Plantation Forestry Management Principles for the 'Dry' Tropics of Northern Australia

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Introduction

Australia has a balance of trade deficit in wood products. For 2004, this deficit is estimated to be $1.85 billion (National Association of Forest Industries, 2004). In order to offset part of this deficit the Australian Government's 'Plantations for Australia: Vision 2020', drawn up in the mid 1990's, called for a tripling of the country's plantation estate to 3 million hectares by the year 2020.

Although Australia currently has a 1.6 million ha State and privately owned plantation estate, consisting mainly of exotic pine and short rotation native hardwoods (the latter destined for the export pulpwood market), over 98% of the country's plantations are in the temperate climate of the southern States (Commonwealth of Australia 2004).

The 'dry' tropics of Queensland are defined as areas north of the tropic of Capricorn, which receive less than 1200 mm mean annual rainfall. Climatic conditions in the Queensland dry tropics are characterised by two distinct seasons (wet and dry), with the majority of rainfall occurring between December and March, followed by an extended dry season (mean monthly rainfall < 40 mm) for up 8 months (Gentilli, 1972).

It may be asked, with the almost perfect growing conditions of the adjacent 'wet' tropics of northern Australia, why should we even need to consider venturing into the much harsher 'dry' tropics environment, to establish commercial timber plantations?

The short answer to this is that there is already a wide range of established rural industries in the wet tropics including sugar cane, cattle, bananas and small crops, all vying for the available agricultural land. This competition for intensive use generally puts the price of such land beyond the price considered economic for forestry. With its longer time frames, plantation forestry therefore cannot compete with annual cash crops and therefore other land options are needed to provide opportunities for plantation establishment (although a proportion of land in the wet tropics is, and will continue to be marginal for agricultural crops and be more suited to forestry).

The low rainfall areas of the 'dry' tropics of north-west Queensland have previously been considered unsuitable for forestry purposes. Irregular rainfall, prolonged droughts, insect plagues, lack of suitable commercial tree species and distance to processing mills and ports are but a few reasons. There has also been the problem of land availability in inland areas. Most of the western properties are pastoral leases and until very recently legislation required that any trees planted on these leases remained the property of the crown.

Recent legislative changes to leasehold tenure on pastoral leases now recognise plantation forestry as an allowable activity providing it does not become the primary purpose of the lease (Natural Resources and Other Legislation Amendment Bill, 2004). This has created opportunities for

plantation development on previously cleared land[1] where soil type, water availability and other factors are conducive. Cleared land under pasture can now be utilised for plantations with the option of reintroducing stock at a later date. Initial discussions with community leaders in western areas have indicated strong support for alternative industries including forestry plantations. The tyranny of distance has diminished as the transport system from western areas has dramatically improved. There are now efficient road and rail links to many eastern and northern ports.

However, the eastern boundary of the dry tropics is at most, only some 60 km from the north-east Queensland coast, and in the Burdekin catchment it extends to the coast. Therefore, with an increasing awareness on Queensland's east coast in minimising the environmental impacts of land use management practices on the Great Barrier Reef, and the development of coastal management plans for north-eastern Queensland to manage the reduction of these influences, such management plans and other plans have to be taken into account, even when considering dry tropics forestry development. It should be noted that a number of rivers in the Cooktown area, the Herbert River and the Burdekin river, and in Central Queensland, the Fitzroy River, all originate in mid to low rainfall areas of Queensland and flow onto the east coast, Great Barrier Reef region,

Silvicultural management

Routine plantation management becomes much more critical when dealing with the often harsh conditions of the 'dry' tropics. The erratic and undependable rainfall and ever-present threat of drought dictates that to be successful, growers must plan for the worst-case scenario.

The information provided below has been compiled from personal experience in the dry tropics as a former Farm Forestry Extension Officer, from research carried out by the DPI&F (Queensland Department of Primary Industries and Fisheries) and from research by DBIRD (Northern Territory Department of Business, Industry and Resource Development). It is an overview of some of the silvicultural issues faced in the adverse conditions of the 'dry' tropics.

