Silvicultural systems for durable sawlog plantations in Gippsland, Victoria – A case study

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Heartwood Plantations

Abstract

A holistic silvicultural system developed to produce sawlogs, from durable species in Gippsland is examined. The silvicultural system starts in the design stage and incorporates all aspects of plantation development. The benefits of strong market involvement in the derivation of the system are outlined. Following definition by market the establishment of southern mahogany (E. botryoides), yellow stringybark (E. muelleriana) and spotted gum (C. maculata) has been targeted. The use of three species provides the necessary flexibility to meet existing market requirements and optimise site productivity. Harvesting and haulage aspects are planned for prior to establishment. Weed control, site nutrition and planting stock/tree improvement are identified as key aspects of the establishment regime. The regular assessment of PSPs is a fundamental component of the system. PSP data provides invaluable insight into the growth and health of plantations and facilitates timely application of silvicultural techniques such as thinning and pruning. Thinning and pruning and their associated economics are discussed. To maximise profitability, pruning and thinning regimes need to be specific to species and site quality. Harvesting and re-establishment practices are outlined.

Introduction

Silviculture can be defined as the manipulation of plantations and the trees within them to produce both sawlog and residual wood products. The potential to direct tree growth and to enhance value makes silviculture a powerful tool (Reid and Stephen 2001) in the armoury of a forester seeking to produce wood products destined for sale.

A silvicultural system is a series of coordinated management actions that are applied to trees or forests over time from establishment through to harvest (Reid and Stephen 2001).

This paper provides a case study of a silvicultural system being applied in Gippsland, Victoria by Heartwood Plantations6 (HP) to produce durable sawlog products for the domestic appearance market.

Heartwood Plantations

HP is a strategic alliance between Woollybutt Pty. Ltd, Radial Timber Sales Pty. Ltd. and Woollybutt Technologies Pty. Ltd. HP is a vertically integrated forestry organisation that brings together a plantation development company, a timber processor and a forestry research company.

Woollybutt Pty Ltd, now trading as Heartwood Plantations, manages approximately 1,400 hectares of privately owned plantation investments in Victoria. Greater than 1,100 hectares (80%) of this resource (Figure 1) is eucalyptus species with class 1 or 2 durability (above ground)7 managed for sawlog production.

Radial Timber Sales (RTS) is wholly owned by Victorian businessman Chris McEvoy. RTS currently processes approximately 5,000 tonnes year-1 of durable hardwood sourced from Vic Forests. The species used are predominately E. seiberi, E. muelleriana and E. botryoides. RTS currently markets a range of predominately external feature timber products. These include decking, external lining boards and screenboards. RTS uses the innovative radial sawing technology that is well suited to plantation sawlogs.

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6 Formerly Woollybutt P/L
7 Class 1 timbers have a probable above ground live expectancy of >40 years. Class 2 timbers have a probable above ground live expectancy of 15 - 40 years (Standards Australia 2005).
Figure 1: Species composition of resource managed by HP.

RTS manufactures approximately 30% (3000m³) of the durable, solid wood products produced in Victoria (Chris McEvoy pers. comm.).

Woollybutt Technologies is a company that undertakes forestry research and development in relation to the growth, management and harvesting of plantation eucalypts for sawlogs. Woollybutt Technologies was formed in 2003 and since that time has undertaken fifteen projects specific to eucalypt sawlog establishment, management and harvesting. Woollybutt Technologies has collaborated with a range of other organizations such as the Australian Low Rainfall Tree Improvement Group (ARLTIG), the Department of Primary Industries (DPI), Elders Forestry and Forests NSW.

Silvicultural System Development

HP’s silvicultural system has changed over time. Initially the client predetermined the location of the property and HP selected the best species in terms of site suitability and market availability. This system led to HP trying to optimise outcomes without having control of essential factors such as site location and subsequently species selection and market direction. This approach led to the establishment of a fragmented resource, which contains well-managed wood that will in many cases be competing with larger plantation owners for market share.

