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Workshop on

PROSPECTS FOR HIGH-VALUE HARDWOOD TIMBER PLANTATIONS IN THE "DRY" TROPICS OF NORTHERN AUSTRALIA

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Towards a viable high-value hardwood (HVH) industry for northern Australia: some strategic issues for planning and management.

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Abstract

Key words: *northern Australia development, economic development, niche marketing, efficiency, vertical integration, critical mass, risk management, civil society, policy and regulation, research and development*

Economic development of northern Australia has been characterised by high optimism, grand schemes, some successes, spectacular failures and inconsistent government policies. Forestry has not escaped the pattern. However some traditional industries, notably mining, sugar, beef and fisheries have survived the vicissitudes of climate, war, pestilence, economic downturn, markets and public confidence to a greater or lesser extent through adoption of coping strategies and by paying attention to the technical base of their industry, innovation, astute marketing and "cutting their cloth to suit their means". Burgeoning but as yet small, new, resource-based industries *eg* tropical fruits, aquaculture and pearling, are following a similar path, but these are also working assiduously in niche markets to assure their long term future. Emerging service industries in education and tourism are also in the business of niche marketing and the defence industry is of course the ultimate expression of this.

A successful HVH industry in northern Australia will also need to embrace an effective niche marketing strategy, domestic and international. However this will require underpinning by

- a technically proficient and efficient, vertically integrated production chain of sufficient critical mass supported by adequate risk management strategies,
- industry organisation and development ensuring smooth and predictable movement of sufficient HV product into the market to be economically attractive,
- careful attention to social imperatives and community expectations so that there is long term civil society backing for the industry, and
- careful attention to government policy and regulatory frameworks - local, state, national and international - to assure long-term government support.

"…the British Colonial Secretary, Earl Grey, enquired of the newly incorporated India and Australia Steam Packet Company whether there were any proposals by the Company to use Port Essington as a refuelling depot or if they had reason to believe that it could be of importance to shipping. The death knell for Victoria was sounded when the Shipping Company answered that the settlement lay right out of the way of the proposed route and the Company had no intentions of using it either for refuelling of for any other purpose. There now appeared no valid reason for the maintenance of the lonely outpost on the northern Australian coast and the final order was given for the withdrawal of the Royal Marines from Victoria." Peter Spillett 1972, on the abandonment of Port Essington in 1848.

"…that extreme northern country of ours, which we have called by courtesy the Northern Territory, but too often, with bitterness, our White Elephant, is a rich possession which other colonies well might envy us." but "*…without a railway I cannot see how the Territory will be a good field for enterprise. Without it must remain almost in statu quo.*" William Sowden 1882.

"Listen – this country's been settled donkey's years, and has had all the chances of development that the rest has. Yet today there's less people here and less business doin' than there was fifty years ago. Why's that? I'll tell you. It's because it's an utterly useless land. You can't grow nuthen properly on account of the climate." Andy, *in* Capricornia, Xavier Herbert 1938.

"…in little developed areas …where land development experience is limited and adaptation of methods of land use has not proceeded very far, it is not always easy at the initial appraisal to recognise all of the factors which may limit productivity or those which are likely to remain limiting. Nor is it possible to predict how the particular assemblage of factors composing the environment will interact to influence potentialities." C S Christian 1959

"…a large section of the Australian public has realized that intensive agricultural and pastoral development in tropical Australia could only be carried out by neglecting more profitable forms of development in other parts of the continent. Northern development schemes are approached more critically and the alleged secondary benefits in the form of axillary industries and an improved defence position are no longer taken for granted. The probability that agricultural development in tropical Australia will be carried out on an economic basis really depends on the level of public knowledge of the subject and on whether the Australian people wish to see the nations resources used as efficiently as possible or simply desire a particular type of development in certain parts of the continent." Bruce Davidson 1966.

"…the development of forestry in the Top End of the Northern Territory has conformed to the general pattern of European rural development projects in this region. With the possible and partial exception of mining, these development projects have failed because Europeans have lacked the ability to realistically appraise the Top End environment." Christopher Lacey 1979.

Introduction

The quotes at the head of this paper, while targeting the Northern Territory, illustrate long-held attitudes to development of northern Australia and encapsulate the perceptions of the major constraints inhibiting its development:

- a harsh and unforgiving physical environment
- social isolation from a more populous and “go-ahead” south
- scarcity of infrastructure and services
- poor and costly market access
- limited skilled labour at an economic price
- restricted land tenure and access
- inconsistent government development policies

Attitudes of governments to northern development from the time of the first settlement at Fort Dundas on Melville Island in 1824 to the aftermath of Cyclone Tracey in 1974 have been ambivalent and wildly varying in enthusiasm and this is reflected historically in public policy towards defence, investment in infrastructure, provision of services and rural research & development activity. The decision to rebuild Darwin post-Tracey was probably the trigger that has led to improved regional infrastructure and increased public investment over the last 30 years culminating in the establishment of a significant permanent defence presence and recent completion of the standard gauge Ghan Railway linking Darwin to southern Australia. As early as 1882, William Sowden acknowledged that this rail link would be essential if northern development had any hope of being other than a pipedream (Sowden 1882). Even so, this latest brave venture has its detractors on economic grounds.

Darwin has emerged as the epicentre for northern development, with its base now set firmly on defence, tourism and education *ie* other than natural resource-based industries. These provide an economic and social buffer, creating opportunities for development of resource-based industries and their trade in a manner inconceivable in the past. In this regard, Townsville (also based essentially on defence, tourism and education, and additionally with mineral processing) and Cairns (still dependent on sugar but with a strong tourism sector) provide similar functions for the eastern edge of the tropical region. All three enjoy entrepot status facilitating movement of exports – potentially important for High Value Hardwood (HVH) development.

Provision of improved transport corridors between Darwin and Adelaide, Townsville and Perth, and to southeastern Australia including by the mooted inland railway from Mt Isa can only further strengthen the potential for resource-based development of this region. Hopefully northern Australia is now on the cusp of an economic and social development which will see the shibboleths of the past which together pronounced the region as incapable of economic development, laid to rest – a hostile environment, social isolation, high costs, poor infrastructure, lack of skilled labour, poor access to markets, and lack of political will and commitment.

Government policy for northern Australia - federal, state and territory - has improved infrastructure and services (I&S) including research and development (R&D) as a public good or through incentive arrangements with the private sector *eg* in telecommunications and mining railways. Developing production sectors are major beneficiaries of these goods and services and therefore are expected to make a financial contribution to I&S upkeep from their economic activities; public infrastructure will only be maintained and retained by governments for as long as it provides a positive return to public investment, in aggregate financial and social terms. Alternative models are predicated on accessing private enterprise- provided infrastructure (eg telecommunications) or private/public sector partnerships (airports, railways, R&D). In such cases costs to users are more likely to be higher because of the necessity to return a profit on investment to shareholders. In a free economy, resourced-based developments therefore must be efficient economically, enabling them to contribute effectively to the long-term viability of the totality of public I&S through taxes and charges without recourse to subsidy. The pressure is therefore on new enterprises and industries in developing regions to pay their way sooner rather than later if they expect long-term access to a steadily improving infrastructure and services essential to their viability.

The imperatives and incentives for the developing HVH industry lie in ensuring the long-term presence of the infrastructure and community services upon which it depends at a level commensurate with its needs and expectations. This demands that in its totality the enterprise is economically viable so that it can cover the costs of providing the infrastructure and services it uses. In order to achieve this, industry must plan its strategies and operations so that it is optimally efficient and effective across the breadth and depth of its operations. Vertical and horizontal integration is one enabling strategy that might be adopted. The industry must also be cognisant of constraining issues arising from the regulatory frameworks and civil society in which it operates and plan its activities accordingly.

The major factors for consideration can be listed as follows:

- ***policy and regulatory frameworks:*** assuring coherence with planning requirements and legal obligations at local, state/territory, national and international levels
- ***community acceptance:*** resolving community issues relating to the environment, land tenure and management, siting and extent of plantings, species and silviculture
- ***marketing:*** addressing fitness of product for purpose, market niche, market range, product volume and value, accessing market outlets
- ***operations:*** establishing vertical integration and locating processing plants *vis a vis* plantings; and managing risk associated with the long-term gestation period of the enterprise and tree rotation length; accessing transport infrastructure and skilled labour; involving aboriginal communities in the venture
- ***technology:*** applying know-how and skills for production of raw material and its conversion and processing to high-value product, and supporting R&D for both.

I would suggest that these factors are in the rank order of importance for the success of any HVH industry. This may not accord with more conventional perceptions but I firmly believe that unless the policy settings are right and community support is forthcoming, no amount of technical expertise or operational efficiency will compensate for lack of convergence on the policy and societal fronts or for market inefficiency. Of course it is essential to have all the settings of these five pillars of enterprise interacting in a fully effective manner; the chain is only as strong as its weakest link and during the holistic planning of the HVH enterprise due regard must be accorded to each and to their interaction. Factors inhibiting resource-based enterprise development these days are more likely to be socio-political rather than technical; this is very evident in the wood-based industries. For better or worse, the days of unplanned development on both public and private lands are over. It is no longer possible to operate in isolation from all but the immediacy of getting on with the relatively straight forward task of developing and applying technical know-how to achieve some physical reality (plantation established or mill operational).

This paper will explore the issues impinging on these strategic factors affecting HVH development. In doing this however, I am cognisant of technical thrust of this Workshop so will attempt to provide only sufficient insight into the higher order issues to provide a context for the technical discussions.

Policy and Regulatory Frameworks

Government policy and regulation impinge on HVH industry development at international, state and local levels. It is important that industry be aware of the policy framework within which it must operate and just as importantly be in a position to influence governments as they develop policies that impact on the industry. With four governments at federal/state level plus several local governments involved in policy and regulation, policy coherence and convergence become significant factors in the success of any enterprise, particularly given the nature and level of constraints operating in northern Australia.

At the *international level* the Australian Government is a treaty party to several multilateral agreements that affect both the growing of plantations and marketing of processed products. Among those of most immediacy are:

The Convention on Biological Diversity 1993 (CBD): The CBD provides the international legal and policy framework for management of genetic resources (GR). Its objectives are the conservation of biodiversity, the sustainable use of its components and the equitable sharing of the benefits from their use. The CBD recognises the sovereign rights of states over their indigenous genetic resources; it requires those wishing to gain access to them to do so under mutually agreed terms with the state of origin of the GR and with their prior informed consent. It is also necessary to enter into an equitable benefit sharing arrangement while respecting farmers' rights and indigenous knowledge in the country of origin (see Hawksworth, Kirk & Clarke (1997) and Lesser (1998) for extensive discussion of the CBD provisions and its implications).

How does this affect HVH development in northern Australia? Tree breeding programmes with exotic HVH species require access to genetic resources; while the current initial breeding efforts are based on material introduced to Australia prior to the coming into force of the CBD in 1993, the introduction of new material from countries of origin or third parties will be desirable in order to meet longer term strategies for tree improvement. As such introductions will be subject to CBD provisions, it will be necessary for breeding programmes to plan their strategies accordingly and open communications with targeted providers sooner rather than later to determine the basis of, and indeed agreement for, any such introductions. The biodiversity conservation provisions flow through to state and territory environmental impact management legislation and significantly affect development of "greenfield" sites for plantations, particularly for those of exotic species.

Intellectual property: As tree improvement programmes gather pace it is highly probable that at some stage there will be a need to protect the intellectual property encapsulated in developed genetic lines and cultivars. This may be necessary for protection from potential market competitors both within Australia and overseas as the impetus for HVH plantations develops. The two forms of intellectual property applicable to improved genetic resources are plant breeders' rights (PBR) covered by UPOV (the International Union for the Protection of New Varieties of Plant) and patents covered by TRIPS (Trade Related Intellectual Property Rights) within the World Trade Organization (WTO). The PBR Office in the Australian Department of Agriculture, Fisheries and Forestry (DAFF) administers the national PBR legislation (Plant Variety Rights Act 1987 and PBR Act 1994). The TRIPS Agreement is managed by IP Australia, an autonomous agency within the Department of Industry Tourism and Resources.