Species selection

Incorrect species selection can virtually guarantee poor performance. In adverse environmental conditions, only the hardiest of trees will survive let alone prosper to produce quality timber in a realistic time frame. In determining the most suitable commercial species for the site, there are some basic guidelines that must be adhered to:

1. Is it suitable for the rainfall and temperature range of your location?
2. Is it drought tolerant?
3. Is it frost tolerant? (important for certain sites);
4. Does it suit your soil type?
5. Does it have any insect pests?
6. Does it have a commercially realistic growth rate?
7. Does the sawn timber value warrant the risk of investment?

Historically very few commercial timber species have been considered hardy enough or have the potential to grow to maturity within acceptable time frames in the 'dry' tropics. Over the past 15 years there have been several species trials established to determine which commercial species have the most potential (Sun and Dickinson, 1993). These trial plots consisted of a range of best bet species thought to be suitable for that environment. This research has highlighted one tree of particular

[1] With current legislation, land clearing for plantation or any other rural development is prohibited in Queensland (where the existing vegetation is classified as 'remnant'; that is it is not 'regrowth' or 'cleared'). However on freehold land, there may still be native forestry and enrichment options in remnant forest, under an approved plan.

interest. African mahogany (*Khaya senegalensis)* has emerged as a stand-out performer in almost all of the trials it has been included in across northern Australia (Nicholson, 1985; Sun and Dickinson, 1997; Whitbread *et al*, 2003).

***Khaya senegalensis*, African mahogany**

The characteristics that make this tree a prospective species are:

- good drought tolerance
- high termite resistance
- wide soil type adaptability
- wide pH tolerance
- high value timber
- fast growth rate
- lack of insect pests including tip moth borers (*Hypsipyla robusta*).
- Once established, these trees are robust survivors.

African mahogany has now been widely planted in small plantations across the tropics of northern Australia. There are still some problems to overcome with poor form and phenotypic variability but early indications are that this species has the potential to provide the foundations for a prosperous plantation forestry industry in the low rainfall areas of tropical Australia. It is the opinion of the authors that currently, African mahogany is the only realistic species choice for successful high-value hardwood plantation establishment in the 'dry' tropics of Queensland.

Seedlings

Only nursery stock that is of high quality should be planted; i.e. it is vigorous, but has been sun hardened and drought stressed in preparation for planting out. Drought stressing involves progressively reducing the irrigation frequency to the plants in the nursery to slowly prepare them for tough field conditions. Tender planted seedlings will not cope well, especially if subjected to drying winds, before they have had a chance to establish an adequate, functional root system in the soil.

Only plant-out seedlings that were actively growing in the tubes and not kept for extended periods prior to hardening-off. Seedlings that had been actively growing will establish more quickly than those that have become root bound and will be less likely to have root deformities.

Site Preparation

Similar principles apply to site preparation in the 'dry' tropics as have been developed over time in the wet tropics. However, there are some critical design considerations that separate the two regions. Rainfall is a precious commodity in the dry tropics and can be utilised more efficiently by good site preparation earthworks. The major land use in low rainfall areas has traditionally been grazing. This can lead to soil compaction and problems with moisture infiltration and root penetration.

Ripping and discing the planting the lines can best alleviate soil compaction. To assist with water retention on the site, designing the cultivation lines along the slope contours will help capture runoff and allow it to better infiltrate the soil profile. If there is a known 'hard-pan' in the soil, deep ripping (to a minimum of 600 mm) is essential.

Key line techniques are also very beneficial in harvesting runoff from storm rains. Key line systems involve the construction of a graded rill on the down-slope side of the planting row to guide excess runoff into storage areas or dams. It is important to keep the fall to a minimum (max 2%) on poorly structured soil types to prevent the runoff water from reaching erosive velocities.

If within-row planting distances are considerably less than the inter-row spacing (eg widely spaced lines of 5 metres or over), align the planting rows approximately east-west. This improves the shading effect of the tree crowns on the ground around the base of the trees, reducing soil and root collar temperature at the base of the tree (and reduces the possibility of sun-scorch).

