IUCN Forest Conservation Programme

Conserving Biodiversity Outside Protected Areas

The role of traditional agro-ecosystems

Patricia Halladay and D. A Gilmour
Editors

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IUCN
The World Conservation Union

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The IUCN Forest Conservation Programme

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Cover photo: Avileña Negra Ibérica cattle grazing among Quercus trees in a dehesa system near Madrid. D.A. Gilmour

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Background

An overview of traditional agro-ecosystems

The effort to conserve biodiversity has largely focused on securing enough protected areas of different categories that could contain large, undisturbed ecosystems. It is obvious, and probably inevitable, that societies are putting a growing pressure on the rest of the biosphere. In order to strike a balance, the exploitation and modification of certain parts of the earth should be accompanied by the absence of human interference in other parts. However, with increasing pressure and demand for land for production, the number and size of such protected areas is probably getting close to a maximum. It is now becoming apparent that in order to increase the opportunities to conserve biodiversity, new, complementary approaches to protected areas must be sought. Conservation concerns both these protected areas — or at least those free from human influence — and other areas where rural activities have shown their capacity to maintain high biological, physical and cultural diversity.

More than 90 per cent of the terrestrial surface of the earth is not covered by any form of protected area category. If this situation does not change, there will be severe loss of biological wealth in the next few decades. Many areas with the highest concentration of this biological wealth, an essential part of our natural heritage, are found in less developed countries.

The most common types of land use relate to agricultural and pastoral activities or combinations of both. A number of traditional agricultural and pastoral systems have succeeded in attaining a sustainable level of production while at the same time maintaining a high level of biodiversity as well as most functional aspects of the ecosystems. In some cases, the biological diversity maintained in agricultural and pastoral systems is greater than that in protected natural spaces in the same region. Landscapes of high environmental, cultural and amenity value have thus been created through these systems.

In 1994, IUCN sponsored a workshop to examine the potential for combining production and conservation of biodiversity outside protected areas. One of the results of the workshop was this book, the publication of which is partly sponsored by the Andalucia Environment Agency. Case studies were selected from regions around the world and used as the basis for discussing the issue of conservation and development in traditional agro-ecosystems.

The workshop was held April 11-14, 1994 in collaboration with the Centro de Investigacion F. Gonzalez Bernáldez and with scientists from the Inter-university Department of Ecology of the Complutense and Autónoma Universities in Madrid. It took place at the foot of the Guadarrama Mountain range, in an area of traditional agro-forestry-pastoral use, whose conservation and management was discussed during the meetings.

Guidelines for conservation planners

Collated by D. A. Gilmour, following discussions and debate at the workshop, with assistance from G. Budowski, A. Wickramasinghe, F. D. Pineda and J. Montalvo.

General strategies for biodiversity conservation

1. Most countries have a protected area system as a central part of their strategy for biodiversity conservation. However, protected areas rarely cover more than five per cent of the land area and are not sufficient to conserve the full range of biodiversity.

2. Significant elements of biodiversity are found outside the protected area system. Traditional agro-ecosystems are particularly rich sources of both biodiversity and indigenous knowledge about its management.

3. Article 8 (c) of the Convention on Biological Diversity states that each contracting party shall, as far as possible and as appropriate: "regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to assuring their conservation and sustainable use".

Recommended actions

Strategies should be developed for biodiversity conservation which take into account:

- *the need for a protected area network to cover the major bioregions;*

- *the need for a policy which recognises the importance of biodiversity conservation outside protected areas, particularly in managed ecosystems; and*

- *a recognition of the high value of traditional agro-ecosystems in contributing to conservation of biodiversity.*

Conserving diversity in traditional agro-ecosystems

- **The value of traditional agro-ecosystems**

1. Traditional agro-ecosystems are important reservoirs of genetic diversity that is not often found outside these systems. As such, they are important sites in their own right for the conservation of wild plants and animals.

2. The traditional knowledge and social organizations that combine to manage and maintain traditional agro-ecosystems are integral parts of the system.

