CHAPTER 2: THE IMPORTANCE OF TREES OUTSIDE FORESTS

2.1 ROLES AND FUNCTIONS

Agroforestry can improve farm production, diversify and increase farm income, help to conserve resources and maintain biodiversity, and contribute to meeting national wood needs. All these functions are described in the form of a review of research on the following subjects: salinization control, hedges and protection against erosion, development of the original vegetation, timber production, and production of minor forest products. The work focuses mainly on Australian agroforestry, but also includes some more international research.

Rainfed Mediterranean orchards traditionally corresponded to very specialized cropping systems, which have too often been replaced by techniques derived from those used for major crops. Some systems still found in some very different environmental regions are presented here: Italian mixed cropping, stone-built terraces, the Tunisian tabiâ, meskât and jessour, and Spanish and Syrian fruit tree and grape combinations. The article shows how such systems, which are often neglected today, can be rehabilitated and updated, thus helping in the development of a sustainable and economically viable arboriculture in these regions.


The agroforestry technique of planting hedges on sloping land seems promising for small farmers in the hilly areas of Haiti. An agroforestry project in operation since 1981 helped thousands of farmers to plant hedges on their farms. The farmers by and large accepted the technique, and the length of hedges planted each year rose from 11 kilometers in 1987 to 140 in 1988. An evaluation carried out on 50 farms where hedges were established shows the effects of this technique on soil conservation and fodder and fuelwood supplies.

This work first describes and defines desertification, before moving on to present the various types of agroforestry system that can help in combating this phenomenon, thanks to analysis of different case studies. The author then lists the principles of desertification control, describing the role of woody species and agroforests, agroforestry practices, and farmer action.

This work is in essence a review, representing an attempt to gather together today’s main knowledge on agroforestry and animals. There may be a variety of interactions between ruminants and woodland—technical, economic, even political. The role of livestock as a production factor is also considered, without forgetting the role of other animals (bees, game, etc.).

30 Bazile, D. 1998. *La gestion des espèces ligneuses dans l’approvisionnement en*
A study based largely on “ethnoscience” methods allows the author to highlight the contribution of the social and human sciences to ecology, forestry and agronomy in the context of tropical geography, in order to understand the relationships between human beings and the environment. Mali depends on fuelwood and wood charcoal for 91% of its energy needs. An ever-widening circle of deforestation around the main towns first led researchers to turn their attention to urban centres. However, the high demographic growth rate is also bringing about a major change in population densities in rural areas. With a view to gaining a better picture of small-farmer practices and decision-making processes, the research is carried out on the different organizational levels of society. An analysis based on interlocking levels constitutes the backbone of the methodology used to define an operational spatial framework for collecting and interpreting information. The systematic processing of indicators and a systematic general approach allow agrarian systems to be divided into categories in regional terms, with an understanding of the processes of access to and management of tree resources in the area, so that farmers’ development strategies can be explained. A model to help in decision-making proposes management rules for the local “agrosystem”, combining the results obtained on the various levels on the basis of three principles. The consumption of fuelwood in rural areas rises with the availability of the resource and the break-up of the African extended family. Fallows represent a potential source of energy (1.5 m³/ha/year), to be boosted within the rotation system in the form of a very short rotation coppicing. Lastly, wooded parkland is a little known and scattered reserve of wood. A reflection on rationalization of the scattered trees would lead to implement linear developments combining agriculture, animal husbandry and forestry. Urban supplies must focus on sustainable management, decided on the rural community level on the basis of the wood surplus available and on the will to market it in order to provide supplementary income.

The important element of hedgerow systems as presented in this article is the use of multipurpose woody perennial plants on steeply sloping land in order to produce fodder for livestock. Vegetatively propagated plantations are also used for large-scale reforestation and to increase crop yields, build up the organic matter in the soil, reduce erosion, increase water infiltration into the soil, and produce fuelwood.

This work gives an inventory of plants that provide food products for the rural community of Sali in Senegal. The food value of each of these species is reviewed, along with the threats endangering these resources.

Agriculture has developed mainly to the detriment of woodland and forests. The need for space and for new land with renewed fertility has helped to push the edges of forests back towards inaccessible or poor land that is unsuitable for any viable agricultural development. Although trees are potential competitors for light, water and the elements needed for growth, they are retained within fields because of their production or service uses and functions. Despite deforestation and desertification, trees are still an important element in the agricultural landscape in Sahelian regions. The fodder produced by trees and shrubs is often the only recourse for herders during lean periods at the end of the dry season. The demand for fuel on the part of an increasingly numerous and densely concentrated population increases the need for
sustainable management of natural stands and makes household plantations even more attractive. The role of trees in improving soil and combating water or wind erosion means that they have a direct impact on agricultural production. However, woodland and trees also contribute to rural life and its maintenance because of the role played by non-wood products in the daily life of the rural population (in terms of food, health and construction) and the income they can generate. The sociological and cultural importance of trees, which cannot be assessed in monetary terms, is complemented by the place they hold in the household budget, which tends towards domestic production, and in the local economy, which is based on the trade and processing of tree products. The establishment of rural markets or structures to market fuelwood, managed by the local population, should encourage the involvement of the latter in the local management of natural resources. In view of the social and economic importance of trees, they are not competitors with agriculture, but in fact act as a major driving force in local development.


A number of different methods are needed in order to grasp agroforestry knowledge and the process behind the generation of such knowledge. This article uses the identification and description of farmers who are expert agroforesters to illustrate this necessity. Informal, participatory methods were used to identify research subjects and understand the concepts of “knowledge” and “agroforestry”. An adaptation of the wealth ranking game was used to define (i) the research subjects, using locally defined criteria of “able to be known in terms of agroforestry” and (ii) how this knowledge is distributed in a community. Supplementary information concerning the subject was gathered together by using formal surveys to collect socio-economic data and drawing up an inventory of all the tree species. The results show that it is important to combine qualitative and quantitative information, participatory methods and formal data collection, inasmuch as they provide complementary and supplementary perspectives on a complex situation.


Three varieties of palm—borassus, oil and raffia—provide a range of resources for the inhabitants of the base of the Baouélé “V” in Côte d’Ivoire, in a transitional environment between forest and peri-forest savannah. The profits from palm wine far outweigh the many other uses (food, technological, medicinal and cosmetic). However, the violent methods used by harvesters means that sap extraction leads to the death of the trees.


This text describes the home gardens in villages in West Java. The authors analyse the botanical composition and very varied products of these gardens, as well as their multistoreyed vertical structure.


The incorporation of tree and shrub products into normal farm management has received little attention in Australia. Despite 40 000 years of use by the Aborigines, very few indigenous species are commercially exploited, apart from those used for construction timber and fodder. Production of the alternative products of non-indigenous species has also been neglected. This paper reviews the present economic importance of many trees and shrubs in Australia, research and development work—or the lack thereof—on these products, and lastly the potential role
they could play in improving farm income. Alternative tree and shrub products in Australia include: essential oils, honey and pollen, wild flowers and tree foliage, nuts, sandalwood, seeds, Christmas trees, medicines, tannin, gum and resin, cane, cork and wood charcoal. Many of the existing industries in this sector depend on the extraction of natural resources, but plantations are increasingly being set up. Some alternative tree and shrub products can be produced on a large scale (for example, honey), but in many cases production is confined to the vegetation of particular climatic zones (for example, the tropical rainforests of Queensland have been a rich source of medicinal plants). The study examines the industries producing major and potentially major tree and shrub products, the species on which they depend, and the agro-climatic region in which they are based. An evaluation of the economic viability of on-farm production is included wherever possible, and on the basis of these evaluations, industries are categorized as already viable, potentially viable or probably viable. It seems at present that many of the industries producing alternative tree and shrub products have little hope of improving their profits, unless there is some pre-existing resource. In many cases, the cost of setting up a plantation specifically for minor or secondary forest products exceeds the expected return, particularly if costly inputs like irrigation are needed. However, in many parts of Australia where replanting is urgently needed, it should be possible to incorporate trees or shrubs for the production of alternative products in plantations being established for shade, shelter or erosion control.

38 Boyle, T.J.B. & Matyas, C. 2000. Conserving genetic diversity of forest trees in managed landscapes. In Forest genetics and sustainability. 4th International Consultation on Forest Genetics and Tree-Breeding. Dordrecht, Netherlands, Kluwer Academic Publishers Group. Some of the most common forms of human interventions in forests (logging, grazing, fire, harvesting of non-wood forest products), and their effects on genetic diversity, are outlined. The effects on genetic dynamics (drift, selection, migration among populations, mating systems) are then discussed. The last part of the paper describes criteria and indicators for use in evaluating and implementing sustainable forest management, and specifically addresses the 4 indicators of genetic processes that have been proposed (the level of genetic variation, directional change in gene or genotypic frequencies, changes in gene flow/migration, and mating system processes) and the demographic and genetic verifiers that can used to investigate these.

39 Bradley, G.A. 1995. Urban forest landscapes: integrating multidisciplinary perspectives. Seattle, Wash., USA, University of Washington Press, 224 pp. Twenty chapters, written by the editor and 20 other specialists, are based on a symposium held in spring 1992. The first part of the book introduces the subject and discusses historical perspectives and the influence of European cultural tradition on urban forestry in the USA. The remaining 3 parts discuss the environmental setting (including landscape ecology, human needs, political and administrative issues), special purpose landscapes (for beauty, amenity, wildlife, water or energy conservation, fire prevention), and integration of sustainability and multiple objectives for urban forest landscapes.

40 Breman, H. & Kessler, J.J. 19?? . Le rôle des ligneux dans les agro-écosystèmes des régions semi-arides (avec un accent particulier sur les pays sahéliens). This book gives a quantitative analysis of the role of woody species in semi-arid regions. This analysis was carried out in order to evaluate the possibilities of integrating these plants into agrosilvopastoral systems, with a view to sustainably increasing production. The various aspects examined and the conclusions drawn are encouraging, and allow an extrapolation of the advantages offered by these plants to other climates, environments and land-use systems. The ecological dynamics and physical conditions of the resource-poor Sahelian and Sudanian zones of West Africa, the particular focus of this book,
have been the subject of indepth study. Extrapolated to other semi-arid regions, the results allow general conclusions to be drawn on the exploitation of an agroforestry potential as a possibility for sustainable land use in these regions.


The authors examine the environmental and social conditions affecting the role and production of trees in plantations and in forest production systems. They analyse various types of ecological situation, including agroforests in temperate and tropical regions, and examine the roles of water, light, nutrition and pest and disease prevention in mixed, annual and permanent crops and in agropastoral systems. Case studies offer innovative strategies that have been successfully used in commercial-scale sustainable production of forest and tree products. These strategies also have a favourable effect on soil conservation and watershed management.


Hedgerows, the lines of trees or shrubs enclosing or separating fields, are made by man. They are part of rural landscapes and should not be studied without considering farming systems and rural societies as a whole. Their specific composition depends on the history of the countryside, as well as on present-day agricultural practices. Land use and demarcation management play major roles in determining the floristic composition of hedgerows and are strongly linked to the mosaic of the landscape. Hedgerow networks break many flows in the landscape because of their straight lines and the fact that they tend to be interconnected. Hedgerows act as a circulation and dispersion corridor for many forest species, small animals and plants. On the other hand, they also cut off or slow down flows of air, and hence the propagules they carry. In the mixed mosaic of fields and wooded areas, hedgerows often increase the interlinked functioning of rural landscapes. The future of hedgerows depends on changes in rural society, which is increasingly including non-farmers. Hedgerows will be seen not only as part of a productive sector, but also as an element in a multifunctional landscape.


This article examines the town of Río Gallegos, the capital of Santa Cruz province in Patagonia. The authors suggest setting up forest shelterbelts in order to combat serious wind problems.


The imaginary landscapes in which fairytales of all origins are set borrow their features from the environment familiar to their listeners, although this landscape is not described but simply sketched in. Characters, objects, and often plants, particularly trees, appear within this landscape, and the species of such trees is never a question of chance, but is always determined by the symbolic code of the culture in question.


This document makes a preliminary evaluation of the state of knowledge and opportunities for urban forestry in developing countries: definition, historical evaluation and present state of urbanization and urban forestry, opportunities, advantages and potential problems, social and cultural aspects, the planting and management of trees, and institutional aspects.

This book describes the various traditional agroforestry systems that have been developed over thousands of years in the islands of the Pacific. Special attention is paid to modern urban agroforestry, agroforestry practised in conjunction with cash monocrops, and agroforestry projects promoted by governments and international agencies. The study consists of ten chapters based on several decades of research. Chapter 1, “Introduction”, describes the framework of the study and its geographical context, defines terms and discusses deforestation and “agrodeforestation” in the Pacific. Chapter 2, “Pacific Island agroforestry : Functional and utilitarian diversity”, examines the sustainable and integrated nature of agroforestry, the diversity of its functions, the bases for innovation, its sustainable character in relation to the aims of national development, and existing models and the need for appropriate innovation. Chapters 3 and 4, “Agroforestry in Melanesia : Case-studies from Vanuatu and Fiji”, describe case studies in Papua New Guinea (one), the Solomon Islands (three), Vanuatu (one) and Fiji (two). Chapter 5, “Agroforestry in Polynesia” contains an introductory note and three case studies (Tonga, Rotuma, the Cook Islands, and the Marquesas Islands). Chapter 6, “Agroforestry in Micronesia”, contains an introductory note and two case studies (traditional agroforestry in the high islands and agroforestry atolls of Tarawa and Abemama, Kiribati). Chapter 7, “Pacific Island urban agroforestry”, examines home gardens, practices on fairly undeveloped land, various problems, and integration into urban and political planning. Chapter 8 discusses “Agroforestry on smallholder sugarcane farms in Fiji”. Chapter 9, “Institutional agroforestry in the Pacific Islands”, examines the more official agroforestry activities promoted by various institutions, involving outside funding, training, agricultural research and development; the subjects discussed include crops combined with a tree crop for commercial or subsistence aims, plantation trees for various uses in relation to agroforestry and agriculture, silvopastoral systems, and future directions. Chapter 10, “Agroforestry in the Pacific Islands: Systems for sustainability”, offers general conclusions and recommendations, and lists a large number of agroforestry species (large and small trees and shrubs) found in traditional Pacific Island systems. The annex gives further details on 100 species.


This paper is a report on part of a series of research projects into the use of natural resources and the dynamics of pastoral systems in the northern part of the Yatenga region. The aim is to restore Pterocarpus lucens to its former ecological and pastoral importance in the region and to provide an up-to-date survey of the state of stands, as well as sketching out future prospects for the species and guidelines for rational management.


Increasing resources are being devoted both internationally and nationally to the collection of germplasm from multipurpose trees (MPTs) for Developing Countries, but little work has been done on defining the roles that small-farm communities wish MPTs to play within their farming systems, what attributes the MPTs need to have to be useful, and how the germplasm can best be disseminated. This book reports on the situation in communities in 3 countries where MPTs are being actively promoted: Honduras, where many MPTs are within their native range; Malawi, where a number of exotic species have recently been introduced; and Sri Lanka, where MPTs such as Gliricidia sepium have been in use for a long time. Accounts are given of how
improved germplasm is incorporated into existing farming systems, and the broad patterns of exchange and use of indigenous and new tree germplasm within the case study communities. Various problems are highlighted. The book is arranged in 6 chapters - introduction, methodology, the 3 case studies, and conclusions.


Three types of oasis can be distinguished in terms of fruit arboriculture: date oases, coastal oases and mountain oases. It is suggested that there is considerable potential for growing cash fruit crops in mountain oases, so long as the species and varieties are carefully selected and marketing efforts are made.


This study, carried out in the Sudanian savannah zone, seeks to categorize different tree stands in cultivated fields, and to grasp their restraints and their potential for regeneration. The functions and uses of woody species by the local population are also discussed.


Trees in desert zones are a fundamental source of life. Suited to an arid environment in both their form and physiology, they are in the first place a source of biological benefits. However, the tree of life is threatened by overgrazing, as well as being overexploited by human beings. Trees not only provide simple sticks, but also household tools, fuelwood, construction timber, vegetable fibres, mineral resources and medicines, as well as being a source of artistic activity. Trees affect the lives of people and cattle in desert zones more than anywhere else. Tree species that have adapted to desert conditions over thousands of years must be protected and propagated. At present the only way of allowing reconstitution and development seems to be to close off certain areas.


With increasing demand for fuelwood and timber and growing concern for environmental protection, planners and implementers of watershed and rural development projects in Sri Lanka are focusing efforts on tree planting programmes. The success of such programmes must be monitored and evaluated not only in terms of productivity but also in terms of impact on environmental protection. Tree planting programmes can be assessed through an index termed ‘Environmental Richness of Plant Community (ERPC)’. The ERPC index should emphasize 3 main aspects: plant diversity, coverage by strata and plant density. The paper introduces the ERPC, classifies existing dry zone home gardens using the ERPC, discusses the nature of variation of the index among the home gardens, and makes recommendations for the botanical composition of home gardens to be environmentally rich. An expression is given for the ERPC, which is a function of the number of species per 100 m2, modified by coefficients denoting the stratal effect of large, medium and trees, and the number of plants per 100 m2 in large, medium and small canopy categories. Some 51 home gardens in the central dry zone of Sir Lanka were surveyed. The results indicated that the environmental richness decreased exponentially as home garden size increased. A high environmental richness was found in 20% of home gardens, and in these, the average number of plants per 100 m2 was 2.9, 6.3 and 6.7 under large, medium and small canopy categories, respectively; the average number of species per 100 m.
The prominent role of forestry and agroforestry systems in the flux and long-term storage of carbon (C) in the terrestrial biosphere has increased global interest in these land-use options to stabilize greenhouse gas (GHG) emissions. Preliminary assessments suggest that some agroforestry systems (e.g. agrosilvicultural systems) can be CO2 sinks and temporarily store C, while other systems (e.g. ruminant-based silvopastoral systems) are probably sources of GHG (e.g. CH4). Agroforestry systems can be significant sources of GHG emissions, especially at low latitudes. Practices such as tillage, burning, manuring, chemical fertilizing, and frequent disturbance can lead to emission of CO2, CH4, and N2O from soils and vegetation to the atmosphere. Establishment and management of agroforestry systems incompatible with prevailing edaphic and climatic conditions can accelerate soil GHG emissions. Non-sustainable agroforestry systems are quickly degraded, and woody and herbaceous crops can become significant GHG sources. Silvopastoral systems can result in soil compaction and erosion with significant loss of labile C and N compounds to the atmosphere. Ruminant-based silvopastoral systems and rice paddy agrosilvicultural systems are well documented sources of CH4 which significantly contribute to the global CH4 budget. Early assessments of national and global terrestrial CO2 sinks reveal two primary beneficial attributes of agroforestry systems: (i) direct near-term C storage (decades to centuries) in trees and soils, and (ii) potential to offset immediate GHG emissions associated with deforestation and subsequent shifting agriculture. Within the tropical latitudes, it is estimated that one hectare of sustainable agroforestry can provide goods and services which potentially offset 5-20 ha of deforestation. At a global scale, agroforestry systems could potentially be established on 585-1275 X 106 ha of technically suitable land, and these systems could store 12-228 (median 95) t C ha-1 under current climate and edaphic conditions.

Forests cannot be separated from agriculture because of their importance for the rural world in the Comoros Islands. Various processes were used (structural analysis of forest plots and gardens containing trees, the collection of botanical samples and surveys of local people) in order to meet the following aims: production of a diagnosis on the state of forests, discernment of farmers’ problems, requirements, wishes and habits with regard to forests and woodland, identification of the plant species whose economic and ecological roles are locally recognized, carrying out of an inventory of the species to be propagated, and proposal of species to be introduced into available ecological niches.

This text gives the results of a survey carried out in two regions in southern Cameroon in order to explore traditional crop and livestock management practices, as well as farmers’ knowledge of local multipurpose trees.

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Starting with the observation of a large number of fig trees in the landscapes of the extreme north of Cameroon, this paper investigates the human and natural reasons for their presence. On the basis of examination of biological, phenological and pharmacological knowledge and the results of interviews with about twenty ethnic groups, conclusions are proposed as to the role of these trees and shrubs. Particular stress is laid on the abundance of the root system, which is used in the mountains to help stabilize agricultural terracing. Various examples are used to show the nutritional importance of the leaves and fruit for human beings and domestic livestock. This function is linked to the special reproduction system of fig trees, which entails the almost constant present of fruit. Lastly, the authors show that the symbolic functions of these trees are often bound up with their abundant dark green foliage, the ease with which they can be propagated from cuttings, the presence of latex, and the form of their fruit. The paper concludes that systemic research is needed on this type of multipurpose resource, which is exploited locally but little known elsewhere because it is non-specific resource.