Following initial ripping and discing, the site should not be planted until it has received enough rain to allow the soil to consolidate and finer particles to fill underground air pockets. These air pockets can cause roots to dry out and result in poor growth rates or seedling deaths requiring expensive replanting. This effect can also be achieved by applying **irrigation** water prior to planting.

Planting

When ordering seedlings, arrange for them to be ready for planting-out with the wet season or storm rains. This will increase survival rates and help seedlings establish quickly.

Seedlings should be watered in after planting to ensure the best result, particularly if rains become sporadic.

Frost prone areas are best left until the threat of frost has passed, as many species are susceptible to frost damage when young. Although the trees may recover initially, many long-term problems can result from frost damage. These patches should be planted with frost tolerant species or avoided altogether. However, once successfully established with a tree canopy, many frost patches may disappear.

Care should be taken when transporting young seedlings for long distances over rough tracks. Root shearing can occur through excessive jarring which results in lateral roots being severed from the main tap root. To guard against root shearing, some type of cushioning material should be placed under the plant trays during transportation.

Spacing

For some species under certain environmental conditions, initial spacing is important. There is often a trade-off: (1) Planting at closer spacing with higher seedling and establishment costs and a more intense initial thin to waste (see the section on Pruning/thinning below) but lower weeding costs and earlier 'canopy closure' *versus* (2) wider spacing, lower seedling and establishment costs but higher and more prolonged weeding period with a later canopy closure. Whether irrigation is provided can also affect the decision on wide or close spacing (it costs more with closer spacings if fixed sprinklers or emitters are used).

In cattle country, there may be a decision needed on whether to run cattle under the trees. In a forestry only scenario, where maximising the value of the trees for timber may be deemed the primary business for the site, close spacing and intensive management to keep the trees 'on the boil' by judicious thinning and virtually total weed and grass control may be the management system adopted (although cattle may be introduced at various times to control and maintain a minimal ground cover). Where cattle production under trees may be deemed the primary business for a site, 'high value' timber production may be secondary and trees may be planted at wide spacing and maintained at such (through heavier thinning) to encourage good grass growth. This grass will compete with the trees therefore the trees will not grow as well under these conditions.

Generally cattle have to be kept out of all young planted areas, until the trees can withstand breakage and be no longer subject to trampling, and at other times when overgrazing and compaction of the soil may occur.

Some tree species have naturally good form, with straight boles and light, even branching. These trees may be planted at wide spacing as form is not compromised by being 'open-grown'. Other species may suffer from weak apical dominance and poor form where there is strong side light. These species are best planted at close spacing, to reduce the side light which in turn encourages the apical shoot to grow vertically and reduce lateral bud development onto branches. Pruning and thinning can be particularly critical for these species.

The effects of too-wide spacing on these latter species can be devastating on subsequent tree form and although tree boles may straighten with time (by diameter growth 'filling in the bends'), the development of reaction wood (tension wood and compression wood) may result in poor quality timber.

Mulching

Mulching can be time consuming and expensive, but in low rainfall areas it is highly beneficial for young seedlings and larger trees alike. Mulch helps to insulate the soil surface, retain soil moisture and restrict water loss through evaporation. It reduces reflected sunlight, which can stress young seedlings, suppresses weed growth around irrigated trees, reduces storm erosion & increases irrigation efficiency. If a management decision is made to retain grass between tree rows (see Weed Control below), it may be decided to slash it in early years, and a side throw slasher can be used to throw the slashed grass along the planting row. This is a cheap and effective method of mulching.

Weed control

Soil moisture is critical for plant growth and must be preserved if satisfactory growth rates are to be maintained. Unwanted grass around young trees will severely retard growth rates by out-competing the trees for available moisture. With scant water available to trees in this region, it makes no sense to allow it to be taken up by grasses and woody weeds. In addition, a number of the species suited to the 'dry' tropics (African mahogany, lemon-scented gum) have very narrow canopies when young and hence have difficulty shading-out competing weeds.

Herbicide application is required pre-planting and usually twice per annum for a few years after planting. This can depend on other factors including the weed spectrum on the site and rainfall frequency. Both pre-emergent and knock-down herbicides are commonly used, often in combination. A new range of grass-selective or broad-leaf-selective herbicides are also becoming more commonly used and offer the plantation manager greater flexibility. If the plantation is being irrigated, herbicide application may be required more often around trees where moisture levels are higher.

