Session A4: Management

Plantations

Second rotation blue gum silviculture

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Biography

Andy has studiously built a comprehensive eucalyptus silviculture portfolio over 14 years working in industrial blue gum plantations. His expertise covers land evaluation, plantation establishment & management, forest planning, mensuration, yield scheduling, fire management, harvesting and fibre logistics. He currently manages 55,000 ha of blue gum estate in the SW of WA on behalf of Elders Forestry retail and wholesale investors. In former roles he developed the company’s forest planning and harvesting systems, and its sandalwood projects in the tropical north and temperate regions. He values innovation and strives for continuous improvement. In spare moments he experiments on his own blue gum plantation situated in Albany, WA.

Abstract

Hardwood plantation management principles apply regardless of first or second rotation: suitable climate, good soil, high quality planting stock, best-practice silviculture, a clear route to market and a hungry market. Managers should, however, be wary of sites becoming resource-limited as a result of nutrient and water-drawdown after the first rotation.

Where a second rotation of blue gum has been deemed economically viable, planning for the next crop commences prior to first rotation harvest. Managers must decide whether they will plant a new seedling and how to manage harvest residues.

Attention to detail at the harvest phase aids second rotation operations, particularly appropriate slash placement and stump treatment. High stumps generally impede follow-up operations.

Further work is being carried out to understand the changed weed spectrum – and therefore control measures – on second rotation sites where summer weeds are more prevalent than grass weeds. Early indications are that fewer chemical treatments will be required.

Fertiliser regimes should be a priority. Where slash has been removed, consolidated or burned through harvest and/or site preparation, nutrition replacement is key-critical. Retaining nutrient-rich slash in a form developing plantations can use often requires costly tertiary treatments. Fertiliser should only be applied where weeds have been controlled or are absent.

Lessons from the first rotation

1. Pushed too far into low rainfall land with high yield expectations. Major contraction from the marginal land expected; say 40% reduction in Australian hardwood plantation estate from current level ~ 1Mha.
2. Stocking too high: could optimise site potential with 600 stems/ha
3. More focus on nutrition required
4. Under-promise and over-deliver, rather than visa-versa
5. Grow efficient trees to optimise returns
6. Land cost is the critical variable
7. Importance of certification for market access
8. Importance of scale critical
Second rotation decline

Western Australian and South African foresters suggest that second and subsequent rotations suffer yield drawdown from water and nutrient mining.

S Africans expect 12% mean decline across all sites in the second rotation.

In WA, growers report a continuum of decline from 0% (possibly uplift on the high productivity sites) to 40% lower yield compared to 1R (on low productivity sites).

Decline is magnified by site limitations, particularly limitations that can’t be managed like low rainfall and shallow soils.

Nutrition and genetics can be managed.

Genetic improvements over the last decade indicate yields of full-sib family crosses could be up to 40% better than yields from plantings sourced from unimproved native seed. Doubt remains over whether genetic gains can be realised on sites limited by other variables, particularly water and soil characteristics.

Nutrients exported off-site through harvest slash sale, burning or consolidation equate to a significant sum (Table 1) Green harvest slash has reportedly been measured at levels ranging from 25 – 60 t/ha. If slash was exported, to return similar levels of nutrient to the land using commercially-available fertilisers would require approximately 1,700 kg/ha of product to be spread through the plantation.

Table 1: Nutrient export (kg/ha) from two sites in the Albany area, Western Australia, as calculated by BPOS (Blue gum Productivity Optimisation System)

<table>
<thead>
<tr>
<th>Element</th>
<th>Manypeaks</th>
<th>Frankland</th>
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<td>N</td>
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<td>P</td>
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<td>Fe</td>
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</tr>
<tr>
<td>Zn</td>
<td>10.6</td>
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</tr>
<tr>
<td>Mn</td>
<td>7</td>
<td>6.2</td>
</tr>
<tr>
<td>Cu</td>
<td>17.4</td>
<td>15.1</td>
</tr>
<tr>
<td>B</td>
<td>3.6</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Considering nutrient balance models is also crucial to second rotation management. Although these elements may not be applied at the same time, additions of the right fertiliser should be staggered, and applied where the tree needs it, at the right time, in the right amounts, to prevent volatilisation and optimise return on fertiliser investment. Fertiliser applications may be a waste of money on sites which do not respond to fertiliser. Note also that some elements listed here may not be limiting. Base fertiliser decisions on soil tests and past experience.