This document is made up of four chapters: (i) “Food and Nutrition”, a section describing food products from forests and trees for livestock and people; (ii) “Income” presents the income connected with forests and cultivated trees; (iii) “Agriculture”: agriculture and soil erosion, and ways of improving soil and water quality; and (iv) “Strategies for improvement”: various improvement strategies from the political, legislative, institutional and research points of view.

This CD-ROM offers a select bibliography on agroforestry systems in South America which also incorporate animal husbandry.

The campiñas of the Peruvian Andes are wooded or bocage landscapes intended for various agroforestry uses: timber production, marking the boundaries of cultivated plots, protection of crops against animals and weather, protection against soil erosion, water conservation, soil fertilization, stabilization of agricultural development schemes (stone walls, irrigation channels), mixed cropping with fodder plants, shelter for livestock, and frames for drying harvests. Andean landscapes have suffered very widespread deforestation since the days of the conquistadors, and this has increased in recent years. The scarcity of wood leads to the use of animal droppings as fuel, leading in turn to a reduction in soil fertility. The example of the Yungay campiña in Peru in 1949 is studied from various angles: land cover, land tenure, agricultural methods, livestock farming on woodland, and the marketing of agricultural produce.

This text offers an analysis of structural and functional aspects of ten selected home gardens in different ecological and geographical regions.

A study in two villages identified 55 woody species that are kept in the form of contour strips across slopes and around fields in a system of subsistence agriculture. These trees and shrubs produce fodder and fuelwood and reduce erosion dangers, allowing crops to be grown on very steep slopes. Data on basic farm management, crop production, etc., are discussed. The performance of the system is assessed, and its strengths and weaknesses brought out. It is suggested that various locally available medicinal plants could be incorporated into these systems.
Data on the effects of hedges, linear plantations or riparian forest vegetation on the movement of fertilizer residues into groundwater or surface water has been lacking in Italy. The Ecosystem Management Department of the comune of Venice, which has supported research into the control and protection of the Venetian lagoon, has initiated a programme to assess the role of hedges in protecting water courses from high levels of fertilizer pollution. The test site is described (cereal crops of maize are grown, and both granular and liquid fertilizers applied), and the structure of the hedge outlined - the shrub *Viburnum opulus*, coppiced *Alnus* sp., and *Salix alba*, and standard trees of *Fraxinus excelsior* and *Populus alba*. The results so far indicate that the hedge has had a significant effect on groundwater nitrate levels, even during the first year after establishment; it has also affected the field microclimate, and to date has not affected crop yields negatively.

The trees and the river ... the river and the trees ... of the capital of Niger are like a never-ending chant repeated by the humble vendors who know the wisdom and the benefits of water and shade.

African farmers see their natural surroundings in terms of utility. Human beings and environment are closely interconnected. Trees are never seen as ornaments but in terms of all the uses to be found in a single exemplar—economic, climatic, religious, ownership rights, etc. Trees are vitally involved in African farmers’ daily lives.

Trees are found throughout the Bamiléké land, playing a role in organizing space and having a range of uses, which are to be assessed not only in economic terms. The use values of trees depend on land tenure, but also on their specific functions. Use values are analysed in terms of the economic and socio-cultural production of trees, and also in terms of their functions. These values underlie control over access to wood resources and allocation of the benefits of their management. By analysing the three levels of spatial organization (plot, settlement and landscape), the use value of trees in the Bamiléké land can be expressed in all its complexity in appropriation gradients. In the present socio-economic context, the functions of trees are often not reflected in the structure of forest stands. Tree systems become specialized, moving towards a simpler and less labour-costly organization.
In Bamiléké land, in the highlands of western Cameroon, the Bambouto mountains have three distinct bocage formations in an altitudinal transect. Starting with botanical considerations, this study moves on successively to the structure of hedges, the organization of the network of hedges and the dynamics of bocage formations. These three types of bocage landscape found on the same slope reveal distinct dynamics—which also raises the question of their future.

In towns and the areas immediately around them, the concept of urban forests, which focuses more on trees, in gaining ground over that of green spaces, which is seen as too general. An importance place must always be given to open-air leisure developments, as well as the indispensable access to them and their control.

Most of the landscapes in Central America consist of a mosaic of grasslands, agricultural fields and remnants of forest, scattered with urban and residential areas. This paper describes a study carried out in Costa Rica on the importance of these forest remnants, isolated trees and windbreaks for the conservation of local and regional biodiversity in the Monteverde area, summarizing over 20 years of research in the region.

Remnant trees may play an important role in conserving biodiversity within agricultural systems because they provide habitats and resources that are otherwise absent from agricultural landscapes. In order to determine the potential importance of remnant trees for conservation, the density and species composition was surveyed of remnant trees occurring in pastures of 24 dairy farms near Monteverde, Costa Rica. In addition, interviews were conducted with farmers to determine why they leave trees in pastures and how they manage them. The 237-ha survey counted 5583 trees of 190 species (mean density of 25 trees/ha). Primary forest trees accounted for 57% of all of the species and 33% of individuals. Over 90% of the species are known to provide food for forest birds and other animals. In addition, many of the species are important locally for humans as sources of timber (37%), fuelwood (36%) or fence posts (20%). Farmers mentioned 19 reasons for leaving trees in pastures. Of these, shade for cattle, timber, fruits for birds and fence posts were most commonly cited. Most farmers were well aware of both the economic and ecological benefits of pasture trees, and were interested in the possibility of increasing tree cover within their pastures. Although the current densities and richness of pasture trees in Monteverde are high, the size distribution indicates that diversity will decrease substantially in the future, both because farmers are harvesting trees and because saplings of primary forest trees are scarce within the pastures.

This article describes the ecological, socio-cultural and economic functions of *Streuobst* (fruit trees scattered over agricultural land), hedges and trees lining water courses in the countries of northern Europe.

The Environmental Monitoring and Assessment Program was initiated in 1989 by the US Environmental Protection Agency to collect, analyse and report quantitative, statistically unbiased information about the state of the nation's environment on a regional basis. During a pilot programme in Nebraska a habitat suitability index was measured for a probability sample of 40 windbreaks (shelterbelts of tree and shrub species) and the results expanded to estimate the potential value of windbreaks as wildlife habitats in Nebraska. The index estimates the suitability of a windbreak as a habitat for wildlife, including breeding birds, small mammals and deer. Index values range from zero to one, where a value of one indicates maximal habitat value. Some 50% (±13% at 90% confidence) of windbreaks in Nebraska were estimated to have a habitat suitability index of 0.25 or less, and no windbreaks had a suitability index greater than 0.6. The results indicate that increasing the area of individual windbreaks is the most effective way of improving their value as wildlife habitats. Monitoring windbreak conditions over time would alert wildlife managers to changes in the resource that might affect wildlife populations. Because the data were highly variable, the power to detect changes in habitat conditions between two measurement periods was low. A much larger sample would be required to detect small changes in habitat conditions. Variability may be reduced, and power increased, by carefully and consistently constructing the sampling frame, keeping data collection as simple as possible, appropriately stratifying sample selection, and using a small number of well-trained data collection teams. However, it is suggested that the index be adapted for use with aerial photography in future efforts to evaluate windbreaks as wildlife habitats in extensive areas.


The forest gardens of south and southeast Asia are a highly productive and sustainable form of agriculture. Although their efficiency has been proved over the centuries, there has been almost no research on such models. The growing destruction of tropical ecosystems is leading planners and research scientists to turn to traditional practices in order to seek solutions to the present-day problem. Such practices can be found in Sri Lanka, where “forest agriculture” has contributed to a harmonious relationship between nature and man. This work describes the forest garden systems of the country so that the traditional concept can be used in future agricultural models throughout the world.


The role of trees in maintaining and improving soil productivity is considered central to the sustainability of many agroforestry systems. This article offers a bibliographical review of the subject, focusing especially on the importance of this role.


Agrosilvopastoral systems hold an important place around the Mediterranean, where they have marked the landscape for many centuries. After an introduction, the authors describe the main types of agrosilvopastoral system found in Mediterranean countries. The variety of fodder provided and the food value of the samples taken are then analysed according to type of pasture: cultivated grassland, mixed wooded grassland, *dehesa*, etc. The authors establish the state of knowledge on their ecological functioning (primary production, animal-plant interactions). The last chapter discusses human interventions with regard to the vegetation and how the latter has responded.

A multidisciplinary team undertook six years of study of the agro-ecological and socio-economic aspects of the dehesa system in the northern Sierra Morena area. The term dehesa is used to describe the land use system in rural zones of southwestern Spain, mainly made up of grazing land containing scattered oaks (Quercus rotundifolia, Q. souseuh, Q. faginea). The system has been known for many centuries for its multiple—mainly silvopastoral—uses of renewable resources and its strong links with the repeated growing of cereals on grazing land. This article summarizes the results of the study and assesses the functional aspects of the system in view of trends and developments in land use in the region over recent centuries. The synergy effects of tree cover on grassland vegetation are discussed in terms of soil fertility improvement and the development of a favourable microclimate. The potential use of this information in future research and development programmes to improve dehesa systems in the Mediterranean region is described.

Jonsson, K. 1995. Agroforestry in dry savanna areas in Africa. Interactions between trees, soils and crops. Umea, Sweden, Swedish University of Agricultural Sciences. This work contains four articles on interactions between trees, soils and crops in dry tropical Africa. Agroforestry is a potential approach to maintaining soil fertility and crop production. This aspect was studied in terms of the distribution of tree roots, soil improvement and changes in the microclimate under trees.

Jordon, C.F., Gajaseni, J. et al. 1992. Taungya forest plantations with agriculture in southeast Asia. Oxford, UK, 153 pp. This book describes the present and past practice of taungya, explaining how the system has developed in southeast Asia since its introduction to Burma in the 1860s. It also assesses the strengths and weaknesses of the system and suggests technical, social and economic modifications that would help to improve the sustainability of forestry in developing countries.


This work focuses on hedges in different regions of France. The author analyses the various aspects of management of this system: the composition and appearance of hedges, rights and customs, the roles of hedges in agriculture, practices in the different regions studied, hedges and cattle, the technical aspect of hedge management, and mechanization of hedges.


This work summarizes the specific roles of hedges for resource-poor people in developing countries. The aims, extent and limitations of these systems are also discussed, as well as social and economic issues and the technical aspects of their management.


This article stresses the importance of urban trees and associated vegetation found within or near densely populated areas, both in industrialized and developing countries. It discusses the benefits of urban forests, efforts to eradicate poverty, partnership between the public and private sectors, and multiresource management.


In arid zones that have become semi-deserts, can oases become the anchoring point for a new organization of pastoralism? Historically
speaking, palm groves have not spread southwards, although well exploited water resources would have allowed the establishment of palms suited to Sahelian conditions, and irrigation know-how would have allowed their combination with a market garden, cereal or livestock type of oasis agriculture. The problems raised by the desertification of now fragile and disturbed environments and changes in pastoralism, which is becoming partially sedentarized in the wake of droughts, together with new types of land use, may perhaps find answers in an oasis model that would allow food security and be economically attractive.

Twenty-six species of indigenous tree are cultivated in tree gardens surrounding villages in the Mussau Islands of the Bismarck Archipelago in northeastern Papua New Guinea. The trees are used for food and non-food (building materials and medicines) purposes. Ethnobotanical information is given on cultivation methods, harvesting, processing and use. Although distribution within the tree cultivation area tends to be random, some species are gathered together within the zone. This gathering together is linked to the restricted habitat and/or the reproductive methods of certain species. The coconut palm (*Cocos nucifera*) is the most frequent species and is randomly distributed. The vertical stratification of these gardens encompasses a distinct grassy layer and an undercanopy of *Pandanus* spp. The introduction of exotic species and the growing availability of western food products are changing the composition of these gardens.


The luxuriance of the vegetation in the humid tropics has always led people to believe the environment to be remarkably fertile, while the low level of development has been attributed to the indolence of the natives. Although the practices of shifting cultivation are considered archaic, they do in fact represent a particularly effective adaptation strategy to environments with poorish fertility. In Indonesia, under cover of rationalization of land use in the outlying islands of the archipelago, various attempts to modernize agriculture have foundered in the face of prohibitive costs or environmental disasters—or both. Until now, the agroforestry strategies developed by the indigenous peoples of Sumatra and Kalimantan have received scant attention from the authorities. With their unique combination of conservation and exploitation objectives, they do, however, represent genuine and environmentally sound development models.

Planted forests are often seen as consisting of tree plantings on a scale large enough to satisfy such objectives as commercial timber and fibre production, watershed protection, and natural habitat preservation. However, trees are also planted on greatly reduced scales in agroforestry systems or as community woodlots and urban plantings, to provide a mixture of products and services to resident households, local communities, and regional cultures. Agroforestry systems represent a major form of small-scale tree planting, where trees are grown in purposeful combinations with agricultural crops and/or livestock in order to take advantage of tree-crop interactions, and thereby enhance crop production, diversify farm output, stabilize or improve soils, or relief harsh environmental conditions. Some important examples of these systems in the tropics include home gardens, alley cropping, improved fallows, intercropped trees for shade and fodder production, and trees planted in hedgerows and along fence lines. Throughout the tropics, there is a large variety of indigenous practices
and species mixtures that represent adaptations of these systems to meet localized needs and opportunities. Research and development programmes have supported the expansion and refinement of many of these systems over the last 20 yr, but substantial constraints on tree planting still exist in the form of land-tenure practices, population pressures that relegate agroforestry practices to degraded lands, subsistence needs that prevent extended periods of tree growth, and insufficient technical information or technology dissemination. Agroforestry systems in temperate, industrialized countries include combinations of trees, pasture, and livestock: fruit or nut trees interplanted with vegetable or grain crops; windbreaks and shelterbelts; multispecies riparian buffer strips; and forest farming systems for speciality crops. Compared with the tropics, however, temperate-zone systems tend to focus on one or two high-value crops, often involve some level of mechanization, and frequently represent an opportunistic approach to improving the economic profitability of farms rather than meeting subsistence needs. In both tropical and temperate regions, agroforestry systems and community woodlots will be an important component of new sustainable agriculture and environmental protection programmes. Although species diversity is an essential feature of all agroforestry systems, community forests generally involve planting only a few species in small woodlots near farms, around villages, along roads, and as riparian buffers. Provincial or state governments and the local populace are often involved in land ownership and plantation establishment. Major objectives of these forests are production of fuelwood for local consumption and of other tree products for market, soil stabilization, reclamation, or improvement, and protection of water quality. As with many other planted forests, the number of species widely used in community forests has been small (mostly from the genera Eucalyptus, Pinus and Acacia). Major issues with these planted forests focus on rights for use of the products, tending responsibilities once trees are established, protection until trees are large enough for their designated use, increasing interest in using native species, and greater community involvement in planning and management. Trees planted along streets and waterways, or as woodlots in parks and other public places, represent a major group of planted forests in many urban and periurban landscapes. In addition to providing many of the same environmental services that agroforests and community forests do, these urban plantings have unique aesthetic and recreational value.

87 Louppe, E. & Yossi, H. 1997. Les haies-vives défensives en Afrique de l’Ouest sèche et subhumide (bilan des connaissances). Abidjan, CIRAD, 17 pp. In many parts of West Africa, a growing demand from rural inhabitants means that there is a pressing need to develop and organize the countryside in order to improve the management of grazing lands, protect crops from cattle, and record and recognize land tenure. One of the tools for organizing the countryside is defensive living fences made up of thorny or non-thorny bushes planted very close together to create a barrier against wandering livestock. These fences also play a major role in reducing water and wind soil erosion. The criteria and methods to be used in selecting the species are described, and lists are given, based on bibliographical sources, of the species suitable, either alone or in combination, for the creation of living fences in the various climate zones. Methods of establishment—sod seeding, planting out of seedlings, or the use of cuttings—are described, together with post-planting and adult upkeep measures, particularly pruning for shaping and maintenance. The production of the fences, their effects on the environment, and their socio-ecological advantages and disadvantages are discussed.

88 Malgras, D. 1992. Arbres et arbustes guérisseurs des savanes maliennes. Paris, Karthala, 478 pp. This study is a contribution to the programme to inventory the medicinal resources of trees and shrubs in Mali’s savannah regions, which have been successfully used for a long time in traditional medical treatment. The first part of
the work is consecrated to the natural, plant and human environment and the cultural context of traditional medicine, and this is followed by a detailed study of 160 species of tree and shrub.

Following the deforestation of the 1970s, agroforestry was seen as a way of countering degradation of plant cover and soils. Study of interfaces between trees, soils, crops or livestock for silvopastoral systems lends agroforestry systems a multidisciplinary character. The spread of the concept and the relevant methods entails the training of extension workers and technical agents, mainly in Africa. Refinement of agrosilvopastoral practices will help the inhabitants to combat erosion while carrying on their agrarian activities. In the perspective of sustainable management of existing ecosystems and reconstitution of forest plantations, the production of fuelwood is compatible with the maintainance of forests and trees in tropical regions.

This article focuses on the place of trees in the landscape and their use by the inhabitants. The method adopted entails study of the features of the landscape on various levels: dominant areas of trees and bushes; landscape facets; stocking inventory. The author considers the apparent stability of woodland in a general context of degradation of plant cover.

Over half the cultivated land in Réunion is made up of andosols. Their constitution and cultivation history give them properties that make them particularly prone to rainfall erosion. Farmers will accept conservation measures only so long as they do not interfere with production and so long as they offer some possible gain. In the western highlands, fodder-focused agroforestry seems to be a satisfactory compromise for farmers. Against this background, particular attention was paid to the protective and productive potential of a pulse, Calliandra calothyrsus, and study indicated promising prospects for this shrub. It seems to contribute effectively to restoring fertility and to erosion control by improving the structural state of the soil. It produces good quantities of high-quality fodder, and does not seem to affect crop yields.

This document describes the various types of system in which trees are found on small and medium-sized farms in Costa Rica, using this as a basis for planning future silviculture activities and offering guidelines for field staff. The introduction to the report describes the topography, soil and climate of the sites available for planting, and summarizes the possible agroforestry choices, as well as the steps in choosing the most suitable of these. The body of the report describes three types of agroforestry combination encountered, together with their objectives, the species used, their distribution, costs and yields: (i) systems that mix trees with crops—trees scattered over farms, intercropped trees, temporary and permanent shade trees, trees and secondary crops (fallow systems), alley cropping, line plantation (similar to the previous type, but with more space between trees), seed trees, and taungya; (ii) tree systems for protective purposes—living fences, shelterbelts and demarcation trees; and (iii) compact plantations for fuelwood, construction timber and fodder, and home gardens. More details on the species used (including those selected for the MADELENA project) are given in the appendices.
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The authors compare various woody species established as windbreaks on an intensive farm in the Sudano-Sahelian zone of Senegal. In terms of success of plantation, speed of growth and protection against winds, *Acacia holoserica* is far better than four local species—*Acacia raddiana*, *A. nilotica* var. *tomentosa*, *A. senegalensis* and *Bauhinia rufescens*—and two other exotic species, *Eucalyptus camaldulensis* and *Prosopis juliflora*. Regularly cut back before the tornadoes of the rainy season, *A. holoserica* produces abundant fuelwood, as well as fodder appreciated by small ruminants in this period of fodder shortage.


Integrated management of natural resources and the multiple use of trees and forests have prevailed in most European societies since prehistoric times. In the Middle Ages, expanding and intensified agriculture resulted in the separation of trees from agricultural fields. During the last century, with the introduction of sustainable and highly productive forest management, the goal of increased wood production has been achieved in most parts of central, northern, and eastern Europe. Today, agroforestry is not considered to be an important land-use option within the region; however, there are many practices that could rightfully be classified as agroforestry. These include tree/crop systems in which trees provide products and/or environmental benefits, and tree/animal systems in which animals are grazed in forests or open woodlands. The future seems to offer some prospects for agroforestry. Large areas, hitherto used for food production, are either marginally suited to agriculture, or will probably be taken out of production due to agricultural policy considerations. Agroforestry may, at least in part, offer alternatives for the use of such lands. The availability of (surplus) fertile soils, capital, and labour may provide incentives for forms of agroforestry, including improved fallow management. The focus of such systems would be on maintenance of biodiversity in the landscape, environmental protection, recreation, and product diversification. There are numerous expectations as to what agroforestry might provide for the land holder and for society as a whole. These expectations should be carefully analysed and evaluated prior to political decisions on future land use. The promotion of agroforestry requires overall investment; agroforestry does not 'happen by itself'. A set of integrated actions - not isolated efforts - must be implemented if agroforestry is to become a successful land-use option.