The criteria for IP protection under these schemes are complex but the essentials are (Bevege 2001):

- IPR refer to the intangible content of goods or to processes, not to the goods themselves
- Ownership of IP is temporary – up to 20 years for patents, 20-25 years for PBR – while ownership of goods and products is perpetual
- Neither PBR nor patents confer ownership of products
- IPR can be exercised only in countries where title has been granted, which presupposes an IPR legislative regime
- PBRs generally confer less protection than patents but are cheaper and generally quicker to obtain
- Patents require demonstration of novelty, non-obviousness and utility, whereas PBR criteria demand distinctness, uniformity and stability.

If the broad strategy of an emerging northern Australian HVH industry is to service niche markets, that presupposes the intrinsic worth of the product is encapsulated in its specialised nature and only available from a restricted number of suppliers (combined growers and processors). IP protection at appropriate points along the production chain is therefore a natural corollary to any HVH strategy; the industry may also wish to access know-how from others, particularly in processing, so again IP aspects become significant.

Necessary R&D inputs also will require working in contractual partnership with R&D providers who are now well inured to application of IPR provisions in research contracts. All this means that the industry must accept the need for IP management and its attendant costs from the outset and plan accordingly; consortia and industry associations are one possible strategy to facilitate this bearing in mind the Trade Practices Act. However Australia's strong government policy on IPR will work in favour of the industry provided it takes the initiative.

Quarantine: Developing a new HVH industry based on exotic species raises issues of crop protection from insect and pathogen attack *eg* insects such as *Hypsipyla* are of particular concern to the Meliaceae (including *Khaya* and *Chukrasia*) while *Tectona* (teak) is host to a plethora of insect and fungal diseases (White 1991), primary concern being with the leaf skeletoniser *Hyblaea puera*. Quarantine therefore works at two levels – preventing the introduction of new attack organisms and facilitating the movement of insect and disease-free products into premium markets or in the exchange of propagating material.

Biosecurity Australia within DAFF is responsible for administration of quarantine in Australia (DAFF 2004). The enabling international arrangement is the WTO Agreement on the Application of Sanitary and Phytosanitary Measures 1995, the plant material standards for which are found in the FAO International Plant Protection Convention (IPPC). The Australian Quarantine and Inspection Service (AQIS) has direct contact points in far north Queensland, Northern Territory and Western Australia. With three major ports of entry (Darwin, Cairns and Townsville) and several minor ports (Broome, Port Hedland, Weipa, Cooktown) the north is particularly vulnerable to entry of pests, diseases and alien species as potential weeds. The North Australian Quarantine Strategy (NAQS) aims at excluding pests, diseases and alien species from Asian-Pacific countries and focuses on issues affecting the region from Townsville to Broome. Current emphases within NAQS of potential significance to HVH development and native tree species are polyphagous insects, wood-borers and rusts, many of which attack either woody perennials currently under horticultural development in tropical Australia (including mango, coffee and citrus) or endemic flora (Myrtaceae, Casuarinaceae, Rutaceae).

At the *national level* the main policy/regulatory institutions concern taxation, farm forestry incentives, export incentives and R&D arrangements; the last three also spill over into the state arena. As these are areas with which promoters of a HVH industry will be familiar, this paper will address only briefly the salient issues to complete the picture. DAFF (2004) and Australian Forest Growers Farm Forest Line (AFG 2004) should be consulted for details.

Taxation: The aspects relevant to plantation and farm forestry investments relate to the recognition of tree growers as primary producers and their access to the tax averaging provisions relating to growing costs and income from sale of trees. Taxation is also linked to R&D through the provision of the R&D investment taxation incentives aimed at encouraging industry investment in R&D. While not particularly robust instruments, the combined effects of these measures currently provide a positive taxation environment for investment in HVH. Whether they will continue to do so several decades hence when current planting initiatives reach harvestable age remains a moot point.

Planting Incentives: Australian Government financial support is provided *via* the National Heritage Trust Farm Forestry Program (FFP) that encourages commercial tree growing in agricultural systems in order to fulfil its policy objectives for sustainable resource management through environmental benefits, regional development and employment (DAFF 2004).

A complementary DAFF program is the Joint Venture Agroforestry Program administered through the Rural Industries R&D Corporation (RIRDC); this provides research and policy development support for agroforestry, including in northern Australia (Turvey and Larsen 2001, Bristow 2004). Other cost-sharing arrangements for planting operate at state level but these might be offset by regulatory constraints in the environmental sphere.

Export Incentives: Australian Government support is provided through Austrade and the Export Finance and Insurance Corporation (EFIC). Austrade has a number of linked programmes including Tradewatch (essentially an information service on export opportunities and markets), New Exporter Development Program (NEDP) and the Export Markets Development Grants Scheme (EMDG). The three state government agencies relevant to tropical HVH development – Queensland Trade, Northern Territory Department of Business Industry and Resource Development (DBIRD) and Western Australia Department of Industry and Resources – all have trade support schemes promoting exports. While it is too early for the HVH industry to access these schemes in any meaningful way (as processing will not start for some years), it should remain aware of possibilities in this area and provide input to federal and state government policies as they evolve to ensure that there is policy coherence among these four governments that promotes a truly national approach to export development opportunities for this new industry.

Research and Development: In the context of rural development, infrastructure and services also include R&D and technical information generation services; these may be regarded as providing public goods (*eg* as provided by state departments of agriculture and forestry undertaking public-benefit research), public corporation (eg CSIRO or university consultancy services) or private corporation (agricultural services companies and consultant extension providers). The ‘user pays’ principle is now an established norm for R&D services even where provided by governments; the public pays through taxation for public benefit research and industry users pay through contractual arrangements where they capture the benefits (including the intellectual property). There are mixed modes with mixed funding where the benefits can be partitioned between the community and private users. In the early stages of industry development such as HVH is currently experiencing, a case can be made for both public and private benefit R&D; the key question as always is – who captures the benefits? What this implies is that the currently small band of HVH protagonists - a mix of private growers, entrepreneurs, private foresters and government-employed scientists - will need to organise in a way that maximises their advantage in accessing both public and private research funds, including the investments of their individual interest groups.

The institutional and organisational arrangements for rural R&D currently in place are many and varied and technically would adequately fulfil the needs for HVH R&D. These include the relevant state R&D agencies, CSIRO, universities, Cooperative Research Centres (CRCs) and R&D Corporations. There are numerous cross-linkages given the organisational nature of CRCs (CRC 2004) and potential for even more through the R&D Corporations (DAFF 2004). These R&D providers are potentially valuable to the HVH industry for generating R&D programmes with medium time horizons provided that research investment funds can be raised to meet the industry contribution.

Currently there is limited state/territory government investment in forestry R&D through DBIRD and Queensland Department of Primary Industries and Fisheries (QDPI&F) and the Commonwealth through the National Heritage Trust FFP and RIRDC. However there is no visible presence of the national public research body CSIRO although the recent announcement of planned increased investment at Cooroy in southern Queensland for research into tropical plantations in collaboration with state agencies might change this (CSIRO 2004). Some corporate funds have been forthcoming *eg* Sylvatech’s joint venture with Tiwi Land Council on Melville Island and there are small private investments by enthusiastic individual private growers in the Northern Territory and Queensland and the Private Forestry North Queensland Association.

It is important that government and private investors be convinced that this industry has potential for a strong economic future, with sharp focus on high value production for elite domestic markets and for exports. Necessary conditions for increased R&D investment will be:

- unity and common purpose of stakeholders
- evidence of considered goals and strategies
- robust industry promotion to government
- formal organisation of industry stakeholders, growers and potential processors
- strong representation to R&D funders and providers.

These efforts will need to be supported by strong documented "proof of concept" and estimates of economic returns. This effort will be a major challenge at least until more technical milestones are reached; hopefully this Workshop will further that end. The establishment of an industry association backing moves to establish a public/private consortium of vested interests to underwrite R&D, and possibly even to create a CRC for HVH under the next round of applications when called by the Commonwealth Department of Education, Science and Training, may be initiatives worth consideration.

At the *state/territory and government level* policy and regulatory frameworks of significance to HVH plantings relate mainly to land management, conservation and operation siting issues. The main issues of planning relevance are:

- ***land use planning*** - including location of plantations *vis a vis* traditional agriculture and siting of processing plants vis a vis pollution, noise and urban amenity
- ***environmental impact*** - including modifying of native vegetation on greenfield sites, biodiversity conservation/management and water conservation
- ***agricultural chemicals*** – herbicides, pesticides and fertilisers and pollution, eutrophication and residue issues relating to health and biodiversity of non-target species
- management of ***weeds and potential weediness*** of alien HVH tree species
- ***resource tenure*** issues separating ownership of trees from land tenure
- ***transport access and maintenance*** - mainly a local government issue particularly with roads)
- ***fire protection*** - issues of scale of operation, siting and risk *vis a vis* other land use, protection strategies including prescribed burning and associated biodiversity issues
- ***harvesting plans and operations*** - though possibly less of an issue with plantations compared to native forests the precedents have been set elsewhere

These are areas where there is considerable potential for regulatory disjunction among state and local governments due to lack of policy coherence among them including lack of policy *per se*. Policy incoherence among governments can only add to costs and create inefficiencies for a developing HVH industry establishing itself on a broad regional front across jurisdictions. Such conflict may not be so apparent at the present time in many parts of northern Australia because of general lack of development pressure and indeed even of awareness of the issues. Government policy positions in response are necessarily still evolving; however the trends have been set elsewhere in Australia where development pressures are greater and it is only a matter of time before these pressures will be felt in the rural north; they are already in evidence on the more closely settled coast of north Queensland. Given the long-term gestation period of any HVH industry, it might find itself inadvertently caught in a web of regulation unpredictable in the time horizon of current planning. Identifying and managing risk associated with these complicating issues must therefore be a key strategy to minimise any potentially adverse affects on the economic development of a viable HVH industry.

Community Acceptance

A paradox of modern society is that while the general community is increasingly alienated from the governments they elect at all levels and feel impotent in the policy making process, the avenues for debate on government policies and community consultation probably have never been greater. This is a global, not just a local phenomenon. However, there is also a perception that special-interest groups professing to represent "civil society" have captured the debate and consultative process and marginalised the "silent majority". These interest groups now *de facto* share the fourth estate with the media and both feed off each other in a mutually reinforcing way creating deviation-amplifying loops that capture the attention of governments, particularly if they are positioned to determine through the ballot box the make up of governments and the policy directions they subsequently take. As a result, policy change through time tends to reflect the interests of these groups. The definition of democracy as being rule by pressure groups has never appeared more real than in Australian society today. This current social environment makes it imperative that a developing HVH industry pays attention to community concerns and how these are being articulated through influential pressure groups; industry however must also be pro-active to ensure emergence of a balanced view that ultimately influences the directions government policy will take.

Plantations: Of prime concern is an antipathy to plantations, especially of exotic species. This is not an issue solely for so-called urban elites with biodiversity concerns and a "deep-ecology" mantra; some farming communities as well are taking exception to what they perceive as negative changes to aesthetic values of rural landscapes, competition for land and water resources, herbicide hazard, reduced rural employment opportunities and increased fire protection and weed problems. Whether these perceptions mirror reality is beside the point - state and local government responses are reflected in the increasingly restrictive policy environment in which plantations can operate. In a classic case of policy incoherence between tiers of government, paradoxically these moves are taking place while the Common-wealth Government is promoting plantation development to fulfil environmental management and regional development objectives through its plantation strategy initiated in 1997 and the associated NHT Farm Forestry Program (DAFF 2004). This strategy, *Plantations for Australia: The 2020 Vision*, was recently confirmed, though with some proposed modifications, by a Senate Enquiry (Senate 2004).

