# Agroforestry Species and Technologies

## A compilation of the highlights and factsheets published by NFTA and FACT Net 1985-1999

A Publication of Winrock International

TFRI Extension Series No. 138

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Winrock International
Taiwan Forestry Research Institute

James M. Roshetko, Editor

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Cover drawings adapted from highlights and factsheets NFTA 90-05, NFTA 94-02, NFTA 95-02, FACT 96-03, and FACT 98-04.

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# Preface

This booklet assembles under one cover the 97 factsheets and highlights published by the *Forest, Farm, and Community Tree Network (FACT Net)* and its predecessor the *Nitrogen Fixing Tree Association (NFTA)* between 1985 and 1999. These 2 to 4 page bulletins are concise summaries of important information on tree species and agroforestry technologies suitable for many environmental and socioeconomic conditions. We hope this booklet is a practical and useful reference tool for former network members and others.

## Background of FACT Net and NFTA

The NFTA was started in 1981 to promote the wise-use of nitrogen fixing trees (NFTs) for rehabilitating degraded lands and enhancing the livelihoods of the world's rural poor. The Association worked with a diverse array of researchers, extension agents, development workers, professors, students, and government officers as well as community groups, non-government organizations, universities and colleges, government agencies, and international organizations. Many of these individuals and institutions were located in remote areas of developing countries and actively involved in agricultural or forestry activities at the community level. These individuals and institutions had little or no access to reliable technical support. NFTA's global extension network effectively bridged the gap that often existed between the formal research community and remote, field-oriented institutions in developing countries.

In 1994, NFTA become part of Winrock International. In 1996, NFTA changed its name to the Forest, Farm, and Community Tree Network (FACT Net) in recognition of its expanded mandate to spotlight all tree species and agroforestry systems of relevance to smallholder farm families. FACT Net closed at the end of 1999 due to a shortage of financial resources to cover general operating costs. Well over half of FACT Net's associates lived in developing countries and received a waiver of annual fees. The Network annually provided hundreds of documents and many hours of free technical consultation to individuals and organizations that had limited financial resources, but an enthusiastic desire to grow trees. A shifting of donors' priorities away from technical services—even cost-effective ones such as FACT Net's— toward other interests placed a severe strain on the Network's core resources and restricted the staff's ability to maintain services.

## A review of programs and accomplishments

For twenty years FACT Net operated as an international extension service providing reliable information and resources to individuals and organizations interested in growing trees. The Network provided services through three basic programs: research, training and communications. These programs were characterized by dynamic flexible activities and services that adjusted to the changing global environmental priorities and the specific biophysical and socioeconomic conditions of associates and other clients. From its inception, over 5000 individuals and organizations participated in the Network. Tens of thousands of others benefited from its publications, services and activities.

The Network's key accomplishments include:

- conducted more than 65 training courses on tree propagation, management and utilization;
- co-sponsored 20 international workshops on important tree species and agroforestry topics;
- awarded 150 small grants to community groups to establish agroforestry projects;
- supported 600 collaborative tree species evaluation trials with associates;
- distributed over 5000 kilograms of quality tree seed;
- published over 160 technical documents;
- translated documents into 7 languages (Chinese, French, Indonesian, Khmer, Spanish, Portuguese and Vietnamese); and
- provided thousands of hours of technical consultation through letters, faxes, email and field visits.

## Operations and staffing

The Network was always a small, cost-effective organization that ran on a lean budget. This was made possible because associates and partner organizations often provided matching support, both financial and in-kind, for network activities. Community groups often provided support in the form of food and local resources. The Network's staff rarely exceeded 4-5 full-time people. During the last 10 years, staff members spent 3-6 months per year implementing activities in the field.

The hardworking people who made the Association and Network a great success included: board members Jim Brewbaker, John Musser, Bill Bentley, Jeff Burley, David Challinor, Narayan Hegde, Ta-Wei Hu, Bill Hueg, and Lynn-Day Weyerhaeuser; and Rodrigo Arias, Bertha Boom, Sonja Bowden, Eric Brennan, Jim Chamberlain, Narong Chomchalow, Doris Cook, Karl Dalla Rosa, Joshua Daniel, Dale Evans, Nancy Glover, Y.S. Huang, Ken MacDicken, Bill Macklin, Erin Moore, Linda Nelson, Mark Powell, James Roshetko, Charles Sorensson, Carol Stoney, Greg Sullivan, Rick van den Beldt, Sidney Westley, Kate Willers, Donna Willson, Dale Withington, Y.J. Yuang, Fuh-Jiunn Pan, and Hsiang-Hua Wang, to name some. In addition, there are many other associates and friends who supported the Association and Network by authoring factsheets or highlights, contributing articles for the newsletter or researcher reports, collaborating on activities or making financial contributions. These hundreds of individuals and organizations are too numerous to list here. Their involvement and collaboration helped develop the Association and Network into a global family that will persist long beyond the end of the formal organization.

## Adieu to the Network!!!

NFTA and FACT Net succeeded beyond expectations in providing practical information and services to thousands of organizations and individuals around the world. These efforts contributed to an increased awareness and appreciation of multipurpose tree species and their uses in agroforestry systems. The Network's departure from the international environmental community creates an information gap that is difficult to fill. We encourage all former staff, associates, friends, collaborators and clients to communicate and share information with each other to further advance our mutual cause—the production, management and utilization of trees to help protect the environment and alleviate poverty.

James M. Roshetko
Mark H. Powell

# Acknowledgements

The Forest, Farm, and Community Tree Network thanks the authors who wrote the highlights and factsheets that appear in this booklet; Marcella Christina of ICRAF (International Center for Research in Agroforestry, Southeast Asia Regional Office) for scanning the original documents and developing the format of this document; and Sonja Bowden and Miriam Boroski of Winrock International and Madah Saskia of ICRAF for assisting with the scanning of documents.

The network owes a special thanks to the Council of Agriculture, Taiwan, and the Taiwan Forestry Research Institute for financially supporting the production of this booklet, and for coordinating its production and distribution.

# Introduction

The highlights and factsheets assembled in this booklet were originally published as separate bulletins by NFTA and FACT Net between 1985 and 1999. The contents of the bulletins appear here in their original form. Some changes have been made to provide a uniform format. The booklet is organized in two sections. The first compiles the bulletins published by NFTA and FACT Net through its communications program. The section starts with bulletins summarizing the importance and uses of nitrogen fixing trees (NFTs) and actinorhizal trees. These are followed by bulletins featuring specific taxa arranged in alphabetical order by genus and species. The first section is concluded with a bulletin on marketing tree products. Early editions of bulletins that were later replaced with updated versions are not included in this document.

The second section is comprised of the bulletins published through the *Agroforestry Information Service for the Pacific (AIS),* a project operated by NFTA with funding from the USDA Forest Service's Tropical Forestry Program between 1992 and 1995. The AIS bulletins are arranged in chronological order by the publishing date. The two species bulletins published through AIS appear at the end of the section.

Appendix 1 provides a list of all bulletins arranged chronologically by publishing date. There also are indices of authors and species.

# Section 1.

# NFTA Highlights
# and
# FACT Net Factsheets

# NFT Highlights

NFTA 89-93

A quick guide to multipurpose trees from around the world September 1989

## WHY NITROGEN FIXING TREES?

**Why Nitrogen Fixing Trees?**
Nitrogen fixing plants are key constituents in many natural ecosystems in the world. They are the major source of all nitrogen that enters the nitrogen cycle in these ecosystems. Many nitrogen fixing plants are woody perennials, or nitrogen fixing trees (NFTs), most of these being found in the tropics. In temperate areas, the nitrogen fixers tend to be herbaceous.

NFTs have been removed or reduced in most man-made ecosystems, such as agricultural and forest lands and urban environments. These lands require expensive chemical fertilizer inputs in order to maintain their productivity. Manmade systems can be improved by learning and adopting from natural ecosystems. For example, the reintroduction of NFTs, with appropriate management, can increase and sustain productivity. Agroforestry land-use practices do this.

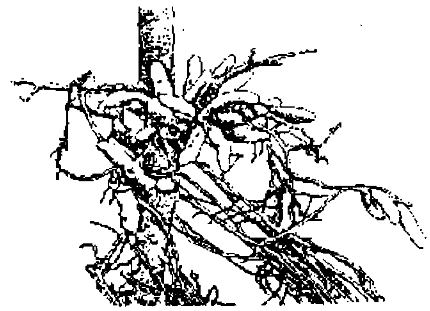
No plant grows without nitrogen, and many tropical soils have low supplies of this nutrient. NFTs do not depend solely on soil nitrogen, but "fix" nitrogen through symbiotic microorganisms that live in root nodules and convert atmospheric nitrogen into a usable form.

