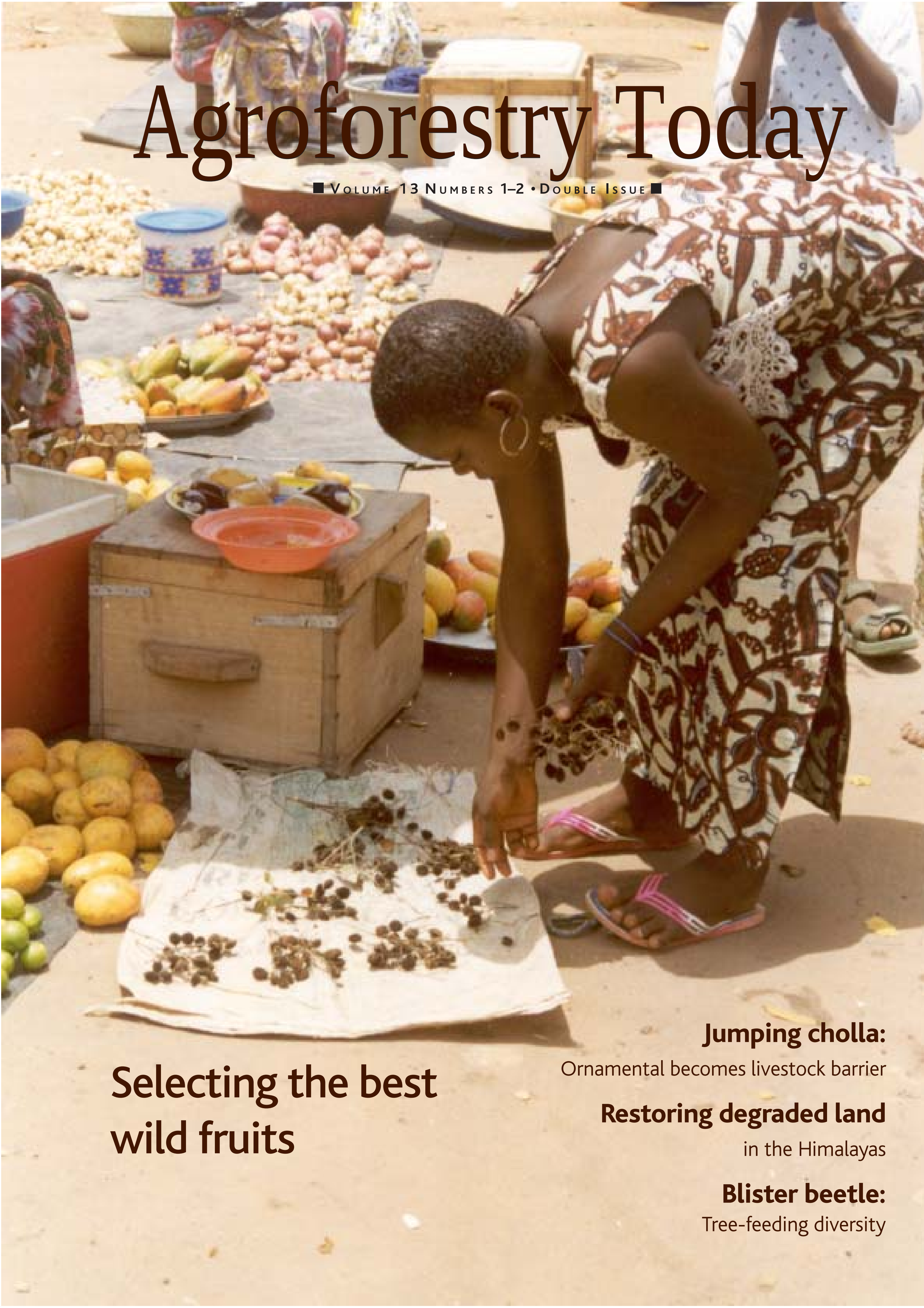

Agroforestry Today

■ Volume 13 Numbers 1–2 • Double Issue ■

Jumping cholla:

Ornamental becomes livestock barrier

Selecting the best wild fruits

Restoring degraded land

in the Himalayas

Blister beetle:

Tree-feeding diversity

Dennis Garrity is ICRAF's new Director General

Dr Dennis Garrity

Dr Dennis Garrity became the fourth Director General of ICRAF on 1 October 2001.

Dr Garrity joined ICRAF in 1992, after 12 years with the International Rice Research Institute (IRRI) in the Philippines. He founded the Centre's collaborative research and development activities in Southeast Asia, building that initiative into ICRAF's largest regional programme with more than 40 international and national professional staff working in six countries.

He led the systems improvement research in the humid tropics of the region to develop and evaluate agroforestry alternatives to slash-and-burn agriculture; developed conservation-oriented agroforestry systems for sloping uplands; and launched institutional innovations related to farmer-led organizations in sustainable agriculture and natural resources management. He was active in promoting the Landcare movement in Southeast Asia.

Dr Garrity, an American citizen, has a BSc in agriculture from Ohio State University, an MSc in agronomy from the University of the Philippines at Los Baños, and a PhD in crop physiology from the University of Nebraska. He served as agronomist and crop ecologist and head of the Agroecology Unit at IRRI between 1982 and 1992.

Born in Cleveland, Ohio, Dr Garrity spent his childhood weekends and summer vacations working on his grandfather's farm in Lorain County, Ohio.

"The farm was 70 acres," he says. "My grandfather grew wheat, corn and hay, and had dairy cattle and chickens. But he always struggled. It was excruciatingly hard for him and my grandmother just to make the mortgage payments. That's where I first learned what it's like to be a smallholder farmer, and what it means to fight to hold on to the family farm."

Dr Garrity learned a lot from his grandfather, he says, but he credits his 11th grade science teacher for turning him towards what would be his eventual career. It was 1968, and Mr Carl Locke announced there would be no lectures or tests in his class. Instead, the students were instructed to go to the library, pick a topic they liked, and write a term paper on it.

In the library he picked up a copy of a magazine with an article describing the coming famines and the population explosion in Asia and India – a gripping global issue at the time. "Reading that article galvanized me. I had always been interested in agriculture and science, but for the first time I realized I could fuse the two together, and do something really useful to solve some big problems."

Dr Garrity then went to Ohio State University, where he earned an undergraduate degree summa cum laude with distinction in agronomy. In 1971, his sophomore year, he had an opportunity to go to the Punjab Agricultural University in India, where he spent three semesters.

On the way back home from India, he backpacked solo through Southeast Asia for five months learning about farming systems in the tropics. It was there he stopped at IRRI in the Philippines, where scientists had just starting work on cropping systems. "I got very excited about their work, and from that time on I was scheming to get back there."

After finishing his BSc at Ohio State, Dr Garrity was raring to go back to the tropics. With an IRRI scholarship, he returned to the Philippines and finished his MSc, testing the methodology that later became the foundation for the Asian Farming Systems Network. He completed a doctorate at the University of Nebraska in 1980, and returned to IRRI.

Dr Garrity believes that with the past decade of solid research results behind it, ICRAF is well positioned to create opportunities for positive change on a truly global level.

"We are poised to improve people's lives and the environment in a unique way and on a much greater scale," he says. "For farmers, employing trees and tree crops for lifting themselves out of poverty is not a pipe dream. This has been going on in many areas of the tropics successfully, if unheralded, for decades. I believe we have the prospect of using the science of agroforestry to champion the opportunities that already exist, and greatly expand them. They can be developed for millions more people as a route out of poverty.

"As scientists and leaders, our vision of what we can do is much sharper than ever before. We have a bold strategy. We are now challenged to really put it to work. And I believe that we will."

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ICRAF is an autonomous, non-profit international research body supported by the Consultative Group on International Agricultural Research (CGIAR). ICRAF aims to improve human welfare by alleviating poverty, increasing cash income, improving food and nutritional security, and enhancing environmental resilience in the tropics. It is governed by a Board of Trustees and has research and development activities in 23 countries in Africa, Latin America and Southeast Asia.

Due to staffing and resource difficulties during the second half of 2000, a second issue of *Agroforestry Today* could not be published. Thus, this first issue of 2001 is, in fact, two issues, combining to give you 44 pages that feature a wide variety – geographical and scientific – of where and how agroforestry practices are having significantly positive effects on the lives and livelihoods of developing-country farmers.

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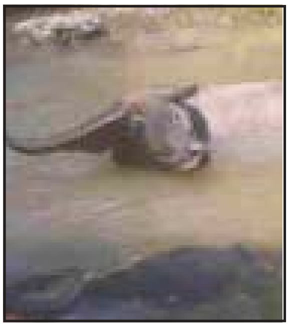

Small-time operations – big-time loss: Illegal logging in the northern Philippines

Blister beetle feeding on green gram inflorescene

How Ivory Coast's Malinké ethnic group select the most beneficial wild fruits

Guy-Alain Ambé & François Malaisse

Seventy-five wild edible fruit species were inventoried and their favourites identified —for taste, for medicinal purposes and to satisfy hunger

The marketing of some wild fruits is important. The fruits of Dialium guineense *are traded alongside other exotic fruits.*

Many studies in various part of Africa stress the importance of edible wild plants in the diet of rural people (Campbell 1987; Baumer 1995; Bergeret 1986; Bergeret et al. 1990; Maydell 1990; Malaisse 1992; Malaisse 1997). Because of agricultural development, the importance of gathering plants and dietary diversity are decreasing. The number of wild foods has dropped dramatically with people's transition from hunter-gatherers to farmers (Tivy 1990). Nevertheless, these wild foods may greatly contribute to the diet of rural peoples by providing rare nutrients and facilitating survival in times of famine. According to Grivetti and others (1987), the best and perhaps the only way of having a healthy and balanced diet is to diversify and vary it by consuming as many different foods as possible.

As the wild edible species are important, their protection must remain a priority. In order to maintain diversity, a "woody revolution" is suggested. It consists of the integration of indigenous species into local agricultural systems. According to Leakey (1994), the integration and re-evaluation of indigenous trees is necessary to protect biological diversity and to provide an opportunity for all inhabitants of the world to have adequate food. For this purpose, it is useful to identify the best species according to local preferences. These are important in any programme of development (Harrison 1991). Local people know species that provide various products for nutrition, medicine, construction, etc.

The setting of priorities for tree improvement is based on various criteria. In the present study, the selection criterion is based on the appreciation of fruits for its benefits (taste, hunger prevention or medicinal purposes). In order to identify the wild species particularly appreciated for this purpose, an ethnobotanical survey was carried out on the selection of appropriate fruit species consumed in Guinea pre-forest savannas of the Ivory Coast.

The wild fruit species that the Malinké ethnic group eats were listed. From these, the most appreciated fruit species were selected.

The region studied

The study was carried out in Séguéla, a department in the northwest of the Ivory Coast. Six villages, located in the south of the department were investigated: Kavena, Somina, Kénégbé, Dangreso, Bingoro and Bac-sémien. The vegetation around these villages is recognized as a Guinea pre-forest savanna (Guillaumet et Adjanohoun 1971). It is characterized by contact between the forest and the savanna and consists of a mosaic of forest "islands" and savannas.

Biological diversity is particularly important because the species that belong to both forest and savanna exist side by side. The inhabitants belong to the Malinké ethnic group. While this ethnic group has the reputation for trade and transportation activities (Arnaud 1987), the inhabitants who live in the villages use many local natural products. However, as a result of human occupation of the region, clearing for cultivation (deforestation, fires) is happening more and more, and threatens soil fertility and biological diversity (Guillaumet et Adjanohoun 1971). Some trees that provide commonly edible fruit, such as *Adansonia digitata*, *Parkia biglobosa*, *Lophira lanceolata*, etc., are selected when clearing land for cultivation. The availability of most wild species is being significantly affected by the increase in cultivated crops.

Material and methods

The method used for the selection of right fruit species is mostly based on steps defined by Franzel et al. (1996).

In the first step, we focused on creating inventories of the wild species of fruits that are edible in the region. From semi-structured interviews, the villagers were asked to list the edible fruit species that they know. They had also to provide knowledge about other uses of each species. Also, from observation, we recognized some species that are listed in the literature as providing fruit for consumption. They were added to the list even though the villagers visited did not eat their fruits.

In the second step, the most important fruit species were selected by means of the "free-listing" method (Cotton 1996). This approach works on the principle that the more significant fruit species are likely to be mentioned by several informants, and are likely to be mentioned earlier in each list.

In the third step, the fruit species selected were ranked according to the amount of interest in their fruits. A sample of 59 informants was selected for their better knowledge of wild edible resources. They were asked to choose their 5 preferred fruit and to order them according to the criteria defined (taste, hunger or medicine). A numerical value was assigned accordingly: 5 for the first choice and 1 for the fifth. Data from each informant were then used to calculate the total number of a

Many wild fruits are used daily and probably greatly contribute to the diet of rural peoples by providing rare nutrients. But it is extremely difficult to quantify their contribution in terms of nutrients because they are eaten throughout the day between meals. In gathering sites, children commonly swallow the delicious and succulent bales of Flacourtia flavescens.

given species; then an overall ranking was determined according to Cotton (1996).

The classification from each informant was verified by the method of "paired testing". This consists of presenting the species to informants in a range of combinations in order to assess consistency of an individual informant's responses. The commonly used fruit species (*Adansonia digitata*, *Parkia biglobosa*, *Tamarindus indica*, and *Lophira lanceolata*) were not taken into account on this step. The reason is that they are widely known and extremely important for local people who protect them using various agroforestry systems (stakes, hedges). Unlike the other wild species, they cannot be considered as being in danger of disappearing.

During the surveys, the species were reported by vernacular names and later converted to scientific names. Unfortunately, some species are not differentiated by vernacular names, so the surveys were based on visual stimuli when vernacular names were not sufficient. For this purpose, a collection "database" was created for the majority of fruits. They were gathered and collected as fresh or dry matter and were pictured *in situ* or in local markets.

The information most useful for each species were the vernacular names (in the six visited villages), the fruit characteristics (taste, colour, height,) and some species characteristics such as ecology, habitat, and height. When given information was not clear, the informant was asked to identify the species mentioned via the visual stimuli (picture, fresh or dry matter). An interpreter, selected for having good knowledge of wild resources, translated and verified the received information. In spite of these precautions, the edible fruits of the genus *Landolphia* could not be differentiated by the informants. These fruits are similar and are indicated by the same vernacular name, Gbéi (in Dioula). Therefore, the term *Landolphia* ssp. was used to indicate the three species *L. hirsuta*, *L. heudelotii* and *L. owariensis*.

Table I. Classification of wild fruits consumed in Guinea's pre-forest savannahs according to the preferences of the MalinkÉ ethnic group.

