harvested an *E. globulus* plantation established in 2000 at Kilmore, that was standing at 100 stems/ha and was pruned to 6.5 m. The harvest generated c. 1,000 GMT of sawlogs and approximately the same of firewood. The sawlogs were supplied to RTA's sawmill. As yet, the company has not taken the other species planted through to rotation and processing, however they have conducted third-thinning of *C. maculata* stands and test processing of sample logs. A current final harvest is underway of a plantation established with advice from Gippsland Farm Plantations (GFP) in the late 1990s.

Box 6: A snap-shot of the Heartwood Unlimited activities statement in 2024. [3]
'Heartwood Unlimited manages agroforestry investments across Victoria for individuals, companies and trusts. Each investment is uniquely designed to protect natural features whilst creating forestry and farming investments to suit the landscape and the Australian carbon market.'

[3] Downloaded from https://heartwoodunlimited.com.au/team on the 21/06/2024.

Species planted

The species planted are considered based on a package of attributes; growth performance and wood attributes as they relate to intended actual markets. See Figure 25 as an example of a boutique plantation managed for sawlog production. It is recognised that a narrow range of species planted as a resource is preferable to a broad and diverse range. Heartwood Plantations presents a series of information sheets on the species promoted and while presenting information on wood properties, they note that *'statistics for plantation-grown timber may vary from these figures'* (Heartwood Plantations, ____ a,b,c,d). A core point of difference with Heartwood Unlimited operations is that there is a significant experience-base in regard to species planted; see Figure 19 to Figure 21.

Figure 25: A Heartwood Plantations established site; the tree species is *E. muellerana* (Yellow stringybark) planted in 2002 – age 14 years (Sylva Systems 3/12/2016).

Multiple species; on a site and within a planting unit

Heartwood Unlimited recognised the challenge to select a definitive and single species for a whole site. The first strategy developed was to stratify sites and plant species in blocks to suit each stratum. A more recent strategy has been exploring mixed species plantings within individual planting units. The species are planted as alternating trees within a single planting row (see Figure 26). This commenced as a risk management strategy and site matching concept, with the benefit of increasing biodiversity potential. It has been found to be effective in motivating slow-starting species (e.g. *E. muellerana*) when paired with a rapid initial growth species. However, this strategy is predicated on an ability to undertake a non-commercial thinning to ensure that the fast species does not suppress the slow starter (if this is the target final crop species). It can also be effective by pairing similar initial growth species (e.g. pairing *C. maculata* and *E. muellerana*) to complement each other. Another mixture that has proven effective is *E. sieberi*, *E. botryoides* and *C. maculata* on higher rainfall sites. Heartwood Unlimited has observed that 'the best species' generally outcompete the other(s) resulting in a single species. Harvesting of mixed species compartments resulting in mixed species logs will pose challenges to be solved; for example, *C. maculata* is relatively easy to identify as a log due to a fluted shape. There is successful harvesting of *P. radiata* with multiple products and native forest harvesting can deal with multiple species, as examples, to inform solutions. Some mechanical harvesting heads can spray different paint colours to identify log species or there is potential to tag/mark the butt of each log to later scan in log yards.

Figure 26: A recently planted *C. maculata* seedling (left) and *E. cladocaylx* (right), planted in the same planting row in East Gippsland (Sylva Systems, 27/10/2023).

Ongoing research and development

Given the Heartwood Unlimited linkage to RTA, species consideration is beyond growth and form and includes wood properties and the company is continuing to explore species options. A hybrid of *E. botryoides* X *E. saligna* has performed well on higher-rainfall sites and the company is assessing whether the sapwood is Lyctid susceptible; based on AS 5604-2005, *E. botryoides* is not susceptible and *E. saligna* is susceptible. With a focus on durable timbers, a species trial was established near Bodman's Creek in South Gippsland in 2016 (currently 8 years old). The site has good quality soils, with a long-term average rainfall of 900 mm/y. The species planted include multiple seed sources; provenances and improved seed from seedling seed orchards (SSO). Interestingly, a number of species are from northern state, including different climatic zones, are included (see Table 4).

Table 4: A summary of the species planted (including seedlots) in the Bodman's Creek trial (Heartwood Unlimited, 2024).

Species	Common Name	Provenance	Seedlot
C. maculata	Spotted gum	Barclays SSO, NSW	ATSC-20541
		Corowa SSO, NSW	ATSC-21061
E. cladocalyx	Sugar gum	Coopers (Lismore NF), NSW	HP-COO14
E. bosistoana	Coast grey box	Genoa, Victoria	Arianda
		Cann River, Victoria	Arianda
		Noorinbee, Victoria	Kylisa Seeds
E. punctata (biturbinata)	Grey gum	Chaelundi NF, NSW	ATSC-19812
E. longirostrata	Grey gum	Diamondy SF, QLD	Dendros-21252
		Cracow SF, QLD	Dendros-21253
E. paniculata	Grey ironbark	Boyne NF, NSW	ATSC-19300
		Bodalla NF, NSW	ATSC-19101
E. propinqua	Grey gum	Unumgar SF, NSW	ATSC-20499
		Taylors Arm, NSW	ATSC-18674
E. sideroxylon	Red ironbark	Ardmona (Killawarra NF), NSW	HP-ARD14
E. argophloia	Chinchilla white gum	Narromine SSO, NSW	ATSC-21143
		Dunmore, NSW	Dendros-1165a

An assessment of the Bodman's Creek trial was undertaken in March 2023 and the outcomes are presented in Figure 27. *E. cladocalyx*, *C. maculata* and *E. bosistoana* have performed the best based on growth rates. Of these best performing species by growth, considering tree form, *E. bosistoana* is an inferior species, however, it may have an edge on sites subject to frost and water logging. The company has a provenance trial of *E. bosistoana* that is almost 9 years old and it includes improved seed from New Zealand. The species has performed well and the trial has been thinned twice but is still yet to produce any seed (as an SSO), hence there is a reluctance to establish this species until Heartwood Unlimited has access to better seed; even then, the species is likely to remain as a back-up. Currently, *E. botryoides* is the only robust durable species for frost-risk sites with rainfall below 750 mm, hence a better form *E. bosistoana* for the lower rainfall sites would assist in managing risk. With tree age, wood properties will be considered; natural forest sapwood of *E. bosistoana* is susceptible to Lyctid borer (AS 5604-2005) which would further discount this species as a commercial option for wood production. Overall, thence there is no real advantage with *E. bosistoana* over *E. cladocaylx.* Based on company experience and insights, Table 5 presents a summary of the Heartwood Unlimited species.

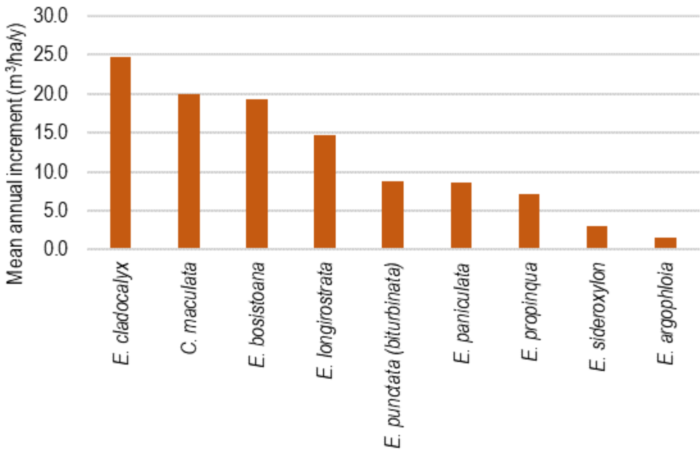

Figure 27: The age 7 years assessment results for the trial located at Bodman's Creek (based on Heartwood Unlimited data).

Table 5: A summary of the current Heartwood Unlimited species options (Lambert *pers. comm.*)

Status	Species	Common name	Rainfall	Site	Soils	Frost	Water logging	Site fertility	Insects	Growth	Form	Sapwood Lyctid status[4]	Durability[5]	
			(mm/y)										Below ground	Above ground
Core	*C. maculata*	Spotted gum	> 550	Flat	Deep, well-drained clay soils	Intolerant		Requires macro fertiliser				Susceptible	2	1
	E. cladocaylx	Sugar gum	> 750	Flat		Tolerant	Suitable					Susceptible	1	1
	E. muellerana	Yellow stringybark	> 600	Flat	Deep, well-drained sandy loam or clay loam soils	Mild tolerance	Sensitive to water logging even when older	Handles low fertility sites (especially 2nd rotation)				Not susceptible	3	2
	E. sieberi	Silvertop ash	> 700	Sloping	Rocky, clay-based soils		Prone to wind throw when soils get wet					Not susceptible	3	2
	E. botryoides X *E. saligna*	A hybrid	> 750	Sloping								?	?	?
Restricted use	*E. botryoides*	Southern mahogany	< 750		Deep, well-drained sandy loam or clay loam soils	Tolerant			Susceptible		Poor	Not susceptible	3	2
Under testing	*E. tricarpa*								Susceptible		Poor	Susceptible	?	?
	E. bosistoana	Coast grey box							Susceptible		Poor	Susceptible	1	1

[4] Based on natural forest timbers; AS 5604-2005.
[5] Based on natural forest timbers; AS 5604-2005.

Large scale reforestation and plantation projects

Summary

Plantation development in Gippsland includes two examples of re-treeing denuded landscapes. The first was afforestation of the Strzelecki Ranges commencing in the 1940s after deforestation for agriculture (in the 1890s and again in the 1920s) and the subsequent failure of agriculture. The second was afforestation (in the 1970s and 1980s) of the Toorongo plateau after a sequence of catastrophic wildfires (1926, 1932 and 1939) destroyed large tracts of forests before the ability to set seed for regeneration. In both examples, the programmes were underpinned by research (e.g. species and silviculture) and a focus on creating a resource. The Strzelecki project was undertaken by the Forests Commission, Victoria (FCV) and APM Forests with *P. radiata* and *E. regnans* planted. The Toorongo plateau project was undertaken by the Government with *E. nitens* and *E. delegatensis* planted. In both cases, species were matched to sites within the project areas.

Introduction

Access to land is a primary consideration for plantation development. While plantations can be primarily focussed on development of resource, the history of Gippsland has included addressing deforestation of large tracts of land. A balance between the intent to reforest and creation of a resource, was underpinned by available land in two examples. The first was the development of the Strzelecki Ranges which were deforested for agriculture and the Toorongo Plateau which was deforested by sequential and in rapid succession catastrophic wildfires. The following provides an overview of the two projects.

Specific Gippsland projects; The Strzelecki Ranges

Afforestation after agriculture fails

The hardwood plantations in Gippsland part reflect past availability of marginal farmland at affordable prices and leasehold land suitable for eucalypt plantation development within economic haul of the Maryvale pulpmill. This marginal farmland was located in the Eastern Strzelecki Ranges (referred to as the Heartbreak Hills) where many farms were abandoned and converted to plantations (Cameron, *et al.,* 2004, p.24). The region carried high-quality natural forest stands of *E. regnans* with the balance as *E. obliqua* or *E. bicostata* (Mann, 1967, p. xvii). The land was made available for settlement in the 1890's resulting in large areas of forest cleared for agriculture and despite numerous difficulties for agriculture, *'a further large-scale attempt at settlement was made in the 1920's'* (Mann, 1967, p. xvii). The land was marginal for agriculture as it was too steep and infested with rabbits and noxious weeds (Cameron, *et al.*, 2004, p.24). Farmers sought to voluntarily exit and sell their land; there were no forced acquisitions. For example, records indicate that a whole farm was *'bought for £5 from an absentee owner who offered to transfer his freehold rights without payment, just to be rid of the responsibilities of ownership'* (Noble, 1976, p.37). The FCV commenced purchasing land in the early 1930s, peaking between 1944 and 1951. Subsequently, the rate of purchase declined due to high prices for primary produce, improving the outlook for agriculture (Noble, 1976, p.37). The programme resulted in over 300 purchases, totalling 22,300 ha (Noble, 1976, p.37).

The plantation programme

The first large-scale plantation development in the area commenced in 1946 at Childers (342 ha of softwoods and 41 ha of hardwoods) and Allambee (225 ha softwoods and 21 ha hardwoods) (Noble, 1976, p.40). A next step was in 1949, establishing a workers camp at Morwell River to accommodate silviculture workers, to create the West Morwell block (502 ha of softwoods and 2,316 ha of hardwoods) (Noble, 1976, p.40). A further development was afforestation of the area around Blackwarry in c.1960 with labour from Yarram and later from the Won Wron prison (Noble, 1976, p.40). A total of 6,117 ha of softwoods and 3,995 ha of hardwoods were established (Noble, 1976, p.43)

In 1959, APM Forests commenced land purchase for plantation establishment to grow pulpwood for the APM Maryvale Mill (a haulage distance of 48 km by road). A consolidated area of approximately 10,100 ha had been acquired by 1964 with 3,520 ha of State Forest leased under the Forests (Wood Pulp Agreement) Act 1961 (Mann, 1967, p. xvii). APM Forests eventually accumulated c. 24,000 ha of freehold and 8,617 ha of leasehold land. Afforestation with *P. radiata* and *E. regnans* commenced in 1960 and by 1964, APMF had 1,660 ha of *P. radiata* and 486 ha of *E. regnans* plantations (Mann, 1967, p. xvii) and overall a total of 5,030 ha of softwoods and 4,502 ha of hardwoods were developed (Noble, 1976, p.43). Establishing the plantations included use of a two-horse team with a single furrow hillside plough on steep slopes which were covered with grass or light bracken (Mann, 1967, p.xix).

Species planted

Research commenced in 1944 to determine the most appropriate species to establish in the Strzelecki Ranges. The trials included a range of softwood and hardwood species (see Table 6). This research concluded that *P. radiata* was the most suitable softwood and that *E. regnans* was the most suitable hardwood (Noble, 1976, p.37). The Government strategy was *P. radiata* planted in areas that originally carried *E. regnans* stands prior to clearing, but which had become overgrown with blackberries, due to the ability of the species to smother the blackberries growing beneath (Noble, 1976, p.49). Species allocation to site recognised that *E. regnans* was susceptible to severe damage from winds, hence on exposed sites *P. radiata* was planted (Noble, 1976, p.49). APM Forests developed a protocol of species-site matching with *E. regnans* planted on all areas considered suitable; mainly southern and eastern aspects and areas which formerly supported natural forest *E. regnans*. *P. radiata* was planted on sites unsuitable for *E. regnans* (Mann, 1967, p.xix) which included the ridge tops (Mann, 1967, p. xvii). At that time, *E. regnans* was the only economic eucalypt species for plantations (Mann, 1967, p.xx). APM Forests also planted smaller areas of *E. globulus* and some other species (Algar, 1988, p.214).

Table 6: The species tested in trials established in the Strzelecki Ranges from 1944 (Noble, 1976, p.37).

Softwoods		Hardwood	
Scientific name	Common name	Scientific name	Common name
P. radiata	Radiata pine	*E. regnans*	Mountain ash
A. cunninghamii	Hoop pine	*E. globulus*	Blue gum
P. sitchensis	Sitka spruce	*E. sieberi*	Silvertop
P. menziesii	Douglas fir	*E. delegatensis*	Alpine ash
		E. viminalis	Manna gum
		E. muellerana	Yellow stringy bark

A Government afforestation project; the Toorongo Plateau

The project, site and cause of deforestation

Afforestation of the Toorongo Plateau was undertaken based on a government research programme to determine the most appropriate species and establishment techniques (McKimm & Flinn, 1979, p.117). The region is located near Noojee in Gippsland, (c.100 km east of Melbourne) with undulating terrain and an elevation range of c.950 to 1,250 m. The soils are brown, friable and gradational, derived from Upper Devonian granite *'which frequently occurs as extensive outcrops or as floaters in the surface soil horizons'* (McKimm & Flinn, 1979, p.117). The original forest included *E. regnans*, *E. nitens* and *E. delegatensis* and in some cases, *Nothofagus spp.* (McKimm & Flinn, 1979, p.117 citing Specht, 1973). Figure 28 presents the Plateau in 1942 after wildfires in 1926, 1932 and 1939 mostly eliminated the natural forests. Post the 1939 fires, 19,500 ha were not expected to naturally regenerate (FCV, 1939, p.11) due to a lack of seed, as the eucalypt overstory was destroyed. By 1943-44, post-fire natural regeneration of *E. regnans* and *E. delegatensis* was well advanced and failed areas were evident, and were noted as 'blanks' by the FCV (FCV, 1944b, p.8). Approximately 10,000 ha of forest failed to regenerate to a satisfactory stocking level and attempts to reforest the more exposed of these denuded sites with eucalypts and softwoods of commercial value failed (McKimm & Flinn, 1979, p.117). Research identified the importance and impact of competition. A simple manual broadcast of seed across bracken areas failed to regenerate due to an absence of adequate rainfall and a loss of moisture due to transpiration caused excessive soil drying (Powles, 1940, p.27&31). Research undertaken and in 1934-35, afforestation with open-rooted *E. regnans* seedlings while successful (FCV, 1944b, p.8), was regarded as impractical due to excessive cost (FCV, 1935b, p.6).

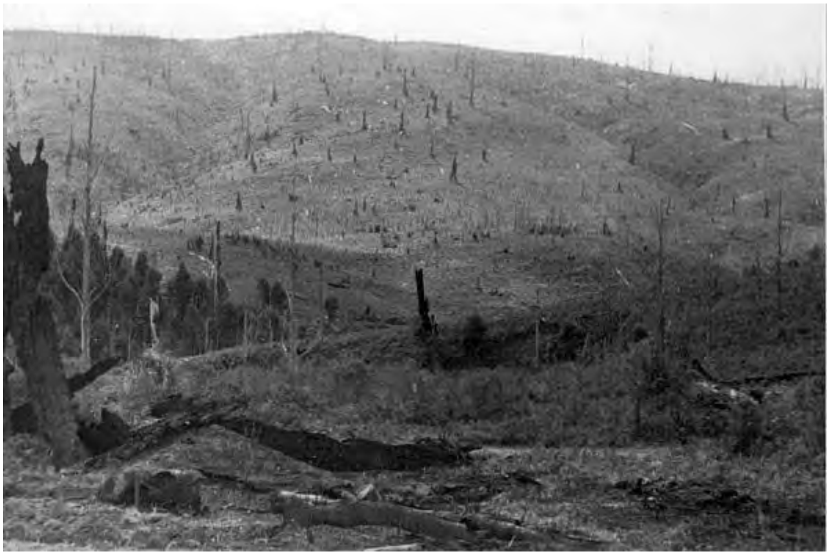

Figure 28: Toorongo Plateau in 1942 (Source: Frank Smith. The FCRPA collection).[6]

A revisited supporting research programme

A Government research project established trials in 1972 across three site types (Site 1: the harshest site with only grass cover; Site 2: a moderate site with bracken and low scrub; Site 3: the least exposed site with tall bracken and scrub), with a range of species (*E. delegatensis*, *E. globulus sub sp. bicostata*, *E. nitens* and *E. regnans*) and site preparation techniques (McKimm & Flinn, 1979, p.118). *E. nitens* had in general, the best survival and early growth rates for the sites included with either ripping, furrowing or ploughing, and a fertiliser containing nitrogen applied at planting (McKimm & Flinn, 1979, p.117). *E. nitens* and *E. delegatensis* had high survival rates and similar growth rates on the less exposed sites, with the selection of species planted proposed to be *'determined largely by factors such as seed cost and availability, and other silvicultural considerations such as timber quality and susceptibility of the two species to snow damage and pest and disease attack'* (McKimm & Flinn, 1979, p.122&123). Regardless of site preparation and site, *E. globulus* and *E. regnans* had poor survival

[6] https://commons.wikimedia.org/wiki/File:Toorongo_Plateau_-_Photo_Taken_by_Frank_Smith_1942.jpg downloaded on 01/09/2020.

(McKimm & Flinn, 1979, p.119). A video interview suggested that the *E. nitens* seed for operational afforestation was collected from local trees (the Toorongo provenance) (Owen Salkin in a Forest Heritage Video, 2021).

Supporting programmes to encourage increased plantations

Summary

Support programmes encouraging planted tree development are considered. The programmes that have operated in Gippsland can be split in to those linked to a processor or resource owner which seek to develop a targeted and narrow resource, or those unlinked and on a broader basis. The linked programmes included a Government Farm Forestry Loan Scheme and a company marketing agreement. These programmes had a narrow focus on locally proven species with current active markets. In effect there was a plan for the species planted. The unlinked programmes were more *laissez faire,* promoting a range of novel species without current markets nor track records of performance. Neither business plans nor business cases were prepared for the novel species promoted.

Introduction

Advice on the species to plant is critical in the absence of internal resources, experience and/or research outcomes. Ferguson (1945, p.13) provided an insight for parties seeking such advice; *'It is always wise, if in doubt to, to consult with someone competent to give expert advice'*. In some cases, it is possible for advice to be provided by parties seeking to expand a complementary resource (e.g. an existing grower with an existing market). In others, advice can be provided by an independent party with perhaps a more *laissez faire* approach to options to address a broad range of interests. This section considers the advice on species to plant in Gippsland by each for type of party.

In support of a complementary estate

The Victorian Farm Forestry Loans Scheme

Development of plantations in Victoria included support for private plantation development via the Farm Forestry Loan Scheme of the FCV aimed at private parties and farmers. The scheme aimed to increase the State's timber reserves and diversify the income of farmers (Semmens, 1977, p.185). The scheme ran from 1966/67 to 1982/83 and included widespread promotion (de Fégely *et al*., 2011, p.54). A summary of the details of the scheme is presented in Box 7. An important attribute of the scheme was a narrow focus on contemporary commercial species; *P. radiata*, Poplars and *E. regnans*. Interestingly, the scheme noted that '*some limited use, now or in the future, may be made of the wood of E. globulus or related species, but the outlook is not sufficiently satisfactory to grant loans to plant this species'* (Semmens, 1977, p.187). It was reported that '*many of these schemes were criticized for being ineffective as incentives for farmers to plant trees and they incurred high administration costs...'*; at that time, a loan cost $4,000 per agreement or $166/ha in administration costs with alterations to agreements and follow-up costs (de Fégely *et al*., 2011, p.55). The area outcomes of the arrangement are presented in Figure 29 with a total area established of 8,270 ha (a rate of 466 ha/y). Recall the species by area presented in Figure 17 with a dominance of *P. radiata* and *E. regnans* up to 1983 and the close to cessation of planting in 1984; it is possible that this reflects the influence of this loan scheme.

Box 7: A summary of the FCV Farm Forestry Loan Scheme (based on Semmens, 1977, p.185 - 187; McCarthy, 1977, p.83&84).	
Scheme	Farm Forestry Loan Scheme of the Forests Commission, Victoria.
Lead agency	Forests Commission, of Victoria.
Commencement	Approved in 1964 with first plantings in 1966.
Authority	Commission seals the agreement and requests Ministerial approval.
Party	Granted to an owner of property in fee simple and to a lessee of not less than six years under a purchase lease from the Crown, to whom a Certificate of Title has been issued. Not enter into agreements with companies, except those established to carry on a family-owned farm or one owned by a small partnership.
Duration	Maximum period of 25 years; free of interest for 12 years
Loan	Fully metricated to loan $125 /ha with a maximum of $5,000. In 1976, the amount was increased to $200 /ha with a minimum of $400 and a maximum of $8,000
Interest rates	Interest was originally set at 5%, but changed to the long-term Commonwealth Bond rate.
Actions	The owner is required to plant a minimum of two hectares within two years of receiving the loan.
Land	Over 750 mm annual rain-fall with reasonable access and not too distant from a conversion centre. Suitable for growing the species proposed. Conditions for logging and log cartage.
Liquidity	Loans are not transferable.
Species	As approved by the Commission the following species shows the most promise: Radiata pine, Poplars *or* Mountain ash. *E. globulus*: Some limited use, now or in the future, may be made of the wood of *E. globulus* or related species, but the outlook is not sufficiently satisfactory to grant loans to plant this species.
Land title	The Commission is not authorised to require a mortgage to be registered in the Certificate of Title. The entire undertaking is subject to an agreement involving covenants on the part of both the landowner and the Commission
Advice	Provides advice on tree farming

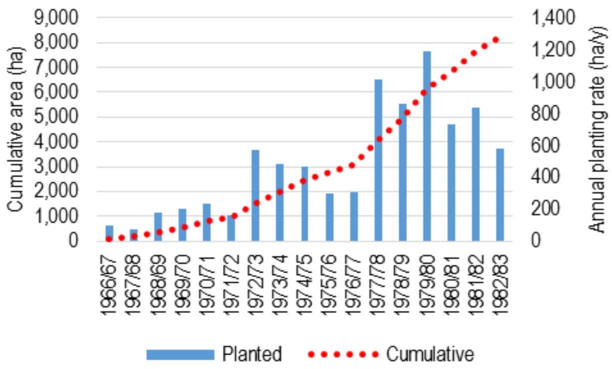

Figure 29: The outcome of the FCV Farm Forestry Loan Scheme for 1966/67 to 1982/83 (Hurley, 1986, p.88, Table 4.1).

The APM Forests Farm Forestry Agreement Scheme

APM Forests developed a Farm Forestry Agreement Scheme as a tool to expand the resource base in Gippsland to complement the company estate, and to produce pulpwood and sawlogs (Pollock, 1977, p.195). The arrangement was a marketing agreement on a first right of refusal basis in exchange for a range of support (Borland *et al.,* 1991, p.41). The programme targeted *P. radiata* on sites with rainfall of 700 mm/y or greater, with well drained soils of adequate depth and with a focus on West and Central Gippsland. The programme was run in parallel with the FCV loan scheme noting that it was possible to hold a FCV loan and enter into a marketing agreement with APM Forests (Pollock, 1977, p.195&196). In support, APM Forests produced a guide to farm forestry in 1977 (Wilson *et al.*, 1977) with two subsequent editions (Mann, 1985; Borland *et al.*, 1991). Interestingly, the guide did not specify species but rather provides a statement of recognising personal preferences. It noted that pines were more site adaptable than eucalypts, but limited by site drainage and frequent snow damage (Borland *et al.,* 1991, p.6). The company noted an ability to provide genetically improved planting stock of *P. radiata*, *E. regnans*, *E. nitens* and *E. globulus* (Borland *et al.,* 1991, p.37).

Unlinked estate expansion promotion

Gippsland Farm Plantations

Gippsland Farm Plantation (Inc) (GFP) (later, Gippsland Private Forestry; GPF) was a Regional Plantation Committee (RPC) established with Federal Government funding; GFP operated from 1996 to 2008. The vision, mission and key objectives of GPF are presented in Box 8, had a clear focus is on commercial and well-managed plantings. The GFP Business Plan states in the Executive Summary that: *'Commercially orientated plantations are the principle focus of GFP. However, the GFP Board clearly recognises the opportunities that exists to integrate productive tree growing with improved and sustainable agricultural activities, and measures to improve environmental and catchment health.'* GFP recognised that commercial trees can be a range of types and scales on private land, integrated with farming enterprises and to produce a range of commercial products, along with environmental benefits to the landowner as well as for broader catchments and the community (GFP, 2002, p.1).

Box 8: The key attributes of Gippsland Private Forestry (GFP, 2000, p.2).	
Element	Narrative
Vision statement	*'Gippsland will have a substantially increased area of commercial wood production on private land, comprising a resource that is strategically located, well managed and market orientated.'*
Mission Statement	• *'Actively seek, and link together land, capital, and markets to accelerate plantation development and assist achievement of commercially attractive returns.* • *Deliver a quality, targeted extension program to new and existing commercial tree growers in the region, in a manner that compliments sustaining the region's natural resource base.* • *Develop networks and cooperation between plantation industry sectors and stakeholders.* • *Seek to increase regional processing and value adding of the Gippsland plantation resource.* • *Promote the economic and environmental benefits of farm forestry to the broader Gippsland community.'*
A key objective	'*To encourage Gippsland landowners to consider plantations as a viable land-use on their properties.'*

There was recognition of the commercial status of species; for example, the GFP strategy noted that the long-term outlook for *P. radiata* in domestic markets was strong with increased export likely (GFP, 2000, p.23) and that *E. globulus* for pulpwood was perceived as a substitute for *E. regnans* (GFP, 2000, p.21). An important point is a clear recognition that natural grown trees generate wood that is different to the wood recovered from plantation grown trees of the same species; the example provided was *E. regnans* (GFP, 2000, p.27).