**Botany:** There are two basic types of N-fixing systems found in trees, based on two different symbiotic microorganisms. Bacteria of the genus *Rhizobium* inoculate trees in the families Leguminosae and Ulmaceae, while an actinomycete of the genus *Frankia* inoculates several other families:

| Family | Genera |
|---|---|
| Betuleceae | *Alnus* |
| Casuarinaceae | *Allocasuarina, Casuarina, Gymnostoma* |
| Coriariaceae | *Coriaria* |
| Elaeagnaceae | *Elaeagnus, Hippophae, Shepherdia* |
| Myricaceae | *Comptonia, Myrica* |
| Rhamnaceae | *Ceanothus, Colletia, Descaria, Kentrothamnus, Retanilla, Talguena, Trevoa* |
| Rosaceae | *Cercocarpus, Chamaebatia, Cowania, Dryas, Purshia* |

The Leguminosae, however, make up a vast majority of the 650 known NFT species. This family is broken into three distinct sub-families:

| Sub-family | # Species | % Fixers | Representative NFT Genera |
|---|---|---|---|
| Caesalpinioideae | 1.900 | 23 | *Chamaecrista, Cordeauxia* |
| Mimosoideae | 2.800 | 90 | *Acacia, Albizia, Calliandra, Enterolobium, Leucaena, Mimosa, Paraserianthes, Pithecellobium* |
| Papilionoideae | 12.300 | 97 | *Cajanus, Dalbergia, Erythrina, Flemingia, Gliricidia, Pterocarpus, Robinia, Sesbania, Tephrosia* |



*Nitrogen fixing trees "fix" nitrogen with symbiotic microorganisms. These legume tree roots have nodulated through an association with* Rhizobium.

**Uses:** Many NFTs are important to rural households throughout the tropics providing a variety of products and services:

*Firewood and charcoal* are the primary energy sources for almost one half the world's population. Fast-growing, high density NFTs make excellent fuelwood and charcoal. Many re-sprout, or coppice, vigorously after cutting, allowing repeated harvests without replanting.

*Fodder* to feed animals is a constant concern to many farmers in developing countries. The highly nutritious and digestible leaves of some NFTs make them excellent feed for annuals. The deeply penetrating roots of NFTs can reach retreating moisture and provide fresh feed during dry seasons.

*Soil fertility* is critical to crop production, but many resource-poor farmers cannot afford chemical fertilizers. Leaves of many NFTs are high in nitrogen and other plant nutrients and can be a renewable, free source of fertilizer.

*Timber and poles* are needed all over the world for house and other general construction. NFTs include both fast growing trees for rough wood, and some of the most valuable luxury timbers in the world.

*Human food* is harvested from several species of NFT in various parts of the world, in some instances supplying important seasonal staples.

**Planting Systems:** Depending on local needs and preferences, a variety of different planting schemes with NFTs can be utilized yielding a wide variety of products and staples.

*Living fences and hedges* protect crops from large pests such as wildlife, domestic animals, and man, and are often managed for fuelwood and fodder production. Trees are arranged densely, or planted as fence posts, and trimmed frequently to attain the desired form. *Pithecellobium dulce* is a favored hedge species in coastal East Africa.

*Windbreaks* are single or multiple rows of trees planted on windward field boundaries. Windbreaks help prevent soil desiccation and yield secondary tree products. Consistent

Written by NFTA staff

foliage closure is achieved by choosing trees with dense canopies and by managing the canopy to encourage lateral branching. *Erythrina variegata* is commonly planted as a windbreak in Hawaii and other Pacific Islands.

*Alley farming,* or intercropping, is a labor intensive management system which leads to major crop yield increases through alternating rows of tree hedges and crops. Cut leaves and green twigs are incorporated into or laid on top of the soil for multiple benefits of green manuring, soil and water conservation, and weed control. This practice is successfully being introduced on steep sloped hillsides in the Philippines using several NFT species, including *Flemingia macrphylla.*

*Shade and support* are attained quickly from fast-growing NFTs. Shade is an important benefit in hot climates for some crops, such as cacao, coffee, and tea, as well as for humans and animals. Living, soil-enriching support is quickly established for vining crops such as yams, vanilla, and black pepper. *Gliricidia sepium* has been used for all these purposes.

*Fodder banks* are intensive plantings of fodder plants, spaced to maximize production, and provide a source of "cut and carry" fodder. Many NFTs have leaves or pods that are very high in protein. *Leucaena leucocephala* is called the "alfalfa of the tropics" because of its extensive use as fodder.

*Pasture improvement* is achieved through increased grass production, tree fodder browsed directly by animals, and shade; livestock digest more efficiently when shade is available. *Acacia* species are found throughout the African savanna grazing lands.

*Home gardens* utilize NFTs for soil fertility, as well as for edible fruits, leaves, or flowers, and as medicinals. *Parkia* species are important seasonal food sources in both Southeast Asia and West Africa.

*Woodlots* planted with fast growing NFTs can yield quick returns, especially in less productive areas of the farm. Coppicing (sprouting) trees are the species of choice, particularly for stands of fuelwood. *Calliandra calothyrsus* is an important woodlot tree in Indonesia.

*Improved fallow* is most useful in areas where slash and burn agriculture is practiced. When a field is exhausted of its nutrients from intensive cultivation, NFTs can be planted for soil enrichment, and hasten the return of fertility. *Sesbania sesban* is utilized for this in western Kenya.

*Land reclamation* using NFTs is commonly practiced on eroded mountainsides, exhausted grazing areas, unproductive mined areas, and for dune stabilization. *Casuarina* has been planted for dune stabilization in over 1,000,000 hectares in China.

**Silviculture**: Most NFTs can be grown readily from seed. Many have seeds with thick coats, allowing long storage, but require scarification for moisture uptake. Some NFTs are easily propagated vegetatively. NFTs are fast-growing, many coppice readily, and can be managed for multiple products.

**Genetic Improvement**: Many NFT species have unique potential amongst trees for genetic improvement because of their short seed-to-seed cycles, often less than one year. Many are also highly variable in the wild, offering unique opportunities for selection.

**Why Not NFTs:** There are alternatives to NFTs for people who need tree products, soil improvement, or other services. Some non-fixing trees are easily established, grow rapidly, coppice readily, and produce desirable products and services. The lack of nitrogen fixation capability may be a drawback, but may not be needed in rich soils or uses which do not require rapid growth, such as watershed protection. Trees that are not harvested can establish a nutrient cycle in which little nitrogen is lost.

Weediness is another potential problem with NFTs. Since some NFTs are aggressive pioneer species adapted to rapid colonization, they may become pests. Species that cannot be controlled by grazing because of thorns or noxious plant chemicals can become especially weedy.

Chemical fertilizers may not necessarily be replaced by NFTs. The role of herbaceous N-fixing plants in soil management is also distinct, and may be a viable alternative to tree species. Local traditions, farmers' preference, and site conditions will dictate the choice of species, which may not include N-fixers.

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# NFT Highlights

A quick guide to multipurpose trees from around the world

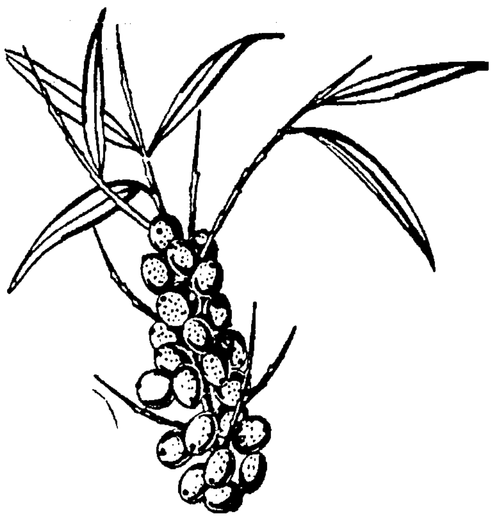
NFTA 86-03
May 1986

## Actinorhizal Trees Useful In Cool to Cold Regions

A class of plants that helped develop soil on glaciated sites in the past has a future in agroforestry and land reclamation projects of today and tomorrow. These plants are known as actinorhizae, as they are nodulated by the nitrogen-fixing actinomycete, *Frankia* These predominately temperate trees are especially useful in areas where the mostly tropical woody legumes can not live or thrive.

Actinorhizal plants have been used historically to increase fertility in agricultural systems. Lack of knowledge about the group's ecology prevents more widespread use but the trees are currently used in the following four ways:

1. As a primary crop for timber and pulpwood (*Alnus, Casuarina* spp.)
2. As an interplanted "nurse" plant for other, more valuable species (*Elaeagnus* spp.)
3. As a component of a multipurpose agroforestry plantation (*Casuarina* spp.)
4 As a plantation for soil reclamation (*Elaeagnus, Shepherdia, Purshia* spp.)



*Hippophae rhamnoides*

Environmental protection and land reclamation are benefits provided by several actinorhizal species. *Elaeagnus, Purshia* and *Shepherdia* spp. are widely planted in North America to prevent soil erosion (Fessenden, 1979). *Hippophae rhamnoides* is used for this same purpose in western and northern Europe. *Casuarina* species are planted in shelterbelts along deserts and coastlines in western Africa, India, China and other Asian countries to stop encroachment of sand dunes, diminish winds and decrease downwind deposition of salt spray (Andeke-Lengui & Dommergues, 1981; Turnbull, 1981). A shelterbelt built mainly with casuarina in southern China forms a "green wall" ranging from 0.5 to 5 km wide for 3000 km along the South China Sea.