Economics

This section assumes that the land owner/manager has conducted discounted cash-flow analyses on a theoretical second rotation crop, determined that the internal rate of return exceeds the business’s cost of capital and that he/she will proceed with a second crop of trees. It also assumes that the first and second rotations are blue gum in the absence (or likely absence) of critical scale plantings of other species.

Various studies have shown that genetic gain from a seedling crop should deliver around 20% more wood than a coppice crop in the second rotation to warrant investing in new seedlings. On current expectations from genetic trials, this appears warranted. However many trials are now showing equivalent seedling and coppice yields at age 10, indicating that something other than genetics restricts growth. As indicated previously, the critical constraints in 2R are thought to be soil water and nutrition, although residual stocking also warrants consideration.

The Drought Risk project in WA and other stocking density trials throughout the state on a range of sites indicate that the optimal stocking, regardless of rainfall, is 600 stems per hectare. With coppice, ‘clumpiness’ or aggregated low-stocked coppice can be managed at coppice reduction time to leave multiple stems per stump around gaps to consolidate yields – this is the recommended silviculture in S Africa, despite also recommending much higher initial stocking (1,666 spha). Managers often report high stump mortality on wet sites, harvested in early summer.

Even where the site is to be managed for coppice, small areas of coppice will fail (say, 5% by area – eg landings, wet hollows) and require enrichment planting.

Whether the site will be managed for coppice or with new seedlings, planning for the new crop begins prior to the first rotation harvest.
Harvest planning

Seedling 2R

If the manager has obtained excellent genetic material and the site is not severely water-limited, the manager may plant seedlings in the second rotation. If the aim is to produce a seedling crop, the harvest site should be managed so as to minimise impediments to follow-up operations. This would mean a harvest plan with:

1. low stumps, so feller-buncher or hot saw harvest; and,
2. consolidated but not accumulated harvest slash.

Coppice 2R

The aim for a coppice crop is to optimise stump survival and use the nutrition from decomposing harvest residues. The manager should plan for a harvest operation which aims for:

1. Uniform slash distribution without smothering coppice growth;
2. Higher stumps with more epicormic buds; and,
3. If a wet site, harvest scheduled between late summer – spring.

Slash management

Where harvest residues will not be retained on site or stockpiled in consolidated areas, such as with roadside processing operations, certain prescriptions should be adhered to. In particular, where residues are to be burned, residues should be:

1. Consolidated in small heaps with no incorporated soil, so that they burn away quickly; and,
2. Away from remnant vegetation/assets, to prevent escapes or damage.

With some roadside processing operations, particularly with in-field chippers, slash can be returned to the paddock as large balls without unduly impeding follow-up operations or adding cost to the harvest operation.

During harvest

Seedlings

To maintain clear access for follow-up operations, stumps should not impeded by harvest slash. Stumps should be kept as low as possible to a) optimise yield and b) minimise epicormic shoots. Before a seedling crop can be established, the stumps from the first rotation must be killed.

Where harvest occurs in spring or early summer, or where the second rotation manager has no control over the first rotation harvest, stumps may coppice and control can occur at a later date using a variety of methods. However, it is possible to return land to production within a month or two of harvest. Current techniques include:

1. **Stump spray at harvest time:** The fastest way to return land to production is to spray stumps with herbicides at harvest time. While sap is still running through the stump (<24 hours summer, <48 hours winter), spray cut surface with chemical to kill stump.

   Chemical: glyphosate at 6 – 10 L/ha plus dye in a directed spray from a hand gun.

   Application $80 – 200/ha; chemical $40 – 60/ha.

   Brickbats: considerable safety risk with non-harvest personnel in close proximity to harvest equipment, high chemical rates, contract rates subject to variation if harvest equipment breaks down,

   Bouquets: immediate access, no water draw-down, relatively cheap, efficient (close to 100% kill with diligent operator), potential to fit the spray equipment to harvester heads as routinely occurs in Europe.

2. **Foliar spray:** when coppice reaches 1.0 – 1.5 m height, must spray every leaf.

