Department of **Employment, Economic Development and Innovation**

African mahogany

Abstracts from ‘Darwin 2011– African Mahogany Plantation Industry Forum’

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Preface

This publication summarises the talks presented at 'Darwin 2011 – African Mahogany Plantation Industry Forum' held at the Department of Resources Research Facility, Berrimah, Darwin, 31st August and 1st September 2011.

The forum brought together a vast amount of experience and knowledge about African mahogany and its prospects as a plantation timber tree in the dry tropics of northern Australia. The abstracts and references represent a valuable body of knowledge, building on information recorded in previous African mahogany workshops in Mareeba (2004) and Townsville (2006).

Besides the presenters' abstracts, this publication provides a list of all the authors and their contact details and a complete list of all the cited references and further reading.

Acknowledgements

The forum was organised jointly by the Northern Territory Department of Resources and the Queensland Department of Employment, Economic Development and Innovation. The forum organising committee comprised Geoff Dickinson, Alex Lindsay (DEEDI) and Don Reilly (DoR).

The committee gratefully acknowledges the support of the forum's major sponsor, Forest and Wood Products Australia, and our additional sponsors: African Mahogany Australia, The Huntley Group, Kimberley Timber Corporation, Plantation Management Partners and Woodmasters.

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Peter Bergin and Rod Connelly for their help leading up to and during the forum;

Jason De Araujo and Susan House for producing versions of the book of abstracts for the forum and as an electronic publication, respectively.

Finally, we wish to thank the forum presenters. The forum marks a watershed in the culmination of knowledge and experience in growing African mahogany, and is rich with contributions from private and commercial growers, research agencies, universities and government departments working across northern Australia. The expertise and dedication of the contributing authors is keenly acknowledged.

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An overview of African mahogany in Africa

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Abstract

The five species of African mahogany (*K. senegalensis*, *K. grandifoliola*, *K. anthotheca*, *K. ivorensis* and *K. madagascarensis*) are under threat across their native range from loss of habitat and indiscriminate logging. The International Union of Conservation of Nature (IUCN) rates all species as vulnerable and *K. madagascarensis* as endangered. The genetic diversity of the genus has been, and will continue to be, reduced unless action is taken. African mahogany timber is widely used for building and furniture and is widely sort after in international markets. Besides its timber value, African mahogany is used for a wide range of medicinal purposes by local communities and is attracting attention from international researchers for its medicinal properties. African mahogany, particularly *K. senegalensis* and *K. anthotheca* is used for amenity, fodder, agroforestry and environmental purposes. Interest in *K senegalensis* as a plantation tree for high value wood products is increasing, and species domestication is in the early stages in a number of tropical countries, although Australia is by far the world leader at this stage. Potential tree improvement programs will benefit from a wide genetic base.

Impact and application

A project to preserve the genetic diversity of the genus *Khaya*, particularly *K. senegalensis* is suggested. Such a project will have international and native community benefits.

Keywords: *Khaya senegalensis*, *Khaya grandifoliola*, *Khaya ivorensis*, *Khaya anthotheca*, *Khaya madagascarensis*, conservation, African mahogany.

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Mahogany industry, research and development in the Northern Territory

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Abstract

The potential of *Khaya senegalensis* (Ks), an African mahogany that produces wood of high value, came under scrutiny of forestry researchers in northern Australia due to its high survival, termite tolerance and promising timber yields in most of the extensive trials of the early 1970s at Gunn Point, Howard Springs and Melville Is. The rapid growth shown in street trees planted after the

1974 cyclone in Darwin and elsewhere including Katherine and other lower rainfall areas indicated further potential as a plantation species in the seasonally dry tropics of north Australia. As well, the species was the most promising among many species planted in replicated trials over a range of locations and sites between 1998 and 2001 via an NHT funded project. Further, Ks is not severely affected by to shoot borer in the Top End.

Provenance trials planted at Gunn Point in the early 1970s showed that a range of natural provenances grew well there. These stands plus those at Howard Springs and Melville Is. contain trees from seed from 24 provenances from 11 countries of nativity. Recognising the breadth of base represented there, superior trees were selected in 2000, grafted then planted in Dec., 2001 into two seed orchards. Some 143 clones are established. One graft flowered in 2003, and a general flowering and seed production occurred in 2007 with the first seed harvest in 2008. The progeny from the seed orchard has now been planted in two successive years; Katherine Research Station in 2010 and AMA land in 2011 for the purpose of progeny testing and, potentially, future seed orchard facilities.

In addition, a hedge garden was established in 2004 at Berrimah (NT) with the aim of producing rooted cuttings for further deployment. The first clone test was planted at Coastal Plains Research Station in 2005 with rooted cuttings derived from the hedge garden. Subsequent clone tests have been established since then with a focus on determining the best clones/families and matching clonal material to specific sites.

As a result, this program is now yielding partially-tested clones for semi-commercial deployment and small quantities of seed from the seed orchards for 2nd cycle progeny evaluations. To date, the Ks Tree Improvement Program (TIP) has been unable to meet the needs of the rapidly expanding commercial plantation estate with supply of improved seed. Therefore companies have been forced to source diverse native Ks from Africa to satisfy their planting needs. A number of provenance trials have been established both in the NT and Queensland by commercial companies in collaboration with the Government *Khaya* breeding program. This will permit evaluation of the many discreet seedlots sourced from Africa over recent times. This has further broadened the genetic base in Australia and complemented the germplasm introduced decades earlier.

Impact and application

From a research perspective, the need is to identify ‘selection age’ trees in clone tests and provenance trials to induce juvenile shoots for propagation and release these to nurseries and tissue culture labs for evaluation.

Keywords: African mahogany, hedge garden, provenance, seed orchard, propagation

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Mahogany industry, research and development in Queensland

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Abstract

Khaya senegalensis is a high value timber species with great potential for plantation establishment in the monsoon and dry tropics regions of Queensland. It was first introduced into Queensland in the mid 1960's as a rehabilitation species for bauxite mined land at Weipa on Cape York Peninsula. It was quickly recognised for its high potential for reforestation, with 160 hectares established by 1985. While little further *K. senegalensis* mine-site plantation establishment has occurred in this region, mahogany's appeal as a shade and amenity tree continued to grow and it has now been extensively planted in tropical towns and cities throughout much of north Queensland.

Since the mid 1990's, the wide adaptability of mahogany and its appeal as an ultra high value timber has resulted in the ongoing establishment of numerous private forestry blocks (60 landowners with plantation block sizes ranging from <1 ha to some 60 ha). Now totalling approximately 250 hectares, these are primarily located in the dry tropics area between Mareeba and Bowen. One Managed Investment Scheme initially established by Northern Tropical Timbers and now managed by the Huntley Group, also established 340 hectares of *K. senegalensis* plantations near Hopevale/Cooktown in 2005-2006. There is now estimated to be a total of 780 hectares of *K. senegalensis* plantations in Queensland in mid 2011.