How might the HVH industry respond? By identifying the basis of any specific concerns and tailoring its operations to meet them, the response will probably vary in different parts of the region depending on the issues involved, the strength of community concerns and the influence of special-interest groups. It is not a question of "rightness"; it is a question of pragmatically developing strategies that overcome the societal constraints before solutions are imposed by government that may or may not be optimal for the industry. Large-scale broad-acre plantations, farm forestry and agroforestry are non-exclusive options but all demand considerations of location, spatial scale, position and dominance in the landscape, integration with other rural enterprises and least not of all, species and their weediness potential. A major issue will be the extent to which plantations or farm forests may be allowed to be established on green-field sites by clearing or modifying native vegetation; it is highly probable that this option will be foreclosed by state regulations on native vegetation clearing particularly if the target species for planting are exotics. It is more likely that government and community acceptance will be more forthcoming for small-scale plantings confined to existing cleared agricultural and pastoral areas undergoing land-use change or crop diversification. This does not necessarily mean a small-scale industry but it does have implications for the ultimate size and organisation of the industry and the distribution of its wood resource *vis a vis* processing centres and market outlets. It will also be fundamental to establish a critical mass of the resource for economic efficiency and creation of market power.

Greenhouse gases and carbon trading: Should the Kyoto Protocol ever come into force, carbon trading under the Clean Development Mechanism will have the imprimatur of governments and be immensely strengthened thereby as an avenue for investment by plantation-based industries. Even without the Protocol and the consequent lack of a political and institutional framework, a carbon market is developing which some think could be lucrative within a decade (Dadwal 2003). Carbon trading may provide the HVH industry with an investment opportunity although this may be compromised to some extent should short rotations be adopted, but this is not likely if high value quality timber is the goal. Economic considerations aside, possibly of more strategic importance would be the positive community perception should the HVH industry become actively involved in carbon trading as its contribution to the reduction in greenhouse gases. The HVH industry might take account of this in its planning thus garnering community support for its legitimate place in the natural resource management and processing sector of northern Australia's development.

Aboriginal participation: Development of a well organised and structured HVH industry based on numerous small to medium scale individual farm-based or plantation enterprises providing feedstock to strategically located medium-scale processing plants lends itself to significant involvement by aboriginal communities. Three issues of relevance dictate their participation:

- aboriginal communities own most of the land suitable for plantation development in the Northern Territory and have significant holdings in Cape York peninsula and northern West Australia; negotiation with Land Councils for access and long-term tenure under equitable arrangements will be required.

- there is a need to create opportunities for forestry enterprise development including through joint ventures, and employment for aboriginal communities on their lands; Tiwi Land Council on Melville Island has shown the way with its Sylvatech project growing *Acacia mangium* and *Pinus caribaea* plantations.

- where non-aboriginal entrepreneurs adopt farm forestry and agroforestry modes of operation, there will be a need for skilled labour for establishment, silvicultural treatment and harvesting; the pool for this lies potentially in the aboriginal workforce.

It is most unlikely that the HVH industry can be developed technically or economically without aboriginal participation. It may require consideration of joint venture arrangements involving landholders, financiers and entrepreneurs. To be fully effective it will also involve commitment by governments to community development and vocational skills training, and by industry to in-service training along the production chain from growing to processing and marketing. Planning for labour demands cannot be left for later consideration because of the long lead times and significant investment involved in training and provision of the associated infrastructure.

Promoting aboriginal participation will achieve industry's economic objectives and help finesse major risks associated with an uncertain rural labour market. However by going down this logical path the HVH industry will gain further approbation from the wider community because it will be seen to be investing in the future of the aboriginal community in a tangible and hopefully sustainable way; in a sense such a close involvement might also be seen as part of a wider risk management strategy although this is not the prime reason for the initiative.

Marketing

World Trade Patterns: Current world trade in tropical hardwoods is built around export of logs, sawnwood, veneers and ply from producer countries in Africa, Asia Pacific and Latin America to Europe, North America and East Asia, and re-export of manufactured value-added products from the latter regions. In 2002, exports were valued at US$ 7.8 billion at an average unit price of $US 136/m^3 for logs (22%) and around $US 300/m^3 (roundwood equivalent) for sawnwood (34%), veneer and ply (44%) – see Table 1 based on ITTO (2003). The high value of manufactured products however is not reflected in the market price of logs or primary conversion products; hence there is a trend to restrict log exports, process to a more advanced stage locally and then export a higher value product. As a result, the contribution of logs to total exports has fallen from over 60% in the 1980s to less than 40% in 2003 (ITTO 2003). Against this trend, China is limiting its import of processed products and increasing log imports to maximise local value-added processing (Sun *et al* 2004); these log imports have come from Malaysia and Gabon with China now Gabon's main log market.

Log and processed wood exports from tropical countries comprise only 25% of log production; the remainder is processed and consumed domestically (Table 2). The relativity between exports of logs and processed products reflects not only the relative levels of timber processing across the producer regions but also policies restricting log export; Latin America is virtually out of log export concentrating on processed products, Asia exports about twice the level of processed wood as it does logs while in Africa it is the reverse with log export double that of processed wood. However the level of export depends on demand and price so production might readily be switched from local to export markets if opportunities arise. Hence there is considerable potential for exports to increase but this must be seen against the background of increasing availability of plantation material and environmental pressure to reduce unsustainable logging of tropical forests. The major producers are Indonesia, Brazil and Malaysia, exporters Malaysia, Gabon and PNG and importers China, Japan and India; China is the major player in the market and the major market for both Malaysia and Gabon.

The pattern of production and trade in high value tropical wood-based products is confounded by trade statistics which do not differentiate between tropical hardwoods and other species, hardwood and coniferous. However if one considers the totality of the trade and the input of the tropical hardwood feedstock to it, patterns emerge that enable some conclusions to be drawn. Table 3 indicates that the total value globally of exported secondary processed (value-added) products in 2001 was $US 42 billion; tropical hardwood producers contributed only around $US 660 million (1.6%) of this while their exports of logs and primary processed products amounting to $US 7.8 billion, on value-adding, contributed to this overall value-added total of $US 42 billion. Wooden furniture and parts comprise by far the greatest components of the value-added export mix, amounting to 62%; major exporters are the European Union (50%), China (9%) and Canada (8%) and importers again the European Union (40%), USA (33%) and Japan (6%) – see Table 4. It is obvious that cross border trade within the EU accounts for most European trade. There is a high coniferous component to the furniture trade particularly that involving China, EU and Poland. The implication of this pattern is that tropical hardwoods comprise a small but significant proportion of the market and they find their place in this market without difficulty. They have a niche that cannot be filled by the large-scale jobbing coniferous species that provide the bulk of the cheaper end of the furniture market.

Some 84 species of tropical hardwoods are differentiated in international trade, each one of which has its market niche within the spectrum of products indicated in Table 3. Of most interest to north Australia HVH producers are those species that have indicative potential for planting here. They include mahoganies (*Khaya, Swietenia*), teak (*Tectona*), rosewoods (*Pterocarpus*) and cedar (*Cedrela*); there are other tropical species with potential (*Gmelina*, *Chukrasia*, *Terminalia* etc) but these as yet do not feature in international trade, at least not as high value solid wood products. In the future they will be more significant as plantation sourced products.

Table 5 provides production and value data for the export trade in these high value species. (*Note*: these data are for logs and primary processed wood and do not include secondary processed products). Teak is by far the most significant of these species with over 1 million m^3 entering the export trade; material is sourced from native forests in Myanmar and Thailand, plantation material from Cote d'Ivoire, Thailand and PNG. Other species together make up less volume and value than teak. The total size and value of the trade in these species is very small compared to tropical hardwoods as a whole - $US 300 million and a volume of only 1.3 million m^3. Prices, although variable, can be very high – notable highs in 2001 were $US 2413/m^3 for teak from Thailand and $US 1090/m^3 for west African mahogany from Ghana. The variation in plantation wood prices is also evident – sawn American mahogany from natural forests in Bolivia commanded $US 887/m^3 against $US 388/m^3 for plantation-grown sawnwood from Indonesia. Rosewood prices in Myanmar were very low ($US 90/$m^3$), much lower than the global average for tropical hardwoods ($US 136/$m^3$) as against a much better price in PNG ($US 434/$m^3$). What this indicates is that markets are very specialised and prices obtained will depend on many factors not the least being location, quality, parcel size and timing.

Environmental Pressures: Restrictions based on biodiversity conservation considerations are also in train. Philippines has imposed an export ban on logs and products processed from native forests and is introducing certification for plantation species. American mahogany (*Swietenia macrophylla*) now has Convention on International Trade of Endangered Species (CITES) Appendix II listing effective November 2003 to ensure that mahogany exports are legal and sustainable (ITTO 2004); Cameroon has responded by marketing mahogany substitutes but this has attracted concerns from environmental organisations. Africa in general suffers from environmentally demanding export markets that inhibit investment in in-country processing. Moves to Forest Stewardship Council (FSC) Certification have gained apace in response mainly to the European and North American markets and the CITES listing of mahogany; in particular tropical countries in central and south America now have FSC certification for both natural forests and plantations, as do Indonesia, Malaysia and Philippines (FSC 2004).

No certification has yet been issued for tropical natural forests in Africa although plantations are covered in South Africa and Zimbabwe. These moves will create further downward pressure on the future availability of tropical hardwoods sourced from native forests; total log production fell from approximately 144 million m^3 in 2001 to 133 million m^3 in 2003 (ITTO 2003). This trend will probably create upward pressures on prices until significant volumes of plantation material come on stream. Offsetting this, rising prices will encourage illegal logging in native forests and encourage countries not concerned with certification to enter the trade – as both sellers and buyers.

Australia in the Global Market: Australia is a consumer member of ITTO but a miniscule player in the global tropical hardwoods market, hardly rating a pixel on the big screen. In 2002, imports amounted to 405,000 m^3 worth $US 82.6 million; 23% of this was sawnwood and 13% ply (Table 6). Main sawnwood imports are the dipterocarps: the merantis (*Shorea*), seraya and lauan (*Parashorea*) for joinery and building products - and limited quantities of specialty hardwoods including American mahogany and balsa *(Ochroma*). Unit sawnwood prices for dipterocarps are in the higher range of world prices, $US 444 – 620/$m^3$; those for specialty timbers ($US 386/$m^3$) lie in the low-median range (ITTO 2003); an exception is African mahogany (*Khaya ivorensis*) from Ghana which commands a price of around $US 700 (Whitbread *et al* 2003). Exports are limited to sandalwood (*Santalum spp*) harvested from native bush and re-export of small quantities of specialty hardwoods.

In terms of import replacement, hypothetically speaking a 50,000 ha plantation area of tropical hardwoods or 20,000 ha of quality eucalypt plantation could provide this material into the domestic market. With a current hardwood plantation estate of 676,000 ha (DAFF 2004) it should not be too difficult to identify suitable supply areas for most of these requirements. For many end uses there is also potential for softwood substitution particularly with the availability of new generation light organic solvent preservatives (LOSP). Much of the current dipterocarp-supplied joinery/building supplies market was previously met by quality ash eucalypts and native rainforest species; substitution by imports has come about by a combination of price and supply factors including the loss of the rainforest resource to meet conservation policy objectives. However there will always be a niche for the high quality specialty purpose tropical timbers and this is provides an opportunity for the HVH industry in northern Australia to develop a domestic market alongside its export initiatives.