The bocage landscape is an ancient system of organizing rural areas by using a hedge network enclosing fields and meadows. It is one form of hedgerow system used as a windbreak, water and erosion barrier, or ecological corridor in numerous regions around the world. Its hydrological impact in temperate countries is poorly known, although paradoxically often cited as important. Research concerning the hydrologic effects of hedgerow systems mainly conducted in the region of Brittany, in France, for the last 20 years is reviewed. The actual or potential evapotranspiration seems little modified by hedges at the catchment scale for a bocage with a hedge density of _100 mthinha-1_. However, local effects are observed on the actual evapotranspiration around the hedges in summer. No effect on the annual rainfall has been measured, but the spatial heterogeneity of the rainfall distribution increases close to the hedge. The bocage has a buffering effect on quick flow during storm runoff of high frequency, modifying the Hortonian overland flow and the contributing flow on saturated areas. The bank and the hedge surrounding the bottom land are the key factor for hydrological effects. Water erosion is limited in bocage
landscape, with no exportation outside the catchment.


A literature review of this topic indicated that there have been very few studies so far on the quantitative and qualitative impact of hedges on water resources in the temperate zone. Work in Brittany, France, shows that the bocage network, and specifically the hedge line surrounding the valley fields, have a buffering effect, by lessening stormflow volume and flood peaks. Regarding water quality, some information suggests that hedges have an impact on the movement of pollutants: hedges retain eroded particles carrying pesticides and phosphorus; anoxic conditions may occur in the soil close to hedges and support denitrification; and trees in hedges may selectively absorb some dissolved elements. Given the rapidly growing environmental problems in temperate rural areas, further research work is urgently needed, particularly to: quantify the hydrological impact of hedges in large basins; use new methods such as distributed hydrological modeling and geographic information systems; and characterize the main processes controlling the fate of pollutants in hedges, in synergy with other landscape elements.


Agroforestry is a new science that has developed over recent years in an attempt to reconcile agronomic, agricultural and forestry sciences. However, the actual practice of agroforestry is very old: in humid tropical zones, where trees and forests were originally present everywhere, small-scale farming does not separate annual crops from tree crops, nor the maintainance of open fields from the development of natural forests. Relations between people and forests in western Indonesia are the outcome of a number of agroforestry systems. The study described here seeks to show the techniques and strategies adopted in order to use and transform the natural forest ecosystem in different situations. Two agroforestry systems are analysed in detail through a combined floristic, structural and ethnobotanical approach: one in southern Sumatra in a sparsely populated region where food crops are grown by opening up tracts in the forest; the other in western Sumatra in an area traditionally dedicated to sedentary rice farming. These two studies are filled out with an analytical review of various agroforestry practices in Sumatra, Java and Kalimantan, ranging from very heavily forested areas (man in the forest) to very humanized areas (man as farmer). The use and management of the trees, forest structures and silvogenetic mechanisms developed in these farming systems are very useful examples for the science of agroforestry. It is recommended that more precise and systematic study be made of the natural vegetation cultivated by farmers in humid tropical zones, with a view to coordinating the development of agricultural development and the preservation of useful or reserved forests in forested tropical countries.


Conflict in Indonesia between the State and local inhabitants over the use and control of resources has led to an accelerated dilapidation of forest resources in the past ten years. This dilapidation goes hand in hand with rapid environmental degradation, and the sustainable development of forest areas is a major issue in national debates. However, there are examples of the positive development of small-farmer systems of forest resource management, especially in the agroforestry sphere. Half-way between
plantation and forest, Indonesian agroforests represent an original strategy for the appropriation and use of natural resources by farming communities, combining agricultural purposes and forest reconstruction. By analysing an agroforest in Sumatra and reviewing its history, an attempt is made to establish the contribution this concept could make to the debate on the dynamics and use of renewable resources in the framework of sustainable development. Focusing particularly on biological mechanisms and the social strategies that have allowed not just the conservation of a specific forest resource, but in fact the restoration of the “forest resource” as a whole, consideration is given to the viability of this agroforestry strategy in a context that is particularly unfavourable to the control of forest resources by small farmers.


This article describes the use of woodlands (defined as those dominated by tree species that are not used mainly for timber) by native Americans. It is recognized that the ecosystems of wooded regions are neglected by ranch owners and foresters, while the spiritual and cultural importance that native American tribes attribute to these lands is stressed. The use of pines (*Pinus edulis* and *P. monophylla*), juniper (*Juniperus* spp.), mesquite (*Prosopis glandulosa* and *P. pubescens*), the Virginia poplar (*Populus* spp.), willows (*Salix* spp.), oak (*Quercus* spp.) and tanbark oak (*Lithocarpus densiflorus*) by the different tribes is described. Three case studies are given to illustrate the integrated management of the ecosystems of these wooded regions: (i) an example from the Uintah and Ouray Ute reservation; (ii) an example from the Hopi reservation in Arizona; and (iii) the inventory and restoration of culturally important resources in the Colorado River reservation (Arizona and California).


This study describes the state of reconstitution of the vegetation of two five-year-old fallows, with the help of various types of analysis: floristic (study of all biological forms—trees, shrubs, lianas and grasses), structural (profile, height, area covered and distribution) and dynamic (percentage of regrowth and definition of four demographic plant groups). The different results obtained on the two fallows increase understanding of the speed of reconstitution of the vegetation, which depends here on such factors as the number of previous cropping cycles and the state of the immediately surrounding environment. Study of these fallows leads to the definition of two different processes of forest reconstitution.


This article contains the results of a survey carried out in five villages. The ten preferred species identified were (in decreasing order of preference): *Irvingia gabonensis*, *Baillonella toxisperma*, *Dacryodes edulis*, *Elaeis guineensis*, *Ricinodendron heudelotii*, *Alstonia boonei*, *Guiourtia demensei* (G. demeusi), *Entandrophragma cylindricum*, *Garcinia lucida* and *Chlorophora excelsa* (*Milicia excelsa)*.


This work describes the current state of knowledge on agroforestry systems in the tropics, on the basis of recent ICRAF publications of results of the global inventory of such systems. This project, which started in 1982, had the aim of increasing understanding of agroforestry systems and their very varied roles in protection and production. The exercise consisted of collecting, collating, evaluating, storing and distributing information. The data collection and collation involved a large number of institutions and individuals. This work describes over 25 agroforestry systems in different parts of the
world, and gives useful information on these systems, such as classification, ecological analysis and extent, as well as the main aspects of some technological innovations.


A bibliographical review was made of works discussing windbreak plantations in tropical and subtropical regions, particularly the humid tropics, where plantations must often be multipurpose. Economic pressures and population growth in tropical countries have led to a shift from traditional slash-and-burn cultivation to a more intensive use of land with shorter fallow periods and lower yields. Since the winds affecting tropical crops are usually hurricanes and violent storms, rather than prevailing winds, windbreaks are less common than in subtropical or temperate regions. Where soil moisture is not limited, yields of some tropical crops can be considerably increased by shelter. However, the use of hedges in the form of alley cropping is better for agricultural fallows than the use of traditional windbreaks. The planting of trees to provide shade has played a vital role in the production of certain crops such as cocoa, coffee and tea. Even so, shade trees can be harmful to yields once the crop is well established and can provide shade for itself, so that stress is now laid on varieties of crops that do not require shade, although multipurpose shade trees are still important elements on small farms. Soil erosion in the tropics and subtropics is caused by water rather than wind, and can be reduced by maintaining plant cover and planting trees. The advantages of agroforestry are also discussed. A short description is given of the main genera planted, together with those at present being considered for planting in the tropics—*Acacia, Albizia, Calliandra, Casuarina, Eucalyptus, Gliricidia, Gmelina, Leucaena* and *Sesbania*. Some other species are also discussed.


This article stresses the nutritional advantages that coconuts can offer in home gardens in Sri Lanka. Advice is given on growing methods, planting material, and the upkeep of a garden containing coconuts.


Scientists, politicians and humanists discuss the contribution of home gardens to food production. This report on research discusses the importance and historical functions of this type of garden. It also gives a definition and develops a typology based on ecological and socio-economic determinants. A comparative bibliographical review is provided in conclusion. Despite growing attention to small farmers by agricultural research organizations, home gardens are still neglected, although they are an important strategy in subsistence.


Wood is an exceptional multipurpose material, and the people of western Cameroon have been drawing heavily on it for centuries as a raw material and energy source, in order to solve a very wide range of daily and ritual problems: building houses, making statues, masks, musical instruments, receptacles, ordinary or ritual furniture, and agricultural implements, building bridges, producing fuel, etc. Its almost excessive consumption has naturally led to exhaustion of the resource, thus upsetting certain customs and traditions. Grassland farmers have therefore implemented some creative reforestation and preservation policies for certain species. The establishment of living fences or enclosures is a fascinating example here.

Proceeedings of a workshop held in Arusha, Tanzania, 12-16 July 1999. Nairobi, African Academy of Sciences & ICRAF.

This document describes a study carried out in Kenya with the aim of defining the role of cultivated trees in different agricultural systems and identifying factors influencing the integration of indigenous and exotic species. The information was collected through a participatory rural appraisal approach.

Local councils’ actions in terms of urban planning are often confined to laying out roads and seldom encompass plans for green spaces, so that new urbanized areas in the third world often lack trees.

From the Sahel to forests, the agrarian landscapes of sub-Saharan Africa always tend to combine trees with fields, although this article confines itself to considering trees growing with crops, and the park landscapes thus created. The composition of wooded areas on agricultural land and the role allotted to them can reveal each society’s strategy with regard to its environment. Parkland throws light not only on needs and techniques, but also on the very nature of the society and its history, and to some extent its structure. Apart from the material relations of a society with the various components of its environment, its type of organization is seen in the landscape.

Trees used to be found in all African savannah landscapes, but are vanishing as a result of a degradation in traditional agrosilvopastoral systems. The author describes the different types of tree-crop-livestock combination found in the zone. He then gives an overview of research into possible ways of improving them, ranging from spontaneous fallows to combinations of fruit trees and irrigated crops, the maintainance of young woodlots, the growing of timber in combination with crops and with grasslands, wooded fallows enriched by planting trees and by fire protection, windbreaks for rainfed and irrigated crops, living fences, alley cropping, traditional or constructed wooded parkland, planted anti-erosion strips, and savannah woodland developed for silvopastoral use.

In humid equatorial zones, increasing population pressure is leading to intensification of tree management within agrosystems. This ranges from the archaic use of spontaneous woody species to regenerate soil exhausted by slash-and-burn cultivation to the skilful constitution of sustainable, diversified and constantly evolving agroforestry gardens. Researchers and developers can monitor these changes.

The role of coffee plantations with shade trees in protecting tropical biodiversity is discussed with particular reference to Latin America. The different parts of the paper are: the economic importance of coffee; coffee cultivation techniques; shade coffee and biodiversity conservation - an overview; arthropod diversity; birds and other vertebrates; biodiversity and the impact of coffee conversion - from shade to sun cultivation; predator-prey interactions and coffee pests; diversity and economic risk reduction; promoting biodiversity on coffee farms - defining environmentally friendly coffee, foreign assistance, marketing environmentally friendly coffee, and internalization of environmental costs; and conclusions.

meeting held in Dakar, 5-10 November 1979. Ottawa, CRDI, 92 pp.
The aim of this study meeting on the role of trees in the Sahel was to allow an exchange of information on the many roles of trees and shrubs in the region, in order to gain an up-to-date picture of knowledge in this regard. The meeting enabled an overview to be gained of the reforestation techniques used in semi-desert zones of sub-Saharan Africa, and also allowed forestry research priorities to be defined.


Agroforestry should be seen less as an alternative to shifting cultivation than as a systematic approach to reorganization of its basic elements into more productive, sustainable and politically viable forms of land use, under the pressure of population growth and competition for use of the resource. Any attempt at improvement, replacement or development of shifting cultivation recognizes that problems are often more political and institutional than environmental and technological. The different technological possibilities are based on the various stages in system intensification. A review of types of shifting cultivation system provides a framework both for identification of specific lines of action with regard to agroforestry systems and for development possibilities. Technical proposals are confined to the most promising: taungya, enriched falls, alley cropping, and tree/agriculture mixed cropping.

Low-density planting of quality timber trees on grasslands is a form of agroforestry that has appeared in Europe recently and is being considered in regions where farmland is being abandoned. This article gives the results of such research, dividing it into three points: the author first gives a summary of the objectives, then assesses various trial plantations and lists some now accepted points of reference.

Agroforestry is a new name for an old activity in the traditional farming world, in other words, a comprehensive approach to land use, in which woody vegetation, agricultural crops and sometimes livestock share the same land management unit. It also represents a new field of scientific activity, with scientists seeking to find out about traditional practices. Such an approach will have the same benefits as those brought about in the past in agricultural, forestry and livestock sciences.

The Villa El Salvador shanty town in Lima is pursuing a voluntary policy of planting trees and fertilizing soil with waste water and sewage.

Urban (including peri-urban) forestry has an important potential role in addressing issues involved in urban development. Two of the major issues to be addressed are the extent to which it can provide needed tree products and environmental services protection, and the enhancement of urban areas. The FAO Forestry Department has examined the role of urban forestry in Developing Countries, developed awareness of the issues involved, and improved documentation and accessibility of information on the subject. This publication is a compilation of 6 detailed case studies: (i) Urban and peri-urban forestry in Africa. A case study of the Sahel (Dakar [Senegal], Niamey [Niger], Nouakchott [Mauritania] and Ouagadougou [Burkina Faso]) (Rouchiche; 1-
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28; 36 ref.) - data collected in 1999; (ii) Urban and peri-urban forestry in Asia. A case study of Hong Kong, Kuala Lumpur [Peninsular Malaysia] and Singapore (Webb; 29-74; 6 pp. of ref.) - data collected in 1996-97; (iii) Urban and peri-urban forestry in Latin America. A case study of Quito [Ecuador] (Murray; 75-106; 54 ref.) - data collected in 1995-96; (iv) Urban and peri-urban forestry in Latin America. A case study of Rio de Janeiro metropolitan region [Brazil] (Pastuk; 107-129; 27 ref.) - data collected in 1996-97; (v) Urban and peri-urban forestry in the near east. A case study of Cairo [Egypt] (El-Lakany; 131-161; 18 ref.) - data collected in 1996-97; and (vi) Urban and peri-urban forestry in the near east. A case study of Iran and its capital, Tehran (Ataie; 163-191; 60 ref.) - data collected in 1996-97. A range of different issues and constraints are highlighted in these studies: in the Sahel urban populations suffer from the desertification process which leads to lack of fuelwood, water and other environmental services; in cities such as Hong Kong, Kuala Lumpur and Singapore, the fast growth rate, high population density and intensively built-up environment are severe constraints to tree establishment and landscape design; in Quito, land tenure and speculation problems are obstacles to land use planning; in Rio, the favelas (shanty towns) on the hillside are a threat to stability and salubrity; and cities such as Cairo and Tehran face an extreme environmental degradation and high levels of air, noise, water and soil pollution.


Understanding the dynamics of indigenous resource management systems can help natural resource development efforts and make on-farm agroforestry research initiatives more effective. This article reports on an investigation into an indigenous knowledge system for the management, cultivation and use of private tree fodder resources at Salijia in the hills of central Nepal. It focuses on the methods used in order to understand the knowledge systems used by farmers in this community in classifying and evaluating fodder trees. A multi-method participatory research approach was used in order to overcome the limitations of traditional survey-based research. The results were analysed together with data from the participants’ observations, a formal survey of households, an inventory of privately cultivated trees and ethnographic interviews. This integrated analysis led to an understanding of the indigenous knowledge system for the management of resources from fodder trees. This knowledge was then used as a basis for a classification and evaluation system for fodder trees.


The process of land degradation is a local phenomenon that occurs field by field. Because of the extent at which it is occurring, however, it also has a global dimension. Agroforestry represents a link between the local and global scales. From the farmer’s perspective, agroforestry can be a way to increase crop yields and the diversity of products grown, but an additional benefit is the creation of a carbon sink that removes carbon dioxide from the atmosphere, and therefore has implications for climatic change. Successful agroforestry systems will also reduce land clearing and maintain carbon in existing vegetation. An extensive literature survey was conducted to evaluate the carbon dynamics of agroforestry practices and to assess their potential to store carbon. Data on tree growth and wood production were converted to estimates of carbon storage. Surveyed literature showed that median carbon storage by agroforestry practices was 9 t C/ha in semiarid, 21 t C/ha in subhumid, 50 t C/ha in humid, and 63 t C/ha in temperate ecozones. The limited survey information available substantiated the concept that implementing agroforestry practices can help reduce deforestation.

123 Schulz, B., Becker, B. et al. 1994. Indigenous knowledge in a “modern” sustainable
The case of 500 hectares of agroforestry farm—or forest garden—in the Gandu region in the coastal mountains of Bahia State, Brazil, is used to show the benefits of integrating traditional knowledge into a scientifically designed farming system. A traditional forest garden is a community forest managed with a view to containing a high percentage of useful indigenous tree species, while eliminating certain species and introducing other cultivated plants. Management of forest gardens seeks to imitate and control the natural sequence of plant growth and is based on two working hypotheses: (i) mature plants have an allelopathic growth, reducing the effect on neighbouring plants, while the growth of younger plants has a stimulating effect; and (ii) there is a positive relationship between the carbon and nitrogen cycles in the cropping system and its productivity. The article gives information on the choice, combination and management of crops (the main crop is cocoa) and includes a table of species used, sorted according to period of use (1-2 years, 1-4 years, 1-10 years, and over 10 years, with most of the species falling into the last category). Details of management practices are also given, including the cultivation, fertilization and protection of plants. The levels of cocoa yields reached without inputs in forest gardens cannot be reached in neighbouring cocoa plantations without the use of considerable amounts of fertilizers and pesticides.

This article gives an analysis of the development and role of urban forestry in Sahelian Africa.

This article introduces the question of the role played by fallows in the production and reproduction of wooded parkland in African savannah regions. Analysing first the material and social functions, and then the present factors involved in maintaining parkland, the article establishes a link between parkland and fallows. The social and environmental importance of parkland species is shown, as well as the advantages of controlling their dynamics through the tools available in a liberal economy, particularly the promotion of products, the organization of producers, generally women, and decentralized community management of small rural spaces.

This article shows that the use of fodder trees to meet the needs of livestock can improve the productivity of farming systems.

The author presents the results of a rapid rural appraisal carried out to throw light on the tree needs and concerns of small farmers, and thus to help in formulating development and planning methods for nurseries on Mount Kenya.

Agroforestry involves managing interactions between tree and agricultural components to produce a stream of productive and environmental benefits over time. By selecting tree and crop species with complementary patterns of light, water and nutrient acquisition, overall system productivity can be higher than for conventional agriculture or forestry and leaching losses can be reduced. Adding trees to agricultural fields provides wildlife habitat and so increases biodiversity,
which in some circumstances may enhance biological control of crop pests through the encouragement of natural predators. The introduction of trees also creates a vegetation structure more similar to the natural ecosystems in which most domestic livestock evolved. This may have benefits for animal welfare and attract price premiums for livestock reared, in what are perceived by consumers to be natural conditions. As trees mature they ameliorate soil and cast increasingly heavy shade creating a succession of different opportunities for intercropping. Thinning and pruning allow the farmer considerable flexibility in controlling the speed and extent to which trees affect agricultural productivity. Increasing tree cover on UK farms has impacts at a range of scales from that of the field and the farm business to whole catchments at the landscape level. Isolated trees behave differently to trees in conventional, closely-spaced forests, so it is not possible to simply scale relationships for forest or woodland by tree density or leaf area to predict impacts of agroforestry. Through research in the UK a knowledge base is being developed that makes it increasingly possible to manage interactions in agroforestry practices to satisfy multiple objectives.