Recommended actions

Efforts should be made to document the details of traditional agro-ecosystems, taking into account biophysical elements, traditional knowledge systems and social organisations that are responsible for the management and maintenance of the systems.

Efforts should be made to publicise the importance of including traditional agro-ecosystems as an integral part of national conservation strategies.

The substantial capacity of local level institutions to manage landscapes should be recognized in developing conservation action plans.

• **Global issues**

3. Many of the instruments of global trade policy, such as the GATT, may have unintended consequences which result in a reduction of biological diversity in agricultural landscapes. The trend toward a global economy, which is one of the aims of such policy instruments, acts against the continuation of traditional agro-ecosystems by fostering a macro economic climate. This encourages the development of industrial agricultural systems. Because these systems are based on a need for uniformity of product to enhance farming efficiency and marketing, they are characterized by a reduction in species, genetic and ecological diversity.

4. The general world economic situation results in inequities of financial flows between north and south. This exacerbates the economic difficulties of those farmers engaged in traditional farming practices.

Recommended actions

Global trade policy instruments should be harmonized with the Convention on Biological Diversity to ensure compatibility of outcomes.

Those people framing global trade policy instruments should explore the consequences of their proposals on biodiversity of traditional agro-ecosystems.

Mechanisms should be sought to compensate local communities that sacrifice economic gain in order to conserve biodiversity which is of national or global value (i.e. where the benefits of conservation accrue outside the local area but the costs are borne locally).

- **National issues**

5. Economic pressures to join the new world order are causing the abandonment of many traditional agro-ecosystems with a resulting loss of indigenous knowledge and a tendency towards loss of ecosystem diversity in order to conform to the needs of modern, industrial management of biological resources.

Recommended actions

National planning through various sectoral strategies should take into account the requirements of the Convention on Biological Diversity.

National conservation and development strategies (including Biodiversity Action Plans) should emphasise the importance of biodiversity conservation outside protected areas, paying particular attention to the role of traditional agro-ecosystems.

Non-conservation agencies concerned with development activities that impinge on traditional agro-ecosystems should be made aware of the importance of these systems in overall biodiversity conservation.

The formulation of national policies for conservation and development should ensure the active participation of all stakeholders, particularly those who have an involvement in traditional agro-ecosystems.

- **Role and perceptions of different actors**

6. Various groups of actors (interest groups) have different perceptions and interests in conservation policies and actions. The perceptions and interests of all groups have validity.

Recommended actions

When carrying out negotiations on conservation/development strategies and actions outside protected areas, all concerned actors and interest groups need to be defined. Their perceptions and needs must be understood and taken into consideration.

Facilitators of the negotiation process should ensure that adequate time is given for each group to present its views and to understand the views of others.

The negotiation process should cover not just the biophysical aspects, but should broaden to take in socio-economic and cultural concerns. The understandings and perceptions of the various groups should be documented and made public.

- **Tenure**

7. Many traditional people managing traditional agro-ecosystems do not own their land outright, but instead work the land under locally accepted, and often quite sophisticated, tenure arrangements. Many of these arrangements define both private and communal property rights and responsibilities for land and other resources.

8. When central governments intervene and effectively "take away" land, local people often lose authority and responsibility for land management. This loss of power often leads to a rapid erosion of the integrity of the traditional agro-ecosystem, with a consequent loss of both biodiversity and local economic value.

Recommended actions

Systems of tenure developed by central governments should recognize and legitimise traditional tenure arrangements where such arrangements are locally acknowledged as legitimate.

- **Socio-economics**

9. Traditional agro-ecosystems are frequently viewed by "outsiders" as being inferior to modern systems.

10. Traditional agro-ecosystems are generally undervalued when their economic and social worth are considered.

11. Government policies often contain incentives that may unintentionally lead to the degradation of traditional agro-ecosystems. This includes policies which make claiming or maintaining tenure dependent on clearing forests.

Recommended actions

Valuation techniques should be applied when valuing the worth of traditional agro-ecosystems. These techniques should aim to internalise externalities.

Government land use policy should be developed within a comprehensive conservation framework.