Marketing Australian-grown HVH: The marketing strategy adopted for HVH will dictate the entire structure of the industry; gone are the days when something could be produced in the vague hope of finding or wishful thinking about a market for it. The on going re-structuring of Australian primary industries is a painful reminder of the dangers inherent in such an approach. Given the particular constraints of industry development in northern Australia, it is even more imperative that close attention be paid to market analysis before significant investments are made. This also includes R&D

investments as the nature of the R&D required will be determined by the product objectives and the market in turn will determine them. This is not to say that a mechanistic approach should be adopted – the opposite in fact with clear identification of potential markets and the options available to service them tempered with the reality of unpredictable consumer trends and time horizons.

This brief analysis indicates that there is a steadily reducing supply of tropical hardwoods from traditional sources as against strong and continuing demand in east Asia, Europe and north America. Individual markets have differing needs and preferences with regard to species, product and the form of import – logs, primary processed (first stage conversion) or secondary processed product (manufactured). Cost is also a strong determinant with price of plantation grown material generally but not always lower than that of forest grown – quality considerations are important. The market for much tropical hardwood is also subject to species substitution; the potential for this in Australia has been canvassed briefly above.

The substitution trend can be seen in the switch in the China market from native to Siberian softwood and hardwood and slowing imports of south-east Asian hardwood (Sun *et al* 2004), and in Malaysia and Thailand from native hardwood including teak to plantation rubberwood (Durst *et al* 2004); *eg* rubberwood prices are $US 57/m^3 *cf* meranti US$183 /m^3. This switch has in fact created supply problems for Malaysia in its burgeoning export furniture market as mature rubber plantations, the source of feedstock, are being replaced with the more lucrative oil palm. In response Malaysia has developed *Hevea* clones with strong silvicultural and wood quality attributes and good rubber yields. India is also promoting lesser-used species as rosewood and teak substitutes (ITTO 2003).

There is undoubtedly a strong and continuing global market opportunity for HVH, particularly at the specialty end of the range that will continue to command premium prices (Morell 2001). Plantations will increasingly supply the demand; this has been recognised for some time with many tropical countries embarking on ambitious planting programmes. Latest FAO data (Brown 2000) indicates total plantings in 1995 stood at over 56 million ha (Table 7) and a planting rate of 472,000 ha/an; Evans and Turnbull (2004) indicate this rate had increased to 1.6 million ha/an by 1998. These tropical plantations are relatively young: in 1995 54% of industrial plantations were <15 years old, 28% were between 15-30 years, 16% 30 and 50 years and 2% <50 years. From then to the present, much of this 1995 estate will have been either harvested or be close to rotation age. Since 1995 it is estimated that a further 12 million ha have been established some of which will have been re-establishment of harvested rotation age plantations. Of the 1995 estate, 3.7 million ha comprised the major HVH, 14.6 million ha utility hardwoods, 13.9 million ha other hardwoods and 24 million ha softwoods. Softwood countries with tropical and temperate plantations: Chile, Australia, South Africa and Brazil skew the data; however softwood will compete in global markets with utility hardwoods but not with the HVH, our primary interest.

Table 7 also shows the composition of the tropical plantation estate. Among the HVH, teak is by far the most important species with some 2.2 million ha in 1995 and possibly closer to 3 million ha by now. Teak and American mahogany are the only HVH plantation species currently featuring in international trade; *Dalbergia sissoo* (sisoo rosewood) services the domestic market in south Asia. *Gmelina arborea* (yemane) and *Terminalia* spp are yet to enter the market. Yemane, although a HVH in its own right, has been planted extensively as pulp feedstock; it is however ill adapted to the monsoonal rainfall pattern conditions of northern Australia. Among the utility hardwoods, some eucalypts (*E. urophylla* and its hybrids) and acacias (*A. mangium, A auriculiformis* and hybrids in Malaysia and Indonesia) have potential to provide HVH material and be competitive with other HVH but that depends on the market niche being targeted. Extensive eucalypt plantation programmes in China, Vietnam and Thailand are likely to enter the product substitution arena but are also well positioned to provide limited quantities of high value material into their markets and opportunistically for export.

Positioning Australia in the HVH Market: Where does this place HVH plantations in northern Australia from a marketing perspective? What is the niche that such plantations might successfully exploit? Some criteria to consider are:

- *First*: it will be important to select HVH species for which there is an ongoing demand with potential for developing both a domestic and export market.

- *Second*: species selected need to be truly of high value-added specialty potential so as not to compete with species which are more plastic in market substitution.

- *Third*: species should not compete with those already well established in the global HVH market or that have more strategically located (and therefore less costly) production centres *vis a vis* markets *ie* there must be a demonstrated comparative advantage for local production.

- *Fourth*: growing and processing conditions must be such that the niche products can be produced economically at sufficient scale and critical mass to provide continuity and predictability of supply.

- *Fifth*: production systems must be sustainable and eligible for FSC or Australian Certification; chain of custody processes for certified products must also be in place if access to European and North American, and possibly Japanese markets is desired.

- *Sixth*: product mix should allow for flexibility in production and ability to switch product streams into the market.

- *Seventh*: product must be marketed at competitive prices and the industry must remain competitive as plantation material from elsewhere enters the global market.

- *Eighth*: market access should be hedged by developing multiple clients across a range of products and prices, and by getting clients to commit to long-term contracts or even contribute equity to the project.

- *Ninth*: the industry must be capable of operating and marketing profitably within international trade and domestic policy frameworks.

- *Tenth*: species must be fully adapted and be able to produce at economic growth rates on available soils and under the variation in climatic conditions to be expected during the anticipated rotation period.

- *Eleventh*: species and products should be responsive to technological change to sustain market demand and respond rapidly to changing consumer requirements.

Species with market potential? It is too early to be definitive about which species should comprise a short list for this enterprise because of the limited technical and marketing information available. Considering some of these criteria against the species listed in Tables 5 and 7, the following short list of species might be considered for closer evaluation of their potential: *Khaya* spp (African mahoganies), *Dalbergia* spp (rosewoods), *Pterocarpus* spp (rosewoods), *Cedrela* spp (cedars). *Tectona*, *Swietenia* and *Gmelina* are omitted from this list because the monsoon north lacks comparative advantage *vis a vis* existing producers of these species *eg* 36 countries grow *Tectona grandis* (10 with improvement programmes) and 18 grow *Swietenia macrophylla* (three with improvement programmes) (FAO 2004). They have doubtful biological adaptability to the generally reigning environmental conditions; small suitable areas may not in aggregate provide sufficient critical mass of product to be viable in the market. *Terminalia* is discounted as not being a specialty high-value timber (Keating and Bolza 1982). Eucalypts and acacias are regarded as lesser interest because they are susceptible to market substitution, but they may in turn provide competition for HVH. The emphasis on such native species for agroforestry in the drier parts of the tropics, particularly in Queensland (Turvey and Larsen 2001, Bristow, 2004) should provide environmental services and values as their major function with some utility timber for on-farm use and local markets, but it is unlikely that these plantings will significantly penetrate the HVH market.

The HVH species above all belong to the families Leguminosae, Meliaceae or Verbenaceae. This may not be coincidental. Evaluation might in time be extended with advantage to other lesser-used species (LUS) within these families; the ITTO data base provides useful insights into the place in the market of some 84 tropical species, not all of which meet HVH criteria or are adaptable to the north Australian environment. There are other LUS now being trialed in all producing regions; some are marketed domestically before entering the international market (Tiexiera *et al* 1988, ITTO 2003). There are no known records of these LUS being subject of domestication programmes with the notable exception of *Chukrasia tabularis* (Pinyopusarerk and Kalinganire 2003) but no doubt there is potential for some of them. Australian subtropical *Santalum spicatum* and *S. lanceolatum* already have very small though long-established niche export markets in Asia based on harvesting from native woodlands. Efforts are now being made to domesticate *Santalum* including *S. album*, indigenous (or naturalised?) from coastal north Australia, and boost its export potential (Doran and Turnbull 1997, Done *et al* 2004). The interest in sandalwood is widespread in the Asia-Pacific region (Radomiljac 1998, Robson 2004). Perhaps consideration might also be given to evaluating native species that have specialty purpose HVH characteristics, such as Cooktown ironwood (*Erythrophleum chlorostachys*). Among the LUS low rainfall HVH species (although important locally in southern Africa) is yet another leguminous species Zambesi teak *Baikiaea plurijuga* (Caesalpinoidae) (Piearce 1986) associated with *Pterocarpus antunesii*.

The literature on tropical plantations and hardwoods will however be very helpful in deciding species for trial and developing appropriate silviculture for them (*eg Swietenia* Mayhew and Newton 1998, *Dalbergia* Westley and Roshenko 1994, *Tectona* White 1991; synoptic treatments include Appanah and Weinland 1993 and Evans and Turnbull 2004; soil and water management of tropical plantations are covered by Nambiar and Brown 1997).

Operations

For HVH from northern Australia to be attractive in the market, a critical mass of product must be available at a pre-scheduled rate. Because of the distance of the region from markets, all markets are effectively for export; *eg* Darwin is closer to Singapore than it is to Sydney or Melbourne. However, back loading on the Ghan may provide cheap rail freight rates to Adelaide and thence to the Melbourne market but such concessions are unlikely from Cairns or Townsville to Sydney. Such distant export markets require, in addition to meeting contractual obligations associated with the flow of minimum quantities of products, a minimum shipment size and value to meet logistic constraints and cover freight costs: *eg* consider wood-chip exports as an analogy, where annual export volumes are determined by shipping capacity and turn around times, not by the logistics of bush operations. Shipping logistics and costs in turn are influenced by and influence product type and mix *eg* logs, flitches, sawnwood, veneer, ply or secondary processed products. Hence the overall market access factors are ultimately the drivers of the HVH enterprise; these cascade down into operations and ultimately into processing and plantation management.

The nature of the potential products and the size, location and access to the projected market will therefore be strong determinants of the size, structure, location and spatial distribution of plantings and processing facilities. The more specialised and high value the product and the
firmer its market niche, the higher the price it can command; the corollary to this is that value production takes precedence over volume production. The high potential cost of growing HVH in north Australia also demands a strategy of intensively managing plantings to produce the maximum

quantity of high quality wood per unit of investment; this may or may not equate with maximising value production per unit area depending on land availability and access prices. As growers are most likely to be individual landholders or aboriginal communities with chronic skilled labour shortages, this militates against large broad-acre plantations in favour of smaller compact areas.

Such an intensive production system lends itself to the woodlot and agroforestry. Whitbread e*t al* (2003) reported favourable financial returns to plantations of 10-50 ha with on-farm processing. This operational scale involving several smaller growers has other advantages: it is easier to select parcels of planting land with optimal physical site conditions (soils, rainfall); access to transport corridors and processing plants can be facilitated; land tenure may be easier to obtain at reasonable rental or purchase; and sharing of infrastructure and physical plant through co-operatives is also possible. Further along the production chain, establishment of group or cooperative arrangements for processing and marketing will provide individual growers with opportunities for rationalising on overheads and fixed infrastructure costs, ensure a critical mass of product and create market power. The viability of this approach whereby many small growers successfully contribute to a large market is exemplified by the contrasting farm forestry systems in Finland (Day 1995) and garden systems in Sri Lanka (Durst *et al* 2004); the former provides all feedstock to mills and the latter some 40% amounting to 500,000 m^3/an.

Processing plants will have minimum input capacity demands for optimum economic efficiency and this factor together with market factors will ultimately determine the volume of feedstock required for processing efficiency and market satisficing. This in turn has implications for the area of plantings required and the form those plantings might take –
broad-acre plantations, farm forestry blocks or agroforestry associated with tropical fruit horticulture. These are not mutually exclusive and the spatial distribution of plantings across these three options will be determined by land capability, availability and tenure. Together the total area of plantings must be sufficient to provide the annual volume of log input required by processing plants for economic operation and to meet market demands. The determination of this area requires realistic estimates of growth rates and assessment of factors likely to affect them and wood quality – pests and diseases, genetics, nutrition, water stress, fire, ill-timed or absent silviculture and harvesting operations. Hence risk assessment and management will be critical to the success of the plantation end of the enterprise.