Fire danger risk is a constant threat that must be managed. Regular slashing of the inter-row spaces is required to reduce grass height and woody weed encroachment. Maintaining 10 metre wide, slashed fire breaks (devoid of the dead grass) around the perimeter of the plantation is essential.

Irrigation

Whether to irrigate or not is a vexed question but one that must be considered in low rainfall areas. The cost of irrigation has to be weighed up with projected returns from the plantation products. Given the low cost of land in drier areas it can be a strong compensating factor for the higher establishment and maintenance costs. Young trees can achieve more predictable growth rates with irrigation and unstressed trees are less prone to insect attack. Correct scheduling is important in reducing costs and increasing the efficiency of the system.

Efficient irrigation scheduling aims to match the delivery of water to meet the seasonal growing needs of the trees. Dry zone species are genetically predisposed to a dry season. Therefore irrigation should best be considered as extending the annual growing season, but not in completely removing a drier

period. Applying excessive amounts of water is an unnecessary expense and also increases weed control requirements. An even annual growth can also reduce the 'figure' and hence the value of timbers that need variable seasonal growth to produce it.

There are numerous types of irrigation systems available for commercial use but only a few are recommended for forestry. All have limitations and often eventuate in a compromise between what works best and what costs less. Drip systems are recommended as the most water efficient.

Spray systems cover a larger area but have several problems in that they:

- Lose a lot of water through evaporation;
- Encourage surface root development;
- Promote competitive grass and other weed growth;
- Are regularly blocked by ants;
- Encourage browsing animals that may damage trees;
- Require more water pressure resulting in higher cost of pipes, pumps and fittings;
- Are prone to damage from browsing animals (chewing off risers).

And:

- Water does not penetrate deep into the profile.

Drip systems are also susceptible to blockages but regular preventative maintenance can reduce this problem. The advantages of drip systems are:

- Minimum losses through evaporation;
- Water permeates deeper into the soil profile;
- Cheaper to establish and operate;

And they:

- Do not stimulate grass growth;
- Require low pressure to operate;
- Encourage deeper root growth and drought tolerance.

Water quality problems are common with irrigation systems in western areas. The build up of calcium carbonate and other accumulative salts can restrict the flow of emitters and eventually block them. Chemicals are available to flush the lines and dissolve these deposits and are required periodically to ensure the efficiency and long life of the system.

'T Tape' is a common material used and applies water along the planting row. Its main benefit lies in the cost and ease of application. Lateral lines should be laid along the soil surface for ease of maintenance. High day / night temperature fluctuations are a feature of the dry tropics. Elastic anchor straps such as old bicycle tubes attached to stakes driven into the ground at the end of the lines offer some flexibility during extreme temperature fluctuations. The poly pipe will contract considerably during the cold nights and expand during the hot daytime temperatures. The elastic straps will pull the line back into position and maintain correct alignment. This method is not recommended for contour plantings however.

As stated earlier, scheduling of irrigation should not be a hit and miss affair but balance the needs of the trees in peak growing periods. It is also not advisable to over-water and make the trees totally dependent on irrigation for their survival. The decision to irrigate or not should be made based on historical rainfall and temperature records. The frequency of prolonged drought or erratic weather patterns can cause major problems in meeting projected growth rates and investment returns. When researching rainfall records for a particular region, the focus should not be on the annual rainfall total but its distribution pattern throughout the year.

Fertilising

Fertilising at the time of planting is highly beneficial. Fertiliser application in low rainfall areas is similar to that of the wet tropics except for a few considerations. Applying granular fertiliser to the soil surface can be very inefficient unless it is closely followed by good rainfall. It is more advisable to apply the fertiliser sub surface to extend its life and deliver optimum benefit to the plant Irrigation systems designed with 'fertigation' capability can supply a low, metered dosage of fertiliser on a regular basis to match the seasonal growth needs of the trees. It can be quickly and easily adjusted and once installed, is also the cheapest method of application as no additional labour or machinery is required. The type of fertiliser required varies from site to site. Soil analysis will reveal the most appropriate blend required to address nutrient imbalances in the soil and best supply the nutritional needs of the particular species of tree in the plantation.