   Chemical: minimum 60 g/ha metsulfuron plus wetter with high water rates (>400 L/ha).

   Application $80 – 100/ha; chemical ~$5/ha.

   Brickbats: water draw-down while coppice gets established, time delay, coppice regrowth can be variable.

   Bouquets: cheap, efficient (close to 100% kill with diligent operator), safe.

3. **Cut-and-spray:** if coppice exceeds 1.5 m height, foliar spray becomes unviable. Motor-manual cut-and-spray coppice with large slasher/cutting head followed by herbicide application to cut stems.
Chemical: 6 – 10 L glyphosate with high water rates (>400 L/ha)

Application ~$200 – 300/ha; chemical ~$40/ha.

Brickbats: water draw-down while coppice gets established (more severe than 1), time delay, biomass clutters site for future cultivation equipment.

Bouquets: efficient (close to 100% kill with diligent operator), safe.

4. **Stump grind**: for advanced coppice, high stumps, unwanted 1R layout or to return to pasture. High powered tractors with tungsten-tipped mulching heads macerate 1R stumps (including root ball), any coppice and laterite rock.

Cost: $400 – 600/ha (stump-size dependent).

Brickbats: water draw-down if coppice gets established, high cost, variable machine operation, fire risk, contractors go broke, machines don’t like granite rock or sand, although resultant soil tilth can appear excellent, high organic matter and air pockets retard seedling growth.

Bouquets: sometimes you just have to get rid of the 1R stumps, mulch beneficial in long run, can plant alongside the mulched stump row in clean soil with good effect, effective way to quickly return to pasture.

5. **Stump removal**: an alternative to stump grinding. Stumps plucked by excavators (>18 t) or ripped out by heavy bulldozers (>KD155 or equivalent), then stockpiled and burned.

Cost: ~$1,000/ha.

Brickbats: high cost, soil profile gets turned upside down (brings high-clay A horizon to surface), windrows with soil incorporated burn for months, secondary treatment likely, site ends up pocked by small hollows.

Bouquets: possible for owner operators wanting to quickly return to pasture.

Method may depend on harvest timing, chemical costs and the site idiosyncrasies following the first rotation harvest and may include a mix of these methods.

**Coppice**

During harvest, supervisors should ensure stumps are not completely covered by slash to a depth greater than 30 cm and that harvest machinery does not tear bark off stumps.

**Seedling re-establishment**

**Cultivation**

On second rotation sites, cultivated mounds may incorporate organic matter into the soil and create air pockets. On sites with non-wetting soils, the original mound can remain under the new mound. Notwithstanding, mounds established on 2R sites have resulted in uniform plantations and are recommended on sites with inundation potential.

If the site is not likely to become inundated, consider a modified rip-only with a single-tine knife ripper. Stumps are left in-situ. Mild soil shatter occurs as the 1R stumps are moved through the ripping process. New seedlings follow old root channels through the soil.

Following the 1R planting lines requires little planning or supervision during cultivation. Where stumps remain from the first rotation, there is a risk of machinery getting hung-up on or striking high stumps, risking machinery and safety of operations personnel. To effectively change the plantation layout, the stumps should probably be removed or mulched, at great expense. The 2R plantation layout can be altered but unless there is a compelling reason to change, following the 1R layout is easiest, safest and cheapest.

If starting a new row between the old rows (that is, cultivating the inter-row), beware coppice (coppice between replanted seedlings) impediment to future access, as well as the aforementioned safety issues from 1R stumps.

**Weed control**

Second rotation weeds are different to first rotation weeds, particularly where the previous land use was improved pasture or cropping. An altered weed spectrum requires a fresh approach to weed control.

Observations to date are that when the first rotation is removed the weed spectrum:

- has more summer weeds and bull rushes;
- has fewer annual grasses; and,
• long-dormant perennials, particularly kikuyu, come to life.

As a result, herbicide spray timing and rates will be dictated by the spectrum with the same principle as controlling 1R weeds – spray an even germination and when actively growing – although this approach can be disrupted by access rights and harvest timing. Weed control is not approached with a blanket approach as with pastured sites. Some sites are only sprayed with knockdown herbicides; some with just residual herbicides; some not at all. Second year weed control is rare.