If growing is in the hands of many producers providing feedstock to centralised processing plants, then organising the orderly and timely movement of material from grower to processor is critical. Vertical integration provides one strategy for achieving this. The Queensland sugar industry provides one proven model of effective vertical integration (NFF 1997), whereby grower cooperatives operate processing plants with growers on assignment for tonnage and sugar content. The Finnish timber industry provides another (Day 1995), working through forward contracts between growers and commercial mills covering volume, price and delivery time. Both involve the rapid and orderly movement of significant volumes of valuable resource to mill to ensure mills operate at full capacity and feedstock does not suffer post-harvest deterioration.

Producing ply and secondary products may require combining HVH with other less valuable timbers (*eg* for ply cores and backs) and other raw materials in their production. Access to, availability and cost of these must be considered particularly if they have to be imported into the region from elsewhere in Australia or from overseas. This is another factor determining the size, nature and location of processing plants *vis a vis* the potential shipping points by sea, rail or road (Darwin, Cairns and Townsville, possibly Cooktown, Weipa and Broome).

In summary, the strategic location of plantings and processing plants is mutually dependent but also dependent on infrastructure (roads, rail, ports) for servicing the industry's logistic and market access needs. This may seem a trite statement but its obviousness is frequently overlooked in planning new rural resource-based ventures. The long gestation period, difficulty in predicting future markets and time preference of investors make it imperative that the operational strategic planning be as comprehensive as possible; it will need to consider all options in order that the industry can respond to changing conditions and risk factors and maintain its long-term economic viability and sustainability.

Technical Considerations

From the outset we must recognise that the objective of HVH planting is to produce quality wood for defined end purposes; growing trees is the means to that end. Technical considerations fall into two categories, those concerned with growing the wood and managing the plantings, and those concerned with its processing into high value secondary products. As has been already mentioned, these two are mutually dependent; hence one cannot be considered to the neglect of the other. If a suitable model is sought perhaps it may be found in the current Malaysian approach to developing multipurpose rubberwood plantations where considerations of horticulture and latex yield, silviculture, timber yield and wood quality, and processing go hand in hand. This multi-dimensioned scene creates a huge challenge for R&D along the entire production chain.

The harshness of the physical environment in north Australia and its influence on previous agricultural and forestry development activities have already been alluded to. The major effects are felt through the vagaries of climate and the refractory edaphic environment - what Christian (1959) calls the "eco-complex". Species selected must therefore be adaptable to the extremes of climate likely to be experienced within a rotation period, not just average conditions, and be responsive to site treatments for ameliorating the edaphic environment.

Adapting to the Climatic Environment: The limitations of climatic factors relate mainly to seasonal and annual rainfall variation and their interaction with temperature to influence evapo-transpiration and site factors to determine water availability. Ultimately, seasonal and annual variation in water availability is as major a limiting factor governing survival and growth of perennial crops as absolute availability; native vegetation adaptation to these factors is based on coping strategies to secure survival and reproduction; however in managed farming and plantation systems, strategies are adopted not only to ensure survival but also to optimise productivity. Hence the success or otherwise of the crop will depend on how well its management is attuned to this eco-complex.

The Bureau of Meteorology National Climate Centre provides comprehensive data on climatic variability. The region of interest for HVH lies within the summer dominant rainfall belt receiving more than 800mm rainfall per annum. Within this zone, variability is low to moderate on an annual basis; this can create a false sense of security as this reflects the low variability (V= 0.5) of the dominant summer rainfall season January to March. For the remainder of the year the dry season is long and monthly rainfall is not only low or non existent, its variability ranges from moderate to extreme – V=0 75->2.0 (BOM 2004). The implication of this is that trees are dependent on the moisture holding capacity of the soil in the root zone to provide moisture sufficient to meet transpiration demand throughout most of the year. Many monsoon tree species are deciduous (*eg Tectona*, *Chukrasia* and *Dalbergia*) thus avoiding high transpiration demand during the extended dry period, but species of *Khaya* are evergreen and therefore will be dependent on stored soil moisture or irrigation during the dry season.

Temperatures are uniformly high; median annual minimum is 21-24^{0}C, with 10-90th percentile range of 18-24^{0}C; median annual maximum is 30-33^{0}C with 10-90th percentile range of 30-36^{0}C. Temperature governs evapo-transpiration and hence actual evapo-transpiration is high - >30mm per month in July and >100mm in January. When precipitation /evaporation ratios are positive conditions favour growth; the Prescott Ratio ($P>0.4E^{0.75}$) is a measure of effective rainfall (CSIRO 1960) and a consecutive five months period with a favourable Prescott Ratio is normally taken as the lower limit for crop growth. While there are limitations to the usefulness of the Prescott Ratio *eg* it does not take into account soil moisture storage capacity, as a first approximation it is a fair indicator of growth potential.

Northern Australia on average just satisfies this limit (December-April), being marginal for perennial crops, particularly broadleaved evergreens actively transpiring for most of the year. These must draw on stored soil moisture, have access to supplementary irrigation or have high adaptation to moisture deficit *eg* having a deciduous or semi-deciduous habit or having an aestivation mechanism, which shuts down transpiration and growth in the dry season.

The HVH species of most interest are savannah or open woodland species from seasonal/ monsoonal rainfall areas of the tropics. As such they show variable adaptation to the climatic conditions of northern Australia and this is confirmed by their survival and growth as demonstrated in amenity plantings dating from the 1950s and small forestry trial plots, some more than thirty years old eg *Khaya senegalensis* (Whitbread *et al* 2003).

Those of lesser potential come from areas with a better rainfall distribution *Gmelina*, *Tectona* and *Swietenia*. Of concern will be the ability to predict with some confidence the productivity of these essentially woodland species when grown at closer spacing in forest plantations than that at which they grow in their natural environment. Too close spacing will place greater pressure on site water supplying capacity relations particularly during the long dry season when transpiration demand will be high and may militate against establishment of broad-acre plantations. Establishment of wider spaced smaller woodlots or agroforestry may have lesser impact on site hydrology and reduce total transpiration demand. Whatever planting strategy is adopted it will demand close attention to water relations of soils; some sites desirable from other perspectives may require irrigation with consequent high costs.

Applying the precautionary principle in risk management, strategic planning should also consider the *implications of climate change*. The planning horizon for HVH over at least two rotations probably implies a time horizon of 60 or more years. This is sufficient time for changed climatic conditions for the maturing second rotation and establishment of the third. Current climate change models (IPCC 2004) predict that northern Australia may in future experience higher temperatures and even less rainfall in the dry season. Although the models are less definitive for change in the wet season, variability will also increase (Pearman 2004). Should this pattern eventuate, the outcome will be increased water stress in the dry season, possibly even an extended dry season, and this could have inimical effects on growth rates and survival. The techniques proposed by Booth (1994) to model species and provenance adaptation to a range of climate scenarios should be used to provide through sensitivity analysis a guide to genotype selection for future plantings. Rising CO_2 levels also have implications for growth because of the interaction of CO_2 with phosphorus nutrition and water stress and the differential effects of rising CO_2 on genotype (Conroy *et al* 1990). Increasing CO_2 associated with rising temperature can increase growth rates; this is diminished by phosphorus deficiency but to different extent depending on genotype. However growth rate can be lowered under conditions of water stress thus negating any positive effect of rising CO_2 level. The potential for these changing physiological parameters affected by the interaction of climate and soil to influence yield of HVH in the future will also need to be taken into account.

Adapting to the Edaphic Environment: Soils and landscapes favoured for HVH planting will probably include the widespread non-calcareous massive gradational red and yellow earths (Gn soils) on undulating topography and the red siliceous sands and alluvial soils (Uc) on the better drained plains (see Northcote *et al* 1975 for soil classification and mapping). While these soils have reasonable texture and rooting depth they suffer from droughtiness because of their freely draining character. They also exhibit a range of nutrient deficiencies for crops and trees; Cameron *et al* (1982) and Cameron (1985) indicate responses to nitrogen phosphorus, potassium, sulphur and trace elements with *Pinus caribaea* and *Khaya senegalensis* near Darwin. Bevege and Leggate (Bevege 1974) obtained responses of *K. senegalensis* to phosphorus, potassium and combined trace elements (copper, zinc, boron), of *Swietenia macrophylla* to nitrogen, phosphorus and trace elements and *Callitris glauca intratropica* to phosphorus, on the related bauxitic red earths (Gn soils) at Weipa. Of lesser interest would be the shallower heavier textured yellow duplex (Dy) soils, which occur lower in the toposequence and are subject to seasonal waterlogging (Bevege 1975); these soils would also be more susceptible to windthrow in cyclonic conditions particularly if the solum is saturated.

The limited information from nutrition research to date indicates that multiple deficiencies might be expected on a wide range of soils and that these will probably vary due to the differing species demands. Broad scale soil surveys and chemical analysis are available for some areas *eg* Melville Island (van-Cuylenburg and Dunlop 1973, Wells and van-Cuylenburg 1978) but there is a dearth of information on nutrient requirements of tree species across soil types; this is essential for establishing economic fertiliser regimes. While this fundamental data is being gathered from fertiliser trials, a start can be made by foliar analysis of existing trial plots thereby relating nutrient status to total growth, current increment and deficiency symptoms, and establishing first approximations to critical nutrient levels. Data on other broad-leaved species will help (Malavolta *et al* 1962, Webb *et al* 2001, Dell *et al* 2001).

Nutrition research will also require examination of the influence of fertilising on wood properties influencing quality. While increased yields from fertilising can more than compensate for any changes in wood properties, there can be some financial penalties if changes in wood attributes reduce quality eg high growth rates resulting in more tension wood, reduced heartwood formation, reduced density and large knots. Interaction of later age fertilising with thinning may lead to large branches (knots) and tension wood (Bevege 1984) if stand gappiness leads to uneven crown development and stem eccentricity. On the positive side, correction of deficiency-induced stem dieback improves stem form and hence bole and log quality. The picture is very complex as fertilising affects different wood properties in different ways; generalisations on the effects of fertilising, and indeed of silvicultural treatment in general, are not possible.

Germplasm improvement: Sufficient has gone before to indicate that germplasm selection for HVH will require multi-attribute selection to meet environmental constraints, productivity targets and wood quality criteria. The more attributes the more complicated the selection process. The early trial plots are now reaching sufficient maturity to give sound indications of productivity potential at least at the species level, and even some indication of wood properties. Tree improvement plans are well advanced for utilising available material of *Khaya senegalensis* (Nikles *et al*, 2004). Injection of fresh germplasm may require access to genetic resources in countries of origin or third countries; if this is done, attention is simply drawn to obligations under the CBD. There is also potential for developing in time high quality genetic lines or cultivars for establishment of clonal plantations on specific sites; the value and market strength of these should be protected by Plant Breeders Rights to ensure the local HVH industry can maintain its competitive edge.

Multi-attribute selection strategies in tree improvement programmes are expensive, complicated and time consuming; nevertheless such a broad approach will be desirable to maximise the benefits from HVH. Strategically it will be necessary to prioritise the order in which traits or groups of linked traits are incorporated in the breeding programme. It would be sensible to adopt a two-stage approach at least, targeting wood properties for HVH once basic adaptability and productivity traits in trees are raised to an acceptable level; selection for wood quality traits might then be undertaken within this population of well adapted, high producing trees. However there will be gains from overlapping the approaches once the basic breeding population is established from early phenotypic selections. Recent work by Wu (2004) indicates that an economic value can be placed on biological traits used in breeding attributes; furthermore, wood quality attributes such as density have higher heritability and strong age-age correlations that should facilitate early selection for wood quality, at least in *Pinus radiata*. Whether these findings apply also to HVH is worthy of close scrutiny; special HVH attributes such as timber figure derive from particular patterns of cambial activity in the laying down of wood cells during secondary differentiation of xylem and colour from deposition of polyphenols *etc* during heartwood formation (Bootle 1983). There do not appear to be any reports on the heritability of such traits although some early selection work for these wood properties was done in Queensland with maple (*Flindersia brayleyana*).