Scientific name	Total number	Rank
Saba senegalensis (A. DC.) Pichon	83	01
Uvaria chamae P. Beauv.	81	02
Dialium guineense Willd.	67	03
Landolphia spp.	67	03
Annona senegalensis Pers.	59	05
Aframomum alboviolaceum (Ridley) K. Schum.	54	06
Diospyros mespiliformis Hochst ex A. DC.	43	07
*Vitex doniana"*Sw.	34	08
Gardenia erubesens Stapf & Hutch.	26	09
Detarium senegalensis J. F. Gmel.	26	09
Pterocarpus santalinoides DC.	21	11
Spondias mombin L.	18	12
Lannea kerstingii Engl. & K. Krause	14	13
Ziziphus mauritiana Lam.	14	13
Parinari congensis F. Didr.	12	15
Parinari curatellifolia Planch. ex Benth.	9	16
Passiflora foetida L.	8	17
Thaumatococcus daniellii (Bennet) Benth.	6	18
Flacourtia flavescens Willd.	6	18
Cordia myxa L.	6	18
*Pentadesma butyracean*Sab.	6	18
Nauclea latifolia Sm.	5	22
Santalinoides afzelii (R. Br. ex Planch.) Schellenbg	5	22
Blighia sapida Koening	5	22
Opilia celtidifolia (Guill. & Perr.) Endl. ex Walp.	5	22
Cola gigantea A. Chev. var. *glabrescens* Brenan & Keay	5	22
Cola laurifolia Mast	4	27
Strychnos spinosa Lam.	4	27
Deinbollia leptophylla Gillg. ex Radlk	3	29
Myrianthus serratus (TrÉcul) Benth. & Hook.	3	29
Nauclea pobeguinii (Pob. ex Pell.) Petit	1	31
Cynometra megalophylla Harms	1	31
Ficus capensis Thunb.	1	31
Syzygium guineense (Will.) DC. var. *macrocarpum* Engl.	1	31

Results and discussion

The rank of importance of each species is presented in table I. The fruits of *Saba senegalensis*, *Uvaria chamae*, *Landolphia* spp. (*L. hirsuta*, *L. heudelotii*, *L. owariensis*), *Annona senegalensis* and *Aframomum alboviolaceum* appear to be particularly appreciated. These fleshy fruits include heart-shaped syncarpous berries (*A. senegalensis*), orange-colored berries (*Landolphia* spp.) or aggregated berries (*U. chamae*). These relatively big fruits contain large delicious edible pulp with a highly aromatic and refreshing taste.

Some other fruit species are also preferred even though their fruits are smaller. The round drupes of *Vitex doniana* (about 2 cm in diameter), the sweet-scented fleshy fruits of *Diospyros mespiliformis,* and the flattened round pods of *Dialium guineense* are well ranked. The reason for this, as mentioned by interviewees, is that each of these big trees bears many fruits during the gathering season. Their consumption is widespread. The fleshy fruits appear in the local markets only in the gathering season. Outside the period of harvest, only some dry fruits such as *Dialium guineense* are widely marketed.

Some fruits were not so well ranked in spite of their delicious and succulent pulp. Examples of this are *Flacourtia flavescens* and *Passiflora foetida.* These two plants seem less important according to villagers because, in addition to the edible part being very small, they are represented by only a small number of individual species growing in a few habitats, such as rocky ground (*F. flavescens*) or roadside (*P. foetida*). Only children commonly eat these fruits at the growing sites.

On the other hand, villagers liked *Gardenia erubescens*, though its fruits are less juicy, because they are available when other fruit species do not occur. Hunters, shepherds and farmers reported that the fruits of *G. erubescens* greatly contribute to satisfying hunger when they are out working for long hours. The fruits do not appear in local markets.

The more appreciated fruits in Guinea pre-forest savannas by the Malinké ethnic group: Uvaria chamae *(1),* Landolphia owariensis *(2),* Saba senegalensis *(3),* Landolphia heudelotii *(4),* Aframomum alboviolaceum *(5) and* Annona senegalensis *(6).*

The fruits were gathered with the participation of rural inhabitants, collected fruit came from big trees (Ricindendron heudelotii) *and undergrowth herbs* (Thaumatococcus daniellii).

Some fruits, not included as first choices, are however important for specific groups of the people interviewed. For example, the fleshy syncarpous fruit of *Myrianthus serratus,* despite its low rank (29/34), is greatly appreciated by the inhabitant of Bac-semien, a riverside village visited.

Conclusion

As presented here, it is evident that fruits are appreciated for two major reasons: taste and ability to satisfy hunger. Species that are widely distributed and those that bear fruits over long periods, including times of famine, are greatly appreciated. These criteria should be taken into account in any planned improvement of fruit species in the region.

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Kodampuli – a fruit for all reasons

T.P. Manomohandas, K.N.Anith, S. Gopakumar and M. Jayaranja

The most sought-after fruit in Kerala, India can be eaten, employed as a food flavouring and for curing fish, used to treat rheumatism, bowel problems, and mouth diseases of cattle, helps coagulate rubber latex, and polishes gold and silver

Farmers in the tropics have available a great variety of plants, including a wealth of tree species, that provide a range of products and services in their farm-based economies. Kerala, on the southwestern coast of India, has a tropical humid climate. With its tremendous diversity in trees, the area is virtually a big homegarden. In this small state, intensive agriculture comprises multistoreyed agroforestry combinations of crops, trees and livestock in a mixed dense pattern. These gardens vary widely in the combinations found in them, but all supply family requirements of food, fodder, fuel and timber, and generate extra income by the sale of surplus products (Salam and Sreekumar 1991).

The government of India has initiatated the National Watershed Development Programme for Rainfed Areas. As part of this programme, scientists attached to the Farm Science Centre and Regional Agricultural Research Station of the Kerala Agricultural University in the Wayanad District of Kerala undertook a series of farm interventions aimed at generally improving the watershed. Farm visits showed numerous tree species being cultivated by the farmers of this region. The common trees included jack, teak, mango, coffee, arecanut, coconut and other perennial woody crops in agroforestry systems based on black pepper.

Garcinia cambogia Desr., locally known as 'kodampuli', is widely grown in the homegardens of Kerala. The genus *Garcinia* to which it belongs is large; its evergreen trees or shrubs are found in tropical Asia, Africa and Polynesia. About 30 species grow in India, mainly in the Western Ghats, a mountainous stretch in southwest India that is identified globally as a major hot spot of biological diversity.

G. cambogia is a medium-sized tree with a rounded crown and horizontal or drooping branches. Its globular fruits are the size of an orange, 60 to 70 mm in diameter. The yellowish or reddish fruits have 7 to 13 (normally 8) deep longitudinal furrows that do not extend to the apex. The apex is smooth, depressed and often nipple shaped. Seeds, one in each groove of the fruit, are long, oval, depressed and surrounded by a copious juicy red or white aril, with pale brown and veiny testa.

Many uses

Kodampuli fruits are widely sought after in the market for various uses. The rind of the underripe fruits is peeled, sun-dried for 3-5 days to a moisture level of 20%, then smoked. This dried rind is a choice flavouring in Kerala cuisine – a substitute for tamarind *(Tamarindus indica)*. Currently, a kilogram of dried kodampuli rind sells in Kerala markets for approximately 250 Indian rupees (US$5). In nearby Sri Lanka, the dried rind is used with salt to cure fish. A decoction of the fruit rind is used to cure rheumatism and bowel complaints in human beings.

Figure 1. There is significant variation in the shape and size of the kodampuli fruit.

It is also used as a rinse for diseases of the mouth in cattle (Geetha 1994). The dried rind is used for polishing gold and silver, and as a substitute for acetic or formic acid in coagulating rubber latex. A translucent yellow resin obtained from the tree is reported to have purgative properties.

Realizing the importance of kodampuli in the local markets and in households throughout Kerala, we made an elementary survey of the trees in the Mannathavady 'taluk' (a taluk is a cluster of villages) located in the northern region of Wayand District, a part of Western Ghats. The aim of this inventory was to verify local farmers' claims of the diversity of kodampuli fruit existing in this region.

The survey and the collection of fruits were carried out in the southwest monsoon season between June and August 1998. We approached local contact farmers and grassroots extension personnel of the Department of Agriculture to identify homesteads where kodampuli trees stood. Usually we found only one *Garcinia* tree in a homegarden, because one tree is enough to meet a household's requirement for dried rind.

Fruits were collected from different canopy levels of several trees spread over an area of 450 km^2. The location of each tree and the level of the canopy (top, centre, base) from which fruits were collected were recorded. The fruits were then graded according to visible characteristics like shape and size, number of rinds, and the presence or absence of a nipple at the fruit tip (Fig. 1). The data on the variability of the fruits are shown in Table 1.

Since the rind is the economically important part, its thickness determines the price that it fetches in the market. Fruits weighing more than 100 grams, with a rind percentage above 80 and a rind-to-seed ratio of above 3.5, sell well. The large variation in fruit size and rind percentage calls for renewed efforts to identify and vegetatively propagate trees with the most desirable fruit characteristics. This is particularly important since kodampuli is androdioecious, that is, the tree bearing male flowers also bears hermaphroditic flowers (George and others 1994) and all the trees we screened had originated from seedlings.

Vegetative propagation needs to be done with care to prevent desirable characteristics from getting lost through cross-pollination. Further, if a more scientific inventory on kodampuli were carried out in the natural ecosystems of Western Ghats, it could unearth more economically important tree types that could be domesticated.

Table 1. Fruit diversity in Garcinia cambogia

Fruit type	Fruit weight (g)	Fruit diameter (cm)	Rind ratio	Rind:% seed
Round mammiform	165.50	7.31	82.0	4.61
	162.50	7.31	80.0	4.00
	157.50	6.86	76.0	3.20
	147.50	6.80	80.0	3.92
	105.00	6.50	71.0	2.50
	97.50	5.89	62.0	1.60
	75.00	5.51	77.0	3.28
Round	128.00	6.97	83.0	4.82
	115.00	6.29	73.0	2.68
	72.50	5.45	83.0	4.8
	63.33	5.39	66.0	1.92
Oval mammiform	70.00	5.14	75.0	3.00
	60.00	5.35	67.0	2.00
	45.00	4.49	89.0	8.00
	30.00	3.95	67.0	2.00
Oval	83.30	5.37	78.0	3.63
	68.33	5.11	68.0	2.15
	50.00	4.53	73.0	2.75
Cylindrical	90.00	5.51	78.0	3.50
	83.00	5.31	78.0	3.55
	71.66	5.42	74.0	2.91

* Numbers in a row represent the average values of 10 fruits collected from a single tree

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Savannization: A runoff agroforestry system for semi-arid and arid zone development

Paul Ginsberg

Savannization is a management tool for restoring and improving degraded shrub lands in the 200–300 mm precipitation belt in the Negev Desert. It creates savanna-like parklands which provide a multitude of goods and services to the local population and the surrounding ecosystem.

Savannization is a land management technique developed by the Forest Department's Southern Region of the Keren Kayemeth Leisrael (KKL) in Israel. The name arises from the landscape aspect of the system's management—the creation of water- and nutrient-enriched patches for forest tree planting, thus transforming a shrublike landscape into a savanna-like one (Shachak 1999). The "Savannization Project" grew out of efforts to expand forest tree planting into the Negev Desert's northern fringes—a zone covered by degraded shrub lands receiving between 100–300 mm. of annual precipitation. The challenge of successfully managing tree establishment centres around the efficient and intelligent use of water harvesting techniques which make available a very limited supply of rainwater to planted trees.

Since its inception in 1986, the "Savannization Project" has evolved into a fully fledged, interdisciplinary research endeavour examining the structure, function and ecology of a degraded, shrubland ecosystem and how it reacts to human, landscape-level manipulations. Early results indicate the project's potential for use in regional development schemes at the urban/rural interface and in semi-arid areas. A multiple-use landscape, created through integrated planning and interdisciplinary management, will thus benefit both the local population and the ecosystem.

Historical perspective

Water harvesting has been practised in the Middle East for over 4000 years (Evenari et al 1982; NAS 1974). In Israel's Negev Desert, the Nabatean culture (300 BC–600 AD) incorporated it widely. Their fortified towns and villages thrived on trade with Arabia, India and China, and on the agricultural goods they produced with runoff-based desert agriculture.

The work of Evenari and his colleagues documents the identification, analysis, and restoration of several Nabatean farms based exclusively on rainwater harvesting via various systems of terracing and water catchment structures. Surface runoff was directed from large catchment areas to small agricultural plots. It was found that an average catchment area ratio of 20 hectares was needed to irrigate and sustain 1 hectare of agricultural land. Evenari's work showed that it was possible to grow grains, pasture, grapes and assorted fruit and nut trees with this method in the 100 mm rainfall zone of the Negev Desert.

Landscape restoration

According to Whisenant (1995), ecological restoration of arid landscapes attempts to manage human intervention by stimulating natural successional processes which can develop stable structural and functional ecosystem dynamics. Landscape processes essential to the establishment and maintenance of arid ecosystems should be identified, researched and then incorporated into a restoration plan.

Degraded arid lands are resource poor. They are limited in water, nutrients, and soil, and tend to suffer from leakages of these resources due to the systems' inability to retain them by physical or biological means.

> *The application of landscape [level] considerations to arid land restoration problems might focus on capturing flows of scarce resources across the landscape… Restoration strategies should link soil-vegetation-landscape associations to the dynamic processes controlling the flow of limiting resources… Careful landscape design contributes to the retention of nutrients, water and other materials. The flows of water, energy, nutrients, propagules, soil and organic matter that flow into, within, and out of landscape elements can be manipulated to help achieve restoration objectives*
> (Whisenant 1995).

One management solution for decreasing resource leakage is to create sink patches. Thse are characterized by two features—the first is a structure that prevents the flow of runoff water, soil, organic matter, and nutrients from a landscape unit; the second is a storage unit that maintains and absorbs water, organic matter, and nutrients (Shachak et al 1998). On the basis of this strategy, the " Savannization Project"" was conceived and implemented.

Management practices

The desertified shrublands in the northern Negev Desert are comprised of scattered shrub patches dispersed over a matrix of crusted soil (Shachak 1999). Water, soil and nutrients are the main resources limiting biological production and diversity in these systems. Resource flow through the system can be characterized as a "sink-source" relationship – the crusted soil matrix is the contributory source of resources and the scattered shrub patches act as sinks capturing the resource flow. Low numbers of sinks (shrub patches) trap a small percentage of resources leaked from the system, thus resulting in low ecosystem productivity and biodiversity.