The greatest use of any one actinorhizal genus is probably the production of *Casuarina* for firewood in the tropics. Large plantations are maintained on 5 to 15 year rotations (Kondas,

Written by Dwight Baker from documents or observations by the authors cited.

1981). Agricultural crops often are interplanted with casuarina during the first few years of the rotation. Harvested trees can be sold as firewood or converted into charcoal.

Planting *Alnus*, or alders, for lumber, pulp or fuelwood production is the second most common use of actinorhizal trees. Wood harvested from native stands is sold as fuelwood (Smith, 1978) or pulped and combined with softwood pulp for paper production (Hrutfiord, 1978). Mean annual wood yields for 8 to 10-year-old red alder, *Alnus rubra*, were nine oven-dry tons/ha/yr in British Columbia, and maximum production was 28 oven-dry t/ha/yr (Smith, 1978). Natural regeneration of alnus stands is excellent. *Alnus acuminata* and *A. nepalensis* are tropical highland species.

Other actinorhizal species are used as nurse crops for other trees. In the United States, *Elaeagnus umbellata* has been shown to greatly increase the productivity and quality of *Juglans nigra*, a hardwood species used extensively in furniture production (Schlesinger and Williams 1984). *Elaeagnus* apparently increased soil fertility, moderated temperatures and/or provided beneficial competition, which led to self-pruning of the tree crop. Alder has been shown to improve the growth of *Populus, Pinus*, and *Pseudotsuga* in mixed stands (Silvester, 1977).

Various *Casuarina* species are planted from the tropics to temperate zones as windbreaks, to control soil erosion, as ornamentals, for particle board, and as a fallow -improvement crop in Papua New Guinea.

Alder foilage, twigs and sawdust have been successfully used as a cattle feed supplement (DeBell and Harrington, 1979).

Actinorhizal plants can contribute as much nitrogen per hectare as the most productive legumes (Torrey, 1978). A Senegal study estimated that casuarina fixed 288 kg/N/ha/yr (Gauthier et al., 1984). Alders accumulate between 40 to 200 kg/N/ha/yr, with maximum accumulations of up to 320 kg/ha/yr (Silvester, 1977).

*Frankia* is present in adequate amounts in most ecosystems for natural nodulation to occur. Inoculation might be necessary in disturbed soil, arid environments or sites where actinorhizal plants are not native. Pure cultures for many of the most important actinorhizal species are now available.

# NFT Highlights

A Publication of the Nitrogen Fixing Tree Association

NFTA 89-02
May 1989

## Acacias for the Hot Dry Subtropics

Of Australia's tropical area, almost 2 million $km^2$ receives less than 500 mm of rainfall annually. Soils are diverse, but typically low in plant nutrients, with widespread and severe deficiencies in phosphorus and nitrogen and some deficiencies in trace elements. Surface soils are physically poor, and in places may be alkaline/sodic or saline (Brown and Turnbull 1986). Summers are extremely hot and elevated inland areas (e.g. the Pilbara region of northwestern Australia) may receive winter frosts.

The dominant woody vegetation of this zone, 120 or so species of *Acacia,* have evolved adaptations such as symbioses with *Rhizobium* and mycorrhizas, to cope with nutritional deficiencies and other stresses. 'These species constitute a unique, potential resource for rehabilitating degraded lands in the dry tropics. A few species have already shown exciting potential in the Sahelian zone of West Africa, but many more species remain untested.

Acacia maconochieana is *a highly salt and waterlogging tolerant tree from northwestern Australia.*

**FUELWOOD**: *Acacia holosericea* has received fairly widespread attention in trials and plantings, and to a lesser extent, so have *A. brachystachya* and *A. cambagei* (NAS 1979, Turnbull 1988). Many other species are in the early stages of evaluation.

In a trial in Senegal, *A. trachycarpa* produced 10.6 t/ha of green wood/year, compared to 12.0 t/ha/yr. for *A. holosericea* at the same site (Cossafter 1985). *A. trachycarpa* appears best adapted to coastal areas where annual rainfall is greater than 500 mm or areas that receive run-on water (Cossalter 1987). At several such sites in Senegal, growth averaged 3.6 m $\pm$ *157* at 5.5 years. In another trial in Senegal on an alluvial soil with a mean annual rainfall of 587 mm and a dry season of 7 months, *A. trachycarpa at* 1.5 years of age had a mean height of 2.68 m and a survival rate of 95% (Hamel 1980).

For firewood production on short rotations, Fox (1987) recommends trying *A. murrayana, A. tumida,* and *A. cowleana;* as well as *A. pruinocarpa; A. xiphophylla* and *A. aneura* for harsher, drier environments. *A. aneura* grew into a healthy, multi-stemmed tree 3 in height with a 2-4 cm DBH and a 1 m crown radius on a site receiving 370 min of rain/yr. and little supplementary water (Kube 1987). It can grow 1 m/yr. with supplementary irrigation.

*A. tumida* (Fitzroy Crossing provenance) has shown the fastest growth in recent acacia trials in Niger, reaching 2.4 m after 14 months, compared to 1.9 m for *A. holosericea* and *A. cowleana.* In trials in several West African countries with dry seasons of 5-8 months, *A. tumida* has exhibited erratic survival, but trees have grown 3 to 4 in in 4 years (CTFT 1983). The results are considered promising enough to merit further trials. *A. tumida* demonstrates wide morphological variation, as well as variation in economically important traits such as coppicing ability, and may constitute more than one taxa as currently circumscribed.

For sandy soils, species that show promise (rapid growth, moderately long life spans and good coppicing/pollarding ability) are *A. ampliceps, A. anaticeps, A. coriacea, A. eriopoda, A. jennerae,*, and *A. salicina* (Thomson, et al. 1988). Specimens of *A. ampliceps have* grown over 2 in in one year in Western Australia (Turnbull 1986). *A. coriacea* has reached 3 to 3.6 in in 7 years and withstood extreme drought periods in Senegal (CTFT 1983). A riverine form of this species from the Pilbara area has proven particularly fast growing in plantings in northwestern Australia. Early growth data from Iran indicated that *A. salicina* can have a mean annual height increment of 1 m/yr. (Webb 1973).

For areas receiving some run-on water and with heavy textured soils, *A. citrinoviridis, A. difficilis, A. distans, A. hemignosta, A. maconochieana, A. pachycarpa, A. stenophylla, A. trachycarpa,* and *A. victoriae* are promising (Thomson, et al. 1988).

**FODDER POTENTLAL-** Stock generally prefer grass and soft herbage to the relatively harsh phyllodes of and zone acacias (Fox 1987). During dry seasons, however, when other plant material is scarce, cattle and sheep will heavily browse certain more palatable species. *A. aneura* commonly called Mulga, is lopped to provide animal feed during drought periods. Biomass studies at Jodhpur, India, indicated that 7-year-old Mulga trees yielded 30 kg of fuelwood and 10 kg fodder when 75% of the canopy was pruned. International mulga trials coordinated by FAO/CSIRO are in progress to identify superior provenances (Midgley and Gunn 1985). Some early trial data suggest more rapid growth by provenances from the Charieville District of central Queensland. Despite its low to moderate digestibility (36-52%), it has a high crude protein content (11-16%), a low phosphorus content (0.05-0.12%) and good palatability, which increases with age (Turnbull 1986). In many parts of Australia, mulga is a significant part of a sheep's diet at all times of the year, but, without supplementary feed, it supplies barely sufficient protein and energy to provide a maintenance ration for sheep (Niven 1983).

*A.trachycarpa* was unknown as a fodder in Australia, but in West Africa the species has been readily browsed by cows, sheep, and goats (Cossafter 1987). A trial in Senegal planted at 3 in x 3 in produced 2.03 t/ha of foliage at 1-5 years (Hamel 1980). Close relatives of this species, such as *A. chisholmii,* and *A. lysiphloia,* grow rapidly on degraded, infertile, lateritic and sandy sites, but their fodder value is unknown.

Vercoe (1987) recommends that *A. shirleyi, A. bidwillii,* and *A. saticina* (with in vivo digestibilities > 50%) and *A. stenophylla* (digestibility < 50%) be further studied for their fodder potential. Turnbull (1986) indicates that *A. ampliceps* , *A. bidwillii* (immature foliage), *A. pachycarpa,* and *A. victoriae* appear to have some

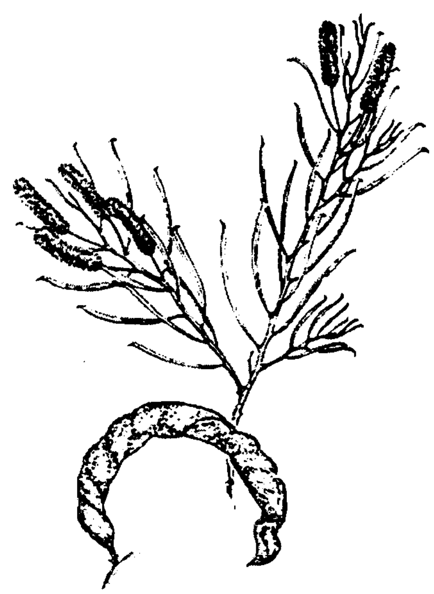
**Written by Dr. Lex Thomson, Australian Tree Seed Centre, CSIRO Division of Forestry and Forest Products, P.O. Box 4008, Queen Victoria Terrace, Canberra A.C.T. 2600 Australia.**

fodder value for cattle and sheep, and *A. salicina* and *A. stenophylla* are grazed by sheep.