The occurrence of tension wood in stems of HVH is also of concern as it creates problems with wood strength, stability and finishing; excessive tension wood may be a consequence of HVH plantations being subject to strong prevailing winds or cyclones. Again, the heritability of this trait in hardwoods is unknown, although it is estimated that heritability of the analogous compression wood in conifers is moderate to very low; *eg* hoop pine *Araucaria cunninghamii* 0.44 (Eisemann *et al* 1990), *P. caribaea hondurensis* 0.02 (Harding *et al* 1991).

Pests and diseases: Some aspects of crop protection have been discussed previously. Risk management is fundamental not only to guard against entry of exotic pests and diseases but also to maintain a competitive export edge by not exporting infested processed products. Silvicultural strategies including mixed species plantings, relative isolation of larger plantation blocks, and effective pest surveillance will mitigate against build up of pests. There may be potential for breeding for resistance but this strategy is questionable in long-lived perennials because pests and diseases can adapt more rapidly *via* generational change than can host trees. Two insect pests appear to stand out as having potential to compromise the enterprise – *Hypsipyla* twig borer of Meliaceae (Floyd and Hauxwell 2001, Speight and Wylie 2001) and termites such as *Mastotermes darwiniensis* capable of infesting living trees (Elliott *et al* 1998). Chemical control of these pests and phytophagous insects may be problematic due to environmental and occupational health constraints.

Basidiomycete butt and root rots caused by *Phellinus* and *Ganoderma* may create problems exacerbated by the seasonal rainfall environment (Evans and Turnbull 2004) although there appears little evidence so far of their being a problem in trial plots. One is mindful of the problem these have become in *A. mangium* plantations under higher more even rainfall regimes in Malaysia.

Environmental stress can pre-dispose trees to pests and diseases: factors include moisture stress, ill-adaptation to temperature extremes, fire damage, and windthrow or crown break during cyclones. While introduced species may exhibit disease escape profiles under stress conditions, indigenous species planted off-site in an attempt to extend their range are potentially at risk from attack by native pests under stress conditions. *Acacias* and *Eucalyptus* are exposed to a wide range of native insect and fungal diseases that can find acute expression under such conditions; this has been the case with acacias and eucalypts in dry tropics plantings in Queensland (Mila Bristow, *pers comm*). Non-gregarious species planted in large monocultures can enable gradual build up of pests and diseases and if stressed these plantations can experience sudden pest outbreaks *eg* the massive attack by *Conifericoccus agathidis* on maturing plantations of kauri pine (*Agathis robusta*) in the Mary Valley which progressively destroyed the plantations from 1959 (Elliott *et al* 1998).

Monitoring of pests and diseases along the lines suggested by Speight and Wylie (2001) and development of management/containment strategies will be essential. These will need to be organised on a regional cooperative basis with early warning systems to be fully effective. There is a role here for government R&D services as capacity in this area outside the public system is virtually non-existent.

Silviculture and Management: Silvicultural strategies revolve around many of the issues already discussed and in effect are resultants of risk management strategies associated with the environmental and economic factors affecting the enterprise. Species, genetic quality, fire tolerance, physiological condition of planting stock are all significant attributes, while establishment techniques, spacing, pruning, fertilising and tending regimes, all are responses to the limiting factors of the environment and the need to produce the quality wood for processing into high value products. Spacing, thinning and pruning regimes in hand with weed control are critical in coping with moisture deficit; together they will determine size and quality of log and have a big influence on rotation length.

Decisions on size and nature of plantings – plantations, woodlots or agroforestry, monoculture or mixed species plantings will determine the silvicultural regime and this in turn will be affected by the nature of the plantings. Mixed plantings utilizing nurse crops of less valuable species (*eg* tamarind with teak, Jordan and Gajaseni 1990) and multiple cropping in agroforestry mode are possible options. Mixed plantations associating nitrogen-fixing trees *eg Pterocarpus* and *Dalbergia* (Brewbaker 1990), themselves HVH species, with target species may satisfy a plantation's nitrogen demand. Labour availability, skills and costs will determine to large measure the intensity of silviculture that can be undertaken. The nature and spatial distribution of plantings, and species fire tolerance are also significant issues for managing fire risk and influence wildfire management strategies. Sound resource management and silviculture must be underpinned by an effective inventory system enabling the determination of productivity and yield and their distribution in time and space – essential information for constructing yield tables and implementing thinning and harvesting regimes. Both the silvicultural and processing sides of the enterprise cannot operate without sound mensurational data on growth and resource inventory data on volume availability through time, and log size assortments. Planning and implementation of inventory needs should be done on an industry-wide basis, ideally coordinated by R&D agencies which can provide the necessary expertise, and this will be facilitated by horizontal and vertical integration.

With regard to *weediness potential* of HVH species, this has implications for tending costs and environmental concerns regarding invasion of natural habitats adjacent to planting sites. Many if not most species of HVH interest are listed as invasive species in the Pacific by the US Forest Service (USDA 2004); whether this invasiveness will be problematic under the conditions of the seasonally dry tropics is a moot point, but both *Chukrasia velutina* and *Dalbergia sissoo* are acknowledged weed species, the former in north Queensland (Faiz Bebawi, *pers comm* to Mila Bristow) the latter in the Northern Territory (Parsons and Cuthbertson 2001). Whether the value of these species as timber and/or nitrogen fixers more than offsets their weediness potential is a question for plantation management. It is also an issue where working within government regulatory frameworks will be obligatory and this may constrain or even eliminate some species from consideration for HVH despite their obvious utility for such purposes. Seeding management is one strategy to consider where seedling regeneration is potentially a problem (*eg Khaya senegalensis*, Bristow and Skelton 2004); this might be done through introduction of seed pathogens or parasites but this has implications for seed orchard management. Another aspect perhaps worthy of consideration is the role of tree breeding in reducing potential weediness by breeding sterile hybrids or introducing lethal genes through gene technology and thence moving to clonal plantations. Where weediness is created *via* root suckering eg *Chukrasia* (Gunn et al 2004) management *via* stand density, shading by nurse species or chemical control may be in order.

Processing: A major decision for the HVH industry will be deciding the level of processing required to service its potential market. Possible outputs range from unprocessed logs through primary processing – flitches, sawn wood, veneer, and ply – to secondary processed products – furniture blanks and furniture, mouldings and joinery, specialised products. A mix of products provides flexibility and an element of buffering in the market but it also introduces complexity into the processing chain.

However the further along the chain, the narrower the market niche, the higher the product value and presumably the profit margin. Higher processing levels also require larger investments in processing plant and greater labour skills that add to costs. A critical mass of raw material as well as market size determines the economics of such investments. The more centralised the processing plants, the greater the aggregation of raw material (logs and primary products) and the greater the level of secondary processing possible. A danger from developing too small and scattered a growing sector is that it may result in the establishment of numerous small capacity processing plants that have not the economies of scale necessary to be economically viable; additionally, they may not be able to undertake secondary processing. The ultimate in undesirability would be a plethora of low technology bush sawmills or walkabout mills processing small volumes of logs to low standard products to minimum specifications. Aggregating such material for the market involves high handling and transport costs and market price may be low because of the inability to meet technical or quality specifications; in fact market access may even disappear. Such has been the Melanesian experience of community level walkabout sawmill operations in attempting to access the tropical timber export market; Martin (1997) documents in detail the Papua New Guinea experience.

It is also important to determine just how far along the production chain onshore processing should be taken. Costs of conversion and finishing must be competitive with offshore processors otherwise the industry will lose comparative advantage and be forced into log export or at best marketing of primary processed products only. Such a situation reduces options for industry, but more importantly, reduces the product value, transferring the high margins for finished high value products to offshore processors. This has always been the traditional approach of the European market in importing tropical hardwoods from Africa, and China has now adopted a similar strategy. At least one Australian blackwood (*Acacia melanoxylon*) grower has exported logs to China for processing and re-imported finished products for retailing in Australia because this was cheaper than local processing (Neil Byron *pers comm*). There is a need for analysing very carefully the market and the desirability for vertical integration, and the possibility of involving offshore partners as processors in joint venture arrangements, if such provide the most economic processing option.

Conclusion

This paper has attempted to scope the factors and explore the issues relevant to the successful establishment and prosecution of a HVH industry in north Australia. Sufficient information is available on both growing and marketing aspects to indicate that a HVH industry has potential (Whitbread *et al* 2003, Reilly and Robertson 2004). Converting this potential to a viable reality will require a concerted R&D effort to confirm technical feasibility; Turvey and Larsen (2001) have documented in detail these R&D requirements. They found however business confidence and lack of information to be major inhibiting factors, and that development priorities were broader than technical R&D, embracing:

- financial issues including ecological valuation of tree-based enterprise
- cultural and policy contexts
- marketing information and certification
- wood quality and processing
- the research-extension continuum.

These are among the issues largely canvassed in this paper. Detailed holistic planning at all levels from governments to growers is essential to secure the necessary business confidence and investment and ensure that R&D activity is carefully targeted on enterprise objectives. Planning might with advantage include the complementarity between developing the plantation/agroforestry sector and native forest management particularly as some enterprises, including aboriginal communities as well as farmers and graziers, have significant areas of native woodlands to manage sustainably for both income generation and conservation objectives. Securing stable long term markets is a necessary corollary to all of this. It should go without saying that sustainable production should be capable of certification through an internationally accepted scheme such as Forest Stewardship Council (FSC 2004) or the Australian Forestry Standard AS 4708(INT)-2003 combined with the Chain of Custody Standard AS 4707 (INT)-2004 (SAI 2004). Such certification should assure market access but will also help to relieve pressures from conservation groups concerned with exotic plantation establishment in northern Australia, and assure governments that their conservation policy objectives are being met.

Ultimately, the long-term viability of any HVH industry will hinge upon the ability to produce economically the basic raw material *ie* quality wood of the target species and process this efficiently into the high value products demanded by the market. Sufficient is known to realise this will be high cost/advanced technology input activity demanding high value precision outputs *ie* products commanding premium market prices; the differential between these will determine the economic viability of the overall enterprise and the profitability of individual growers and processors. A high degree of confidence that this can be achieved can only be generated if the knowledge and skills base along the production chain from grower to marketer is adequate to the purpose. This dependence highlights the desirability of developing a strongly integrated industry, horizontally and vertically.

In a strategic planning sense an industry business plan is highly desirable; this ideally should be prepared with a time horizon of at least one, preferably two rotations. This however is not possible given the current state of knowledge and the time horizon involved; neither is it yet possible to set the optimum rotation length because there is insufficient information of the potential growth rates and processing possibilities that together determine log size and the wood properties desirable for target products. However, in the absence of sufficient information to prepare a realistic business plan a start can be made on strategic planning. This involves several steps:

- *First step* will involve a situation analysis that includes a detailed assessment of the economic, social and technical environment in which the industry might be established, and a review of all available information. The SWOT analysis process is useful in this regard (*ie* analysing strengths, weaknesses, opportunities and threats).

- *Second step*, defining the desired scope and objectives of the industry, synthesising and analysing available knowledge, and identifying knowledge gaps requiring further investigation and research.

- *Third step* will be to develop a strategic plan to achieve the objectives involving identification and provision of the resources – human, technical and financial – required, and the development of options, activities and timelines for implementation.

This paper has attempted to initiate this process by scoping the environment and providing some pointers that might be explored further in a SWOT analysis. Hopefully this Workshop will provide further information that will assist in completing the second step. The third step is for the future when sufficient interest is generated in this Grand Idea to support its further development.