Savannization focuses on creating additional artificial patches of relatively high productivity by planting trees in desert landscapes of low productivity. These patches benefit from soil-water enrichment generated by the collection of surface runoff from the undisturbed area (JNF 1994). Boers et al (1986) discuss the applicability of microcatchment-water-harvesting (MCWH) technologies for runoff-based reafforestation projects in the arid zone. As a restoration process,

> *it stops desertification, increases the abundance and diversity of organisms, allows for multiple land use, and leads to environmental benefits. The savannization approach establishes an ecologically based, human-made, artificial ecosystem in desertified environments, leading to partial restoration of environmental disturbances. This concept represents a continuous manipulation process controlled by natural succession and managed by humans* (Sachs & Moshe 1999).

Detailed site planning, in-depth soil surveys, and simple agro-technical techniques can alter the landscape mosaic by creating new sinks to trap otherwise lost system resources. Four types of sink patches used in the project are: (1) hillslope minicatchments – earthen structures for individual tree planting; (2) earthen contour terraces – earthen barriers created mechanically along slope contours for the planting of widely spaced strips of trees; (3) limans – sites in which earthen dams are constructed across stream beds, creating small oases of planted trees; and (4) stream bed terraces – stone dams constructed across stream beds to collect and store runoff water and eroded sediment (Shachak et al 1997). Contour ploughing, terracing, and microcatchment construction entrap water, soil and nutrients in small, localized patches. These resources are subsequently made available to planted trees and natural seed banks.

The most commonly planted tree species are: *Eucalyptus torquata, E. sargentii, E. stricklandii,Prosopis alba, P. chilensis, P. juliflora, Acacia anera, A. elatior, A. raddiana*, Pinus brutia, P. halepensis*, Pistacia atlantica*, Tamartx aphylla (=T. articulate)*, Ceratonia siliqua*, Zizyphus spina-christi*.*

Secondary species include: *Eucalyptus astringens, E. occidentalts, E. umbellata, E.loxophleba, E. subcinerea, E. salubris, E. camaldulensis;Pinus eldarica;Prosopis nigra;Pistacia palaestina*;Acacia victoriae, A. negevensis*, A. salicinia;Tamarix aphylla var. stricta*; Cupressus sempervirens;Ficus carica**, *F. sycamorus*.* (from Shachak et al 1997). **native species*

Prior to tree planting, the site is fenced in and closed to grazing in order to allow undisturbed growth and ecosystem recovery. After 4–5 years the once degraded landscape resembles a savanna of widely spaced trees (100–20 trees/hectare) with a diverse understorey of seasonal, herbaceous vegetation and shrubs.

Savannization can thus be characterized as a form of dryland forestry combining integrated watershed management planning on the micro-scale, with a silvopastoral-type agroforestry system (Ffolliot et al 1995). The managed flow and storage of limited, water-borne resources results in increased biomass, primary productivity, and diversity of herbaceous species, and is the basis for successful tree establishment. Thus, a multilayered ecosystem of trees, shrubs, herbs, and grasses serves as the biological infrastructure for social forestry uses of this system.

Social forestry applications

According to Pickett et al (1999), ecological systems should be managed for multiple uses, such as to yield commodities, amenities, or services, for economic, social, aesthetic, cultural, or other values. The process of ecological management [restoration] should accommodate multiple societal goals, be they economic, agricultural, cultural, or wildlife preservation, among others. These statements reflect those stated in the Summary Report on Social Forestry presented to the Eleventh World Forestry Congress (1997) in Antalya, Turkey – that social forestry projects should, and must, provide a multitude of non-commodity goods and services to the society that undertakes such an endeavour.

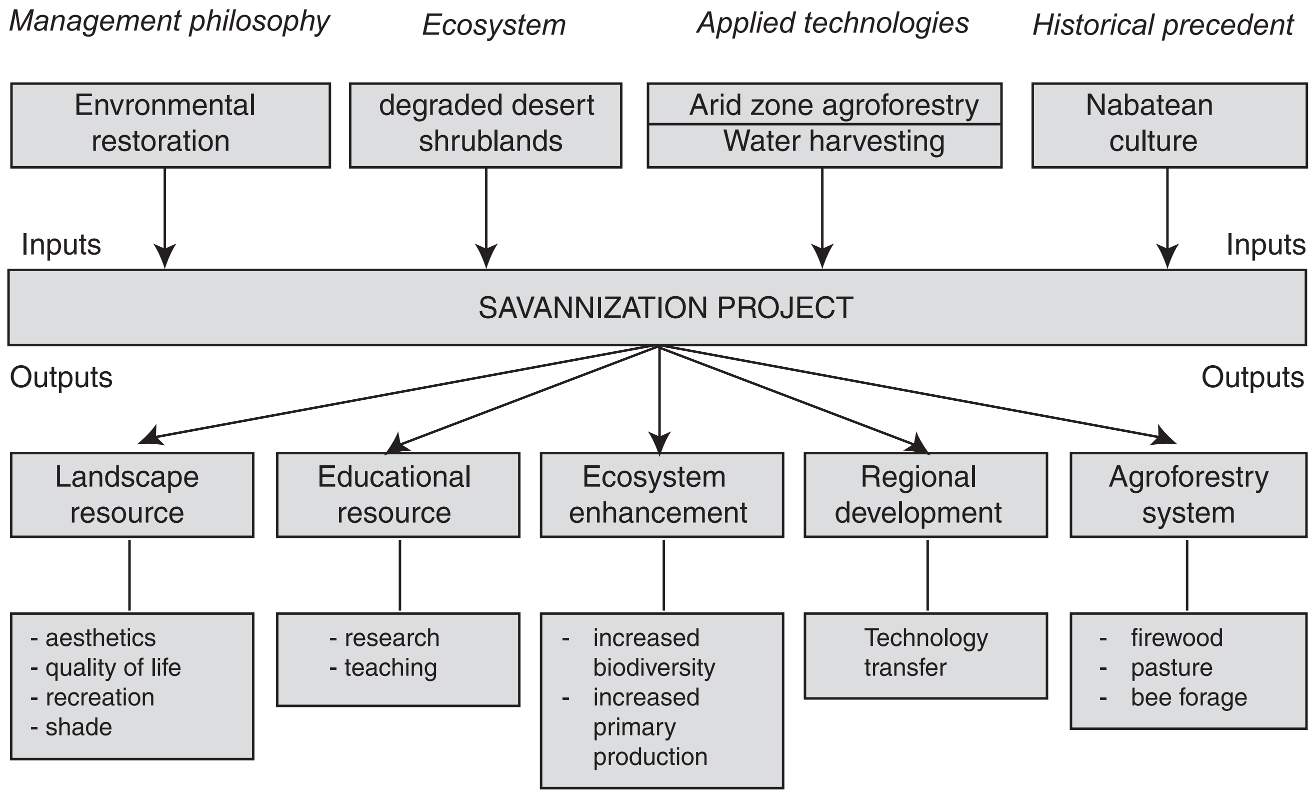

Figure 1. System model of the savannization project.

As illustrated in Figure 1, the "Savannization Project" is modelled as a social forestry-type enterprise. It integrates three information-rich areas of knowledge (management philosophy, applied technologies, historical precedent) within an ecosystem (degraded desert shrubland), and generates a set of multiple benefits – an improved landscape resource, enhanced ecosystem productivity, a silvopastoral agroforestry system, an educational resource, and a transferable technology for regional development work – for the local society's good. A successful combination of integrated watershed management with a runoff-based agroforestry system of tree planting and grazing management has created a new landscape in the arid zone of Israel, and shows the possibilities of multidisciplinary, integrated management.

The goal of the Forest Department's savannization effort is to stop desertification and increase the value of the land for human use by ecological management of vegetation, soil and water (Sachs & Moshe 1999). The basic management approach – adding man-made sink patches enriched with runoff water and nutrients for planting trees and enhancing natural vegetation growth – has not only rehabilitated a degraded ecosystem, but has added new uses in the form of grazing lands and recreational parks (Shachak et al 1998).

Located near urban settlements, the savanna landscape system serves as a green belt, resulting in increased land value for the local population. The addition of scenic roads, walking trails, and observation points fulfil the needs of the nearby urban population for an accessible, green, open space resource.

According to Boeken & Shachak (1999), artificial patches can be used as a tool for the sustainable management of lands threatened by desertification. Firewood, shade and enriched pasture outputs will benefit humans, wildlife and domesticated animals alike. Some areas have been successfully opened to controlled sheep grazing 4-5 years after planting (JNF 1994). In addition, patches rich in plant species numbers and biomass can function as biodiversity reserves for species whose habitats may be threatened by desertification.

Another potential by-product of the system is the creation of short-season bee pasture from the trees', shrubs' and herbs' flowers. Several native and exotic tree species (*Ziziphus spina-christi; Ceratonia siliqua; Eucalyptus camaldulensis, E. occidentalis, E. stricklandii, E. torquata*) show great promise in this field, especially during the dearth

Tree Species	Fuelwood	Fodder	Bee pasture	Nitrogen fixation	Landscape
Acacia aneura		*			*
Acacia eliator					*
Acacia negevensis					*
Acacia pendula					*
Acacia raddiana	*	*			*
Acacia salicinia	*				*
Acacia victoriae					*
Ceratonia siliqua	*	*	*		*
Cupressus sempervirons	*				*
Eucalyptus astringens					*
Eucalyptus camaldulensis	*		*		*
Eucalyptus loxophleba					*
Eucalyptus occidentalis	*		*		*
Eucalyptus salubris	*				*
Eucalyptus sargentii					*
Eucalyptus stricklandii			*		*
Eucalyptus subcinerea					*
Eucalyptus torquata			*		*
Eucalyptus umbellata					*
Ficus carica		*			*
Ficus sycamorus		*			*
Parkinsonia aculeata					*
Pinus brutia	*				*
Pinus eldarica	*				*
Pinus halepensis	*				*
Pistacia atlantica		*			*
Pistacia palaestina		*			*
Prosopis alba	*	*		*	*
Prosopis chilensis	*	*		*	*
Prosopis juliflora	*	*	*	*	*
Prosopis nigra					*
Tamarix aphylla (*articulata*)	*				*
Tamarix aphylla var. *stricta*					*
Ziziphus spina-christi	*	*	*		*

Table 1: Tree Species in the Savannization Project and Their Potential Uses (Goor & Barney 1976; NAS 1980; Purdue University 2000)

period between the dry summer and early winter (Eisikowitch & Masad 1980; Reves & Eisikowitch 1981).

As a landscape management tool, savannization has potential to improve the quality of life at the urban/suburban/rural interface in arid zones. When utilized as a greenbelt planting surrounding cities and villages, aesthetics and land values increase, as does the possibility for recreational development and use. The "greening" of desert landscapes encircling urban centres has immense value for the local population's well-being and can act as an incentive to attract newcomers to desert fringe settlements. (Table 1 illustrates all of the benefits associated with each tree species used in the project.)

Conclusion

Overall, the "Savannization Project" has shown that an arid landscape properly understood and developed can yield multiple goods and services. By combining historical knowledge, ecological understanding, a relevant management philosophy, and proven agrotechnical and silvicultural methods in an intelligent and measured way, desertification of arid and semi-arid landscapes can be halted and even reversed. Social and ecological benefits will arise from a once degraded ecosystem through proper management and the willingness to succeed.

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Potential agroforestry species identified in the Tamaulipan thornscrub of north-eastern Mexico

Pando-Moreno Marisela and Villalón-Mendoza Horacio

Large arid and semiarid areas of north-eastern Mexico are subject to prolonged droughts, very hot summers and winter frosts. These adverse climate conditions limit the possibilities for successful agriculture, and alternative methods to single crops need to be promoted to improve the economic status of the rural inhabitants.

Tamaulipan thornscrub in north-eastern Mexico includes about 80 woody species. Many of them have traditionally been used to produce firewood, charcoal, and wood for furniture, construction and fence posts. However, in spite of the significant contribution that these species can make toward increasing rural family incomes, they have barely been used as part of an agroforestry system. Now, a recent study has concluded with the selection of species with high agroforestry potential for the region.

The selection was made in an area located in the north-east of Mexico (24°47' North and 99°32' West). It lies in a gently sloping, undulated terrain with an average altitude of 355 m and a semiarid, subhumid climate. Precipitation is highly variable from year to year, with a maximum recorded rainfall of 1847.7 mm and a minimum of 390.1 mm. Mean annual rainfall is 810.6mm. Temperature is also variable through the year with very hot summers and occasional severe frosts during winter. Extreme temperatures are 44°C and –11.5°C while the mean annual temperature is 22.4°C (Cavazos & Molina, 1992).

Up to now, there has been a lack of studies in this region aimed at evaluating interactions between native woody species and crops. Thus, selection of the species was based on only three criteria: (1) species reported in literature to be used for more than one purpose, (2) species native to the region, and (3) species under current use by the rural population in the area.

Eleven native woody species were initially selected from literature as being used in the region for more than one purpose. Sources for this information were: Cabral & Treviño, (1989); Reid and others (1989); Reid and others (1990); Peñaloza and others (1989); Benavides, (1989); de la Garza, (1989); Carrillo (1991); and Infante (1993).

A list of the 11 selected species was taken to the field and informal interviews were made with 50 rural inhabitants—10 people from 5 different communities—about the use of such species. Every interviewer reported that 9 out of the 11 species were being used for several purposes. A list of the finally selected species as well as their current uses is shown in Table 1. A proposed agroforestry system for each species is also included in the table.

This is obviously a very first approach to the implementation of agroforestry systems in the region. However, the species selected here can be taken as starting points for further studies since they meet two very important requirements for an agroforestry system to succeed: (1) species are well known and accepted as useful by the local rural population and (2) they are multipurpose species. Another valuable characteristic is that they are native to the region so their use and reproduction would contribute to preserve local diversity.

Pando-Moreno Marisela and Villalôn-Mendoza Horacio are professors in the Agroforestry Department of the Universidad Autónoma de Nuevo León, Mexico.

Species	Common name	Family	Current use	Proposed agroforestry system
Acacia berlandieri	Huajillo	Leguminosae	Construction, firewood, fodder, fence posts.	Silvopastoral system
Acacia farnesiana	Huizache	Leguminosae	Firewood, fence posts, charcoal.	Agrosilvopastoral system
Condalia hookeri	Brazil	Rhamnaceae	fence posts, fodder construction,	Silvopastoral system
Diospyros texana	Chapote	Ebenaceae	fire-wood, fodder	Agrosilvopastoral system
Ebenopsis ebano (*Pithecellobium ebano*)	Ebano	Leguminosae	Construction, furniture, fence posts, charcoal, handcrafts.	Agrosilvopastoral system
Eysendhardtia polystachya	Vara Dulce	Leguminosae	fire-wood, fodder	Agrosilvopastoral system
Havardia pallens (*Pithecellobium pallens*)	Tenaza	Leguminosae	Construction, fire-wood, fodder, fence posts, handcrafts.	Silvopastoral system
Helietta parvifolia	Barreta	Rutaceae	Construction, fire-wood, fence posts.	Agrosilvopastoral system
Prosopis laevigata	Mesquite	Leguminosae	construction, fire-wood, fence posts, furniture, and parquet.	Silvopastoral system

Table 1. Potential agroforestry species for the region (NE, Mexico), their current use and proposed agroforestry system.