In more recent times, the alliance with RTS under the HP brand has led to a shift in silvicultural approach. RT aims to be processing 100% plantation grown wood by 2030 to improve security, consistency and quality of supply. To do this it needs to gradually replace the durable sawlog species it currently sources from Vicforest in Gippsland (i.e. *E. muelleriana*, *E. botryoides* and *E. seiberi*) with wood from the same species or species with similar wood properties grown from plantation sources. This objective required HP to refine its preferred suite of species to *E. muelleriana*, *E. botryoides* and *Corymbia maculata*. These species all have class 1 or 2 durability (above ground), grow well in plantations when sited appropriately and produce wood that is suitable for the suite of RTS products.

With three preferred species, HPs’ new focus is to seek sites which have the characteristics to support plantations that meet productivity and wood quality guidelines required by clients and RTS. To minimise cartage costs these sites are generally within 150km of the mill, located in Yarram, South Gippsland.

This firm link between the market and plantation development has led to the growth of a more concentrated and uniform resource with superior saleability qualities compared to earlier establishment efforts. This outcome demonstrates the benefits of a silvicultural system that is strongly aligned to market demands.

Grealy (2008) notes that supplies of naturally durable timbers continue to fall short of market demand (Victoria only supplied 20% of its requirement in 07/08) opening the door for imports, preservative treated non-durable species and alternative non-wood materials. However, these options have not fully satisfied the marketplace and market values and demand for naturally durable timbers continue to climb. The opportunity now exists to establish plantations to meet both traditional and expanding high value timber market demands for naturally durable species (Grealy 2008).

In southeast Australia, RTS is a major player in the production of high value timber from naturally durable species. RTS understands the supply gap and the probability of its expansion. Hence they have been a key driver for the formation of HP, and more specifically, the selection of three core species for plantation development.

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8 In 2007/8 only 20% of Victoria’s demand for durable wood products was met by timber products manufactured in Victoria (Chris McEvoy pers. comm.).
HPs’ silvicultural system comprises the following key phases; species selection, site selection plantation design and establishment, management, harvesting and re-establishment;

**Species selection**
HP has been growing and trialing durable eucalypt species since 2000. This experience has so far demonstrated very encouraging results for *E. botryoides*, *Eucalyptus muelleriana* and *C. maculata* in Gippsland.

In addition to their timber marketability, the selection of these three species has been based on climate suitability, versatility across a range of soils, growth rate, sawing performance and residual wood marketability. The site requirements and management regimes for these species varies significantly. This is due to them being from different sub genera within the eucalyptus genus (Figure 2). Therefore, they are physiologically distinct.

Most pronounced is the difference in root structures, growth pattern and nutritional requirements. The use of three species provides flexibility across a range of proposed sites in Gippsland. *E. muelleriana* is highly suited to unfertilized duplex and gradational soils with sandy to light clay texture. Spotted gum is preferred where exposure is moderate to high and the risk of frost is minimal. On protected more fertile sites, southern mahogany is the preferred option This species is also highly tolerant of frost and has rapid initial growth making it ideal where browsing pressure is high. The form of southern mahogany suffers considerably where fertility is poor and/or exposure is moderate to high. As a consequence of these diverse characteristics, it is not uncommon for two, or even all three of these species to be sited on an individual property to achieve an optimum outcome. Many commercial eucalyptus investments have been sited poorly in Victoria. The incredible versatility and consistent growth of radiata pine (*P. radiata*) across southern Australia has created the misconception that similar outcomes can be achieved with eucalyptus species such as blue gum (*E. globulus*). In practice, eucalypts are more specific in their site requirements, which is evident from the great diversity found in the native forest environment.