Thinning / Pruning

Consideration of the final plantation timber product is vital when determining the initial stocking rate and any subsequent thinning operations throughout the rotation (see also the section on spacing above). Thinning is necessary in any timber plantation to select the better trees and reduce competition for available nutrients, light and moisture. This becomes much more important in low rainfall areas where soil nutrition may be poorer and soil water availability much lower. With limited site resources (primarily moisture, light and nutrients) only a small number of trees (generally 100-300 trees/ha) have any chance of reaching merchantable sizes in an acceptable rotation length (< 35 years).

> Original planting densities depend on several factors including the tree species involved and genetic quality of the planting stock. With species such as African mahogany, there is still much work to be done with selecting the best provenance for the low rainfall areas of northern Australia. To overcome this factor, the trees are planted at a stocking rate of around 1000 per ha. (spacing 4.0 m. x 2.5 m or 3.0 x 3.0 m). This provides a greater opportunity to cull trees of poor form and retain the better trees. Close spacing also reduces branch size and competition in the crown with the leader. This translates to lower pruning costs. Thinning operations should not be delayed as unwanted trees will be consuming vital resources.

Form pruning may be a necessary activity with a number of commercial species. Form pruning is 'additional' pruning done in the first few years after establishment to remove 'wayward' shoots that may lead to heavy low branching and loss of single apical dominance.

Stems to be pruned or thinned are usually marked first so that changes can be made before an irreversible action. The first 'normal' prune is usually done to all stems that are not going to be felled at the first thinning (usually a thin-to-waste). This is usually done at least one year before the first thin-to-waste and is done to a height of 2 metres above ground, using a hand held pruning saw. It should be noted that, except for form pruning, the first pruning need not be done until most stems have reached a diameter at breast height of about 7 cm and the trees are of a minimum height of 4 to 5 m. Branch wood (as long as it is not loose or decayed) within this 7 cm core is of no consequence to the sawing quality or to the eventual value of the commercially harvested log.

Pruning is necessary to remove lateral branches to encourage clear wood development and maximise sawn timber value. It is usually done in two to three stages to a total of about 6 m in height (the final prune being only done to trees marked as final or late-thinning crop). It should be carried out after trees have recovered from any adverse growing conditions so that they are actively growing. A high prune (5 metres and above) is usually specialist work, this is hard work and requires acquired skills and a specially adapted (or purchased) ladder to be done successfully.

Pruning should **not** be done just prior to, or after (within one year either side of) a thinning. The extra light entering the forest stand after a thinning will promote the development of latent buds in the axils of the cut-off branches (and this may even negate the effort and cost of the prune). Pruning carried out immediately before a thinning may put additional stress on the remaining trees by having had crown removed at the same time as an increase in light, and thus they may not be able to take immediate advantage of the additional light. Both thinning and pruning put immediate but temporary stresses on trees. To ensure the trees are not unduly stressed, no more than one third to one half of the depth of the crown should be removed at any one time.

Summary

The 'dry' tropics of northern Australia are the new frontier for plantation forestry. Increasing environmental pressures from urban sprawl and agricultural development on the wet tropics coastal strip has limited opportunities for additional forestry development in that region.

Research into commercial timber species suitable for the 'dry' tropics has identified African mahogany (*Khaya senegalensis*) as a potential high value cabinet timber species suitable for large-scale plantation development. African mahogany may be able to produce commercial returns in as little as 20 years. This time frame makes it an attractive proposition for investors.

There is an abundance of land suitable for forestry purposes across the dry tropics region of northern Australia. For a successful forestry industry to exist and supply domestic and export markets, it must be able to develop a critical mass of resource. Suitable land is available to develop this critical mass in large areas of northern Australia. These areas are currently under utilised and could be used for alternative and sustainable industry opportunities.

Incentive mechanisms are urgently needed to publicise the potential of the industry and attract public and institutional investment in plantation development. The economic, environmental and social benefits of this industry to northern Australia should not be underestimated.

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