

Development of the Indian Sandalwood Industry on the Ord River Irrigation Area

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Abstract

Since the early 1980's the authors have been involved in various capacities in trials of *Santalum album* (Indian sandalwood) for commercial production in Western Australia. As far as they are aware this species had not been tried in Australia in recent decades and perhaps not at all. This paper describes the evolution of a new forestry industry based on *Santalum album* in the tropical area of the east Kimberley of Western Australia. This industry has evolved in a period of only about 20 years from the first trial plantings and government-sponsored research to a commercial enterprise, which has attracted corporate investment on a significant scale.

Key Words: *Santalum album*, Kimberley, Western Australia, research, plantation, management, host, hemi-parasitic.

THE ORD RIVER IRRIGATION AREA (ORIA)

Situated 2200 km north east of the Perth and 500km south-west of Darwin, the Ord River Irrigation Area is a progressive farming area in the east of the Kimberley Region. Any "white elephant" label it was unfairly burdened with in the mid seventies has been well and truly laid to rest and current annual production from the 13,000 hectares of irrigated farmland varies between about \$40million and \$55 million.

Water for the project is captured from the Ord River in the massive Lake Argyle from which it flows by gravity (via a hydro power station which supplies power to the Argyle Diamond Mine and the towns of Wyndham and Kununurra) to Lake Kununurra, from which it is diverted, again mostly by gravity, to the irrigation areas on the Ivanhoe and Packsaddle Plains.

The main crop by area is sugar, which is processed in the ORIA and of which the crystalline product is all exported to Korea. Other important crops include a wide range of cucurbits, maize, sorghum, chick pea, sun flower, mango, grapefruit, bananas, beans, snow peas, onions, salad vegetables, pawpaw and some cotton along with a few specialist hybrid seed and vegetable seed crops. Farmers found through bitter experience that reliance on a single crop, for example cotton, was fraught with problems, principally associated with pest control.

Indian sandalwood (*Santalum album*) has become a significant part of the crop mix in the ORIA over the last five years. There are currently approx 1000 Ha of commercial sandalwood plantations in the area, with an annual planting of approx 100 ha. Harvesting is likely to commence in about 10 years time.

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Sandalwood

Sandalwood growing and harvesting is one of the world's oldest, and still one of its most valuable forestry enterprises. There are 16 species of *Santalum* (not all of which are harvested commercially), containing highly aromatic oil in the heartwood that is prized in India and Asia (Shea et al 1998). Both the Indian sandalwood and the West Australian sandalwood (*S. spicatum*) have extremely high oil content, making them the two most commercially valuable species of the genus.

A feature of all sandalwood species is that they are hemi-parasitic, i.e. require a host species to grow successfully. Understanding the host-sandalwood relationship has been one of the most critical aspects in the emergence of the sandalwood plantation industry, especially for Indian sandalwood.

WESTERN AUSTRALIA'S SANDALWOOD INDUSTRY

West Australian sandalwood (*S. spicatum*) was once widespread across the southern half of the state, especially in areas that now comprise the southern agricultural and rangelands zones. In other words it is adapted to a temperate-arid climate. It is a small tree, richly endowed with oil. The normal host species is *Acacia acuminata* (jam wattle)

WA sandalwood has been pulled and the product exported since the earliest days of settlement. It has generated many millions of dollars of export income, and the industry survives to this day. Natural stands have largely disappeared from the agricultural areas, and the industry is concentrated in the rangelands, mostly on areas also used as sheep stations. In these areas, regeneration is a serious problem because (i) regeneration events are sporadic and (ii) young sandalwood trees are highly palatable to sheep, rabbits and goats.

By the late 1970's it had become clear that West Australian sandalwood alone could not satisfy the demand for the product. Production from other areas such as India, Indonesia and the Pacific islands had declined rapidly as a result (we understand) of over-harvesting, forest clearance for agriculture, disease and illegal logging operations. The WA Forests Department had also at that time introduced a number of measures aimed at making future supply of native sandalwood sustainable. These included strategies such as setting aside of reserves in appropriate areas, protection of regeneration from grazing and feral animals, planting sandalwood in the wild and research into sandalwood plantations. Finally, the department looked at the potential for introducing *Santalum album* as a plantation crop in Australia and specifically on the Ord in the state's tropical Kimberley region.

INDIAN SANDALWOOD (*Santalum album*) ON THE ORIA

In 1980 the Forests Department of Western Australia and the Australian Sandalwood Company sent a party to India to look at various aspects of the sandalwood industry there. Forester Peter Richmond represented the department and was able to arrange for the importation of a small quantity of *S. album* seed to Australia. This seed was distributed to three Forest Department sites in WA and each area obtained about 100 seeds. One of the locations was Kununurra, where the author (CD) was stationed at the time. Eventually (with colleague Ian Scott) 30 reasonably healthy seedlings were raised. No seedlings were successfully raised at either of the other locations.