The recognition of the importance of end-use of the trees grown was extended to promote the selection of species and provenances that met quality objectives for both sawlogs and pulpwood production (GFP, 2000, p.27). The GFP strategy included encouraging the development of boutique (specialty timber) tree growing as a basis of a local self-sustaining industry (GFP, 2000, p.29). This was to be achieved by demonstration of the potential to grow high-quality, boutique species (GFP, 2000, p.31) and to seek to develop an understanding of the suitable species for Gippsland. At the time of establishment of GPF, there was a significant industrial plantation estate with the geographic range limited by rainfall requirements and distances to markets (at that time). Therefore, the GFP strategy included encouraging establishing tree farms in lower rainfall areas defined as with less than 650 mm/y rainfall, to result in multiple environmental, social and economic benefits to landowners and the community (GFP, 2000, p.36). There were no business plans nor business cases developed for the various species promoted.

A Department of Primary Industries grant scheme; Sawlogs for salinity project

The Sawlogs for Salinity project aimed to *'encourage the planting of trees to produce sawlogs while delivering environmental benefits in the form of salinity reduction and sustainable water management.'* As a result of a call for submissions, 11 were received and six were successful for funding. The project was expected to support establishment of 132 ha in woodlots from 15 ha to 40 ha in Gippsland. The species include were *E. muellerana* (46 ha), *C. maculata* (38 ha), *E. nitens* (16 ha), *E. globulus* (14 ha), *E. botryoides* (11 ha) and *A. melanoxylon* (7 ha) (DPI, 2006). An example follows. A farmer in the north-Foster area of South Gippsland, had a 12 ha of *P. radiata* plantation via a FCV Farm Forestry Loan in 1979. With assistance from Heartwood Plantations, the *P. radiata* was harvested and replanted with *E. nitens*, and additional blocks of *C. maculata*, *E. muellerana*, *E. sieberi* were created on the farm (Gray, 2022, p.10). The owner purchased additional land in the Woodside area in 2005 and was later the recipient of a 'Sawlogs for Salinity' grant to establish 40 ha of *C. maculata*, *E. botryoides* and *E. muellerana* (Gray, 2022, p.11).

VicForests now The Department of Energy, Environment and Climate Action

The State Government developed a grants programme to support plantation development in Gippsland (VicForests, 2023a, p.3) with the programme objectives presented in Box 9. With the cessation of VicForests as an entity at the end of June 2024, most of the staff, functions, processes, agreements and stakeholder relationships, transferred to The Department of Energy, Environment and Climate Action (DEECA) (Notman, 2024, p.1). A stated objective was to increase the Gippsland estate by 300 ha with a maximum of 50 new sites (VicForests, 2023a, p.3). Grants would support woodlots, wide-spaced plantings and shelterbelts (see Box 10). The programme supported a range of species; hardwood (usually eucalypt species) and softwood species (usually *P. radiata*) over a short or long rotation were considered as eligible (VicForests, 2023a, p.3). The VicForests programme provides a list of preferred species that allowed a degree of species matching to individual plantation objectives and site factors (see Table 7; VicForests, 2023a, p.4). The programme includes potential for mixed species stands where species could perform a complementary role within the plantation regime. Other species were considered for funding on a case-by-case basis. To complement the objective of timber production, the programme notes a requirement for *'species / provenances and silvicultural regimes that are suitable for meeting future timber, fibre and other markets is essential'*, but excludes firewood production as a primary objective (VicForests, 2023a, p.7). Of the species listed, only *P. radiata*, *E. globulus, E. nitens* and *E. regnans* have been commercialised with logs harvested and sold on an ongoing basis. All other species are at various stages of commercialisation.

Box 9: The stated objective of the Gippsland farm forestry program (VicForests, 2023a, p.3)
'The Gippsland farm forestry program's objectives are to support plantation growth on farms to expand and diversify Victoria's timber resources, while generating other benefits such as enhancing farm productivity; diversifying income streams for landholders through the sale of timber and potentially carbon credits (or contribute to carbon offsets via other industry schemes); and generating economic activity in regional communities.'

Table 7: The preferred species listed by VicForests (VicForests, 2023a, p.4) and the other species as listed on the project website.

Level of focus	Species name	Common name	Claimed species status in Gippsland
Preferred species	*C. maculata*	Spotted gum	Established durable plantation species. An excellent prospect east of Sale within 50 km of coast. Cooler climate of south and west Gippsland makes performance more variable.
	E. bosistoana	Coast grey box	High durability of timber has led to small but increasing areas being established since 2017.
	E. botryoides	Southern mahogany	Established durable plantation species on protected sites.
	E. cladocalyx	Sugar gum	Being planted as a plantation species on a small scale. Likely to find a niche in drier areas (rainfall <700 mm/y) where frost is not an issue.
	E. globulus ssp. globulus	Blue gum	Mainstream
	E. grandis	Rose or Flooded gum	Minor. Superior options available in most cases.
	E. muellerana	Yellow stringybark	Mainstream durable sawlog species.
	E. nitens	Shining gum	Mainstream for sites at >300 m asl
	E. saligna	Sydney blue gum	Has been trialled locally and is generally regarded as inferior to the closely related southern mahogany.
	E. sieberi	Silvertop	Becoming increasingly popular. Has found a niche on exposed sites and where fast growth is required.
	E. tricarpa	Red ironbark	Being trialled as a plantation species on a small scale. May find its niche as a furniture and/or firewood species in drier areas that have frost issues.
	P. radiata	Radiata pine	Mainstream
Other species	*A. dealbata*	Silver wattle	Minor. Most often used as a nurse crop species. Has potential on high rainfall, clay loam sites.
	A. mearnsii	Black wattle	Minor. Most often used as a nurse crop species. Has great potential as a fast growing firewood option.
	A. melanoxylon	Blackwood	Considerable interest in establishment as a plantation species. However intensive silvicultural and site requirements act as a deterrent.
	C. cunninghamiana	River she-oak	Not mainstream, but has found a niche in shelterbelts as a multipurpose tree that adds wood and fodder versatility.
	C. macrocarpa	Cypress	Minor. Some interest in the *Cupressocyparis ovensii* (Oven's Cypress) hybrid that shows potential with good form and growth rate.
	E. baxteri	Brown stringybark	Not a commonly trialled plantation species. Early performance is promising. Potentially more frost hardy and tolerant of poor drainage than Yellow stringybark.
	E. globoidea	White stringybark	Not recognised as a plantation species in Gippsland. A preferred New Zealand plantation eucalypt.
	E. globulus ssp. bicostata	Victorian blue gum	Not recognised as a plantation species in Gippsland.
	E. macrorhyncha	Red stringybark	Minor. Generally superior options available in most cases.
	E. regnans	Mountain ash	Prior to early 1990s mainstream, but now rarely planted for plantation forestry.
	E. viminalis	Manna gum	Often included in trials and usually performs well. However, its poor sawing performance and durability mean that other species are preferred.
	S. sempervirens	Coast redwood	Becoming increasingly popular due to impressive performance and aesthetics on various properties in high rainfall west and south Gippsland.
	Toona ciliata var. australis	Australian red cedar	Restricted to a few isolated plantings. The narrow siting preference of the species indicates that it is not suited to being planted across large areas spanning different site classes.

Box 10: The stated planting arrangements eligible for support by a Victorian Government grant (VicForests, 2023, p.3&4).	
Arrangement	Narrative
Woodlots	*'Small scale plantations, generally between 5 and 20 hectares.'*
Wide spaced plantings	*'Trees planted several metres apart (minimum 400 trees/ha) to enable effective grazing of livestock (once trees are of sufficient size) or growth of crops, whilst producing timber.'*
Shelterbelts	*'A strip of trees, at least 20 m wide, strategically planted to shelter livestock, crops and pastures from the elements, as well producing timber products in future years. The total planted area must be at least 3 hectares but can be less if the area reaches 3 hectares when tallied with other new plantings. Other species may be used in conjunction with the primary timber species to provide the necessary structure for an effective shelter belt.'*

Information on a broad range of species was presented on the VicForests website which included individual species profiles. This list and the information presented was based on a database developed by GPF. Much of the information relied on, relates to natural forest trees and wood, and from other regions (Table 8). A specific statement was provided as to the status of each species and the basis for this set of claims in unclear. There have not been any business plans or business cases developed for the various species promoted. VicForests provides a specific disclaimer as to reliance on this information (Box 11).

Table 8: A summary of the information base claimed by Gippsland Private Forestry (____) and the VicForests website.

Reference listed	GPF	Reference listed	VF website	Reference listed	VF website
Bootle (1983)	X		X		
Bird *et al.* (1996a)	X	Carnegie (2002)	X	Tepper (2008)	X
Bird *et al.* (1996b)	X	Beadle & Brown (2007)	X	AS 3959:2018	X
Carter (1998)	X	Boland *et. al* (1992)	X	AS 5604-2005	X
Costermans (1994)	X	Clarke *et al.* (2009)	X	Farm Forestry New Zealand (____)	X
Cremer (1990)	X	Mortimer (2003)	X	Farm Forestry New Zealand (2024a)	X
Fry & Hateley (1992)	X	NAFI (2004)	X	Farm Forestry New Zealand (2024b)	X
Jarvis (1997)	X	Nicholas *et al.* (1997)	X	New Zealand drylands forests innovations (2024).	X
Noble (1996)	X	Phillips (1996)	X	University of Tasmania (______)	X
Thornton & Johnson (1997)	X	Poole *et al.* (2017)	X	Wood Solutions (_____).	X
Waugh *et al.* (1997)	X	Reid (2017)	X		
Anon (1997)	X	Tepper (2002)	X		

Box 11: The VicForests disclaimer.[7]
'This material is published for information purposes only. VicForests does not warrant, guarantee or make any representations regarding the accuracy of the material or its appropriateness for particular purposes. VicForests' material is based on the best available data at the time of publication. Changes in circumstances after the time of publication may impact the accuracy of the material and VicForests gives no assurance that any information or advice contained will be up-to-date at any point in time.'

[7] Accessed from https://www.vicforests.com.au/vicforest-forest-management/farmforestry/species-information-sheets on 16/04/2024.

Specific species trials established in Gippsland

Summary

To support plantation expansion by generating a robust evidence base, a range of trials have been established in Gippsland. A series of 12 eucalypt species and provenance trials were established in the 1980s (annual rainfall from 600 to 1,210 mm/y) with a final assessment at age 10 to 12 years. A collaborative assessment and analysis of the trial outcomes provided species and provenance recommendations by site (soils and rainfall). *E. globulus* performed the best and was recommended for sites with 600-1,000 mm/y rainfall, with *E. botryoides* recommended for 600-699 mm/y rainfall sites with deep sands. *E. nitens* was recommended for sites with greater than 1,000 mm/y of rainfall. A waste water irrigation and dryland species trial established in 1996 indicated that *C. maculata* performed best and was superior to *E. botryoides*. Dry-land *E. globulus* performed better than irrigated *E. botryoides* and *E. saligna*. A series of trials were established from 1999 in the Red Gum Plains (between Sale and Bairnsdale) to complement the gap in sites from the 1980's trials. The Red Gum Plains trials included a species trial (33 treatments), a best-bet management trial, an alternative silviculture trial and a spacing trial. The records for this series of trials are incomplete with undocumented management inputs (including thinning) and patchy inventory data. Some species trial data was recovered with assessment of all treatments (sites and species) at age 4 and 5 years, and only for the Princess Highway clay soil site for the best 14 species at 9 years. Based on productivity and form, the best performing species at age 5 years were; *E. nitens*, *E. globulus*, *E. benthamii*, *E. botryoides*, *E. muellerana, E. smithii* and *P. radiata* seedlings. At age 9 years for the single clay site, *P. radiata* seedlings and *E. globulus* were the best performing species based on productivity. There is an opportunity to explore the other trials of this series and all species trials to salvage performance data and perhaps information on species wood properties.

Introduction

The use of results from trials to determine which species to develop in plantations has been a consistent theme in Victoria and Gippsland. With time and changes in agencies, trials have been harvested and much of the data has become difficult to access. Where the outcomes have been documented, this provides a foundation for decision making. A more recent set of trials has been established in Gippsland with the outcomes either published or un-documented. Based on recovered files, it was possible to undertake analysis of otherwise lost data to generate a range of insights. This section of the report documents the recent trials established in Gippsland and the outcomes where available.

The Victorian 150th year Anniversary trials

As part of the 150th Anniversary of the State of Victoria (in 1984/85), the Victoria's 150th Anniversary Board awarded a grant of $210,000 to the Department of Agriculture and Rural Affairs (DARA) to establish an Agroforestry Research Project as a co-operative project between DARA and the Department of Conservation, Forests and Lands. The outcome was to establish agroforestry research trials at six localities over the period of 1983 to 1985 (Box 12). The overall aim was to provide definitive information on the costs and benefits of a range of agroforestry combinations; the trials included 93 tree species grown in combination with specific types of agriculture (Baldwin *et al.,* 1986, summary). Of the wide range of species planted, a Neerim South site had *E. regnans*, *P. radiata* and *Juglans nigra* established (Baldwin *et al*., 1986, Appendix 3). Based on the trial map (see Baldwin *et al*., 1986, p.20), online aerial imagery of the site was inspected and no planted trees as described could be observed. The outcomes of this series of trials are unknown.

Box 12: The sites included in the 150th Anniversary trials (Baldwin *et al.*, 1986, p.iv)
• Carngham (near Ballarat): Sheep grazing and *P. radiata*. • Hamilton (several sites): Sheep grazing and mixed tree species. • Kyabram: Irrigated pastures and *E. grandis*. • Rutherglen: Cereal cropping and shelterbelts. • Myrtleford: Irrigated mint and two clones of *Populus spp*. • Neerim South: Cattle grazing and mixed tree species.

A joint analysis of APM Forests and government agency eucalypt species trials

The trials

A series of 12 eucalypt species and provenance trials were established by APM Forests and Victorian Government Forest agencies in Gippsland. The trials included 140 seedlots (natural provenances and from seed orchards) of 36 eucalypt species (see Table 9). Growth to age 10-12 years was published by Duncan *et al.* (2000, p.vii) with growth trends determined and related to climatic and soil factors. The trials sites were located as follows; in 1986 (Mt Worth West, Narracan East, Yinnar, Maryvale and Gormandale), 1987 (Mt Worth East, Delburn, Flynns Creek, Stradbroke and Stockdale), 1988 (Tostaree), and 1989 (Waygara) (Duncan *et al.*, 2000, p.vii). A detailed site description is presented in Duncan *et al.*, (2000, p.4) with site rainfall varying from 600 to 1,220 mm/y (see Box 13). A more detailed description of the soils of each site is presented in Wong *et al.* (2000, p.7). A summary of the sites is presented in Table 10 and Figure 30 presents a map of the trial locations in Gippsland. The study cautions to limit extrapolation of outcomes to comparable sites which excludes *'the higher altitude regions of the Strzelecki or Great Dividing Ranges, or the lower rainfall zone between Traralgon and Bairnsdale (commonly referred to as the 'Red Gum Plains')* (Duncan *et al.*, 2000, front inside).

Box 13: A snap-shot of the trial sites (Duncan *et al.*, 2000: p. vii).
'Trial sites were previously Pinus radiata plantations, improved pasture or native forest. The sites range in altitude from 40 to 400 m, have an annual rainfall between 600 and 1220 mm, and average daily maximum and minimum temperatures range from 22-26 and 10-13°C in January, and 9-14 and 2-5°C in July. Soils vary in profile from uniform deep sands and texture contrast soils to gradational textured soils.'

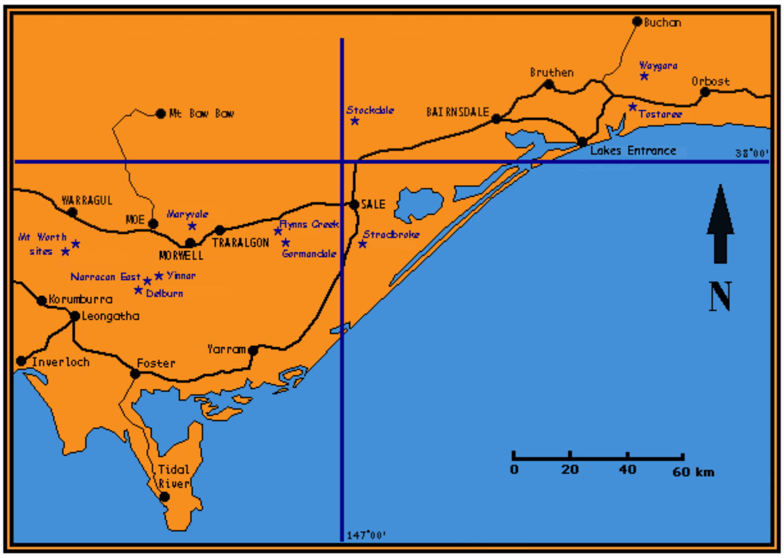

Figure 30: The trial site locations taken from Duncan *et al.* (2000: p.3, Figure 1).

Table 9: The species and provenances included across the 12 trial sites located in Gippsland.

Species	Provenance / seedlot	Waygara	Tostaree	Stockdale	Flynn's Creek East	Stradbroke	Delburn	Mt Worth East	Mt Worth West	Narracan East	Gormandale	Maryvale	Yinnar
E. badjensis	Nimmatabel			X	X	X	X	X					
E. benthamii	Wenthworth Falls			X	X	X	X	X					
E. bosistoana	Nowa Nowa			X	X	X	X	X					
E. botryoides	Jirrah	X	X	X	X	X	X	X					
	Meroo Pt	X	X	X	X	X	X	X					
	Narooma	X	X	X	X	X	X	X					
	Tildesley	X	X	X	X	X	X	X					
E. brookerana	Benwerrin		X	X	X	X	X	X					
	St Marys	X											
E. camaldulensis	Horsham								X	X	X	X	X
E. cameronii	Grafton			X	X	X	X	X					
E. cladocalyx	Gilgandra				X	X							
	Wirrabarra				X	X							
E. cypellocarpa	Fitzroy Falls					X	X	X					
	Jeeralang Nth			X	X	X	X	X					
	Mt Erica	X	X										
E. delegatensis	Ben Nevis			X	X	X	X	X					
	Geehi							X					
	Royston			X	X	X	X	X					
E. dendromorpha	Mt Budawong			X	X	X	X	X					
E. denticulata	Bonang		X	X	X	X	X	X					
E. dunnii	Kangaroo Ck SF			X	X	X	X	X					
	Urbenville			X	X	X	X	X					
E. elata	Brown Mountain				X	X	X	X					
	Narooma	X	X	X	X	X	X	X					
	Nepean River			X	X	X	X	X					
E. fastigata	Bendoc			X	X	X	X	X					
	Robertson				X	X		X					
	Wolgan River			X	X	X	X	X					
E. fraxinoides	Eden	X	X	X	X	X	X	X					
	Pikes Saddle			X	X	X	X	X					
	Tuross Falls Rd				X	X	X	X					
E. globulus	Apollo Bay	X	X										
	Cannans Track	X	X										
	Denison				X	X	X	X					
	Eden	X	X										
	Jeeralang	X	X	X	X	X	X	X	X	X	X	X	X
	Judbury	X	X										
	King Island	X	X										
	Kuark	X	X						X	X	X	X	X
	Mansfield	X	X										
	Mt Cole			X	X	X	X	X	X	X	X	X	X
	Pelverata			X									
	St Helens	X	X										
	Tantawanglo			X	X	X	X	X	X	X		X	X
	Wye River	X	X										

Species	Provenance / seedlot	Waygara	Tostaree	Stockdale	Flynn's Creek East	Stradbroke	Delburn	Mt Worth East	Mt Worth West	Narracan East	Gormandale	Maryvale	Yinnar
	Yarram	X	X										
	Jericho								X	X	X	X	X
	Macquarie Harbour								X	X	X	X	X
	Mt Dromedary										X		
	Scamander								X	X	X	X	X
E. grandis	Bulahdelah	X	X	X	X	X	X	X					
	Bulahdelah East			X	X	X	X	X					
	Coffs Harbour	X	X										
	Mt Lewis			X	X	X	X	X					
	South Africa SO			X	X	X	X	X					
C. maculata	Batemans Bay	X											
E. melliodora	Baradine				X	X	X	X					
	Beaufort			X									
	Pikedale				X	X		X					
E. muellerana	Curlip	X											
	Genoa			X	X	X	X	X					
	Hartland	X											
	Maramingo	X											
	Mt Kembla			X	X	X	X	X					
	Yarram	X		X	X	X	X	X					
E. nitens	Bonang	X											
	Kaye	X	X										
	Mt Erica	X	X										
	Mt St Gwinear			X	X	X	X	X		X	X	X	X
	Mt Toorongo			X	X	X	X	X	X	X	X	X	X
	New England NP			X	X	X	X						
	England NP							X					
	Powelltown	X	X										
	Snobs Creek	X	X	X	X	X	X	X	X	X	X	X	X
	Tallaganda	X	X	X	X	X	X	X					
	Toorongo Plateau	X	X										
E. obliqua	Kangaroo Island				X	X		X					
	Lavers Hill			X	X	X	X	X					
	Mawbanna			X	X	X	X	X					
	Powelltown				X	X		X					
	Styx River			X	X	X	X	X					
E. oreades	Bell-Mt Wilson							X					
	Lithgow	X	X										
	NSW					X		X					
E. paniculata	Coffs Harbour			X	X	X	X	X					
	Nowra				X	X	X	X					
E. quadrangulata	Albion Park	X	X	X	X	X	X	X					
E. regnans	VRD 1 (25% cull)			X	X	X	X	X	X	X	X	X	X
	VRD 1 (Fam. 11)			X	X	X	X	X					
	VRD 1 (Fam. 33)			X	X	X	X	X					
	Jeeralang								X	X	X	X	X
	VRD1 (Fam. 3)								X	X	X	X	X

Species	Provenance / seedlot	Waygara	Tostaree	Stockdale	Flynn's Creek East	Stradbroke	Delburn	Mt Worth East	Mt Worth West	Narracan East	Gormandale	Maryvale	Yinnar
E. robusta	Huskisson	X											
E. rubida	Strathbogie	X	X										
E. saligna	Batemans Bay	X	X	X	X	X	X	X					
	Beaumont	X	X										
	Blackdown Tableland			X	X	X	X	X					
	Coffs Harbour	X	X										
	Glenn Innes	X	X	X	X	X	X	X					
	New Zealand plantation			X	X	X	X	X					
	Wondandian			X	X	X	X	X					
E. sideroxylon	Murrungowar	X											
	Raymond	X											
E. sieberi	Bimmil Hill	X	X										
	Erica	X	X					X					
	Lithgow					X		X					
	Orbost							X					
	Scamander Island	X	X			X		X					
	Timbillica							X					
	Waygara	X	X										
	Yarram	X	X										
E. smithii	Albion Park			X	X	X	X	X					
	Bodalla			X	X	X	X	X					
	Mt Buck	X	X	X	X	X	X	X					
E. tereticornis	Bairnsdale			X	X	X	X	X					
	Camden			X	X	X	X	X					
	Kennedy River			X	X	X	X	X					
	Oro Bay to Emo			X	X	X							
	Sale			X	X	X	X	X					
E. triflora	Morton NP					X		X					
E. viminalis	Bendoc			X	X	X	X	X					
	Big Badja	X	X	X	X	X	X	X					
	Deepwater			X	X	X	X	X					
	Fingal	X	X	X	X	X	X	X					
	Martha Vale	X	X										
	Morwell	X	X	X	X	X	X	X					
	Templestowe	X	X										
	Timbarra	X	X										
	Warburton			X	X	X	X	X					
	Wye River	X	X										
	Yarram			X	X	X	X	X					

Table 10: A summary of the trial site attributes based on Duncan *et al.,* (2000, p.4) with broad soil type from Wong *et al.,* (2000, p.7).

Trial	P year		Location		Altitude	Annual rainfall	Previous land-use	Soils
			Latitude	Longitude	(m, ASL)	(mm)		
APMF	1986	Mt Worth West	38°18’	145° 59’	380	1,210	Improved pasture	Cay loam
		Narracan East	38°17’	146°16’	180	960	*P. radiata* plantation	Sandy clay loam
		Yinnar	38°18’	146°18’	100	930	*P. radiata* plantation	Clay loam to sandy loam
		Maryvale	38°12’	146°28	40	770	*P. radiata* plantation	Cay loam to sandy loam
		Gormandale	38°16’	146°42’	200	830	*P. radiata* plantation	Loamy sand
	1987	Mt Worth East	38°19’	145°59’	400	1,220	Improved pasture	Clay loam
		Delburn	38°21’	146°14’	200	1,000	*P. radiata* plantation	clay loam
		Flynns Creek	38°16’	146°36’	110	760	*P. radiata* plantation	Sandy loam to sandy clay loa
		Stradbroke	38°16’	147°03’	60	600	*P. radiata* plantation	Loamy sand
		Stockdale	37°51’	147°11’	90	690	*P. radiata* plantation	Sandy loam
NRE	1988	Tostaree	37°47’	148°11’	40	820	Improved pasture	Loamy sand
	1989	Waygara	37°41’	148°19’	80	870	Native forest	Sandy clay loam

The outcomes

The analysis generated site X species X provenance data for the seedlots included. With seedlots common between sites (see Table 9), site impact analysis was possible. The trials ranged from 10 to 12 years of age at final assessment providing a robust indication of species growth performance on the site established. The utility of the species will depend on the intended markets (and products) and the authors provide this caveat (Duncan *et al.*, 2000, p.35). The species included in the trial were very broad representing a range of sub-genera (see Table 11) and varied in potential wood properties and product options. While the species included were mostly lower density and lighter in wood colour (based on natural forest sourced wood), higher density species and species with durable wood from natural forest trees were included. This provides invaluable insights for a wide range of sites and intended products in Gippsland.

Given the large number of seedlots, Figure 31 presents the mean annual increment (MAI) of the top 5 best performing seedlots (species – provenance) for each site. A useful summary of the outcomes is provided by the authors (see Box 14). The study provides a species by site (soils and rainfall) recommendation matrix; this is based on the trial at final age and does not consider wood properties (see Table 12). Of the species recommended, *E. globulus* and *E. nitens* are the only species that have been grown through to rotation with harvest and sale of wood products on an ongoing basis, and *E. botryoides* is yet to achieve this status. Cameron, *et al.*, (2004, p.27) noted based on experience, that the ‘*existing* E. regnans *and* E. nitens *plantations in Central Gippsland are generally located on favourable sites, but some of the* E. globulus *is planted on duplex soils [which are] now considered unsuitable’.*

Table 11: The classification of the species included in the trials to the series level (based on Pryor and Johnson, 1971).

Series	*Species*		Series	*Species*
Capitellatae	*E. cameronii*		Salignae	*E. botryoides*
	E. muellerana			*E. grandis*
				E. robusta
Cladocalyces	*E. cladocalyx*			*E. saligna*
Melliodorae	*E. melliodora*		Tereticornes	*E. camaldulensis*
	E. sideroxylon			*E. tereticornis*
Obliquae	*E. delegatensis*		Viminales	*E. badjensis*
	E. dendromorpha			*E. benthamii*
	E. fastigata			*E. brookerana*
	E. fraxinoides			*E. cypellocarpa*
	E. obliqua			*E. denticulata*
	E. oreades			*E. dunnii*
	E. regnans			*E. globulus*
	E. sieberi			*E. nitens*
	E. triflora			*E. quadrangulata*
				E. rubida
Odoratae	*E. bosistoana*			*E. smithii*
				E. viminalis
Paniculata	*E. paniculata*			
			Genus; Corymbia	*C. maculata*
Piperitae	*E. elata*			

Box 14: The summary statement by the authors of the analysis (Duncan *et al.,* 2000, p.vii).

'Mean annual increment (MAI) of the most productive seedlot at each site varied from 13 m³/ha at Yinnar to 57 m³/ha at Mt Worth West. Stem volume varied greatly within each site, with a 15 to 60-fold difference between the best and worst seedlots. E. globulus, E. nitens and E. viminalis were generally the most productive species at each site, while E. camaldulensis, E. tereticornis, E. melliodora and E. sideroxylon had generally poor productivity.'

'Species x site interactions were present at most sites. Growth trends were generally similar within the Viminales (E. globulus, E. viminalis and E. nitens) and within the Salignae (E. saligna, E. botryoides and E. grandis). On the highest productivity sites (1000+ mm rainfall and gradational textured soils) the growth of E. nitens was outstanding. On the lowest productivity site (600-699 mm rainfall and uniform deep sands) E. botryoides was the most productive species. On all other sites, E. globulus was the most productive species.'