*A. tumida*, which is moderately palatable to stock in West Africa, yielded an average of 2.6 kg of dry phyllodes/tree and 8.7 kg of wood/tree when planted at 3 x 3 in and harvested after 18 to 23 months (Cossafter 1987).

**SALINE/ALKALINE SITES**: *A. ampliceps*, called the salt wattle, is a very fast growing shrub/small tree from northwestern Australia that has considerable promise for fodder plantings on alkaline/saline soils, especially where its roots have access to a shallow brackish water table. Other highly promising multipurpose small trees for saline soils include *A. ligulata, A. maconochiena, A. salicina, A. sclerosperma, A. stenophylla,* and, *A. victoriae* (Thomson 1987, Aswathappa, et al. 1987).

**FOOD VALUE:** Seeds of many Australian *Acacia* species, including *A. ampliceps, A anaticeps, A. aneura, A. cowleana, A. dictyophleba, A. holosericea, A. jennerae, A. murrayana, A. stipuligera, A. tumida,* and *A. victoriae* are traditional foods of Australian aborigines (O'Connel et al. 1983). The Highly nutritious seeds are readily harvested (Brand and Cherikoff 1985) and can be stored for many years. Certain precocious and prolific seeding species, such as *A. holosericea* and *A. tumida* can yield in excess of 100 kg seed per ha from degraded and infertile sites within 2-3 years of planting. These species may have potential for food production on difficult sites in developing countries.



Acacia trachycarpa *is well adapted to coastal areas with annual rainfall greater than 500 mm, or in areas that receive runnoff water. Drawing from* Acacias in Australia *by M. Simmons, Thomson Nelson Australia 1982.*

**OTHER USES:** Many of the Australian acacia species, particularly ones adapted to the driest environments, may prove most useful in stabilizing sand dunes. Firewood and other products could be secondary benefits. *A. ampliceps* and its close relatives *(A. bivenosa, A. ligulata* and *A. sclerosperma)* have excelled in sand-dune stabilization plantings in Australia, Africa, the Middle East and India. *A. stenophylla*, of temperate Australian origin, has been extensively planted in dry parts of Tunisia for sand stabilization, honey production, and fodder/fuelwood production, but seed of sub-tropical provenances has become available only in recent years (Thomson and Cole 1987). Some species such as *A.coriacea* var. *pendula, A. cyperophylla* (pendulous variant from Nullagine), A. *grasbyi, A. hamersleyensis* (pendulous variant from Tom Price), A. *orthocarpa, A. sibilans, A. stipuligera,* and *A. wanyu* have superior potential as ornamentals. Others, such as *A. cambagei* and *A. pachycarpa* have offensive odors. Although competition for water and slow growth have made alley farming in and and semi-arid areas less successful than in humid regions, some of the more rapidly growing Australian acacias with a moderately long life spans, good coppicing/pollarding ability, and useful fodder/green manure, may be useful for this purpose (Thomson, et al. 1988).

**PROBLEMS AND LIMITATIONS**. Heavy seeding, root suckering or a tendency to form thickets make some of these species potential weedy pests. Turnbull (1986) indicates *A. bidwillii A. cowleana, A. ligulata, A. murrayana, A. salicina,* and *A. victoriae,* in particular, are potentially weedy. Since many species occupy wide geographic and environmental ranges, or may comprise several taxa, provenance testing and special attention to seed source are advised.

**SEED SUPPLY**. The Australian Tree Seed Centre of CSIRO's Division of Forestry and Forest Products stocks seed of many of the above mentioned species and will provide a quotation on request. Its address is:

CSIRO; P.O. Box 4008; Victoria Terrace; A.C.T. 2600, Australia.

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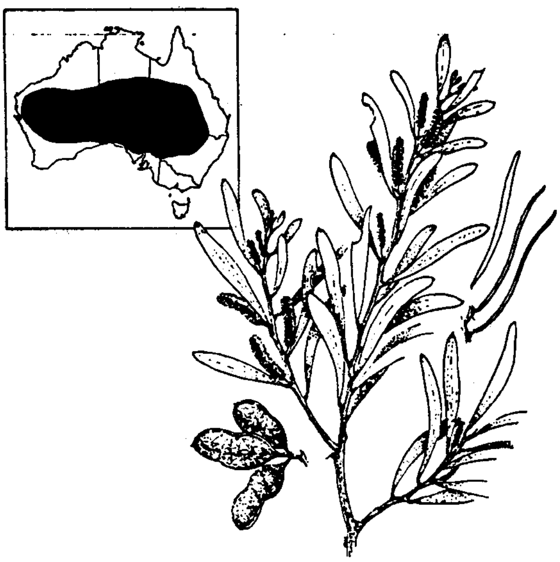
# NFT Highlights

A publication of the Nitrogen Fixing Tree Association

NFTA 90-03
July 1990


## *Acacia aneura* : A Desert Fodder Tree

*Acacia aneura* is known as mulga in its native Australia where it is one of the best known species in the genus. Mulga is the Aboriginal word for a long narrow shield made of acacia wood. It is probably the most important woody forage plant in Australia because it is palatable, abundant and widespread in regions of low rainfall. Its use as an exotic, however, has been restricted by its relatively slow growth rate and its limited capacity to regenerate after fire or severe branch lopping.



Acacia aneura, *reprinted with permission, M. Simmons, 1981. Inset map shows natural distribution of mulga in Australia (Turnbull et al. 1986).*

**BOTANY:** *Acacia aneura* F. Muell. ex Benth. is one of many thornless acacias endemic to Australia. It occurs as a 10-15 m tall, often single stemmed tree in higher rainfall areas but is a 2-3 m high shrub in dry situations or on very shallow soils. Its form and phyllode morphology are exceptionally variable (Midgley and Gunn 1985). The phyllodes range from short and needle-like to long (20 cm), broad (1 cm) and flat. Very fine hairs give the foliage an attractive silvery-grey appearance.

Small yellow flowers form spikes 1.5-2.0 cm long. Thin, flat membranous pods, 2-5 cm long, usually with an obvious narrow wing along their edge, contain dark brown seeds, each with a small pale aril at the base.

Flowering depends on favorable weather conditions and only late summer flowering followed by winter rain leads to seed set (Davies 1976).

**ECOLOGY:** Mulga is the one of the dominant species in Australian shrub woodlands. Natural populations extend over an area of 1.5 million km2 chiefly in the and climates where the annual rainfall is 200-250 mm. Mulga ranges in elevation from sea level to 300 m elevation. In many of the drier parts of its distribution mulga occurs as the only species in groves up to 50 m wide and 400 m long with intergrove areas acting as water catchments to provide substantial run-on water.

In the eastern part of its range in northern New South Wales and Queensland mulga is found in semiarid conditions with a mean annual rainfall of 300-500 mm. It experiences hot summers and cool winters with light frosts. Soils supporting mulga are usually acidic sands or sandy loams, which permit easy filtration of water into the upper horizons, but are usually very low in nitrogen and available phosphorus (Turnbull 1986). *Acacia aneura* can live for more than 50 years, it is drought-tolerant, but very fire sensitive (Kube 1987).

**PROVENANCE TRIALS:** The wide variability in soils and climate together with a high degree of polymorphism suggests that major provenance differences will occur in growth rates and drought and frost tolerance. International provenance trials were initiated in 1984 by FAO and CSIRO Division of Forestry and Forest Products, Canberra (Midgley and Gunn 1985) and trials were established in South Asia, the Middle East, Africa and South America.

**WOOD USE:** The heartwood of mulga is dark brown with contrasting markings of golden yellow; the sapwood is white. The wood is very hard, heavy (850-1100 kg/m$^3$) and durable in the ground; it turns well and takes a high polish (Boland et al. 1984). Mulga also makes an excellent firewood and charcoal. In Australia the wood has been used extensively for fence posts but a log size rarely exceeding 2 m x 25 cm usually restricts the use of the wood to small turnery items.

**FODDER:** In many parts of Australia mulga forms a significant part of a sheep's diet at all times of the year but without supplementary high quality feed it supplies protein and energy barely sufficient for maintenance of dry-range sheep (Goodchild and McMeniman 1987). Phyllodes have a high crude protein level (11-16%), low phosphorus content (0.05-0.12%) and good palatability (Turnbull et al. 1986, Vercoe in Boland, 1987). Excessive grazing may result in the death of mulga.