Sacred groves are small plots of natural vegetation that have traditionally been protected by local communities on the basis of religious faith. A case study is presented from the Kulu area of Himachal Pradesh, India, where social change and agricultural development (such as monocropping) are leading to the destruction of these remaining scraps of virgin forest. This deforestation has a major impact on the biodiversity of certain zones. A table is given, showing 25 tree species with socio-cultural functions that are often found in sacred groves.


This document shows the impact of farmland trees on water wherever they are closely linked to agricultural production, affecting both the quality and amount of water available. It also shows that throughout Europe, small farmers’ anxiety to make the most of their natural resources has led them to create a wide variety of agroforestry systems, all remarkably suited to local constraints, with fruit-tree meadows, *dehesas*, windbreaks and “traditional” bocage landscapes. The lack or abundance of water is one of the factors taken into account in the positioning of trees, the density of planting, the choice of species, etc. Knowledge of this know-how means that some first management advice can now be given. The present document provides support for all those who believe that rehabilitation of agroforestry is one of the possible ways of preserving, or even improving, the quality of water and combating soil erosion.


The author, a sociologist, examines farmers’ perceptions of the impact, management and potential of hedgerow intercropping in a district of Kenya.


A survey carried out in southern Zambia to evaluate soil conservation and agroforestry needs yielded valuable information on the needs, constraints and development opportunities and choices perceived by smallholders themselves. The survey was based on questionnaire-style interviews with a sample of 479 smallholders. The results show that inadequate soil conservation efforts are a result of technical and socio-economic factors and not a lack of awareness of the threat of erosion. Planting fruit trees and establishing windbreaks, as well as protecting natural regeneration of *Faidherbia* (*Acacia*) *albida* on farmland are popular agroforestry interventions, and their positive effects have
been widely recognized. Forty-two perennial species have been found that contribute directly to food production. Although local shortages of fuelwood and fodder, together with the need for enclosure, were recognized, only a few of those questioned were planning agroforestry solutions such as establishing fuelwood and fodder plantations or living fences. Most of the smallholders were interested in planting trees, but had so far planted only a few. Those planted were exotic fruit trees, and it is recommended that development services should supply drought-, termite- and grazing-resistant perennial plants suitable for farmers to plant in combination with trees. The widespread exclusion of women from decision-making and their lack of security of tenure have hampered their participation in agroforestry development and have thus endangered sustainable development.

This document gives the results of surveys concerning traditional hedges around Lake Alaotra in Madagascar. Hedges appear to be confined to colluvial and alluvial formations (which are not prone to flooding) and are very rare on the hills. Although they are not very productive and are made up of a fairly small number of woody species, they play some essential roles within rural systems. Hedges clearly have a high potential, particularly for fuelwood and fodder production, and research and development should focus on this aspect.

The incorporation of indigenous knowledge into agroforestry development should take place through farmers’ participation in setting up and planning research. An outside survey of local needs would act as the basis for planning research, and an active synthesis of indigenous and scientific knowledge would allow the most to be made of their potential complementarity.

Explicit representation of farmers’ knowledge of fodder resources from trees on farmland has been developed, using systems software based on this knowledge and a methodology developed by an agricultural research centre in the eastern hills of Nepal. This approach revealed sophisticated knowledge of interactions between trees and crops and the food value of various fodder trees. Farmers’ environmental knowledge is more developed in some zones than others and is to a large extent complementary to that of agricultural researchers in Nepal and scientific literature in general. The creation of explicit and encyclopaedic databases, allowing evaluation of farmers’ knowledge combined with that of researchers on interdisciplinary problems concerning land use, offers the possibility of pinpointing gaps in research that act as a constraint on the productivity and sustainability of farming systems.

Fodder trees play a central role in farming systems in the hills of Nepal. With shrinking forest resources, farmers are increasingly coming to rely on the establishment of fodder resources from trees on farmland. An inventory of the fodder species cultivated and a detailed survey of farmers’ knowledge concerning the comparative quality of fodder from different species revealed a complex combination of criteria used in comparing the 90 species cultivated. Fodder quality is determined by: its capacity to satisfy appetite; its effects on milk and butter (fat content); its effects on the smell of milk; its capacity to improve livestock growth (weight gain); its effects on livestock health; and the preference
of different animals for different types of fodder. A certain number of attributes are known to affect fodder quality: leaf texture, leaf maturity; leaf bitterness; toxicity; season; and how fodder trees are managed.


Although tropical agroforestry home gardens are considered a stable and sustainable production system, little detailed study has been undertaken to support this claim. A bibliographical survey of writings on home gardens was thus undertaken, in order to see how sustainable the system really is. This analysis revealed that agroforestry home gardens possess a certain number of sustainability features, and that these concern not only their capacity to satisfy farmers’ needs without affecting resources, but also their capacity to meet economic, social, environmental and institutional needs, thus contributing to their maintainance.


The geomorphological location of oases, their past, the roles they have played or continue to play, and the activities their inhabitants carry on within them affect the development issues that farming systems must face in order to continue and develop. A typology of different oasis production systems drawn up on the basis of key selected criteria highlights the delicate balance of oases and the importance of a systemic approach for development.


Participatory rural appraisal methods can be effective ways of collecting information on local knowledge and use of trees. This paper describes the use of transect lines followed by group discussions to identify the number of species of value for various uses in eight villages in Cameroon and the Central African Republic. Among other things, the study revealed the differences between men and women in preferences over species qualities, as well as in access to wood resources. Major differences were also revealed from village to village, suggesting that it is useful for communities to share information.


This study analyses farmers’ experiences with four tree species, and also includes a review of tree planting activities by women in a Ugandan district, as well as constraints faced by such planting.


This paper examines agrosilvicultural systems in different countries and their contribution to food production. Socio-economic aspects are considered and the obstacles to the development of agrosilviculture in tropical zones are described. Constraints include farmers’ feelings of frustration, insufficient rural investment, the lack of sufficient knowledge, and foresters’ fairly narrow view of an agrosilvicultural system (*taungya*) as a cheap means of reforestation.


A discussion of the advantages of growing mixed species of multipurpose food (edible seeds, oils, beans, nuts, honey, etc.) producing trees in place of agricultural crops (and even fruit tree monocultures, such as apple orchards) in deforested mountain regions in the Indian Himalayas, as a means towards
conserving biodiversity, and protecting and conserving the region.


This article examines the use of fruit trees in Vanuatu. Such trees include about 40 species present before the arrival of Europeans and others introduced since then. The article also includes notes on: access to land; linguistic aspects and their high intraspecific variability; the different uses of fruit trees, including a calendar of their availability, multipurpose trees, and their various uses by different communities; and traditional management of fruit trees. Fruit trees may be planted close to houses for private use or grow naturally in forests where they are accessible to all.

144 Watson, R.T., Noble, I.R., Bolin, B., Ravindranath, N.H., Verardo, D.J. & Dokeen, D.J. 2000. *PCC Special report on land use, land-use change and forestry*. This Special Report discusses the global carbon cycle and how different land use and forestry activities currently affect standing carbon stocks and emissions of greenhouse gases. It also looks forward and examines future carbon uptake and emissions that may result from employing varying definitional scenarios and carbon accounting strategies, linked to the Kyoto Protocol, within the forestry and land-use sectors.


Bushes and hedges are important elements in the landscape in Germany. In former times most shrubs were used by farmers. Apart from use as animal fodder and for heating, brushwood fires were needed especially for baking bread. Moreover brushwood was used as working material for agricultural tools and for building timber-framed houses. Nowadays, the use of bushes has lapsed in most cases. Shrubs are seen as a hindrance to land management, and in grasslands of less favoured areas shrubs block landscape vistas and threaten species-rich, ecologically valuable biotopes. The spread of shrubs must be controlled if landscapes are to be preserved. Steep, stony and/or wetland sites are considered most endangered. Grazing animals can retard growth of shrubs; but with under-grazing shrub growth may even be accelerated. Maintenance work on pastures after grazing is necessary. Farmers' willingness to carry out manual maintenance work on grasslands was investigated. Farmers are prepared to do this work if enough money is paid, and most machines needed are available on the farms. However, scrub control on pastures is not promoted by existing conservation programmes.


This article discusses the growing use of woodfuel from home gardens and trees on farmland, coconut wood and husks, rubber trees, and residues from processing.


Windbreaks can improve crop production and health while conserving soil and water. Farmers in the Pacific islands have to face many challenges in designing windbreaks, apart from the scarcity of land, which makes its efficient use all the more vital. The planting of multipurpose windbreaks can improve benefits by producing marketable products. These guidelines describe the basic criteria in designing windbreaks, including orientation, spacing, thickness, height, breadth, the number of lines, and whether they are broken or unbroken. They also give criteria connected with the various functions and products, including wood, fruit, fodder, straw and habitats for wildlife. A list is also given of
over 90 multipurpose species suitable for use in windbreaks in the Pacific islands.

The first part of this chapter provides an introduction to agroforestry in North America under the following headings: history and background; farms, forests, woodlots and land-use changes; driving forces in agroforestry; and agroforestry, wildlife and biodiversity. The second part describes the agroforestry systems and related practices found: windbreak systems for fields, livestock, farmsteads and other areas; silvopastoral systems - range management and silvopasture, silvopasture in the SE, Pacific NW and British Columbia, the mid-west and NE, and mesquite [Prosopis glandulosa] in the SW (problems and opportunities). The third part discusses various aspects of intercropping/alley cropping systems: with black walnut [Juglans nigra] and other nut production systems; weed control in tree rows and other cultural considerations; and ecological interactions. The remainder of the chapter discusses integrated riparian management systems, forest farming systems, biomass production and other plantation systems, and agroforestry policy - institutional requirements and learning processes.

This document gives guidelines for assessing yields of specific tree products in agroforests. Basic sampling and statistical principles are included.

This work comprises a review of the potential of agroforestry to contribute to soil conservation. It summarizes the present state of knowledge, including known capacity and apparent potential, then indicates research needs. The general conclusion is that appropriate agroforestry systems can control erosion, maintaining the organic matter and physical properties of the soil.

A review. Trends in soil conservation research and policy are discussed and the effects of trees and shrubs on the factors of erosion outlined. Brief experimental data on the rates of erosion under various land use systems involving trees are given (very little is available), and the use of agroforestry practices for erosion control described. These practices are: rotational (e.g. shifting cultivation, taungya), spatial mixed (plantation crop combinations, multistorey tree gardens), spatial zoned (hedgerow intercropping, trees on erosion control structures such as terraces, ditches and banks), silvopastoral, and the integration of agroforestry with reclamation forestry and watershed management. Research needs are highlighted.

An assessment of agroforestry systems in the southern United States, based on a survey of experts concerning land use and on a bibliographical review, revealed a good potential for agroforestry. The survey indicated that silvopastoral systems are the commonest form of agroforestry in the region. Increased financial returns, diversification and a rise in liquidity were the most frequently mentioned benefits associated with the establishment of silvopastoral systems. Some of the problems found with alley cropping systems (less often observed than silvopastoral systems) are smaller than expected: lower productivity, lower profitability, damage to trees during harvesting of agricultural products, and constraints connected with labour and management skills. The advantages of establishing agroforestry systems in the region were identified on the basis of the bibliographical review and the survey:
improvement in marginal land; the use of windbreaks and buffer zones to improve water quality and as habitats for plant and animal wildlife; economic growth linked to natural conifer woodland and the plantation of hardwoods and conifers; and the supply of products, especially to small landowners.
2.2 EVALUATION


This paper gives the results of the planting of trees in 157 villages in Tanzania. The scale of previous planting and that envisaged by farmers are analysed, together with variations in scale within and between geographical areas, and socio-economic and demographic differences.


The Energy II Project, which aims at promoting long-term management of fuelwood resources, launched a research and development programme in May 1996, based on selective clearing of bush cover when fallow land is put back under cultivation, and on the reintroduction of tree species that are no longer found there. The 16 fallows selected for the study take place in the south of Niamey. Inventory and analysis of the woody structure meant that clearing these plots allowed the quantity of wood produced by each fallow to be measured. The average density of the tree population of fallow land was 784 specimens.ha\(^{-1}\) (omicron = 441). The geographical positions of 24 woody species were inventoried in the 16 fallow plots studied. The number of species per plot varied considerably, but was never high: an average of 2.8 to 9.3, depending on location. The woody vegetation on 14 plots was dominated by Combretaceae (< 90% of individuals), *Guiera senegalensis* in particular (83 to 94% of individuals). The other two, which were located in valley bottoms, were covered by *Pilostigma reticulatum* (86.5% of individuals). Formations were made up for the most part of small-diameter stems: 91% were between 1 and 4 cm. The average quantity of green wood with a diameter greater than 1 cm was 2 984 kg.ha\(^{-1}\) (omicron = 3 475), including 1 126 kg of marketable wood with a diameter of 2 cm or more, representing a volume of 4.5 steres.ha\(^{-1}\) (with an average weight of 270 kg per stere). The values of the parameters studied varied widely from one fallow to another. In most cases, these differences were not linked to geographical zone, position in the toposequence or the age of the fallow, but were a result of different ways of managing the crop-fallow system. This variability meant that only major trends could be identified, particularly the floristic poverty of the vegetation and a relatively high wood production, constituting a good complement to forest wood resources.


A trial with *Eucalyptus tereticornis* was carried out in the form of a Latin cross with five trial plots. After three years, trees representing every category of size were felled and used to determine above-ground biomass production for some, while others were dug up in order to determine the biomass production of the roots. Production met the initial objectives of providing high yields of fuelwood and poles with the use of short rotations.


The neem (*Azadirachta indica*) is a native of the Indian subcontinent, where it has a wide range of medicinal and other uses. Its potential for agriculture and rural development in
developing countries is evaluated here. Pesticides produced from it can be used effectively to reduce dependence on imported synthetic pesticides, while producing an income for poor rural inhabitants. Analysis shows that the transfer of parasite control technology should not pose any serious problem in countries where the neem is indigenous, nor in those where it has been recently introduced. The potential of the neem for agriculture and rural development lies in the manufacture and use of its oil (for soap) and of “neem cake” (used as fertilizer, nitrification inhibitor and livestock feed). Parasite control substances are found in neem leaves, fruit, bark and seeds, and also in its oil and cake. Neem oil at present sells in India for US$ 1.20-1.30/kg, and neem cake for US$ 0.10/kg.

In this report on trees outside forests in Togo, the author offers a country-wide review of this resource, together with data as to quantities (production, area, etc.) and quality (goods and services provided by trees outside forests). The data are based on field observations and a bibliographical review.

A survey of the selling prices of 844 residential properties in Athens, Georgia, indicates that the value of land with trees is 3.5 to 4.5% higher. During the period of the study (1978-1980), the average house sold had a price of US$ 38 100 and had five trees in its garden. The average increase in price resulting from the presence of trees was US$ 1 475 to US$ 1 750 and involved especially medium and large diameter trees, regardless of species. This increased local taxes on the property by US$ 100 000.


The study used as an example in this teaching bulletin concerns the design and country-wide application of a methodology allowing the land resource potential of each of Kenya’s 41 districts to be established, in order to facilitate formulation of development policies and planning. The bulletin describes the results obtained on the methodological level, as well as the database on resources set up for this detailed study of the country.

This work provides basic information on multipurpose resource inventories for inventory planners and for provincial- or national-level decision-makers, although it can also be applied on the local level. The need for multipurpose resource inventories is discussed in depth, and the document also describes the information and structures needed for such an inventory, as well as problems connected with its design and implementation.

With a view to extending the results of the national hardwood volume forestry inventory to biomass results, a sampling of 54 small coppices and nine reserved oak forests was carried out on hedges in the bocage region of France’s Loiret department. A regression equation of the type BST = aVBF+b could be calculated for the coppicing, depending neither on species (oak, hornbeam, ash) nor on the perched or normal nature of the coppicing. On the other hand, it is not comparable with results obtained previously from enclosed stands. An equation of the same type was estimated for reserved oak forests, in which the crown proportion is 42%. The validity and extended applicability of these results, which were obtained in clearly defined conditions, are discussed.

174 Ayuk, E. 1997. Adoption of agroforestry technology: the case of live hedges in the

A “logit-econometric” model is used to study farmers’ decision-making processes and the factors influencing the adoption of live hedges. This study also includes a quantitative assessment of farmers’ perceptions of the advantages and disadvantages of live hedges and their criteria for the choice of species.


*Irvingia gabonensis* is one of the tree species preferred by farmers in the humid lowlands of Cameroon, as well as having a major place in international trade in West Africa. Although empirical data do exist on the volume of international trade, no data are available regarding production on the farm level. The species generally grows in the wild, and very little effort has been made to domesticate it. A survey was carried out in three regions of Cameroon with different infrastructures and population characteristics, in order to evaluate the economic importance of the species on the farm level. The uses, management and improvement objectives of farmers were also identified. The results of this survey indicate that *Irvingia gabonensis* is found mainly in fields where trees, for example cocoa and coffee, are cultivated. The kernel trade is large. Kernels are processed into a paste used in sauces, but also have medicinal uses and are a source of oil. The pulp of the fruit is edible. The wood is used for building, dead branches for firewood, and the bark for medicine. The annual value of *Irvingia* fruit and seed production is between $US28 and 93 per farmer/collector for the three regions. Improvement objectives include increasing the size of fruit, improving taste, increasing yields and reducing the height of trees.


This report is the result of agroforestry surveys in the Sikasso region of Mali. It is based on an *ad hoc* field survey in villages likely to provide a varied sampling of practices, and is intended to provide examples and highlight trends in management of the rural environment.


In West Africa, where one of the features of agriculture over vast areas is a close linking of cover trees and cash or food crops, the question of the advantages and disadvantages of trees is widely discussed. This study furthers knowledge of the contributions of trees and also of the losses they cause to crops. It is based on analysis of 22 farms in three villages in southern Mali. The species considered, karité (*Vitellaria paradoxa*, Gaertn. f., Hepper) and locust bean (*Parkia biglobosa* [Jacq.] Benth.), provide a wide range of goods and services. The study assesses their contributions and consequent losses in monetary terms on the basis of a series of models. The balance is very positive on almost all the farms, with the best results being obtained on farms with a high density of trees, particularly locust bean.


This report deals with trees outside forests in different countries in East Africa: Kenya, Uganda, Tanzania, Ethiopia, Eritrea, Sudan and Djibouti. The authors seek to offer a review of this resource throughout the whole region, together with data as to quantities (production, area, etc.) and quality (goods and services provided by trees outside forests). The data are based on field observations and a bibliographical review, and refer especially to trees contained in silvopastoral and agrosilvicultural systems.

Mali’s fuelwood production sector meets 91% of the country’s energy needs. The wood comes from natural forest stands and off-forest formations—trees scattered on agrosilvopastoral land. The scattered stands are strongly affected by human factors, are spread over village land, and are subject to rapid transformation. Even the distribution of woody species within these stands is nuclear, with bare soil alternating with islands of dense vegetation, and appropriate methods are needed in order to assess them. This document focuses on wood resources on fallows, and gives the results and conclusions of a method tested in eight villages in Mali. It would seem that definition of a method to assess wood resources in these stands cannot confine itself to a simple adaptation of the sampling methods used for forest stands, but must incorporate a strong socio-economic component.


This study focuses on production from crops and shade trees and the distribution of organic matter in the system. The parameters studied are: standing biomass, the production of cocoa trees and shade trees, leaf litter production, root biomass, total biomass, total organic matter, soil organic matter, net primary productivity, and productivity indices. These values are then synthesized in models. In the experimental conditions of this study, which included moderate applications of fertilizer, the agroforestry systems of Erythrina peoppigiana or Cordia alliodora with Theobroma cacao increased agricultural production as well as net primary production during the second five-year period. The use of C. alliodora is recommended in the conditions studied, and that of E. peoppigiana on less fertile soils without fertilizer.


This paper gives three examples of timber-producing tropical agroforestry systems: multilevel systems with permanent crops (e.g. coffee or cocoa), small woodlots on private farms set up using the taungya system, and silvopastoral systems incorporating a timber component. After giving data taken from case studies, which also show the regional importance of timber production, some of the medium- and long-term lessons drawn from this experience are discussed, including research methods and the selection of components and systems. The combination of socio-economic and biophysical research results with results obtained on different levels is also discussed.