The company is still working out best approach here and further research is underway.

Planting

Planting principles mirror the first rotation:
• robust, hardened-off seedling;
• root plug saturated, seedling turgid;
• planted deep (plug buried at least 10 mm);
• heeled-in (not toed-in or a mix of the two - this is not a bush dance) to remove air pockets;
• planted upright (not leaning); and,
• in the middle of the row.

There are no 2R-specific planting prescriptions although tighter supervision may be warranted on rough sites.

Nutrition

Forest nutrition is the most critical aspect of 2R management. For a neat synthesis of current industry and academic paradigms, see May et al (2009).

Sites are most likely macro-depleted after the first rotation, particularly if harvest slash is exported off-site.

To return adequate levels of nutrition, current thinking is to use these fertiliser principles:

1. At establishment, high P and trace elements incorporated into the root zone;
2. In the first autumn after planting, NPK blend; and,
3. High N every second year at minimum 70 kg/ha elemental N until canopy closure, being mindful of pushing the trees into micronutrient deficiency (particularly Cu).

Harvest slash carries high amounts of nutrient. Many companies are exploring ways to retain nutrient on site for second or subsequent rotations. Studies in WA show that while the second rotation gains little benefit from slash retention, big gains are expressed in the third rotation. Depending on the harvest system adopted, tertiary slash treatment may be required which, at 25 – 60 gmt slash/ha, would be very expensive. Current thinking is to incorporate slash retention into the harvest process at nil cost, and perhaps tertiary treat later. One potential means is to smear slash snowballs from in-field chipping operations with a loader at age 2, when the slash has partially broken down (cost ~ $100/ha). On the upside, this is cheaper than a fertiliser addition and has lasting weed control benefits. On the down side, decomposing organic matter has a strong nitrogen drawdown from microbial activity and there may be short-term negative outcomes, as well as increased fire risk for up to five years with all slash retention initiatives.

Nutrition trials are still too young to determine whether fertiliser additions early in the rotation increase returns, however early trial evidence indicates a strong response in young trees on 2R sites and intangible benefits such as reduced susceptibility to pests and diseases and early canopy closure. On low rainfall sites, growing trees fast may not increase overall yields but if rotation lengths can be reduced, this may increase IRR.

Figure 1 shows the growth response at three sites in the Albany region of WA. In this scenario, combinations of weed control and high fertiliser (over 1t/ha) showed strong early responses to the treatments. Note that low-rainfall Katherine was severely attacked by insects in the first year. Also note the increased early growth on WC + F treatments, with greatest increase on the higher rainfall site (Jeffries).
Figure 1: Growth response to weed control and fertiliser at three sites in the Albany region, WA.
Case studies: Millbrook, Cheynes & Pickles

Treefarms

Table 2 shows three farms established over the past four years and improvements in cost over this time. Millbrook represents an extremely difficult site where stump grinders were employed. At Pickles, all operations occurred in an orderly manner with tight cost control.

Table 2: Second rotation costs on three sites established in 2006, 2008 and 2010

<table>
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<th>Treefarm</th>
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<th>Snowball</th>
<th>Pickles</th>
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<tbody>
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<td>Establishment year</td>
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<td>2008</td>
<td>2010</td>
</tr>
<tr>
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<td>Gravel</td>
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<td>Clean-up (stump spray)</td>
<td>$ -</td>
<td>$ 195</td>
<td>$ 150</td>
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<tr>
<td>Clean-up (machinery)</td>
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<td>$ 32</td>
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<td>Cultivation</td>
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<tr>
<td>Pre-plant weed control</td>
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<tr>
<td>Seedlings</td>
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<tr>
<td>Fertilise during cultivation</td>
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<tr>
<td>Post-plant WC (inc 2YR WC)</td>
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<td>$ 33</td>
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<td><strong>Total Yr 1 costs</strong></td>
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<td>$ 809</td>
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Acknowledgements

The bluegum industry shows a mature approach to sharing silvicultural improvements. In particular, thanks to Richard Breidahl and Russell Walter at WA Plantation Resources, who are many years ahead of their industry colleagues in all silvicultural facets and have provided useful guidance and mentoring over the years.

References