**Written by Dr. J. W. Turnbull, ACIAR, P.O. Box 4008, Queen Victoria Terrace, ACT 2600 Australia.**

*Acacia aneura* (tree form) in a natural stand in Queensland

**OTHER USES:** Mulga can be used in arid areas to provide shelter and shade, its attractive silvery grey foliage makes it a popular choice for amenity plantings. The Australian Aborigines ground the mulga seed for flour. The seeds have a protein content comparable to dried split peas or peanuts (Caffin et al. 1980). Aborigines also used the resinous phyllodes of desert mulga form as an adhesive resin (Turnbull et al. 1986).

**ESTABLISHMENT:** For good germination, seed (50,000-110,000/kg) should be scarified by mechanical abrasion or immersed in undiluted sulfuric acid (95% 36N) for 30 minutes and then thoroughly washed in water. Alternatively, immersion in hot water (90°C) for 1 minute will usually break dormancy (Doran and Gunn 1987). Seeds sown in a germination tray are ready for separating into containers within 10 days. The potting mix needs to drain freely but have good moisture holding capacity (Kube 1987).

Nursery growth is slow with seedlings often taking 6-8 months to reach 20 cm tall. When transplanted to the field the seedlings usually require several months without severe moisture stress to survive and in arid areas may need supplementary irrigation. Established seedlings have the ability to survive severe drought. They develop a long tap root and an extensive lateral root system in the top 30 cm of the soil. *Acacia aneura* needs to be protected from browsing animals while young.

**GROWTH:** Growth rate is generally slow but is related to moisture conditions. In central Australia planted specimens receiving an average of 370 mm of rainfall a year grew in ten years into multi-stemmed shrubs 3 m tall and 2-4 cm dbh with a crown diameter of 2 m (Kube 1987). Cultivated specimens receiving regular irrigation have reached 10 m tall and 10 cm dbh in 10 years. In trials where rainfall is relatively high, the Charleville, Queensland provenance, a broad phyllode form, has grown more rapidly than provenances from central Australia (Ryan and Bell 1989). Trees with different phyllode forms have been observed to have different growth rates (Fox 1980).

**SYMBIOSIS:** *A. aneura* forms nodules with *Rhizobium* with which it exhibits a degree of specificity (Roughley 1987). Ectomycorrhizal associations have been observed and there is almost certainly VA mycorrhizal symbiosis (Reddell and Warren 1987).

**PESTS AND DISEASES:** In its natural habitat *A. aneura* is subject to partial defoliation by a range of insects and root damage by termites. Termite damage was light (4% mortality) to moderate (30% mortality) to two provenances aged 18 months in a trial in Zimbabwe (Mitchell 1989).

**WEEDINESS:** With its relatively slow growth rate and irregular seeding habits *A. aneura* is unlikely to become a serious weed.

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# FACT Sheet

FACT 99-01
A quick guide to multipurpose trees from around the world January 1999

## *Acacia angustissima* : A Promising Species For Agroforestry?

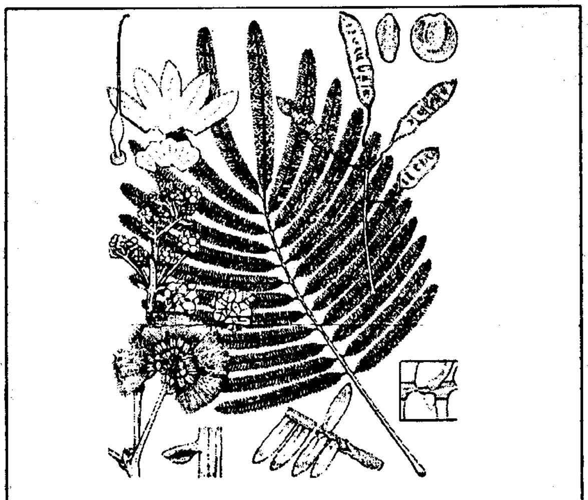
*Acacia angustissima* (Miller) Kuntze is a member of the Mimosaceae family and is thought to have originated in Belize, Central America (Dzowela 1994). Until recently very little work or study had been carried out on *A. angustissima*, but there is new interest in the use of this species in agroforestry systems due to its high potential growth rate and nitrogen fixing capabilities. Its common names include white ball acacia, fern leaf acacia and prairie acacia in the USA, while in Mexico and Central America it is known as barba de chivo, cantemo, guajillo, palo de pulque timbe and timbre. *Acacia angustissima* is closely related to and often confused botanically with *A. boliviana* and *A. villosa* (Gutteridge 1994).

### Botany

Turner (1996) carried out the most recent general study on *Acacia angustissima*. He recognized *A. angustissima* as having six intergrading varieties (var. *angustissima*; var. *hirta*; var. *suffruticosa;* var. *chisosiana*; var. *leucothrix* and var. *oaxacana*). *Acacia angustissima* grows as a thornless shrub or small tree mostly 2-7 m high with a single short trunk. It exhibits much variation in pubescence (almost none, or of the branchlets mostly of short appressed hairs), in size and venation of the leaflets, and in size of flowers and heads (McVaugh 1987). The leaves are mostly asymmetric with a displaced mid-vein and 10-25 cm long, with 10-20 pairs of pinnae and leaflets without secondary venation (Isely 1973, Turner 1996). The inflorescences are ellipsoidal with whitish heads 1-1.5 cm in diameter, turning pinkish to dull orange when dried (McVaugh 1987). The species flowers throughout the year in its natural range, and at the end of the dry season in trials in Zimbabwe (Dzowela 1994). The pod is oblong, 3-6 cm long and 6-9 mm wide, with straight or sinuate margins (Isely 1973). The pods are initially green, turning coffee-brown as they ripen (Dzowela 1994).

### Ecology

In its natural range *A. angustissima* is found on hillsides, rock slopes, summits, and in grassland with other shrubs. It is often found in tropical deciduous or semi-deciduous forest (McVaugh 1987). In the native range, annual rainfall varies from 895-2870 mm, and mean temperature ranges are between 5° and 30°C. It grows from near sea level to 2600 m, but shows better growth potential at higher elevations. At lowland sites (20 m) in Papua New Guinea, *A. angustissima* flowered but did not seed, while at higher elevation (1650 m) it seeded prolifically (Brook et al. 1992). It tolerates cold climates (occasional temperatures below freezing) and free-draining acid soils (Dzowela 1994). It also withstands periods of drought, possibly due to its substantial taproot. It retains green foliage in the long (8-month) dry season in Timor, Indonesia (Gutteridge 1994).



*Acacia angustissima* (Miller) Kuntze, drawn by Emmanuel Papadopoulos

*Acacia angustissima* grows rapidly and responds well to regular cutting. However, it produces weak branches that break off in moderate winds (Brook et al. 1992). This ability to grow quickly has resulted in *A. angustissima* becoming weedy and forming thickets, especially along roadsides and in sandy soil in pastures in its native range (McVaugh 1987). This weed potential has created concern among some researchers about the advisability of its use in agroforestry or agricultural systems (Bray et al. 1997).

### Distribution

*Acacia angustissima* occurs in tropical and subtropical mesic habitats along both sides of Mexico from the states of Jalisco and Nuevo Leon southward to Panama (Turner 1996). *Acacia angustissima* is now also commonly found in Southeast Asia, particularly Indonesia, as well as in Australia, where it is used in experiments. There are similar experiments in Zimbabwe, Ethiopia, Hawaii, Haiti, Papua New Guinea, Brazil, and Indonesia to determine its potential as a fodder or mulch crop in tropical countries.

### Uses

Fodder. *Acacia angustissima* produces large amounts of foliage with fodder potential. The crown architecture enables the tree to withstand frequent cuttings or defoliation with a high recovery and growth rate (Gutteridge 1994). Acacia angustissima has also been shown to respond well to coppicing. Biomass production has been shown to range from 10.3 t DM ha$^{1}$ (Dzowela et al. 1997) to 11.4 t DM ha$^{1}$ (Brook et al. 1992) at 2-m spacing. At 3-m spacing the biomass increases to a range from 11.5 t DM ha$^{1}$ (Bino 1997) to 12.4 t DM ha$^{1}$ (Isaac et al. 1994). These figures are based on cutting the trees back to 50 cm above ground level and oil yearly cuttings taken during, and/or at the end of the

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wet season. Research shows that *A. angustissima* cuttings contain high levels of N, P and K, but due to a high tannin content (6% DM), the protein is less accessible to the livestock. Tests have shown that *Acacia angustissima* leaves degrade poorly in the rumen of cows (48% after 48 hours of incubation) (Dzowela 1994). Bray et al. (1997) found similar results noting that *Acacia angustissima* produced significantly more leaves than other shrub legumes, notably *Leucaena spp., Calliandra calothyrsus, Gliricidia sepium, Cajuns cajan,* and *Sesbania* spp. But he also concluded that even though *A. angustissima* has the potential to produce a high leaf yield, the high tannin content and low palatability means it is of limited nutritional value to livestock. During feeding trials at the International Livestock Research Institute (ILRI) in Ethiopia, sheep fed 300 g of *A. angustissima* supplement per head per day died between 9 days and 21 days after consuming only 75-100 g per head per day at any time (Odenyo et al. 1997). This shows that the feed may contain toxins, and that the sheep did not particularly like it. Gutteridge (1994) found conflicting information regarding palatability and intake by livestock. In some areas of Indonesia *A. angustissima* leaf is reported to be eaten well and is regarded as an important source of forage. Additional trials are needed to evaluate the use of fresh and dry leaf for livestock feed, and to document any toxicity problems.