Table 12: The recommended species matching to site based on the trial analysis at age 10 to 12 years.

		Rainfall (mm/y)				
		600-699	700-799	800-899	900-999	1000+
Soils	Uniform deep sands	*E. botryoides*		*E. globulus*		
	Texture contrast soils	*E. globulus*	*E. globulus*	*E. globulus*	*E. globulus*	
	Gradational texture soils				*E. globulus*	*E. nitens*

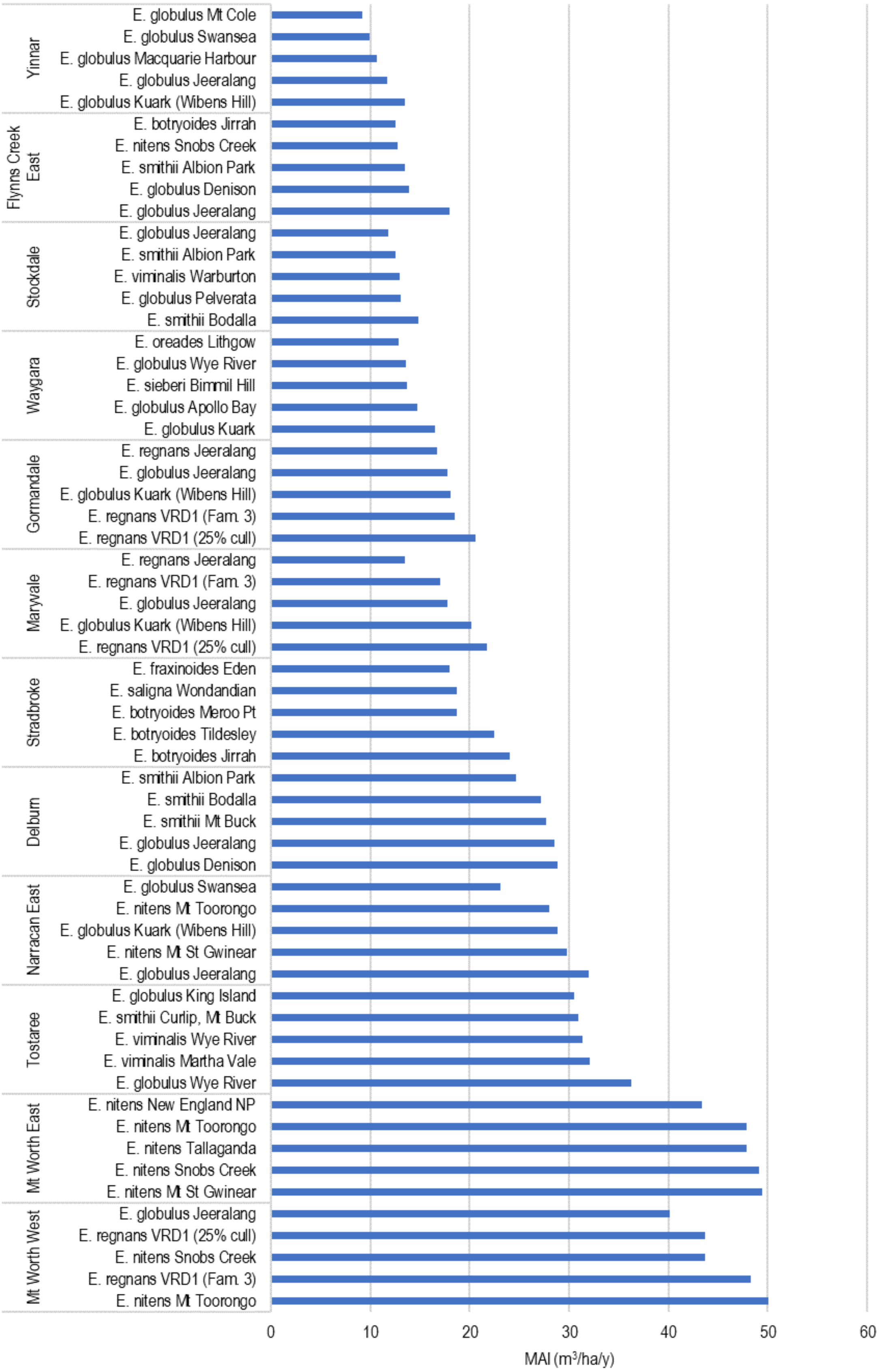

Figure 31: The top 5 performing species / provenance by MAI per site based on Duncan *et al.* (2000, p.10-17).

Considering the data for *E. globulus* and the indicated site rainfall (see Table 10), a mean annual rainfall (MAI) for rainfall function was prepared and is presented in Figure 32. The model is based on the performance of the best two *E. globulus* seedlots in each trial (see Duncan *et al.*, 2000, Table 4). The model is robust for the sites included with an $R^2 = 77.8\%$; that is, rainfall explains 77.8% of the variation in MAI and other factors (e.g. soils and past management etc.) explain 22.2% of the variation. The data point well-below the trend-line (rainfall = 930 mm/y) was on a medium to heavy clay soils site, which may have reduced tree growth. This relationship can be used to gain an insight into MAI expected for rainfall subject to the limitations noted by the authors. It is acknowledged that the trial sites included ex- *P. radiata* plantations but the site preparation and management was to a high standard (e.g. weed control and fertiliser) part off-setting any differences to pasture sites. The highest productivity sites were ex-pasture sites.

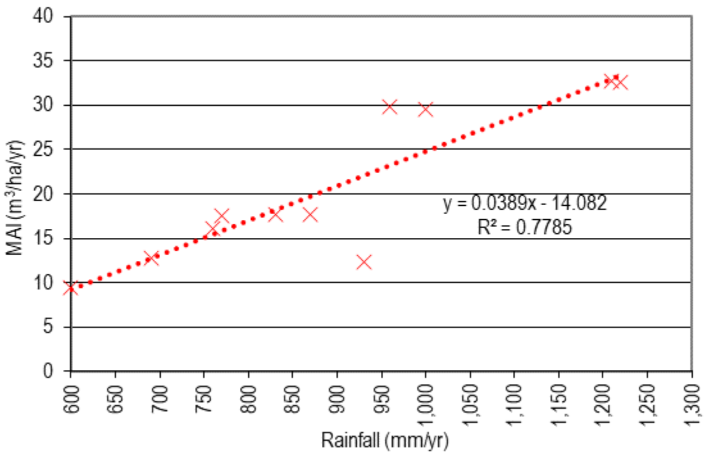

Figure 32: Average rainfall and outcome MAI for the trial sites. A predicted MAI for rainfall function is presented as a simple empirical model.

An irrigated eucalypt plantation trial established in 1996

In 1996, East Gippsland Water established a plantation adjacent to the Bairnsdale Waste Water Treatment Plant to test municipal wastewater irrigation methods, tree species and two sawlog management regimes (a wide-spaced agroforestry and fully stocked dryland plantation) (Poynter, 2007, p.192); see Figure 33 for a current aerial image of the site. The site received a long-term average of 700 mm/y rainfall but the actual rainfall was 580 mm/y (Poynter, 2007, p.193&195). The trial site soils included Red Gum Plains soils and deep well drained sandy loams (Poynter, 2007, p.193). The irrigated plots were established at 600 stems/ha (a 5 m X 7 m grid) and the conventional plantation at 1,000 stems/ha (Poynter, 2007, p.194). The plots were non-commercially thinned and pruned (Poynter, 2007, p.195). Figure 34 presents the species MAI at age 10 based on trial results with *C. maculata* (irrigated) and *E. globulus* (dry-land) performing the best at this age. The performance of the *E. globulus* plots was suggested to relate to the site's deep, well drained, sandy loams (Poynter, 2007, p.195). Tree form was considered (Poynter, 2007, p.197). *E. saligna* and *E. botryoides* had poor form and heavy branching under wider spacing conditions. In addition, *E. botryoides* stems were brittle and the trees were susceptibility to wind damage. The *C. maculata* trees had much finer branching under wide spacing but there was often a need to correct poor stem form. It was suggested that the provenance planted may have contributed to the performance outcomes (Poynter, 2007, p.197). The trial indicated that wide-spaced planting does not foster good tree form. Poynter (2007, p.102) concluded to limit future *E. globulus* sawlog plantations to sites with long-term rainfall averages of at least 800 mm/y, and to plant *E. cladocalyx* (not included in the trial) or *C. maculata* in the 600–800 mm rainfall zone.

Figure 33: The East Gippsland Water Trial site based on Poynter (2007, p.193, Figure 1).

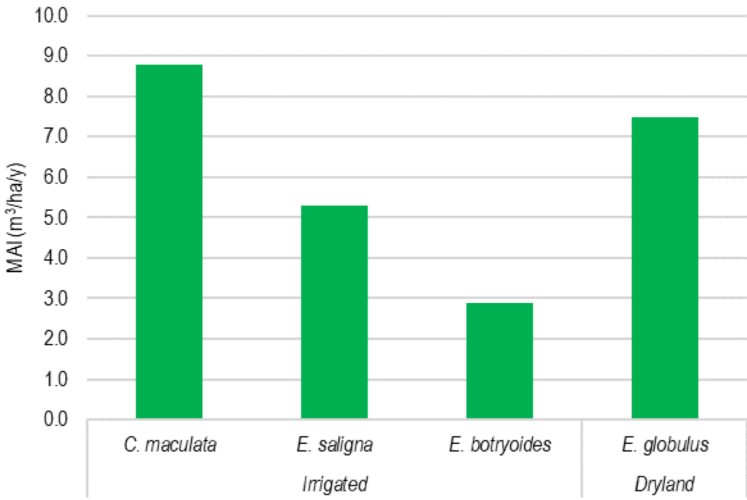

Figure 34: The outcomes at age 10 years of the East Gippsland Water dryland and irrigated tree trials (Poynter, 2007, p.198&199).

The Gippsland Farm Plantations Red gum plains trial series

The 1999 trials; location and intent

In 1999, GFP commissioned a series of trials to be established in the Red Gum Plains area of East Gippsland (from Sale to Bairnsdale). This complemented the area omitted by the trial series noted above. Jenkin (1998) presents details of the proposed species to be included and GFP (1999) presents details of the other trials. The trials included a species and provenance trial, a best-bet management trial, an alternative silviculture trial and a spacing trial (see Table 13). The sites established included Red Gum Plains clay and Perry sands soils. The sites were deep ripped to 1 m using a D8 bulldozer and good weed control was applied. The records available are limited in detail of the actual establishment activities undertaken (including the dates) and subsequent management (e.g. thinning) for all trials. Further, it is not known whether the trials are intact, have been managed and indeed whether they are all still in existence; some insights are possible based on aerial imagery.

Table 13: The trials included in the 1999 Red Gum Plains trials series (GFP, 1999, p.1).

Planting	Location	Red gum plain clays	Perry sands
		(ha)	(ha)
Species trial	Princes Highway, Bairnsdale	5.9	5.9
Best bet management trial	Aitkens Rd, Benworden	4.0	4.0
Alternative silviculture trial	Turners Rd, Bengworden	2.0	2.0
Spacing trial	Bengworden Rd, Meerlieu	1.25	1.25
Totals		13.15	13.15

The 1999 trials; best bet management

A best bet management options trial was established in 1999 to test management towards specific log size outputs as presented in Table 14 (based on GFP, 1999, p.5&6). The trees were planted at 1,000 stems/ha in 100 tree plots across different soil types (the clay and sandy soils) with four replicates per site. The treatments included clearfalling for small roundwood and thinning to grow larger trees. The thinning options were a non-commercial or a commercial thinning. The status of the trial including any assessment outcomes or the implementation of the treatments is unknown.

Table 14: A summary of the species and treatments included in the best bet management trial.

Species	Small roundwood	Large roundwood	
		A non-commercial thinning	A commercial thinning
A. mearnsii	X		
E. botryoides			X
E. cladocalyx			X
E. globulus			X
C. maculata			X
E. muellerana			X
E. tereticornis	X	X	X
P. radiata		X	

The 1999 trials; alternative silviculture

The alternative silviculture trial included planned 2nd row and 3rd row out-rows planted to species intended for harvest as a commercial thinning to recover firewood. The species planted were in pairs as presented in Table 15. The trial was designed on a randomised block basis with two replicates. It is not known whether any assessment of this trial has been undertaken nor what ongoing management has been implemented.

The 1999 trials; tree spacing trial

A trial was established with *E. globulus* and *P. radiata* planted to achieve 600, 900 and 1,200 stems/ha after an assumed 85% survival (GFP, 1999, p.9&10). Variation in stocking was achieved with all treatments planted at 4 m spacing between the rows and varying the within row spacing; 3.5 X 4.0 m, 2.4 X 4.0 m and 1.8 X 4.0 m. The treatments were replicated twice on each of the two soil types. It is not known whether any assessment of this trial has been undertaken nor whether there have been any management interventions.

Table 15: The species combinations in the alternative silviculture trial (Tepper, 2000).

Combination	Final crop species	Out-row species
1	*P. radiata*	*E. benthamii*
2	*C. maculata*	*A. mearnsii*
3	*E. globulus*	*A. mearnsii*
4	*E. tereticornis*	*A. mearnsii*
5	*B. integrifolia*	*E. cladocalyx*

The 1999 trials; species and provenance trial

The species and provenances planted in the species trials are presented in Table 16. A conscious choice was made to exclude *E. camaldulensis* as this species readily hybridises with *E. tereticornis*, and would have created a risk of localised 'genetic pollution' (Jenkin, 1998, p.34). The trials have been assessed three times; at age 4, 5 and 9 years (based on datasets, GPF, 2005; GPF, 2008PP). The outcomes of the age 5 years assessment are presented in GPF (2005) and for the age 9 years assessment, in GPF (2008PP). The age 5 years assessment measured all species and provenances at the five sites (three with clay soils and two with sandy soils) (GPF, 2005, p.1). The age 9 years assessment measured 14 species planted at the MacArthur clay soils site (GPF, 2008PP, s.2). A number of spreadsheets with the assessment outcomes were accessed and via a process of cross-checking, the details of the data was documented (e.g. due to a lack of details in the files). Further, the trials have had silvicultural interventions (e.g. thinning) which would have reduced the standing volume at the time of assessment. It was noted by Goldstraw (____) that *'many of the trials have been thinned and pruned to demonstrate good forest management for the production of high quality sawlogs. The trials will continue to be managed on a sawlog regime and measured every second year to keep track of their relative performance.'* This reduces the utility of the trials, but still enables an indication of species performance. The age 5 year assessment note stated that the assessment was undertaken to obtain a final analysis before thinning (GPF, 2005, p.1), but the spreadsheets noted species that had had thinning undertaken.

Table 16: Details of the species and provenances planted in the species trial (Tepper, 2000, p.8, Table 14&16).

Species	Provenance	Genetics supplier	Nursery
A melanoxylon	Smithton, Tas	Moormurng	Moormurng
A. implexa	Dunolly, Vic	ATSC	Moormurng
A. mearnsii	Kyneton, Vic	ATSC	Kleins
B. integrifolia	Wallagoot Lake, NSW	Kangarusa	Kangarusa
B. integrifolia	Woodside Beach, Vic	Kleins	Kleins
C. cunninghamiana	Uriarra Crossing, NSW	ERA	ERA
C. glauca	Tuross Lake, NSW	ERA	ERA
C. lusitancia var. benthami	Longwoods seed stand, NZ	Treecorp	Treecorp
C. macrocarpa	Lismore seed stand, NZ	Treecorp	Treecorp
C. maculata	Currvall SF, NSW	ATSC	Kleins
Callitris glaucophylla	Milbruhong SF near Lockart, NSW	SFNSW	SFNSW
E. benthamii	Kedumba Valley, NSW	ATSC	Kleins
E. bosistoana	Woodside Beach, Vic	Kleins	Kleins
E. botryoides	Orbost, Vic	ATSC	Kleins
E. cladocalyx	Wilmington, SA	ATSC	Kleins
E. globoidea	Murrurindi, NSW	ATSC	Kleins
E. globoidea	Murrurindi, NSW	ATSC	Moormurng
E. globulus ssp bicostata	Wee Jasper, NSW	ATSC	Kleins
E. globulus ssp globulus	APP Seed Orchard, VRD 32-35	APP	AP Maryvale
E. grandis	Wedding Bells SF, NSW	ERA	ERA
E. grandis x E. camaldulensis	Possibly *E. grandis* - Coffs Harbour, NSW & *E. camaldulensis* - Petford Qld.	Dendros	Yuruga
E. muellerana	Orbost, Vic	ATSC	Kleins
E. nitens	APP Seed Orchard VRD 26 & 36	APP	AP Maryvale
E. occidentalis	Gibson, WA	ERA	ERA
E. oreades	Newnes SF, Lithgow, NSW	ATSC	Kleins
E. polyanthemos	Talbot, Vic	NRCL	NRCL
E. sideroxylon	Orbost, Vic	Kleins	Kleins
E. smithii	Wingello SF, NSW	ATSC	Kleins
E. tereticornis	Maryland, NSW	ATSC	Kleins
E. viminalis	Uriarra Forest, ACT	ATSC	Kleins
P. pinaster	Seedlot no. MP100	CALM	CALM
P. radiata cuttings	APP Stool plants at Cowwarr, Vic	APP	APP Cowwarr
P. radiata seedlings	HVP Lal Lal Seed Orchard, Gelliondale Vic	HVP	HVP

Figure 35 presents the standing volume at the age 5 years assessment of the three clay soil sites based on GPF datasets. As presented, not all species were planted at all sites or survived at all sites. Those species identified as thinned (T) are presented separately to provide a clear indication of species un-thinned performance. There are differences in performance between the sites, with the Aerodrome site generally performing better than the other two sites. The best performing species for the sites where included were *E. globulus*, *E. nitens*, *A. mearnsii*, *E. smithii*, *E. muellerana*, *E. botryoides* and *E. benthamii*.

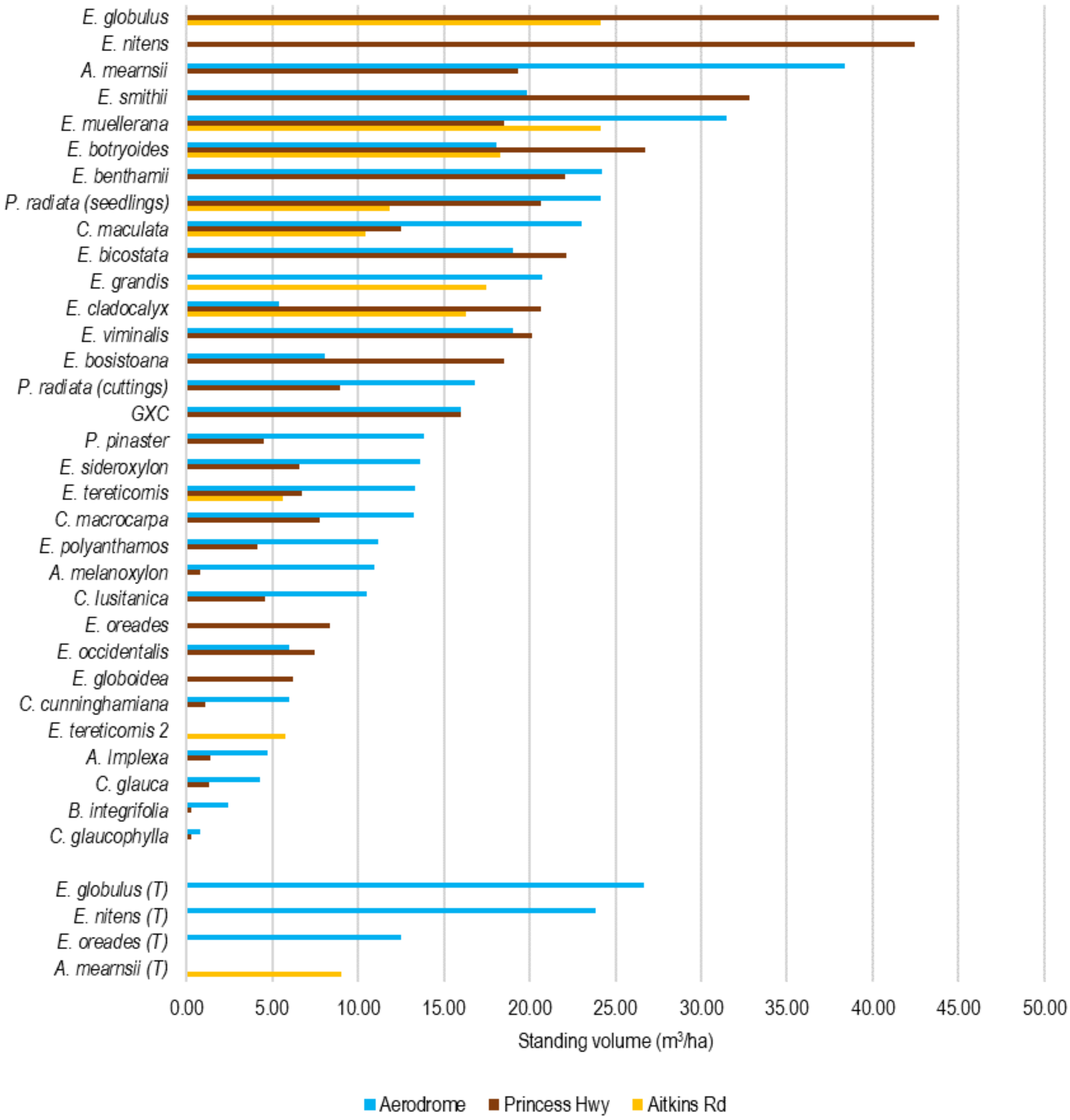

Figure 35: The results of an assessment of the species trials on the clay soil sites at age 5 years (based on GPF dataset). Note: (T) denotes species thinned.

Figure 36 presents the standing volume at the age 5 years assessment of the two sand soil sites based on GPF datasets. As presented, not all species were planted or survived at all sites. Those species identified as thinned (T) are presented separate to provide a clear indication of species un-thinned performance. There are differences in performance between the sites, with the Princess Highway site generally performing better than the Aitkins Road site. The best performing species for the sites where included were *E. benthamii*, *E. globulus*, *E. nitens*, *E. botryoides, E. smithii*, E. viminalis and *E. bosistoana*.

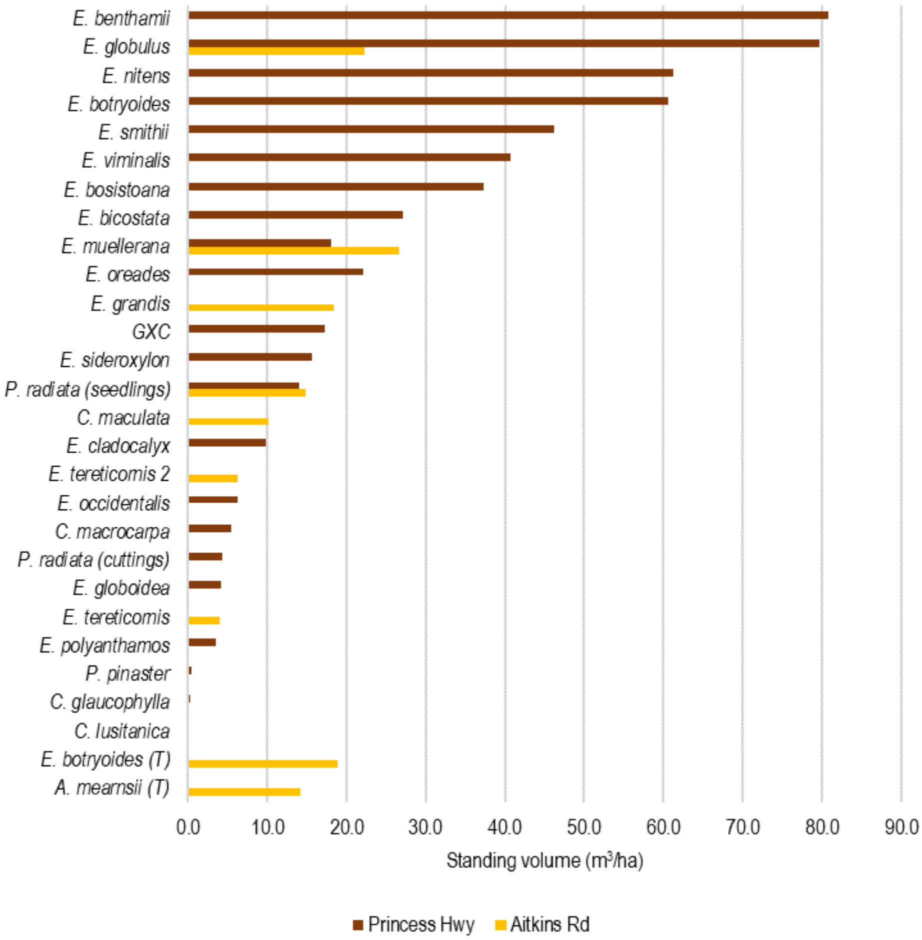

Figure 36: The results of an assessment of the species trials on the sand soil sites at age 5 years (based on GPF dataset). Note: (T) denotes species thinned.

To address a lack of uniformity in the species planted across the two soil types and five sites, Table 17 was prepared. For each site and soil type, the species planted were numerically ranked based on volume at assessment; 1 being the largest. This score was then presented as a percentage of the total number of species include at a site to provide a relative score. The percentage score was then allocated into quartiles of 'performance'; Q1 equates to the top 25% of species, Q4 the lowest 25% of performance and Q2 and Q3 combined. This analysis excluded the thinned treatments. There are general patterns of performance evident; *E. globulus* is in Q1 for the four sites where this species was included and unthinned. *E. muellerana* has performed well with four sites out of the five planted in Q1 and *E. benthamii* is in Q1 for all three sites included.

Table 17: A grouping of the ranking by volume of species by site, after the age 5 years assessment; Q1 indicates the species was in the top 25%, Q2&Q3 in the 25% to 75% class and Q4 in the bottom 25%. Species with a (T) indicate thinning and therefore exclusion.

	Clay sites			Sand sites	
	Aitkins Rd	Princess Hwy	Aerodrome	Aitkins Rd	Princess Hwy
A. Implexa		Q4	Q4		
A. mearnsii		Q2&Q3	Q1		
A. melanoxylon		Q4	Q2&Q3		
B. integrifolia		Q4	Q4		
C. glaucophylla		Q4	Q4		Q4
C. cunninghamiana		Q4	Q2&Q3		
C. glauca		Q4	Q4		
C. maculata	Q2&Q3	Q2&Q3	Q1	Q2&Q3	
C. lusitanica		Q2&Q3	Q2&Q3		Q4
C. macrocarpa		Q2&Q3	Q2&Q3		Q2&Q3
E. grandis x E. camaldulensis		Q2&Q3	Q2&Q3		
E. occidentalis		Q2&Q3	Q4		Q2&Q3
E. benthamii		Q1	Q1		Q1
E. bicostata		Q1	Q2&Q3		Q2&Q3
E. bosistoana		Q2&Q3	Q2&Q3		Q2&Q3
E. botryoides	Q2&Q3	Q1	Q2&Q3		Q1
E. cladocalyx	Q2&Q3	Q2&Q3	Q4		Q2&Q3
E. globoidea		Q2&Q3			Q4
E. globulus	Q1	Q1		Q1	Q1
E. grandis	Q2&Q3		Q1	Q2&Q3	
E. muellerana	Q1	Q2&Q3	Q1	Q1	Q2&Q3
E. nitens		Q1			Q1
E. oreades		Q2&Q3			Q2&Q3
E. polyanthemos		Q4	Q2&Q3		Q4
E. sideroxylon		Q2&Q3	Q2&Q3		Q2&Q3
E. smithii		Q1	Q2&Q3		Q1
E. tereticornis	Q4	Q2&Q3	Q2&Q3	Q4	
E. tereticornis 2	Q4			Q4	
E. viminalis		Q2&Q3	Q2&Q3		Q2&Q3
P. pinaster		Q2&Q3	Q2&Q3		Q4
P. radiata (cuttings)		Q2&Q3	Q2&Q3		Q2&Q3
P. radiata (seedlings)	Q2&Q3	Q1	Q1	Q2&Q3	Q2&Q3

Q1	2	7	6	2	5
Q2&Q3	5	16	15	5	11
Q4	2	7	6	2	5

As part of the age 5 years assessment, trees were scored for form. This data was combined for all sites in a GPF dataset with the form categories of '% good', '% OK' and '% Poor'. The outcomes are presented in Figure 37. Of the species included, only *E. nitens* recorded greater than 50% the trees as 'good'. If we consider a combined score of 'good' and 'ok', then more species have greater than 50% in this combined class. There are 11 species with 75% of greater of trees as 'poor'. While it is possible to thin from below and by form to improve stand quality, the lower the overall stand quality, the fewer the options for selecting good form final crop trees.