In addition to the advantages of site optimization, there are also strong market factors in favor of using 2-3 species over a plantation estate. The timber characteristics and colors of the three species provide for brown (*C. maculata*), blonde (*E. muelleriana*) and red (*E. botryoides*) timber colors. Although each is either of class 1 or 2 durability, there are other important differences in the timbers. *C. maculata*, for example, is ranked highly for its fire retardant qualities (Lambert et al. 2007). The sapwood *E. muelleriana* and *E. botryoides* have the rare quality of not being susceptible to Lyctus borers (Standards Australia 2005), theoretically enabling the sapwood to be used without treatment. There may also be future demand for a pale brown timber that has class 1 or 2 durability. Currently native forest supplies of *E. seiberi* (silvertop ash) are filling this void for Radial Timber Sales. This species has the added advantage of a high pulp yield (Mamers et al. 1991) and is currently being trialed as a plantation species by HP with promising early results.

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**Figure 2. Presentation of Eucalyptus Genera, subgenera (subset) and species examples. Adapted from Boland et al. (1992).**
Through growth monitoring and a range of assessments on semi-mature plantations in Victoria and W.A., it is estimated that each of the species will attain a growth rate or mean annual increment (MAI) of 15 - 20m³ ha⁻¹ year⁻¹ over a 20-25 year rotation. This is assuming appropriate site selection and optimal management. To maximize radial sawing outputs, the silvicultural regime currently targets the production of 45–50cm average diameter (at breast height) trees with a final stocking of approximately 100-250 stems/ha.

Site selection

For sawlog plantation establishment, HP seeks land located within 150km of key markets in Gippsland. Larger distances are considered for sites where higher than average productivity is achievable. Prospective sites are carefully assessed for suitability to the preferred three species using climatic, edaphic, topographic, historic/existing forest type, land use history, regional plantation performance and risk criteria (Tepper 2008).

To assist with this process, comprehensive profiles for *E. muelleriana* (Tepper 2002), *E. botryoides* (Nicholas 2009 unpub.) and *C. maculata* (Lambert et al. 2007 unpub.) have been prepared that outline site preferences for each species.

Well-drained soil types containing soil volumes synonymous with at least two metres above an impeding layer (rock or heavy clay) are required. Sites to be avoided included those that have one or more of the following characteristics; <600mm/yr mean annual rainfall (MAR), altitude >350m, severe nutrient imbalances, waterlogging, salinity, high exposure/frost, high rock content, net plantable area <70%, difficult to harvest and/or access and/or regulatory impediments. These characteristics are identified during HP’s standard site evaluation. Site climate research and physical and chemical soil appraisal are fundamental steps in this work.

HP seeks sites that can support the target growth rates for their selected species. When a site is selected, species are matched to the various site classes that are inevitably found across a typical Gippsland site, to maximize overall productivity.

Site assessment is universally recognized as an essential preface to eucalypt plantation establishment (Tepper 2008) because it reduces risk. Risk needs to be addressed because a eucalypt sawlog plantation has substantially greater temporal scale than many other forestry, horticulture and agriculture investments. For example, they are exposed to a higher risk of multiple drought, fire and storm events (Tepper 2008). Site assessment is a pivotal module of HP’s silviculture system. Decision support systems such as those outlined by Wood et al. (2009) are very useful for analyzing plantation risk profiles.

Plantation design and establishment

An integral element of establishment is plantation design, particularly with regard to future harvesting and cartage options. Over a rotation, harvesting and cartage are easily the most expensive components of a plantation investment (commonly 4 times the cost of establishment). Being mindful of these elements during the establishment phase can significantly improve profitability. In the design phase, HP plans a basic track network that can be used for all plantation development activities including harvesting. Where track construction is required, establishment costs are increased. However, savings follow immediately, as costs associated with subsequent establishment and management operations are reduced.

The elements of plantation establishment for mainstream species have been well documented (Davidson et al. 2006). However, sawlog production using relatively un-researched species brings additional considerations to the establishment equation. Factors such as longer rotations, different log specifications, growth rates, root configurations and different tolerances /responses to herbicide and fertilizer regimes necessitate alternative prescriptions to optimize establishment success (Tepper 2008).