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Small-time operations – big-time loss

Illegal logging in the northern Philippines

Ben J. Wallace

The most common method of moving "squared" logs from the mountains to the lowlands.

While illegal logging operations are often carried out on a grand scale by large corporations, in the extreme north-western part of the Philippine province of Ilocos Norte in northern Luzon illegal logging operations are carried out by small-time operators. The results, however, are the same: primary forest cover is rapidly disappearing.

As part of a long-term research and development project in the Philippines, named "Good Roots: *Ugat ng buhay*", the primary causes of deforestation (slash-and-burn cultivation, illegal logging, charcoal making, and fuelwood use) are being examined (see Wallace 1994, 1995, 1997). In three of the Good Roots research *barangas* (communities or villages), with a combined population of 2,754 people, there are 15 illegal logging teams, each one composed of four to seven men. Because of the sensitive and dangerous nature of collecting data on this activity, the villages where these teams are based are referred to here as Village I, Village II, and Village III. Village I has four teams, Village II has two and Village III has nine. The basic tools of illegal logging in the area are chainsaws, axes, machetes, and digging bars.

Logging by these teams is done in primary forest growth areas, usually three to four hours walking from the home village. The most common species being cut by the illegal loggers are narra (*Peterocarpus indicus*), tanguile (*Shorea polysperma*), apnit (*Shorea contorta*), guijo (*Shorea guiso*), yakal (*Shorea astylosa*), almaciga (*Agathis philippinesis*) and dao (*Dracentomelon dao*). In this area of the Philippines these species are found almost exclusively in primary forest growth areas. They are found above 300 m in elevation. Most forest areas below 300 m are secondary growth. Legal logging in the immediate area ceased two decades ago.

Each logging team consists of a main chainsaw operator, an assistant operator and two to three companions. The team usually stays in the forest for 3-5 days. The number of logging trips they make each year depends on current demand and price of illegally cut wood. Most of the loggers maintain a reserve stock of felled trees in the forest in order to avoid detection by authorities and to ensure a supply of wood on demand from buyers. Loggers say that freshly cut logs are too heavy to transport out of the forest and that logs are best seasoned in the forest.

The responsibility of the chainsaw operator and his assistant is to decide the direction of the falling trees and the size of the squared logs to be cut from them, plus maintenance of the chainsaw and the carrying out of all major sawing cuts. The companions are responsible for cleaning the cutting area, cutting and preparing trees as scaffolding in case the buttress is too high or cutting at the base of the tree is not possible. They also oversee the routing of log transportation, and the moving of logs away from the cutting site.

Transportation of the logs, generally cut into what are called "squared logs" (usually 25 cm by 30 cm by 4 m), are pulled from the forest by carabao (water buffalo) or by what is called the "balloon method" (where the logs are supported by inflated automobile tire tubes and floated down river). The buyers and end-users of the illegal logs are usually outside the home villages of the loggers. Depending on the buyer, the logs are purchased as logs, squared logs, or as sized lumber.

Data from general interviews with villagers and loggers, detailed interviews with logging team leaders, visits to logging sites, and actual measurement of trees and cut logs in three logging sites, suggest that although illegal logging in the Good Roots villages is small-scale, it is a significant activity. The total volume of major timber trees cut by the four teams in Village I is 120.5 cubic metres per year. The two teams in Village II cut 60.2 cubic metres. Village III, with nine teams, cuts a total of 271 cubic metres. In addition, smaller timber tress and those of lesser value are cut or destroyed in preparing the site. Village I cuts 8.3 cubic metres of smaller trees per year. Village II destroys 4.1 cubic metres and Village III cuts 18.6.

When maturing saplings, destroyed or seriously damaged in association with illegal logging activities, are included, the people in Village I extract from the forest 183.3 trees each year; Village II loggers extract 91.7 trees, and the logging teams in Village 3 extract 412.5 trees. In total, the Good Roots communities extract from nature 687.5 hardwood trees, or .25 trees per person each year, all from primary forest growth areas. As there are 2,750 trees/ha (70 of this number with a diameter of 50 cm or more) in primary forest in the Good Roots area, this amounts to 24% of a hectare of primary forest growth. The villages under investigation constitute only 34% of the population in the immediate area, and other villages also have teams of illegal loggers.

Transportation of the logs, generally cut into what are called "squared logs" (usually 25 cm by 30 cm by 4 m), are pulled from the forest by carabao (water buffalo) or by what is called the "balloon method".

It is estimated that there are at least 50 logging teams in the immediate area. It is estimated that almost 1 ha of non-replaceable hardwood timber is being cut each year, just in the Good Roots area. Except for an occasional pioneer slash-and-burn plot, the bulk of primary forest cutting is carried out by illegal loggers. Most slash-and-burn activity and fuelwood cutting is done in secondary forests.

Not all cut trees are of equal loss to the environment. The cutting of a single hardwood tree in primary forest growth is a greater loss than the cutting of a fuelwood tree in secondary forest growth. Most fuelwood trees, because they are abundant and fast growing, will regenerate in only a few years while the loss of a hardwood tree may be a loss forever. This becomes even more important considering that there are 858 cubic metres of wood per hectare in trees in primary forest growth in the Good Roots area while there are only 98 cubic metres per hectare in secondary forest growth.

It is projected that in the Good Roots and adjacent villages 2,025 trees per year, or .73 ha, are cut each year from primary forest. It should be remembered, however, that there is almost nine times the volume of wood in the primary forest as there is in the secondary forest. Given this situation, illegal logging, even though practised on a small-scale basis, is having a significant impact on the local environment.

Reducing the extent to which farmers cut the best and largest hardwoods from the primary forest will not be an easy undertaking. As long as there is a market for the logs, as long as the Philippine Department of Environment and Natural Resources is so understaffed that it cannot enforce the laws, and as

Rural woodworking shop for processing timber

long as the farmers remain poor, the illegal logging activities will continue. With each year, and with fewer hardwood trees available, the price of quality lumber will continue to increase, making the illegal cutting activities even more profitable. Supply and demand will continue to control the market for the foreseeable future.

The best opportunity for reducing the number of illegally cut trees is the improvement of economic opportunities for rural Filipino families. Cutting trees from the primary forest, hauling the logs to the lowlands, and turning the logs into lumber, is difficult and time-consuming work. Given these labour-intensive demands and the risks of fines or jail or worse associated with illegal logging, interviews with farm families suggest that they would prefer more profitable and safer economic opportunities.

As long as there is a market for the logs, as long as the Philippine Department of Environment and Natural Resources is so understaffed that it cannot enforce the laws, and as long as the farmers remain poor, the illegal logging activities will continue.

Assuming that population growth in the Good Roots region is comparable to the Philippine national average, the population in the area will double over the next two to three decades, placing even greater demands on the environment. Under this situation, it is estimated that in less than a generation these forests will be almost fully denuded. Unless the farmers of upland Northern Luzon are able to slow the process of deforestation, it is most likely that land that was once covered with primary forest will be become a sea of cogon grass (*Imperata cylindrica*), rendering it basically useless for humans and animals.

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Agroforestry trees restore degraded land in the Himalayas

Girish C.S. Negi and Varun Joshi

How can the severely degraded land around many Indian villages be revegetated? Villagers in the Central Himalayan mountains are eager to start by planting agroforestry trees.

In the Central Himalayan mountains in India, subsistence agriculture, which is the mainstay, demands massive quantities of fodder, leaves for manure, fuelwood, wood for agricultural implements, and timber for minor construction projects. Although 63 percent of the geographical area of this region is classified as forestland, only 40 percent is forested and in only 16.6 percent of the area are the forests well stocked (Ramakrishnan and others 1992). The rate of biomass harvest far exceeds the rate at which these forests regenerate (Singh and Singh 1991). People—mainly the women and the rural poor—may have to spend twice as much energy collecting forest biomass as they spend directly on agricultural activity (Ralhan and others 1991). This skewed expenditure of energy makes life miserable.

Obviously, much of the biomass harvested comes from the village surroundings, which are frequented year-round. Further, large herds of free-grazing livestock degrade the vegetation base. These practices lead to marginal rainfed terraces being abandoned and the wasteland around human settlements increasing (Negi and Joshi 1997). On average, there exists about one hectare of degraded land for every hectare of cultivated land in this region. Thus, the first task necessary to increase the resource base is to 'revegetate' the village wastelands and degraded forests.

Agroforestry trees and shrubs—the suitable choice

A number of indigenous agroforestry trees and shrubs (AFTS) grow in and around the crop fields in this region. Year-round, they serve many purposes and fill many needs (Table 1). Most occur either as isolated individuals in the native vegetation or on the crop field bunds and village surroundings. Villages protect the existing trees, but they make minimal efforts to plant new stock. They lack know-how in propagation and in nursery and plantation technology. Nor are they sure about the performance of new stock under erratic rainfall, which is the only source of moisture in the degraded lands. But they strongly feel the need to grow a few AFTS that give promise of surviving and growing under the prevailing agroclimatic conditions.

Under our institute's integrated watershed management project, located at an altitude of 1400 m in Garhwal Himalaya, we planted 10 locally available AFTS. The species were selected for their particular uses and for their ecosystem services such as nitrogen fixation and soil and water conservation (Negi 1995). The village people participated in collecting seeds from the surroundings, raising seedlings at the site, and planting them out in 10 m x 10 m blocks. In doing this, the people found out about the seed source and learned nursery raising and plantation techniques.

After three years in plantation, *Alnus nepalensis* had grown the tallest (262 cm), but its survival was the poorest (26 percent) among all the species (Table 2). This species fixes nitrogen (29–117 kg of nitrogen per hectare per year) and regenerates profusely (Sharma and Ambasht 1988), but the villagers consider it inferior for fodder and fuelwood. The maximum survival rate (77 percent) was recorded for *Grewia optiva*, but its growth was poor; it reached a height of only 64 cm. This species yields quality fodder (crude protein, 26 percent) during summer, good fuelwood, fibre (used for rope making) and endures heavy lopping

Pant Institute staff often train rural women in nursery and plantation technology. Here a scientist of the institute demonstrates Albizia stipulata, Bauhinia variegata *and* Dalbergia sissoo *growing in Styrofoam trays.*

Species	Main use	Minor use	Crude protein content(%)	Season of major use	Proportion in local vegetation (%)	Proportion planted by people (%)
NON-NITROGEN-FIXING						
Bauhinia variegata	FD, FR	AG, F	18.1	winter	0.9	1.0
Celtis australis	FD, FR	AG	8.2	summer	6.1	1.9
Grewia optiva	FD, FR	F	26.1	winter	24.2	4.5
Melia azedarach	MT, FR	FD	18.4	rainy	1.1	1.8
Prunus cerasoides	SC, S	FR, FD	19.2	year-round	5.6	0.0
Quercus leucotrichophora	FD, FR, SC	AG	18.1	year-round	4.2	12.3
NITROGEN-FIXING						
Albizia stipulata	FR	FD	15.0	summer	0.0	12.5
Alnus nepalensis	SC	FR, FD	12.6	year-round	0.0	2.5
Dalbergia sissoo	T	FD	9.1	summer	0.0	62.9
Ougeinia dalbergioides	FD, AG	MT, M	18.2	summer	0.0	0.7

FD = fodder, FR = firewood, MT = minor timber, SC = soil and water conservation, S = sacred, T = timber, AG = agricultural implements, F = fibre, M = medicine

Table 1. Agroforestry trees and shrubs, their uses and use period, proportion in native vegetation, and people's preference in private plantations

Species	Height (cm)	Survival (%)	Phenological attributes					Agroforestry traits
			Growth form	Leafing Period	Leaf drop period	Seed maturation period	Period of canopy closure	
NON-NITROGEN-FIXING								
Bauhinia variegata	143.7 + 7.1	62	D	summer	summer	summer	July–Feb	deep rooted, endures heavy lopping stress
Celtis australis	75.9 + 5.9	70	D	spring	autumn	autumn	June–Nov	sparse crown
Grewia optiva	63.9 + 3.9	77	SE	summer	summer	autumn	June–Feb	endures heavy lopping stress, short stature
Melia azedarach	66.8 + 5.9	65	D	spring	winter	winter	July–Nov	sparse crown
Prunus cerasoides	167.8 + 10.9	36	SE	autumn	autumn	winter	Dec–Aug	sparse crown, short stature
Quercus leucotrichophora	115.7 + 8.1	25	E	summer	summer	winter	June–Mar	deep rooted
NITROGEN-FIXING								
Albizia stipulata	3.9 + 5.6	51	D	summer	winter	winter	June–Oct	sparse crown
Alnus nepalensis	262.3 + 15.0	26	D	spring	winter	autumn	May–Nov	sparse crown, fast growing
Dalbergia sissoo	134.0 + 9.8	69	D	summer	winter	winter	June–Dec	sparse crown, fast growing
Ougeinia dalbergiodes	60.0 + 3.3	66	D	summer	spring	summer	June–Jan	short stature
Average non-NFT	107.4 + 15.2	56.1 + 7.1						
Average NFT	137.6 + 44.2	53.0 + 9.8						

D = deciduous, SE = semi-evergreen, E = evergreen

Table 2. Growth and survival and phenological records of the agroforestry trees and shrubs

(Negi 1994). Similarly, *Quercus leucotrichophora,* although its survival rate was low and its growth slow, is greatly valued as it provides quality fuelwood, leaves for manure and fodder during lean months, and is also a key species for soil and water conservation. On average, height growth of nitrogen-fixing trees and shrubs (NFTS) was higher than of the non-NFTS. Survival rate, however, was almost the same.

One cannot recommend a set of MPTS based merely upon growth and survival records. People rightly attach a number of other values to each species. For example, the timber value of *Dalbergia sissoo* is high, *Melia azederach* suits minor timber needs, flower buds of *Bauhinia variegata* are used as a vegetable, *Ougeinia dalbergioides* is best for agricultural implements, and *Prunus cerasoides* is a sacred species. All these species can also provide green fodder year-round (Nautiyal and others 1987).

However, to green the wastelands rapidly and to reduce soil erosion, it is pertinent to plant AFTS species that will upgrade soil fertility through nitrogen fixation and litter quality (Maikhuri and others 1997). Our experimental plot served as a demonstration unit, from which local people picked out the species of their choice and gained know-how on how to cultivate them. On about 3.3 hectares of land, they planted 1837 seedlings of nine species. About 63 percent of the people preferred *D. sissoo;* next choices were *Albizia stipulata* (12.5 percent) and *Q. leucotrichophora* (12.3 percent). As the other species (Table 1) already grew in their surroundings, villagers were less interested in cultivating them.