**Farming systems.** No information has been found about *A. angustissima* being used within farming systems in its native habitat. Elsewhere, research has been carried out to try and determine the tree's potential as a multipurpose tree to be used in agroforestry systems. In Papua New Guinea, trials have been carried out using *A. angustissima* in an alley cropping system intercropped with sweet potato. *Acacia angustissima* provided enough N, P and K for the crop, but due to the rapid growth shaded the crop and inhibited the tuber yield (Brook 1993). During other trials its potential as a mulch producer has come into question, because of the presence of secondary compounds that bind the N and result in low-quality (slowly decomposing) prunings. This may mean that the mulch is a poor N source for the present crop, but it may have greater residual effects that could benefit the subsequent crop, or be a good N source to help build up organic matter in the soil (Dzowela 1994, Mafongoya et al. 1997). These long-term benefits could outweigh the initial low nutrient return- to the-soil over a number of years. Slowly decomposing prunings may have value for suppressing weed growth in associated crops.

**Other uses.** Although *A. angustissima* is not commonly used for agroforestry in its native range, it is an important medicinal species for the Tzotzil and Tzeltal Maya Indians in Mexico. They rank it the 4$^{th}$ most important species in the cure of bloody diarrhea and 7$^{th}$ in the treatment of mucoid diarrhea. It is also used as a cure for toothache, rheumatism and skin lesions, and is reported to inhibit growth in malignant tumors. Tests also show that *A. angustissima* possesses a mild antimicrobial effect on *Escherichia coli* and *Staphylococcus aureus* (Berlin et al. 1996). The bitter astringent bark is also used in Mexico for precipitating mucilaginous matter and inducing fermentation in the making of alcoholic drinks (Graham 1941). During laboratory tests *A. angustissima* has been shown to completely inhibit growth (after 48 hours) of *Staphylococcus aureus, Bacillus subtilis, Klebsiella pneumoniae,* and *Candida albicans* (Hoffman et al. 1993). This indicates that A. angustissima has the potential to be used in applications against human diseases caused by bacteria and yeasts.

**Silviculture**

**Propagation.** *Acacia angustissima* seems to fare better when grown from transplanted seedlings then from direct seeding. If it is to be directly seeded, then it is important not to sow too deeply. Roshetko et al. (1995) suggested sowing the seed on the surface of cultivated soil and covering with a layer of soil equal to the width of the seed. Weeds can suppress early growth and the establishment of the seedling; it is therefore necessary to maintain a weed free zone around the seed or seedling for successful establishment (Maasdorp and Gutteridge 1986).

Pretreatment of seeds has been described by Roshetko et al. (1995)-the best results for germination came from 12 hours soaking in cool water before sowing. The standard hot-water treatment (a two-minute soak in hot water followed by 12 hours in cool water) resulted in inferior germination. Shelton (1994) suggested scratching or nicking the round end of each seed with a file, knife or nail clipper (without damaging the cotyledon) before sowing.

The seeds are very small, 90,000-100,000 seeds/kg, and initially green then a coffee-brown. *Acacia angustissima* forms an association with soil *Rhizobium* to fix atmospheric nitrogen. When introducing *A. angustissima* into a new area it may be necessary to inoculate with an appropriate Rhizobium before planting. FACT Net's site on the world wide web has a list of suppliers of seed and *Rhizobium* bacteria.

**Fertilization.** The application of fertilizer to *A. angustissima* has been shown to have different effects depending on when added. Fertilizer added to seeds had a negative effect on emergence and did not improve the competitive ability of the seedling against weeds once it started to grow (Maasdorp and Gutteridge 1986). Once *A. angustissima* is established the application of fertilizer has a positive effect on the growth of the tree (7-fold increase in crown volume on acid soils (Cole et al. 1996)). Costa and Paulino (1997) estimated that 53.8 mg/kg K and 104.2 mg/kg P would give maximum dry matter production and showed that nodulation significantly improved with K and P fertilization.

**Pests.** In its native habitat *A. angustissima* is eaten by the *Acacia* skipper butterfly, *Cogia hippalus,* and by the moth larva of *Sphingicampa blanchardi* and S. *raspa.* Two local birds also eat the seeds, the masked bobwhite and the Arizona scaled quail (Graham 1941). In trials in Hawaii the tree has been shown to be naturally resistant to attack from the Chinese rose beetle (Cole et al. 1996).

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*A full set of references is available from FACTNet*

Fact Net

# FACT Sheet

FACT 96-05

A quick guide to multipurpose trees from around the world September 1996

## *Acacia auriculiformis* : A Multipurpose Tropical Wattle

*Acacia auriculiformis* A. Cunn. ex Benth. is a multipurpose, leguminous tree in the subfamily Mimosoideae. It has been planted for fuelwood production, erosion control, ornament and shade in many tropical areas in the world. Its rapid early growth; ability to fix nitrogen; tolerance of infertile, acid, alkaline, saline or seasonally waterlogged soils; and tolerance of moderate dry seasons make it a very useful species for rehabilitation of degraded lands. The scientific name comes from the Latin 'auricula'-- *external ear of animals* and 'forma'-- *form, figure or shape*, in allusion to the shape of the pod.

*Leaves, gland, pod and seed of Acacia auriculiformis. (Drawing: Margaret Pieroni)*

### Botany

It is commonly a tree, 8-20 m in height, heavily branched with a short bole. On favorable sites it can grow to 30-40 m tall and 80-100 cm diameter with a straight, single stem. The bark is gray or brown, more or less smooth in young trees, becoming rough and longitudinal fissured with age. Mature foliage consists of phyllodes, which may be straight or falcate, acute or sub-falcate, 10-20 cm long and 1.5-3.0 cm wide. Phyllodes of sapling may attain 30 cm in length and up to 5.0 cm in width. There are 3 prominent longitudinal nerves running together towards the lower margin or in the middle near the base, with many fine crowded secondary nerves, and a distinct gland at the base of the phyllode (Pedley 1978).

Inflorescences are in spikes up to 8 cm long in pairs (seldom three) in the upper axils. Each inflorescence is comprised of about 100 tiny (3.8 x 4.1 mm) bright yellow flowers (Ibrahim and Awang 1991). Flowers are 5-merous; the calyx 0.7-1.0 mm long, with short lobes; the corolla is 2- 2.5 times as long as the calyx. Stamens are approximately 3 mm long. The pods are slightly woody, glaucous and transversely veined, about 6.5 cm long and 1.5 cm wide. They are initially straight or curved but become very twisted and irregularly coil on maturity. The seeds are broadly ovate to elliptical, about 4-6 mm long and 3-4 mm wide. Each seed is encircled by a long red, yellow or orange funicle. There are 60,000 seeds per kg.

### Ecology

*Acacia auriculiformis* occurs from near sea level to 400 m, but is most common at elevation less than 80 m. It is redominantly found in the seasonally dry tropical lowlands in the humid and subhumid zones. The mean annual rainfall in its natural range varies from 700-2000 mm, and the dry season (i.e. monthly rainfall less than 40 mm) may be 7 months. The mean maximum temperature of the hottest month is 32-34° C and the mean minimum of the coolest month is 17-22° C.

The species is commonly riparian, i.e. ringing perennial rivers and semi-perennial creeks, and tends to form discontinuous populations along drainage systems. It is found most commonly on clay soil types, however it exhibits the ability to grow in a variety of soils including calcareous sands and black cracking clays. It can also tolerate highly alkaline and saline soils. Seedlings have the ability to compete with *Imperata cylindrica* during early growth phases and once mature may reduce the grass to a sparse ground cover.

### Distribution

*Acacia auriculiformis* is endemic to Australia, Papua New Guinea and Indonesia, having a disjunct distribution in three main areas: the lowlands of southern half of the island of New Guinea (Papua New Guinea and Irian Jaya, Indonesia); the lowlands of tropical Northern Territory, Australia; and the Cape York Peninsula of northern Queensland, Australia. It has been widely introduced to many tropical countries in South and Southeast Asia, Africa and Latin America.

### Uses

**Wood.** Heartwood varies from light brown to dark red. The wood makes attractive furniture and is suitable for construction work, turnery and carving. Plantation-grown trees have shown promise for the production of unbleached kraft pulp -- for bags and wrapping paper; and high quality neutral sulphite semi-chemical pulp -- for corrugating, medium and higher-grade packaging products (Logan 1987). The wood has a high basic density (500-650 kg/m$^3$) and a calorific value of 4700-4900 kcal/kg, which make it ideal for firewood and charcoal.