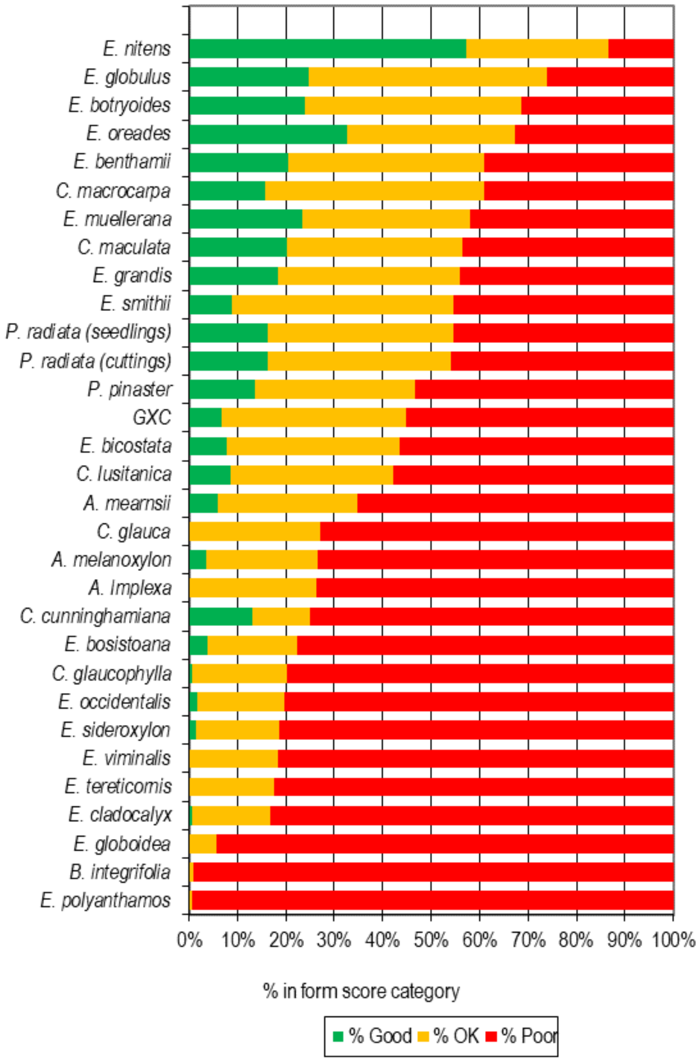

Figure 37: The combined results of all sites assessments of tree form at age 5 years (based on GPF dataset).

The GPF datasets provides an opportunity to expedite knowledge on species selection considering productivity and tree form (see Figure 38). While both attributes can be influenced, it is prudent to consider the timeframes of potential outcomes. Tree form can be improved by some management interventions to current trees (e.g. stem singling to remove addition leaders or multi-stems) and tree improvement of future trees (e.g. breeding for form as a trait). Management interventions are unlikely to amend significant stem defects and tree improvement will take generations of plantings. Species productivity can be improved by nutrient application, competition management and thinning of current planted trees, and by improved site matching for future trees. Site selection can be informed by immediate experience and be implemented relatively quickly, whereas tree improvement is a longer-time scale intervention.

Species productivity	Upper 50%	<u>Poor form and higher productivity</u>: Not an issue for woodchip or biomass markets. An issue for processing of stems into EWP or sawn timbers.	<u>Better form and higher productivity</u>: Maximum market options.
	Lower 50%	<u>Poor form and lower productivity</u>: A least attractive species option.	<u>Better form and lower productivity</u>: A longer-term tree crop with broad market options.
		Lower 50%	Upper 50%
		Species form	

Figure 38: A two-way matrix of species performance and tree form as a basis of classifying the outcomes of the species trials.

The GPF 2005 trial assessment productivity and tree form outcomes were combined and are presented in Figure 39 (clay soils) and Figure 40 (sandy soils). The x-axis presents the combined form score for all sites to show the percentage of trees for each species that were 'ok' or better form (based on Figure 37). It is acknowledged that this is a combined single score for all sites and that there is likely to be variation between sites. The y-axis presents the average productivity ranking on a relative basis for each species on the sites were planted and not thinned (based on Figure 35 for the clay sites and Figure 36 for the sandy sites). The presentation indicates the better performing species; for example, the species in the upper 50% for each attribute could be considered as having more potential than those in the other three quadrants. The species in this upper preferred quadrant (i.e. best form and productivity) show a degree of consistency between the two soil types.

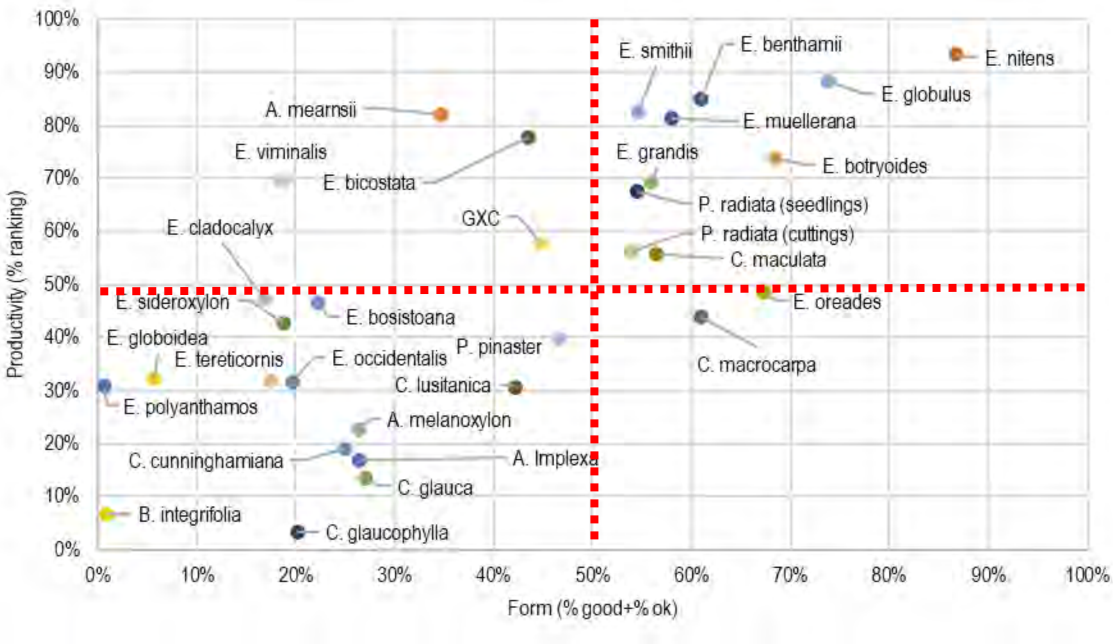

Figure 39: A combined growth performance and tree form matrix for the age 5 years assessment of the clay soil sites. Note: the tree form data is the combined dataset for all sites.

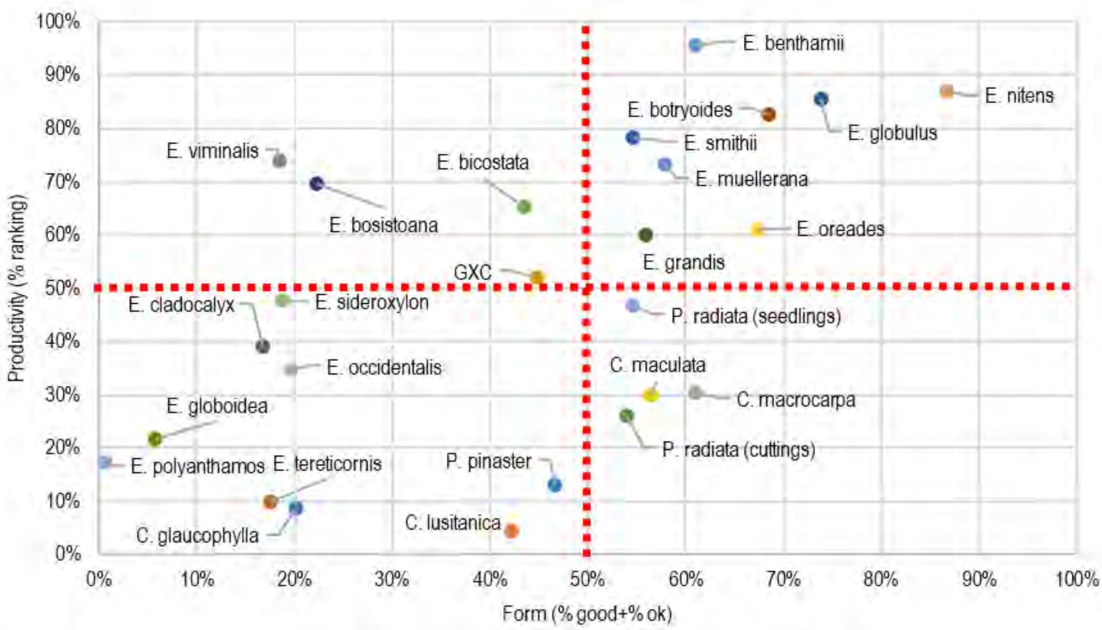

Figure 40: A combined growth performance and tree form matrix for the age 5 years assessment of the sand soil sites. Note: the tree form data is the combined dataset for all sites.

Figure 41 was prepared based on a series of available GPF datasets with three measurement ages; 2.4, 5.1 and 6.8 years. The thinning status of the stands is not known. The dataset included *E. globulus* on clay and sandy sites with the species performing better than the other species included. Trends overtime are indicated as follows, with *E. nitens* appearing to slow in growth or it may have been that the species was thinned. The *C. maculata* plots could be increasing in performance with an increasing upward trend in volume.

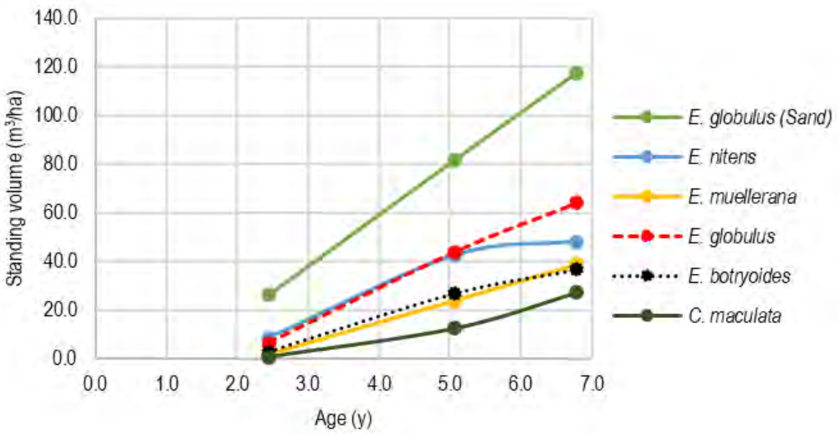

Figure 41: The outcome of a series of assessments of the Red Gum Plains Princess Highway clay site trial completed at age 6.8 years (a sand plot of *E. globulus* is included).

Figure 42 presets the standing volume outcomes at age 9 years for the Princess Highway site at Bairnsdale. As noted, this assessment only included the top 14 species by performance. The results were converted into MAI by GPF and these outcomes are presented in Figure 43. Based on standing volume, *P. radiata* seedlings and *E. globulus* have performed the best with a jump down to the next best performing species on this site. The MAI of the best performing species was between 10 and 11 m^3/ha/y. Consider the outcomes for the age 5 years assessment (see Figure 39) which suggests that at age 9 years, *P. radiata* had either increased in relative growth rate or the other species have reduced production to result in this outcome.

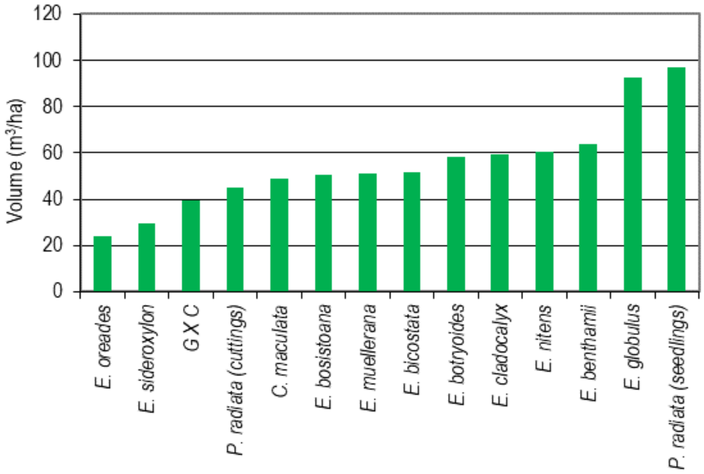

Figure 42: The standing volume outcome of the assessment of the Princes Highway Red Gum Plains clay site trial at age 9 years (based on GPF datasets).

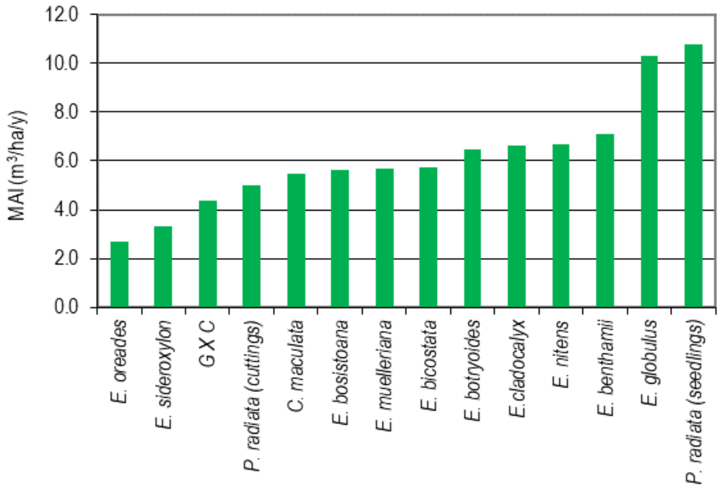

Figure 43: The MAI outcome of the assessment of the Princes Highway Red Gum Plains clay site trial at age 9 years (based on GPF datasets).

The 2006 trials; species and provenance trials

A subsequent series of species (*C. maculata*, *E. botryoides* and *E. muellerana*) by provenance trials were established in 2006 (GPF file notes including correspondence and maps); see Table 18. Of interest is the inclusion of genetically improved seed. These trials were located near the Stockdale-Fernbank Road (clay soils; north of the Princess Highway, Fernbank) and near Stracey's Lane (sandy soils; south of the Princess Highway, Fernbank). The trials were established in 48 tree plots, with four replicates at each site. Based on a file note (GPF, 2008), the initial plantings failed and were re-established. There are no other details on subsequent management of the site available. No other information on performance is available and a scan of aerial images suggests that at least the Stracey's Lane trial remains in place.

Table 18: A summary of the identified species and provenances included in the 2006 trials.

Species	Provenance	Included		Seed source	Nursery
C. maculata	01/21; Termeil via Batemans Bay, NSW.	Sand	Clay & buffer	Kylisa	Klein's
	Seedlot 20772, CSIRO; could be SSO at Deniliquin and/or CSO at Corowa, NSW.	Sand	Clay	CSIRO	Klein's
	02/01; Kangaroo State Forest, Coffs Harbour, NSW.	Sand	Clay	Kylisa	Klein's
E. muellerana	03/13; Larry's Mountain, NSW	Sand	Clay	Kylisa	
	M31; Mt Watt Track, Orbost, Vic.	Sand	Clay	Goy	Klein's
	EU 0220 or 02/20; Lower Carrajung, Vic.	Sand	Clay	Klein's	Klein's
	Coongulla, Vict.	Sand	Buffer		
	M49; Albert River Rd Yarram, Vic.	Sand		Goy	Klein's
E. botryoides	92/32; Sam's Range via Narooma, NSW.	Sand	Clay	Kylisa	
	98/26; Brodribb via Orbost, Vic.	Sand	Clay	Kylisa	Klein's
E. saligna	01/19; Termeil, NSW.	Sand	Clay	Kylisa	Klein's

The Trials Review, Information and Genetics (TRIG) Project

A 2023 Federal Government funded project (delivered via the Victorian Government's Department of Jobs Precincts and Regions and Forestry Australia) sought to document the status of a range of planted species in Victoria. The project; Trials Review, Information and Genetics (TRIG) Project sought to improve information pathways to assist advancing trees into farming in Victoria (see Box 15). Of the 123 sites included in the TRIG database, three were located in Gippsland (one at Lake Tyers and two at Woodside). The sites included an Australian Low Rainfall Tree Improvement Group (ALRTIG) *E. tricarpa* seed orchard and trees planted under the Sawlogs for Salinity project (TRIG DATABASE); see page 50 of this report. The seed orchard was established in the year 2000 and covers 1.8 ha (Harwood *et al.,* 2005, p.13). The project updated the farm forestry trial database with new trials and information compiled by the project. A series of priority sites were identified, inventory conducted, and works completed at these sites. The project selected *E. cladocalyx* and *C. maculata* as key species and generated Victoria wide productivity maps based on inventory data. Model plantings were identified to be used as demonstration sites which would include signage to aid with interpretation (Lacey *et al.*, 2023, p.v).

Box 15: A summary of the TRIG project objectives (Lacey *et al.,* 2023, p.1).

'The purpose of the TRIG Project is to support the integration of tree plantings into farms in Victoria through four key activities:

1. *Provide a comprehensive update to the farm forestry trial database information and identify priority sites to target for ongoing treatment and data collection.*
2. *Identify model plantings of various species/provenances that have performed well in representative environments. Where appropriate, and in conjunction with the landowners, plan and manage approved stand management activities (such as thinning).*
3. *Enhance the management of existing seed orchards and explore establishment of new seed production areas (SPAs) and identify the need for the establishment of new seed orchards and SPAs to supply improved seed.*
4. *Collate, clean and disseminate relevant updated datasets, reports and advisory information via a publicly accessible web platform hosted by the Victorian government and Forestry Australia and other promotional activities.'*

Potential activities

The recent past trials represent a significant opportunity to expedite a range of knowledge capture in regard to wood properties at close to rotation age and perhaps species performance information (e.g. productivity and form). Given the range of species planted with known provenances, there is potential to convert trials into SSO by selection and thinning of replicates. A key insight is that there is a need for a sunset-clauses for all trials to ensure a legacy of the investment in the establishment of the trials is not lost.

Demonstration plantings in Gippsland

Summary and insights

A number of important demonstration plantings have been established in Gippsland; Lardner Park Field Days demonstration site, an indigenous to Gippsland species planting (seven species each at six sites) and 29 species planted at the Bairnsdale Aerodrome. These plantings have been designed to promote tree planting as part of agricultural systems and include trees older than 20 years of age. While there are standing trees, based on reports and observations (e.g. at the Lardner site), there have been a range of management interventions and other activities undertaken. However, there are limited records to any level of detail. As the trees are standing, there is potential to explore wood properties and high-level statements of productivity. The indigenous species and Bairnsdale Aerodrome sites offer potential for inventory to determine productivity, but with the onset of competition between trees, this may result in unrepresentative results compare to the true potentials. These insights reinforce the importance of clear and continuous professional management of demonstration plantings to maximise the information captured. A snapshot is presented of an individual farm which provides an insight to a focus on commercial species, with minor experimentation with other species.

Introduction

Development of demonstration plantings of trees is a useful component of an extension strategy to promote expansion of the plantation base. A premise is that land owners will seek to observe first-hand outcomes (e.g. standing trees) which can be supported by information such as species planted (fundamental), management inputs to create the current state, data on the outcomes (e.g. tree survival and growth rates) and wood properties as a basis of understanding the potential use of the trees. As part of a range of programmes and funding, there have been a range of demonstration plantings in Gippsland. The following provides details of the main initiatives and an individual farmer example in regard to species and outcomes.

Lardner Park Field Days demonstration site

The history and species planted

Lardner Park is a well-recognised site which has hosted agricultural field days since 1963 (GFD, 1991). A demonstration tree planting was established in 1978 and was reported as the oldest such planting in Victoria (Waring, 1992). The site included woodlots, agroforests and weed control trials established by APM Forests in co-operation with Ciba Geigy, CSIRO Division of Forest Products, Du Pont, Pivot and the Department of Agriculture (Hastings, 1987, p.1; Anon, 1991). The purpose of the plantings has been to demonstrate and promote the potential of trees planted into agricultural systems (see Box 16). Figure 44 presents an aerial photograph of the site taken in the 1980s. Management of the site was supported by management plans (see Waring, 1992). The site has had five phases of plantings; see Table 19 for a compiled history of the site (based on Hastings, 1987, p.1&2; Abbott *et al.*, 1988; Gippsland Field Days Agroforestry Group, 1989; Hirst, 1991; Anon, 1991; Abbott, *et al*., 1991; Anon, 2002; Notman, 2022; a site visit on 16/05/2024). Management of the site has swapped between agencies with the current arrangements with DEECA (after cessation of VicForests). Prior to that, the site was managed in collaboration with the Gippsland Field Days' committee, the Department of Natural Resources and Environment and the Gippsland Agroforestry Network (GAN).

The p.1978 *P. radiata* plantation and agroforest was harvested in autumn 2002 (Anon, 2002). GAN established the next rotation in spring 2002 with 1,600 seedlings or cuttings of 14 different species or seedlots planted (Anon, 2002). A commercial harvest was undertaken in October 2015 to clearfall a series of woodlots; 0.6 ha of *E. globulus* and 0.5 of ha *P. radiata* planted in 1992, and 0.3 ha of *E. regnans* planted in 1978 (Leslie, 2015, p.1). Overall, there are limited detailed records of any of the activities undertaken during any of the phases of development and management of this site.

Box 16: The intent of the plantings was to demonstrate aspects of woodlot management (Hastings, 1987, p.1).	
i.	*'A spacing and thinning demonstration with* P. radiata *planted at initial spacing of 1,200 and 1,800 stems/ha,*
ii.	*A weed control demonstration with* P. radiata *and* E. regnans *and*
iii.	*An agroforestry demonstration with (a) radiata and (b) regnans. Initial spacing in the agroforestry demonstration was 7.0 m between and 2.4 m within-rows (600 stems/ha).'*

Figure 44: An aerial photograph of the Lardner Park site in the early 1980s (believed taken by Arthur Lyons).

Outcomes

With the objective to demonstrate tree related 'activities', information on all aspects of the plantings should support this intent. The site has had a range of management interventions (e.g. planting, re-filling, weed control and thinnings) but no adequate records have been maintained. Further, the only available inventory data was for the original plantings as presented in Table 19. It is possible to consider sampling of trees for wood properties, but in the absence of stand records, it would be difficult to determine growth and yield outcomes.

Table 19: A summary of the species and management regimes applied at the Lardner Park Agroforestry demonstration site.

Phase	Plot	Species	Year	Arrangement
1	1	*P. radiata*	1978	Planted at 1,200 stems/ha
			1978	Planted at 1,800 stems/ha
	2	*P. radiata*	1978	Weed control demonstration
		E. regnans	1978	Weed control demonstration
	3	*P. radiata*	1978	Agroforestry demonstration planted at 600 stems/ha
		E. regnans	1978	Agroforestry demonstration planted at 600 stems/ha
	4	*P. radiata*	1988	Agroforestry demonstration
2	1	*P. radiata*	1988	Double row shelter belt
	2	*P. radiata*	1988	Double row shelter belt
		Pittosporum undulatum	1988	
	3	*A. melanoxylon*	1992	Woodlot; A provenance trial with a buffer of two rows eucalypts as a shelter crop
		E. regnans	1992	Woodlot; A 2 row shelter crop; refilled with *E. nitens* in 1994
	4	*E. obliqua*	1993/94	Timber belts
		Casuarina	1993/94	
		Haekia	1993/94	
	7	*E. globulus*	1992	Agroforest with APM Forests select planting stock
3	1	*C. maculata*	1993	Single rows in a timber belt along the eastern boundary
	1	*C. cunninghamiana*	1993	Single rows in a timber belt along the eastern boundary
	1	*Hakea salicifolia*	1993	Single rows in a timber belt along the eastern boundary
	1	*E. muellerana*	1994	Single rows in a timber belt along the eastern boundary
	1	*E. nitens*	1994	Single rows in bottom half of a timber belt along eastern boundary
	1	*A. melanoxylon*	1994	Single rows in bottom half of a timber belt along eastern boundary
	1	*Melaleuca ericifolia*	1994	Single rows in bottom half of a timber belt along eastern boundary
4		*E. botryoides*	2002	Woodlots planted at 952 stems/ha
		C. macrocarpa	2002	Woodlots planted at 816 stems/ha as alternate rows
		C. lusitanica	2002	Woodlots planted at 816 stems/ha as alternate rows with *C. lusitanica*
		Q. alba	2002	Woodlots as alternate rows with *Q. robur 'fastigiata'*
		Q. robur 'fastigiata'	2002	Woodlots as alternate rows
		C. deodara	2003	Infill of the failed *Q. robur 'fastigiata'*
		E. muellerana	2002	Woodlots planted at 952 stems/ha
		E. grandis x E. camaldulensis	2002	Woodlots planted as alternate rows with *B X S*
		E. botryoides x E. saligna	2002	Woodlots planted as alternate rows with *G X C*
		A. dealbata	2002	Woodlots planted at 952 stems/ha
		S. sempervirens	2002	Woodlots
5	2	*C. cunninghamiana*	2023	Shelter belt
		Callistemon understorey	2023	Shelter belt
	8	*C. maculata*	2023	Silvo-pastoral planted groups of 3, in rows 10 m apart
	9	*A. mearnsii* alternating with *C. maculata, E. sieberi, E. globulus ssp globulus* & *E. fastigata*	2023	Mixed species woodlot planted in alternating rows with *A. mearnsii*

Table 20: Outcomes of an age 8 years assessment of the original plantings (Abbott, *et al.*, 1991). Note that the nominal initial stocking is lower than the stocking at age 8 years.

Species	Treatment	P. year	Stocking		Mean DBHOB	Mean dom. height	Volume	Basal area	MAI
			Nominal at planting	At year 8					
			(stems/ha)	(stems/ha)	(cm)	(m)	(m^3/ha)	(m^2/ha)	(m^3/ha/y)
P. radiata	Woodlot	1978	1,200	1,310	19.5	16.4	200.1	40.68	25.0
	Woodlot	1978	1,800	1,717	18.4	16.3	234.5	47.28	29.3
P. radiata	Agroforest	1978	600	684	23.5	14.9	131.9	30.38	16.5
E. regnans	Agroforest	1978	600	380	24.8	21.7	106.0	19.54	13.2

Gippsland Farm Plantations demonstration plantings

The Indigenous species demonstration planting project

To support their objectives, GPF organised field days and information packages, and established demonstration sites (GFP, 2000, p.37). A significant contribution was establishment of an indigenous species planting programme (see GFP, 2002). The organisation received funding from the Australian Government Envirofund to assist with the establishment of indigenous species, 8 to 10 ha demonstration plantations on three private properties in the Gippsland Plains (between Bairnsdale, Stratford, Sale, Rosedale and Seaspray). The intent was to encourage consideration of plantations in parts of the Gippsland where commercial tree growing was yet to be widely regarded as a viable land-use. The project built on the Red Gum Plains trials experience and established sites on six properties between Stratford and Bairnsdale with three each in 2003 and 2004 (GFP, 2002, p.1). The species planted are presented in Table 21. It remains possible to identify the sites planted using aerial imagery (see Figure 45). No records of any assessment have been found and this series of plantings would provide an invaluable source of species performance data, outcomes and wood properties at the current age of 20 years.

Table 21: A summary of the species planted in the GFP Indigenous species demonstration planting project (GFP, _____a).

Planting year	Site	Area (ha)	*A. mearnsii*	*C. maculata*	*E. bosistoana*	*E. botryoides*	*E. muellerana*	*E. sideroxylon*	*E. tereticornis*
p.2003	Bairnsdale	8	X	X	X		X	X	X
	Bairnsdale	7	X	X		X	X	X	
	Dutson Downes	7	X	X		X	X	X	
p.2004	Rosedale	11		X			X		
	Hazelwood North	4	X	X		X	X		
	Loy Yang Power	9	X	X		X			

Figure 45: A Bairnsdale Indigenous species demonstration site.