Awareness-raising about the conservation value of traditional agro-ecosystems should be an integral part of national conservation strategies.

- **Education and training**

12. There is a lack of knowledge about the value, complexity and sophistication of many traditional agro-ecosystems, and particularly about the level of knowledge needed to manage and maintain them.

Recommended actions

Conservation education at all levels should include segments on the biodiversity values maintained in traditional agro-ecosystems.

Biological, social, political and economic scientists should exchange views on matters relating to biodiversity conservation. They should attempt to learn from traditional ecosystem managers in order to enhance their own understanding of biodiversity and ecosystem management.

Visit to Dehesón del Encinar

On the third day of the workshop, participants visited Dehesón del Encinar, a typical traditional dehesa. It is located in west-central Spain, 70 kilometres from Madrid. The farm is also used as an agricultural research centre in cooperation with the Spanish government, the Junta de Castilla la Mancha and, occasionally, with the Department of Ecology of the Complutense University of Madrid and other research groups.

Research focuses on problems related to conservation of the Spanish dehesa. During the visit, various work programs related to pasture and livestock were discussed.

Improvement of pastures with acid soils, dehesas of Castilla-La Mancha, Spain

Celia López-Carrasco

Introduction

Many dehesas with acid soil are found west of Toledo and Ciudad Real in the Talavera de la Reina and Valle de Alcudia districts. Grasslands in the areas are used for widespread grazing of sheep and cattle. Although pastures are the main source of animal feed, quality and production are low and vary throughout the year (Casado et al. 1985, Diaz-Pineda 1989). There are two significant periods of low production: summer, which is the dry season, and winter. The dehesa ecosystem partially compensates for these periods of low production by providing other resources, such a acorns, oak twigs for browsing, ash and mulberry leaves, shrubs etc. (Ruiz 1986).

Research on improving grassland has been ongoing since 1986, the first project being focused on fertilization and establishing legume species. Current work is aimed at:

- better management of pastureland;
- phosphate fertilization and management; and
- re-establishment of native legume species.

Phosphates were added to the soil to try and increase the pasture's legume content. Legume seeds would increase the level of protein in the dry pastures, thereby increasing their grazing capacity over a longer period of time. The extended grazing period would lower the risk of fire by reducing dry matter accumulation.

The project was carried out to test the viability of indigenous species *Trifolium subterraneum,* var. Coria, Areces and Orellana, *Ornitopus compressus* and *Trifolium glomeratum.* Low to medium levels of superphosphate (200, 150 and 100 kilograms per hectare) were applied in autumn after the first rainfall. The pasture was grazed extensively and continuously by sheep (Talavera and native breeds). There was one lambing per year, in March-April, and an attempt was made to align this period of greater food requirement with that of greater pasture productivity. Several results were noted, as outlined below.

- The lack of rainfall and the cold winters were the main factors limiting dry matter production. In normal years dry matter production was better in fertilized areas.
- The persistence of introduced species was low. Pasture production may have been adversely affected by ploughing before sowing. Fertilized areas took three years to achieve the same production level as the control pasture (Casadoetal. 1985).
- It was possible to double, and, in some cases, triple, the average stocking rate with minimum nutrient output and low additional supplementation. Production and reproduction rates can be considered good (but see Lopez et al. 1991).

Current research, with the goal of increased grazing capacities, is now focused on regrazing abandoned cereal crops in marginal areas using various pasture improvement techniques.

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Avileña Negra Ibérica cattle production systems, Castilla-La Mancha

Ruben Rodriguez and Celia López-Carrasco

Introduction

Livestock are an important part of the dehesa system. The Avileña Negra Ibérica is a breed of beef cattle that has adapted to the prevailing conditions in these extensive pastures: harsh climate, poor pastures, irregular food source and great distances.

Strategies have to be developed to overcome the dehesas' low productivity. Traditional transhumance, consisting of periodic journeys from dehesas to nearby mountain areas, still involves up to 30,000 cows per year.