In 2001, a collaborative conservation and tree improvement program was initiated between the Northern Territory and Queensland governments. This joint government program is now yielding partially-tested clones and seed for a second cycle of tree improvement, with the first progeny tests established in 2009. A comprehensive summary of industry research and development progress and needs to achieve a sustainable *K. senegalensis* plantation industry in northern Australia were summarised in detail by Nikles *et al.* (2008). This presentation updates the information reported in 2008 with particular reference to research work in Queensland in recent years.

In 2008, a major R&D funding boost was injected into the *K. senegalensis* industry via the Queensland government funded Smart Forests Alliance project; a unique collaborative research venture between the Queensland and Northern Territory Forestry Research groups, CSIRO and the University of the Sunshine Coast. Utilising world-leading biotechnology and other smart sciences, this project has made substantial progress in *K. senegalensis* research over the past 3 years.

Impact and application

This paper describes key initiatives of the Smart Forests Alliance project in molecular breeding cloning technologies, wood and fibre resource characterisation and reproductive biology.

Keywords: *Khaya senegalensis*, industry, Smart Forests, molecular, breeding, tree improvement, cloning, reproductive biology, resource characterisation, Australia.

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State Government African mahogany research plantings in the Ord River irrigation area, Kununurra, WA

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Abstract

Early sandalwood (*Santalum album*) silvicultural research in the late 1980's tested several timber species in conjunction with sandalwood including *Khaya senegalensis*. The aim was to discover suitable hosts for sandalwood that could provide an additional commercial product. Under this scenario sandalwood growth was not always favourable; however the encouraging growth rates of some host species stimulated the planting of trial plots for timber species monocultures. Subsequent trials were established from 1996 to test the growth performance of 11 high value timber species including *Khaya senegalensis* on flood irrigated, cununurra cracking clay soil.

All trial plots were laser levelled and mounded for flood irrigation. The plots received minimal silviculture; with limited stem pruning, no thinning and no fertiliser application. Flood irrigation was applied approximately once a month during the dry season since establishment.

Trials were measured in 2008 and the results summarised in Table 1. African mahogany had good survival under Kununurra conditions. More than 90% of trees survived within all trial plots

assessed. Growth rates (DBH MAI) across trials was relatively constant at between 2.4 and 2.8 cm per year. Bole volumes as measured are presented however they are greatly influenced by bole length which was not optimised due to a lack of early pruning.

Whilst there was no formal assessment made of stem straightness, it was observed across all trials that a large proportion of trees had crooked stems and very few trees displayed apical dominance. The ability of African mahogany to survive and grow well in a range of competitive environments, including presumed parasitism from sandalwood, should allow for flexible silviculture regimes with various thinning options likely to produce desirable growth rates

Table 1. Summary description of trial plots in which *Khaya senegalensis* was planted.

Year	Total SPH	Khaya SPH	Mean DBH (cm)	Bole length (m)	Ht (m)	Est Bole Vol (m^3)	Ha Bole Vol (m^3 ha^{-1})	Design note
1987	1100	40						Mixed host demonstration site, random spacing
1996	926	116						Progeny trial for sandalwood, planted with *Dalbergia* and *Cathormion*
1996	1389	694	33.6	3.4		0.302	209.6	Alternating line planting at 1:1 ratio with *Enterolobium* sp.
1996	1136	1136	22.3	3.5	11.2	0.137	155.4	Single species block planting
1997	1235	146	26.4	2.7	13.6	0.148	21.6	Multi-species plot with sandalwood, *Sweitenia*, *Cassia* and *Cathormion*. Established host:sandal ratio 2:1
1997	1170	1170	15.3	3.5	11.3	0.064	75.3	Timber species trial with *Dalbergia retusa*, *Swietenia mahogani*
1999	926	463	24.3	1.7		0.079	36.5	Block plantings with sandalwood, established host sandal ratio 1:1
1999	833	833	24.7	4.7	12.8	0.225	187.7	Single species block planting

Impact and application

These plots offer opportunities to explore mid-rotation thinning options and collect data on wood quality, wood chemistry, water relations, carbon allometrics and phenotypic genetic improvement.

Keywords: Flood irrigated, *Khaya senegalensis*, sandalwood host, species evaluation, tropical hardwoods.

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Moongubulla: African mahogany farm forestry plantation in north Queensland

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Abstract

This is a case study from a small-scale grower who planted mahogany on her property 60 km north of Townsville, The author had been impressed by mahogany tree growing on harsh sites in western Queensland, where she had run a cattle station for several decades before moving to the coast.

The property at Moongubulla is well suited to running cattle and also meets the rainfall and soil conditions required for growing African mahogany. The non-irrigated trees have performed very well in the face of record dry conditions and three cyclones.

The industry needs to overcome current impediments to growing African mahogany such as scarce funding for genetic improvement; scarce, accessible advice and information; a lack of timber mills that would attract investment; the instability of MIS companies; a lack of market options for thinnings and mature timber. Given the success of the trees in western areas, the industry should look at the potential for small-scale woodlots around homesteads, using water provided by artesian bores. Overall, the experience of growing trees has been positive, and personally very rewarding.

Impact and application

This paper describes one grower's experience and discusses some challenges that currently constrain African mahogany plantation development in northern Australia.

History, status and suggested collaborative strategy for furthering the domestication of African mahogany (*Khaya senegalensis*) in northern Australia

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Abstract

Background on African mahogany (*Khaya senegalensis* - Ks) in Africa and examples of fine furniture made from it in France in colonial and later times are given. Some of the excellent products of Australian, plantation-grown Ks trees are illustrated. Features of the species in northern Australia, including its broad adaptability and a few currently negative traits, are mentioned. The locations of substantial plantings established sporadically since the 1960s in the Northern Territory (NT), Queensland and Western Australia (WA) are shown, including more than 9,000 ha established since 2006 in the Douglas-Daly region of the NT where, significant private-sector planting is ongoing. An abbreviated chronology of R&D with Ks in Australia covering the 1960s to

the present is provided. **Australia has a strong competitive advantage to exploit in developing a Ks industry.**

The moderately-broad genetic base re-discovered in the NT in 2000 and the strategy adopted then to begin the domestication of Ks in Australia via small, grafted seed orchards and clone and progeny tests, as well as some achievements and needs, are outlined. The internationally-unsurpassed breadth of germplasm accumulated via the programs of governments in the 1960s–2000s and new, complementary and supplemental accessions via the private sector in the 2000s, and the need for its conservation are emphasised. In view of the illustrated success of genetic improvement of other forest tree species, and evidence of genetic variation within Ks, it is suggested that this species also will respond to breeding by recurrent selection.

It is proposed that the genetic and other resources accumulated in the public- and private-sector programs be pooled for a collaborative, domestication program. A broad strategy for the genetics component of such a joint program is diagrammed, and some optional/sequential methods of genetic improvement (not mutually exclusive) that could be implemented are described briefly. The methods, including identification of promising clones in the preliminary tests as old as 6.5 y and their re-propagation for inclusion in advancing-front seed orchards, breeding and further testing, would bear further investigation.