Unfortunately, development in northern Australia is littered with failures and marred by lost dreams; for an HVH industry not to go down the same path of initial enthusiasm followed by disillusion, a clear-eyed vision of what is possible and a practical plan for its fulfilment are essential. Success will be determined not by narrow technical expertise but by taking the enterprise forward on a broad front, working to its strengths and advantage within the socio-political environment. There is a narrow window of opportunity through which the many operating factors come together such that the success of the enterprise might be assured. It will be critical to identify this area of convergence and work pro-actively within its boundaries to achieve the desired outcomes (Figure 1). This will require a cooperative effort by a multitude of stakeholders, not the least being with the aboriginal communities whose land may largely provide the physical basis of the enterprise and their people the labour force.

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References

Appanah, S and Weinland, G. 1993. Planting Quality Timber Trees in Peninsular Malaysia. Forest Research Institute Malaysia, Kuala Lumpur, 247p.

AFG. 2004. Laws, tax and support for farm forestry. Farm Forest Line Website www.farmforestline.com.au Australian Forest Growers, Canberra.

Bevege, D.I. 1974. Revegetating surface-mined areas and spoils in northern Australia, particularly bauxite at Weipa, pp 33-54. In: Symposium Proceedings July 1974, Some Aspects of Mine Rehabilitation in Northern Australia. Comalco, Weipa.

Bevege, D.I. 1981. An Evaluation of Site Potential for Caribbean Pine on Melville Island and Adjacent Mainland Areas, Northern Territory. Report to the Conservation Commission of the Northern Territory, August 1981, 51p + 11photos.

Bevege, D.I. 1984. Wood Yield and Quality in Relation to Tree Nutrition, pp293-326. In: Bowen, G.D. and Nambiar, E.K.S. (Eds) Nutrition of Plantation Forests. Academic Press, London.

Bevege, I. 2001. International frameworks and arrangements for conservation development and management of plant genetic resources: their significance for the Pacific, pp 64-69. In: Wells, K and Eldridge, K. (Eds) Plant Genetic Resources in the Pacific. ACIAR Monograph 76, ACIAR, Canberra.

Booth, T.H. 1994. Determining the climatic requirements of trees suitable for agroforestry. Climatic Change 27: 93-102.

Bootle, K.R. 1983. Wood in Australia. Mc Graw-Hill Book Co., Sydney, 443p.

Brewbaker, J.L. 1990. Nitrogen Fixing Trees, pp253-262. In: Werner, D. and Muller, P. (Eds) Fast growing Trees and Nitrogen Fixing Trees. Gustav Fischer Verlag, Stuttgart, 396p.

Bristow, M. 2004. Review of Agroforestry in Tropical Savanna Regions of Northern Australia. Report for RIRDC/Land & Water Australia/FWPRDC/MDBC Joint Venture Agroforestry Program, RIRDC Publication No 04/025, 40p.

Bristow, M. and Skelton, D. 2004. A preliminary weed assessment of *Khaya senegalensis* in forestry plantations in northern Australia. Working paper presented at a Workshop on "Prospects for high-value hardwood timber plantations in the 'dry' tropics of northern Australia", Mareeba, Queensland. 19-21 October, 2004. Published as CD-Rom by Private Forestry North Queensland Association Inc., Kairi, Queensland.

Brown, C. 2000. Global Forest Products Outlook Study. Working Paper GFPOS/WP/03, FAO, Rome, 66p.

Cameron, D.M., Rance, S.J. and Williams, E.R. 1982. Effects of fertilizers on growth, form, and concentration of nutrient in the needles of *Pinus caribaea* var. *hondurensis* in the Northern Territory. Australian Forest Research 12,2: 105-119.

Cameron, D.M. 1985. Forest Crops, pp165-178. In: Muchow, R.C. (Ed) Agro-Research for the Semi-Arid Tropics: North west Australia. University of Queensland Press, St Lucia Qld, 608p.

Christian, C.S. 1959. The eco-complex in its importance for agricultural assessment, pp587-605. In: Keast, A., Crocker, R.L. and Christian, C.S. (Eds) Biogeography and Ecology in Australia. Monographae Biologicae VIII, Dr W.Junk, den Haag.

CRC. 2004. Cooperative Research Centres. Website www.crc.gov.au Department of Education Science and Training, Australian Government, Canberra.

Conroy, J.P., Milham, P.J., Bevege, D.I. and Barlow, E.W.R. 1990. Influence of phosphorus deficiency on the growth response of four families of *Pinus radiata* seedlings to CO_2-enriched atmospheres. Forest Ecology and Management 30:175-188.

CSIRO.1960. The Australian Environment. CSIRO and Melbourne University Press, Melbourne, 151p.

CSIRO.2004. CSIRO Forestry and Forest Products boosts regional presence. Forestry and Forest Products Newsletter Winter, CSIRO, Clayton.

Van-Cuylenburg, H.R.M. and Dunlop, C.R. 1973. Land Units of the Seventeen Mile Plain, Melville Island, 1973. Technical Bulletin 14, Animal Industry and Agriculture Branch, Department of the Northern Territory, Darwin, 38p +map.

Dadwal, S.R. 2003. Kyoto Protocol and the Future of Carbon Trading. Financial Express Monday 27 October, net edition. Website www.financialexpress.com Financial Express, Bombay.

DAFF. 2004. Website www.daff.gov.au Department of Agriculture, Fisheries and Forestry, Australian Government, Canberra.

Davidson, B.R. 1966. The Northern Myth. Melbourne University Press, 283p.

Day, L.1995. Strong Finnish government support for forestry. Australian Forest Grower 19,4: 19.

Dell, B., Malajczuk, N., Xu, D. and Grove, T.S. 2001. Nutrient Disorders in Plantation Eucalypts. ACIAR Monograph 74 Second Edition, ACIAR Canberra, 187p.

Done, C., Kimber, P. and Underwood, R. 2004. Development of the Indian Sandalwood industry on the Ord River Irrigation Area. Working paper presented at a Workshop on “Prospects for high-value hardwood timber plantations in the ‘dry’ tropics of northern Australia”, Mareeba, Queensland. 19-21 October, 2004. Published as CD-Rom by Private Forestry North Queensland Association Inc., Kairi, Queensland.

Doran, J.C. and Turnbull, J.W. 1997. Australian Trees and Shrubs: Species for Land Rehabilitation and Farm Planting in the Tropics. ACIAR Monograph 24, ACIAR, Canberra, 384p.

Durst, P.B., Killman, W. and Brown, C. 2004. Asia’s new woods. Journal of Forestry 102,4: 46-53.

Eisemann, R.L., Harding, K.J. and Eccles, D.B. 1990. Genetic parameters and predicted selection responses for growth and wood properties in a population of *Araucaria cunninghamii*. Silvae Genetica 39, 5-6: 206-216.

Elliott, H.J., Ohmart, C.P. and Wylie, F.R. 1998. Insect Pests of Australian Forests. Inkata Press, Melbourne, 214p.

Evans, J and Turnbull, J. 2004. Plantation Forestry in the Tropics. Third Edition. Oxford University Press, Oxford. 467p.

FAO. 2004. Website www.fao.org/forestry/foris/reforgen Reforgen: FAO World-wide Information System on Forest Genetic Resources, FAO Rome.

FSC. 2004. Website www.fsc-info.org Forest Stewardship Council, Bonn.

Floyd, R.B. and Hauxwell, C. 2001. *Hypsipyla* Shoot Borers in Meliaceae. ACIAR Proceedings 97, ACIAR Canberra, 189p.

Gunn, B., Doran, J. and Pinyopusarerk, K. 2004. Early performance of species and provenances of *Chukrasia* in the Darwin region. Working paper presented at a Workshop on "Prospects for high-value hardwood timber plantations in the 'dry' tropics of northern Australia", Mareeba, Queensland. 19-21 October, 2004. Published as CD-Rom by Private Forestry North Queensland Association Inc., Kairi, Queensland.

Harding, K.J., Kanowski, P.J. and Woolaston, R.R. 1991. Preliminary genetic parameter estimates for some wood quality traits of *Pinus caribaea* var. *hondurensis* in Queensland, Australia. Silvae Genetica 40, 3-4: 152-156.

Hawksworth, D.L., Kirk, P.M. and Dextre Clarke, S. (Eds) 1997. Biodiversity Information: Needs and Options. CAB International, Wallingford, Oxford, 194p.

Herbert, X. 1938. Capricornia. Angus and Robertson, Sydney, 510p.

IPCC. 2004. Website www.ipcc.ch Intergovernmental Panel on Climate Change, Geneva.

ITTO. 2003. Annual Review and Assessment of the World Timber Situation. International Tropical Timber Organization, Yokohama, 230p.

ITTO. 2004. Workshop on capacity-building for implementation of CITES Appendix II listing of mahogany (*Swietenia macrophylla*). Website www.itto.or.jp International Tropical Timber Organization, Yokohama.

Jordan, C.F. and Gajaseni, J. 1990. Interplanting of *Tamarindus indica* L. In Teak Plantations, pp76-81. In: Werner, D. and Muller, P. (Eds) Fast growing Trees and Nitrogen Fixing Trees. Gustav Fischer Verlag, Stuttgart, 396p.

Keating, W.G. and Bolza, E. 1982. Characteristics, Properties and Uses of Timbers, Vol 1 South-east Asia, Northern Australia and the Pacific. Inkata Press, Melbourne, 362p.

Lacey, C. 1979. Forestry in the Top End of the Northern Territory: Part of the Northern Myth. Search 10,5: 174-180.

Lesser, W. 1998. Sustainable Use of Genetic Resources Under the Convention on Biological Diversity. CAB International, Wallingford, Oxford, 218p.

Malavolta, E., Haag, H.P., Mello, F.A.F. and Brasil Sobr°, M.O.C. 1962. On the Mineral Nutrition of Some Tropical Crops. International Potash Institute, Berne, 155p

Martin, R. 1997. Small-scale community based forestry: issues in the conservation of Papua New Guinea's biodiversity, pp269-292. In: Filer, C. (Ed) The Political Economy of Forest Management in Papua New Guinea. NRI and IIED, Boroko and London, 517p.

Mayhew, J.E. and Newton, A.C. 1998. The Silviculture of Mahogany. CABI Publishing, Wallingford, Oxford, 226p.

Morell, M. 2001. Vision of forestry 50 years on. Unasylva 52,1: 70-76.

Nambiar, E.K.S. and Brown, A G. 1997. Management of Soil, Nutrients and Water in Tropical Plantation Forests. ACIAR, Canberra, 571p.

NFF. 1997. Australian Agriculture. National Farmers Federation, Morescope Publishing Pty Ltd, Hawthorn East Vic, 450p.

Nikles, G.N., Reilly, D. and Robertson, B. 2004. Status of tree improvement with high value hardwoods in northern Australia. Working paper presented at a Workshop on "Prospects for high-value hardwood timber plantations in the 'dry' tropics of northern Australia", Mareeba, Queensland. 19-21 October, 2004. Published as CD-Rom by Private Forestry North Queensland Association Inc., Kairi, Queensland.

Northcote, K.H., Hubble, G.D., Isbell, R.F., Thompson, C.H. and Bettenay, E. 1975. A Description of Australian Soils. CSIRO Australia, 170p.

Parsons, W.T. and Cuthbertson, E.G. 2001. Noxious Weeds of Australia. Second edition, CSIRO Publishing, Melbourne, 712p.

Pearman, G. 2004. The Climate is Changing: Linking the Science with Forest and Plantation Growers. Australian Forest Grower 27,2: Special Liftout, 8pp.

Piearce, G.D. (Ed) 1986. The Zambesi Teak Forests. Proceedings First International Conference on the Teak Forests of Southern Africa, Livingstone Zambia March 1984. Forest Department, Ndola Zambia, 535p.