The various breeds of native cattle (including the Avileña) have lower productivity (87 kg/cow) in dehesa systems than in other agricultural systems (161 kg/cow). This reflects the difficulty of managing these marginal areas. Low nutrient levels during critical times, such as the mating period, result in intervals between births that are long (average 449 days) and variable (362-528 days). This has a negative effect on the reproduction rate.

A research project has been developing since 1990 that attempts to bring the Avileña Negra Ibérica breed's mating and calving periods in line with pasture production. Research will also be carried out to determine the necessary levels of supplements during these critical periods.

The project involves an area of 135 hectares, which is divided into three parts, each with 15 cows. The grazing rate is 0.3 to 0.4 hectares per cow. Three options are being tried:

- continuous calving and poor body condition (as in the traditional system);
- concentrated calving, in February, March and April, and poor body condition; and
- concentrated calving, in February, March and April, and good body condition.

Several results have been noted:

- supplementary levels of feed have been lower than those usually indicated (3 kilograms of hay and 0.8 kilograms of compound feed per cow per day versus 4-5 kilograms of hay and 1 kilogram of compound feed per cow per day);

- fertility rates (intervals between births or calved cows/cows at mating) were high and there were no significant differences between continuous and concentrated calving;
- there were no significant differences in results among the three plots; and
- calves born as a result of concentrated calving were larger (215-220 kilograms) than those born as a result of continuous calving (203 kilograms).

Adaptation by Talaverana sheep to the dehesa environment

Alejandro Cañadas

Introduction

The Talaverana breed has its origins in the adjoining provinces of Avila, Toledo and Cáceres in central and western Spain. The provinces are found where two geographic areas join: Extremadura, an area of typical pastureland; and the Castilian plateau, where the Manchegan and Merina breeds were traditionally raised. The Talaveran breed was a cross of these two breeds.

The Talaveran breed is extremely well adapted to the agro-climate of the dehesa (pastureland cork-oak forest). This area receives little rainfall and is subject to seasonal periods of growth and heavy frosts.

The breed is known for the quality of its wool (entrefina) and of the meat of the lambs. Lambs were originally considered only as a by-product; wool being the principal focus. Subsequent modifications in the market, however, made it necessary to adapt the breed more to meat production. Traditionally, a system of continual reproduction was used to ensure a supply of meat. This system changed over time and developed into the pattern of three births in two years. A lack of information about the system and its results led the Centre of Tavaleran to direct its energies to studying this production method.

The current project of the research group was developed during 1991, 1992, 1993 and 1994 in the Dehesón del Encinar. Sheep bom in 1989 and 1990 were divided into one of two groups when they reached puberty. One trial attempted to achieve one birth per year, with a distribution of three sheep per hectare feeding on grass and acorns. The goal was a lamb with a liveweight of 20-25 kilograms, fattened with supplementary food.

Another trial involved three births in two years; coverings began when the animals reached eight months of age. Coverings were divided into three periods: February, June and October, with births in March, July and November. The goal was a lamb with a liveweight of 16 kilograms. Food supplementation was carried out according to body condition at the end of gestation and the beginning of lactation.

Some considerations in this experiment were:

- the body condition and weight of the sheep;
- the number of lambs born per sheep per year;
- lamb mortality and miscarriage rate;
- the size of the lambs;
- gross profit (kilograms of lamb per hectare); and
- the rate of fertility.

A large drop in the rate of fertility was observed in the coverings undertaken at eight months (fertility of 72-88 per cent). There were no significant differences observed with regard to weight at covering, so the drop in fertility must be attributed to age at covering. There was also a reduction in the rate of growth. This lower growth rate was especially noticeable in February and June, as was an increased perinatal mortality. This is attributed to poor growth of grass in July and August and to the presence of foxes. The gross profit per sheep per year favours the system of three births in two years.

Conservation and selection of Iberian pigs

L. Silió, J. Rodrigáñez, M. C. Rodríguez and M. A. Toro

Introduction

The Iberian pig has been found in the southwest portion of the Iberian peninsula for centuries. A census in 1955 established the number of reproducing sows at 567,424. The characteristics of the breed — dark skin and hair, large snout, reduced appetite and metabolism, small size and early maturity — developed from a long process of adaptation to the harsh conditions of the dehesas in the area. There were several well-differentiated regional types: Rubio, Retinto and Negro lampiño (Dobao et al. 1988).