Benefits of collaboration are indicated and examples of existing collaborative arrangements in Australian Forestry and Horticulture are given. The outcome of a collaboration-development workshop concerning other species with participants from the public and private sectors held in south Queensland in 2010, *viz*. a decision to move jointly towards a Subtropical Tree Improvement Alliance, is noted and is suggested as one possible guide for planning collaborative R&D with Ks. Ten sectors of the current or future Ks industry are listed as potential sources of collaborators to further domestication of the species in Australia.

Reasons to pursue a collaborative approach to domestication are summarised and a challenge is issued to growers and other industry stakeholders to form and implement an ‘African mahogany improvement alliance’. A goal, tasks and targets for such an alliance are suggested.

Impact and application

Currently Australia is the world leader in domestication of African mahogany and holds the broadest *ex situ* collection of genetic resources internationally. However, the work is fragmented and other resources are limited. It is proposed that the well-recognised benefits of collaboration might be realised by pooling genetic and other resources accumulated in the public- and private-sectors for a joint domestication program. Examples of successful existing collaborative arrangements in Forestry and in Horticulture encourage this approach.

The challenge to growers and other industry stakeholders is to combine forces in a well planned and efficiently implemented collaborative effort with a clear goal, tasks and targets.

Keywords: Domestication, African mahogany, *Khaya senegalensis*, breeding, collaboration, industry challenge

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The African mahogany breeding Joint Venture

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Abstract

Establishment of African mahogany (*Khaya senegalensis*) plantations commenced in the Northern Territory in 2004, and now stand at approximately 11,000 hectares. The seed to establish these plantations was collected from wild sources in the Sahel region of Africa with most collected in Mali. During the period when Great Southern Plantations were involved in African mahogany plantations in the Northern Territory, five provenance trials were established with provenances from across the natural range, although biased towards localities in the western extent of the range. Four trials were established in 2008 and one in 2009. The 2008 trials have recently been measured and the results are presented. Results show consistencies across all sites. A further trial was established in 2011 which included entries from Sudan.

A tree improvement Joint Venture (African Mahogany Genetics) has been established to rapidly develop resources of genetically-improved *Khaya* for deployment in Australian and overseas plantations. AMG will draw on the existing provenance trials for information and material to advance the Joint Venture.

Impact and application

Develop a commercial tree improvement program for *Khaya senegalensis*.

Keywords: *Khaya senegalensis*, tree breeding, genetics, provenance trials, plantations.

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Floral structure, reproductive biology and pollination methods of African mahogany (*Khaya senegalensis*)

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Abstract

We studied flower structure, reproductive biology and pollination of *Khaya senegalensis* over two flowering seasons. Flowering trees in Darwin, NT and Walkamin, QLD seed orchards and of individual select trees were observed. *K. senegalensis* is monoecious, and both male and female flowers are produced on the same panicle. Panicles contain several hundred flowers and until now this has made controlled pollination difficult. The flowers are either functional male or female and can only be distinguished by the naked eye at flower opening by differences in the appearance of the anthers. Most flowers on a panicle are functionally male.

Our research has found a strong peak in female flower opening between 15 to 19 days after the first male flower opens on the panicle. This is an important finding as female flowers can now be identified and pollinated en mass for tree improvement. Additionally, we found that functional female flowers occur at specific positions within the inflorescence. The presence of pollen tubes in the style 24 hours after the opening of the female flower, suggest that fertilisation occurs within 24 hours after flower opening.

With this increased knowledge on floral structure and reproductive biology the first controlled pollination experiment on *K. senegalensis* was conducted at the Walkamin seed orchard during the 2010–11 flowering season. Treatments included self-pollination, intra-provenance cross pollination, inter-provenance cross pollination, open pollination and no pollination (bagged control).

Impact and application

We report here successful pollen germination and pollen tube growth through the style in our controlled pollination treatments, but not in our bagged control, showing that our methods have potential for producing improved *Khaya senegalensis* through a breeding program.

Keywords: floral structure, *Khaya senegalensis*, pollination, reproductive biology

Khaya senegalensis: Population structure

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Abstract

Information about the intra-specific diversity of *K. senegalensis* is of key importance to enhance existing domestication and breeding programs e.g. by parentage assignment of selected elite clones and facilitating marker assisted selection, and to improve the conservation management of this threatened species. To assess genetic variability in natural populations of valuable agroforestry tree species DNA fingerprinting techniques have been widely used in the past. Microsatellite markers are considered the method of choice for the study of plant populations due to their co-dominant nature, high levels of polymorphism and reproducibility and are more informative than dominant marker data for the estimation of population structure and genetic diversity.

The major drawback of microsatellite markers has been the high cost of developing species-specific markers. Recently, this has been alleviated with the advent of next-generation sequencing that allows the rapid identification of microsatellite loci. A lack of suitable DNA markers has hampered assessment of molecular genetic diversity, phylogeography and co-ancestry of the breeding populations of *K. senegalensis*. Application of such knowledge would allow more informed selection of parents in future breeding programs and reduce the problems of inbreeding. Genotype information will also assist in determining priority in conservation efforts and aid selection of novel germplasm for incorporation into breeding programs.

Here we report the development of novel microsatellite markers for *K. senegalensis* derived from next generation sequence data and a preliminary assessment of the genetic diversity based on a sample of 151 *K. senegalensis* accessions sampled from across its natural range.

Analysis of the RAPD data gave a weak indication of an East-West separation of two main genetic groups. RAPD data are not very informative compared with microsatellite data. We addressed this problem with the identification and development of novel microsatellite markers that will help to facilitate a more thorough evaluation of this species.

The capture of native range biodiversity for conservation and breeding purposes is a priority given the declining populations of *K. senegalensis* in Africa. Initial investigations have indicated higher levels of genetic diversity present in western Africa. This suggests that new seed collections from this region may yield more diverse genotypes than those originating from Sudan and Uganda in eastern Africa. It is likely fortunate, therefore, that the much greater part of numerous recent seed collections (2007–2009) has been from western Africa. However, there may be non-neutral markers and genes within eastern populations conferring adaptive advantage in some exotic environments, so monitoring of such populations in existing trials should continue.

Impact and application

This study represents first pan-African assessment of genetic diversity for *K. senegalensis*. We initially studied populations with the RAPD method due to a lack of microsatellite sequence information at the time.

The STRUCTURE analysis of microsatellite data inferred a population structure with two groups representing samples from eastern Africa and western Africa, with an overlapping zone in central Africa.

Keywords: *Khaya senegalensis*, molecular breeding, microsatellite, biodiversity, population structure.

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The *Khaya senegalensis* breeding program of the Northern Territory and Queensland Governments

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Abstract

Khaya senegalensis is an internationally recognised, high-value, forest tree species that has great potential for plantation expansion in northern Australia. Annual plantation establishment over the past 3 years has been 1500–2000 hectares/annum; and the total estate is presently about 10000 ha. All plantations have been primarily established using seed from native trees in Africa or occasionally from Australian land race sources. Genetic improvement of this species for Australian conditions is urgently required to improve growth, straightness, average bole length and branching and the proportion of trees with a high heartwood percentage and quality in short-rotation plantations.