People have already domesticated the AFTS examined here that are suitable for revegetating degraded lands. They use them to meet a variety of needs, from fodder to fibre and fertilizer (Nautiyal and Negi 1994). Some are short in stature and have a sparse crown, permitting abundant sunlight to filter through to the agricultural crops, hence affecting crop yield only marginally. Canopy closure and active growth in most of them occur during rainy season (Table 2). In some, leaf drop coincides with germination and growth of winter crops.

As the trees complete their leafing, flowering and fruiting during summer (the fallow period of the crop fields), they stagger the demand for nutrients and moisture from soil and least affect the development of rainy season crops. Some endure high lopping stress and have a deep root system, competing very little with food crops for water and nutrients.

Conclusion

It is apparent that the benefits harvested from the AFTS are many. In this region, where 85 percent of the agriculture is rainfed and crop cultivation is practised on tiny terraces carved out of hill slopes, growing AFTS on degraded lands and food crops under their canopy helps ensure a year-round supply of various resources for the subsistence living of the people and helps deteriorating mountain ecosystems recover.

Before we recommend these agroforestry species as suitable for a crop mix in this region, however, we need studies on their nutrient demands, soil-ameliorating properties, allelopathic effects, nursery and plantation technology, and the effect of lopping and silvicultural operations on their growth.

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Feeding diversity of blister beetle and extent of damage it does under agroforestry systems

Chitra Shanker and K.R. Solanki

Plate 1. Blister beetle feeding on green gram inflorescence

In the recent past, agroforestry as a land-use practice has gained momentum, but information available on the changing pest status under agroforestry systems is scarce. It has been suggested that the pest problem under agroforestry would decline based on some extensive reviews of the arthropod diversity under diversified agroecosystems. (Root, 1973; Risch *et al*., 1983; Andow, 1991).

These studies are based on the heterogeneity in agricultural crop species. Some reports have also been made on the moderating effect of species diversity on the pest status of trees. A mixed plantation of *Chlorophora excelsa* and *Maesopsis eminii* (Engl.) had reduced infestation of the gall bug, *Phytolyma lata* (Mchowa and Nyugi, 1994, quoting Schaefer and Siva, 1990). Presence of weed species in orchards was found to increase vertebrate and invertebrate natural enemy activity thereby reducing pest population levels. (Chakravarty *et al*., 1986; Dix *et al*., 1996). Vegetational diversity does not always result in reduced pest populations.

When the tree and crop component shares one or more key pests, the pest interaction is of the primary type. Selection of tree-crop species should be made with caution to avoid such interactions. The insect under this study, Mylabris *pustulata* or the banded blister beetle, is a polyphagous flower beetle feeding on the flowers, pollen and sometimes on leaves of a number of plant species. It feeds on flowers of many agricultural crops, mainly pulses (Hill, 1987), ornamental and medicinal plants (Murugesan *et al*., 1997) and a few forest trees (Sivaramakrishnan, 1984). It is distributed in Africa, India, Bangladesh, Sri Lanka and Southeast Asia.

In northern India this beetle makes its appearance at the beginning of July, soon after the arrival of monsoon showers and continues to remain in the field till October. During this period a number of trees and crops flower in synchronization. At Jhansi, we observed the host range of *M. pustulata*, its seasonal distribution and the extent of its damage under agroforestry.

Jhansi, situated at 25°27' N latitude and 78°35' E longitude, has unimodal rainfall with an annual range of 800-1000 mm in 53 rainy days. The rainy months are July to September. Two predominant cropping seasons exist – *Kharif* (July to October) and *Rabi* (November to February). The most preferred crops during Kharif, especially under rainfed situations, are pulses such as green and black gram. More than 25 multipurpose tree species grown with and without crops were observed for blister beetle damage. The ornamental plants grown around the farm, and weeds associated with the field, were also observed.

Host range of *Mylabris pustulata*

The tree/plant species mentioned above were closely scrutinized for feeding by beetles from June to October. The preference rank was calculated from the number of beetles feeding on a host (sum of 25 inflorescences) during the peak active period (August). The blister beetle was found feeding on the flowers of seven tree hosts, all the pulse crops, cucurbits, okra, a few ornamentals belonging to three families, and three weed species (Table 1). The trees and crops belonging to the super family Leguminosae were most attractive to the beetles. Among trees

A. tortilis was the most preferred with 6–8 beetles clinging to a single flowering branch of 30 cm length.

Murugesan (1988) reports that accumulation of flavonols, aurones and carotenoids in sufficient amounts in the flowers are more attractive to the beetles while lower concentrations reduce its palatability. The flowers need to be examined in this light.

D. cinerea flowers are an attractive pink and *A. nilotica* flowers a bright yellow. Yet the white flowering *A. tortilis* and *L. luecocephala* are more attractive to the beetles.

Abundance of beetles under agroforestry

The research trials of NRCAF for the evaluation of various tree species under agroforestry were observed for abundance of beetles. All trees were planted deliberately for research purposes under agrisilvicultural and agrihorticultural systems within the agricultural field, except for *A. tortilis*, which was a border plantation. The beetles were visually counted on the crop in a 1 m^2 quadrant selected randomly to cover the entire field.

The abundance of beetles on the pulse crops *V. mungo* and *V. radiata* grown under different agroforestry tree species — *Zizyphus mauritiana*, *Emblica officinalis*, *Dendrocalamus strictus*, *Anogeissus pendula*, *Hardwickia binata*, *A. tortilis*, *Albizia procera*, *Tectona grandis* — was studied. The maximum number of beetles was found on the crop of green gram grown with *A. tortilis* followed by black gram grown with the same tree species (Table 2).

The total beetle population increased five times on the green gram crop adjoining border plantations of *A. tortilis* when compared to the area away from the tree border. (Fig 1). The average beetle count at 1-4 m from tree base was 15, while at 5-9 m it was 5 and at 10-14 m it was 2. During the *kharif* season of 1998 the beetle population was so high that the crop was totally devastated by the beetles. The inflorescence was eaten away by the beetle, leaving behind the spikes. (Plate 1).

In general, the beetles were more abundant when the tree and crop combinations belonged to the same botanical family *viz*., Leguminosae. Singh, 1995, has alluded to the possibility of such interactions when the tree-crop combinations under agroforestry belong

Table 1. Host range of blister beetle on tree/plant species associated with agroforestry

Name of Host	Family	Preference rank on a 1 - 5 scale
Trees		
Acacia tortilis	Leguminosae	5
A. catechu	Leguminosae	1
A. luecophloea	Leguminosae	1
A. nilotica	Leguminosae	1
Dichrostachys cinerea	Leguminosae	3
Leucaena luecocephala	Leguminosae	3
Pongamia glabra	Leguminosae	3
Crops		
Vigna radiata	Leguminosae	5
V. mungo	Leguminosae	5
V. unguiculata	Leguminosae	5
Cucurbitaceous vegetables	Cucurbitaceae	5
Others		
Ornamentals	Malvaceae, Fabaceae, Compositae	4 - 5
Cleome gynandra (weed)		2
Tridax procumbens (weed)	Compositae	2
Ipomea sp. (weed)	Convolvulaceae	3

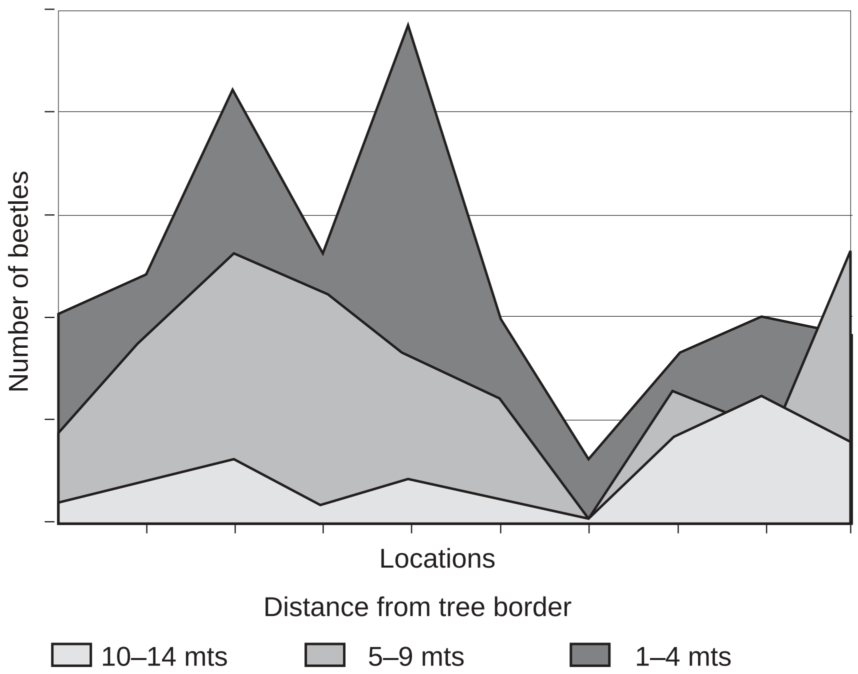

Figure 1. Blister beetle distribution on v.radiata *in relation to tree border*

to the same botanical taxa. It is with caution that such combinations should be recommended for agroforestry. If recommended, a vigilant monitoring should be undertaken for possible outbreaks through primary interactions.

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Table 2. Abundance of blister beetle under different agroforestry systems

System Tree	Crop	Spacing	Mean beetles/ m^2
Zizyphus mauritiana	*Vigna mungo*	10 x 6 m	5.0
Emblica officinalis	*V. mungo*	10 x 6 m	5.1
Dendrocalamus strictus	*V. mungo*	8 x 8 m	4.6
Anogeissus pendula	*V. mungo*	6 x 8 m	2.0
Azadirachta indica	*V. mungo*	5 x 8 m	3.3
Hardwickia binata	*V. mungo*	6 x 8 m	3.5
Acacia tortilis	*V. mungo*	5 m	12.0
A. tortilis	*V. radiata*	5 m	15.4
Albizia procera	*V. mungo*	5 x 5 m	3.2
Tectona grandis	*V. mungo*	5 x 5 m	2.0
Only crop	*V. mungo*		3.3
Only crop	*V. radiata*		4.2

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Jumping cholla—the ornamental that became a wildlife and livestock barrier

Pritpal Soorae

Jumping cholla (*Opuntia exaltata*) is a naturalized cactus found in Kenya, but is originally from Bolivia, Peru and Ecuador in South America, where it grows between 2600–3700 metres above sea level. The stems are approximately 2–5 metres high with a definite trunk. The joints are fleshy and are easily detached, and the fleshy leaves are about 1–7 cm long. The long, sharp spines are 1–5 in number and can be 5–13 cm long, and the flowers are brick red with green unpalatable fruit usually containing sterile seeds (Britton & Rose, 1963). Cholla was originally planted as an ornamental but its use as an effective barrier has subsequently been recognized. It only propagates via vegetative reproduction and is not a prolific pest like the prickly pear (*Opuntia ficus-indica*) that has a palatable fruit and fertile seeds.

Use as a live barrier

This cactus is extensively used as a live fence in the Nakuru and Laikipia districts of Kenya, which lie at an altitude of between 1800–2000 metres and receive an annual rainfall of between 400–800 mm/yr. The use of cholla as a wildlife and livestock barrier was investigated in these two districts (Soorae, 1994).

It is used as a live barrier against wildlife and livestock, a security barrier against human intrusion,

Cholla fences can form suitable live barriers in arid to semi-arid areas where physical fences (e.g. electric fences) may be too expensive and other types of live fences (e.g. kei apple and Mauritius thorn) unsuitable.

a firebreak (the juicy stems stopped a bush fire from entering a ranch), and for protecting earthen dam walls from destruction by elephants. It was also found to be effective against wildlife species such as antelopes and gazelles, baboons, bush pigs, warthogs, buffalo, zebra, giraffes, and hippo. A cholla fence is opaque so a lot of wildlife species will hesitate to jump over a fence they cannot see through. Since cholla stems are easily detachable, they fall and litter the base of the fence and, with their long spines, act as a further deterrent to animals approaching or challenging the fence. A survey in the two districts showed that 27.5% of the inhabitants thought that cholla was an excellent barrier, 62.5% a good barrier and only 10% a poor barrier.

Methods of planting and growth rates

The three main methods of planting cholla fences are by (a) laying stems flat on the ground, (b) digging a small furrow and placing the stems in this and partially covering with soil, and (c) planting each stem vertically. The most successful method of planting was the furrow method, as the soil covering allowed roots to develop and avoided desiccation during the early stages of growth. The vertical planting method was considered too labour intensive and dangerous, due to the necessity of handling stems with such sharp spines. An experimental fence planted in Naivasha, Nakuru District in January 1993 attained a height of 0.73 m by May 1993 and 1.63 m by August 1995.

Invasiveness can be easily managed by pruning a fence annually and disposing of excess cuttings in a pit where they can be burned with other farm wastes. Smaller fences can be trimmed manually by using machetes or grass slashers. Larger ranches sometimes use bulldozers to push any newly fallen joints or stems, or new growth, into the base of the fence.

Problems associated with cholla fences

Invasiveness

Opuntia species such as the prickly pear are known for their invasive potential. A cholla fence becomes invasive only by gradual widening since its seeds are sterile, and spreads by dropping its stems, which take root and give rise to a new plant. A fence planted in Naivasha, Nakuru District, Kenya in the 1960s is now approximately 7.5 m wide, widening at a rate of approximately 0.3 m/year.

Invasiveness can be easily managed by pruning a fence annually and disposing of excess cuttings in a pit where they can be burned with other farm wastes. Smaller fences can be trimmed manually by using machetes or grass slashers. Larger ranches sometimes use bulldozers to push any newly fallen joints or stems, or new growth, into the base of the fence. This method also has the advantage of creating a thicker growth at the base. It also compacts the soil on either side of the fence, which prevents the spread of new growth.

Slow growth and gaps in the fence:

Slow growth, gaps in the fence and poor growth are mainly caused by soil compaction and poor moisture retention. Soil analysis (chemical and physical), nutrient analysis and soil water retention studies were conducted along fences where growth was good, marginal and poor. The factors causing poor growth were (a) shallow soil depth, (b) high soil compaction, and (c) poor moisture retention capacity of the soil. The levels of major nutrients were not found to be significantly different in the three growth zones and growth differences were found to be mainly affected by the physical status of the soil as shown in Table 1.

Another observation was that medium shade helps the fence to grow faster and at a higher growth rate. It was found that the shade under the savanna tree *Maerua triphylla* actually promoted a faster growth, resulting in a barrier with good width and height. The shade provided by the yellow fever tree *Acacia xanthopholea* is much deeper and results in a poorer growth. The soil under these savanna trees was found to contain moisture for longer periods and had a deeper layer of leaf litter debris.