This document gives the preliminary results of a study on the biomass production of living Gliricidia sepium fences on a livestock farm at Palmera, San Carlos, Costa Rica. These saplings are five years old, between 2 and 2.5 m tall, and planted 1.5 m apart. Pruning at three- and six-month intervals was compared, using a method of random blocks of ten posts per plot and four repetitions. One pruning after six months offers a better overall production (dry weight) than two prunings with a three-month interval. The total biomass produced is 4.4 against 2.1 metric tons/km of fence at six and three months respectively. However, there is no significant difference in the quantity of fodder produced (1.6 and 1.4 metric tons/km at six and three months respectively).

183 Bergez, J.E., Msika, B. et al. 1997. Modélisation des systèmes agroforestiers...

The “biophysical” model presented here, based on multidisciplinary research carried out jointly by many European research institutes, concerns the description of a silvopastoral plot. One of the main problems in validating this model is the absence of data on real cases over a long enough time span. The biophysical model now works on the plot level. Simulation of geobiochemical cycles, which is needed to calculate production, also contributes to scientific knowledge of the ecological functioning of a complex system.


The traditional combination of trees and crops plays a considerable role on village land. These agroforestry systems, which appear to be sustainable, produce a variety of products and services for those managing them. Through studies carried out on *Faidherbia albida*, *Parkia biglobosa* and *Vitellaria paradoxa* parklands in western Burkina Faso and northern Côte d’Ivoire, a systematic, multidisciplinary approach was adopted in order to identify how these parklands function and their dynamics. Analysis was carried out on different levels, from that of the village land as a whole, through the individual plot as the site of human management, right down to the tree. The use of a geographical information system meant that for both plots and trees, georeferenced data (obtained with topographical surveys) could be combined with the results of field surveys. When thematic maps were redrawn by intersecting human factors with the distribution of the main tree species, the most typical effects of parkland management and development were seen. On the village land or general parkland, the overall heterogeneity of agroforestry species is a result of morphological and soil conditions, but analysis of stands on the plot level shows that human factors are far more determining.


After carrying out a demographic census and a short sociological study in the village of Dolekaha, the boundaries of the village’s land were surveyed, together with the location of large trees. Maps were drawn up, using a geographical information system, and two distinct types of tree system were defined. Around the village is a *Faidherbia albida* parkland, the extent and composition of which have varied little over the past 30 years. The fertility transfer carried out by livestock means that mixed crops (cereals and pulses) can be grown under the *Faidherbia* trees without any need for a fallow. The second type of parkland is found nearer the boundaries of the village land and is dominated by locust bean and karité. The authors show the importance of trees on rural land in numerical and economic terms.


The survey carried out in 1986 had a variety of aims: (i) to learn more about the woody species used by farmers, how they are treated, and their needs, in order to adapt seedling production policy; (ii) to study and define crop combinations and systems; and (iii) to draw up a questionnaire that can be applied widely. The whole process took 18 months, and the main results are described and commented on here.

This study had the aim of examining the present state of knowledge on the roles of trees as shelter for grasslands, crops and livestock, in controlling soil erosion, and in improving the productivity and sustainability of crop production in Australia. Soil degradation (the loss of trees and the associated salinity, wind and water erosion, acidification, and structural and nutritional degradation) in Australia are proof that the primary production systems being used are not sustainable. About half the farmland and rangeland in Victoria is affected or under threat. In Western Australia, about 25% of farmland is suffering from erosion and 60% is potentially vulnerable, while 430 000 ha of land and over half the surface water are affected by salinity. Similar problems are found in other states. At least 43 million ha, or 13% of the rangeland, have been seriously degraded by wind erosion as a result of overgrazing, often coinciding with drought or a series of dry years. One of the main focuses of Australian agricultural research has been minimal tillage and the use of stubble to control erosion. A harsh climate and the imperfect adoption of appropriate harvesting and grazing management systems show the weakness of these erosion control methods. However, the complementary use of windbreaks to reduce gulleying is rare, and there has been no campaign to promote their establishment, despite widespread adoption of this technique in other countries. The systematic planting of 10% of the land with a network of shelterbelts and patches of trees could cut wind speeds by 50%, which would considerably improve pasture production in both the short and long terms. Wind erosion could be radically reduced and harvest yields probably increased through the use of windbreaks. For example, studies of wheat and oat harvests at Rutherglen, Victoria, and lupins at Esperance, Western Australia, have shown that yields increased by 22, 47 and 30% respectively in areas with such shelter. In semi-arid and dry temperate zones, planting 5% of the land could reduce wind speeds by 30 to 50% and soil loss by up to 80%. Such planting would also contribute considerably to meeting other objectives of sustainable agriculture. Agroforestry will be important in the long-term replanting strategy.


Deforestation has reached an alarming level on the eastern coast of Madagascar, mainly as a result of the change in crops. The authors assess present and future timber resources and the timber requirements of the inhabitants of a specific area. Trees are extremely important to rural communities, providing construction timber, fuelwood, edible fruit, shade, medicines and hedges. *Eucalyptus* spp., *Pinus caribaea* and *Dracaena* spp. are the species most commonly planted.


Development projects aimed at increasing the number of trees for fuelwood first of all need a solid picture of the quantity, form and function of existing stocks of woody biomass. The author describes the methods and results of a study undertaken in Kenya to assess wood stocks on individual farms on the basis of certain hypotheses as to consumption. He then tries to assess the shortfall in domestic fuelwood.


Living fences are widely used in Costa Rica and other Central American countries as a sustainable agricultural (silvopastoral) practice. Data on Costa Rican farmers’ empirical knowledge of this subject were assembled through a questionnaire, field measurements and a bibliographical review. Ninety-two multipurpose species used for living fences were identified, and data were
recorded on propagation, uses (fodder, fuelwood, medicines, nitrogen fixation, honey production and ornamentation) and environmental features. Management practices (preparation of posts, planting, cutting) and uses are discussed in general and for specific species. Biomass production data are given for a kilometre of *Erythrina berteroana* living fence cut back every four, six and eight months. It is concluded that the use of such fences is a very promising sustainable practice and deserves further research and development.


Measurements taken on a network of young agroforestry plantations in France and the United Kingdom supplied the initial elements for building a model of forest tree growth in agroforestry situations. On the basis of analysis of the collected data, the growth models used in a classical forest measurement method were adapted in order to take into account the absence of competition between trees in the first years and of competition with grassy vegetation. Account was also taken of modifications in growth in height resulting from the presence of individual protection tubes and the absence of competition between crowns. Variability between individuals was also incorporated into the model.


In many parts of Australia, the destruction of woody vegetation on rangelands has led to soil degradation. Although agroforestry could represent a solution to the resulting problems, it has often been identified with the introduction of livestock into natural forests or plantations of trees for grazing, while little study and few experiments have been dedicated to the reverse process—planting trees on grazing land. The Soil, Trees and Grass Project was drawn up to examine the possibilities of designing a wooded pasture system suited to the subtropical environment. This article gives the results of experiments carried out on a plantation of eucalyptus grown on *Setaria sphacelata* grassland, in order to discover the effects of spacing on above-ground and total biomass production and on the growth of the grassy cover.

193 **Campbell, B., Clarke, J. et al.** 1995. *The hidden harvest: the role of wild foods in agricultural systems. Local-level economic valuation of savanna woodland resources: village cases from Zimbabwe*. UK, IIED.

The project described here focused on evaluation (including participatory rural appraisal techniques) of wild food resources and tree resources within the context of two research programmes, the Hidden Harvest Project and the Value of Trees Project. The work was carried out in a workshop attended by experts from different disciplines: resource economics, human ecology, sociology, energy, silviculture, environmental policies and ecology. The different sectors of the report consider the study zone, the methodology, the description and evaluation of resources, production flows from woodland, tenure and institutional issues involved in the control of resources, evaluation of products, commercial and non-commercial aspects of local perceptions of value, and, lastly, sustainability.


This article continues analysis of data on line-planted trees in Mexico City carried out in 1994. It describes the situation of street trees in different sections of the city, including the precise number of trees per block. Relations between the features of the different sites, the health status of the trees, their dimensions and the characteristics of the various species are also analysed.

One of the objectives of the French National Forestry Inventory is to assess the volumes of wood contained in linear elements, particularly hedges. Hedges have been defined as irregular, linear, wooded elements with a minimum length of 25 m and a maximum breadth of 10 m, containing at least three trees to be inventoried, and an average of one every 10 m. Various methods were used — the intersection method (squares and crosses) and the associated strip method. Only the latter is now being used, because of its advantages in terms of simplicity both for the interpretation of photographs and for taking field measurements and making calculations.


This study examines variations in the cutting of trees in home gardens in four Kerala villages. A socio-economic and land-use survey was made of 247 households, recording harvesting models and details of tree growth. A harvesting intensity index was developed in order to compare various types of mixed farming, and different intensities were refined for seasonal and annual harvesting, permanent harvesting, tree harvesting and harvesting of various other products. Using the size of plot as an indication of economic status, comparisons were made between the households in each village and between different villages. No difference was observed in the intensity of tree harvesting between different-sized plots in any of the villages. However, the tree density varied considerably. The intensity of tree harvesting has decreased while the intensity of permanent harvesting has increased. When the combined intensity of permanent harvesting and tree harvesting was considered, the highest intensity was found on the smallest plots in three of the four villages. Considering the intensity of all harvests taken together, the smaller plots had higher harvesting intensities. Multipurpose trees accounted for 50 to 70% of the trees in home gardens in the different villages. The average number of trees per hectare varied considerably from village to village and between different plot sizes. In all the villages, a reduction in the variety of trees went together with a reduction of the plots’ area. Socio-economic factors - such as plot size - leveled out, and many other factors – such as the source of income, the number of sub-systems found in the home garden and their period of development,... - contributed to crop intensification in home gardens, within agroclimatic limitations and soil conditions. Multipurpose or high-value trees were preferred when planting afresh.


This paper discusses the fact that in most cases new methods for a model and analysis of agroforestry experiments are not needed. Tried and tested approaches and methods are already available but are often not used.


Zoning is a tool that should allow agricultural services to adapt their lines of action to differences in production conditions. It aims at highlighting these differences in spatial terms by identifying areas within which the problems are the same. On the basis of analysis of the features of each of the oases in the region, seven groups of oases were identified. The land inheritance system, investment capacities and the efficiency of tillage systems were the main discriminating criteria. It seems that the farms making up these different groups have widely varying capacities for development and adaptation to the market economy. Recommendations are made for each of the groups identified.


Farming communities in the Andean Cordillera in northwestern Peru use an efficient tree management strategy that helps
to meet their main needs. Trees supply many types of goods for the farmers, including timber for building and making furniture, glue, rope, medicines, soap and poison. Despite this, the weakness of common tenure rights means that there is inadequate control over access to forest zones, leading to an overexploitation of forest resources, overgrazing and soil erosion. An inventory of the main tree and shrub species in the catchment area of the Mangas waters (an area of 173 km²) was compiled in order to provide a basis for more sustainable management, and also to allow better planning of future reforestation in the region. Priority was given to the description of each species in terms of its local use, applicability for agroforestry, and position in the soil and in the context of the landscape in which it has grown. There are eight vegetation formations in the area: tropical montane forest, secondary shrubby formations, woodland, wooded savannah (two types), semi-desert shrubland with cacti, shrubby steppe, and gallery forest. Forty-seven of the seventy-one species of tree and shrub identified have several uses. The genera *Acacia*, *Alnus*, *Cordia*, *Erythrina* and *Prosopis* are considered the most effective in improving those forest zones that are used for grazing.

200 **Croze, H. & Gwynn, M.D.** 1983. The global environment monitoring system: its value for analysis and development of agroforestry land use systems. In P.A. Huxley, ed. *Plant research and agroforestry*, p. 291-296. Proceedings of a consultative meeting held in Nairobi, 8-15 April 1981. Nairobi, ICRAF. The Global Environment Monitoring System is a worldwide collection of networks focusing on the environment and dedicated to coordinating data collection and analysis methods. The main function of the network is that of providing managers and planners with an assessment on the state of the environment and on trends, so that such information can be taken into account in decisions.


Precise measurement of the covering of woody species in open vegetation is vital, particularly in studies of dynamics. It is made much easier through the use of Cooper’s gauge, based on the principles of Bitterlich’s relascope.


Since vegetation on grazing land is by nature mixed, analysis of its biomass with the classic methods is inadequate, since they are based on the hypothesis of the Gaussian distribution of measurements made on samples taken from a homogeneous population. It is better to define biomass through observation and to use non-parametric tests for comparisons.


An evaluation of the impact of coconut intercropping with cassava reveals many advantages. As opposed to the general belief, intercropping with cassava is beneficial to coconuts, and the yields on intercropped plots are better than those on plots planted solely to coconuts.


An inventory of wood volumes was made in five urban zones in the Republic of Niger, using the interpretation of Landsat satellite images and medium-range aerial photographs. The aim was to provide the Government with information on the amount of available fuelwood for the population in the five zones—a total area of about 150 000 km²—for planning purposes. With the aid of a soil/vegetation/landform map, a total of 349 field sites were divided for data collection. The sites were chosen using a multi-level list
sampling method, and the choice was weighted towards forested areas. Quantitative data were collected through a transect system, and the volume of fuelwood was calculated through a multiple regression process.


There are a certain number of difficulties in assessing the woody biomass of individual trees and shrublands. From the point of view of measurements, differences in the form of the stems and crowns and variations between species pose problems. Carrying out such an assessment then comes up against constraints connected with cost, time and labour. From the point of view of statistics, questions arise as to the model to be used in regression analyses. This paper discusses some of the approaches adopted, and a recently developed method of subsampling trees, which solves some of the above-mentioned problems, is described. Regression analysis approaches are also discussed, and examples are given for a number of countries in different climatic zones.


In a study of farmers’ knowledge and experiments on trees and tree planting, two categories of farmer were identified: tree experts (44 in number) and control farmers (70), through a two-stage classification process of acquaintance and community interviews in three southern Rwandan communes in 1992. A detailed inventory of tree species was made, revealing two key features of trees on farmland: their multipurpose character and their high flexibility as to location. In order to organize the inventory of species logically, two indices—a utility index (UI) and a locational flexibility index (LFI)—were developed. Values according to the two indices were calculated for each species and then transferred as axes onto a bivariate chart. While few exotic species had both high utility and high locational flexibility values, most indigenous species did. These are species that have been used in agroforestry systems for many years (for example Euphorbia tirucalli, Vernonia amygdalina and Erythrina abyssinica). Some naturalized exotic species introduced in the 1930s (for example Grevillea robusta, Eucalyptus camaldulensis, E. saligna, E. maidenii, Cupressus lusitanica and Persea gratissima) were also appreciated for their multiple uses and their locational flexibility. Farm sizes vary, with an average of 1.27 ha among the tree-expert farmers and 0.18 ha among the control group. The average number of species cultivated was significantly higher on the tree-experts’ farms, although the tree density was much lower there (731 trees per ha) than on the control farmers’ land (1689 trees per ha). Competitive species were found mainly on larger farms, while the smaller ones had more species with high UI and LFI values. The farmers showed well thought-out and reasoned choices of species, taking into account their utility and flexibility, as well as the availability of land.


In a concern to learn more about the fruit tree potential of central Guinea, a survey entitled Orchard Composition was carried out in May 1997 by research experts from the Citrus and Fruit Tree Programmes of the Guinean Agricultural Research Institute, with the aims of: (i) identifying fruit tree species with economic potential found in farmers’ orchards, in order to draw conclusions for fruit diversification in the region; (ii) surveying and categorizing the major constraints on the progress and promotion of fruit tree cultivation in the region; and (iii) working out how much potential exists, with a view to forecasting trends and providing guidelines for forthcoming years.
Evaluation of agroforestry plots on farms should provide further useful information for the design of improved agroforestry systems in research and development projects. Little such evaluation has been carried out, however, because of methodological problems in examining plots on farmland, which vary considerably, and difficulties in identifying the key variables for measurement. This paper describes a range of methods and tools used in evaluating alley-cropped plots and tree borders around cultivated fields established by farmers working with the Agroforestry Extension Project of CARE in western Kenya. Details of the design of surveys, sampling methods and implementation are discussed, and suggestions are made for agroforestry evaluations in other projects. A condensed version of the questionnaire used in the survey is given in the annexes.

The place of Javanese agroforests or home gardens in household budgets is declining, following global development and the growing diversification of activities. A phenomenon of concentration can be observed, with only the richer households with more land now having home gardens. Even many of these households are having financial problems. One of the solutions to such constraints is that of pawning (gadai) trees from the home gardens. The cost of the loan corresponds to the production of the tree, which goes to the lender until the loan is repaid. Analysis of 80 oral gadai loan contracts involving durians (Durio zibethinus Murr.) indicates that the real cost of such loans is not excessively high compared with the costs of formal loans. It also appears that the purpose of the loan (consumption or investment) or the degree of relationship between the two parties to the transaction makes no difference to the prices and sizes of loans.

Urban zones (towns, villages, etc.) cover 3.5% of the 48 states and contain over 75% of the population. Within these urban areas, about 3 800 million trees cover 27.1% of the land. On a broader scale, metropolitan zones (counties) cover 24.5% of the United States and contain 74 000 million trees, which cover 33.4% of these counties. Between 1950 and 1990, the metropolitan zones almost tripled in size, while urban zones have doubled in size over the past 20 to 25 years. This report is the first national assessment of the urban forest resources of the United States, and details are given by state, county and individual urban area. It shows local-level variations, the complexity of the resource, and how it has changed over the years. The report ends with a description of sectors for future investment in order to facilitate an integrated, flexible and sustainable management of urban forests and improve the quality of the environment and human health.

This article describes the functions of individual trees in the biomass in acacia woodlands. The main aim here is to use these functions for multi-phase sampling, in order to assess the biomass of acacia woodlands in the Ethiopian Rift Valley.

This paper briefly summarizes a research programme funded by the European Commission.
Commission. After describing the general framework of the programme, which aims on the one hand at reducing intensive agricultural production, and on the other hand at increasing high-quality timber production, it discusses various aspects of model building. Biological mechanisms, especially interactions between agricultural and forestry components, are also described. Medium- and long-term consequences are forecast. Social and environmental aspects are also taken into account.

This work describes the systems approaches that appeared between the late 1950s and the 1970s and that are still in use today. A large part is dedicated to describing the French and Belgian approaches to study of farming systems.

Wood charcoal is produced from a short rotation of the tropical species Leucaena leucocephala and Tectona grandis. Combustion-linked properties, moisture content and the percentage of carbon, hydrogen, oxygen, etc. and ash in wood and charcoal were determined for each of the species, as well as their combustion heat.

Econometric models explain how variables linked to households and farms affect the adoption of decisions. Decision tree modelling takes the perceptions used by farmers in deciding on a technology and examines them from another angle.


This report examines studies concerned with trees outside forests in Sudan, providing quantitative field data as well as statistics available within the country.

This study adapts land cover analysis to a dry tropical natural environment through the combined use of remote sensing and field surveys in land cover inventories. The inventory method proposed is based on the principle of random circular plot sampling in the study area. The survey segments are all the same size, and they are divided up by a non-aligned systematic selection that can be described as systematic and random. Environmental observations are then carried out within the segments, with the aim of rationalizing the preparation and collection of satellite data as well as the production of land cover maps and statistics for dry zones. The areas falling into different categories of land cover are estimated, and the precision of these estimates is also estimated. These estimates are carried out with and without the input of satellite data, and the results are then compared. The contribution of remote sensing, produced by correcting estimates with the help of a regression estimator method, increases the precision of the estimates and the efficiency of the field survey.

This study reviews work undertaken to produce a diagnosis concerning oasis agriculture in the Kiffa (Asaba) region of Mauritania on the basis of SPOT remote sensing material from December 1987 and its numerical processing. A specific survey
methodology is tested for mapping land cover, in correlation with field work. Various oasis sites were identified and pinpointed in order to establish a correspondence between land cover and the representation of this cover on printed colour documents resulting from numerical processing. The first tests using high-resolution satellite imaging have given promising results, with the selected subjects being satisfactorily represented. Complementary tests carried out on the basis of images taken in February-March (off-season crops in oases and the end of grazing in neighbouring rangelands) will allow validation of the initial work and confirm the possibility of assessing cover in the palm grove, identifying date palm zones and hyphenae (or doum) palm zones. It would then perhaps be possible to make a quick estimate of the area of palm groves of different densities.