Khaya senegalensis has a very wide and disjunct natural distribution across 19 countries in sub-Saharan Africa. Given the great diversity of its habitats and its disjunct populations, different provenances are expected to exhibit a considerable variation, reflecting genetic and physiological adaptation. Thus a genetic improvement program with a broad base of germplasm is expected to realise large gains.

In 2001, a conservation and tree improvement program was initiated in the Northern Territory using selects from provenance and other trials established in the late 1960s and 1970s. Selects from all 26

provenances from 11 countries and some of unknown origin were grafted and established in clonal seed orchards. Work by the Queensland Government began later in the 2000s; this has now been merged with the Northern Territory program. This joint government program is now yielding partially-tested clones for further evaluation and small quantities of orchard and select-tree seed for a second cycle of tree improvement that commenced with the planting of progeny tests from orchard seed in 2009, 2010 and 2011.

Seed orchard management (irrigation, nutrition, canopy architecture), flower induction (e.g. paclobutrizol treatment) and pollination biology activities are underway to increase and enhance seed production. Over the past 2 years, seed orchard seed has been established in five progeny trials in Queensland and the Northern Territory, to quantify improvement gains and to act as second generation facilities to continue the breeding cycle. An exchange of this germplasm with African native provenance select seed has also been initiated with the Burkina Faso National Forestry Seed Centre. The program has also collaborated in studies of vegetative propagation, of molecular diversity of the species and of wood products. This paper describes some of these most recent activities.

Impact and application

The main priority of the Northern Territory – Queensland government program is to improve our understanding and management of existing clonal and provenance seedling seed orchards to increase seed supplies for breeding purposes and for commercial deployment to industry.

Keywords: *Khaya senegalensis*, breeding, tree improvement, conservation, provenance, Australia.

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Early performance of a wide range of African provenances of *Khaya senegalensis* grown in Queensland and the Northern Territory

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Abstract

Khaya senegalensis is the most widely planted high value timber species in northern Australia, with over 10,000 hectares established in the Northern Territory, Queensland and Western Australia, mainly since 2005. All plantations are established utilising either African natural provenance or Australian land race seed sources. Despite the high plantation potential of this species, there is an urgent need to improve growth, straightness, average bole length and branching. Earlier production and a higher proportion of heartwood is also desirable.

African mahogany has a very wide and disjunct natural distribution across 19 countries in sub-Saharan Africa. Given the great diversity of its habitats and its disjunct populations, provenances are expected to exhibit considerable variation, reflecting genetic and physiological adaptation. Unmanaged Australian land race seed sources are also more likely to suffer from inbreeding depression and hence poor progeny performance. The identification of superior provenances and the advancement of a genetic improvement program with a broad base of germplasm are expected to realise large gains.

Large provenance trials involving 23 provenances from 11 African countries and three landrace provenances from New Caledonia, were established in the Northern Territory in the early 1970's, although these were compromised by cyclones and poor management. Growth and wood quality assessment analysis was greatly affected by site variation; however there was some evidence that some provenances from west-African countries (particularly Senegal) performed better and the landraces from New Caledonia the poorest. Over the past few years, private plantation companies have acquired diverse native sources of *K. senegalensis* seed (>100 provenances from 7 countries). These recent infusions complement the germplasm introduced in the 1960s and 1970s, as they include new provenances which are not represented in the Northern Territory – Queensland government breeding program. Pooling of these two resources would greatly broaden the genetic base in Australia, enhancing tree improvement and conservation outcomes.

Five large provenance trials were established by Great Southern Limited in collaboration with the Queensland government in 2008 and 2009. These sites have now changed ownership. Recently, with the approval of one of the new managers; African Mahogany Australia Teak (AMAT), a large provenance trial near Ingham, Queensland (comprising 43 provenances from 7 countries) was remeasured at age 3 years.

Impact and application

Statistically significant variation was observed between provenances and between country of origin for the parameters of height, diameter, straightness, axis persistence, leaning (cyclone effect) and

the canker disease (*Erythricium salmonicolor*) at age three. Implications of these results are discussed.

Keywords: *Khaya senegalensis*, provenance, Africa, Australia, landrace, seed.

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Comparison of mahogany clones planted on a range of sites in the Northern Territory and Queensland

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Abstract

The *Khaya senegalensis* (African mahogany) Tree Improvement Program has, as its main aim to improve the species for Australian conditions. Major improvements in tree form and increasing bole length are seen as key attributes to increase commercial returns from plantation grown trees.

A hedge garden, established at Berrimah Farm in 2004, now comprising more than 560 individual plants has been used as source of 'cuttings' material for deployment in replicated trials at numerous sites across the NT and Qld to evaluate individual clone performance and 'clone x site' interaction. Seedlings from selected sources, used as controls were also deployed with the clonal material. The clone test program began in 2005 with the first tests being established at a Government research station east of Darwin.

Subsequent clone tests have been established on commercial and Government lands in the Katherine/Daly regions where the plantation development is occurring. This region is characterised by a mean annual rainfall of 800-1000mm with a distinct dry period from May – October. Additional tests were planted on wetter sites in the NT (Melville Island) and in Queensland, but results are not presented here.

Each clone test has a unique combination of clonal material from the hedge garden, although many clone numbers are repeated across the series of tests. The clones are planted in replicated blocks, varying from 2–5 reps in any one test. The low numbers of replicates per test and/or clones in some tests can be attributed to the great clonal variation in rootability. The position on the hedge plant from where the cuttings are sourced may also account for the great deal of inconsistency apparent

across the reps. The very young age of the clone tests (oldest now 6.5 years old) could also account for the inconsistency of promising clone numbers resulting from each measure. At each measure event, the list of 10–20 most promising clones, changes. This is most evident from the list of 'seemingly better clones' from CT 1(a) released to industry at their request when the first CT was only 18 months old.

Impact and application

Clone tests have been measured on a regular basis with a view to identify promising clones and/ or families. To this stage the more promising families can be identified with some certainty, but superior individual clones are proving much more difficult to determine.

Keywords: African mahogany, clone test, plantation, replicates.

Commercialisation and mass production of mahogany clones – a nursery view

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Abstract

Clonal Solutions Australia Pty Ltd (CSA) is licensed to commercially produce 55 *Khaya senegalensis* clones selected from the DEEDI-DoR alliance. CSA has successfully produced the clones by cuttings and tissue culture, and has produced about 100,000 plants to date. One of the key factors determining cost and hence commercial viability of clonal *Khaya* production, is the 'propagatability' of each of the individual clones. For cutting production, CSA determines 'propagatability' in terms of a propagation index based on a combination of three key factors: strike rate, motherstock yield and production time. CSA's propagation data to date show that the 55 *Khaya* clones vary considerably in their propagatability, with propagation indices ranging from 800 for the best clones down to 30 for the worst. CSA has ranked the 55 clones and is now seeking to correlate this ranking with field performance data in order to select the best 5–10 clones for commercial production for large-scale plantations.

Other factors that impact on the cost of clonal production are the size of orders and the lead time given to produce the orders. Since the biggest costs in clonal production relate to skilled labour, motherstock production and maintenance, and high-tech facilities, efficiencies (and therefore cost savings) are achieved where the maximum quantity of plants is produced from the minimum amount of motherstock, and where the motherstock is used for steady continuous production over a long period of time.