The Bairnsdale Aerodrome demonstration planting

The species established at the Bairnsdale Aerodrome demonstration site in 1999 are presented in Table 22. This demonstration site is still in place (see Figure 46). No records of any assessment have been found and this series of plantings would provide an invaluable source of species performance data, outcomes and potentially wood properties at the current age of 20 years.

Table 22: The species planted in the Bairnsdale Aerodrome demonstration planting (GFP, _____b, p.2).

Scientific name	Common Name	Scientific name	Common Name
B. integrifolia	Coast banksia	*E. botryoides*	Southern mahogany
P. radiata (seedlings)	Radiata pine	*E. cladocalyx*	Sugar gum
P. radiata (cuttings)	Radiata pine	*E. globulus ssp. globulus*	Blue gum
P. pinaster	Maritime pine	*E. globulus ssp. bicostata*	Southern blue gum
C. macrocarpa	Monterey cypress	*E. muellerana*	Yellow stringybark
C. lusitanica var. benthamii	Mexican cypress	*E. grandis*	Flooded gum
Callitris glaucophylla	White cypress pine	*E. grandis x E. camaldulensis hybrid*	Flooded gum x River red gum Hybrid
C. cunninghamiana	River oak	*E. nitens*	Shining gum
C. glauca	Swamp oak	*E. oreades*	Blue mountains ash
A. mearnsii	Black wattle	*E. smithii*	Gully gum
A. implexa	Lightwood	*E. tereticornis*	Forest red gum
A. melanoxylon	Blackwood	*C. maculata*	Spotted gum
E. viminalis	Manna gum	*E. bosistoana*	Coast grey box
E. occidentalis	Swamp yate	*E. sideroxylon*	Red ironbark
E. benthamii	Camden white gum	*E. polyanthemos*	Red box

Figure 46: The Bairnsdale Aerodrome demonstration site.

Private plantings as demonstration sites via field days

There are numerous private tree plantings on farmland across Gippsland that provide potential to determine species productivity and wood properties. For example, Table 23 presents a snap-shot of the species planted by members of the GAN. As part of the Latrobe Catchment Landcare Network, GAN is a Special Interest sub-group focussed on growing, converting and marketing farm-grown timber[8]. As an example of a small-scale grower, based on a 1995 document and details provided by the farmer, the following insights are presented. When the Mirboo North farm was purchased in 1982, *'it was overworked, weed infested with few fences standing, derelict buildings and about 30 trees'* (Speedy, 1995, p.2). The bare hills had signs of erosion, the heads of gullies were expanding uphill due to cattle damage and the gullies were filled with blackberries and thistles. In general, ragwort and tussock were in abundance elsewhere (Speedy, 1995, p.2). A lack of shelter for stock was a motivation for tree planting. A small-wind break was planted in 1983 along a boundary and in the subsequent two years, the wind-break was extended to the full length of the boundary. In 1985, consultation with local Department staff commenced the process of whole-farm planning (Speedy, 1995, p.2). In 1987, the farm was one of six Victorian properties selected to participate in the 'Agroforestry for Land Improvement project' funded through the Victorian Rural Industry Training Committee. A farm plan was developed in consultation with enthusiastic but somewhat unknowledgeable people in the then new 'science' of agroforestry (Speedy, 1995, p.3). The planting programme was undertaken over a number of years with an initial focus on the recognised commercial species at that time; *P. radiata*, *E. regnans*, *E. globulus* and *E. nitens*. A broad range of other species were planted in smaller numbers (Figure 47). The outcome of integration of trees into this farm has stood the test of time with many insights developed in regard to tree growing, the timber industry and the market (Speedy, 1995, p.3).

[8] See https://www.lcln.com.au/gan accessed on 08/07/2024.

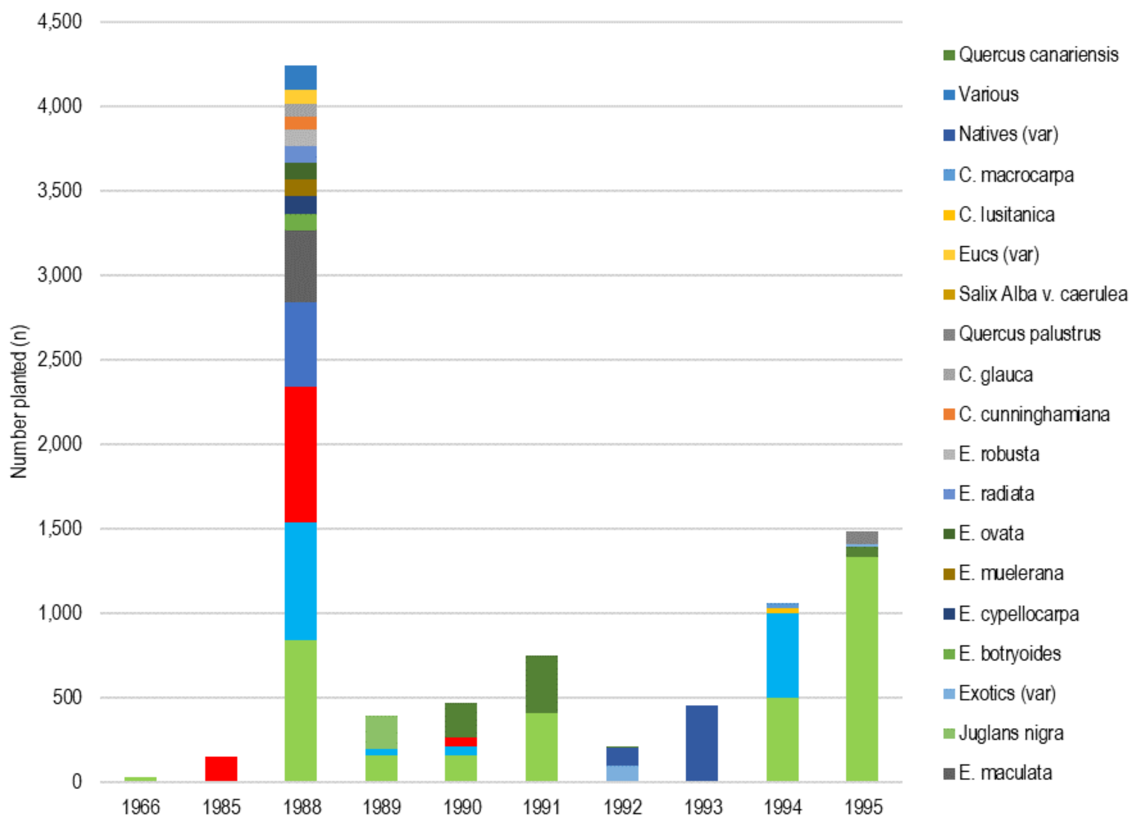

Figure 47: The species planted by year of establishment on a property near Mirboo North (based on Speedy, 1995 dataset)

Table 23: A snap-shot of the species by number of records of planting by GAN members (GAN, Devonshire*, pers. comm.*)

	A. dealbata	*A. mearnsii*	*A. melanoxylon*	*A. pycnantha*	*A. littoralis*	*C. cunninghamiana*	*C. maculata*	*E. macrorhyncha*	*E. bosistoana*	*E. camaldulensis*	*E. cladocaylx*	*E. globoidea*	*E. globulus*	*E. muellerana*	*E. polyanthemos*	*E. regnans*	*E. sieberi*	*E. sideroxylon*	*E. strzeleckii*	*E. tereticornis*	*E. tricarpa*	*G. robusta*	*Q. robur*	*S. sempervirens*	*Toona ciliata*
	Silver wattle	*Black wattle*	Blackwood	*Golden wattle*	Black she-oak	River she-oak	Spotted gum	*Red stringybark*	Coast grey box	River Red Gum	Sugar gum	White stringybark	Blue gum	Yellow stringybark	*Red box*	Mountain ash	Silvertop ash	Red ironbark	Strzelecki gum	Forest red gum	*Red ironbark*	*Silky oak*	English oak	Coastal redwood	Red cedar
2002	1		1				1						1	1											
2003									1												1				
2007							1							1											
2012			1		1											1		1	1			1	1	1	1
2015														1											
2016							1				1	1												1	
2022		1		1	1			1	1	1		1			1					1	2				
2023						2	2		1		1			1			1			1	2			1	
2024							1																		
Totals	1	1	2	1	2	2	6	1	3	1	2	2	1	4	1	1	1	1	1	2	5	1	1	3	1

Insights and lesson

Demonstration plantings and the private estate offer a significant opportunity to capture species performance and to sample wood properties. The species planted are broad and, in some cases, includes provenance details. The utility of this potential can be reduced due to limitations in the records kept. This is important where stands have been thinned resulting in loss of tree volume which would add to the overall plantation production. Regardless of these limitations, it would be possible to collect wood properties data. A key lesson from the current range of demonstration plantings is a need for continuity of management and record keeping between any party with responsibility for sites. A project or programme sunset clause for arrangements is required to ensure the continuity of management and record keeping. This should include requirements on record keeping and report preparation beyond reliance on the memory of individuals and anecdotal evidence.

Plantation productivity in Gippsland

Summary

Research is fundamental to support the planting of *the right tree in the right place* to ensure good growth and product recovery. This intent can be enhanced by use of improved genetics. In Gippsland *P. radiata*, *E. globulus*, *E. nitens* and *E. regnans* have a long history of tree improvement from select provenances to seed orchard generated improvements. A manager of emerging species (*E. botryoides*, *E. cladocalyx*, *E. muellerana*, *E. sieberi* and *C. maculata*) has commenced such an improvement. This genetic material is proprietary and owned by individual companies. Insights from comprehensive species by provenance trials could assist in selection of species and provenance of seed suited to Gippsland. It is unfortunate that this opportunity may have been lost due to a lack of ongoing management of many of the trials. In support of expansion, land suitability for plantations studies have been undertaken (in 1999, 2000, 2018 and 2021) to generate statements of the land-base potential. Curiously, none of the studies considered the outcomes of previous studies. While useful on a regional basis to indicate broad potential (ranging from 25,000 ha to 1.39 million ha depending on approach), it is only by consideration of land at the farm and sub-farm level, that the true potential is understood. This includes which species to plant and the units of land actually best suited to planting trees (e.g. as part of whole farm planning). Underpinning the studies has been the use of either empirical (e.g. correlation between rainfall and soils with productivity) or process-based (e.g. mimicking plant physiology responses to the environment) models to estimate site productivity. Analysis of the two studies using empirical models compared to actual results indicated an over estimate of productivity. To support management of plantations, a manager will make use of inventory data and models to predict future yield and again such tools are propriety. There are publicly available Gippsland-specific tools that could be used to estimate yield for a range of species planted in this region.

Introduction

As presented, development of the Gippsland plantation estate has been supported by research and seeking to understand site - species interactions; to understand what is the *right tree* in the *right place*. To take the step from research to estate development requires a range of supporting information and tools. An understanding of the land-base and land potential is required, underpinned by an understanding of the drivers of productivity. This combined with tree improvement by tree breeding can enhance species growth rates on a site and the quality of the wood grown. Consider Appendix 2 and the steps required for species commercialisation with tree improvement and genetic material supply as fundamental steps. Tools applied by plantation managers can combine this cohort of information to assist with management decisions and estimates of future resources. Smethurst *et al.* (2022, p.15) noted that *'historically, in-house computerised resource assessment and forecasting systems were developed, used and maintained to support the business needs of forestry enterprises beginning in the late 1960's'*. In support, in-house biometric (and other models) were developed and used to estimate stand attributes (e.g. tree or stand volumes by product) from manual tree measurement in sample plots. Models are used to extrapolate from current to future conditions, providing estimates of growth and future yield. In short, management of commercial plantations should be supported by species-specific inventory, productivity data and ultimately yield modelling. This section of the report addresses tree improvement, plantation productivity and recent land-base studies in Gippsland.

Tree improvement of species grown in Gippsland

Steps in tree improvement

The end-game of tree improvement is to grow superior trees with superiority defined by reference to the intent of a plantation. As noted in Appendix 2: Species domestication and commercialization, supply of select genetic material is a key step in commercialisation. There are a number of strategies and elements. Installation of provenance trials for a species aim to select the best populations of wild seed. A point of caution is whether there would be future access to commercial seed collection in natural forest stands. Provenance trials can be thinned to retain the superior individuals based on growth, form and wood properties to create a SSO. Selected superior individuals can be grafted onto planting stock and planted together to create a grafted seed orchard. An alternative or subsequent step is to undertake controlled crosses of elite individuals to a generate a superior next generation from which to select. A tree improvement programme can also include vegetative propagation and clonal strategies with some species. A point of caution with a tree improvement programme is to reduce the risk of in-breeding, un-intended hybrids and genetic pollution of natural stands of a species. A key point is that tree improvement takes time; that is, waiting for next generations and the ability to select trees, and the age at which flowering and seed production begins. A strategy to side-step this wait, is to import improved seed into a region (e.g. from interstate or from international programmes).

Softwoods

Tree improvement of *P. radiata* has had a long history in Australia, with State and indeed company (region) specific programmes (Lewis & Ferguson, 1993, p.176 – 183). As an example, the status of tree improvement of *P. radiata* in 1962 is provided. The FCV tree improvement programme for *P. radiata* included a process of selection of the most outstanding trees from a large and variable population. These were then cross-pollinated seeking to combine the desirable characteristics in genetically superior progeny. For large-scale production of improved seed for operational plantings, vegetative multiplication of the most outstanding trees by grafting was undertaken to establish a grafted seed orchard (Pederick, 1962, p.1). Selection aimed to reduce stem deformities (e.g. trunk bends, curves, cone holes and coarse knots) and double-leaders to reduce harvest residues. In parallel, wood property improvement was an objective; increased wood fibre length and a reduction in spiral grain. A contribution to a trade-off between increased juvenile wood (of poorer quality) due to wider spacing of trees was the use of genetic improvement to improve the wood quality of the juvenile wood was noted (Pederick, 1962, p.21&22). With a separate tree improvement programme to the Government, APM Forests made use of semi-lignified cuttings from 1984 for their *P. radiata* plantation programme as a method to rapidly deploy genetic gains. By 1988 APM Forests was the first large commercial manager to make use of 100% genetically improved cuttings (Whiteman, *et al.*, 1990, p.99). It was reported that Australian Paper Plantations (APP; an evolution of APM Forests) established all *P. radiata* plantations with improved genetic stock (Hescock, *et al.,* 1999, p.176).

Hardwoods

Eldridge *et al.* (1997) provided a comprehensive account of eucalypt domestication and breeding, which includes examples from Australia and overseas; it includes statements for a range of species of interest in Gippsland (e.g. *E. fastigata*, p.88; *E. globulus*, p.93; *E. grandis*, p.103; *E. nitens*, p.114; *E. regnans*, p.131; *E. viminalis*, p.154). Commencement of tree improvement of eucalypts in Australia was later than for *P. radiata*.

As noted, commencing in 1958, development of the APM Forests estate was supported by an *E. regnans* tree improvement programme to improve productivity and wood quality, and increase resistance to damage by fire (Eldridge, 1964, p.35). For example, *E. regnans* altitude of provenance trials were established in the Strzelecki Ranges in 1960 and 1963 (Eldridge, 1972). The FCV undertook similar research of provenance impacts on *E. regnans* performance. In 1966, an *E. regnans* provenance trial was planted at two locations; near Powelltown and Toolangi. The trial included four seedlots; three were from individual dominant trees, including an outstanding tree from central Tasmania, and the fourth was a routine Mirboo natural forest seed collection. The superiority of the Mirboo trees first appeared at about age 5 years and was very marked at 10 years at the Powelltown site. For the Toolangi site, even by 10 years, the Mirboo sourced trees were not significantly better than the other provenances. This indicated a large provenance by location interaction (Pederick, 1966, p.35) and the ability to make use of early age data to predict later age outcomes. It was reported that all APP eucalypt plantations were established with improved genetic stock in 1999 (Hescock, *et al.,* 1999, p.176). The *E. globulus* and *E. nitens* planting stock for the Red Gum Plains species trials were sourced from APP. The *E. nitens* seedlings were grown from seed from the VRD26 seed orchard (a CSIRO provenance trial converted to a SSO by culling to the best 10% of individuals). The provenance trial included Toorongo, Rubican and Macalister seedlots (Cameron, 2000). The *E. globulus* seedlings were grown from seed collected from a SSO (VRD32-35). This SSO included E*. globulus spp. globulus* and *E. globulus ssp. pseudoglobulus* (Krygsman, 2000). Other species are supported by tree improvement programmes in Gippsland. For example, there is an ALRTIG *E. tricarpa* SSO located near Lake Tyers (TRIG DATABASE).

The importance of genetics is recognised by Heartwood Unlimited (Lambert *pers. comm.*). The company has a tree improvement programme for the core species planted (e.g. *C. maculata*, *E. botryoides*, *E. muellerana* and *E. cladocalyx*) based on SSO created by thinning provenance trials from below. An *E. sieberi* tree improvement programme has been commenced by Heartwood Unlimited, as a potential additional core species and is currently at the stage of waiting for the trees to reach an age suitable for further thinning.

As noted, there are a number of species trials and demonstration sites with known and diverse provenances which could assist with tree improvement. The Gippsland wide eucalypt trials reported by Duncan *et al.,* (2000) included a broad range of species of known provenance and for a number of species, there were multiple provenances included. The outcomes presented by Duncan *et al*., (2000) (see Figure 31) indicated superior performance by individual provenances as a basis of selection of wild seed sources for planting stock. The Red Gum Plains trial series included species of known provenance (Tepper, 2000). For example, the 2006 species and provenance trial established on the Red Gum Plains could be converted into a SSO, provided that it still exists. Heartwood Unlimited has a provenance trial of *E. bosistoana* (almost 9 years old) which included improved seed from New Zealand. The trial trees have performed well and the trial has been thinned twice, but is yet to produce any seed. A strategy of including improved seed from interstate and overseas has been a common theme; the trials reported by Duncan *et al.* (2000), the Red Gum Plains species trials and the 2006 Red Gum Plains species and provenance trial. The potential of select provenances has been demonstrated by Heartwood Unlimited who found that while as a species *E. tricarpa* has shown limited potential, an East Gippsland provenance has performed well on some sites, but doubt remains as to the potential to achieve a tree of commercial size.

Plantation productivity and land suitability for plantations in Gippsland

Studies in support of plantation expansion

Expansion of the plantation estate can be supported by an understanding of potential growth and yield of wood products. For example, the development of plantations in the Strzelecki Ranges by APM Forests was supported by plantation productivity data. After commencing in 1960, by 1967 the company documented growth rates as satisfactory with an MAI of 21 to 28 m^3/ha/y expected for *P. radiata* and *E. regnans* plantations at 25 years of age. This was supported by plot data indicating an MAI at age 8 years of 23.1 m^3/ha/y for *E. regnans* on a marginal site. At that time, the oldest company *P. radiata* stands (all sites) had achieved an MAI of 22.3 m^3/ha/y at age 17 years (Mann, 1967, p.xix&xx). While not at the full rotation of 25 years, this type of data indicated the trajectory of growth to harvest. More recently, to assist with plantation development, studies of the Gippsland land-base potential have been published; Stephens *et al.*, (1998) as part of a review of the current status of plantation potential studies, an Australian Bureau of Agriculture and Resource Economics (ABARE) nationwide study with a chapter addressing Gippsland (Burns *et al.*, 1999, p.139 to 159), a specific study by the Bureau of Rural Sciences (Borschmann *et al.*, 2000), a 2018 land-base study undertaken by Severino and Hasanka, (2018) defining the potential of cleared private land relative to processing hubs, and a 2021 study making use of biophysical constraints on tree growth (PFOlsen, 2021, p.19). It was noted that later studies did not consider the outcomes of previously published research for Gippsland.

A 1999 land for plantations study

Burns *et al.* (1999) applied site attributes to assign species-specific *(E. globulus*, *E. nitens*, *E. regnans* and *P. radiata*) productivity classes (low, medium and high) to the land in Gippsland on a high-level basis (see Table 24). The study reported on plantation suitability based on estimated values of agricultural land (EVALs). An EVAL is an estimate of land value based on crop returns. If the returns from plantations are greater than the current agricultural land-use, then theoretically, the plantation is a 'better' land-use. Prior to the EVAL analysis, the study made use of the Booth and Jovanovic (1991) modelling of land productivity and found that of the 1.23 million ha of cleared agricultural land in Central Gippsland, 1.13 million ha were suitable for plantation development (Burns *et al.*, 1999, p.38). As with previous analysis, given the inclusion of land in NSW in the East Gippsland / Bombala zone, this region is not included. The EVAL analysis indicated that plantation enterprises were more attractive for 25,000 ha of the cleared agricultural land (Burns *et al.*, 1999, p.52); this represented 2.0% of the cleared agricultural land or 2.2% of the land determined as suitable. This analysis assumed whole of farm replacement with trees. The analysis presented land mapped as 'not cleared for agricultural' or 'not suitable for plantations' from east of Sale (the Red Gum Plains).

Table 24: The assumed plantation productivity by site attributes in Gippsland (Burns *et al.,* 1999, p.169, 141, 150 & 151).

		Softwoods			Hardwoods							
Site quality		Low	Medium	High	Low		Medium			High		
Rainfall	(mm)	<700	700-900	>900	<700		700-900			>900		
Central Gippsland												
Species		*P. radiata*	*P. radiata*	*P. radiata*	*E. globulus*		*E. globulus*	*E. nitens*	*E. regnans*	*E. globulus*	*E. nitens*	*E. regnans*
Products		Sawlogs / pulplogs	Sawlogs / pulplogs	Sawlogs / pulplogs	Pulplogs		Pulplogs	Pulplogs	Pulplogs	Pulplogs	Pulplogs	Pulplogs
Rotation	(y)	14 - 35	13 - 35	11 - 35	9-15		9-15	20-30	20-30	9-15	20-30	20-30
MAI	(m^3/ha/y)	16	20	26	15		26	26	21	30	32	27
East Gippsland / Bombala												
Species		*P. radiata*	*P. radiata*	*P. radiata*		*E. nitens*		*E. nitens*			*E. nitens*	
Products		?	?	?		Pulplogs		Pulplogs			Pulplogs	
Rotation	(y)	22 - 40	22 - 40	22 - 40		9 - 15		9 - 15			9 - 15	
MAI	(m^3/ha/y)	12	15	20		14		23			32	

A year 2000 land for plantations study

Borschmann *et al.* (2000) applied empirical models to estimate species productivity (e.g. geology and rainfall) as part of an assessment of the Gippsland private land-base (e.g. cleared agricultural land and private native forests). The analysis segmented Gippsland based on plantation productivity, road distance to potential processing nodes and slope classes; Table 25 presents a summary of the outcome. The inclusion of slope class is an important delineator of suitability; steeper sites are difficult to manage and significantly more expensive to harvest. The study did not make assumptions on limitations of the land-base and the outcome was species-specific data tables and productivity maps for *E. globulus*, *E. nitens* and *P. radiata*. Figure 48, Figure 49 and Figure 50 presents the outcomes in detail for the cleared land-base for the three species. The species-specific maps present productivity from 'unsuitable', and an MAI of 11 to 15 m^3/ha/y to 31 to 34 m^3/ha/y; see Figure 51 for *E. globulus* as an example. If a suitable MAI is defined as greater than 15 m^3/ha/y, the suitable land-base is reduced as presented in Table 25. In general, the cleared agricultural land-base in Gippsland was found to be more suitable to *P. radiata* than the two eucalypt species considered. The Red Gum Plains were assigned a productivity class of an MAI of 11 to 15 m^3/ha/y for *P. radiata* and 11 to 20 m^3/ha/y for *E. globulus* (Borschmann *et al.*, 2000, *E. globulus* and *P. radiata* maps).

Table 25: The area of cleared agricultural land by modelled plantation productivity classes (based on Borschmann *et al.*, 2000, p.18, 24 & 30).

MAI	*P. radiata*	*E. globulus*	*E. nitens*
(m^3/ha/y)	(ha)	(ha)	(ha)
0–10	125,838	120,839	9,862
11–15	116,486	131,557	0
16–20	101,962	207,946	12,185
21–25	794,761	538,393	37,368
26–30	99,754	298,381	194,142
31–34	155,695	0	0
Totals	1,394,496	1,297,116	253,557
Total MAI > 16	1,152,172	1,044,720	243,695

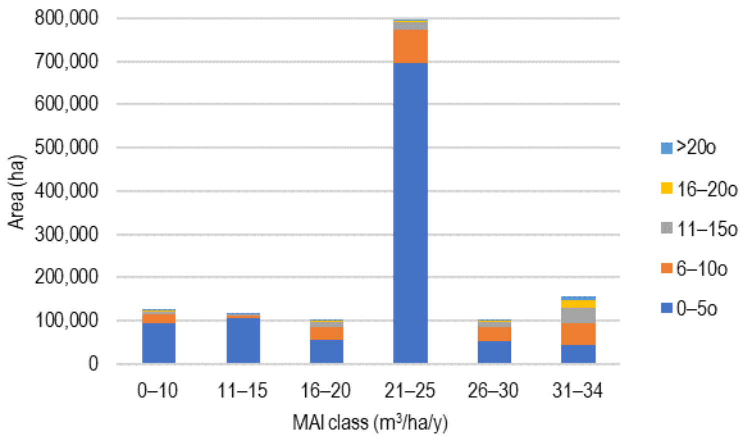

Figure 48: A breakdown Gippsland's cleared agricultural land by slope and productivity class for *P. radiata*.

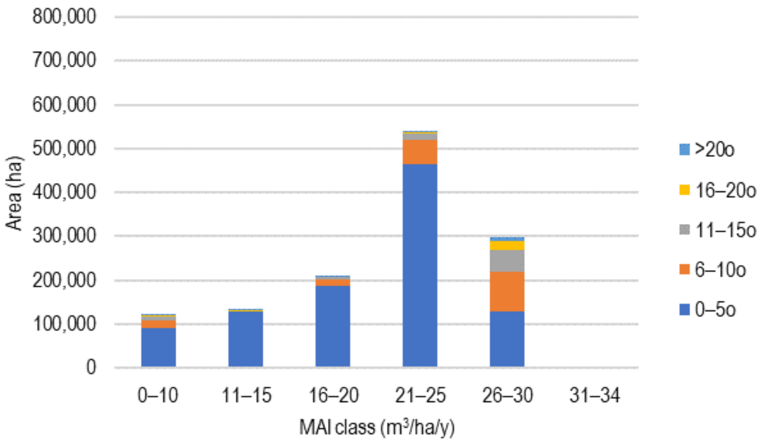

Figure 49: A breakdown Gippsland's cleared agricultural land by slope and productivity class for *E. globulus*.

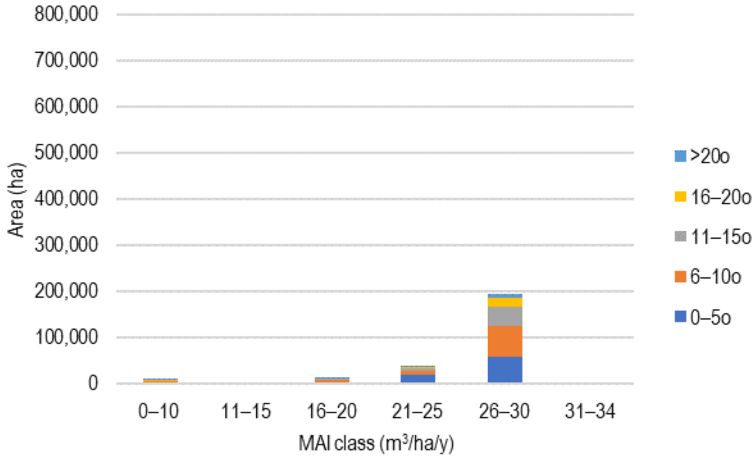

Figure 50: A breakdown Gippsland's cleared agricultural land by slope and productivity class for *E. nitens*.