Conservation based on agroforestry systems has been developed for possible adoption in place of a high-risk agriculture on land capacity classes I to IV in buttress zones of 2 million ha in northern India (Punjab, Haryana and Himachal Pradesh). The field studies described in this paper were carried out in the 1980s and used a typical toposequence of four land capacity classes from the valley bottom to the top of the foothills on the Water and Soil Conservation Research Farm and the Chandigarh Training Institute in the state of Haryana. The sequence covered a horizontal distance of 900 m and a vertical distance of 117 m. Class I of the system (the irrigated valley bottom) was agrosilvohorticultural, combining *Leucaena leucocephala*, lemon (*Citrus auranti [I] folia*) and papaya (*Carica papaya*) in the upper storey, and *Curcuma domestica* (*C. longa*) and okra (*Abelmoschus esculentus*) in the understorey. The average sustainable net return is 17 006 rupees per ha per year (against 7 852 rupees for a double-crop agricultural system). Class II of the system (the lower terraces) is agrosilvicultural and consists of *L. leucocephala* var. K8 intercropped with maize (*Zea mays*), *Vigna Mungo* and *Cycamopsis te (?) ragonoloba*; the latter has given the highest net annual returns (3 540 rupees per ha). Class III of the system (the middle terraces) is silvopastoral, with *Eucalyptus tereticornis* and *Eulaliopsis binata* in the understory. After four years (1985-1988), the average annual above-ground dry grass yield is 4.2 for the October cutting (used for paper paste) and 1.19 for the June cutting (used for fodder). The annual net returns from the grass component is 4 672 rupees per ha.

Class IV of the system (marginal sloping ground) is also silvopastoral and is made up of bhabbar grass under five drought-resistant species of acacia. Grass yields and net returns are highest under *A. senegal* and fall under the other four species in descending order: *A. tortilis*, *A. modesta*, *A. suma* and *A. lenticularis*. The average annual grass yield and net returns (after six years, all species) are 3.9 and 2 402 rupees per ha respectively. All four of the agroforestry systems described are better than traditional farming systems in each land capacity class.


Data concerning trees outside forests are inadequate for Africa. Inventories of this resource must be made with forestry and agricultural inventories if they are to be economically viable. In most areas, a systematic sampling is the simplest type of inventory to implement. If mapping and remote sensing data are available, a multiphase sampling could bring greater precision. Permanent plots are recommended for measuring growth and trends. Species, heights and crown and stem diameters are most often used in biomass equations.

221 Hasenauer, H. 1997. Dimensional relationships of open-grown trees in Austria.
This article studies the breadth of crowns, the diameter at breast height, the height of the base of the crown, and the conicity of trees without competition from other trees throughout their lives. Such trees represent the empirical maximum for tree dimensions, and this can be used to work out management guidelines and construct models of the competition and closedness of tree cover.


Tropical trees are planted on commercial plantations or smallholdings. This article describes a method for assessing the sustainability of smallholder cocoa production in West Africa, proposing a procedure to evaluate the hypothesis that cocoa plantations under shade and less intensively cultivated are more sustainable than non-shaded and more intensive ones. The approach is based on environmental, economic and social indicators of sustainability and takes account of the demands of experimental design to allow statistical evaluation. The research is structured according to several research hypotheses: assessment of sustainability in time and space; and the survey design (sampling, data collection, data analysis and institutional set-up).


This report gives an overview and appraisal of studies regarding trees outside forests in Costa Rica, providing quantitative field data, as well as statistics existing within the country.


This article gives the results of a woody biomass survey on farmland in Kenya, which is part of the FINNIDA Kenya Forestry Master Plan Project. The survey covered 10 million ha of high-potential land (20% of the country) inhabited by 80% of the country’s population. A two-phase sampling was made, the first phase based on low-altitude aerial photographs following a systematic grid, and the second on field measurements of a subsample. Woody biomass was classified as planted (hedges, demarcation planting and woodlots), riparian (degraded and undegraded) or natural woodland. Contrary to widespread belief, the survey discovered a rapid increase in planted woody biomass between 1986 and 1992, with an estimated annual increase of 4.7%, the dominant planted species being eucalyptus. The survey also showed that wood on cultivated land can become a major source of raw material for the timber industry, since the volume is greater than that found in conventional forests. The previous conclusions, i.e. that population density is positively correlated to the volume of planted woody biomass, were confirmed by the results of a high correlation survey ($r^2=0.64$) on the district level. The results indicate that pessimistic views regarding the extension of land use in Kenya are unjustified. Instead of an increase in the shortfall in fuelwood and a degradation of land following rapid population growth, Kenyan farmers seem to be applying wise and sustainable management practices, including the planting of trees. It is suggested that the tenure system—most farmland in Kenya is privately owned—is a major factor in this recent development.
zone. It helps in assessing forestry potential in terms of the fuelwood used by rural inhabitants, and aims at producing an estimate of the area of cultivated land involved and at gaining an overall picture of the productivity of this wooded resource.


Using a combination of remote sensing and mapping as a background in studying the contracted vegetation known as striped bush on lateritic uplands, the idea of its origin as linked exclusively to the uni-directional flow of runoff is not enough to explain the existence of a contracted structure. The study highlights consideration of the nature of the substratum in terms of both geology and soil science. This form of contracted vegetation is a far from fragile ecosystem, representing a natural balance attained by nature. The hydrology of these systems concentrates the little rain that falls towards clearly defined production sites for woody and grassy species, which reach a level comparable to, or even better than those in zones where the vegetation is uniformly distributed. These highland ecosystems thus represent landholding, pastoral and forestry reserves for the Sahelian inhabitants of towns and countryside, and better knowledge of them is needed with a view to correct long-term management.


This study was made in the framework of the programme concerning fragile Sahelian zones and had the aims of (i) defining a medium-term indicator of the state and changes in Sahelian environments, which should be perceptible and quantifiable on satellite images, and (ii) developing a reproducible method of using satellite data in order to monitor Sahelian environments in space and time. The combined analysis of the distribution of the woody cover and of landscape units was carried out on the basis of SPOT images and field data for the dune area of Oursi in Burkina Faso and the sandy Ferlo area in Senegal. It led to development of a method using both radiometric and morphological data from satellite images. Identification of the distribution of woody cover on SPOT images, with the help of morphological indices, showed the variety of ways woody species are distributed in different dune environments. This variation in structures is closely related to differences in the topography, soil and water of the environments occupied by woody species.


This study analyses the dynamics of plant cover in a Sahelian environment, making use of a quantifiable indicator that can be picked out on satellite images: the spatial distribution of woody species. The idea underlying this research, which is above all methodological, is based on observed changes in plant cover in a Sahelian dune environment over the past thirty years.


This application of Landsat thematic mapping (TM) data was urged by the pressing need of the Sri Lankan 1995 Silviculture Masterplan to update information on the area occupied by trees outside forests, a sector in which home gardens—a highly developed agroforestry system incorporating crops and forest trees—play a major role. The area of these gardens was estimated by using a combination of image classification and visual interpretation
techniques. While image classification is a very quick way of extracting information and is hence appropriate when information is needed in a hurry, it is unsatisfactory for obtaining a good distinction between types of forest. The trial described in this document showed that greater precision can be obtained for a simple classification of ground cover as “forest” and “non-forest”. This broad classification is made by subsuming the large number of land use classes identified on the satellite image into one of these two categories. Home gardens are then placed under “forest”, and their area can then be discovered by taking the total “forest” figure and subtracting estimates from 1992 satellite images of natural, sparse and planted forest, as well as estimates from the recent departmental survey of rubber, coconut and other cultivated trees.

This study examines tree cover in the context of urban growth in Hong Kong, and its classification according to geometric criteria of massiveness, connectivity and closeness. Three main types were distinguished on the basis of these three variables: isolated, linear and grouped. Their uneven distribution shows a predominance of small, sparse, disjointed patches of tree cover. A concerted effort seems to be needed in order to improve the quality of the urban landscape.

The main aim of this study was to establish a method for estimating tree densities in savannah-type vegetation systems by using the highest possible spatial resolution on the basis of satellite data (SPOT-1 panchromatic = 10 m resolution), on the hypothesis that for trees scattered on grassy cover, spatial filters can provide a direct mapping of the tree cover. This study was carried out in dehesa systems—woodland in southern Spain marked by the presence of oaks.

The dehesa ecosystems in the southwest of the Iberian peninsula are considered a type of savannah grassland and are dominated by scattered evergreen oaks. This article presents the results of a study on how these isolated trees affect the water balance of these ecosystems, as well as the implications for models that assume that soil water resources are always the same.

This study focuses on the wood production of fallows and its uses in Sudanian and Sudano-Sahelian zones. The aim is to assess the woody biomass production level of fallows and the fallow period needed for an optimal production, taking account of the present uses of this resource. It also seeks to determine how human pressure has affected the woodland on these fallows.

This work is based on a doctoral thesis for Wageningen University, which developed a soil loss and runoff model for hedgerow barrier systems, based on data from the ICRAF Machakos field station in Kenya, where measurements were taken on Cassia siamea hedgerow systems (alley cropping) between 1987 and 1992. Chapters 1 to 5 and 7 to 8 of the paper describe the system, representing and discussing the collected data. The barriers constituted by hedges control water erosion thanks to the presence of trees and an increase in infiltration beneath the hedges. The infiltration rate below hedges is
three to eight times greater than in the alleys
where crops are grown. Measurements of the
water content of the soil in hedgerow systems
indicate that water penetrates the soil beneath
the hedges to a greater depth than soil beneath
the alleys and on the control plot. An
analytical framework is given in Chapter 6 to
calculate the impact of hedges and mulch on
infiltration, runoff and soil loss. The
framework was extended with algorithms in
order to calculate the impact of hedges of
varying thicknesses and in one to four lines. It
was applied on a seasonal basis, and the
forecasts were satisfactory. A dynamic
simulation model known as SHIELD
(Simulation of Hedgerow Intervention against
Erosion and Land Degradation) was
developed, and was used to explain
experimental observations concerning runoff,
soil loss and crop yields, using daily
measurements. This is described in Chapter 9.
The application of the model (Chapter 10)
shows the importance of the conditions of soil
dynamics and of plants connected with soil
loss, and demonstrates that SHIELD can be
used to calculate the maximum distance
between hedgerows while keeping soil loss
within acceptable levels.

235 **Kiyiapi, J.L.** 2000. Tree resources
assessment, anthropogenic influences and
monitoring strategies in medium to low
agricultural areas: some examples from
Tharaka Central and Transmara Districts,
Kenya. *In A.B. Temu, G. Lund, R.E.
Malimbwi et al., eds. Off-forest tree resources
of Africa*, p. 22-43. Proceedings of a workshop
held in Arusha, Tanzania, 12-16 July 1999.
Nairobi, African Academy of Sciences &
ICRAF.
In low-intensity agricultural zones in Kenya,
the predominant land use is pastoralism and
small-scale subsistence agriculture. The
landscape is composed of a mosaic of isolated
trees, clumps of trees and a remaining
complex natural vegetation. Assessment of
resources must take this complexity into
account, combining a forest inventory with
simple participatory methods. The transect
sampling technique seems the most effective
when trees are scattered. Assessment of trees
outside forests must take into account the
continuum of different uses of woodland,
ranging from farms to the edges of forests.

236 **Kleinn, C.** 1999. *Compilation of information
on trees outside the forest: a contribution to
the forest resource assessment 2000-FAO.
Regional study for Latin America (including
also Haiti).* In collaboration with C.G. Baker,
D. Bolivar, J. Botero, L. Girón, J. Morales, R.
Muschler, C. Schneider, C. Soihed & A.
Skorupa. Costa Rica & Rome, CATIE &
This report summarizes and synthesizes
information collected by different countries in
Latin America—Brazil, Colombia, Costa
Rica, Guatemala, Haiti, Honduras and Peru. It
gives various types of classification and
definition, together with available statistics on
trees outside forests in these countries.

237 **Kleinn, C.** 2000. On large-area inventory and
assessment of trees outside forests. *Unasylva*,
51(1): 3-10.
This article first seeks to define and classify
the resource to be inventoried, then focuses on
an inventory and assessment of trees outside
forests. It concentrates on inventories made of
large areas, and particularly on the different
forms of survey possible, offering some
examples and experiences from Latin
America.

238 **Kleinn, C.** 2000. Tree resources outside the
forest in Central America: a regional
assessment approach based on remote sensing
and field survey. *In A.B. Temu, G. Lund, R.E.
Malimbwi et al., eds. Off-forest tree resources
of Africa*, p. 44-53. Proceedings of a workshop
held in Arusha, Tanzania, 12-16 July 1999.
Nairobi, African Academy of Sciences &
ICRAF.
This paper describes the structure and
relevance of a project to develop an
assessment and mapping method for trees
outside forests in Central America. The
research methods used are also described,
and the initial experiences discussed. The method
chosen is a combination of remote sensing and
sampling. The main aim of the project is to
identify an optimal use and combination of
these information sources, together with an adequate presentation in a geographical information system.


In this report on trees outside forests in Namibia, the authors offer a country-wide review of this resource, together with data as to quantities (production, area, etc.) and quality (goods and services provided by trees outside forests). The data are based on field observations and a bibliographical review.


A survey was carried out in 17 selected sub-districts in the state of Kerala to discover the floristic structure and composition of home gardens and to measure the similarities and diversities in their composition, with particular reference to their size—small (under 0.4 ha), medium (0.4 to 2 ha) and large (over 2 ha). The potential of home gardens to supply commercial timber and fuelwood was also assessed. About 250 farmers were chosen through a stratified random process. Apart from the collection of general information on agricultural and livestock farms, all the scattered trees and shrubs (with a diameter at breast height of at least 15 cm) on the farm, as well as demarcation trees (apart from palms and rubber trees) were recorded. There were differences in the numbers of trees and shrubs and in species on the farms chosen in the different sub-districts. All the various size categories also showed major variations in the number of woody species and individuals found. In all, 127 woody species with a DBH of at least 15 cm were found. The average number of woody species found in home gardens ranged from 11 to 39. The floristic diversity was greatest on small plots and fell in larger ones. The main Simpson diversity index for plots ranged from 0.251 to 0.739, suggesting that floristic diversity is moderate to low (compared with a value of over 0.9 for species-rich evergreen forests in the Western Ghats). The Sorensen similarity index suggested a moderate to high degree of similarity for the different tree species found. Trees and shrubs were scattered all over home gardens or around their edges. Farmers tend to prefer trees for construction timber, such as tree of heaven or Chinese sumac (Ailanthus triphysa, the most frequently found) and teak (Tectona grandis), and fruit trees such as mango (Mangifera indica), jackfruit (Artocarpus heterophyllus) and cashew (Anacardium occidentale). The main home garden species is found in every class of diameter. So far as diameter is concerned, however, there was a slight bias (+) in the distribution model, with the highest frequency in the 20 to 30 cm classes, thus assuring an adequate regeneration status and making home gardens a sustainable and dynamic land-use system. The average permanent commercial standing stock for construction timber in home gardens ranged from 6.6 to 50.8 m³/ha, while the volume of fuelwood ranged from 23 to 86 m³/ha. The fact implicitly shown by these large volumes is that a substantial proportion of society’s wood demands is met from home gardens. However, palms constitute the dominant component of commercial construction timber and fuelwood—63% and 72% respectively of the total wood in these categories.


An intercropping trial was set up in 1980 at the Divo station in Côte d’Ivoire, combining cocoa trees and food crops within fruit hedges, with the following experimental lay-out: 3 lines of cocoa trees, 10 x 1 m (A); 3 double lines of cocoa trees (2 m + 8 m) x 2 m (B); 3
lines of cocoa trees (10 x 2 m) x 2 m(C); control plot 3 x 2.5 m (T). The cocoa trees were Upper-Amazonian, and various food crops were planted between them. The first two harvests showed no significant difference between plots, but in the third harvest, A, B and T produced more healthy pods than C. The food plants showed no incompatibility with the cocoa trees. Soil analysis after four years showed a significant impoverishment in phosphorus between the lines in the space intended for food crops, and this would have to be compensated for with a mineral fertilizer.


Tree species for windbreaks in the southern Sahelian zone of West Africa were assessed according to a number of criteria: rapid establishment, effectiveness, fodder production for livestock, and fuelwood production. Trials were carried out in Niger between 1988 and 1993 to assess these criteria for seven species used in planting windbreaks. This article gives details of these trials and their results.


Computer models have shown that the appropriate placing of trees around buildings can make a significant contribution to energy savings through a cooling effect in the summer months and a heating effect in winter. A study carried out in a residential neighbourhood of Ann Arbor, Michigan, used the statistics of the electricity and natural gas companies to examine the energy demands of homes in three sectors with very different tree densities. Field measurements assessed the density of vegetation that provides direct shade for the buildings, and aerial photographs were interpreted to assess the potential protective effect of vegetation against wind and adjacent buildings. Statistical analysis of the data showed that the effectiveness of air conditions and the variability of structures, including the level of insulation, masks the effects of the vegetation on energy consumption. Analysis is complicated by the wide variety of energy consumption habits of individual owners. Nevertheless, the trends discerned suggest that the appropriate placing of trees, with regard to gains in sunlight depending on the season and the direction of winds, can bring substantial savings in energy.


This volume provides an overview, giving methodological pointers, both on problems specific to the intercropping of trees with crops, and on the organization of nurseries or the design and participatory implementation of projects with the rural population. It gives an overview of agroforestry and its uses, and follows the progress of an agroforestry intervention, from diagnosis, through the choice of methods and the production of plant material, to evaluation. It also examines the main methodological approaches used in agroforestry, as well as the links between agroforestry and research.


This volume is composed of technical instruction notes on agroforestry, giving practical, operational form to the technical and methodological information found in volume 1 on the design and implementation of agroforestry programmes and projects. The instruction notes explain the main techniques for collecting the data needed to draw up a diagnosis, specifications or an assessment. They also describe the tools for implementing a project, from organization to management and from communication to the choice of species.

The distribution of woody species and the structure of miombo were studied in a deforested agricultural area of central Zimbabwe (Ward 2, Shurugwi), and the plant ecology was examined in relation to the past use of this wooded region. The area is classified as moist dystrophic savannah, with an average annual rainfall of 675 mm and soils of granite or dolerite origin. Data on the specific composition, land area, height and features of the woody vegetation are given for 11 different landscape zones (divided on the basis of soil type, proximity to villages or water sources, and geology). The nature and degree of disturbance caused by the extraction of fuelwood and construction timber are evaluated. Fruit trees, other trees with cultural functions, and species that rapidly invade modified ground (these last may be extremely productive in terms of woody biomass) tend to dominate wooded regions in arable sectors close to villages. Grasslands occupy the main wooded areas in the sector under study. On deeper soils that have been cultivated in the past, an open wooded formation remains, which has had a tendency to be dominated by coppices of Brachystegia spiciformis and Combretum molle (both of which are also predominant in the less modified miombo).

On rocky soils that have not been deforested in the past, coppices also dominate through climax species. Woody vegetation on kopjes and along streams is less disturbed in terms of distribution, species composition, density and height, than in wooded zones in other parts of the landscape. It is shown that the spatial model and the nature of felling vary depending on land-use category, species and the dimension of individual stems. The miombo show a relatively high degree of stability in species composition under the disturbance caused by felling: of the 94 species included in the analysis, relatively few are significantly associated with a particular soil type or a particular land-use category.


This report analyses the forestry practices of farms and villages in six countries in South and Southeast Asia—Bangladesh, Indonesia, Nepal, Philippines, Sri Lanka and Thailand—and studies the use of tree products from farms of different sizes. At least 50 households in 26 villages, including landless families, were surveyed. Four general trends were found: (i) farm size affects the way a household uses tree products; for example, households on medium and large farms use these products as a primary source of fodder more often than those on small farms; the latter use State-owned forests as a major source of fuelwood more often than the others, while charcoal is used more by households on large farms; households on medium and large farms are more similar to one another and use wood regularly; (ii) although the extension of government facilities contributes to agroforestry practices, socio-economic and other factors are also important; (iii) the most common place for cultivating trees is the garden, while the second most common source of wood is trees scattered among crops; and (iv) trees provide food in general, and fruit trees are the most popular, especially multipurpose trees, whatever the size of farm.


The authors of this report on trees outside forests in Morocco offer a country-wide review of this resource, together with data as to quantities (production, area, etc.) and quality (goods and services provided by trees outside forests). The data are based on field observations and a bibliographical review. The report also contains a detailed study of the carob (Ceratonia siliqua L.), a multipurpose forest fruit species.