In Late January 1981 three plots of Indian sandalwood were planted on the Kimberley Research Station (then a CSIRO/WA Agriculture Department establishment some 20 km from Kununurra on the ORIA) and at the Agriculture Department's nearby Research Farm. At the time we knew almost nothing about which host species to plant and when. However, several seedlings were coaxed into surviving for long enough to indicate that, given proper treatment, the species had potential.

Over the next few years we had difficulty obtaining additional seed from India and I (C.D) became aware that there was a collection of five or six *Santalum album* plants in the Northern Territory Herbarium. These came from "naturally" occurring trees at widely separated sites along the NT north coast. The author (C.D.) was able to visit some of the sites and locate one of the original trees at a site near Darwin. No seed was available to be collected at that time. I was unable to locate the other trees, including at the site on Melville Island⁴. A vigilant look out for the species along the Kimberley coast has been to no avail.

Some of the original planted out seedlings on the Ord started flowering at about two years of age and seed set was eagerly awaited. Eventually several seed were almost ready on one tree. These were checked regularly but birds eventually took all seed just prior to proper ripening. We are now aware that Great Bower Birds (*Chamydera nuchalis*) have a great liking for these seeds.

At about this time Forester Peter Kimber became heavily involved in the seed procurement, project planning and research for the, to date almost unfunded and unresourced Kimberley Indian sandalwood project. In due course the department was able to procure more seed from India, and despite the fact that it appeared to be of poor quality, we raised more seedlings and in 1986 planted a plot of about 140 Indian sandalwoods in the Forests Department's Kununurra Arboretum.

In about 1988 an agreement between the Department of Conservation and Land Management (CALM⁵) and the Department of Agriculture had been reached. This allowed for long-term access to land on the research station for tree trials. The author (PK) designed a series of trials of planting configurations and host species; this work was implemented from 1989. Plots were also planted at about this time by Ian Richmond⁶ to test various other host relationships.

At this time also the Department (CALM) developed a strategy to plant some 20 hectares per annum of Indian Sandalwood as a commercial venture. Seed supply problems and nursery techniques had been solved to a certain extent but inability to control weed regrowth in the former agricultural paddocks prevented this programme becoming established in its first year.

By 1993 some local farmers had expressed an interest in growing Indian sandalwood privately as a commercial crop and during that year the first two private plots were established including one by the senior author (CD).

⁴ The origin of these NT trees is unknown but it is speculated that they may be descended from either seed or plants distributed by Macassan fishermen who frequented the north coast in large numbers from the late seventeenth century specifically to collect and process trepang but also to trade with Aboriginal people. Perhaps they saw some potential for sandalwood to grow here or conversely, perhaps the introductions, if indeed they were introductions, were accidental. The Macassans left other evidence of their visits including major processing sites (mainly rock hearths) and Tamarind trees. (Macknight 1976, Morwood and Hobbs 1997 and Kenneally et al 2003).

⁵ CALM had been created in 1985 by an amalgamation of the Forests Department, the wildlife section of the Department of Fisheries and Wildlife and the National Parks Authority.

⁶ Son of Forester Peter Richmond, who arranged for the original seed to be imported. This was privately funded research.

ADVENT OF A FORMAL RESEARCH PROGRAMME

Up until this time research into propagating *S.album* and the technology of plantation establishment on the Ord had been fairly ad hoc. No dedicated scientist or realistic budget and other resources had been allocated to the project, with all the work being done by the authors (CD and PK) largely out of personal interest and having to be fitted in to other work. It had become clear to us, however that the species had considerable potential for commercial establishment on the ORIA.

The big unanswered questions were (i) consistent access to good quality seed; (ii) how to raise seedlings in bulk, ensuring optimum recovery from scarce seed supplies; (iii) site preparation and weed control; and (iv) the correct mix of short and longer term host species which would carry the sandalwood right through a rotation. There was also the ongoing worry for all forestry projects in the north of how to protect trees from attack by termites in particular *Mastotermes darwinensis*.

In the early 1990s, funding for research and also for maintenance and development of plantations became available from a Sandalwood Conservation and Regeneration Project (Scarp) established by CALM. This funding was derived from profits from the WA sandalwood industry.

The first full time research scientist (Andrew Radomiljac) was appointed and located at Kununurra. Andrew was quickly able to pick up on the work that had previously been done and he put in a large number of new trials, in particular focussing on host species, nursery technology, site preparation and weed control.

A break-through in producing quality seedlings from the nursery followed the development of a “pot-host” (*Alternanthera sp.*) that ensured that the seedling went into the field already established to a host. Weed control and ground preparation were improved and field establishment was markedly upgraded. Previously identified field hosts were evaluated further with *Sesbania formosa* and *Acacia trachycarpa* being confirmed as important secondary hosts and *Cathormion umbellatum* as a very satisfactory long term host. New host identification trials were implemented and tree improvement work in the form of “family” trials was commenced.