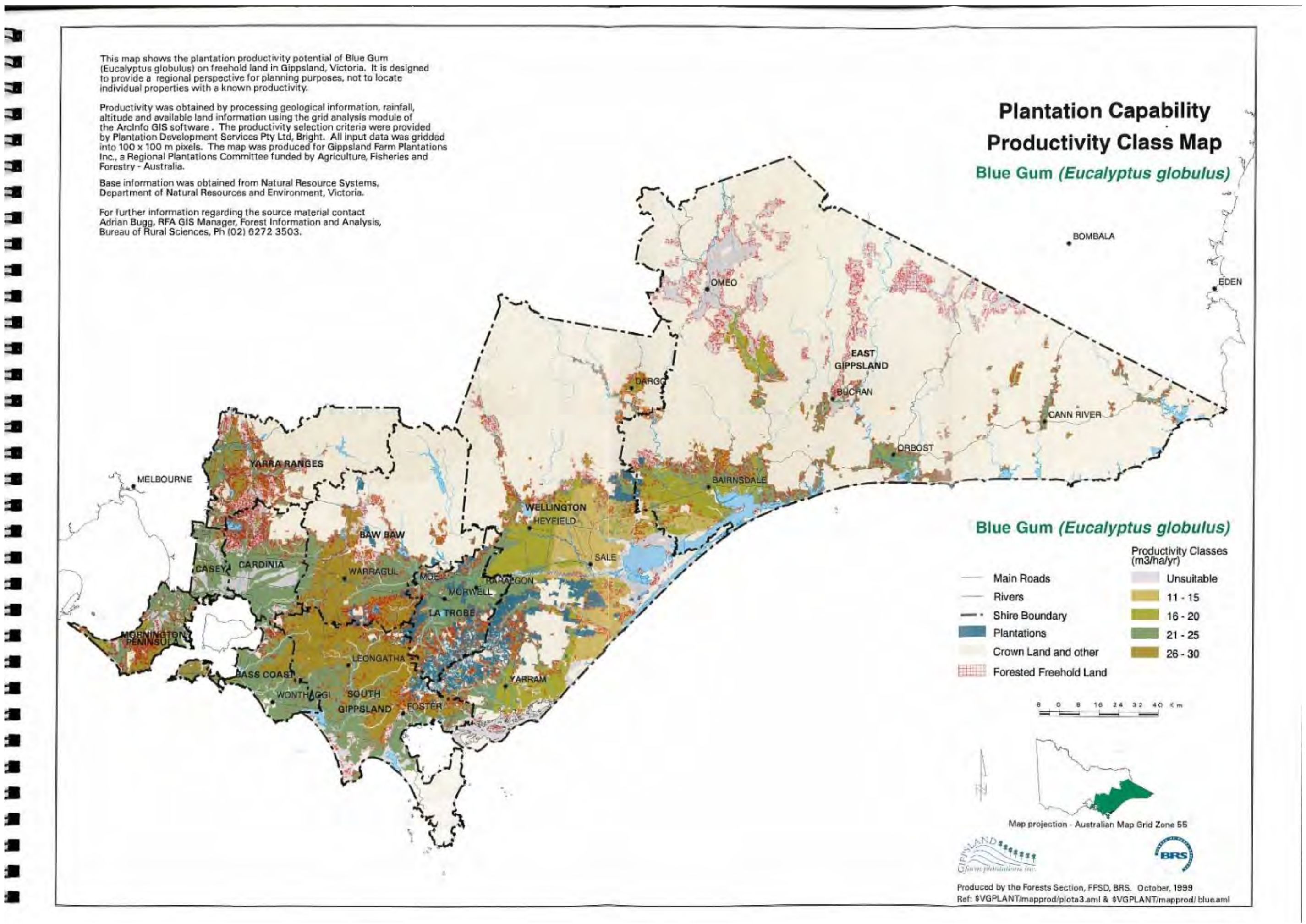

Figure 51: A Borchmann *et al.* (2000) Gippsland plantation productivity map for *E. globulus*.

A 2018 land for plantations study

A study published in 2018 sought to generate data on land for plantation development in south-eastern Australia. The study defined the cleared private land-base in Gippsland relative to project partner's processing hubs, with three plantation regimes (Severino & Hasanka, 2018, p.4). It included an *E. globulus* pulpwood regime and, an *E. globulus* and *P. radiata* sawlog regime on a 25-year rotation with the growth rates applied based on modelling by Waterworth *et al.* (2007) (Severino, & Hasanka, 2018, p.4). The productivity model applied was developed for Australia's National Carbon Accounting System to allow spatial estimation of carbon stocks over time (Waterworth *et al.*, 2007, Abstract). Severino and Hasanka (2018, p.4) describe the model as a 3-PG2 systems with a caution that 3-PG2 was regarded as likely to overestimate productivity. The research test-calibrated modelling against industry data and it indicated variable location and species-based differences (Severino, *et al.*, 2018, p.10). The study included a range of assumptions to generate a mill-door net present value revenue as a metric of plantation suitability. This was calculated based on the mill-door price for logs less the cost of harvest and haulage to a processing site. For Gippsland, this was centred around the Maryvale pulpmill site. The analysis found that for the land-base with a mill-door plantation net revenue of greater than $2,000/ha, there were 731,150 ha for 'softwood sawlog' land, 888,270 ha for 'hardwood sawlog' land and 729,500 ha for 'hardwood pulpwood' land (Severino & Hasanka, 2018, p.9, Table 3). A break-down of the area by regime by mill-door net revenue category is presented in Figure 52.

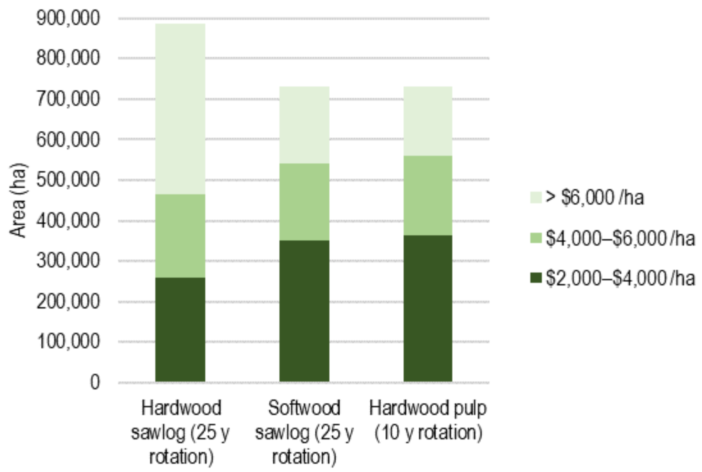

Figure 52: A breakdown Gippsland's cleared agricultural land net mill-door revenue categories for the regimes indicated (based on Severino & Hasanka, 2018, p.9, Table 3). Note: each species is presented in isolation of considering the alternatives.

A 2021 land for plantations study

A 2021 study of the Gippsland land-bases made use of biophysical constraints on tree growth (PFOlsen, 2021, p.19). The study generated data on the area of land available by LGA categorised by qualitative statements of 'very poor', 'poor', 'moderate', 'high' and 'very high'. The outcomes of the analysis are presented in Table 26. Assuming a cut-off of suitability of 'moderate' or better land, the area of suitable land is 1.15 million ha.

Table 26: The outcomes of a 2021 study of land suitability for plantations by LGA (PFOlsen, 2021, p.21).

LGA	Area by suitability class (ha)					
	Very poor	Poor	Moderate	Moderate high	Very high	Grand total
Wellington Shire	72	7,947	182,774	163,409	30,550	384,752
East Gippsland Shire	892	41,375	98,308	180,027	17,216	337,818
South Gippsland Shire			276	132,053	70,236	202,565
Baw Baw Shire		5	81	36,609	82,639	119,334
Latrobe City		2	398	58,151	35,070	93,621
Bass Coast Shire			521	53,843	3,632	57,996
Totals	964	49,329	282,359	624,092	239,342	1,196,086

A 2021 modelled woodflows study; plantation productivity assumptions

Assumptions of regional plantation productivity underpin estimating future log flows. The NPI regional woodflows estimates by ABARES make use of proforma plantation productivity assumptions. This analysis is segmented by species (*P. radiata* and eucalypts) and log outputs (sawlogs and pulplogs). The yield assumptions are based on forecasted log availability provide by plantation managers, and where this data was incomplete, the estimates are based on yield models (Legg *et al.,* 2021, p.69). The assumptions applied to the Gippsland NPI zones are presented in Table 27. The productivity assumptions broadly align with the Borschmann *et al.* (2000) outcomes. While regional based modelling is possible, site-specific influences are a reality to be addressed by species allocation. While a general outcome for *E. globulus* managed over a 12-year rotation in Gippsland is an MAI of c.18 m³/ha/y, where the species in planted on duplex soils a lower rate of growth would be expected (Cameron, *et al.*, 2004, p.27).

Table 27: The assumed plantation regimes applied by ABARES to model regional woodflows as reported in 2021 (Legg *et al.*, 2021, p.73).

Species		*P. radiata*	*Eucalypt*	
Products		Sawlog / pulplog	Pulplog	Sawlog / pulplog
Central Gippsland				
MAI	(m³/ha/y)	20	18	20
Rotation	(y)	30	12	27
East Gippsland / Bombala				
MAI	(m³/ha/y)	16	19	14
Rotation	(y)	30	12	27

Consideration of land-base studies

The land-base assumptions

While useful at a high-level, regional land for plantations studies must be placed into a practical context. Recall the break-down of the Gippsland land-base presented in Figure 2 to Figure 5. Land-use studies make use of regional attributes at a resolution defined by the land unit data (e.g. whether a 1 km² or 10 m² square grid of data). Where consideration of plantations as an option is for property fence-to-fence planting, then it is the total value of agriculture on that land which is the benchmark for comparison. If we consider the land currently under irrigation in East Gippsland and Wellington LGAs, the value of the agricultural enterprises would likely make plantations un-attractive based on the Burns *et al.* (1999) analysis. If the resolution of assessment is at the sub-farm level, then each unit of land is assessed for the actual rather than whole of farm average value. Some land units will be difficult to manage for agriculture; consider the insights from the example of the farm located at Mirboo North where degraded land within the farm was planted to trees, or the use of *P. radiata* pine in the Strzelecki Ranges to shade-out blackberry. Consideration and site matching of species must be based on the actual unit of land (e.g. as done with plantations in the Strzelecki Ranges, the Toorongo Plateau, by APM Forests and by Heartwood Unlimited). As noted by Speedy (1995, p.2) the process of whole-farm planning was a useful tool. Such an approach was applied by Severino and Hasanka (2018, p.27 - 35) in a series of case studies in Gippsland which included high-value horticultural and dairy land. Reflecting back on the irrigated land in Gippsland, it is likely that establishing of trees could be integrated into that land-base to complement the agricultural enterprises. Another consideration is that the land-base studies presented species outcome in isolation rather than comparing between species. It is suggested that regional productivity mapping as undertaken by Wilson and Hay (2023) for the Green Triangle, to the Otway Ranges and to the Fleurieu Peninsula be considered for Gippsland.

Productivity

Productivity is a key driver of plantation suitability at a specific site and empirical models of productivity were used by Burns *et al.* (1999) and Borschmann *et al.* (2000) to generate the required information at a lower level of resolution. The MAI for rainfall assumptions utilised in the 1999 and 2000 studies are presented in Figure 53 with the function presented in Figure 32 based on the Duncan *et al.* (2000) research outcomes. With limited exceptions, the 1999 and 2000 assumptions are more bullish compared to the actual data function. Further, the Duncan *et al.* (2000) results presented in Figure 31 demonstrates variation between the top five species – provenance combinations, which reinforces a need to consider the actual genetics to be planted and the attributes of an actual site. Considering the East Gippsland Water trial site, Poynter (2007, p.196) reflected on productivity estimates based on Borschmann *et al.* (2000) and the actual results. It was found that the achieved growth rate was significantly less than the 16–20 m^3/ha/y predicted for an un-thinned short-rotation (10–15 y) *E. globulus* plantation. It was concluded that, the differences were due to modelled long-term average rainfall rather than actuals, and use of non-commercial thinning which would have lowered productivity by reducing site occupancy.

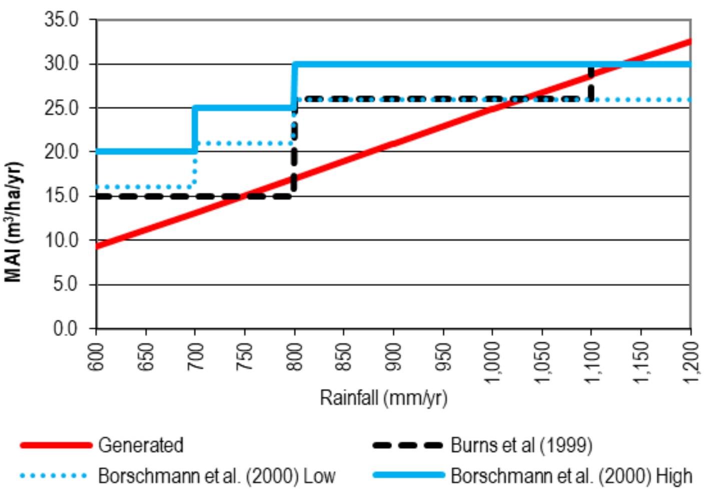

Figure 53: A comparison of the MAI for rainfall assumptions for the studies indicated and the 'generated' function presented in Figure 32 based on Duncan *et al.* (2000) data.

Productivity models

Propriety productivity models for the species planted in Gippsland

Professional plantation managers rely of a detailed understanding of their resource-base and make use of a range of tools. For example, APP (later part of HVP) indicated a programme of continuous inventory for 37 years (in 1999) of Permanent Sample Plots (PSP) across the mostly *P. radiata* and eucalypt plantation estate. This dataset indicated an overall 63% mean increase in plantation productivity since the 1970s with variation between soil and site type (Hescock, *et al.,* 1999, p.176). This improvement was attributed to silviculture and genetics. As part of routine management, Heartwood Unlimited makes use of PSPs in the plantations under their management. This is part of the services provided to plantation owners (e.g. evidence-based feedback) and forms part of the company monitoring systems. As a result, the company has developed species-specific functions for diameter at breast height over bark (DBHOB), dominant height, basal area and total stem volume (Lambert, *pers. comm*.). In general, information generated by private plantation manager is proprietary and for use by the company.

A publicly available simple productivity model for select eucalypt species in Gippsland

Making use of datasets (from Gippsland - Duncan *et al*., 2000; south east South Australia), Wong *et al.* (2000, p.vi&1) generated regional-specific plantation productivity models for six species; *E. globulus*, *E. nitens*, *E. viminalis* and Salignae (*E. botryoides*, *E. grandis* and *E. saligna*). The models generate predictions of height, basal area and volume for a range of sites by making use of actual stand measurements at a known age to define the commencement of a growth trajectory of a stand. This allows growth rates to be estimated for a site with known annual rainfall and general soil characteristics. Table 28 presents possible site indexes (height in metres at age 10 years) for species in Gippsland by soil type and rainfall. These can then be applied to the volume for age functions presented in Figure 54. This figure is based on-site quality defined as the height of a stand in metres at age 10 years and, presents the estimated standing under-bark volume to a small-end stem diameter of 2 cm for *E. globulus* in Gippsland at the ages indicated (Wong *et al.,* 2000, p.16). These models are readily available and require capture of stand specific inventory data. To place this into context, Figure 55, Figure 56 and Figure 57 present photographs of *E. globulus* at three sites in Gippsland and the estimated MAI based on height at age.

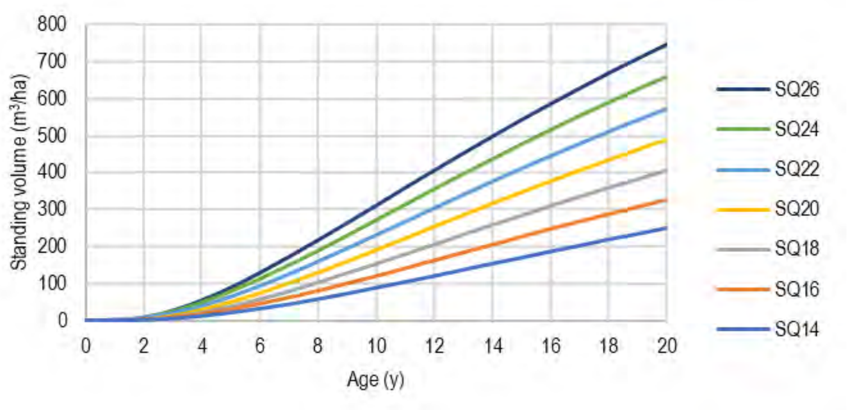

Figure 54: Estimated standing volume for age in a *E. globulus* plantation in Gippsland (based on Wong *et al*., 2000, p.39).

Table 28: Possible tree height at age 10 (the site index) for *E. globulus*, *E. nitens*, *E. viminalis* and the Salignae (*E. botryoides*, *E. grandis*, *E. saligna*) series, on sites with various soil and rainfall combinations in Gippsland. The data in parentheses indicate the site index for ex-pasture sites with a good fertiliser history (Wong *et al.*, 2000, p.35).

Soil group	Species	Rainfall (mm/y)				
		600-699	700-799	800-899	900-999	1,000+
Deep sands	*E. globulus*	13-16		18-21		
	E. nitens	10-13		15-18		
	E. viminalis	11-14				
	Salignae series	14-18				
Texture contrast soils	*E. globulus*	14-17	16-19	19-22 (25-29)		
	E. nitens	12-15	14-17	16-19 (24-28)		
	E. viminalis	13-16	13-16	15-18 (23-27)		
	Salignae series	11-14	11-14	13-16 (18-22)		
Gradational textured soils	*E. globulus*				20-24	(26-30)
	E. nitens				19-23	(26-30)
	E. viminalis					17-20
	Salignae series					14-18

Figure 55: (Left) A photograph of *E. globulus* in the Bairnsdale NAP woodlot with a mean annual rainfall of 673 mm/y. The trees are 13 years old (p.1991) with a height of 10 m. It is estimated that the trees have grown at an MAI of < 10 m^3/ha/y based on Figure 54. (Sylva Systems Pty Ltd, photograph taken 05/09/2004.)

Figure 56: A photograph of *E. globulus* in the Churchill area with a mean annual rainfall of 750 mm/y. The trees are 14 years old (p.1990) and have a height of 10.4 m. It is estimated that the trees have grown at an MAI of < 10 m^3/ha/y based on Figure 54. (Sylva Systems Pty Ltd, photograph taken 04/09/2004.)

Figure 57: A photograph of *E. globulus* at Tostaree with a mean annual rainfall of 820 mm/y. The trees are 16 years (p.1988) old and have a height of 21.7 m. It is estimated that the trees have grown at an MAI of 27 m^3/ha/y based on Figure 54. (Sylva Systems Pty Ltd, photograph taken 05/09/2004.)

Markets, processors and products

Summary

A commercial plantation for wood production requires access to markets and this will be significantly driven by the species grown. In Gippsland, *P. radiata*, *P. pinaster, E. globulus*, *E. nitens* and *E. regnans* have been grown for a full rotation and sold into markets on a fully commercial and continuous basis (i.e. not simply spot sales). Indeed, these species are the only fully commercialised plantation grown trees in Gippsland at this time. While other species are being grown, some wood properties under plantation conditions remain to be determined. The wood properties of significance are whether a tree is a softwood or a hardwood (a fixed status by species), density, pulping attributes, sawn timber hardness, strength, durability, sapwood Lyctid borer susceptibility and appearance. Prudent advice on species selection will note that the wood properties of a plantation grown tree may not be the same as those of the same species grown in natural forests. For example, wood basic density is likely to be lower for a plantation compared to natural forest grown tree but Lyctid borer susceptibility may not change. A key driver of differences in wood properties is that a plantation grown tree will reach the same size faster than a natural forest tree. With a generally fixed number of sapwood rings in eucalypts (at five or six rings), this results in a greater percentage of sapwood in a log with a range of implications (e.g. Lyctid requirements). Processing by radial sawing or quarter sawing may have advantages in better recovery of heartwood, while ensuring all sapwood is removed (where required). Experience in Gippsland has shown *P. radiata* to produce good quality resources for sawing and pulping on lesser quality sites, with lower quality wood on higher quality sites resulting from faster growth.

A sawlog is defined by the requirements of an intended processor and the target markets. There has been plantation grown *E. regnans* sawlogs recovered from 30- to 40-year-old trees on clearfalling of thinned plantations in the Strzelecki Ranges and as part of a post-windstorm salvage harvest. Eucalypt logs from plantations have been supplied into pulpwood markets (including for export woodchips) but there are limitations on which species will be accepted; *E. globulus* and *E. nitens* are preferred and accepted species. A point of caution is that harvesting a plantation has inherent risks and requires specific skills and equipment usually beyond a farmer; this is coupled with liability and insurance considerations, making 'do it yourself' problematic.

Introduction

Returns from a plantation will be driven by the volume and quality (relative to processor specifications) of the logs sold, the price paid at the mill gate and the cost of harvesting and haulage. Indeed, recall the ATO requirements for plantations as primary production to sell logs on a commercial basis. The time between establishment costs and harvest returns adds another dimension to this consideration. For example, a market for pulpwood from thinnings makes a significant difference to the length of time a grower must wait for returns on investment (Jacobs, 1967, p.7) and increases the total volume of wood sold. There have been products recovered from a range of small plantations scattered across Gippsland. For example, Figure 58 presents a mid-1980s planted *E. globulus*, *E. muellerana* and *E. globoidea* plantation located near Yarram with a commercial thinning operation. The thinning aimed to remove approximately one third to one half of the standing trees. The logs recovered were predominantly pulpwood going to the Maryvale pulpmill (at that time), some small sawlogs to export and some *E. globulus* logs to a small sawmill at Fish Creek. In the absence of a commercial market for thinnings, a grower can plant wider and/or thin to waste (Figure 59) which is an additional cost of management (Jacobs, 1967, p.7). A fundamental point is that the market will define the intended and indeed required wood properties of the logs purchased and therefore the species acceptable. This section considers the state of knowledge and evidence of the wood properties of the species grown in Gippsland.

Figure 58: A commercial thinning operation in a small hardwood plantation near Yarram (Sylva Systems, 01/09/2016).

Figure 59: A non-commercial thinning to waste operation in a small hardwood plantation near Yarram (Sylva Systems, 10/11/2023).

Wood properties and products

Wood properties of importance

A fundamental point is consideration of the match between the wood fibre resource available, processing requirements and market demand for products. The wood properties of importance when considering a species or indeed which species to plant are defined by the intended market. The wood properties of plantation grown trees are likely to differ from natural forest logs and an example follows (based on Boas, 1947, p.106). In 1914 Mr H. E. Surface (an eminent American expert papermaker) was brought to Tasmania in an attempt to manufacture paper from Australian natural forest eucalypts and his research resulted in a poor yield (30%), poor quality and difficult to bleach pulp. As a result, he reported adversely on the prospects. Later, during a 1916 visit to Western Australia, the Conservator of Forests at Dijon (France) suggested test pulping of immature eucalypt wood as in France, research on pulping of young plantation grown *E. globulus* wood had proved promising. There are successful examples of transition from natural to planted forests of the same species; the *E. regnans* plantations in the Strzelecki Ranges supplemented the supply of natural forest sourced logs of the same species. The main wood properties of importance are presented in Box 17; the required value of each (e.g. a basic density of 500 kg/m^3) will be defined by the intended use. This is of particular relevance to species in Gippsland and any intent to expand the estate.

Box 17: The main wood properties of commercial importance.		
Attribute	Narrative	A suggested reference
Wood type	Whether a species is a softwood or hardwood.	Bootle (1996, p.9)
Density	The density of the wood on a basic, dry or green basis.	Bootle (1996, p.27)
Pulping attributes	The quality and quantity of wood fibres (pulp) recovered from a green tonne of logs.	Bootle (1996, p.130)
Hardness	The JANKA hardness of the wood surface.	Bootle (1996, p.60)
Strength	The modulus of rupture and modulus of elasticity of wood, and the resulting strength groups.	Bootle (1996, p.34)
Durability	The durability of the wood above ground and inground.	Bootle (1996, p.13)
Lyctid borer	Whether the sapwood and/or heartwood is susceptible to this borer infestation and damage.	Bootle (1996, p.182)

Tree species guides can define species by use in a region and reference to Bootle (1996), which provides comprehensive details of the wood attributes of natural forest grown trees and many of the softwood species grown in plantations. Use of published data on species wood attributes requires caution as to whether the data is representative of the actual species and trees grown in plantation. The need for caution is driven by many factors affecting wood properties (see Jenkin *et al.*, 2023) with a fundamental driver that a plantation grown tree will reach a log size sooner than a natural forest grown tree of the same species. This increases the percentage of sapwood compared to heartwood in a log (see Figure 60). The rings of sapwood present in a tree are a genetic characteristic of a species (Bootle, 1996, p.8). The width of sapwood of natural forest eucalypts growing in south-eastern Australia is generally the five external growth rings (Hillis, 1984, p.268, citing Nicholls and Phillips, 1970). Fast grown trees can have sapwood of a greater width but in four to six rings (Hillis, 1984, p.268). For example, an 18- to 20-year-old planted *E. camaldulensis* in Israel had five growth rings of sapwood which accounted for 31% of the cross-sectional area of the lower section of the stem (Hillis, 1984, p.268, citing Tischler, 1976). This would suggest that 31% of the log volume is sapwood. This has end-use and market implications for plantation grown eucalypts in Gippsland.

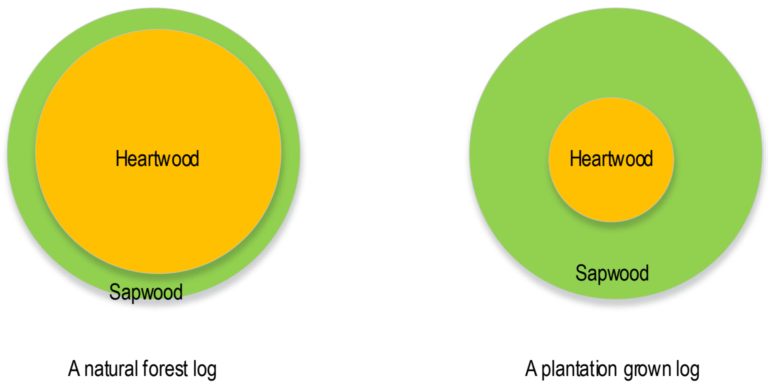

Figure 60: A simple presentation of the implication of a faster grown plantation trees reaching the same size as a natural forest tree of the same species, but in a shorter period of time (based on Jenkin *et al.*, 2023, p.49).

As an example, Figure 61 presents wood basic density data for natural forest and plantation grown trees of the same species; a key point is that the wood is different rather than better or worse and processing will need to address such differences. Prudent species descriptions highlight this consideration; for example, Bird (2000, p.35) notes that wood properties of a species may differ markedly between those reported for natural forest sourced material and from plantation. Heartwood Plantations presents a series of information sheets for the species developed in Gippsland and while presenting information on wood properties, they note that *'statistics for plantation-grown timber may vary from these figures'* (Heartwood Plantations, ____a, b,c,d). A similar warning is provided by VicForests as a point of caution (see Box 18).

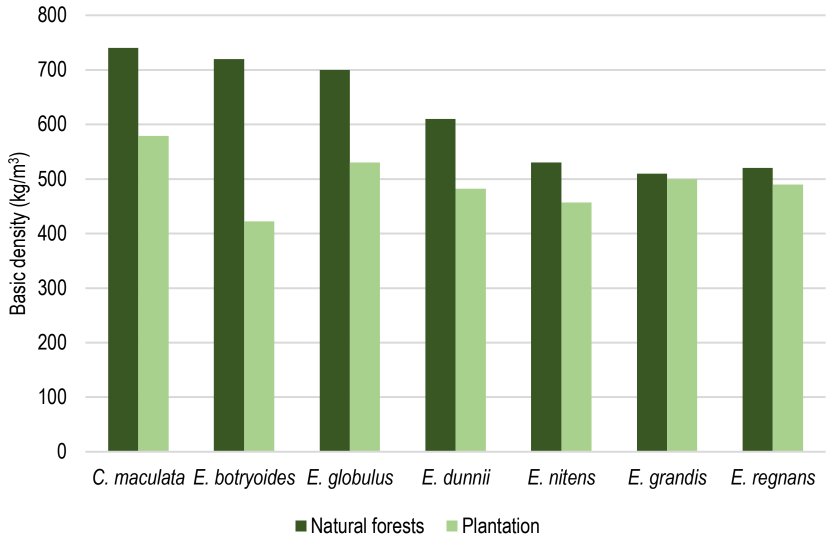

Figure 61: Variation wood basic density between natural forest and plantation grown trees for the species presented. Data from Knapic *et al.* 2018 p.23470; Harwood *et al.* (2005, p.14, Table 40); Whiteman (1997).