During the establishment phase of sawlog plantation development, HP have found it particularly important that seedling survival, vigor and form (at age 1) consistently meet high standards for the following reasons:

- Survival and tree form: high survival rates (>85%) facilitate a competitive environment that encourages good tree form and results in a reduced requirement for correction (form pruning at age 1-2). Sawlog specifications are relatively tight, so good form is essential. High survival rates provide a greater selection differential for sawlog tree identification at age 2-3 years;
- Vigor: fast growth after planting (1.5-3m tall at age 1) reduces later establishment costs (2nd year weed control, browsing animal control, monitoring) and reduces the window for damaging pathogen attack.
To meet survival, form and growth targets, the establishment sequence must be well planned, coordinated and undertaken in a timely fashion. HP’s establishment program spans two years and includes the following: physical and chemical soil analysis, GPS net area mapping, seed and seedling purchase, site clean-up including noxious weed control, soil cultivation, pre-plant weed control, browsing animal control, planting, fertilizer/insecticide application, monitoring and post planting assessment, summer weed control, second year weed control and foliar sampling/analysis.

All of these operations are important. The works that have the most significant impact on the establishment result are associated with (listed in order of importance) weed control, nutrition maintenance and seedling procurement.

Weed control
Weed control in farm plantations and woodlots is crucial during the first two growing seasons. Without adequate weed control, competition for water, nutrients and light can lead to high early mortality of trees (Tomkins 2002). Minimum weed control in eucalypt plantations should be a weed free strip of 1.5-2m in width, maintained until canopy closure (Volker 2006). *E. muelleriana* is particularly sensitive to weed competition because, being a *Monocalyptus* species it has a shallower rooting habit than *C. maculata* and *E. botryoides* and is therefore more sensitive to early competition for soil resources.

Site nutrition
HP regards the development and maintenance of adequate site nutrition to be second in importance only to weed control. As stipulated by Smethurst (2006), poor nutrient balance can result in reduced survival, slow growth, additional weed control, increased susceptibility to pests and diseases and ultimately a non-profitable enterprise. In accordance with Dell and Huang (2002), HP has found that nutrient imbalance, particularly micronutrients, can be associated with extreme crown dieback and/or distortion that can quickly and severely compromise sawlog yields.

Fertilizer requirements are site and species specific. Species which grow naturally on poor-quality sites, often show a modest response to added nutrients (Kriedemann and Cromer 1996). For example, in *E. cladocalyx* established on two sites with <800 mm yr⁻¹ MAR, there was no significant response to fertiliser addition at age 1 and 2 years (Severino et al. 2005 unpubl.).

Research undertaken by Woollybutt Technologies has emphasised species specificity in fertiliser requirements. Figure 3 demonstrates the considerable differences in nutrient concentrations between *E. muelleriana* and *C. maculata* at age 1 year on a trial site in South Gippsland (Severino 2007 unpub.). Such trial work has assisted HP to develop guidelines for siting species. It also demonstrates the importance of physical and chemical soil evaluation prior to establishment. To determine the nutrient balance of trees following planting, regular site monitoring and foliar sampling has proved invaluable to optimise nutrition and subsequently tree form and growth.

![Figure 3. Nutrient concentrations in foliage of 1 year old C. maculata and E. muelleriana foliage (Severino 2007 unpublished. ms.).](image)
Seedling procurement

High quality planting stock is fundamental to the successful establishment of HP’s plantations. Stock that does not meet basic specifications such as those specified by Tepper (1999) will generally grow more slowly and be more susceptible to frost, browsing and disease damage. These factors could reduce seedling survival and growth below benchmark levels. Sub-standard planting stock will increase planting and maintenance costs and ultimately reduce profitability.

Tree improvement can be defined as applying knowledge of genetics to develop improved trees (Schmidt 1997). Wherever possible HP acquires improved seed to propagate seedlings for plantation development. Improved seed is commercially available for C. maculata and most recently E. botryoides. Seed for E. muelleriana is obtained from interim seed production areas based on thinned plantations of known best provenances. In similar circumstances this seed has been described as “somewhat improved” (Harwood et al. 2007).