Table 1 Growth of cactus compared to soil depth and depth of concretions

Growth	Height of cactus (m)	Soil depth (cm)	Depth of concretions (cm)
Good – medium	1.6–2.5	63–100	37–70 (non-coherent)
Poor	1.0–1.1	67	21
Very poor	0.45–0.89	3–17	Over hard rock

Establishing a cholla fence

1) Planning stage

a) What specific use is the barrier being planted for?
   - To protect crops?
   - As a wildlife / livestock barrier?
   - As a firebreak barrier?
   - To protect dam walls from erosion by wildlife?

b) If cholla is being used as a wildlife barrier:
- What species of wildlife will cholla be used against?
- Is the barrier function going to be year-round or on a seasonal basis?
- There might be a need for a temporary barrier – what choices are available?
- Jumping species of wildlife can be easily deterred by planting cholla in a wide-strip approximately 3–4 metres wide.

c) The intended fence may be along a common boundary and so there must be a consensus amongst neighbours. During this study a fence that had been planted on a ranch in Laikipia District, Kenya was continuously uprooted because of a boundary dispute.

d) Natural barriers such as escarpments and rivers can be used in conjunction as they reduce cost.

2) Harvesting

a) A suitable site should be located where cholla exists and can be harvested to provide planting material.

b) In places where such barriers are to be planted nurseries can be established.

c) Harvesting should be done by using grass slashers and machetes to cut the joints of the main stem. These should be raked into piles and loaded onto a cart or vehicle for transporting.

3) Planting

a) This should be done during the dry season as fungal infections can cause major losses of cuttings. Over 80% of an experimental plot during this study was lost to fungal infections due to unseasonal rain during the planting stage.

b) The main cause of poor fence development is mainly due to soil and climatic conditions.
   - Soil auger samples should be taken along the intended fence line to determine the soil's physical structure. Ideally the soil depth should not be less then 75 cm and without the presence of gravel or compacted layers.
   - The main reason for patchy growth is due to varying soil conditions, failure of some stems to grow and presence of trails or paths passing through a fence line.
   - A trench, about 1 m deep by 1 m wide, should be dug along an intended fence line. The soil, or other type if the existing soil is unsuitable, should be returned with alternating layers of soil and organic wastes mixed with manure. This results in a soil with an improved structure and which acts as a sponge to retain moisture. In arid areas the area surrounding the trench should be gently sloping towards the trench to act as a microcatchment and channel rainfall into the trench.
   - The cuttings should then be gently laid on the surface of this trench and partially covered with soil.

4) Post-planting management

- After planting, some control should be kept over weeds and grasses, which can smother the cholla cuttings.
- During the first two years, extra cholla cuttings should be added in places where stems have failed to take root as this prevents gaps forming. In difficult areas where growth is not possible the gaps can be closed with posts and wire.
- The fence should also be pruned once a year and excess cuttings disposed by burning.
- Baboons are notorious for feeding off the stems of cholla joints. Therefore newly planted fences should be covered with thorny bushes.

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Presowing treatment with acid strongly influences germination and seedling growth of gum Arabic

R. Marimuthu, R. Swarnapriya, K. Vairavan and C.V. Dhanakodi

Gum Arabic—*Acacia senegal* (L.) Willd.—is a small, thorny, deciduous tree native to North Africa. A drought-hardy species, suitable for dry tropics, it tolerates temperatures as high as 48°C and long periods of drought up to 11 months per year. It thrives from sea level to an elevation of 1700 m. It grows well in rocky deserts and hills, on dry sand flats and in clayey soil, but cannot tolerate waterlogging. The wood is used to make poles and agricultural implements and for firewood. The gum is obtained from the bark of the trunk. The seedpods are used as fodder for goats and sheep. The tree is also used in desertification control to re-establish vegetation in degraded areas, for sand dune fixation and wind erosion control (Vimal, 1986).

Gum Arabic is multiplied by seeds. However, seed germination is poor under normal conditions (14%). To see if it could be improved, a study was undertaken at the National Pulses Research Centre (NPRC), Vamban, India in 1998 to investigate better methods of germinating *A. senegal* seeds.

Gum Arabic—Acacia senegal *(L.) Willd.—is a small, thorny, deciduous tree native to North Africa.*

Materials and methods

The NPRC is situated at 8°N latitude at an elevation of 121m. It receives an annual rainfall of 1233 mm in 68 rainy days. The soil type is red loam with pH 5.0, available N 78.4, available P_2O_5 12.6 and available K_2O 60 kg ha^{-1}. Cropping is possible only for 3-4 months during September-December and that, too, is dictated by monsoonal rains.

Pure seeds of *A. senegal* selected for the study were treated as follows: cold water soaking for 12 hrs and 24 hrs, then soaking the seeds in 80°C hot water for 10 minutes, followed by treating them in 20 N sulphuric acid for 10 minutes and 20 minutes, then treating the seeds with cow dung extract for 12 hrs and, finally, an untreated control. After these treatments, the seeds were thoroughly washed and sown in pots filled with red soil, sand and compost at a ratio of 1:1:1. The pots were irrigated as and when necessary.

The dates of germination and growth parameters were measured from Day 5 onwards, the germination count was recorded daily, and a final stand count was recorded 30 days after sowing. Five plants from each treatment were selected randomly in each replication for biometric observations. They were uprooted without snapping the roots and root and shoot lengths (cm) were measured. Root and shoot dry matter production was recorded after drying to a constant weight in an oven at 70°C for 48 hrs on the 90^{th} day after sowing.

Results and discussion

Germination:

The results of the experiments (Table 1) show that there was significant difference among the treatments for germination. The sulphuric acid treatment for 20 minutes (T1) registered the highest germination of 98 %, followed by the sulphuric acid treatment for 10 minutes (T4) with 96 %, whereas the untreated seeds registered only 14 %. Improvement of seeds germination under sulphuric acid treatment might be due to softening of the hard seed coat and helping the seeds to germinate by breaking the seed dormancy. A similar observation with commercial sulphuric acid treatment for the improvement of seed germination was reported by Shaybany and Roughani (1976) in *Acacia cyanophylla*, Subburamu and Sridhar (1977) in *Phaseolus mungo*, Kumari and Kohli (1984) in *Cassia occidentalis*, Sheikh (1988) and Masilamani and Vadivelu (1997) in *Prosopis juliflora* (honey mesquite).

Seedling growth:

The seedling growth of *A. Senegal* revealed that the root length was a maximum 19.95 cm in sulphuric acid treatment (T5). The lowest (11.58 cm) was recorded in the untreated control (T7). Similarly the shoot length was significantly influenced by sulphuric acid treatment. Sulphuric acid softens the hard seed coat and breaks the dormancy, which helps the early emergence of seedlings and produces more seedling growth. The maximum shoot length of 26.6 cm was recorded in pots treated with sulphuric acid (T5) and the minimum in untreated control (13.21).

Dry-matter production:

The DMP was significantly influenced by different seed treatments. The maximum root weight (1.24g) was observed in the treatment with sulphuric acid for 20 minutes (T5) followed by sulphuric acid treatment for 10 minutes (T4). The shoot weight (2.33g) was also higher after sulphuric acid treatment for 20 minutes (T5) followed by the 10-minute treatment (T4) (2.25 g) and at par with each other (T4 & T5).

The higher value of root, shoot length, root and shoot dry weight exhibited by the seedlings with sulphuric acid treatment for 20 minutes (T5), followed by the same sulphuric acid treatment for 10 minutes (T4) might be due to the softening of the hard seed coat and early emergence of seedlings which might have resulted in early commencement of growth.

It could be inferred from the study that seeds of *A. senegal* treated with sulphuric acid for 20 minutes before sowing induced the germination and enhanced the root and shoot growth. Hence, we can infer that the sulphuric acid treatment can be effectively used in *A. senegal* for inducing germination.

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Table 1. Effect of seed treatment on germination and growth of Acacia senegal *seedlings*

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)	Dry root weight/seedling (g)	Dry shoot weight/ seedling (g)
T1	18.0 (10.2)	18.07	18.95	0.81	1.96
T2	12.0 (7.0)	14.97 **	19.15	0.71	1.88 **
T3	8.0 (4.7)	16.43 **	18.63	0.89	2.07
T4	96.0 ** (73.0)	18.06	21.44	1.07 **	2.25 **
T5	98.0 ** (79.0)	19.95	26.60 **	1.24 **	2.33
T6	12.0 (7.0)	16.68	13.63	0.66	1.57
T7	14.0 (8.0)	11.56	13.21	0.67	1.64
Cd 0.05	0.74	1.26	2.96	0.09	0.12
Cd 0.01	1.04	1.77	4.15	0.13	0.17

Figures given in parentheses are the transformed values.

News and Notes from around the world

Camels as candidates for agrisilvopastoralism

Many pastoralists in northern Kenya regard the camel as their favourite animal, says Omar Bulle Mohamed of the Ministry of Agriculture and Rural Development in Mandera, Kenya. Why? Because camels have an exceptional tolerance to heat, they can go without food and water in that arid region for many days, they can still produce significant amounts of milk during extreme drought conditions, and they have the ability to walk fast—80 km in a day—at the same time carrying heavy loads of up to 300 kg.

Although there is an estimated camel population of nearly 800,000 in northern Kenya alone, the species has not been seriously considered for modern husbandry practices or to gauge its production potential under agrisilvopastoralism. Yet it could contribute to food security and poverty alleviation, thinks Mr. Mohammed.

He says that in Mandera only a few progressive farmers keep camels on their farms along the seasonal River Dana. They comfortably feed on finger euphorbia (*Euphorbia triculli*), planted as a live fence, which increases milk production and weight gain. Saltlick supplements are minimally required. *Salvadora persica* trees left along boundary lines for demarcation purposes on adjacent farms, and grasses and herbs within the farming units form the principle diet.

In the evening during milking, leguminous bean fodder, a high protein source, is given as a feed supplement. Animals reared under

Camels can contribute to enhancing food security during critical hunger periods

this practice produce relatively more milk compared to those reared on rangeland. The few trees that are palatable to the camel are easily pruned, making the camel an efficient 'bush control' animal.

Mr. Mohammed feels that if the camel is experimented with in zero-grazing units – with the benefits of research, veterinary services, and access to artificial insemination and breeding facilities, and if there was professional marketing of camel meat and by-products – the animals can contribute significantly to enhancing food security during critical hunger periods, and alleviating poverty.

"The major constraint affecting riverine camel production in agrisilvopastoralism practices is the prevalent camel disease, trypanosomiasis, caused by *Trypanosoma evansi* and transmitted by numerous biting flies," cautions Mr. Mohammed. "However, the prophylactic and curative camel drug, Triquine, is commonly used to treat infected animals, though availability is sometimes a problem with the few veterinary chemists in the area."

Biological weed control of *Imperata cylindrical*

Papa Dagomba is a settled farmer at Gomoa Ojobi in the Central Region of Ghana, about 38 km from Accra, the capital city. Farming is the mainstay of the inhabitants and land scarcity, poor soil fertility and weed infestation are the main constraints to food production. Albert Kojo Quainoo of the University for Development Studies in Tamale, Ghana first met Papa Dagomba in

1988 when he was a student. At that time, Papa Dagomba's farm could sustain his family of five throughout the year.

Many years later, the story was different. "Speargrass has colonized my farm," said Papa Dogomba. "I do not know what to do, I have no land to cultivate." Mr. Quianoo advised Papa to put his field under leguminous shrub fallow for two years. Neighbours laughed when he did so. But today the laughter has died as they see him harvesting grain and selling it to a ready market in Accra.

Speargrass (*Imperata cylindrical*) is a stubborn weed that is very difficult to control once established in a field. It has grassy leaves, the young shoots being sharply pointed while the full-grown leaves are like spear blades with two sharp edges. It is the most common weed in Gomoa Ojobi and the surrounding area and a threat to agricultural productivity. Farmers often abandon their fields when they become infested, reports Mr. Quainoo.

Pigeonpea, *(Cajanus cajan),* a fast-growing leguminous shrub, has been found to effectively control imperata. Seeded in the soil at the time of land preparation, pigeonpea overshadows the speargrass, rendering it ineffective. For more effective control, planting for two years is recommended. Papa Dagomba said that using this system ''almost doubled my maize yields without applying any inorganic fertilizer after two years of fallowing.''

Besides controlling imperata, says Mr. Quianoo, pigeonpea also improves the soil with abundant leaf litter. The extensive root system ensures that nutrients are recycled to the soil for plant use, and the formation of nodules helps fix atmospheric nitrogen. The grain is edible and features prominently in the diets of the people of northern Ghana. Extra grain is sold in the markets to improve family incomes.

"Following Papa Dagomba's success, the abandoned fields are now under *Cajanus cajan* fallow," concludes Mr. Quainoo. "The war against the stubborn *Imperata cylindrica* has been won, fields regained, and soil fertility improved, resulting in bumper harvests without the use of expensive herbicides to remove the grass, and costly fertilizers to increase crop production. The technology means lower costs, better yield and an environmentally safe and friendly practice of controlling weeds".

Pigeonpea, (Cajanus cajan), *a fast-growing leguminous shrub that effectively controls imperata*

Wodesa – a promising indigenous tree species in Ethiopia

Western Oromia, Ethiopia, is well endowed with many indigenous tree and shrub species, but many are suffering from severe exploitation. Of these, *wodesa (Cordia africana* Lam.) is the most important economically, but is becoming a highly endangered species, reports Abbebe Yadessa from Bako in Oromia, Ethiopia. The tree is so important that places, hotels and business firms are named after it.

The tree is widespread in Africa as shown by its many local names: wodesa (Oromo), Sudan teak (English), wanza (Amharic), gambil (Arabic), and miringaringa (Kiswahili). In Ethiopia, the species is found in the northwest and southwest, at altitudes ranging from 550 to 2600 m, with mean annual rainfall from 700 to 2000 mm. The species is a forest remnant in cultivated areas.

Mr. Yadessa describes wodesa as a branched deciduous tree, from less than 9 m to 25 m in height. The trees are usually found growing singly, a desirable characteristic making them suitable as scattered trees on cultivated fields, grazing areas, and farm boundaries. Their good coppicing ability is an added advantage.

The leaves of wodesa trees are covered with soft, light brown hairs, which help the trees trap dust, and other particles created during cultivation and wind erosion, and which are eventually returned back to the soil system through precipitation. The tree has beautiful white flowers that are sweet-scented, attracting bees. Beehives are often hung on the trees for local honey production. The money earned from the sale of locally produced honey is considerable in this area. The mature fruit has a sticky, sweet inner flesh, which is eaten by people and animals. In rural areas it is a favourite snack for both herdsmen, who spend long hours outdoors, and schoolchildren, who often travel long distances to reach home.