Box 18: The VicForests disclaimer in regard to wood attributes.[9]
'This material is published for information purposes only. VicForests does not warrant, guarantee or make any representations regarding the accuracy of the material or its appropriateness for particular purposes. VicForests' material is based on the best available data at the time of publication. Changes in circumstances after the time of publication may impact the accuracy of the material and VicForests gives no assurance that any information or advice contained will be up-to-date at any point in time.'

Lyctid borer susceptibility

There are a range of insect species that can bore into timber and create physical damage and consideration of this issue is controlled by Australian Standard 1604.1. The most common species in Australia is *Luctus brunneus* and this borer is generally referred to as Lyctid borer. The female lays eggs in the pores of the end grain of susceptible timber at while at 8 to 25% moisture content. Therefore, this borer only attacks hardwoods and only where the pores are of sufficient diameter to allow egg deposition. A further requirement is adequate starch in the wood to sustain the larvae; starch is found in sapwood (Bootle, 1996, p.182&183). In regard to the relative importance of these three attributes, *'in only a few hardwood species are the pores too small (<90 µm) to permit attack, hence susceptibility is usually governed by starch content'* (AS 1604.1, Appendix A). The risk related attribute of timber is addressed by Australian Standards. AS 1604.1 *Specification for preservative treatment - Sawn and round timber* (s.1.4.5) requires an assessment of timber susceptibility to Lyctid borers and provides methods to undertake such an assessment. This attribute of plantation grown timber would require assessment. AS 5604-2005 (Appendix A) provides a normative (legally binding to the standard) statement of the sapwood susceptivity to Lyctid borer attack for a range of tree species. Variation between species with source location is noted. For *E. regnans* and *E. delegatensis*, susceptibility shows a consistent variation with Tasmanian sourced timber susceptible and New South Wales and Victoria sourced timber as not susceptible (AS 5604-2005, Appendix A3.2). For a hybrid, it is possible that the parental traits of susceptibility to Lyctid borer is found in that hybrid; this was the case for a natural hybrid of *E. regnans* X *E. obliqua* and the

[9] Accessed from https://www.vicforests.com.au/vicforest-forest-management/farmforestry/species-information-sheets on 16/04/2024.

researcher proposed that this outcome would be likely for a *E. grandis* X *E. saligna* (Cookson *et al.*, 2009, p.20). A key point is that susceptibility must be assessed for plantation grown timber, particularly where the standard lists natural grown timber of that species as susceptible.

Under AS 5604-2005 clause 3.2.2, which applies to the use of seasoned framing timber south of the Tropic of Capricorn and *'where the lesser cross-sectional dimension is equal to or less than 45 mm. All lyctid-susceptible sapwood shall be fully preservative-penetrated.'* Indeed, for timber sales in Queensland and NSW there are specific legal requirements (see Box 19). The legal treatment of Lyctid susceptible species in NSW and Queensland relates to a history of using hardwood species with thick bands of sapwood of Lyctid-susceptible timber (Cookson *et al.*, 2009, p.20). Where sawn timber is supplied to flooring and furniture manufacturers, AS 2796.2-2006 prohibits inclusion of Lyctid-susceptible sapwood (Cookson *et al.*, 2009, p.20). AS 2796.2 describes the four grades of appearance products recovered from hardwood logs (AS 2796.2, s.1.1); select grade, medium feature grade, high feature grade and parquet clear sawn timber (AS 2796.2, s.1.5). The standard states that for select grade, medium feature grade and high feature grade timber (parquet clear is treated as select grade) that Lyctid susceptible sapwood is a non-permissible feature on any surface (AS 2796.2, Appendix B, Table B1).

Box 19: The legal requirements on timber sales in Queensland and NSW (AS 5604-2005, s.5 notes).
'In Queensland the Timber Utilization and Marketing Act 1987 and in New South Wales the Timber Marketing Act 1977 require approval of a preservative treatment and registration of a brand before timber, offered for sale in either of these states, can be described as preservative-treated. Detailed information about the requirements of such legislation may be obtained from the state government agencies concerned.'

Recall Figure 60 which presents the implication of a faster growth rate of plantation grown species and a set number of sapwood rings on the outside of the tree, resulting in a greater percentage of sapwood by volume in a log compared to a natural forest sourced log of the same size. Where a species is targeting sawn timber production for appearance grade end-uses (e.g. flooring or furniture), the value of a log will be impacted as the sapwood cannot be included in Australian Standard compliant products, reducing recovery on processing. Given that sapwood is the outer rings, the strategies to reduce corewood in softwood plantations (e.g. high initial stocking) to confine this wood to a smaller cross section (see Jenkin *et al.,* 2023, p.35) are not an option. Further, where pruned, the sapwood while clearwood, may not be able to be used in appearance grade situations. In general, susceptible timbers will require some form of preservative treatment to enable greater hardwood sawn timber recovery and utilisation where this is an option (Cookson *et al.*, 2009, p.20).

Natural durability

Natural durability is an important attribute which defines the possible use of timber products. Durability varies between sapwoods and heartwood (Bootle, 1996, p.13), hence the impact of growth rate on the relative proportions is important. Again, this categorisation of timber products is addressed by AS 5604-2005 (Appendix A) which provides a normative statement timber durability for a wide range of species. It cannot be assumed that timber from a plantation grown tree has the same properties as those of natural forest sourced wood.

Softwoods

The plantation sourced *P. radiata* resources in Gippsland show variation in wood properties with site, age, silviculture and genetic improvement (Cameron, *et al.*, 2004, p.21). The quality of the Gippsland resource allows processing for sawn timber, kraft pulp and packaging paper production. Overall, the average log and wood quality are considered '*to be better than many* *other softwood resources because of the relatively infertile sites, low altitude and moderate latitude'* (Cameron, *et al.*, 2004, p.21). In general, sands produce better quality sawlogs than the duplex and clay loam soils, as defined by straightness, branch diameter and basic density. Pulpwood for kraft pulping is of better quality from sand sites with a higher basic density than for duplex and clay loam soils. On high-fertility sites in Gippsland, *P. radiata* can have poor stem straightness, branch quality and lower basic density (Cameron, *et al.*, 2004, p.21).

Hardwood logs

A sawlog defined

Consider sawlogs, sawmills and sawn timber. Gippsland's timber industry was historically supplied with large diameter hardwood logs from natural forests to process into sawn products. For example, in the late 1960's in Australia, a log mid-point diameter of 50 cm was considered *'a small log'*, as most logs had a mid-point diameter of at least 60 cm with a mid-point diameter of 140 to 250 cm as not uncommon (Page, 1978, p.321). Sawmilling technology was developed accordingly. While industry has adapted to smaller natural forest logs, processing of plantation grown logs is evolving. A definition is required but the definition of a sawlog is relative to a specific processor and the target sawn timber market; see Box 20.

Box 20: Extracts from a 1990 Gottstein Fellowship study of eucalypt plantation management in South Africa partly focussed on plantation grown sawlog production.	
'Prior to the commencement of any discussion, a definition of a sawlog must be addressed. A sawlog is logically a log from which sawn products are recovered, but any log can be cut to recover some sawn products. Therefore, qualification must be applied to the definition. Consideration must be given to both quality and quantity of sawn product recovery. However, sawn product recovery percentage is a function of log quality and sawmilling technology within the constraint of market demands. A suitable definition is that a sawlog is a log of certain physical attributes, able to be processed by the available technology into sawn products as demanded by the market.'	Jenkin (1992, p.125).
'Based on the above definition, it is not possible to look at 'sawlog' silvicultural practices in isolation of processing technology and market forces.'	Jenkin (1992, p.125).
'Sawlog size material can be produced, but can it be processed by existing technology? The ability to process will be a function of log sawing characteristics and the sawmill itself. Certain handling practices such as rapid transport and processing can help reduce log degrade and increase recovery percentage. The sawmills inspected [in South Africa] *had technology not unlike many of Australia' s modern P. radiata sawmills. Drying schedules would be required to be developed, taking into account the different climatic conditions at each sawmill.'*	Jenkin (1992, p.125).
'Australian eucalypt plantations would be able to grow South African size sawlogs. We have adequate growth rates (table 19.1) and it would be possible to derive suitable thinning regimes. However, processing characteristics would be different, as the South African industry has selected and genetically improved species to optimise sawing behaviour.'	Jenkin (1992, p.119).

Plantation grown hardwood sawlogs

There is a current supply of longer-rotation plantation grown *E. nitens* sawlogs from Tasmania to some Gippsland sawmills which can provide insights to this potential. An ambit claims of an ability to produce plantation grown hardwood sawlogs must be cautioned. The first point of caution is that a specific definition of a sawlog both in terms of dimensions (e.g. length and small-end-diameters) and attributes (e.g. straightness) is required. This will drive the plantation rotation length and growth rates required, as well as define management inputs. The second consideration is that the ability to recover products on a commercial basis must be defined (e.g. recovery rates, cost of production, drying and products sold on a profitable basis). This will be mostly driven by the species planted (with some ability of silviculture to influence wood properties) combined with the processing technology, and any specific market requirements such as addressing Lyctid susceptibility.

The log and wood quality of Gippsland eucalypt plantations varies with site, age, silviculture and genetic improvement (Cameron, *et al.,* 2004, p.26); recall comments on kino veins in *E. regnans* and the adverse effect on the value of wood (Doran, 1975, p.21). Overall, some smaller-scale eucalypt plantations in Gippsland have been thinned and pruned with an objective of sawlog production, but this is not the case for plantations managed for pulpwood production (as noted by Cameron, *et al.*, 2004, p.28). It is important to note that there is a lack of a price premium for pruned logs. With a focus on sawing, Heartwood Unlimited considers the species planted based on a package of attributes combined with specific management (e.g. thinning and pruning), growth performance and wood attributes as they relate to the intended markets. For example, while natural forest sourced timber of *E. bosistoana* is Class 1 above and below ground durability (see AS 5604-2005, Appendix A), the sapwood is susceptible to Lyctid borers, hence compared to growing *E. cladocaylx,* there is no real advantage, all other points being equal, to grow this species. This reinforces that a narrow range of species planted as a resource is preferable to a broad and diverse range (Lambert, *pers. comm*.).

Actual experience with plantation grown eucalypt sawlogs is considered. Plantation grown *E. regnans* logs over a 30-to-40-year rotation have been supplied to a number of sawmills in Gippsland to produce green, kiln dried dressed structural grades, some appearance grade sawn timber and sawn timber manufactured into pallets (Cameron*, et al.,* 2004, p.26). Many of these plantations were commercially thinned in the late 1980s and early 1990s. A salvage harvest in South Gippsland following the February 2024 wind-storm has recovered sawlogs supplied to a local mill for production of non-structural timber (Figure 62). Plantation grown *E. nitens* and *E. globulus* in Gippsland have only been sawn commercially on a small-scale basis (see Coote, 2017 describing the harvest and processing of a *E. globulus* stand). Cameron, *et al.* (2004, p.26) suggested that the *'production of select appearance grade sawn timber from plantation grown eucalypts is expected to be challenging due to drying degrade, including internal and surface checking and distortion'*. Enhanced silviculture (e.g. thinning and pruning) and improved drying and sawing regimes may increase the utilization of plantation grown *E. nitens* and *E. globulus* for sawn timber (Cameron, *et al.,* 2004, p.26). The issue of Lyctid susceptibility will remain an important consideration when linked to intended end-use requirements. The current supply of plantation grown eucalypt sawlog imported into Gippsland suggests processing and drying has been addressed.

Figure 62: A commercial salvage harvesting operation at a Mirboo North farm post the February 2024 wind event (Sylva Systems, 24/04/2024).

Hardwood pulpwood

Despite variation in wood properties, *E. globulus*, *E. nitens* and *E. regnans* are suitable for kraft pulp and white paper production (Cameron, *et al.*, 2004, p.26). Of these three species, *E. globulus* is a preferred kraft pulping and papermaking species due to wood attributes resulting in relatively low costs of pulping and papermaking; high wood basic density and pulp yield, result in low wood consumption and target paper sheet density at relatively low harvest ages. Both *E. regnans* and *E. nitens* generally display poorer values for these properties on a short rotation, which can be partly offset by increasing rotation lengths (Cameron, *et al.*, 2004, p.26). In regard to accessing export woodchip markets, the export facility at the Port of Geelong will accept *E. globulus* and *E. nitens* and 'other eucalypt species' provided that they meet product specifications (which includes a basic density of 500 kg/m^3, a dry matter content of 55 to 58% and a total kraft fibre yield at KAPPA 18 of greater than 52%) (Midway, undated). This will exclude many species currently promoted or growing in Gippsland.

Harvest and processing options

Consideration of onsite process in Gippsland

Harvesting and processing of plantation resources requires specialist skills, experience, equipment and indeed licencing. Coote (2017, p.8) promotes the possibility for farmers to harvest trees grown and process the resulting logs recovered. It is specifically noted that *'after appropriate training and with adherence to safety practices, farmers can use chainsaws to fell, limb and cross-cut farm-grown timber trees into sawlogs'.* This ignores the issues of liability and insurance requirements for what is a materially different activity to farming. This difference is addressed by WorkCover Victoria which has an industry classification system based on the claims experience of each industry sectors[10], with each workplace in Victoria assigned an industry classification based on the predominant activity undertaken (WorkSafe Victoria, 2013). A promotion of on-site processing by the resource owner, must address the impact on the primary production status for the tree crop, as the ATO requires the sale of logs as the unit of trade, to an external party for a profit (see Box 1).

Sawing patterns and sapwood management

Management of sapwood content of sawn boards to address Lyctid requirements is an important consideration in Gippsland. It is possible to use docking of sapwood from boards sawn to reduce sapwood content. Figure 64 and Figure 65 present conventional and radial sawing patterns of logs. Given that sapwood is the generally the outer five rings, it is possible to visualise the content of this wood in the boards produced. For the logs in Figure 64, if the logs had 20 equally spaced growth rings, the width of sapwood would be 25% of the log diameter. With a back-sawing pattern, whole boards would be non-compliant, whereas with quarter-sawing, it would be possible to dock the edges to remove the sapwood. The log presented in Figure 65 has 10 growth rings and if the sapwood is docked, recovery would be significantly reduced. If the log was 20 years of age, the reduction in recovery of compliant boards would be much less.

[10] Information accessed from https://www.worksafe.vic.gov.au/industry-classification-how-it-affects-your-premium on the 27/06/2024.

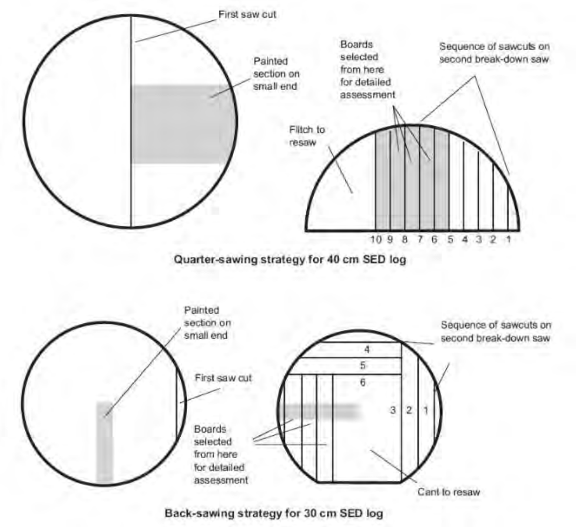

Figure 63: A conventional sawing pattern applied to a small sawlog (taken from Washusen, *et al.,* 2009, p.43).

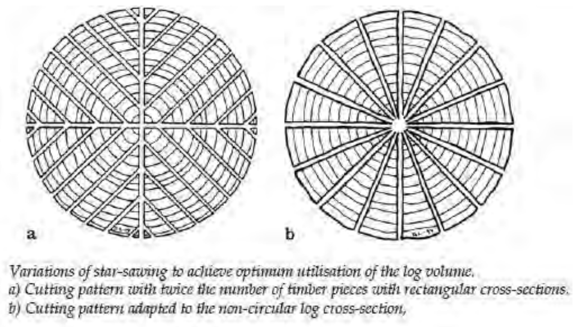

Figure 64: A radial pattern of sawing (taken from Sandberg, 1996, p.147).

Wood properties of species planted in Gippsland

The current wide-range of species planted in trials, demonstration plots and in woodlots in Gippsland provides an opportunity to undertake wood sampling to determine the wood attributes and suitability for a range of markets. A range of techniques are possible, including use of destructive sample (e.g. recovery of stem cross-section discs) and non-destructive sampling (e.g. use of the resistance drilling tool - IML PD series power drills; a Resi-tool). See Jenkin *et al.* (2023) for examples of both techniques.

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Appendix 1: The history of plantations in Victoria

This presents a chronology of the development of the Victorian plantation estate; 1891 to 1998 - Williams (2018) and 2000 to 2011 - McCarthy (2019).

Period	Action	Narrative
1851	State of Victoria proclaimed.	
1850s	Destructive clearing	The discovery of gold in Victoria led to the destructive clearing of forests causing adverse impacts including loss of productive forests, widespread erosion and proliferation of weed infestations.
1865-67	Need for plantations recognised	Boards of Inquiries recognise the need for plantations of broadleaved and coniferous species to generate revenue, provide softwood timber to replace imports and support jobs in local mills.
1872	First nursery	Macedon nursery was established to raise plants for plantations - initial emphasis was on broadleaved species but Radiata & Nigra pines were also planted.
1888	Early environmental plantations & employment for miners	Plantings at Macedon were extended and new plantation projects were commenced at Creswick (1888) and the You Yangs (1889) to rehabilitate land eroded by mining, and to provide work for miners who were unemployed following the decline in gold production. The plantings, of mainly commercial softwood species, were also to produce softwood timber to reduce the volume of imported timber.
1888-90	More nurseries	Nurseries were established at Sawpit Gully (Creswick) nursery in 1888 and Havelock, Gunbower Island & You Yangs in 1888-90.
1890	Plantation management regimes	Plantation management regimes were adopted initially for hardwood plantations but also applied for exotic softwoods. Regimes were based on 2.4 metre * 2.4 metre spacing and multiple thinnings aimed at yielding final crop trees from which high quality round and sawn timbers could be produced. The regime continues to underpin Radiata Pine silviculture in Victoria.
1896	Expert advice	The Government commissioned a Report on the State Forests of Victoria (1896) by Inspector General Ribbentrop, Indian Forest Service to review and make recommendations on Victorian forestry. His comprehensive report concluded, among many matters, that there was merit in establishing softwood plantations but cautioned against broadcast introduction of *Pinus insignis* because whilst fast growing, he considered the wood to be of 'low character'.
1907	A Forests Act	The first Forests Act created a new Forests Department, under Conservator of Forests Mackay, and supported the establishment of plantations over the following decade.
1910	Victorian School of Forestry	Established at Creswick to train foresters to manage Victoria's forests.
	New conifer nursery at Creswick	The new nursery employing larger scale 'production line' techniques was a significant advance, successfully producing large numbers of hardy seedlings at low cost thus avoiding the undesirable previous practice of broadcast seeding.
	Continued seedling losses	From grazing animals required expensive fencing of newly planted areas. The large cost adversely affected the rate of plantation expansion.
1910-1925	Early failed plantations	By the early 1900's there were extensive coastal areas which were not suitable for farming. Some of these areas were tried for plantations. New plantations were established at Frankston and Harcourt (1910), French Island (1911), Wilsons Promontory (1913), Bright (1916), Port Campbell (1919), Anglesea (1923) and Mount Difficult (1925). Virtually all of these areas totalling more than 10,000 ha failed. This highlighted the importance of pre-requisite site assessment surveys which became the norm in subsequent new projects.
1915	Need to increase plantings	Conservator of Forests Mackay affirmed the need to lift the annual planting rate, particularly for conifers.
1918	Forests Commission Victoria	Forests Commission, Victoria established. One of a number of principles governing its formation was the establishment of adequate plantations of exotic softwood species.
1924	State cooperation and Commonwealth funding	The Interstate Conference on Forestry attended by all State forests departments advocated co-operation between the States to establish a national plantation estate funded by the Commonwealth Government. This became a reality more than 40 years later under the Softwood Forestry Agreements Act.
1925	FCV Target	The FCV stated its policy to increase softwood plantations and set a target for the estate of 80,000 ha.
1926	The School Plantation Scheme	The scheme was formalised with the FCV providing plants free of charge and foresters to provide advice and assistance with the establishment and management of school plantations.
1927	FCV Plantation Policy	The FCV stated its policy to increase softwood plantations.
Late 1920s	Private plantations	The first significant areas of private softwood plantations were established by bond selling companies in south west Victoria in the late 1920's. Private plantation establishment over the following three decades was largely confined

Period	Action	Narrative
		to three companies – APM Forests Pty Ltd, South Australian Perpetual Forests Ltd (SAPFOR) and Softwood Holdings Ltd.
1930	Douglas Fir	The first plantings of Douglas fir occurred in the Otway Ranges.
1930s	Jobs planting trees	The Rural Relief Fund was established to provide employment during the Depression. Employment relief included establishing softwood plantations. Planting increased in 1931 to 92ha which was a three-fold increase on the previous year. The higher rate continued through the decade. Main existing plantations at Macedon, Creswick, Scarsdale, Myrtleford and Bright were expanded, and new plantations were commenced at Beech Forest, Narbethong and Noojee (Loch Valley). Rural Relief Funds were terminated in 1938. By that time the total area of softwood plantations had grown to 18,000 ha.
1930s	New Paper Mill	Australian Paper Manufactures (APM) constructed a pulp and paper mill at Maryvale to be supplied with pulpwood from surrounding public native forests.
1939	APM supply forests burnt	APM's public native forest supply area was burnt in the 1939 fires, just two years after the mill was constructed thus creating pulpwood supply uncertainty.
	Fire losses	About 4,400ha of FCV softwood plantation was destroyed by the fires, principally at Narbethong, Noojee and Bright.
1940s & 1950s	Slow down	Slowdown in plantation expansion occurred due to the War initially, then labour shortages, lack of money and the increasing costs post-war. Plantations at Rennick were modestly expanded and a new project was commenced to plant cleared land which had been acquired by the State Rivers and Water Supply Commission at Delatite Arm, Lake Eildon.
	Need for plantation timber	The post-war reconstruction boom resulted in tight supplies of timber for housing, and demonstrated the need for timber from plantations in the future to supplement the supply of hardwood timber from native forests.
1949	Hardwood Plantations in Strzelecki Ranges	A plantation program was started on government-purchased failed farmland. The hardwood estate expanded to more than 7,000 ha over next 40 years.
1950	APM Forests	APM decides to establish its own plantations to supplement supply from the FCV, and thereby reduce supply risk.
1952	Softwood Holdings	The private company was formed and established softwood plantations in South West Victoria. It was followed shortly after by construction of a new sawmill at Dartmoor, in 1954, which drew logs from both government and private plantations.
1955	AKD Softwoods	The small private company was formed and built a mill at Colac to process logs from Government plantations. The Company established its own modest plantation program. The Company continues its expansion to now be the largest softwood log processor in Victoria.
1959	Wood Pulp Agreement	The agreement with APM provided for the supply of pulpwood and leased land in Strzelecki's for APM to establish plantations.
1961	Government support for plantation expansion	The Government supported FCV's commitment to a plantations expansion program, termed 'PX' program. Together with supplies from native forests and future private plantations the program aimed to make the State self-sufficient in timber by 2000. An annual target of 2,000 ha by 1964 and continued for 40 years was to produce a Government plantation estate of 80,000 ha with radiata pine as the principal species.
	Sirex	The first confirmed detection of Sirex wood wasp in Victoria and mainland Australia.
1962	Plantation Program Takes Off	More than 1300 ha was planted representing more than a three-fold increase on 1961. New plantation areas were established in Upper Murray, Alexandra, Portland, Central Gippsland and Yarram (hardwoods) with new areas in Wangaratta, Colac, Benalla and Ballarat commenced in the following few years.
Mid-1960s	National Sirex Fund	Established to search & destroy the wasp including on private land.
1964	Australian Forestry Council	The formation of the Australian Forestry Council (AFC) was an important milestone for Australian forestry. It was composed of Forest Ministers from the States and Commonwealth Minister to provide a co-ordinated national approach. Its first priority was to analyse supply and demand for timber and develop solutions to meet projected supply shortfalls. The Council set a national estate target of 1.2 million ha by lifting the average annual planting rate from 16,000 ha in 1965 to 28,000 ha and maintaining at that level until 2000. The targets were based on a national population of 20 million by 2000. Australia's population reached 19.3 million in 2000. Australia's one millionth hectare of softwoods was planted at Ovens, North East Victoria in 1992.
	FCV requests Commonwealth funding	The FCV in its evidence to the Commonwealth Government's Distribution of Population Committee indicated there was derelict land available in Victoria which was suitable for pine plantations. It requested £200,000 per year from the Commonwealth Government to establish plantations on the land.
	Assistance for private plantations	Private plantations were an integral component of the overall timber supply plan. Accordingly, the Softwood Plantations Loan Scheme was created to assist the establishment of plantations on private land.
		The FCV also emphasised the importance of being able to fund preferred cultural operations to ensure optimal growth and sawlog production.
1967	Softwood Forestry Agreements	The Commonwealth Government provided loans to State Governments under the Softwood Forestry Agreement Act 1967 for the expansion of softwood plantations over and above each State's base programs that existed at the time. The agreements enjoyed bi-partisan support in Federal parliament The first agreements covered five years.