Management

A typical management regime for HP is shown in Table 1.

<table>
<thead>
<tr>
<th>Yr</th>
<th>Operation</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Trees planted and first year management</td>
<td>As outlined in Establishment section</td>
</tr>
<tr>
<td>1+</td>
<td>Monitor pests/diseases &amp; tree nutrition</td>
<td>Install monitoring plots that are surveyed 1-2 times/yr.</td>
</tr>
<tr>
<td>1-2</td>
<td>Form pruning</td>
<td>Ensure 500 sawlog quality stems/ha</td>
</tr>
<tr>
<td>3-5</td>
<td>1st stem prune</td>
<td>Prune best 300sph to 2.5m</td>
</tr>
<tr>
<td>5</td>
<td>Non-commercial thinning</td>
<td>Use excavator to thin to 500-600sph</td>
</tr>
<tr>
<td>6-7</td>
<td>2nd stem prune</td>
<td>Prune best 200sph to 4.5m</td>
</tr>
<tr>
<td>8-9</td>
<td>3rd stem prune</td>
<td>Prune best 150-200sph to 6.5m</td>
</tr>
<tr>
<td>8-12</td>
<td>1st Commercial thinning</td>
<td>Thin for pulpwod or other residual products</td>
</tr>
<tr>
<td>15-20</td>
<td>2nd commercial thinning</td>
<td>Thin for pulpwod and small sawlogs.</td>
</tr>
<tr>
<td>20-30</td>
<td>Clearfall</td>
<td>Harvest for residual product &amp; sawlogs when average dbh &gt; 45cm</td>
</tr>
</tbody>
</table>

HP has installed over 80 permanent sample plots (PSPs) across the resource it manages. These PSPs are located near soil exploration pits and assessed annually for tree growth and health characteristics. Their regular measurement enables the plantations to be managed dynamically on a scientific basis. This is imperative given the ever changing plantation environment and market conditions.

To optimize the power of silviculture in plantation management, it is imperative that relevant, quantitative data is regularly collected. Measurement of PSPs generates a range of data that provides invaluable insight into the growth pattern of plantations. This is particularly important when managing a range of species and site classes as illustrated by the data shown in Figure 4. The graph shows mean annual increment (MAI) data for E. botryoides, E. muelleriana and C. maculata across HP’s managed estate. These species are closing in on an average MAI of 10m³ ha⁻¹ yr⁻¹ at age 10 years as they approach the half way mark of the rotation, giving HP confidence that a mean annual increment of 15-20m³ ha⁻¹ yr⁻¹ is realistic over a rotation of 20-30 years. Such data can be extremely useful when combined with site information as it can assist HP to refine its site selection practices to improve the probability of future plantations achieving productivity objectives.
**Thinning**

Thinning is often the most powerful tool available to forest managers for influencing the growth rate of final crop trees and their size at harvest (Forrester et al. 2010). Thinning influences the future size distributions of a stand and the products it will deliver, so regimes will also depend on market demands (Forrester et al. 2010).

A prime objective for HP is to maximize plantation profitability. In durable eucalypt species this entails maximizing wood production with an emphasis on pruned sawlog production. HP aims to thin its plantations in a fashion that makes optimal use of site resources whilst maximizing sawlog yield. Medhurst et al. (2001) showed that there was little difference in yield of pruned sawlogs between residual stockings of 200 and 400 sph. High intensity thinning (e.g. <200sph) can produce a stand that is unable to regain the full use of site resources during the rotation (Medhurst et al. 2001) leading to serious under utilizing of site resources and lost income potential.

![Figure 4. MAI figures from PSP’s across HP managed estate](image)

The timing of thinning is very important. To maximize thinning response, thinning interventions should occur while trees have a high growth rate and vigor (Forrester et al. 2010). Medhurst et al. (2001) suggests that some growth opportunity for final crop trees may be lost if thinning is delayed beyond the canopy closure stage. A well planned and implemented monitoring program underpinned by PSPs, equips HP with the information it requires to schedule thinning at the optimal time.