"Almost every part of the tree has a use," says Mr. Yadessa. "It is a good source of firewood, lumber, medicine, animal feed, and helps improve soil. When coppiced during the dry season, wodesa provides cattle fodder containing about 12-25% crude protein. It also enriches the soil, because its leaves decompose quite readily, and it provides valuable timber for home use or for sale.

Western Oromia is noted for its manufacture of high-quality furniture and household materials made from wodesa trees. The wood is hard (544 kg/m^3) and durable, thus useful for making house furniture, beds, mortars, boxes, cupboards, shelves, doors and windows. The income generated from the sale of these products and timber helps improve livelihoods, especially during periods when household incomes are low.

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The tree also provides roots and leaves for medicinal purposes – leaves are mixed with butter to treat skin infections. Branches of wodesa (left over from timber production) are used to make livestock sheds, fences, and bases, known locally as muka-tuullaa, for piling crops in the fields before threshing. This helps the farmers to protect the harvest from damage by termites and mice, and from premature germination due to unexpected weather changes.

Growing trees successfully on sand

"As we have no modern equipment such as electricity, telephones, computers and typewriters, it is not easy to contribute to your magazine", writes Erik Jessen of the Onankali Community Trust in Namibia. "However, now I think we have something to tell your readers, so it's worth the effort."

The Trust is situated in the northern part of Namibia in a flat area at an altitude of between 1100–1130 m. The average rainfall is 400–450 mm per year and the potential evaporation some 2500 mm. The soil is Kalahari sand although there are some variations due to clay and silt content. The project was given one hectare of pure sand that, according to the local population, could not produce plants. The sand is more than 2 m deep all over the area.

"Since 1992," says Mr. Jessen, "93 species of trees, fruit trees, bushes and herbs have been tested for growth and production planting *Leucaena leucocephala* in N–S lines for every 8 m. Indigenous plants are only watered initially and even exotics are only given a minimum of water or no water at all after a short establishment period. Twenty indigenous tree species have been included with various results."

As termites constituted a problem in the initial stages, especially for leucaena, the Trust members—5 local people and Mr. Jessen—looked for favourite food for them outside the fenced area of sand. Hand weeding had removed all the termites' potential food. Dry branches from bitter bush proved to be a valuable fodder for the termites and many branches were placed in the area to attract them. This method provided the needed time for most of the leucaenas to reach sizes where they were more or less resistant.

All weeds are plucked by hand. During the first 3–4 years the

Agroforestry trees and shrubs complement traditional medicine

"Trees and shrubs are the source of many products which make an important contribution to the welfare and quality of life in urban and rural areas," says

Owuor Bethwell of ICRAF's Tree Domestication Programme. A one-year, ethnobotanical study in Migori District, Kenya, has found that a number of introduced and native agroforestry trees and shrubs were significant components of local medicines.

During the survey, formal and informal interviews were conducted with 23 herbalists, 9 herb vendors and 99 villagers to determine their knowledge of plant names and usage. The results showed 312 medicinal plants in use. In the table below, Mr. Owuor briefly describes six of them also used in agroforestry systems. "All these plants contribute to health care in Migori and are used by herbalists and non-herbalists alike," he says.

Species	Local name	No of independent reports	Part of plant used	Ailment cured
Tithonia diversifolia	Maua madogo	22	Leaf	Stomach ache, witchcraft and 'evil eye', malaria, antidote for snakebite
Tephrosia vogelii	Jinga	3	Crushed leaves	Used for washing livestock and as fish poison
Senna siamea	Oyieke/ ndek owinu	9	Bark and root	Gastrointestinal complications, gonorrhoea; mixed with *Zanthoxylum chalybeum* for snakebite antidote
Eucalyptus camaldulensis	Bao	7	Crushed leaves	Inhaled as decongestant for flu, colds, throat infections
Sesbania sesban	Sawosawo/ oyieko	7	Crushed leaves	Used for jaundice/yellow fever, persistent hiccups, skin rashes, dementia
Markhamia lutea	Siala	13	Leaves, roots, thicker branches	Eye injuries, used as purgative, body pains

weeds were used for mulching the trees but the project could not grow enough for a cover for more than 2–3 months per year. Now it is self-sufficient with mulching materials, and green weed is incorporated into the sand near plants that are watered. A hole (22 cm diameter, 120 cm depth) is dug half a metre from the tree, and 15 cm layers of fresh weed, alternating with 5 cm of sand, are deposited in the hole. When it is full, a funnel (plastic bottles with bottoms removed) is placed on top, surrounded with sand. Water is added once a week.

During the following weeding season, the holes (600 of them) are refilled as the material inside has decomposed. This system forces the roots of the tree deeper to get the water and the weed is 100% reused compared with only 10% as mulch.

"Many species have been abandoned for various reasons," says Mr. Jessen. "*Sesbania sesban* was too short-lived, *Acacia karroo* and *Dichrostachys cinerea* were too invasive. *Carica papaya* performs extremely well on rainfed soils but is useless on deep sand.

"Among the exotics, *Morus alba* and *Tamarindus indica* are still watered and show almost 100% survival. Well-performing exotics that are not watered include *Acacia galpinii, Leucaena leucocephala, Tecoma stans, Azadirachta indica* and *Melia azerdarch*. The latter two, plus many indigenous species, compete favourably with old eucalyptus within our area. Promising indigenous species include *Moringa ovatifolia, Ricinodendron rautanenii, Vangueria infausta,* *Sclerocarya birrea* (100% survival rate) *Kigelia africana,* and *Peltophorum africanum* (100% survival rate).

"As leucaena here is near its limits concerning altitude, rainfall and soil," says Mr. Jessen, "it could be replaced with peltophorum when fodder is not an objective, as the latter is not disturbed by termites and establishes easily."

The most astonishing result, however, is reported to have been made with passion fruit (*Passiflora* spp.) locally known as granadilla. The species have not been identified but there are two, producing yellow and purple fruit respectively, both of which reach maximum weights of 180 grams. They have also proved to be the best windbreaks, give the best shade, and provide the best mulch of all tested plants.

"And they have also been the most productive in economical terms," says Mr. Jessen. "Once established (6–8 months), they are merely rainfed and not given manure or other inputs. Since April 1995, only one month has produced no fruit. More astonishing, the quality of the fruit has no equal. They are sold locally and to a gourmet restaurant in the capital. The biggest plant covers 400 m^2 and produced 150 kg of fruit in 1998 when it had already passed the age of 5 years."

As the life span of granadilla is only 4–8 years, plants are replaced regularly, propagated either by seeds or cuttings. Using hormone cuttings is the most favoured method as flowering begins earlier (2 months compared with 6–24 months for seedlings).

The reason for this remarkable growth, according to Mr. Jessen, "is the deep sand that provides for a deep and extensive root system. But this still does not explain the quality of the fruit produced without the use of organic or inorganic inputs."

*The most astonishing result, is reported to have been made with passion fruit (*Passiflora *spp.) locally known as granadilla. They have proved to be the best windbreaks, give the best shade, and provide the best mulch of all tested plants.*

For more information on this project write to Erik Jessen, Manager, Onankali Community Trust, PO Box 2768, Ondangwa, Namibia.

Paths to prosperity through agroforestry

ICRAF's corporate strategy for 2001-2010 provides more options for improved livelihoods for millions of poor people in the developing world

As readers of *Agroforestry Today* have learned from these pages over the years, ICRAF's business is agroforestry — growing trees on farms, alongside crops and livestock, to improve the livelihoods of the rural poor and to protect the world's natural resource base. This is an activity of major global importance, for it has been estimated that about 1.2 billion people — 20% of the world's population — depend to a large extent on agroforestry products and services for their survival.

Although the word itself is relatively new, having been coined in the mid-1970s, the ideas encapsulated in it are based on a vast store of indigenous knowledge developed by farmers since the dawn of agriculture. However, researchers began to link this indigenous knowledge with modern science only during the past two decades, yet this partnership is already providing powerful technological and policy innovations that are rapidly spreading throughout Africa, Asia, Latin America, and more recently in several developed countries.

Last year, backed by cutting-edge science and working with a broad range of research and development partners, ICRAF embarked on a bold undertaking, which is described in detail in the corporate strategy, *Paths to prosperity through Agroforestry: ICRAF's Corporate Strategy 2001 to 2010*. The strategy sets out some very speci˚c goals. During this current decade, ICRAF and its partners will:

- Help farmers plant 5 billion trees†— the equivalent of another major tropical forest
- Reach 80 million of the world's agricultural poor, giving them knowledge and opportunities to improve their way of life, increase incomes and assets in the developing world by US$3 billion
- Help move 20 million people out of poverty
- Remove 100 million tonnes of carbon from the air, thereby directly attacking global warming
- Increase tree biodiversity on farms in the developing world by 20 percent.

To make this promise become a reality, ICRAF is simultaneously building its organizational capacity and scaling up its development work with the farmers of Africa, Asia and Latin America. A key component of this activity is the Trees of Change campaign.

Trees of Change

This is ICRAF's campaign to meet the needs of the agricultural poor in developing countries, and involves undertaking major flagship projects. Each of these major projects is rooted in high-quality research and is tailored to the people and the environmental conditions of a specifc region but with the potential for broad application. Each flagship project contains proven mechanisms to facilitate rapid farmer-to-farmer adoption, along with boosting family income, increasing access to food, and improving the natural resource base. The flagship projects are:

- Seedlings of Change: implementing small-scale tree nurseries in Africa, Latin America and Southeast Asia
- Greening the Sahel: scaling up agroforestry solutions for the most extreme conditions of poverty, hunger and environmental degradation in the world
- Alternatives to Slash-and-Burn in Latin America: working with farmers on sustainable and pro˚table agroforestry options to save rainforests, which are being destroyed at the rate of 4.6 million hectares a year†— equivalent to a country the size of Denmark.

To put in place the financial, technical and development resources necessary for success, ICRAF is seeking funding to launch scaled-up demonstration projects and to build the organizational capacity necessary to succeed with the Trees of Change campaign. The initial funding goal is $1.5 million.

ICRAF's vision for 2010

Through agroforestry, 80 million poor people will have more options for improved livelihoods, and the global environment will be more sustainable.

ICRAF's mission

To conduct innovative research and development on agroforestry, strengthen the capacity of partners, enhance worldwide recognition of the human and environmental benefits of agroforestry, and provide scientific leadership in the field of integrated natural resource management. This will be achieved by combining the best of science with farmer knowledge in a wide range of strategic alliances across the research-development continuum.

ICRAF's three goals

The corporate strategy rests on three interdependent goals, each one integral to the achievement of the mission and the realization of the vision for 2010. ICRAF will:

- Conduct interdisciplinary natural resource management research to improve agroforestry trees, enhance their ecosystem functions, and improve policies
- Rapidly scale up the adoption and impact of agroforestry research by engaging with development partners
- Provide a strong, diversified human and financial resource base that supports the centre's research and development efforts.

The research–development continuum

The heart of ICRAF's corporate strategy is its work across the research-to-development continuum. All its activities are located somewhere along that continuum. Efforts at the development end of the continuum generate results that feed back into the Centre's research, helping to keep research relevant to the needs of the poor. Efforts at the research end of the continuum produce the new technologies and policy innovations needed to make ICRAF's downstream efforts successful. This interdependence between research and development is the defining element of the strategy.

Research

At ICRAF, research is conceived and implemented as an integrated natural resource management agenda. It focuses on generating new knowledge on domesticating indigenous trees that generate high-value products for income generation; improving the ecosystem services of trees — such as soil fertility replenishment, watershed hydrology and carbon sequestration — for attaining food security and ecosystem resilience; and conducting policy research to improve decision-making that facilitates agroforestry innovations.

Development

In a departure from traditional research institution approaches to disseminating knowledge and technologies, ICRAF has assumed, through its Development Division, a more hands-on, proactive role in understanding, facilitating and catalysing the process of 'scaling up'. The Centre believes that it will have greater and earlier impact on poverty reduction and environmental sustainability by directly engaging in the development process through strategic partnerships. The main elements of ICRAF's development strategy are strategic alliances, innovation assessment, germplasm supply, market development, policy dialogue, knowledge sharing, capacity building and technical support.

ICRAF's Corporate Strategy 2000-2010 *is available electronically on the ICRAF web site http://www.icraf.cgiar.org/. Those who are unable to access it this way can obtain a printed copy by writing to* Agroforestry Today.

Poverty: What does it really mean?

In the poor countries of Africa, Asia, and Latin America, poverty means people go to sleep hungry every night. Adequate food, clothing and shelter are beyond their reach. Clean water, basic health care, and education for their families are only dreams. Being poor in the developing world means a constant, unrelenting daily struggle to merely survive.

Despite decades of progress in the last half of the 20th century, poverty remains rampant in the developing world. About half of the world's six billion people live on less than US$2 per day. Well over one billion people live on less than US$1 per day. Every day, 40, 000 human beings in the developing world — most of them women and children — die from causes related to malnutrition, the most immediate effect of poverty.

Compelled by desperation, people practise unsustainable farming methods, such as slash-and-burn farming, that result in environmental damage at local and global scales and decreased food production. The poor flood into cities, looking for better lives — most times in vain.

The only way to lift people out of poverty and save our planet from environmental degradation is to make life better for the world's rural poor by helping them grow more food, produce high-value products they can sell, and improve the local and global environment at the same time.

This is the mission of the International Centre for Research in Agroforestry — to help feed the world, eliminate poverty and improve the environment.

Book Review

Agroforestry Parklands in sub-Saharan Africa

J.M. Boffa

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The huge increase of environmental pressure and degradation on sub-Saharan farming systems has resulted in a much greater interest in agroforestry systems. Limited successes with systems such as alley cropping, live fences, shelterbelts, woodlot afforestation and other high-density tree plantings have turned attention to agroforestry systems with scattered trees, such as parklands, savanna woodlands, certain types of open taungya systems and orchards, as well as silvipastoral systems. In such systems trees have productive as well as protective (thus economic as well as ecological) functions – jointly grown with, or left growing while raising, food crops, or in temporary fallows or with grazing animals.

West Africa in particular has many examples of parklands in its semi-arid and sub-humid parts. The October 1993 Ouagadougou Conference on Agroforestry Parklands of the West African Semi-Arid Regions, organized by ICRAF, brought together for the first time people from various disciplines interested in improved resource use in such agroforestry parklands. However, parklands did not become a major object of study until fairly recently – said to be due to its multi-disciplinarity – so that knowledge on and experience with the utilization of such a system and its various components remains scattered throughout literature of very different kinds. It is therefore fortunate that FAO has attempted with one of its Conservation Guides to bring together much of the existing information on parkland agroforestry systems in "a state of knowledge paper integrating a wide range of information on the biophysical, socio-economic and policy aspects relating to the understanding and sustainable management of parkland species and systems".