Pinyopusarerk, K. and Kalangire, A. 2003. Domestication of Chukrasia. ACIAR Monograph 98, ACIAR, Canberra, 76p.

Radomiljac, A.M., Ananthapadmanabho, H.S., Welbourn, R.M. and Rao, K.S. (Eds) 1998. Sandal and Its Products. ACIAR Proceedings 84, ACIAR, Canberra, 203p.

Reilly, D. and Robertson, B. 2004. Results of recent trials of high-value hardwood species in the Northern Territory of Australia. Working paper presented at a Workshop on "Prospects for high-value hardwood timber plantations in the 'dry' tropics of northern Australia", Mareeba, Queensland. 19-21 October, 2004. Published as CD-Rom by Private Forestry North Queensland Association Inc., Kairi, Queensland.

Robson, K. 2004. Experiences with sandalwood in plantations in the South Pacific and north Queensland. Working paper presented at a Workshop on "Prospects for high-value hardwood timber plantations in the 'dry' tropics of northern Australia", Mareeba, Queensland. 19-21 October, 2004. Published as CD-Rom by Private Forestry North Queensland Association Inc., Kairi, Queensland.

SAI. 2004. AS 4707(INT)-2004, Chain of Custody for Certified Wood and Forest Products; AS 4708(INT)-2003, The Australian Forestry Standard. Website www.standards.com.au Standards Australia International Ltd., Sydney

Senate. 2004. Inquiry into Australian Forest Plantations: A Review of Plantations for Australia: the 2020 Vision. Tabled in the Australian Senate, 2 September 2004, Senate Rural Affairs and Transport Committee, Parliament House Canberra.

Sowden, W.J.1882. The Northern Territory As It Is. W.K.Thomas & Co., Adelaide, 192p. Reprint (ND) Government Printer of the Northern Territory for the History Unit of the University Planning Authority.

Speight, M.R. and Wylie, F.R. 2001. Insect Pests in Tropical Forestry. CABI Publishing, Wallingford, Oxford, 307 p.

Spillett, P.G. 1972. Forsaken Settlement. Lansdowne Press Pty Ltd, Melbourne, 196p.

Sun, X., Katsigris, E. and White, A. 2004. Meeting China's Demand for Forest Products: An Overview of Import Trends, Ports of Entry, and Supplying Countries, with Emphasis on the Asia-Pacific Region. Forest Trends, Washington, 31p.

Teixiera, D.E., Santana, M.A.E. and de Souza, M R.1988. Amazonian Timbers for the International Market. Technical Series 1, ITTO, Yokohama, 94p.

Turvey, N. and Larsen, P. 2001. Agroforestry R&D Priorities for Northern Australia. Report for RIRDC/Land & Water Australia/FWPRDC Joint Venture Agroforestry Program, RIRDC Poblication No 01/142, 93p.

USDA. 2004. Plant Threats to Pacific Ecosystems. Website www.hear.org/pier Pacific Island Ecosystems at Risk (PIER), Institute of Pacific Islands Forestry, USDA Forest Service, Hawaii.

Webb, M.J., Reddell, P.and Grundon, N.J. 2001. A Visual guide to Nutritional Disorders of Tropical Timber Species: *Swietenia macrophylla* and *Cedrela odorata*. ACIAR Monograph 61, ACIAR Canberra, 178p.

Wells, M.R. and van-Cuylenburg, H.R.M. 1978. Land Units of Areas Adjacent to the Tuyu and Yapilika Forestry Plantations, Melville Island, N.T.1978. Land Conservation Unit, Territory Parks and Wildlife Commission, Darwin, N.T., 74 p + map.

Westley, S.B. and Roshetko, J.M. 1994. *Dalbergia*: Proceedings of an International Workshop. Special Report, Nitrogen Fixing Tree Association, USA and Taiwan Forestry Research Institute, Taipei, 207p.

Whitbread, M., Reilly, D. and Robertson, B. 2003. African Mahogany Timber Industry Strategy for the Top End of the Northern Territory. Agroforestry Section DBIRD, Darwin, 32p.

White. K.J. 1991. Teak. Some Aspects of Research and Development. FAO/RAPA, Bangkok, 53p +xvii.

Wu, H. 2004. Breeding for profit. Ensis Link 1:7.

Table 1

Value of Trade by Producer Countries in Tropical Timber Products 2002 (roundwood equivalents)

Region	Product	Exports Value (US$1000)	Exports Unit Price (US$/m^3)	Imports Value (US$1000)	Imports Unit Price (US$/m^3)
Africa	log	814,376	181	2,892	172
	sawn	594,912	338	3,967	165
	veneer/ply	238,353	433/287	3,819	357
	total	*1,647,541*		*10,678*	
Asia Pacific	log	940,202	112	521,213	187
	sawn	1,643,705	288	353,278	152
	veneer/ply	2,932,002	219/301	54,307	337/351
	total	*6,172,669*		*928,797*	
Latin America	log	19,922	138	933	79
	sawn	467,925	342	10,831	201
	veneer/ply	278,115	247/274	14,714	955/375
	total	*765,963*		*26,478*	
Total	**log**	**1,774,501**	**136**	**525,038**	**186**
	sawn	**2,634,203**	**309**	**368,076**	**153**
	veneer/ply	**3,448,470**	**293/299**	**72,839**	**355/357**
	total	**7,857,174**		**965,954**	

Data from ITTO (2003)

Table 2

Log Production and Export of Tropical Hardwoods 2003 (roundwood equivalents 1000m^3)

Region	Log Production	Log Exports	Processed Exports
W. Africa	18,960 (14%)	4,655	2,198
Latin America	40,182 (30%)	116	2,394
Asia Pacific	74,026 (56%)	8,601	15,574
Total	**133,167 (100%)**	**13,373[1] (10%)**	**20,166 (15%)**
	Major Log Producers	**Major Log Exporters**	**Major Log Importers**
	Indonesia (21%)	Malaysia	China
	Brazil (22%)	Gabon	Japan
	Malaysia (15%)	PNG	India
	India (9.7%)	Liberia	Taiwan
	Thailand[2] (5.8%)	Myanmar	Portugal
	Nigeria (5.3%)	Indonesia)	France)
	Ecuador (4.0%)	Congo Republic)[3]	Thailand)[3]
	Gabon (3.0%)	Cameroon)	Republic of Korea)

[1] Excludes non-ITTO producers that exported approx 1 million m^3; Solomon Islands and Equatorial Guinea are main non-ITTO exporters

[2] Comprises mainly rubberwood and other plantation logs

[3] 2002 data; pattern for 2003 follows 2002

Data from ITTO (2003)

Table 3

World Export of Secondary Processed (Value-Added) Wood Products 2001

(Value US$1000)

Product	ITTO Producers (tropical spp)	ITTO Consumers (all sources)	non-ITTO (all sources)	**Total**
Wooden furniture & Parts	391,928	22,773,175	3,070,912	**26,236,015** (62.3%)
Builders Woodwork	67,918	6,053,982	657,519	**6,779,419** (16.1%)
Specialised Products	134,822	5,999,964	518,225	**6,653,011** (15.8%)
Mouldings	64,214	2,215,139	182,329	**2,461,682** (5.8%)
Total	**658,882** (1.6%)	**37,042,260** (87.9%)	**4,428,985** (10.5%)	**42,130,127** (100%)

Data from ITTO (2003)

Table 4

Major Players in World Trade in Value-Added Wooden Furniture and Parts

Value of Trade 2001 ($US1000)

Country	Exports	Imports
European Union	13,241,977 (50.4%)	10,896,780 (40.5%)
China	2,416,306 (9.2%)	770,540 (2.9%)
Canada	2,239,240 (8.5%)	723,633 (2.7%)
Poland	1,602,688 (6.1%)	
Malaysia	992,041 (3.8%)	
USA	867,965 (3.3%)	8,939,999 (33.2%)
Indonesia	738,296 (2.8%)	
Japan		1,536,469 (5.7%)
Switzerland		856,460 (3.2%)
World	**26,236,015 (84.1%)**	**26,898,691 (88.2%)**
Europe	14,844,665 (56.5%)	11,753,249 (43.7%)
Asia	4,146,643 (15.8%)	2,307,009 (8.6%)
N America	3,107,205 (11.8%)	9,663,632 (35.9%)

Data from ITTO (2003)

Table 5

Export Trade in Major High Value Tropical Hardwoods 2001

Species	Volume (1000m3)	Unit Value (US$/m3)	Total Value (US$1000)	Product	Countries	
Khaya	29	254	7,366	sawnwood	C D'Ivoire	
ivorensis	10	555	5,550	sawnwood	Ghana	
	2	1,909	3,818	veneer	Ghana	
total	*41*		*16,734*			
Tectona	127	198	25,146	logs	C D'Ivoire	
grandis	293	472	138,296	logs	Myanmar	
	694	115	78,810	sawnwood	Myanmar	
	6	2,413	14,478	sawnwood	Thailand	1
		854	854	sawnwood	PNG	
	1	277	277	veneer	Myanmar	
	14	163	2,282	plywood	Myanmar	
total	*1,136*		*261,143*			
Swietenia	7	887	6,209	sawnwood	Bolivia	
macrophylla	9	388	3,492	sawnwood	Indonesia	
total	*16*		*9,701*			
Pterocarpus	114	no data		logs	Gabon	
macrocarpus	30	90	2,700	logs	Myanmar	
	6	89	534	sawnwood	Myanmar	
indicus	1	434	434	sawnwood	PNG	
total	*151*		*3,668*		*excludes Gabon*	
Cedrela odorata	19	515	9,785	sawnwood	Bolivia	
Total	**1363**		**301,031**			

Data from ITTO (2003)

Table 6

Australian Imports of Tropical Hardwoods 2002

Product	**Volume** (m^3)	**Unit Value** (US$)	**Aggregate Value** (US$1000)
Logs	1,492	484	722
Sawnwood	94,105	514	48,370
Veneer	16,418	691	11,345
Ply	54,970	404	22,208
Total	**415,225 [1]**		**82,645**

[1] estimated roundwood equivalent assuming 40% recovery for processed products

Data from ITTO 2003

Table 7

Nett Area of Tropical and Sub-Tropical Plantations 1995

Species/Group	Area (ha)	Percentage	Major Countries
Major High Value Hardwoods			
Tectona grandis	2,246,559	4.0	India, Indonesia, Central America, Caribbean, Bangladesh, Cote D'Ivoire
Dalbergia sissoo	626,020	1.1	India, Pakistan, Bangladesh, Nepal
Gmelina arborea	418,050	0.7	Latin & Central America, Brazil, Congo, West Africa, Philippines, Malaysia, Indonesia, Solomon Islands
Terminalia spp	303,957	0.5	Costa Rica, Congo, West Africa, Solomon Islands, PNG
Swietenia macrophylla	151,214	0.3	Indonesia, Fiji, Central America, Caribbean, Philippines, Cameroon, Sri Lanka, West Africa
Total	3,745,800	6.6	
Utility Hardwoods			
Eucalyptus spp	9,949,588	17.7	India, Brazil, South Africa, Vietnam
Acacia spp	3,904,307	7.0	Indonesia, China, Bangladesh, Thailand, Philippines, Sierra Leone, India
Casuarina spp	787,200	1.4	India, Vietnam, Thailand, East Africa, West Africa
Total	14,641,095	26.1	
Other Hardwoods			
Miscellaneous	13,920,826	24.7	
[Rubberwood	8,910,000		Malaysia, Thailand, Indonesia, Philippines] [1]
Softwoods			
Pines	14,538,234	25.8	Chile, Brazil, Australia, South Africa, China
Other Softwoods	9,479,495	16.8	China, East Africa, Australia
Total	24,017,729	42.6	
Total	**56,325,450**	**100.0**	

Data from Brown (2000)

[1]Data from Durst *et al* (2004); area not included in totals or percentages

Figure 1

Factors Influencing Success of a HVH Industry