An establishment and management regime was settled upon as a result of the research findings as well as the incorporation of on ground experience. This regime was similar to that detailed below (under “Current Plantation Establishment and Management Prescription”)

COMMERCIALISATION OF INDIAN SANDALWOOD ON THE ORIA

In the mid 1990s CALM was approached by the promoters of a Managed Investment Scheme who wanted to develop an Indian sandalwood plantation by selling woodlots to investors. CALM agreed to a commercial arrangement in which it provided expertise for the nursery (established by the promoter) and advice on the technical aspects of plantation establishment. Initially a project of 50 ha was proposed, but this grew rapidly to 150 ha in the first year. The huge jump from small-scale trial plantings to large-scale commercial plantings proved to be unsustainable and the venture was not a success. A number of mistakes were made, including the use of African mahogany (*Khaya senegalensis*) as a host. This species has proven to be not a good host tree and in fact its eventual broad, spreading crown suppresses the sandalwood.

From the point of view of foresters interested in growing sandalwood commercially (if not from point of view of the investors!), this project provided many useful lessons. It was obvious that

Sesbania formosa was a critical short term host species and also that the quality of nursery stock, time of planting, standard of ground preparation and capacity for follow-up operations in year 1 were all essential ingredients.

THE ADVENT OF OTHER MANAGED INVESTMENT SCHEME (MIS) OPERATIONS

Despite the problems experienced in the first commercial project, the new industry had developed a momentum of its own. Two new MIS's emerged and each secured sufficient interest to establish in excess of 100 ha of plantation each in the period 1999/2000.

There have been a number of company name changes and various restructuring but both MIS projects have continued with annual plantings through the early 2000s.

As at September 2004, the total area of sandalwood plantation in the ORIA is now over 1000 ha and new plantings exceed 100 ha in most years.

CURRENT PLANTATION ESTABLISHMENT AND MANAGEMENT PRESCRIPTION

The establishment approach has been steadily refined over recent years. Typically today this involves the following broad steps.

- Soil surveys are undertaken to ensure the right soil types are acquired, and the land is either purchased or leased.
- If necessary the paddocks are laser-levelled, and irrigation requirements installed
- The ground prepared into raised beds. A fine tilth is necessary for best results.
- There is an comprehensive program of weed control at the end of the wet season, so that by the time of planting, the ground is completely weed-free
- The ideal planting time is the cooler months of the dry season, namely mid May till late August.
- Total weed control is aimed for during the first year, and this is achieved by a combination of or individual application of 1) very careful use of herbicides and 2) manual hoeing.
- The hosts (a combination of short, mid and long-term hosts) are planted concurrently with the sandalwood seedlings to nurture the sandalwood throughout the rotation. Short-term hosts die within 3 -4 years but the long-term hosts have to last the full life of the plantation.
- Carefully regulated irrigation schedules. Over watering can induce infection by *Phytophthora spp.* The senior author (C.D.) is currently involved in monitoring the relationship between soil moisture and tree growth.
- The sandalwood trees are lightly form-pruned by about age 2.
- Weed control continues through the rotation.
- Pest control is carried out as required.
- Fire prevention is catered for by the installation of wide firebreaks surrounding the individual blocks.

Some managers are currently experimenting with sowing seed directly into the planting site, so as to avoid the need for nursery operations. This is the approach used with some success in southern WA in plantations of *S. spicatum* (Department of Conservation and Land Management 1990)

ISSUES

- **Land availability**

The ORIA is of limited extent with only some thirteen thousand hectares currently under irrigation. Whilst a second stage for the scheme has long been proposed⁷ it has never got off the drawing board and land shortages threaten the long-term viability of some horticultural crops⁸. However, land for sandalwood plantation development itself has not been limiting, as so far it has always been possible to lease or buy sufficient area.

Land in the ORIA is very expensive (currently in the order of \$8,000 - \$10,000 per ha) and this sort of price is only possible to pay given the likely projected returns from the sandalwood.

- **Soil type**

Cununurra Clay (a heavy, cracking black clay) is the preferred soil type given its ease of irrigation with the use of the flood irrigation technique. With this type of irrigation Cununurra Clay is not suitable habitat for the potentially devastating termite (*Mastotermes darwinensis*)⁹. Sufficient soil of this type has been available to service the sandalwood industry to date.

- **Risks and Risk Management**

- **Insect pests**

- Cossid moths may attack all species. Larvae of these moths can ring bark small trees.
- Looper caterpillars, stem borers and occasional white flies can cause damage to sandalwood.
- Scale, white fly, red-shouldered leaf eating bugs and the caterpillars of a yellow butterfly can cause problems on several of the host species.