HP’s PSP data provides a scientific basis for developing species-specific thinning regimes. This is particularly important for relatively unresearched species such as *E. botryoides*, *E. muelleriana* and *C. maculata*. Figure 5 shows the basal area at various ages in these species. Early trends show that *E. muelleriana* and *E. botryoides* are tolerant of higher basal areas than *C. maculata*. Based on this, HP has developed interim prescriptions for some sites that entail lighter thinning prescriptions in these species relative to *C. maculata*. In all species, HP adopts the 50% rule outlined in Medhurst et al. (2001) whereby less than 50% of the standing basal is removed.

10 Basal area is the cross sectional area (m²) of a tree at breast height (1.3m). The sum of the basal area for all trees in a unit area is used as a measure of stand density or competition between trees and is expressed in m²/ha.
To maximize the total production of potential sawlog crop trees, the stand density after the final thinning would need to be that which leads to a closed canopy at the end of the rotation (Beadle et al. 2008). Differences in tolerance to competition between species will influence decisions regarding predictions of final stocking and subsequently the number of trees pruned at the final pruning lift.

To compliment PSP data and provide a solid basis for thinning prescriptions, HP in partnership with Elders Forestry, have several thinning trials in durable species located in HP plantations across Victoria. These trials are pointing towards a regime of non-commercial thinning between age 4-6 years followed by further commercial thinning at age 10-12 years.

![Figure 6. Basal area data from PSP’s across HP estate](image)

**Figure 6. Basal area data from PSP’s across HP estate**

**Pruning**

Stem pruning is undertaken in sawlog plantations to allow the production of timber which is free of knots and other defects associated with branches such as encased bark, decay and kino (Volker 2008).

*E. muelleriana*, *C. maculata* and to a lesser extent *E. botryoides* all shed branches naturally in their native forest environments. However, when grown in plantations established at 1000-1250sph and non-commercially thinned by age 4-6, these species do not shed branches in a satisfactory manner and subsequently defects associated with branches occur internally. This is primarily due to the lateral branches intercepting more light in the comparatively lightly stock plantation environment. Plantation grown *E. botryoides*, in particular, is prone to producing big branches in the absence of stem pruning.

Forrester et al (2010) points out that variations in characteristics such as shade tolerance, crown architecture and growth rates between species can necessitate different pruning regimes. This is reflected by HP experience where *E. botryoides* will often require pruning at an earlier age than *E. muelleriana* or *C. maculata* because it tends to produce larger branches. Site quality and stand density also influence HP pruning regimes. At standard establishment stockings, lower branches will tend to die earlier on less fertile sites. At lower stand densities, more light reaches the lower canopy and the green crown canopy rises more slowly (Nielsen and Gerrand, 1999).

HP’s pruning regime is similar to that of Forests NSW (Alcorn et al. 2008). HP usually prunes durable eucalypts in three lifts up to 6.5 metres, removing <40% of the green crown in any one lift.

**Economics of thinning and pruning**

Based on results from the production of sawn timber from 10 year old *E. nitens* grown in a riparian buffer Reid and Washusen (2001) conclude that un-pruned or small diameter eucalypt logs (<40cm in diameter) appear to be unviable to harvest for sawn timber.
Sawing trials in *E. globulus* and *E. nitens* undertaken by Washusen et al. (2004) show a trend of increased recovery, product quality and value as the length of time following thinning increases. This has been most pronounced where pruning and thinning were combined at 3-5 years of age. Given the large differences in stumpage values, pruning should be recommended to improve wood quality and product value. Washusen et al. (2004) adds that an economic analysis of pruning is warranted to support this recommendation.

Using net present value (NPV) criteria, Volker (2008) showed that better returns could be achieved from a pruned and thinned regime than from the unthinned/unpruned regime.