Period	Action	Narrative
		The national target was an average of 26,000 ha per year for 35 years plus at least 4,000 ha per year of private plantations. Victoria's annual target was increased steadily from 2,800 ha in 1967 to 4,800 ha to reach an estate of 20,000 ha by 1971
		The AFC also requested the Commonwealth Government provide tax concessions to encourage private plantations and the Commonwealth and State Governments defer estate and probate duties to encourage private plantations. The Commonwealth Government provided $18 million over the five year period for the States to plant a total of 100,000 ha.
1969		Record Planting Year – a record 5,183 ha was planted by the FCV.
1970		Land Conservation Council – the Government established the LCC to undertake studies and make recommendations on public land-use in Victoria with requirement to ensure environmental values were incorporated in its recommendations. Whilst the major impact was on public native forests, the LCC made recommendations on public land for future plantations. The LCC's work raised the awareness of environmental values and thereby contributed to the changing public expectations about public land-use.
1970s	Markets for thinnings	There was an increasing awareness that pulpwood markets would be needed to support commercial thinning of the expanding plantation estate to optimise sawlog production.
	1970's aerial spraying	Spraying became a preferred practice for controlling weeds during plantation establishment. Initial weedicides included 2,4,5 – T (2,4,5 – Trichloropyrimidine) and 2,4 – D (2,4 Dicholrophenoxyacetic acid) which were chemicals that had attracted wide spread attention because of association with defects in new born from their use in Vietnam. These were subsequently replaced with other weedicides.
		Later in the decade aerially-applied chemicals were also used to control Dothistroma, a needle blight fungus. Chemical use became a rallying issue for opposition from impacted communities across the State. Plantations became more visible and impacted more communities as the program expanded.
	1970's environmental studies	FCV commenced major studies into environmental aspects of plantations in North East Victoria. These studies represented a proactive response to growing questions about the environmental effects of plantations. One component included comprehensive surveys of the biology of existing plantations and covered plants, mammals, birds, insects and water biota. Another component was the study of the impact of plantations on the hydrology. Three catchments were monitored before one of the catchments was converted to plantation. This was a significant long-term study into the hydrology of pine plantations. The hydrology was again measured when the second crop was established over 30 years later. Also the opportunity arose to measure the impact of fire when the area was burnt by wildfire in 2006.
1971 - 1977	Second Softwood Forestry Agreements	Legislation for the second agreement period was contested by the Labor Opposition who sought amendments to replace the concept of "sound forestry practice" with the need for consideration of flora and fauna impacts associated with plantation establishment. The DLP (Democratic Labour Party) wanted to ensure that native forests would only be cleared under special circumstances. The legislation was passed.
		The debates foreshadowed the changing times of the 1970's for plantations and native forests.
		Victoria's area target for the five years was increased to 26,000 ha which was exceeded.
		Victoria's public plantation estate was 83,000 ha by 1973.
1972	Bowater-Scott Agreement	An Agreement was provided to Bowater-Scott for supply of logs for a new integrated mill at Myrtleford.
1973	Need to expand the plantation program	The FCV articulated the need for further expansion of plantation expansion planting to provide timber for future needs. It expressed concern about the reliability and future cost of reliance on imported timber.
1974	National Estate Committee opposes clearing native forests	The Commonwealth Government National Estate Committee of Inquiry recommended that clearing of native forests be discontinued until more research had established the environmental impacts.
1976	Review of Softwood Agreements	The effectiveness of 1967 and 1971 agreements was reviewed by a House of Representatives Committee. The recommendations included: • Support for the continued plantation program but at a reduced scale. • Clearing native forests for plantations should cease. • Other states should copy Victoria's Land Conservation Council for independent recommendations on public land-use, incorporating public expectations with respect to contemporary conservation. • FCV was commended for high environmental standards and planting on purchased private land. • There was a need to improve financial returns from funds provided under the agreements. • Victoria was performing well and should continue to be assisted under the agreements.
		The Government decided that further Commonwealth assistance for additional softwood planting was not justified and the 11 year program to boost softwood planting was terminated.
1980	Pulpwood supply to Australian Newsprint Mill	The supply of pulpwood to the new mill at Albury provided an outlet for pulpwood from Upper Murray plantations.
1981	Plantations	Too much or not enough?– different government bodies expressed contrasting views. The LCC recommended land for a doubling of the plantation area in North East Victoria. In contrast the Senate Standing Committee on Trade

Period	Action	Narrative
		and Commerce's report on Australia's Forestry and Forest Products Industries concluded the area of pine plantations was excessive.
		The LCC North East Victoria plantations recommendations became an active regional issue in the State election campaign.
1980s	Opposition to plantations	Opposition from a number of groups on a number of issues grew over the decade particularly in the Strzelecki and Otways Ranges and North East Victoria.
		Environmentalists, local community groups and farmers were opposed at different times for a number of reasons including "Too Many Pines" and "Pine Free Zone" campaigns, potential environmental effects, need to cease clearing native forests for plantations and loss of agricultural land to plantations.
1984	'No more pines' campaign	The Campaign was launched in the Otway Ranges to oppose expansion of pine plantations on public and private land.
1986	Timber Industry Strategy	The TIS provided a major new government policy direction for the industry and management of public forests and plantations. The main plantations elements were: • Plantation management objectives included optimising financial returns, ensuring timber for a competitive integrated industry and encouraging establishment of private softwood plantations. • TIS provided longer supply contracts and agreements ratified by legislation based on major new investment in processing mills. • TIS also foreshowed the phasing out of native forest clearing for plantations. • Plantation area target was set at 125,000 ha to be established by 1996 to provide for contracted volumes in future and support ongoing investment in a competitive processing sector. The estate reached 113,209 ha in 1993 when it was vested in the Government-owned Victorian Plantations Corporation (VPC).
	Bowater-Scott supply increased	A new agreement provided a 100% increase in log volume for a new larger mill.
	Long-term Supply to Victree	The log supply supported a new sawmill built at Colac. The company also had its own modest plantation program
	Aerial spraying banned	Premier Joan Kirner banned aerial spraying of Velpar weedicide in Stanley plantation.
1988	Pine free zone	Activist community groups declare the Tallangatta Valley a 'Pine free zone'.
1989	Plantation Impact Study	The Government established a Plantation Impact Study to review and recommend on whether there were better ways to achieve plantations area targets. A number of subsequent government statements and decisions included: • The TIS plantation target of 125,000 ha was reduced to 120,000 ha. • The study recommended that plantation expansion should be private sector enterprise.
	Plantation Share farming Scheme	Launched to assist farmers establish an additional 6,000 ha of private plantations to make up for the reduced government area target.
1990	Plantations for sale	Premier Joan Kirner confirmed the plantations would be sold for an expected price of at least $200 million for the "cutting" rights. Another $200 million could be expected if the land was also sold. In the event, the "cutting" rights were sold for $550 million in 1998.
	Plantation values	Merchant banker CS First Boston valued the plantations at $300 million but noted that what was being sold and how it was sold are major determinants of the sale price.
late 1980s - early 1990s	Government role	Government questions its role in commercial plantation business given challenging TIS objective of improving $ return in a government business.
1992	One million hectares	The one millionth hectare of Australian softwood plantations was planted at Ovens, North East Victoria.
	Planning controls	To help small owners State planning controls are amended to allow small plantations (40 ha or less) to be established without obtaining a planning permit.
1993	Auditor-General reviews TIS	The AG's review reported that a number of TIS plantation management objectives were being achieved, but concluded the commercial performance objective was not achieved.
	Commercialisation	The plantations were vested in the newly formed VPC as the first step in exiting the business. The Government sought to commercialise the business before sale to maximise the price, and ensure the business was in an appropriate state to support a competitive processing sector in the future. The task under VPC required the following: • Improve the financial return. • Provide a record of financial accounts consistent with Australian Accounting Standards. • Replace government licences and agreements with commercial contracts. • Establish legal plantation boundaries. • Amend law to provide for industrial fire brigade.

Period	Action	Narrative
	Returns to Government	VPC returned $68 million to the Government over its five-year life.
	Valuation	The VG valued the plantations when they were vested which was the VPC's starting point. VPC reported a valuation $202 million at the end of its first year of business in its 1994 Annual Report.
1990's	Markets for pulpwood	New markets were required to provide outlets for increasing pulpwood volumes in the North East and Western plantations as the large plantings through the 1970's and 1980's approached first thinning age. Such markets would support commercial thinning to ensure maximum sawlog production. New markets were established as follows.
1994	Benalla Particle Board Mill	Pulpwood for a new particle board plant at Benalla provided an outlet for surplus from Benalla plantations.
1996	Wangaratta medium density fibreboard mill	Pulpwood for a new medium density fibreboard (MDF) plant at Wangaratta provided another outlet for surplus from North East plantations.
1997	Softwood Plantation Exporters	VPC partnered with its customers (AKD Softwoods and Victree) to export woodchips from sawmill chips and plantation pulpwood to provide outlet for Western plantations.
1998	Government exits	The Government exited the plantation business after 110 years when it sold VPC to Hancock Natural Resources Group to form Hancock Victorian Plantations (HVP). The sale price for the 'cutting' rights was $550 million. The asset was a perpetual licence for the "cutting" rights meaning that replanting by HVP as areas were harvested was necessary for the ongoing right. This was an effective way of ensuring the estate would continue to be used as plantations in the longer term.
2000	AMCOR demerger of plantations	AMCOR demerges its business printing papers to focus on global packaging. The spin off company was named PaperlinX, and included Australian Paper and Australian Paper Plantations Pty Ltd.
2001	Grand Ridge Plantations created	Hancock Victoria Plantations Holdings Pty Ltd purchases the assets of Australian Paper Plantations for over A$150 million.
2011	HVP.	Grand Ridge Plantations and Hancock Victorian Plantations changed their trading name to HVP.

Appendix 2: Species domestication and commercialization

A driver of success

The requirements of a robust plantation project are understood (see Box 21) but often ignored. The species planted is a key driver of success when combined with the other requirements. This initial list of requirements for success was expanded as presented in Box 22.

Box 21: The requirements for a successful plantation documented in the past.

The value and success of a stand of trees will be determined by:

- The species and how it has been managed;
- Its distance from a processor and its accessibility;
- The volume of product available; and
- Whether production can be continued in the long-term.

Species: While it is important to choose a management regime that suits the skills and objectives of those involved, species selection will also help determine the viability of the operation.

Critical mass & continuity of supply: Is the volume of product available annually enough to maintain a long-term, economically viable industry? This needs to be determined within a region.

Marketing: The type of market and selling strategies are linked closely to the product being produced.

Box 22: A summary of the identified key success factors for a plantation project (Jenkin, 2021, p.28&29).

- A project must have a detailed, factual and fully-costed plan.
- A project must seek to develop a resource of appropriate scale and with attributes to satisfy a specific market.
- A project must have highly motivated parties to drive the project and that the parties are empowered (funded) to make it happen.
- The underlying project must be commercially proven and viable.
- The information provided to the parties to a project must present a factually based and defendable expected outcome.
- A project must be framed from the landholder's perspective and complement their agricultural enterprises.
- All legal instruments should include full disclosure and be expressed in language appropriate to the landholders to allow full transparency.
- A project should have a degree of ability to create bespoke land-access options to capture the broadest cohort of landowners but be commercially realistic about the administrative cost of such choices.
- Stimulus of uptake of a forward supply arrangement as part of a project agreement between a landholder and a resource consumer should find a trade-off between the interests of the parties and potentially include hybrid arrangements.
- A successful project will have an incentive strategy that is fit-for-purpose and flexible to change with the evolution of the target recipient / project.
- During project plan development and due diligence, a check should be undertaken of variable and enabling incentives or the lack thereof and a strategy should be developed to either by-pass such road blocks or to seek to rectify any impediment.
- Not all successful projects (e.g. as defined by area established) have been free from adverse externalities and impacts on social licence; a critical success factor is to carefully assess and weigh-up project externalities and attempt to mitigate negative impacts and maximise the net benefits.

A first step in determining species options is to define the fundamental considerations commencing with the motivation of the grower. For example, Race (1993, p.119) poses two questions to determine species options; what is the tree's purpose (e.g. pulpwood, sawlogs, specialty timber, land protection etc) and what is the site's environment (e.g. rainfall, number of frosts, aspect, soil type, and fertility, exposure)? The next step is to seek the information to enable answering these questions. Information on species is readily available but caution is required. A 1990 reference (Cremer, 1990, p.22-35) provides a list of species with a caveat of *'.... tentative selection should be checked by reference to the description given for each species, as* *well as seeking confirmation from references available and from people who may have field knowledge of how a given tree or shrub grows in their locality'* (Cremer, 1990, p.21). More detailed considerations include; suitability and life span, weed invasion, scientific endeavour, wildlife habitat local attributes and self-perpetuation by regeneration (Venning, 1988, p.16-18). Guides exist to species selection for specific situations (see Box 23) noting a process to focus on a limited number of species options.

Box 23: A structured process to species priority setting and selection (Franzel *et al.*, 1996, p.xiii & xiv).
✓ Assessment of client needs. ✓ Assessment of species used by clients. ✓ Ranking of products. ✓ Identification of a limited number of priority species (four to six). ✓ Valuation and ranking of priority species. ✓ Final choice.

A pragmatic approach to species

A simple test

A range of eucalypt species grown in plantations will often sprint in height growth for the first 2 to 4 years until site limitations under competition are expressed, and growth can slow substantially. However some plantations (e.g. softwoods) will commence with slower initial height growth which increases with age. An important point is that projection out to at rotation yields is highly problematic from young trees, hence for confidence, close to full rotation experience is required, more so where wood properties are an important issue. A pragmatic test is presented in Box 24. The greater the distance travelled to inspect a species, the greater the risk with that species in Gippsland (i.e. due to a lack of local experience).

Box 24: A pragmatic test is to pose the following question: *how far do I need to travel to see the proposed regime (including the species proposed) through to harvest and processing for the target products?*
• Can I comfortably drive to a site? If so, then the proposed regime experience is available 'locally'. • Can I fly to a site in Australia to see the same regime? If so then regime may require tailoring to the local situation. • Can I fly to another country to see the same regime? If so, then the regime will require significant adjustment (e.g. to take account of differences in growth rates due to site fertility and insect pest issues). Differences in labour costs may also be significant and must be addressed.

Considering the state of local species experience

While reference to local experience is important (Cremer, 1990, p.21), selection of species has been described as potentially *'hit or miss'* for smaller scale planting due to a lack of coordination of information (Alexandra & Hall 1998, p.xxii). Since that time, information on the species planted by NPI zone is available and generally a zone has a current commercial species to guide selection. In some cases, while a suite of primary commercial species is available, alternative species in the same or a new geographic zone could be required. For example, a shift to dryer or more frost prone sites. Such insights underpinned development of Figure 65 which presents a species by location experience matrix (Jenkin, 2021, p.28) as a framework for considering the evolution of species selection and experience. Consideration of markets within each cell is linked to the level of experience with a species.

		Region	
		Current	Novel
Tree species	Current	**More of the same:** The same species as grown and supplied into existing supply chains / markets. Requires an ability of markets to take additional resource	**New horizons:** A proven commercial and accepted species is grown in a new location. Requires development of a critical mass with leverage on past species specific experience.
	Novel	**A new kid on the block**: A new species in a region. Exchangeability of species either by direct substitution OR development of a new product using current capacity is required.	**A blue sky pioneer:** A new species in a new region with nil species experience nor current local processing capacity. Requires development of a critical mass and markets based on underlying species knowledge.

Figure 65: A species by location matrix defining requirements for combinations of current and new species in current and new zones (Jenkin, 2021, p.28).

A 'more of the same' approach is a safe strategy provided that markets remain. Planting the same species in a region is a simple strategy. Cremer (1990, p.21) notes that this is a safe and least risk option and the *'ten rules to successful tree planting'* include to plant a proven species (Boomsma, 1975, p.31). Current plantation species are likely to be fully commercialised providing resources into a market and are likely supported by a region-specific tree improvement programme. The ability of a local market to take any additional resources needs to be understood.

A 'new kid on the block' strategy increases risk. Introduction of a new alternative species into a region, steps away from local experience and potentially access to local markets. While introduction of a new species could be warranted (e.g. as a direct replacement for local species proving difficult to grow on farms or suffering disease problems, Reid & Stewart, 1994, p.75), this is a higher-risk strategy. It was proposed that where timber value suggests that markets are expected to be easily found (e.g. for black walnut), introducing a new species is a sound strategy. However, a point of caution remains on the ability to find and supply a market; it cannot be assumed that a new species will be accepted by a market. A further point of caution is the level of understanding of species silviculture and access to improved genetics.

A 'new horizons strategy' can be successful. It takes a successful species from one locality to a new planting region. This allows a degree of transference of silviculture and improved genetics, but with a need to consider local difference in edaphic factors (e.g. soils), climatic factors (e.g. rainfall distribution), physiographic (e.g. topography as it relates to drainage) and biotic factors (e.g. soil microorganisms). While it may be biologically possible to grow a species, a critical mass is required to allow development of a market for a new type of resource. This may be facilitated by experience with a species in another region which can provide confidence in wood properties and log attributes.

A 'blue sky pioneer' strategy is the highest-risk. There are many unknowns to address in regard to species requirements (e.g. silviculture) and site attributes. It is likely that a range of information can be sourced in regard to site; for example, soil attributes, rainfall data and experience with agricultural crops, assessed against the requirements of a new tree species. The risk associated with such a species is compounded by a need to develop a critical mass to allow market development and supply of products.

Species commercialisation

A species supported by actual growing experience, supplying of logs at rotation and with ongoing markets, can be regarded as a commercial species. A small number of species have been fully commercialised under Australian conditions through to harvest, sale and utilisation of the resulting fibre resources. Many species remain at the experimental stage as they have not gone through to harvest, sale, processing AND supply of a product on a commercial scale. A species can be domesticated and commercialised for use with or without genetic improvement beyond selection of provenance. From a blank page to a commercial species with active markets requires a series of steps; some can be in parallel, while others are linear. Figure 66 presents the steps defined by markets, biological considerations and costs. Where a new species is proposed, it is prudent to understand whether you can see that species being grown, harvested and processed in an area of interest. Based on discussions with commercial sawmills, it would take at least two years to prove up a new species as a wood type and provide a product into the market. Such an investment would require a significant pool of resource supplied over the next 8 to 10 years to allow continuous supply of a new wood product to the market to justify such an investment.

	Initial species selection	**Species and provenance trials**	**Development of germplasm supply**	**Operational deployment**	**Operational cycle: harvest & product**
Markets	This process should consider the needs of the market and the potential to develop markets based on wood attributes. A point of caution is differences between natural forest and plantation grown wood of the same species. It becomes a matching process of what can be grown (species) and what can be sold.	Tree growth and wood properties determined. At the end of trials, wood properties and therefore product options should be understood.	Tree breeding should include wood properties to enhance the properties demanded by the market.	Initial wood properties and log attributes are determined and where possible projections made of the expected outcomes at rotation.	The wood attributes of the trees grown are known and supplied to the market. Logs are supplied to the market and products are manufactured.
Biological requirements	Determine the proposed site attributes and match to species requirements. This can include the use of published information and locally planted examples of species.	This should include development of an understanding of the silviculture required (e.g. pruning, thinning etc). At the end of the trials, potential yield and log by product volumes are understood.	The technology, methods and capacity for planting stock production is explored and expanded. For the selected species, seed and/or cuttings material supply must be developed and nursery capacity increased.	The required sites are secured and the recommended silviculture applied. With experience both elements may be adjusted.	The actual operational yields across a range of sites are understood and documented to give greater confidence in a species.
Costs	Determine the likely / potential cost profile for the target plantations.	Determine the likely / potential cost profile for the silviculture required.	The cost of planting stock is understood.	An operational growing cost profile is understood and documented. The end result is that growing costs are understood.	A full operational cost of supply is understood and documented. The end result is a net mill door price (mill door price *less* land access *less* growing *less* harvesting *less* haulage costs).

Figure 66: The process of full commercialisation of a tree species.

Appendix 3: The species planted in Gippsland or Victoria (historically)

Broad	Status	Genus	Scientific name	Common name	Historic name		Durability		Not listed in
						Lyctid susceptibility	In ground contact	Above ground	AS5604
Softwoods	Exotics	Abies							
			A. alba Mill.	Silver fir		NS			X
Softwood	Exotic	Calocedrus							
			C. decurrens Torr.	Incense cedar	*Libocederus decurrens* Torr	NS			X
Softwood	Exotic	Cedrus							
			C. deodara (Roxb.) G.Don	Himalayan cedar		NS			X
Softwood	Exotic	Chamaecyparis							
			C. lawsoniana (A. Murr.) Parl.	Lawson's cypress; Port Orford cedar		NS			X
Softwood	Exotic	Cupressus							
			C. macrocarpa Hartw.	Monterey Cypress		NS			X
			C. lusitanica var benthamii	Mexican Cypress		NS			X
Softwood	Exotic	Cupressocyparis							
			C. ovensii A.F. Mitch.	Ovens cypress		NS			X
Softwood	Exotic	Picea							
			P. sitchensis (Bong.) Carr.	Sitka spruce		NS	4	-	
Softwoods	Exotics	Pinus							

Broad	Status	Genus	Scientific name	Common name	Historic name		Durability		Not listed in
						Lyctid susceptibility	In ground contact	Above ground	AS5604
			P. canariensis C.Sm.	Canary Island pine		NS	4	4	
			P. caribaea Mor. *var caribaea*	Caribbean pine		NS	4	4	
			P. muricata D. Don	Prickle pine		NS			X
			P. nigra Arnold var maritima (Ait.) Poir	Corsican Pine	*P. laricio*	NS	4	4	
			P. nigra var. laricio	Corsican Pine		NS	4	4	
			P. pinaster Ait.	Maritime or Cluster Pine	P. maritima	NS	4	4	
			P. elliottii Engelm.	Slash pine		NS	4	4	
			P. ponderosa Dougl.	Western Yellow or Bull Pine		NS	4	4	
			P. radiata D. Don	Radiata pine; Monterey Pine	P. insignis	NS	4	4	
Softwood	Exotic	Pseudotsuga							
			P. menziesii (Mirb.) Franco	Douglas fir	*P. douglasii*; *P. taxifolia*	NS	4	4	
Softwood	Exotic	Sequoia							
			S. sempervirens (D.Don) Endl.	Californian redwood		NS	4	4	
Softwood	Exotic	Sequoiadendron							
			S. giganteum (Lindl.) J.Buchh.	Giant redwood		NS			X
Softwood	Exotic	Tsuga							
			T. heterophylla (Raf.) Sarg.	Western hemlock		NS	4	4	
Softwood	Natural	Araucaria							
			A. cunninghamii Ait. Ex D.Don	Norfolk Island Pine	*A. excelsa*	NS	4	4	

Broad	Status	Genus	Scientific name	Common name	Historic name		Durability		Not listed in
						Lyctid susceptibility	In ground contact	Above ground	AS5604
Softwood	Natural	Callitris							
			C. glaucophylla Joy Thomps. & L.A.S.Johnson	White cypress pine		NS	2	1	
Hardwoods									
Hardwood	Exotic	Quercus	*Quercus spp.*			S	2	-	
			Q. alba	White oak; American white oak		S	-	4	
			Q. canariensis	Algerian oak					X
			Q. palustris Münchh.	Pin oak					X
			Q. robur L.	European oak; English oak		S	2	-	
			Q. robur 'Fastigiata'	Upright English Oak					X
			Q. suber L.	Cork Oak					X
Hardwood	Exotic	Juglans				S			
			J. nigra L.	Black walnut					X
Hardwood	Exotic	Salix	Salix spp.	Willows		S			
			S. alba v. caerulea (Sm.) W. Koch	Cricket bat willow					X
Hardwood	Exotic	*Poplus*	*Populus* spp.			S	4	-	
			P. nigra L.	Black wattle					X
			P. deltoides Barr. Ex Marsh	Eastern cottonwood		S			X
			P. deltoides x Nigra L.	Black poplar Clone A.N.U. 65/31		S			X
			P. deltoides Bartr. Ex-Marsh	Cottonwood Clone A.N.U. 70/51		S			X

Broad	Status	Genus	Scientific name	Common name	Historic name		Durability		Not listed in
						Lyctid susceptibility	In ground contact	Above ground	AS5604
Hardwood	Exotic	Paulownia							
			Paulownia spp			S	4	4	
Hardwoods	Native								
Hardwood	Native	Acacia							
			Acacia spp						X
			A. dealbata Link	Silver wattle					X
			A. implexa Benth.	Lightwood					X
			A. mearnsii De Wild,	Black wattle					X
			A. melanoxylon R.Br.	Blackwood		S	3	3	
			A. pycnantha Benth.	Golden wattle					X
Hardwood	Native	*Banksia*							
			Banksia spp.						
			B. integrifolia L. f.	Coast Banksia					X
Softwood	Native	Callitris							
			C. glaucophylla	White Cypress		NS	2	1	
Hardwood	Native	Allocasuarina							
			A. littoralis (Salisb.) L.A.S.Johnson	Black she-oak		NS	3	-	
		Casuarina							
			C. glauca Sieber ex Spengel	Swamp oak		NS	-		
			C. cunninghamiana Miq.	River Oak		NS	-		

Broad	Status	Genus	Scientific name	Common name	Historic name		Durability		Not listed in
						Lyctid susceptibility	In ground contact	Above ground	AS5604
Hardwood	Native	Corymbia							
			C. maculata (Hook.) K.D. Hill & L.A.S.Johnson	Spotted Gum	*E. maculata* Hook	S	2	1	
			C. citriodora (Hook.) K.D. Hill & L.A.S.Johnson	Lemon scented gum	*E. citriodora*	S	2	1	
Hardwood	Native	Eucalyptus	*Eucalyptus spp.*						
			E. bicostata X E. viminalis	Natural hybrid					X
			E. botryoides X E. saligna	Hybrid					X
			E. globulus x E. camaldulensis	Hybrid					X
			E. grandis x E. camaldulensis	Hybrid					X
			E. regnans X E. obliqua	Natural hybrid					X
			E. argophloia Blakely	Chinchilla white gum					X
			E. badjensis Beuzev. & Welch	Big badja gum					X
			E. benthamii Maiden & Cambage	Camden white gum					X
			E. bosistoana F. Muell.	Coast grey box; Coast grey gum		S	1	1	
			E. botryoides Smith	Southern Mahogany; Coast Mahogany; Mahogany Gum		NS	3	2	
			E. brookerana A.M. Gray	Brookers Gum					X
			E. camaldulensis Dehnh.	River red gum		S	2	1	
			E. cameronii Blakely & McKie	Diehard stringybark		-	3	-	
			E. capitellata Sm.	Stringy-bark					X
			E. cladocalyx F.Muell.	Sugar-gum	*E. corynocalyx*	S	1	1	
			E. cornuta Labill.	Yate		NS	2	1	
			E. cypellocarpa L.A.S. Johnson	Mountain grey gum		S	3	2	

Broad	Status	Genus	Scientific name	Common name	Historic name		Durability		Not listed in
						Lyctid susceptibility	In ground contact	Above ground	AS5604
			E. delegatensis R.T. Baker	Alpine ash		NS (Vic & NSW)	4	3	
			E. dendromorpha (Blakely) L. Johnson & Blaxell	Budawang ash					X
			E. denticulate I.O.Cook & Ladiges	Errinundra shining gum					X
			E. dunnii Maiden	Dunns white gum		S	4	-	
			E. elata Dehnh	River peppermint		S	4	3	
			E. fastigata H. Deane & Maiden	Brown barrel; Cut-tail		S	4	3	
			E. fraxinoides H. Deane & Maiden	White ash	S		4	-	
			E. globoidea Blakely	White Stringybark		NS	2	-	
			E. globulus Labill *ssp globulus*	Blue gum; Southern blue gum	S	S	3	2	
			E. globulus Labill. ssp. *bicostata* (Maiden, Blakely & Simonds) Kirkpatrick	Gippsland blue gum					X
			E. globulus ssp. pseudoglobulus (Naudin) Maiden	Eurabbie					X
			E. grandis W.Hill ex Maiden	Flooded gum; Rose Gum		NS	3	2	
			E. leucoxylon F. Muell.	Yellow gum;White Ironbark; Iron bark		S	2	2	
			E. longirostrata (Blakely) L.A.S.Johnson & K.D.Hill[	Grey gum	Eucalyptus punctata var. longirostrata Blakely				X
			E. macrorhyncha F. Muell. ex Benth	Red stringybark		S	3	2	
			E. marginata Donn ex Smith	Jarrah		S	2	2	
			E. melliodora A. Cunn, ex Schauer	Yellow box		NS	1	1	
			E. muellerana A.W. Howitt	Yellow stringybark		NS	3	2	
			*E. nitens (*Dean & Maiden) Maiden	Shining Gum		S	4	3	

Broad	Status	Genus	Scientific name	Common name	Historic name		Durability		Not listed in
						Lyctid susceptibility	In ground contact	Above ground	AS5604
			E. obliqua L'Herit	Messmate stringybark; Stringy-bark (common)		S	3	3	
			E. occidentalis Endl.	Swamp Yate; Flat topped yate		-	-	-	
			E. oreades R. Baker	Blue Mountains Ash		NS	4	-	
			E. ovata Labill.	Swamp gum					X
			E. paniculata Smith	Grey ironbark		NS	1	1	
			E. polyanthemos Schauer	Red box	*E. polyanthema*	S	1	1	
			E. propinqua Dean & Maiden	Grey gum		NS	1	1	
			E. punctata D.C.	Grey gum		NS	1	1	
			E. quadrangulata	White-topped box	NS	NS	2	2	
			E. radiata Sieber ex D.C.	Narrow-leaf peppermint		S	3	3	
			E. regnans F. Muell.	Mountain ash	(See Note in Paragraph A3.2)	NS (Vic & NSW)	4	3	
			E. robusta Sm.	Swamp mahogany; Redgum					X
			E. rostrata	Redgum					X
			E. rubida H. Deane & Maiden	Candlebark, Ribbon gum		S	4	3	
			E. saligna Sm.	Sydney blue gum		S	3	2	
			E. siderophloia	Northern grey iron bark		NS	1	1	
			E. sideroxylon A. Cunn. ex W. Woolls	Iron bark; Red iron bark		S	1	1	
			E. sieberi L.A.S. Johnson	Silvertop; Silvertop ash		NS	3	2	
			E. smithii R.T. Baker	Gully gum					X
			E. strzeleckii K.Rule	Strzelecki gum					X
			E. tereticornis Smith	Forest red gum		NS	1	1	
			E. tricarpa (L.A.S.Johnson) L.A.S.Johnson & K.D.Hill	Red ironbark					X
			E. triflora Maiden & Blakely	Pigeon house ash					X

Broad	Status	Genus	Scientific name	Common name	Historic name		Durability		Not listed in
						Lyctid susceptibility	In ground contact	Above ground	AS5604
			E. viminalis Labill	Manna gum; Whitegum		S	4	3	
Hardwood	Native	Grevillea							
			G. robusta Cunn. ex R. Br.	Silky oak		S	-	-	
Hardwood	Native	*Haekia*							
			H. salicifolia (Vent.) B.L.Burtt[	Willow-leaved hakea					X
Hardwood	Native	Melaleuca							
			M. ericifolia Sm.	Swamp paperbark					X
Hardwood	Native	Pittosporum							
			P. undulatum Vent.	Sweet pittosporum					X
Hardwood	Native	*Toona*							
			T. ciliata M. Roem.	Red cedar					X

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