Clonal propagation is exponential, and hence there is a lengthy lead time between the initiation of a clone into the nursery propagation system and the production of commercial quantities for deployment to plantations. In breeding programmes, this lead time can be reduced considerably by running propagation trials in parallel with breeding and field trials (rather than finishing the breeding programme and then passing the selected clones to the propagation nursery) so that the final clonal selection is based on both field performance and propagatability. Therefore, the most successful clonal production programmes are based on close relationships and partnerships between the breeders and the propagation nursery.

Impact and application

Propagation data is presented to support the reduction in the number of clones from 55 down to the best 5–10 clones. Factors affecting the cost of clonal propagation are explained to assist plantation owners in reducing costs in establishing clonal plantations.

Keywords: Clonal propagation, Clones, *Khaya senegalensis*, Propagation index

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Clonal Solutions Australia Pty Ltd www.clonal-solutions.com.au

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Synthetic seeds to transport and propagate tissue-cultured plants

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Abstract

Establishment of *Khaya senegalensis* plantations has been constrained by limited seed supply and slow plant production using conventional cuttings. We have developed micropropagation and encapsulation methods for proliferating and storing juvenile germplasm of this species. Shoots are proliferated in Murashige and Skoog (MS) medium containing 4.4 µM benzyladenine (BA), and most shoots (76–90%) form roots after treatment with 19.6 µM indole-3-butyric acid (IBA). Each seed produces 61.5–96.1 plantlets within 25 weeks. Shoot tips can be encapsulated as synthetic seeds by immersion in 3% sodium alginate, MS medium and 4.4 µM BA, followed by transfer to 100 mM calcium chloride.

Most synthetic seeds (92–100%) produce shoots when transferred to an MS regrowth medium with 4.4 µM BA, and most synthetic seeds (52–98%) form roots *in vitro* after treatment with 245 µM IBA. Synthetic seeds can be sown directly into non-sterile substrates, although root formation is slightly lower *ex vitro* (42–86%) than *in vitro*. Synthetic seeds can also be preserved for 12 months in darkness at 14°C, with high frequencies of shoot regrowth (71–98%).

These techniques can be used to produce juvenile shoots, plantlets and synthetic seeds of *K. senegalensis* for laboratory storage, nursery production, field testing and germplasm distribution.

Impact and application

Synthetic seeds combine the storage and handling benefits of true seeds with the true-to-type propagation benefits of cuttings. The next challenge is to develop methods for micropropagation and synthetic seed production of selection-age trees.

Keywords: *Khaya*, mahogany, tissue culture, propagation, synthetic seeds.

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Propagation of *Khaya* seedlings

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Abstract

Territory Tree Nursery, 50 km south of Darwin, is the main nursery supplying *Khaya senegalensis* to the plantation industry. Since 2007 more than eight million seedlings have been dispatched. The narrow planting window in the Douglas Daly region (between too dry and too wet) feeds back to the nursery, as the production of planting stock needs to be concentrated as well. The challenges involved with pre-treating seed, mechanical sowing, quality control and staggered germination are discussed.

During the growing and hardening phases, *Khaya* has certain attributes that make nursery management quite challenging, and labour-intensive. The production of cuttings is also outlined, including the preparation of the mother stock, the optimum substrate and hormone, and the controlled humidity required during root initiation. Whether seedlings or cuttings, stock should be 'hardened off' for at least four weeks prior to dispatch, to have the best chance of becoming established in the torrid Territory environment.

Impact and application

In the Top End of the Northern Territory, it takes 22 weeks to produce field ready seedlings, and 32 weeks to produce field-ready cuttings in time for planting in the early wet season. This lead time needs to be factored in during the planning phase of plantation establishment.

Khaya senegalensis wood quality, processing options and product potential

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Abstract

Wood quality assessment of increment cores and the screening approaches used are discussed. Cores from 5.5-year-old NT clonal and seedling trees and 9.5-year-old Queensland (Qld) seedling trees produced heartwood percentages of 22% to 47% (NT) and 32 % to 68% (Qld). This variation is promising as it indicates that by age 10 trees can be selected for increased heartwood percentage and therefore potentially increased product value. Heartwood colour was measured on air-dry cores and after 12 days placed under an ultraviolet (UV) lamp to simulate sun exposure. UV light darkened the samples from a pale colour to light brown colour.

As well, plantation trees from NT (33, 14-y-old) and Qld (31, 18- and 20-y-old) were sawn and veneered (rotary and sliced) to assess recovery and quality. Log end-splitting was minimal and heartwood ranged from 50–92 % of butt cross-sectional area (dark central heartwood and lighter coloured transition wood combined). Dark central heartwood proportion was positively related to tree size (R2 = 0.57). Chemical tests failed to assist in determining heartwood – sapwood boundary. Mean basic density of whole disc samples for QLD trees was 658 kg/m^3 and ranged among trees from 603 to 712 kg/m^3.

Finished sawn board tallies produced 27–30% select grades from both sites with a very low (3–6%) proportion of rejects. Defects that downgraded boards reflected on the poor management history or young age of the stands. The green veneer recovered from seven billets rotary peeled on a spindle-less lathe produced a recovery of 83% of green billet volume with most suitable for use in structural plywood. Total dry sliced veneer recovery from the two largest logs from each location was about 41%, which is quite a good recovery of usable sheets from relatively small logs.

A portable colour measurement spectrophotometer was used to objectively assess heartwood colour variation over time. Selection of phenotypically superior breeding trees for colour differences based on dried samples exposed to sunlight or UV light should be feasible.

Tangential to radial shrinkage ratios, important indicators of wood stability, were low. Near infrared (NIR) spectroscopy models examined their predictability of radial shrinkage (76%) and density (75%). Results suggested the method has potential as a non-destructive means to predict both traits from core samples.

Impact and application

These small scale studies produced very acceptable recoveries of both sawn and veneer products with good wood colour development for young trees. The good representation of higher grades in

the product distribution is encouraging. The prospects for significant improvement in these results from well managed and productive stands of genetically improved stock grown for high quality timber are good.

Keywords: *Khaya senegalensis*, wood quality, veneer, sawing, heartwood colour, NIR, Near infrared spectroscopy

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Utilisation of *Khaya senegalensis* thinnings

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Abstract

The utilisation of *K. senegalensis* thinnings is being explored to ensure the crop realises its maximum value, avoids waste and reducing operating costs. Significant scale thinning operations are due to commence over the next 24 months. African Mahogany Australia conducted two trials testing the viability of both milling and slicing of thinning material.

For the slicing trial,14 logs (20 cm diameter x 3 m length) were sent from Katherine to Brisbane. It was found that the logs kept in a stable condition with minimal end splitting. The logs were soaked at 50°C to soften the log for effective peeling. Logs were sliced on a US slicing machine to 0.6 mm; there was no staining caused by the machinery.

Log form effected recovery rates; shorter logs with less sweep had higher recovery rates. The trial showed colour variance within the logs, meaning the species lends itself to rotary peeling without dying. After slicing, leaves were dried to 10–14% moisture content: the leaves rippled, indicating stress. Further drying alleviated this problem.