In this report on trees outside forests in Zimbabwe, the author offers a country-wide review of this resource, together with data as to quantities (production, area, etc.) and quality (goods and services provided by trees outside forests). The data are based on field observations and a bibliographical review.

The coastal region of Ecuador produces considerable quantities of coffee and cocoa. The farms and ranches in the region also produce industrial timber for sawmills, with most of the timber coming from shade trees and trees on rangeland. Since little is known about the supplies of timber from these farms, a survey was carried out, taking a sample of 122 farmers in different subregions. The results show an abundance of land suitable for planting trees and an excellent regeneration of many species on most farms. Despite this, present tree stocks are well below the potential, and less than half the farmers interviewed manage trees with timber sales in view. Only 2.2% of farm income comes from the sale of timber, although over half those interviewed had sold trees to industrial purchasers at least once. The constraints on the production and sale of trees include the risk of damage to the coffee or cocoa, the belief of incompatibility with present farming practices, inadequate classification methods, the low price of trees, and, lastly, insufficient knowledge of the industrial uses of trees by developers. These limitations should be countered by a research, development and information strategy on selected demonstration farms.

This document summarizes knowledge on trees outside forests in Senegal, defining this resource and discussing its roles and functions, as well as the management methods adopted. Evaluation methods are also suggested.

This study seeks to determine the environmental and human factors affecting coffee and cocoa yields in Côte d’Ivoire. It presents the results within a geographical information system (GIS) in order to show the causes and effects obtained on the plots surveyed. The field study and the established GIS show that in the Daloa pilot zone, cocoa and coffee yields are linked to the condition and upkeep of the plantation. The cocoa trees from hybrid plant material have a considerably higher yield than those from *amelonado* material. In the case of coffee bushes, shade has a negative effect on yields. In the Soubré zone, cocoa and coffee yields are closely linked not only to condition, upkeep and plant material, but also to the amount of insect damage and shade. This information and satellite image processing should show how yield levels can be classified, together with the corresponding inputs.

In this report on trees outside forests in Malawi, the author offers a country-wide review of this resource, together with data based on field observations and a bibliographical review. He also attempts to define this term and other terminology used with it, and suggests classification systems for trees outside forests.


This document describes woody biomass survey activities undertaken in 1993, 1996 and 1998 in two districts of Kenya. The 1993 inventory used aerial photographs and field inventories, in which all the trees were counted, in order to provide a basis for assessment of the tree cover on 62 farms in the two districts. In 1995, the Kenyan Forestry Plan estimated that 65% of the total timber produced in the high- and medium-potential districts came from farms, and planned to increase this to 80% by 2020. The 1996 inventory was thus carried out on the same farms, and it gave encouraging results regarding the increased tree potential in these areas.


This article describes the methods and first results of a research project on urban forestry set up in Chicago, Illinois. It examines the interdependent functions of the urban forestry ecosystem now under study—climate change, energy savings, air quality and carbon dioxide retention—and analyses the costs and advantages of urban vegetation.


The yields from two intercropped cocoa/kola plots at the Cocoa Research Institute were compared with those from two monocropped plots, one under cocoa and the other under kola. A monocropped plot of 1.75 ha gave the same yield (in kg/ha) as 1 ha of mixed crops. The cocoa trees fruit earlier than the kolas and continue to produce each year. Intercropping cocoa and kola is practical and economically attractive.


The Monitoring Wood Resources and Land Degradation in Kordofan, Sudan, Project was launched by the Physical Geography Department of Lund University in 1981/1982. One of the aims was to develop a methodology, based mainly on remote sensing, to estimate the volume of woody biomass in arid and semi-arid environments. A second aim was to study the fuelwood consumption model in the study zone in order to relate it to the desertification process. Knowledge of the history of the landscape is needed in order to understand its contemporary state, so this aspect was also included in the study. The results indicate that canopy cover and woody biomass can be linked to Landsat multispectral scanner system (MSS) data in a given physical environment. No serious fuelwood supply problem appears to exist, although the situation in certain zones seems to be deteriorating, with shortfall pockets being indicated, especially around villages. The most serious treatment for woody vegetation seems to be a reduction in the crop/fallow cycle, which can create problems by increasing wind erosion and decreasing soil fertility.


About 60 woody species have been recorded in the savannah of northern Cameroon as playing a part in the food of domestic ruminants. The phenology of some of these species was monitored for four years both on natural rangelands and on plantations. The study showed that the trees and shrubs most widely used are, in order of preference: Ficus sycomorus, Daniellia oliveri and Afzelia africana for their leaves, and Acacia albida, Dichrostachys cinerea and Prosopis africana for their fruit. The flowers of Daniellia oliveri, Pterocarpus erinaceus and Bombax costatum are also widely appreciated. Ficus sycomorus, Pericopsis laxiflora, Daniellia oliveri and
Detarium microcarpus also have a phenology in the natural environment compatible with optimal use of their leaves during the lean period.

259 Pandey, D.N. 2000. Ethnoforestry and trees outside forests in India. INEF Occasional Paper. Bhopal, India, Indian Institute of Forest Management. This study seeks to assess officially designated trees outside forests in India. The study reveals a total of 18 397 120 000 trees, covering the equivalent of 22 980 000 ha, of 7% of the land area of the country. It would cost 427 542 900 000 rupees, or $US 6 607 700 000, to plant 22 980 000 ha at current reforestation costs. This is thus the present minimum value of trees outside forests in the country.

260 Pauleit, S. & Duhme, F. 2000. GIS assessment on Munich’s urban forest structure for urban planning. Journal of Arboriculture, 26. A geographical information system (GIS) was developed and applied in order to assess the spatial model and environmental functions of Munich’s urban forest. Urban land types were defined as spatial units, distinguished by such physical and land-use attributes as percentage cover by construction and vegetation. Urban forests are described on the basis of the cover provided by trees and shrubs and their maximal age. The survey is coupled with statistical databases and environmental data such as those from habitat surveys and thermal infrared photography. Trees and shrubs cover approximately 5 400 ha, or 18% of Munich’s total area. The spatial model of the urban forest was closely linked to the division into land-use zones and the density of the buildings. The relationship between cover, size and age of the woody vegetation and the presence of birds as indicators of wooded regions was used to assess the role of the urban forest in nature conservation. Moreover, it was shown that the urban forest can effectively reduce temperatures during warm summer days. Specific urban silviculture programmes are proposed, which would increase forest cover to 22% of the city’s area. An estimate of the overall costs of establishing further forested zones is given.

261 Peltier, R., Lawali, E.M. et al. 1994. Aménagement villageois des brousses tachetées au Niger. 1ère partie: le milieu: potential et contraintes. Bois et Forêts des Tropiques, 242: 59-76. The city of Niamey depends on wood for 95% of its domestic energy supply. This represents about 150 000 metric tons of wood per year at present, while the production of forests in the region is estimated at 300 000 metric tons per year. It appears that these forests would be capable of covering annual urban and rural needs if the pressure of felling were properly distributed (whereas it is at present concentrated around the capital) and if forestry management assured renewal of the resource. The “offer component” of the Energy II Project hopes to contribute to the development of 250 000 ha of bushland in ten years, with the support of other projects. Between 1991 and 1992 the Say district development team thus chose nine villages that wanted to develop a sector of uplands of about 10 000 ha, located around the village of Tientiergou. The authors describe how the region functions in socio-economic terms (including agricultural and pastoral practices), the ecology of striped and leopard bush, and the failures and successes of the first forestry development trials carried out in the country. With the help of a forestry and pastoral inventory, they try to work out the potential of the zone and the reaction of the environment to felling combined with grazing.

262 Penot, E. & Wibawa, G. 1997. Complex rubber agroforestry systems in Indonesia: an alternative to low productivity of jungle rubber conserving agroforestry practices and benefits. In Symposium on Farming System Aspects of the Cultivation of Natural Rubber, p. 56-80. Beruwala, Sri Lanka, 6 November 1996. Brickendonbury, IRRDB. The major constraint for the agroforestry system known as jungle rubber, which is an indigenous alternative to shifting cultivation, is its low productivity. Rubber-based agroforestry systems tested in the framework
of the project are based on the use of improved genetic material (clones). A low to medium level of inputs and labour are features of these systems. A preliminary cost-benefit analysis of rubber-based agroforestry techniques was carried out in comparison with jungle rubber and with the monocropping system advocated by the TCSDP (a World Bank project), taking labour productivity into account. This analysis gives an idea of the improvement in economic results brought about by using clones. Rubber-based agroforestry systems, which show a good labour productivity for a limited initial investment, are particularly suitable for planters with little money available.


Precise information on fuelwood flows in France is hard to come by because declared sales represent only a small part of the volume actually consumed. This difficulty can be overcome by using a number of surveys and cross-checking them. This document describes the results of such surveys carried out in the Midi-Pyrénées region.


Financial appraisal of agroforestry is not different in kind from appraisals applied to pure forestry. Existing techniques for valuing non-market effects may also be applied. Effects on hydrological and carbon fluxes might be less favourable than those of pure forests. In the confusing field of biodiversity valuation too, only limited and specific claims can be made for agroforestry. Amenity valuation techniques developed for trees and woodlands encounter additional problems of interpretation in an agroforestry context. Agroforestry may offer a quantifiable value in short-term sustainability, and might meet recent economic definitions of long-term sustainable development, without encountering the full dangers to future generations embodied in conversion of natural to human capital.

265 **Raintree, J.B.** 1987. *D&D user’s manual: an introduction to agroforestry diagnosis and design*. Nairobi, ICRAF, 110 pp. This work is a new overview of the procedures involved in practical applications of the diagnosis and design (D&D) method. The elementary concepts are described in the first section of the work, together with the main lines of the D&D method. More detailed suggestions are then given on procedures to be followed in national research programmes. The following section examines case studies, while the final section deals with the use of this method in national agroforestry research programmes.


This article describes a tree/crop interface (TCI) experiment undertaken at the ICRISAT Center at Patancheru in India, designed to examine the effects of the orientation of lines of *Leucaena leucocephala*. Each TCI plot consisted of regularly pruned *L. leucocephala* hedges in the centre, with 12 rows of crops on each side. Eight plots were set up, arranged at 45° around a single plot of *L. leucocephala* with rows oriented in four directions: North-South, East-West, Northeast-Southwest and Northwest-Southeast. Either sorghum or sunflower was grown as an annual crop. The *L. leucocephala* was first pruned five months after planting (at a height of 0.75 m) and then whenever the regrowth reached 1.5 to 1.8 m in height—usually four times a year. After pruning, the wood and leaves were separated, dried and weighed. Harvest yields over four years (1984-1987) showed no effect from the orientation of the rows, nor from location to windward or leeward of the hedge. The effect of the TCI was positive on the first row of
crops in the first year, because the *L. leucocephala* grew slowly, but in the following years, the yields of the first four to six rows of crops (1.8 to 2.7 m from the hedge) were lower. The negative effect of *L. leucocephala* was greater for the sunflowers (grown in 1985) in a relatively dry year than for the sorghum, which was grown in the other years. The results from the TCI plots were used to evaluate the yields of five intercropping systems of hedges with alleys of varying breadths (2.7, 3.6, 4.5, 6.4 and 9.9 m). Comparison with plots of *L. leucocephala* alone and crops alone indicated that hedgerow intercropping systems are more productive, particularly when alleys are narrower.


An economic evaluation of tree/grassland/livestock combinations requires the use of an economic method that takes account of the non-commercial concerns of owners and the specific technical and temporal constraints of the farming systems in question. A model was designed based on the economic concept of “utility” and the results of technical experiments. The result of the planting of trees was assessed on the individual farm level in terms of consumption, inheritance and the use of non-commercial goods throughout one life cycle. First a survey was carried out and an estimation made of changes in the plot, farm production and household budget brought about by the introduction of agroforestry. The tool developed during this work can encourage the adoption of agroforestry in temperate zones under certain conditions.


This thesis includes a cost-benefit analysis and a model to assess the influence of selected socio-economic factors on the adoption of live fencing and windbreaks in Senegal.


A number of different alley-cropped plantations with sweet maize (*Zea mais*), *Alnus rubra* and *Robinia pseudoacacia* were evaluated over a period of four years. The highest cereal yields correspond to the lowest compost mass production from trees. The area devoted to maize is a significant parameter in forecasting cereal yields. Although maize yields were higher on the single-crop control plot, the reduction in yields owing to the planting of trees between the lines of maize was proportionally lower than the reduction in area under maize owing to the presence of the trees. *Alnus rubra* and *Robinia pseudoacacia* are thus suitable species for alley cropping. *Alnus rubra* biomass production rose constantly throughout the study, whereas the capacity of *Robinia pseudoacacia* to form biomass fell after each cutting. A comprehensive approach was adopted, taking into consideration outputs (cereal yields and biomass production from the trees) and their interactions, total performance and feasibility.


In this report on trees outside forests in Mauritania, the authors offer a country-wide review of this resource, together with data as to quantities (production, area, etc.) and quality (goods and services provided by trees
outside forests). The data are based on field observations and a bibliographical review.


Farmland in the North-West Frontier Province carries about 80 million trees, two thirds of them on irrigated land. The average number of trees per hectare is 46 for all types of land, 72 for irrigated land, and 27 for non-irrigated land. The poplar (Populus, 24%), China berry or Persian lilac (Melia azedarach, 18%), palisander (Dalbergia sissoo, 15%), tree of heaven or Chinese sumac (Ailanthus glandulosa [A. altissima], 13%) and mulberry (Morus alba, 10%) are the commonest species on irrigated land, while the jujube (Zizyphus jujuba [Zizyphus mauritania], 23%) and tree of heaven (14%) are the commonest on non-irrigated land. Most of the trees are of small diameters, with diameters of 5-9, 10-14 and 15-19 cm accounting for 42, 14 and 13% of the total number of trees respectively. The estimated volume of growing stock is 14 million m$^3$, with 10.6 million m$^3$ (76%) of this being found on irrigated land. The volume of growing stock per hectare is 8.0, 13.8 and 5.3 m$^3$ on lands of every type, irrigated land and non-irrigated land respectively. The growing stock on irrigated land is mainly made up of silver date palm (Phoenix sylvestris, 27%), palisander (19%), mulberry (13%) and poplar (12%). On non-irrigated land, the growing stock is made up of tree of heaven (21%), jujube (15%), mulberry and fig (Ficus palmate, 9%). In 1989, farmers felled about 10.8 million trees (13.5% of the total) and extracted 2.9 million m$^3$ (21% of the total growing stock) to meet their own needs and for sale. The other species for which data are given are: willow (Salix tetrasperma), Indian olive (Olea cuspidate), prickly acacia (Acacia nilotica), Eucalyptus camaldulensis, Acacia modesta, Celtis australis, Robinia pseudoacacia, Debrecengia hypoleuca, Tamarix articulata (T. aphylla), Russian olive (Elaeagnus angustifolia), chir pine (Pinus roxburghii), oriental plane (Platamus orientalis) and walnut (Juglans regia).


In this report on trees outside forests in Sri Lanka, the author offers a country-wide review of this resource, together with data as to quantities (production, area, etc.) and quality (goods and services provided by trees outside forests). The data are based on field observations and a bibliographical review.


The author presents and analyses different results concerning the demand, consumption and supply of fuelwood from non-forest areas of India.


As part of theManaging Our Indigenous Tree Inheritance Project, the Southern Alliance for Indigenous Resources (SAFIRE) has developed a range of methods for participatory appraisal of resources, with the aim of involving rural communities in assessing the quantity and value of their natural tree resources. Using a combination of participatory rural appraisal and forest evaluation methods, the information collected by SAFIRE and the communities focused on the volume of harvestable wood, the potential production of fruit, the structure of the tree population, its ecological distribution and the density of tree species.
A model was developed in order to estimate the wood production of a shade giving plantation of Cordia alliodora on coffee farms. The model envisages timber production of 9 to 24 m³/ha/year of total volume and 6 to 15 m³/ha/year of stripped volume for a planting density of 120 to 190 trees/ha. Current production on four sample farms are below these figures. The model is used to show the transitory trajectory of Cordia alliodora stands with different DBH distributions at the outset. The main recommendations concern how farmers should manage their trees in order to obtain a stable output of timber in the shortest possible time.

Guided transect sampling is suggested for assessments based on transects of sparse and geographically scattered populations. This is a two-stage model, with broad strips being selected in the first stage, followed by a subsampling procedure in the second stage on the basis of the previous information. This article compares the method with a traditional strip assessment under various simulated forest conditions. This comparison shows that the proposed method can improve the precision of transect-based inventories of sparse populations.

In the recent proliferation of research on multipurpose trees, insufficient attention has so far been paid to the development of rational, reproducible methods for evaluating them. Even the measurement of such variables as height and diameter can be ambiguous and confused. Standardized evaluation methods for trials concerning hardwood species in the dry zone of Central America were developed at the Oxford Forestry Institute in order to solve this problem. The various aspects of the methodology are discussed with specific reference to one of these trials, including methods for measuring height and diameter and the use of these variables to forecast the production of dry woody biomass.

There is an urgent need to standardize the methods used in assessing the growth of multipurpose trees. Most of the standard methods described until now were developed specifically for use in trial networks in different places. This article makes a critical review of these methods for measuring heights and diameters and assessing biomass, in order to provide researchers with a series of methodological choices, while stressing the need to define clear evaluation methods.

This paper describes the method and results of a study on soil conservation and agroforestry needs in Zambia’s Mazabuka district between 1986 and 1987. The aim was to gather information on conservation and agroforestry problems, constraints and needs, and on indigenous and traditional knowledge. The study also offers recommendations for appropriate soil conservation and future agroforestry extension strategies.

This work is a response to ongoing concern to provide the Malian Forestry Service,
particularly the Woodfuel Unit, with a practical tool for evaluating fuelwood production in felling zones. After field survey / identification with the local population, a transect is opened with felling units of four trees every 100 paces being set up along the transect. The inventory covers not only the four trees, but any other woody stems that could be used as fuelwood (a minimum circumference of 10 cm. at breast height).


This article is divided into two parts. The first concerns methodological aspects of an economic evaluation of a multiple land-use system in which the same piece of land is put to both forestry and agricultural uses. The second gives the results of application of this method to a mixed poplar/cereal/sheep agroforestry system.

282 Tourret, V. 2000. Coûts de gestion de quelques modèles de haies. Lyon, France, IDF.

In 1999, the IDF described technical aspects (together with statistical data) of the planting and maintenance of various distinct types of hedgerow, within the framework of studies on lines of trees in the Midi-Pyrénées region of France, with the collaboration of the Forestry and Wood Service of the Regional Agriculture and Forestry Directorate.


Growing awareness of the importance and potential of agroforestry has led to a proliferation of site specific case studies. There are now enough good-quality studies of this type for use in research on a broader scale. This article describes an approach for the aggregation and use of agroforestry case studies in agroforestry research on a broader scale than the local site. It shows how the ICRAF agroforestry database can be used in combination with satellite images and additional information, by way of cross classification and a geographical information system (GIS), in order to produce a GIS-based agroforestry research tool for sub-Saharan Africa. This tool is used on a broad scale and as an initial step in estimating areas where appropriate agroforestry systems could be developed in Africa.


Since the early 1980s, development experts have focused their attention on improving methodological approaches to producing information on the village communities in which their institutions will be established or their activities carried out. Such methodological improvements are still continuing through the farmer participatory research (FPR) and participatory rural appraisal (PRA) methods, which are increasingly being used to produce information on village communities. PRA tools and techniques include in particular: configuration, participatory diagrams, interviews, classification, transects and institutional analyses. One of the features of PRA is that it stresses visual expression, allowing local people to participate directly in the creation and analysis of the information gathered. The main focus of this paper is the use of certain PRA tools and techniques in producing information on community knowledge and traditional uses of different tree species. It makes a synthesis of the results of PRA surveys carried out by the German Agency for Technical Cooperation and the United States Agency for International Development in five villages in Cameroon and
three in the Central African Republic. The figure of 444 known uses of tree species in the eight village communities involved in the study justifies the development of agroforestry activities and of research to show the service and production functions of trees as well as throwing light on gender issues. The paper holds that the use of PRA tools and techniques produces the most appropriate and useful tools for the initial information and for agroforestry research and development interventions.


This paper examines (i) the present results concerning the development of a change detection method, (ii) the sensing of changes in land use and forest cover with present methods, and (iii) the applicability of these methods in East Africa.