With 460 references, this book is without doubt the most elaborate collection of knowledge on such agroforestry parklands, dealing in successive chapters with definitions/terminology, system dynamics, biophysical factors in their management, improved parkland management and the institutional factors involved, production levels, and socio-economic benefits of parklands.

> *With 460 references, this book is without doubt the most elaborate collection of knowledge on agroforestry parklands, dealing in successive chapters with definitions/terminology, system dynamics, biophysical factors in their management, improved parkland management and the institutional factors involved, production levels, and socio-economic benefits of parklands.*

Illustrated with many figures (maps and photographs, but no scientific drawings), tables, and boxes containing specific information on important subjects, the book makes for very informative and also pleasant reading. It contains much data on the most abundantly occurring species of parkland trees in sub-Saharan Africa and where they are found, at different scales. These scales go from continental, to regional, to around the villages, at varying distances and land uses, and as influenced by ethnic specificities and agricultural policies.

There are both pessimism and optimism on the future of parklands, with specific examples that illustrate both outlooks, but there is also a definite lack of quantitative data to allow firm conclusions to be made on trends and likely developments. Climatological, biological, cultural, socio-economic and demographic factors, as well as agricultural development policies, are discussed as influencing – some positively and others negatively within the same category – the extent, density and age distribution of parkland trees. It is interesting to note that some of the examples are very much in line with the outcome of "more people, less erosion" of Tiffen et al. in Machakos, Kenya. According to Boffa: "Within reasonable limits, farmers' response to rapid population growth can therefore lead to more intensive sustainable land management practices". However, the opposite occurs as well.

After highlighting the abundant proof of higher soil fertility in the presence of larger trees, the mechanisms that are discussed in the book include soil microbial activity, atmospheric inputs, nitrogen fixation, dung deposition, pre-existing soil fertility, and soil management practices. One conclusion is that more specific information is needed on the dynamics of soil fertility with increasing tree size in relation to the performance of associated crops, and recommendations on size/age and related conditions of tree stands from which increased nutrient availability can potentially generate enhanced crop yields. It is also stated that, so far, the depressive effect of tree-crop competition and its spatial patterns have not been clearly measured and demonstrated in agroforestry parklands, because it has a complex relationship to tree size and density. However, it is well known that the difference in productivity between tree-covered and treeless sites is substantially reduced when fertilizer is applied and/or abundant water is available.

On parkland management practices the book discusses (i) regeneration of trees, although often practised in a non-parkland setting; (ii) planting of trees, in compounds and non-compound fields, together with crops or at high-fertility microsites, identified by previous cropping; (iii) improved fallows, with slow fertility improvement by, particularly, N-fixing trees, preferably not too young, that are thoroughly managed; and (iv) fire protection, because burning should be avoided as much as possible in the Sahel. Instead, field clearance residues should be spread over the fields as mulch after the largest woody parts have been removed. Further issues reviewed include silvicultural techniques, management techniques for improved crop production (such as pruning, mulching and crop selection), and genetic improvement of parkland species.

Because implementation of improved management and conservation techniques, to be successful and sustainable, has to be complemented by institutional arrangements, a very long separate chapter deals with customary land and tree tenure and state land and forest law. It is clear from the material collected that these are complicating, sometimes confusing, and often very harmful factors in sustainable tree resource management that should not be overlooked in any research projects on agroforestry parklands. Participation and active resource management by farmers, including women and pastoralists as particularly neglected stakeholders, appears served by the devolution of access and use rights and by institutional change within forest administrations, with far greater emphasis given to training of staff in participatory approaches, and acknowledgement of the often sustainable nature of traditional management practices.

The final section of the book, before the conclusions and recommendations, contains a review on socio-economic benefits of parklands and some, but not much, material on parkland production levels (fruit, foliage, gum and wood), due to little quantitative data being available. There are also sections on food security aspects, health care, economic importance of parklands products at the local level, parkland products of international economic importance, social differentiation in Non-Timber Forest Products (NTFP) activities – including gender aspects, socio-cultural and spiritual values of parkland products – as well as an analysis of costs and benefits of the direct use of parkland production. It is also concluded that collection, processing and commercialisation activities surrounding parkland products are the source of a strong interdependence between participants, promoting social integration, transfer of technical knowledge and economic exchanges.

This conservation guide review of agroforestry parklands should be read by researchers on agricultural production under the discontinuous cover of parkland trees, as well as by principal policy and decision makers. It is absolutely necessary background material for the long-term efforts to conserve and enrich existing parklands and to establish new ones that are critical to the sub-Saharan African environment and economy.

The book also contains helpful guidance material on additional research needs and on key constraints, which can be useful in the set-up of projects in any field of resource management improvement in which non-forest trees occur. It is likely, however, because parklands reflect deliberate human manipulation of trees in agricultural production systems, that still more information remains hidden in local grey literature on sub-Saharan Africa. Perhaps the appearance of this book will stimulate the emergence of such valuable data.

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Wageningen University and Research Centre, The Netherlands

Q & A

Where ICRAF scientific staff answer questions from readers

Dr Robert Otsyina,

Two questions from Benedict Kavugushi, Kasulu, Western Tanzania, answered by Dr Robert Otsyina, senior scientist in range management, ICRAF.

Apart from susceptibility to the psyllid in varying degrees, *Leucaena leucocephala* and *L. diversifolia* have been well received as fodder plants in Kasulu, Tanzania. However, availability of timber is still a dilemma. Are there any species in the genus Leucaena that may solve both timber and fodder deficits simultaneously?

The genus Leucaena has several species that are suitable for fodder as well as fuelwood. Evaluations of lesser-known leucaena species for fodder and fuelwood have shown that species such as *L. pallida*, *L. diversifolia* and *L. macrophylla* can be managed both for fodder and for wood production. These species will grow best in well-drained sandy clay loams with neutral to alkaline soil reaction. Environmental and soil conditions in Kasulu will present a perfect environment for rapid growth of leucaenas.

Tobacco that is flue-cured or fire-cured is a good cash earner for farmers, and also for national governments in the form of taxes and fees paid by tobacco-buying companies. However, although they help to alleviate poverty, these tobacco firms encourage deforestation where tobacco is grown. Could *Agroforestry Today*:

(a) address any recent advances in tobacco-processing technology that are environmentally friendly, which farmers in the developing world may easily adopt?

(b) recommend an agroforestry regime and possible species that may be used in tobacco-growing areas?

(c) provide any literature in this field for my use?

Tobacco curing is one of the major agents of deforestation in most tobacco-growing areas in Tanzania and southern Africa. ICRAF and its partners in Tabora, Tanzania have been developing agroforestry technologies to help farmers grow trees on-farm for tobacco curing. At the same time, we have been trying to introduce improved curing stoves to reduce the amount of fuelwood used for curing tobacco.

Considerable progress has also been made in the development and evaluation of rotational woodlots with fast-growing Australian acacias. The rotational woodlot technology involves growing trees together with crops during the establishment phase for 2–3 years; then the trees are left to develop in a fallow phase until harvested in 5–8 years.

Australian acacias such as *Acacia crassicarpa*, *A. jilifera* and *A. leptocarpa* have produced 80–150 tons/ha of firewood in five years in Tabora. The technology has been evaluated on farms and several farmers are now adopting rotational woodlots. We believe this can reduce pressure on the miombo woodlands.

Further reductions in wood use—as high as 70% in traditional furnaces—can be achieved through the adoption of the Malakis furnace, which is being promoted by the government extension system in Tabora.

For further literature and information on the rotational woodlots and the Malakis furnace please contact Dr. Robert Otsyina, Tanzania/ICRAF Project, Tumbi Research Station, Box 3006, Tumbi, Tabora. He can also be reached by email at rotsyina@africaonline.co.tz or icraftb@africaonline.co.tz.

James Were

A question from Wanja Elizabeth and Naaanyu Solomon, Tajeu Kenya, Narok, Kenya, answered by James Were, ICRAF research officer, Nairobi, Kenya

Which methods shall we use to promote replanting of indigenous medicinal trees/plants to grow quickly, and how can farmers plant them in areas that are different from the original areas? Shall we have to transport the soil?

The best way to promote planting of medicinal trees by farmers is to take a participatory approach. You should involve the farmers in selecting the tree species to be planted, involve them in seed collection, and train them how to raise the plants in the tree nursery and how to plant and care for the trees. For the trees to grow quickly, you need to have a clean area for planting, free of weeds, tree diseases and tree pests. Protect the trees from browsing by domestic or wild animals. You can also use some organic or inorganic fertilizers, to promote tree growth where possible. You should avoid transporting soil because it is uneconomical and is not a sustainable method, especially when dealing with resource-poor rural farmers. Always try to grow tree species within their natural geographic range (area).

Three questions from Dr E.P. Whiteside, agricultural consultant, Moshi, Tanzania, answered by James Were, ICRAF research officer, Nairobi, Kenya

We have a few leucaena and calliandra trees growing. Please list suitable fodder trees for Kilimanjaro and Arusha regions of Tanzania, with average rainfall of 738 to 923 mm.

For fodder, suitable species include *Calliandra calothyrsus, Gliricidia sepium, Grevillea robusta, Leucaena trichandra, Populus deltoids,* and *Sesbania macrantha.*

We are planning to grow organic coffee in the following coffee belts: lower coffee belt, 900–1250 m, average rainfall 875 mm; middle coffee belt, 1200–1550 m, average rainfall 1374 mm; upper coffee belt, 1550–1850m, average rainfall 1500 mm. Which trees in the different zones will give the most bulk for mulching or feeding to livestock?

Generally, coffee-growing areas are characterized by high rainfall, moderately high altitude and well drained, slightly acidic to acid soils. ICRAF has developed an *Agroforestree Database* that is a good species reference and guideline for determining tree species suitable for various areas and functions. This database lists the following species as suitable for intercropping with coffee: *Acrocarpus fraxinufolius, Albizia amara, Albizia lebbeck, Albizia procera, Artocarpus heterophyllus, Bridelia micrantha, Ekebergia capensis, Elaies guineensis, Erythrina abbysinica, Ficus thonningii, Flemingia macrophylla, Gliricidia sepium, Luecaena trichandra, Paraserianthes fulcataria, Senna siamea, Tephrosia candida,* and *Trema orientalis.* Other species that provide good quality mulch for coffee growing are *Cordia africana, Grevillea robusta, Hagenia abyssinica, Prunus africana, Polyscias fulva, Senna siamea, Sesbania sesban, Vitex doniana Vitex keniensis,* and *Warbugia ugandensis.*

We are also planning to plant fodder grasses. In the lower coffee belt we shall plant elephant grass. There seem to be two types: thin leaf and wide leaf. In the middle and upper coffee belts we will plant Guatemala grass and *Setaria splendida*. Can you recommend where can I get the various seeds of trees and grasses? Which organization in Kenya does work on grasses and legumes?

ICRAF has also developed a Tree Seed Suppliers Directory (TSSD) that provides information on various suppliers who provide tree seeds. You can access and find sources of seed of different agroforestry species in both the *Agroforestree* database and the TSSD at the ICRAF website http://www.cgiar.org/icraf. More specifically, grass seed in Kenya can be obtained from Kenya Seed Company, PO Box 553, Kitale, Kenya, or from its subsidiaries. For legume seeds please contact the Kenya Forest Seed Centre, PO Box 20412, Nairobi, Kenya. In case you require further assistance on seed procurement, please contact James Were, Research Officer, Domestication of Agroforestry Trees Programme, ICRAF, PO Box 30677, Nairobi, Kenya; phone +254 02 524000, fax +254 02 524001; e-mail j.were@cgiar.org

About ICRAF

The International Centre for Research in Agroforestry is a Future Harvest centre, receiving its principal funding from 58 governments, private foundations, and international and regional organizations known as the Consultative Group on International Agricultural Research. Future Harvest builds awareness and support for food and environmental research for a world with less poverty, a healthier human family, well-nourished children, and a better environment. Future Harvest supports research, promotes partnerships, and sponsors projects that bring the results of research to rural communities, farmers and families in Africa, Latin America, and Asia.

The International Council for Research in Agroforestry was established in 1978 to promote agroforestry research in developing countries. ICRAF was created in response to a visionary study led by Canada's International Development Research Centre (IDRC). The study called for recognizing the key role trees play on farms and coined the term 'agroforestry'. During the 1980s, ICRAF operated as an information council focused on Africa until it joined the Consultative Group on International Agricultural Research (CGIAR) in 1991 to conduct strategic research on agroforestry at a global scale, changing its name from Council to Centre.

ICRAF's business is agroforestry - growing trees on farms to improve livelihoods of the agricultural poor and to protect the natural resource base. About 1.2 billion people in developing countries depend on agroforestry products and services for their well being.

Our vision

By 2010 ICRAF sees 80 million agricultural poor with access to agroforestry innovations that will improve their livelihoods and help sustain the global environment.

Our mission

To conduct innovative research and development on agroforestry, strengthen the capacity of our partners, enhance worldwide recognition of the human and environmental benefits of agroforestry, and provide scientific leadership in the field of integrated natural resource management. we will do this by combining the best of science with farmer knowledge in a wide range of strategic alliances across the researchdevelopment continuum.

Our goals

ICRAF's corporate strategy rests on three interdependent goals, each one integral to the achievement of our mission and the realization of our vision for 2010. We will:

- conduct interdisciplinary natural resource management research to improve agroforestry trees, enhance their ecosystem functions, and improve policies
- rapidly scale up the adoption and impact of agroforestry research by engaging with development partners, and
- provide a strong, diversified human and financial resource base that supports ICRAF's research and development efforts.

Our investors

African Development Bank
African Academy of Sciences
Asian Development Bank
Austria
Australia
Belgium
Brazil
Canada
CIAT
Consultative Group on International Agricultural Research (CGIAR)
Cornell International Institute for Food, Agriculture and Development
Denmark
Department for International Development, UK
European Union
Finland
Food and Agriculture Organization of the United Nations (FAO)
Ford Foundation
France
German Development Service
Germany
International Development Research Centre (IDRC)
International Foundation for Sciences
International Food Policy Research Institute (IFPRI)
International Fund for Agricultural Development (IFAD)
International Livestock Research Institute {ILRI)
International Plant Genetic Resources Institute (IPGRI)
Internationaler Verband-IUFRO
Ireland
Japan
Kenya
Kenya Agricultural Research Institute
Mexico
Norway
Netherlands
Norwegian Agency for Development Cooperation
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Winrock International
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New Zealand
United Nations Development Programme (UNDP)
United Nations Educational, Scientific and Cultural Organization (UNESCO)
United Nations Environment Programme (UNEP)
Unites States of America
University of Wisconsin
World Resources Institute
World Bank
World Vision

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