For the sawing trial, 24 logs were sent to Tasco in Geelong to be milled in a Hew saw. Sixteen were rejected for poor form or for the end diameter being too small. Eight suitable logs with minimal end checking were sawn. 27 mm x 85 mm x 3 m boards were produced. The issues identified were low yield, size and form of logs, and low janka factor (hardness).

Other options of thinning utilisation include biofuels. The Douglas Daly region is powered by individual property diesel gensets. Thinning material is deemed suitable to fuel a co-gen or gasification plant, reducing the power cost of residents. Other minor market possibilities for thinning products are pellets and garden mulch.

Impact and application

Thinning utilisation is paramount; it will not only assist in offsetting expenses incurred when thinning the plantations, it assists in promoting the industry as one that prevents waste, value adds, creates more employment and promotes new uses for this high value crop. These trials have proven that veneer and timber are possible products from *K. senegalensis* thinnings.

Keywords: African mahogany, biofuel, hew saw, K. senegalensis, sawing, slicing, thinning, utilisation.

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Sawmilling and furniture making: using African mahogany in Darwin

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Abstract

African Mahogany trees have been planted as street trees around Darwin since the 1950s, particularly after Cyclone Tracy (1974). These trees are now quite large, and are being progressively removed, either deliberately or sometimes when they fall over during major weather events. The wood from these trees is highly attractive, and small quantities are being used by Darwin businesses such as Evolution Furniture. Photographs are shown of mahogany desks, filing cabinets, beds, tables, bench tops and bathroom suites.

After a decade of sawmilling experience, it has been found that best results come from allowing logs to dry slowly: for at least two years in log form, then several months after sawing using a combination of air-drying and kiln-drying. Recovery rates of 90% can be realised using the customised bandsaw mill, through thoughtful planning of the initial cutting pattern. The major problem with mahogany wood is "checking", especially in the darker wood. These defects need to be filled in, before finishing the article with lacquer. Mahogany timber that is sawn green can distort badly, giving the timber a bad name. There is room for a public awareness campaign: at the moment "Mahogany" has a bad name in Darwin, but when people see the timber their opinion changes. The other problem is that councils are not proactive in offering mahogany logs for salvage, so a lot of potentially valuable wood goes to the tip.

Impact and application

African mahogany is a very suitable timber for furniture manufacture, and is recognised in the market place as a desirable product. Governments should work together to ensure there is plenty of mahogany timber in the future.

Silviculture of small-scale mahogany woodlots in North Queensland - some observations

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Abstract

Khaya senegalensis has been promoted as the most promising farm-forestry timber species in the Townsville region, but there has been little systematic analysis of expected growth rates or silvicultural prescriptions. This presentation provides an assessment of silvicultural practices and prescriptions, based on two data sets: a network of growth plots established by DEEDI within 150 kilometres of Townsville, and a Nelder Fan Wheel established on the campus of James Cook University. For stands aged between 5 and 10 years, average growth rates were between 6.0 and 9.0 $m^3ha\text{-}1yr^{-1}$, with the fastest growth of 13.5 $m^3ha^{-1}yr^{-1}$ recorded on a free-draining site. Woodlots were typically planted at 4.0 x 4.0 m spacing (625 sph) or 2.5 x 4.0 m spacing (1000 sph).

Total volume did not vary greatly with stand density. This supports the calculation of optimum stand density of 543 stems per hectare (sph) in the Nelder Wheel. Tree form did not appear to be correlated with stand density.

Small-scale woodlots are managed more intensively than broadscale plantations, so the significance of spacing on weed growth is less important. Woodlot owners typically undertake more pruning operations than could be economically justified, including deformed and forked stems which have no potential for timber production. Thinning should be undertaken well before crowns become interlocked, for ease of operation. Planting *Khaya senegalensis* at densities greatly in excess of 625 sph is seen as inefficient: the main advantage is to provide selection intensity for thinning, however this will be less important in future given the availability of improved seed and clones selected for straightness. Wide-spaced *Khaya senegalensis* may be suitable for silvo-pastoral agroforestry systems in the seasonally-dry tropical lowlands around Townsville.

Impact and application

Predicted yields are reported and efficiency measures are suggested, to provide additional confidence and added expertise to potential future growers.

Keywords: Agroforestry, Farm forestry, *Khaya senegalensis*, Silviculture, Woodlots

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Silvicultural operations for managing large-scale mahogany plantations

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Abstract

Decisions on silvicultural regimes and practices must firstly take into consideration a number of variables relating to the management of the plantation: What are the growth habits of this species? Do operational constraints exist? What is the objective for growing this plantation and what will be the final crop? What economic boundaries are we operating within and are there any site limitations with the regime? Is there flexibility for new research findings/field trial results? And how does seasonal variation impact on the implementation of the chosen regime? The solutions to these problems are being worked through, with sound execution of initial establishment operations, plantations will be in good health and vigour to manipulate into a valuable final crop.

Current silvicultural practices being conducted in the Douglas Daly by African Mahogany Australia involve planting into carefully prepared sites at high densities, form and lift pruning to value add, with the intention to thin on two separate occasions. Small variances to these current approaches may occur in the future (e.g. site variances requiring altered silvicultural regime).

Nutrition management, genetic improvement and effective weed control are three elements that are being worked on strategically to continually improve the quality of newly established plantations.

Impact and application

Plantations are responding well to current silvicultural practices. Stocking levels are encouraging straight stems, tree responses to pruning are good and nutrition management is alleviating nutritional stresses.

Keywords: African Mahogany, genetics, nutrition management, plantation management, prune, silviculture, thinning, weed control.

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Landscape-level water-use of mahogany plantations and other land uses

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Abstract

Over the last decade, north Australia has been viewed increasingly as a potential focus for future food and fibre production, given issues of salinisation, soil acidification, over-allocation of water resources and rainfall declines in southern Australian agricultural regions. Some proponents have suggested extracting water resources in north Australia for transport to southern agricultural basins. An alternative is enhanced primary production in the north, achieved via expansion or intensification of grazing on improved pastures, broad-acre agriculture, horticultural and/or the development of plantation forestry.

Further agricultural development in north Australia, especially in the NT and Kimberly regions, would involve clearing native vegetation. Such land use change will have implications for water, carbon and nutrient balances, greenhouse gas emissions and biodiversity, and would increase fragmentation of one of the most intact savanna regions in the world. Cleared sites may be converted to plantation forestry using a fast growing, exotic tree species *Khaya senegalensis* (African mahogany). The water resource implications of these land uses are unknown. To expand these activities in a sustainable manner, land management agencies require data and process-based understanding to adequately assess long-term environmental impacts and assess risks to ecosystems services.

Impact and application

This project will examine the impacts of savanna afforestation and deforestation on carbon, nitrogen and greenhouse gas dynamics and water resources. Specifically, stand scale water use will be compared with native vegetation and effects on soil moisture dynamics and recharge to surface aquifers will be assessed.