A high population density and a rapid human expansion, coupled with an accelerated economic growth, have led to heavy pressure on forest resources in the Asia-Pacific region. The remaining forests seem incapable of meeting fuelwood and industrial raw material needs. Most countries will have to turn increasingly to trees outside forests in order to make up the shortfall. This document assembles and analyses data on wood material from trees in non-forest areas of this region.


This article shows how little is known about perennial plants in comparison with agricultural crops, a situation that represents a serious obstacle in the analysis of agroforestry systems and their future development. This lack of knowledge applies particularly to quantitative data on the production of trees and shrubs used in agroforestry systems. The article also makes preliminary suggestions on how yield evaluation parameters could be standardized in order to improve their comparability, and also on how this type of data could be made more accessible by establishing supplementary databases.


Animal production in the Latin American tropics has developed by incomplete adaptation of temperate systems. Extensive cattle production based on grass has caused ecological damage and loss of biodiversity, and has not contributed to rural employment and development. Agroforestry systems are alternatives to intensify animal production, while promoting plant and animal biodiversity and environmental conservation. Agroforestry implies the presence of trees and shrubs. It includes silvopastoral systems with grazing beneath or among trees in natural or planted forests; industrial and fruit tree plantations; pastures with forage and multipurpose trees (in fences, banks and throughout the area); and integration of animals (in confinement) within mixed farming, and intensive cut-and-carry systems. Specialized silvopastoral systems have the following advantages over grass monocultures: greater amount and higher quality of fodder distributed in various plant strata; better micro-environment for animals; greater plant and animal biodiversity; larger carbon reservoir (counteracting CO2 emissions); and various other benefits at farm level (provision of fuelwood, posts, wind barriers, watershed protection, landscape improvement). Constraints to the development...
and extension of silvopastoral systems include: identification of suitable plant species for each stratum and location; technologies for plant introduction; methodologies for farm conversion to silvopastoral systems; financial support; availability of labour; and land tenure aspects. Key factors for the success of agroforestry systems are re-training of technical people and setting up demonstration units.


The SRAP research programme, launched by CIRAD-CP and ICRAF, is developing complex rubber based agroforestry systems in Indonesia that conserve biodiversity and maintain the ecological environment. The purpose is to generate sufficient income for smallholders from the production of rubber and agroforestry products (fruits, wood, rattan and other non-woody products), whilst rehabilitating severely degraded environments. The programme consists of testing rubber agroforestry systems in the smallholder environment (hands-on approach involving 100 smallholders in a network covering 3 provinces in Kalimantan and Sumatra), involving high-yielding Hevea clones with other tree crops (wood and fruits, rattan, etc.) and annual crops (while Hevea is immature). Exogenous technical innovations (clones, fertilizer application, tapping techniques, weeding, etc.) are combined with indigenous innovations.


The role of forests and trees in FAO's Special Programme for Food Security (SPFS) launched in 1994 to help farmers in low-income food-deficit countries (LIFDCs) increase food production to meet growing market demand, and eradicate food security, is discussed with reference to Africa. Aspects addressed include the direct contribution of forests to food security and ways to improve it (with examples of edible forest species), forests, jobs and income in relation to sustainable forest management, and improving agricultural production by exploiting the role of trees (agroforestry parklands and modern agroforestry systems) and diversifying farming systems through tree planting and agroforestry (the SPFS programme started a diversification component in 1998, specifically to address these issues). The energy contribution of forest and tree resources to household energy supply, and the contribution of wild animal resources are also discussed.
2.3 RESOURCE DYNAMICS

This is a collection of articles focusing on why farmers do or do not plant trees. Four case studies examine trends in tree-growing on farms, examining farmers’ increasing efforts to plant and manage trees in the hills of Nepal and on overexploited common land under the influence of rapid social and economic change in Rajasthan in India. The factors affecting farmers’ choices are also analysed.

Wherever we may be in a rural landscape in Europe, we recognize the type of region thanks to an identification process that is based in large part on the form and arrangement of forest shelterbelts within the landscape. People tend to think that these landscapes are thousands of years old, but most of the hedges in fact date back less than 150 years. Historians and geographers of bocage landscapes identify several major periods in the constitution of these networks. Although we may think that hedges have always had a whole series of roles, it is striking that in any given period only a few of these functions were actually taken into account.

Since the great droughts of the early 1980s, many projects have focused on reforestation of Sahelian zones. In view of the failure of many government plantations, which were often composed of exotic species, research experts and developers started paying more attention to the local species cultivated by farmers. Attempts to enrich tree systems were carried out in many countries, but unfortunately, and for no apparent reason, the attention and care given to these trees by the farmers varied widely depending on individual, ethnic group, region and agrarian system. The CIRAD agroforestry programme therefore decided to focus its research on the development and future of traditional tree systems, taking social, land tenure and economic issues into account. Against this background, a study was carried out on the analysis of agroforestry systems on the village lands of two villages, not just examining the tree systems themselves, but placing them in the context of the wider area managed by a whole village community. The aim of this research was to show how different factors explained the dynamics of the various components of a tree system, with a view to being able to offer guidance in due course.

This publication is a collection of texts concerning the dynamics of agrarian systems from the viewpoint of rural engineers, agronomists and geographers. The agrarian situation—or more specially the relations between rural societies and their environment—can be interpreted in a number of ways, with geographers focusing on landscapes, village land, agrarian structures, etc., while agronomists are concerned with technical factors, production processes, etc. These complementary approaches lead to some mutual questioning.

The future of small-scale producers in the oases scattered from the Sahara to Central Asia is of major concern today. A combined historical and spatial approach is proposed in order to throw light on the issue. Identification of major
changes in oases over the long term shows fairly similar social situations, despite differences in water management approaches. Under the pressure of strong internal constraints (unequal distribution of land, exploitation of their labour force, economic and social exclusion, etc.), most of the inhabitants, especially small-scale producers, have to find their place in newly emerging economic and geographic spaces. The article describes the approach adopted and draws some operational conclusions. The latter represent a possible way of developing the outlying arid spaces where each state has its own way of managing a piece of the magnificent heritage of the great oasis networks that have been on the wane since the 16th century as a result of mastery of the oceans, the rise of capitalism, the rural exodus, urbanization and burgeoning oil revenues.


This work uses a comparative analysis of parkland in Dossi (Sudanian zone) and in Watinoma (sub-Saharan zone), to study Faidherbia albida (Del.) A. Chev. parklands in Burkina Faso. The aim is to reach a diagnosis and define the features of these tree systems (floristic composition, structure, dynamics and functioning) by assessing the role of biophysical and human factors that affect these parkland development and future. Surveys and inventories have identified the following features: a high social and land tenure stability; management by men, who are often old; crops dominated by cereals, which are continuous on miniplots and are fairly well manured close to the settlement. However, the parkland in Dossi, a long-established and almost single-species parkland, homogeneous in structure and in distribution over more than 300 ha, is shrinking. Regeneration is more abundant than in Watinoma and fallows increasingly long. The change is a result of the development of cotton in the parkland, to which all investment is devoted. On the other hand, the Watinoma parkland is broken up, composite and multilayered. Although cutting back, seed-eating insects and livestock affect the seed potential, while hoeing and environmental conditions act as constraints on regeneration, this tree system has been expanding over the past generation. Most of the trees are young, with an average age of 20 years in Watinoma, against the 40 year average in Dossi. Watinoma, a poor and overpopulated area, shows a certain interest in Faidherbia, but prefers a more diversified parkland. The species grows faster here, however—roughly 1 cm on the rays—with the cutting back extending its foliation into the middle of the rainy season. While cutting back is only very moderate in Dossi, it tends to be much more drastic in Watinoma and to affect most of the trees, which then throw out new shoots from the top. The leaf production from total cutting is constant from one season to another. It ranges from 5 to 40 kg of dry matter depending on the size of the tree, as well as 40 to 100 kg of wood. However, the cutting reduces fruit production, which is only a few kg of MS per tree in Watinoma, as against 20 to 25 kg in Dossi. The pods are two to three times more digestible than the leaves, but the latter are an indispensable fodder complement for livestock at the end of the dry season. The trees improve soil fertility right to the edges of the crown, increasing MO, C and N by 50% and P, K, Ca and Mg to varying degrees. The effect of this rises with the size of the tree. It is less on the more fertile soils of Dossi. In all places, it is linked to the fact that livestock halt beneath the trees. The trees also raise the moisture content of the surface horizon on the driest site in Watinoma. The improvement in crop grain yields is greatest in the most extreme site and climate conditions, with an increase of over 150% beneath the crowns. The effect increases with the size of the tree, with the grain yield peak found at the inner edges of the crown, while stem production is greatest close to the trunk—the most shaded area. In Dossi, maize seems more sensitive than sorghum to the improving effect of trees, giving yields of over 4 000 kg per hectare. The cardinal orientation of trees appears to have no
significant effect. In conclusion, it is shown that on the plot level, an improvement of 25% in productivity is a decisive advantage for Watinoma farmers, guaranteeing a food self-sufficiency that the Dossi parkland no longer provides.


Recent studies carried out in the agropastoral zone of Sideradougou, south of Bobo Dioulasso in Burkina Faso, have shown a close link between a decrease in populations of tssetse flies, insects with narrow environmental requirements, and the amount of human activity carried on close to their biotopes—gallery forests. The present work seeks to assess changes in gallery forests in this area, particularly the impact of processes of human origin. The results confirm the importance of agricultural activities carried on close to gallery forests (less than 100 or 150 m away). Cultivated plots close to watercourses give rise to water processes that accelerate erosion of the banks. The felling of fuelwood is also very detrimental to gallery forests, while other activities such as hunting or fishing have a lesser impact. Animal husbandry does not seem to be a factor in degradation, except perhaps in very localized terms at watering points.


The Bamiléké country in the highlands of western Cameroon is famous for its bocage landscape. The typical hedge forming this landscape is multifunctional, made up of a number of species, and horizontally belted with raffia “bamboos”. Set out around the edges of farms, marking property boundaries, or in the form of enclosures, these traditional hedges evolve parallel with production systems, the factors in any change being: the introduction of monetarized agriculture, a decrease in small animal husbandry, pressure on land, and a shortage of labour. Hedges can thus be considered a good indicator of the dynamics of the Bamiléké landscape and of changes in agrarian systems.


Farmers in the central hills of Nepal depend to a large degree on tree products as back-up to their agricultural systems. They manipulate the plant cover on their farmland, in general on the edges of terraces and on uncultivated plots within their farmland. Trees are also found on public land around villages, and their use is also managed by the farmers, even if the land falls under the legal authority of the Water and Forestry Department. This article examines changes in the plant cover on different types of land in a drainage basin of 14 000 ha near Kathmandu. Comparisons were made with the help of aerial photographs taken in 1972 and 1989. The area of each category of land use was determined for eight study sites, and the percentage of plant cover was calculated for each category. The results indicate that there has been no change of public land (forests and grasslands) into farmland between these two dates. The percentage of plant cover on the main agricultural land use category (hillside terraces) and on public land increased considerably between the two dates. Inasmuch as these two categories account for 86% of the study sites, it would seem that the landscape has as a whole been the object of continuous afforestation, which can be attributed to farmers.


Tree systems linked to agricultural activities are subject to management conditions and uses that lead to a wider variety of structures, both internal and external, than are found in public
This article describes the methodology adopted to study two communes in the Aurignac region of France. First, a photo-interpretation of wooded and pre-wooded structures and their evolution between 1942 and 1992 was made on the cadastral plot level, after which surveys were carried out to confirm the management approach adopted and define farmers' uses and aims. The first results show a remarkable stability in wooded area over the past 50 years, interpreted as a balance between natural woodland and artificial, agriculture-linked woodland. These stands are almost exclusively coppices, often in the form of small sub-plots of one or a few hectares, which are felled at least every 20 years. A clear decrease in the lengths of linear elements (hedges and lines of trees along watercourses) and in the number of isolated trees can also be seen.

Agriculture and agroforestry have been carried on in China in forests, developing side by side since their start. Archaeological evidence shows that the Chinese settled in forests, where they sought shelter from outside dangers and lived on the edible parts of plants and animals, thanks to hunting and gathering activities. Starting in the Neolithic Age (7000 to 8000 BC), fire was generally used to burn forests for shifting cultivation, which is a primitive form of agroforestry. With rapid population growth, the annexation of tribes, the collapse of clan-based societies and the development of the slavery system, the nomadic system of shifting cultivation gave way to sedentary agriculture during the Xia Dynasty (2000 to 1600 BC). During the Shang and West Zhou Dynasties (1600 to 800 BC), sedentary agriculture encouraged the development of private land ownership. Farmers planted trees in or around cultivated fields, grew fruit-bearing plants and vegetables, and reared domestic animals for self-sufficiency. After this, various forms of agroforestry gradually developed, providing the fundamental framework of the Chinese small farming economy for over 3000 years. The Chinese population has grown rapidly since the 1950s. During the same period, the area of arable land has shrunk drastically, and the environment has suffered from rapid degradation with industrial development. Traditional working methods and inefficient agroforestry management practices have not been adapted to the present situation. In view of the economic, environmental and social potential, it is suggested that a simple biological production system for crops, trees and livestock should be converted into a system combining agricultural production, trees and livestock, and including processing and marketing. Such a management system—modern agroforestry, in fact—could be very helpful in development of the rural economy of modern-day China and in environmental conservation.

In China, major agroforestry systems are estimated to cover 45 million ha. Agrosilviculture is a dominant practice. Aquasilvicultural systems, e.g. tree-fish-arable crop and tree-fish-livestock systems, are alternatives for land use in the wetlands. Silvopastoral systems are popular in the northern and western regions. Compared with a monoculture, well-managed systems have many benefits. The recycling of residues is expected to increase the efficient use of natural resources. The C sink in the vegetation of major agroforestry systems in China was 179 Tg yr⁻¹, and agroforestry is reported to have a positive effect on soil conservation and biodiversity. The major constraint on agroforestry is that most of the systems are on a low level of management, primarily resulting from a shortage of technical support. However, there is a great potential for the development of agroforestry in China. This paper presents recommendations concerning policy options, technical support, extension, and marketing in agroforestry.

This working document for the bocaging project initiated in 1991 by the Technological Research and Exchange Group (GRET) consists
of a bibliographical synthesis, providing very full details on African bocage landscapes, especially in the Bamiléké country. This example is helpful in showing not only the knowledge of bocage dynamics in Africa, but also the methods that have already been used in studying it.


African societies could well be more capable of offering solutions to the problem of environmental protection than the outside experts working alongside them. Examples of bocage systems taken from Fouta-Djalon in Guinea and Niumakélé in the Comoros help to show that, contrary to common belief, farmers’ practices do in fact help to preserve the environment. In these two tropical highland regions, the extension of cultivated land, crop diversification and the intensification of production systems rely on the use of live enclosures intended to protect crops from livestock. On the edges of reserved or protected forests, the establishment of bocage systems on the part of farmers shows that an increase in farm production can help to preserve and enrich an environmental heritage.


In the central Fouta-Djalon highlands of Guinea, the Timbis plateau is densely populated by the Fulani, who practise a semi-intensive, sedentary form of agriculture based on cattle, goats and sheep. Belts of trees separate their land from the large open lands managed collectively for cereal cultivation. The Fulani’s farming systems are examined in this document, looking at how this land-use model, based on the establishment of hedges and demarcation trees, developed. Changes at present taking place are also examined. Constant population growth, leading to increasingly intensive agricultural methods and an expansion of demarcated plots, increases the pressure on land resources and also the risk of crop destruction by livestock. This pressure on resources, combined with migration, has increased the need for demarcation and the development of enclosures. Coupled with a changing economic and political environment, these factors are probably having a major effect on traditional farming systems in this region.


Although small farmers live in traditional societies ruled by custom and routine, this does not prevent them from receiving and accepting innovations, which then gradually lead to changes. The adoption of rubber cultivation led farmers in Sumatra to make radical changes to their whole agrarian system—and in a remarkably short period of time. By introducing rubber on their freshly cleared land, Sumatran farmers have replaced the gathering of products scattered through the forest with that of a species that is artificially concentrated within the plant cover and more commercially developed. The high prices of rubber and the active role of traders encourage the introduction of innovations. The remarkable adaptation of the plant to the physical and socio-economic conditions of the region works in favour of its spread. The development of individual land appropriation forces even the more reluctant to join the general trend. The accumulation of productive capital allows the farmers to look to a future well beyond the next rainfed rice harvest. Rubber, a real miracle plant, is the source of wealth, but also of social division.


This work seeks to throw light on the origins of olive cultivation. Examination of
palaeobotanical data gathered both outside archaeological sites (pollen diagrams from core-drilling) and on such sites (olive stones and charcoal), together with historical data, indicate major local variations since 2000 BC. These variations can very plausibly be explained by arboriculture, an arboriculture that saw periods of expansion and contraction between the introduction of the cultivated species by the Greeks and the present-day olive fever.

317 Ould, S.C. 1999. Présentation des oasis mauritaniennes. In M. Ferry, S. Bedrani & D. Greiner, eds. Agroéconomie des oasis, p. 49-51. Montpellier, France, CIRAD. The total area of oases occupied by date palms in Mauritania was estimated at 10 000 ha in 1972, whereas according to recent statistics, the figure is now no more than 4 700 ha. In 20 years, 52% of the palm heritage of the country has vanished. Several oases found in the Adrar region in the 1960s have completely disappeared, either buried beneath dunes, or abandoned on account of desertification, or attacked by undiagnosed disease.

318 Seignobos, C. 1980. Des fortifications végétales dans la zone soudano-sahélienne (Tchad et Nord-Cameroun). Cahiers de l’ORSTOM, 17: 191-222. From Sudan to Senegal, the widespread conversion of crop defence hedges into enclosures has very often disguised the past function of these elements. However, villages and cultivated land were in many places protected by live ramparts combining a variety of species. Certain natural, historical or geo-strategic conditions—particularly an endemic insecurity—led to the establishment of such systems. In northern Cameroon, for example, the Mandara mountains and their approaches suffered pressure not only from the Bornu and Wandala empires, but also from lowland ethnic groups, which had been in turn driven out by these empires or to a greater or lesser extent fallen under their yoke. Lastly, the establishment of Peul lamidats (territory under the authority of a chief called Lamidé) in the 19th century simply reinforced the already existing defence structures. These plant installations made up for the relative absence of buffer zones and of natural bushland. They did well at a latitude where woody vegetation was fairly sparse, as well as in the foothills of mountain massifs where it was hard to build earth walls. They were always established in relatively densely populated regions, and, on the whole, within the context of individualized ethnic groups and not in that of multi-ethnic empires where the capital was the only place with the right to fortify itself. Undoubtedly facilitated by a particularly favourable terrain, northern Cameroon has a considerable wealth and a great variety of plant defence systems, in contrast to a certain poverty in Chad, where the great empires in the North and vegetation along watercourses in the South have restricted the development of such structures.

319 Simons, A.J., Jaenicke, H. et al. 2000. The future of trees is on farm: tree domestication in Africa. In B. Krishnapillay, E. Soepadmo, N.L. Arshad et al., eds. Forest and Society: the role of research, 1: 752-760. 21st IUFRO World Congress, Kuala Lumpur, 7-12 August 2000. Kuala Lumpur, IUFRO World Congress Organising Committee. Present deforestation levels indicate that the growing demand for tree products should be mirrored by the planting of trees. Although traditional forest planting will meet some of this demand, there will certainly be an increase in the trees planted on agricultural land. Farmers in zones with growing population levels already have an incentive to plant trees on their land because of the benefits they bring, and this trend will continue. However, the tree species cultivated need to be improved by domesticating high-value tree species (timber, fruit, medicinal products).

320 Tersen, G. 1994. Les arbres d’alignement. Arbre Actuel, 14: 28-44. This article provides an overview of line-planted trees in France—their origin, their history, the question of their validity, and the recent wave of planting, using new techniques and new species.

Land use in three types of zone is compared, covering 571 km² or 18% of the Upper Mahaweli Catchment in Sri Lanka, on the basis of data from 1956 and 1979-1981 and from 1991 land-use maps. The results indicate that in the space of 35 years, there has been a 59% increase in forest cover. There has been a considerable shift in crop cultivation toward home gardens, with a decrease in tea and the almost total disappearance of rubber. Natural forests have been maintained or increased, and man-made forests have increased enormously.