Most can be easily controlled chemically but vigilance is required for timely control work to be undertaken.

- **Host species selection and management**

The selection of host species by the plantation manager can be difficult. Some species may be good hosts but their growth may be too vigorous, overtopping and subsequently suppressing the sandalwood. *Albizia lebbek/procera* is an example of this. Other species may not be vigorous enough to ensure adequate contribution to the sandalwood crop. Again others may be good hosts but the sandalwood parasitises them so strongly that they are ultimately killed. Such species are used in the ORIA as short-term hosts. Most of the best short and long term hosts are leguminous.

⁷ Ord Stage Two would increase the irrigable area to more than 60000 hectares about 25% of which would be in the adjacent Northern Territory.

⁸ For example, the sugar industry is operating at the lower end of the scale in terms of economical mill throughput. Chronically low world sugar prices are reflected locally and farmers sometimes sell the land to sandalwood interests. Additional land dedicated to tree crops (ie tied up for a long period), means less land available for sugar leading to fears that the mill itself will become non viable.

⁹ "Masto" can create havoc in tree crops grown on lighter soil types in the area.

Another aspect of “host” selection, which was a feature of two of the early commercial ventures, was the attempt to use high value timber species as “hosts”, thus producing a multi-value crop. Some leguminous species such as Indian Rosewood (*Dalbergia latifolia*) may in fact have some good properties as hosts but their capacity to prosper when “hosting” sandalwood is an unknown quantity

In our view the use of valuable tropical timbers as “hosts” when their contribution to sandalwood growth is negligible should be avoided. African Mahogany (*Khaya senegalensis*) and teak (*Tectona grandis*) are examples of species that have been tried in this way. The silviculture of *S.album* is probably the most complicated of any tree grown under plantation conditions and trying to manage for other valuable timber species in the mix complicates it even further.

The potential sandalwood plantation developer can do no better than to search the literature (mostly Indian) on suitable host species and to use those that are best suited to their particular soil and climate combination.

The more progressive plantation managers in the ORIA tend to segregate sandalwood and their long term hosts into separate rows – so aiding the specialist management requirements of both.

- **Fungi**

To date the fungal problems that have been associated with the Indian sandalwood plantations have been infection by *Phytophthora* and *Pythium* species. The former is invariably associated with over generous irrigation regimes.

A number of host species have been recorded with infections of the pathogenic fungus *Ganoderma sp.* Species in which mortalities have been recorded to date include some species that may have other qualities making them less than ideal hosts. *Albizia lebbek* is one example of this. However, vigilant monitoring is required to check that our favoured host species are not susceptible to *Ganoderma sp.* infection.

- **Over-optimistic prices**

Indian government auctions of sandalwood billets and other sandalwood pieces are held regularly in Tamil Nadu State. The highest quality sandalwood billets may go for \$US 38000 per tonne or more. We understand however that for every tonne auctioned legally, 2 or 3 tonnes of high quality stolen sandalwood is sold on the black market for less than \$US 25000 per tonne.

International trade in sandalwood is rife with illegality and corruption. Australian businessmen entering this market with a lot of sandalwood to sell will need to be very careful. The question of security of our plantations also arises. Sandalwood rustling and smuggling is common in most countries where it is grown, and our totally unguarded plantations will be a significant temptation to organised crime.

- **Over-production**

A great risk to potential plantation owners is the possibility of over-production. Various estimates have been made of world demand for sandalwood. All these

estimates consider demand to be less than 7000 tonnes of heartwood per annum (eg Radomiljac et al 1998). Sandalwood is too difficult a crop to grow in plantation for it to become widespread at present. However, breakthroughs in *S. album* silviculture and the rapid expansion of the industry in the ORIA, together with new plantations of WA sandalwood now being developed in the southern wheat belt of WA, indicate that a new large sandalwood resource will be coming on the market in about ten years time.

CONCLUSIONS

The evolution of the Indian sandalwood industry in the Ord River Irrigation Area provides an interesting example of the development of a new high value plantation crop. Early development arose from the enthusiasm of local foresters, which led to leader trials and in turn to formal scientific research work. The jump from research to commercialisation was probably made too soon, or was too large a jump because the first plantations were largely a failure. However, the technical aspects of the project had been properly researched, and the returns promise to be high, leading to ongoing private investment and the establishment of a whole new industry.

Questions of management of host species through the rotation, and control of pests (especially water-borne fungal pathogens) persist, but are not regarded as project-threatening.

Research still continues on a limited scale and is carried out by the Western Australian Forest Products Commission¹⁰ and by commercial interests. The future of this industry is now not so much a question of science and technology, but of commercial aspects, including demand, supply and price. Consumption of sandalwood products is almost entirely overseas, indicating that these commercial aspects will be determined largely by what goes on in the international marketplace.

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¹⁰ This statutory body took over the project from CALM.