Variation between African mahogany clones to damage from two major insect pests

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Abstract

Pilot plantings of African mahogany, *Khaya senegalensis* (Desr.), have showed that this species grows well in the wet-dry tropics of northern Australia, but pest damage has been identified as an important constraint. Of 19 species of pests that are known to attack different parts of African mahoganies in the Darwin area, the fruit spotting bug, *Amblypelta lutescens* (Distant), and the hypsipyla shoot borer, *Hypsipyla robusta* (Moore), are the most important pests, causing considerable damage to the growing shoots, resulting in the death of the shoots and multiple shoot formation. Green ants can successfully control these two pests on mahoganies, but it would be better to have mahogany clones that are resistant to the damage caused by the pests.

A field experiment with regular monitoring was conducted in a block of 145 4-year-old African mahoganies (1.5–3.5 m high; planted at 5.0 × 3.6 m) at Berrimah Farm, Darwin between April 2006 and December 2008. Ninety-five clones were planted randomly in a block. Nine clones that only had a single shoot flushing were not included for detailed analysis.

Fruit spotting bug damaged 71 clones (49 clones were attacked more than twice) but did not damage the other 15 clones. Hypsipyla shoot borer damaged 40 clones (17 clones were attacked more than twice) but did not damage the other 46 clones. Forty clones were attacked by both fruit spotting bugs and hypsipyla shoot borers. Fifteen clones were not attacked by either pest. These clones should be tested further, using larger numbers of individuals per clone and more sites, and taking the other characteristics of the clones into consideration.

Impact and application

Fifteen African mahogany clones were determined, preliminarily, as resistant to damage from the two most important pests, and further testing was suggested. In addition to the use of green ants for insect pest control, the resistant clones may also provide additional confidence to potential growers.

Keywords: Fruit spotting bugs, hypsipyla shoot borer, *Khaya senegalensis*, clone resistance.

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Biology and management of giant northern termite, *Mastotermes darwiniensis*

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Abstract

The giant northern termite, *Mastotermes darwiniensis*, is the main termite pest of horticultural and forest tree crops in NT, although other species, such as *Microcerotermes* species, can cause problems in some situations. The giant northern termite is endemic to northern Australia but also became established in Papua New Guinea last century. The species lives in underground colonies, with no mounds, and in disturbed areas colonies can become very large in terms of numbers (millions) and the area covered. It tunnels up through the centre of trees and early damage can be difficult to detect. Later hollow branches will break or fold, the termites will ring-bark and deposit mud on the outside of the trunks, and death of the tree can result. Activity can be assessed by drilling trees and then checking for mudding after 24 hours. In African mahogany this species will hollow out young trees and ring bark older trees, and this can lead to the death of the plants.

Colonies can cover large areas as shown by evidence from radioactive tracers (CSIRO), fluorescent dyes and DNA (CSIRO). In NT termites have been dusted with dye and the particles are then spread through the colony through grooming, food sharing and coprophagy. Microscope examination of smears of termite faeces under ultra violet light can detect the dye particles and show how far they have spread. Trials have demonstrated transfer of particles up to 140 m in one week and colony sizes up to 220 m in length.

A good termiticide is toxic to termites, non-repellent and slow acting to allow transfer by colony members through the colony by food sharing and grooming. Fipronil (Termidor® and Regent®) has these properties and trials in a number of crops have allowed rates to be set and demonstrated the distance of spread. In African Mahogany the chemical can be soil-injected around plants, but the use of aggregation drums allows a larger number of termites to be treated, which is better for colony

suppression. There is a minor use permit issued by the Australia Pesticides and Veterinary Medicines Authority which allows its use in forestry and another for aggregation drums.

Impact and application

Methods for controlling giant northern termite in African Mahogany are presented, based on experience of this insect in other tree crops.

Keywords: Agroforestry, *Khaya senegalensis*, termites, *Mastotermes darwiniensis*, giant northern termite, fipronil.

Natural resources and regional development through vegetation management planning for land use in the Northern Territory

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Abstract

Healthy landscapes provide essential ecosystem services to deliver clean water, store carbon and maintain biodiversity. To avoid problems from over clearing, development can be planned at a pace we know landscapes and wildlife, rivers and fish can sustain. A draft Native Vegetation Management Bill and amendments to the *Pastoral Land Act* provide the mechanisms for that. They include entirely new controls to deal with greenhouse gas emissions, and regional plans to manage native vegetation and promote orderly development focusing on areas where environmental effects can be minimised.

Safety net retention levels specify how much native vegetation must be retained at large spatial scales. At the scale of individual catchments and sub-catchments, 80% of the pre-settlement level of native vegetation must be retained. At a larger scale (river basin), 90% of the extent of native vegetation must be retained. This means that at least 90% of the whole of the Territory's native vegetation must be kept.

As knowledge improves enough to permit the framing of a meaningful plan for native vegetation management in a region (basin/catchment), a different set of safety nets could be applied through a regional plan. A regional plan is the vehicle by which communities deploy information about a region and its vegetation and other natural resource management issues, aspirations for economic development, and natural and heritage conservation issues raised by land clearing and use it to map a path to a sustainable future. The plans will be subject to approval by the Minister, who will be obliged to ensure that they advance the objects of the proposed Act and adhere to the principles it establishes. The proposed Act requires the participation of a regional committee including strong community representation in preparing the plan.

Impact and application

The draft Native Vegetation Management Bill and proposed amendments to the Pastoral Land Act are at the consultation stage as the first in an integrated array of actions to maintain healthy Northern Territory landscapes and rivers through regulatory reform around vegetation, water and soil.

Keywords: Native vegetation management; healthy landscapes; vegetation retention; regional planning.

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Indigenous forest industry development

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Abstract.

Much of the land with potential to be plantation forestry in northern Australia is indigenous land. This presentation is a case study of the development of a 30,000 hectare plantation forestry estate on the Tiwi Islands. The land owners, the Tiwi people, have had an involvement with forestry since the early 20th century, and the Tiwi elders see forestry as an important part of realising their desire for an economy independent from welfare. On the back of education, the Tiwi elders wish to build a future based on the sustainable use of their natural resources, creating jobs and an economy, so Tiwi people can work and reside on their own country. There are many challenges to overcome, including unwillingness by major banks to lend money to indigenous groups, opportunists who seek "cheap" land rather than longer-term partnerships, and government policies, which do not necessarily align with indigenous economic development.

Impact and application

Developing commercial projects on indigenous land is challenging. It is intended this paper adds to the debate and leads to an alignment of Government and commercial interests to help indigenous Australian's realise a welfare-independent economy.

Future direction of the forestry and forest products industry in northern Australia

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Abstract

The northern Australia forestry study examines opportunities for the northern Australia forestry industry in the wake of the CSIRO *Northern Australia Land and Water Science Review* (October 2009); collapse of agroforestry managed investment schemes, and aspirations to utilise native forest for limited timber production.

A fundamental aspect of this study is to consider whether commercial forestry is a long term viable option in northern Australia taking into account sustainable management of natural resources and economic, social and environmental goals.