**Land Rehabilitation & Landscaping.** The spreading, densely-matted root system stabilizes eroding land. Its rapid early growth, even on infertile sites, and tolerance of both highly acidic and alkaline soils make it popular for stabilizing and revegetating mine spoils. It is used for

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shade and ornamental purposes in cities where its hardiness, dense foliage and bright yellow flowers are positive attributes.

**Other Uses**. The bark has sufficient tannins for possible commercial exploitation (Abdul Razak et al. 1981). A natural dye, used in the batik textile industry in Indonesia, is also extracted from the bark. Its flowers are a source of bee forage for honey production (Moncur et al.1991).

### Silviculture

**Propagation**. Propagation is generally by seed. Pregermination treatment is essential to promote seed germination. Immersion of seed in ample boiling water for 1-2 minutes is suitable to break dormancy. Germination is rapid after pretreatment and typically exceeds 70%. In general, 3-4 months are needed to raise seedlings to a plantable size, 25 cm in height. Inoculation with appropriate rhizobia may be beneficial, especially when seedlings are raised in sterilized soil.

**Management**. Establishment is successful by containerized seedlings or by direct seeding. Containerized seedling generally give higher survival, especially in areas of heavy weed competition. In the field, weed control is essential during the first 1-2 years. A small dose of NPK fertilizer in the first year helps improve initial growth - fertilization rates depend on site quality. Recommended spacing is 2x2 or 2x4 m. *Acacia auriculiformis* has the ability to coppice, but it is not a vigorous sprouter. It responds well to pollarding.

**Yield**. An increment in height of 2-4 m per year in the first few years is common even on soils of low fertility (Boland 1989). On relatively fertile Javanese soils receiving 2000 mm annual rainfall, a mean annual increment of 15-20 $m^3$/ha is obtainable but on less fertile or highly eroded sites the increment is reduced to 8-12 $m^3$/ha (Wiersum and Ramlan 1982). Recommended rotation is 4-5 years for fuelwood, 8-10 years for pulp and 12-15 years for timber. One or two thinnings are required with longer rotations, depending on initial spacing, site quality and tree growth.

### Symbiosis

*Acacia auriculiformis* can fix nitrogen after nodulating with a range of *Rhizobium* and *Bradyrhizobium* strains. It also has associations with both ecto- and endo-mycorrhizal fungi.

### Limitations

The propensity to produce multiple and crooked stems reduce its utility. It is susceptible to fire; even trees 10-15 years old can be killed. Stressed trees are found to be highly susceptible to attack by leaf insects.

### Genetics & Provenances

Isozyme studies revealed marked genetic variation in *A. auriculiformis*. Three distinct groups of populations corresponding to the geographic distribution in Papua NewGuinea, Queensland and Northern Territory (Wickneswari and Norwati 1991). These regional groupings are also apparent in seedling morphology (Pinyopusarerk *et al.* 1991). Additionally, field trials have shown marked differences in growth and form. Provenances from Papua New Guinea have the highest production while those from Queensland have a high proportion of single stems. Those from the Northern Territory are inferior in both growth and form (Harwood et al. 1991).

### Research Needs

Selection and breeding for superior growth and stem form are now underway in many countries, including Thailand and Vietnam. Natural hybrids of *A. auriculiformis* x *A. mangium* have shown desirable characteristics; e.g. vigor, fine branching and tendency for a strong apical dominance. These characteristics lead to healthy trees with single stems and a good clear bole. Production and vegetative propagation of these hybrids warrant detailed study.

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# NFT Highlights

A Publication of the Nitrogen Fixing Tree Association

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## *Acacia holosericea* : A Successful Newcomer for the Dry Tropics

This shrubby acacia is little used in its native Australia, yet it promises to be an outstanding multipurpose tree for the dry tropics. Its excellent potential for fuel, charcoal, animal fodder, land rehabilitation and as an ornamental is now being realized in Africa and the Indian subcontinent.

**BOTANY:** *A. holosericea* A. Cunn. ex G. Don is one of some 850 thornless species of the genus endemic to Australia. It bears large phyllodes, 10-25 cm long and 1.5 to 10 cm broad, usually covered densely with fine hairs, giving the tree attractive silvery foliage. Small bright yellow flowers are aggregated in prominent spikes 3-6 cm long.

Narrow, hairless pods, 3-6 can long, are coiled in dense clusters and contain shiny black seeds, each with a yellow aril at the base. Flowering is heavy and precocious, and abundant crops of mature seeds may be formed within two years of planting. It commonly forms a spreading shrub to 5 m in height with many ascending branches from just above ground level. Occasionally it grows as a small tree up to 8 m in height.

**ECOLOGY:** Natural populations occur in a wide range of tropical climates. In semiarid areas mean annual rainfall can be as low as 300 mm and in these conditions it is confined to seasonally dry stream banks. Throughout much of its natural distribution annual rainfall is 600-1200 mm with most rain concentrated in four months. It does occur, however, in areas where rainfall exceeds 1500 mm (Booth and Jovanovic 1988). Most of the distribution is frost-free, but up to ten frosts each year occur at some inland sites. It occurs on a variety of soil types, but mainly on shallow, acidic, stony sands and loams of low fertility (Turnbull, et al. 1986).

In Senegal, tests have shown that the species behaves satisfactorily with rainfall over 500 mm in areas under coastal influences and over 600 mm in continental Africa (Cossalter 1987). In extremely dry areas when annual rainfall is less than 250-300 mm seedlings can survive for 2 to 3 years but then die. In the island environment of Cape Verde, however, where low rainfall is counterbalanced by higher air moisture, cooler temperatures and lower evapotranspiration, *A. holosericea* has withstood an average annual rainfall of about 200 mm in a 5-year period. In Senegal, it reportedly tolerates saline and water. logged soils (Cossalter 1987).

The wide variability in soils and climate suggest major provenance differences will occur in growth rates and drought and frost tolerance. Provenance trials have been started, but results are not yet available.

**FUELWOOD AND CHARCOAL:** The wood is hard and has a high density of about 870 kg/m3. With calorific values for wood and charcoal of 4670 Kcal/kg and 7535 Kcal/kg, respectively; it is a good quality fuel (Cossalter 1987; CTFF 1983). The rapid early growth rate makes it a highly productive fuelwood source.

*The shaded area is the natural range of Acacia holosericea (Turnbull, et al. 1986)*

**FODDER:** The fodder potential is mainly due to the large phyllode biomass produced during the dry season, a period when most non-Australian acacias traditionally used for fodder shed their leaves. Fresh phyllodes are not palatable for cattle and sheep, but when the branches are lopped the dry foliage is eaten readily. Four-year-old trees in Senegal have produced about 3 tons of dry phyllodes per hectare, but estimates of crude protein and *in vivo* digestibility are low and suggest *A. holosericea* has a low feed value (Vercoe 1987).

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**WINDBREAKS & LAND REHABELITATION** The large, dense crown of this shrubby acacia enables it to form a screen. In Africa it is used to form the lower part of a multistorey windbreak with the taller *Eucalyptus camaldulensis,* a species with which it is frequently found in its natural range (Hamel 1980).

Advantage can be taken of the fast growth, dense crown, nitrogen fixing ability and vigorous colonizing characteristic of this species to revegetate and restore degraded mining areas (Langkamp and Dalling 1983). It also shows promise for sand dune fixation in Senegal and Somalia (Hamel 1980).

**ORNAMENTAL:** The silvery foliage, early appearance of long yellow flower spikes, and prominent twisted pods make *A. holosericea* an attractive ornamental shrub or small tree.

**ESTABLISHMENT:** For good germination, seed (95,500 to 175,000/kg) should be scarified by mechanical abrasion or immersed for one minute in boiling (100°C) water. Coppicing is generally regarded as poor, but contradictory reports suggest its resprouting ability may be influenced by tree age, season of cutting and height at which the cutting takes place.

**GROWTH:** Seedling growth is rapid. On favorable sites in Central Australia it has reached 4 m tall in 18 months. On drier sites 3 m growth in 3 years is average, and growth rate diminishes in succeeding years (Kube 1987). In Senegal a growth rate of 4.8 m in 40 months has been recorded in an area with 585 mm rainfall and a 7-month dry season (Cossaiter 1987). At Bambey, Senegal, 4 year old *Acacia holosericea* produced 13 tons/ha of green wood and ahnost 3 tons/ha of dry phyllodes, demonstrating its considerably greater productivity dm the local *Acacia senegal.*

**SYMBIOSIS:** *A. holosericea* forms nodules with rhizobium and develops endomycorrhizal associations. Greatly stimulated growth has been reported when seedlings were inoculated with a selected rhizobium and the endomycorrhizal fungus, *Glomus mosseae* (Comet and Diem 1982).

**PESTS:** This acacia appears to be relatively free of pests and diseases in cultivation and resists termite attack.

**PROBLEMS:** The early and abundant seeding habit has the potential to make *A. holosericea* a weed species under certain conditions. Like many acacias, it is relatively short-lived, from as little as 4-5 years to not more than 10-12 years, and this may be a problem under some circumstances.