Wood et al. (2009) modeled the economic and silvicultural outcomes of 60 different management scenarios across four site qualities\(^{11}\) for the Forestry Tasmania resource of *E. nitens*. Several notable conclusions were made from this study:

1. For each scenario, profitability increased with increasing site quality;
2. Regimes incorporating one or two commercial thinning/s were always more profitable than the base regime of no thinning;
3. Only at the highest site qualities was high pruning and commercial thinning the most profitable regime.
4. Lesser pruning regimes coupled with thinning became more profitable as site quality decreased;

The research shows that HP’s inclusion of commercial thinning shall assist to make sawlog regimes more profitable. Perhaps most importantly though it suggests that to maximize profitability, pruning regimes should be altered with changing site quality.

HP high prunes plantations because RTS require defects associated branches to be minimized. Prior to plantation establishment a cash flow budget is prepared using a customized proforma based entirely on current day cost (including pruning/thinning costs) and return figures. Generally speaking HP proceeds with durable species projects in Gippsland that have an internal rate of return\(^{12}\) (IRR) of >=7%\(^{13}\).

However as HP’s resource approaches harvesting age, Woollybutt Technologies will begin work to understand the properties of harvested timber and both wood quality and total recovery might be improved by adjusting silvicultural and/or processing strategies.

**Harvesting**

HP has commenced commercial thinning trials on some of its older plantations in recent years. These operations have demonstrated a unique process where approximately one third of the plantation is marked and thinned without the use of out-rows, which are common in the radiata pine industry. The majority of purpose-built harvesters and forwarders have a width of no more than 3.0 metres (and zero tail swing). This allows for comfortable operation between 4.0 metre rows in non-commercially thinned plantations.

The primary reason for this approach by HP has been to maximize the sawlog yield, which is often challenged by poor form (and low genetic improvement) in some of the species being grown. In addition, this approach maintains a more even competition between the retained stems, which has the potential to keep growth stresses to a minimum. Early results suggest that these operations are commercially viable (Lambert 2008 unpub.).

**Re-establishment**

In recent years an increasing percentage of HP’s works program has involved establishing durable eucalypt plantations on second rotation pine sites. These sites commonly have different weed and nutrition profiles and require a different silvicultural system relative to ex-pasture sites. The presence of stumps and harvesting debris makes it difficult to treat weed and nutritional problems post planting. Hence there is a greater need to predict such issues by monitoring weed populations and soil nutrition after harvesting to facilitate treatment prior to planting.

**Conclusion**

Definitive market direction has assisted the development of HP’s silvicultural system in a fashion that has consolidated new plantation expansion, improved establishment results and focused the associated research program.

Silvicultural systems are most effective when they are implemented holistically from the conceptual stage of plantation establishment.

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\(^{11}\) Site quality was based on peak MAI (pMAI). pMAI is the maximum MAI for an unthinned stand with an initial stocking of 1100sp.h.

\(^{12}\) IRR is the discount rate at which the net present value (NPV) equals zero.

\(^{13}\) This figure includes no provision for associated carbon and/or agricultural returns.
Plantation establishment regimes must be designed to foster superior standards of survival, growth and form. All establishment operations are important. However in HP’s experience the works that have the most significant impact on the final result are weed control, site nutrition maintenance and seedling procurement.

Plantation monitoring and the compilation/analysis of PSP data are intrinsic components of a scientifically based silvicultural system. They allow the various silvicultural techniques to be applied appropriately and for future plantation expansion to meet objectives.

Processor requirements and profitability objectives mean that multiple thinning operations and high pruning works must be applied in HP’s plantations.

To improve sawlog yield and even out competition between trees HP implements a commercial thinning methodology that does incorporate an out-row system.

Contrasting site conditions require HP to employ different establishment regimes for ex-pasture and second rotation sites.

The strong link between the silvicultural system and market has improved economic and risk profiles of the HP resource. The overarching market guidelines, combined with an accountable monitoring process, create a dynamic silvicultural system that has the capacity to change as market, site and research parameters require.

References


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