Within 'theme' activities, the study provides the broad direction of suggested future, forestry industry-related development in northern Australia. Such actions would need to be supported by:

- Maintenance and/or an increase in Federal and state government financial and technical inputs.
- Development and implementation of forest policy, plantation codes of practice and good neighbour charter.
- Promotion of forestry as a viable alternative to other land use activities.
- Funding mechanisms and models for plantation development.
- An audit of native forest suitable for limited, sustainable timber production.
- Assessment of land availability for viable plantation development.
- Collaborative research and development to address a range of forestry activities.
- Development of technical services, including those related to pests and diseases.
- Research and development of forest products, including the sawing, drying and further processing of solid wood products from small diameter logs.
- A study of wood flows, project economics and markets to underpin the development of processing facilities.

Impact and application

The study suggests there is merit in refocusing the present emphasis on temperate forest industry research and development towards northern Australia. The study concludes that by doing so opportunities identified to expand the tropical forestry based on sound commercial, planning, advocacy and research foundations could be progressed.

Keywords: Northern Australia, commercial forestry, development, sustainable management, research

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Benchmarking the African mahogany plantation industry in Australia; with an eye toward emerging SE Asian markets

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Abstract

The Australian plantation forestry industry is undergoing a structural change as a consequence of the demise of a number of Managed Investment Schemes (MIS), and privatisation or monetisation of State owned resources. Overarching the current structural change in the Australian marketplace,

is the poor outlook for the world economy on the back of debt issues in Europe and the United States of America, creating tight funding conditions for Private Equity investment in Timberland assets. This paper reviews recent African mahogany plantation development in Australia, and in light of the fragile global economy, identifies the challenges the industry faces in attracting new greenfield investment with an emphasis on competing with our emerging market neighbours.

Impact and application

The overall attractiveness of greenfield plantation development is discussed in light of the prevailing investment environment.

Keywords: African mahogany, Australia, cost, investment, plantation, South East Asia

Further reading

Australian Bureau of Statistics www.abs.gov.au
National Institute of Statistics of Cambodia www.nis.gov.kh
World Bank www.worldbank.org

Where to now, no more money, no more trees

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Abstract

This presentation provides some background to the investment structure of parts of the African mahogany plantation industry in northern Australia. The industry started in a pressure cooker environment fed by the Managed Investment Industry. The interest in the north was probably sponsored by the comparatively low cost of new forest lands. There has been a consolidation of ownership of forestry in Australia since the Global Financial Crisis (GFC) which led to the collapse of Managed Investments in Australia such that only one company has any plans for planting African mahogany in the coming financial years in the Northern Territory.

A reality check is in order when talking about the prospects for an African mahogany industry in Australia. Although the trees grow well, the risks in growing the crop are still untested, there is no existing processing industry, no established market for plantation-grown mahogany and limited infrastructure in the area that the trees are being grown. From an investment perspective this makes African mahogany a highly speculative investment .

The industry needs to compete with other 'venture capital' investments. Venture capital investments aim to return more than 20% return on investments with a risk profile such as mahogany in the tropical north. In the post-GFC and post MIS world venture capital funds are still there but are looking to investments with sound fundamentals.

Forestry investment is a specialist long term placement for funds and is still attractive to specialist investors, however there is a quantity of discounted forest assets in the market that is proving more attractive than green field projects such as African mahogany in the Northern Territory.

The one consortium, GMO/AMA, is still investing in mahogany plantations in the NT. It has a history of investing in assets that it regards as being underpriced. It may well be that it sees the land

asset of the Douglas Daly as much of a prime asset over time as the forest venture in which they are at this time planting.

Impact and application

Although the expansion of the mahogany plantation estate in northern Australia seems impressive from a local perspective, policy makers and researchers should be aware that the industry is in a 'fledgling stage' and should it end up as an industry with one dominant player it may lack stability.

The way forward - obstacles and opportunities for tropical plantation development

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Abstract

Strengths and opportunities

African mahogany (*K. senegalensis*) has proven to be a suitable species to grow in the savannah tropics of Northern Australia. Commercial scale development of this species is occurring in the Northern Territory, based on a sound balance of business strategy elements, which include a favourable working environment, presence of and distance to markets and low sovereign risk.

Opportunities are being taken in this juvenile industry to improve the species, implement first class environmental management and explore options in alternative markets to ensure the maximum value of this high value species is realised. Excellent, base-line data have been collected for the fundamental elements of plantation development (wood quality, environmental suitability and genetic traits and improvement). This is being expanded with ongoing research efforts in genetic improvement, nutrition management and weed control.

Suitable land availability is due to increase significantly, as current legislation is being reviewed to enable non-pastoral land use exist on pastoral leases, this will open up many opportunities to pastoral lease holders to diversify their business and for plantation growers to access land that was previously unavailable.

New products are continually being explored, to build on mahogany's strong brand as a high quality timber, both internationally and domestically.

Weaknesses and threats

The variation in genetics and subsequent tree form of *K. senegalensis* is being addressed by industry and Government with a number of genetic improvement research projects, including nutrition. The lack of infrastructure in the growing region for options to value add or vertically integrate is being addressed: feasibility studies have been commissioned to assess the viability of biofuel and co-gen plants; government lobbying has been instigated; and the threat of fire to the plantation estate is being managed with sound fuel-reduction burning programs and ongoing detection and suppression.

As the *K. senegalensis* estate increases in size in Northern Australia, more opportunities will present themselves as commercial volumes of this high-value and sought after timber become available.

Impact and application

The direction that commercial growing of African mahogany in Northern Australia is taking is one of excitement. Fantastic opportunities exist to develop the resource in this region into a world-renowned supplier of high quality timber that will assist in replacing illegal logging in Africa and rainforest species in Asia. Combined efforts of industry and Government will see growth in employment and investment in regional Australia in a sustainable and environmentally sound industry.

Keywords: African Mahogany, direction, *K. senegalensis*, opportunities, strengths, threats, weaknesses.

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The future of science delivery to the *Khaya* plantation sector

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Abstract

Development of *Khaya* has reached a fork in the road and the options ahead are clear. One option, business as usual, will see a mothballing of the research under taken to date with the germplasm owned by the government research community maintained but with no new work undertaken. The second option involves co-investment by the industry and the government and university researchers, with benefits including increased productivity by capitalising on the research to date and continued investment by the research community on a dollar for dollar basis.

Under the first option, germplasm will continue to be sourced from wild seed from provenances across Africa and this is a low plantation productivity option. A slight improvement is to move to deploying better provenances (+ option), guided by results from the provenance and seed orchards trials established in the Northern Territory and Queensland. Better options for the industry are to lift plantation productivity by deploying the clonal seed orchard seed that is currently available (++ option). This improved germplasm should improve plantation productivity in the order of 10% over the current mixed native provenance seed stock. Other sources of planting material that could shortly be available include rogued clonal seed orchard seed (in two to three years time; a +++ option) and clones from the Northern Territory – Queensland Government clonal trials. This latter material should be tested in large blocks trials before full operational deployment occurs.

Impact and application

Future research needs to be linked to the individual strengths of universities, governments and companies, and funded appropriately, including cash, by industry.

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