*(Simmons 1981)*

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# NFT Highlights

NFTA 94-08
A quick guide to multipurpose trees from around the world September 1994

## *Acacia koa* : Hawaii's Most Valued Native Tree

Koa (*Acacia koa* Gray.) is unquestionably Hawaii's most prized tree species—culturally, ecologically and economically. Hawaiians have always valued koa for its exceptionally beautiful and durable wood. It remains the premier Hawaiian timber for furniture, cabinetry, interior work and woodcrafts. Equally important, native koa forests provide unique wildlife habitat, critical watershed recharge areas and recreational opportunities. Unfortunately, forest clearing for agriculture, cattle grazing and feral pig activity have much diminished Hawaii's once extensive koa forest. The scarcity of koa wood is reflected in its ever increasing price—high enough now to economically justify helicopter logging.

**Botany and Ecology**

*Acacia koa* is a large, evergreen broadleaf tree and the only *Acacia* native—and endemic—to Hawaii. Trees occurring in dense, wet native forest stands typically reach heights of 25 m and stem diameters (DBH) of 150 cm, while retaining a straight, narrow form. In the open, trees develop more spreading, branching crowns and shorter, broader trunks. Koa bark is gray, rough, scaly and thick. Observations indicate that koa has one main tap root - and an otherwise shallow, spreading root system.

Koa belongs to the thorn-less, phyllodinous group of the *Acacia* subgenus *Heterophyllum* (Whitesell 1990). Like other phyllodial species, mature koa trees do not have true leaves. Instead they produce phyllodes, or flattened leaf petioles. Young seedlings have bipinnate compound true leaves with 12 to 15 pairs of leaflets. Where forest light is sufficient, seedlings stop producing true leaves while they are small less then 2 m tall. True leaves are retained longer by trees growing in dense shade.

Phyllodes are sickle-shaped and often more than 2.5 cm wide in the middle and blunt pointed on each end. Investigations suggest that true leaves promote more rapid early growth when moisture is adequate, whereas phyllodes are better adapted to drought. Phyllodes transpire only 20 percent as much as true leaves, and their stomata close four times faster after dark. Phyllodes typically hang down vertically, a position that enhances their ability to capture light during early morning and late afternoon hours. Seedlings are able to switch back from phyllode to true leave production when the sunlight reaching them is reduced (Walters and Bartholomew 1990). This adaptation allows them to survive and grow under a wide range of light regimes.

Observations suggest koa can flower almost any time of year, depending upon local weather conditions. The inflorescence of koa is a pale yellow ball averaging 8.5 mm in diameter, one to three on a common stalk. Each inflorescence is composed of many bisexual flowers. Each flower has an indefinite number of stamens and a single elongated style. One known pollinator of koa is the honeybee (*Apis mellifera*). Koa appears to be fully self-fertile (Brewbaker 1977).

Koa pods are slow to dehisce and about 15 cm long and 2.5 to 4 cm wide. They normally contain between 6 and 12 seeds that vary from dark brown to black. Pods reach maturity at 4 to 6 months, depending on location and weather conditions. Insect larvae of many species typically destroy a large proportion of the mature seeds before they dehisce.

Seed production typically begins when trees are 5 years old. Koa bears seed often and abundantly. Seeds are seldom dispersed far from the tree and remain viable in the soil for up to 25 years. Thus remnant koa stands are capable of dominant regeneration under favorable conditions. Koa seeds do not require sunlight to germinate, but seedling growth is slow in dark understories or in thick grass. The species thus requires large forest gaps, such as those created by storms, to successfully regenerate.

*Acacia Koa*, from E.L. Little and R.O. Skolmen. 1989. Common forest trees of Hawaii (native and introduced). Agricultural Handbook 679. Washington, D.C.: USDA, p. 131.

This issue was written by Karl Dalla Rosa, Hawaii State Deptartment of Land and Natural Resources, Division of Forestry and Wildlife, 1151 Punchbowl Street, Honolulu, Hawaii 96813.

**Distribution**

*Acacia koa* occurs at elevations from 180 to 6000 meters between 19 and 22 latitude on all of the major Hawaiian islands. It prefers an annual rainfall of 1900 to 5100 mm, and well drained acid soils. However, koa adapts to almost any of Hawaii's diverse environments indicating its potential elsewhere in the Pacific. Koa is found on all volcanic soil types of all geologic ages. It grows well in moderately to well-drained, medium to very strongly acid soils on both flatland and steep slopes. On dry, shallow, poorly drained soils koa's growth is slow and its form generally poor.

Occurring in both pure and mixed forest stands, koa is most commonly associated with the native ohia (*Metrosideros polymorpha*). It is also a codominant in several other major forest types including: Koa/Mamane (*Sophora chrysophylla*) Montane Dry Forest and Koa/Ohia/A'e (*Sapindus soponaria*) Forest (Wagner et al. 1990). Today *Acacia koa* stands are fragmented and concentrated in areas between 600 and 1800 meters elevation (Whitesell 1990). This distribution is largely the result of land conversion to agriculture and ranching. Cattle avidly graze koa seedlings, preventing regeneration.

**Silviculture**

Propagation is most successful from seed. One study recommends air-layering as the best vegetative propagation technique (Skolmen 1978). Koa seeds are durable and easy to store. They germinate after many years of storage if kept in a cool, dry place. The most effective method for improving seed germination is mechanical scarification. However, hot water soaking works well and is a more practical method. Boil water and remove it from the heat source. Soak seed in the boiled water for 24 hours. Once treated, seeds are typically sown in nursery beds. One week after germination, seedlings are transplanted into nursery tubes or bags. Seedlings are ready for transplanting into the field when they are approximately 20 cm tall—after 3 to 4 months in the nursery. Observations suggest that heart rot problems may be partially caused by root damage during transplanting. Therefore, establishment by direct seeding or encouragement of natural regeneration is recommended. On favorable sites, planted seedlings typically grow to 9 m in 5 years time (Judd 1920).

Koa's wide branching form is the result of open growth. Trees with long clear boles—called "Canoe trees" by native Hawaiians are now rare, but still found in forest gaps created by fallen trees. Dense stocking of seedlings, which mimics the competitive environment where superior "canoe trees" grow, encourages straight and rapid height growth. Initial spacing of 1.2 x 1.2 meters is currently recommended. Observation indicates that effective self-thinning will result in an adequate number of potential crop trees by age 25.

Where scattered koa cover is adequate, plantation establishment is most easily and successfully accomplished through the stimulation of natural regeneration. Pasture soils are scarified and competition from grasses reduced by the application of a contact herbicide. Gaps in the regeneration are filled with planted seedlings. Fertilizers are applied to give seedlings an initial "boost". Plantation thinning prescriptions should be based on desired products and management capabilities. The most important factors to consider in picking koa crop trees is stem form and height. Research on koa plantation management and various spacing and thinning regimes is direly needed.

**Uses**

Wood. Koa heartwood is highly valued by furniture and crafts people throughout Hawaii, and consumers the world-over, for its unique grain, varied color and workability. It seasons well without serious warping or splitting. Curly-grained wood, the result of both stress and genetics, is preferred over straight-grained wood. Wood color ranges from a subtle yellow to a striking dark red-purple. The specific gravity of koa wood averages .40, but with curly-grained wood can be as high as .65. Mature koa boles are commonly forking or fluting and often suffer from heart rot. These characteristics and wide branch angles limit its value as a large timber. Fortunately, these defects may be corrected through silviculture.

**Forage and Wildlife Habitat**. Cattle, sheep and pigs browse koa foliage aggressively, especially its juvenile leaves. Koa is spread geographically throughout Hawaii and thus offers a variety of wildlife habitats of diverse moisture regimes, soils and vegetative compositions. An overlay of a koa forest area map onto a forest bird "habitat island" map produced by Walker (1986) shows remarkable correlation.

**Land Reclamation**. Most koa plantations in Hawaii have been established to provide vegetative cover on sites degraded by decades of intense grazing. Where scattered koa already exists, seed stored in the soil will likely germinate if the soil is scarified and grass competition controlled.

**Symbiosis**

*Acacia koa* is nodulated by the slow-growing *Bradyrhizobium* spp. common in tropical soils. It nodulates heavily in a variety of soils, suggesting it is effective with a wide variety of *Bradyrhizobia* strains.

**Pests and Diseases**

Banana poka (*Passiflora mollissima*) is a fast growing vine that commonly outgrows and smothers young koa trees. Kikuyu grass (*Pennisetum clandestinum*), a dominant and extremely aggressive highland grass in Hawaii, is a major deterrent to the emergence of koa seedlings on cleared or formerly grazed lands. Successful koa plantation monoculture has historically been difficult to achieve due to associated insect and disease problems. Examples include the defoliating koa moth (*Scotorythra paludicola*) and a lethal "koa blight" first observed in 1988 on the island of Oahu.

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