This began to change in 1960 due to the first outbreaks of African swine fever; society's preference for meat with reduced animal fats; and the change in markets toward more intensively exploited domestic pork. The number of Iberian pigs was reduced by 90 per cent and the remaining animals began to be crossbred with the Duroc breed. In 1988 there were 32,882 Iberian sows and 64,704 crossbred sows. The population of Iberian pigs has recovered somewhat with the development of a specific market for their products.

The drastic drop in the number of Iberian pigs led to the disappearance of some traditional strains. To obtain optimal results in cross-breeding it is necessary to preserve these old strains and to develop new lines of Iberian pigs well-adapted to the dehesa but with better productive performance (Rodrigáñez, et al. 1993). Research programmes in this area of study are being carried out on the experimental herd of Iberian pigs belonging to El Dehesón del Encinar Agricultural Research Centre, in cooperation with the Instituto de Investigaciones Agrarios (INIA), the Spanish government and the Servicio de Investigacion Agraria (SIA), Castilla La Mancha Government.

The objectives of the El Dehesón del Encinar experimental herd are conservation of genotypes of Iberian pigs threatened with extinction, and obtaining breeds with superior productive abilities. The findings will help illustrate the dehesa's value as a system which unites environmental well-being and profitable forms of animal production.

The Dehesón del Encinar Iberian herd was established 50 years ago from four strains: two from Portugal and two from Extremadura, Spain. These represented the main traditional types of Iberian pig:

- Ervideira, Dorado alemtejano of Evora;
- Campanario, Negro lampiño of La Serena;
- Caldeira, Retinto of Elvas; and
- Puebla, Negro lampiño of Guadiana.

The strains showed noteworthy physiological and productive differences (García-Casco 1993) and were kept genetically isolated until 1963, when they were bred into one line. This line was called Torbiscal, which today is considered the main genetic reservoir of the Iberian pig. The old Puebla breed, an extremely fatty black hairless pig, is separately conserved under the name Guadyerbas. Table 1 summarizes the geneological description of the existing contingent of pigs.

Conservation of strains

Genetic conservation programs must be designed very carefully, since conserving genetic resources in animal populations with reduced numbers runs the risk of losing genetic variability and of inbreeding depression. Conservation of these strains of Iberian pig has been distinguished from the beginning by its methodological focus aimed at limiting the inevitable increase of inbreeding. Until the beginning of the 1980s this focus was maintained, combined with a certain empirical selection in favour of high weaning weight (Béjar et al. 1993). After 1982 more rigorous norms were adopted, both in the replacement of reproducers and in the design of mating methods (J. Rodrigáñez et al. 1994).

Table 1. Geneology of reproducers 1994

		G	F	C_a	C_b	C_c	C_d
Torbiscal	15 boars	19.4	13.0	26.9	14.6	23.4	35.1
	56 sows	19.2	12.9	26.9	14.6	23.4	35.1
Guadyerbas	7 boars	18.5	33.0	0.0	0.0	0.0	100.0
	28 sows	18.0	32.8	0.0	0.0	0.0	100.0

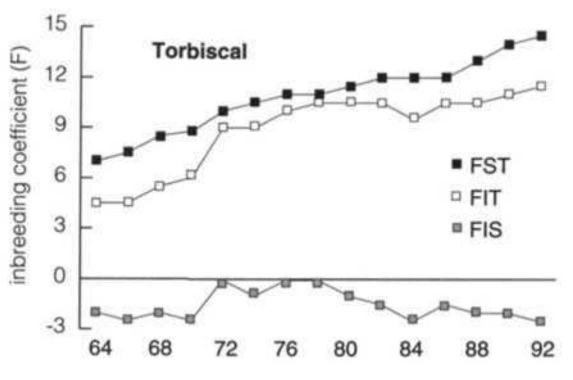
G: generational coefficient; F: inbreeding coefficient (%); C_a C_b C_c C_d founding strains

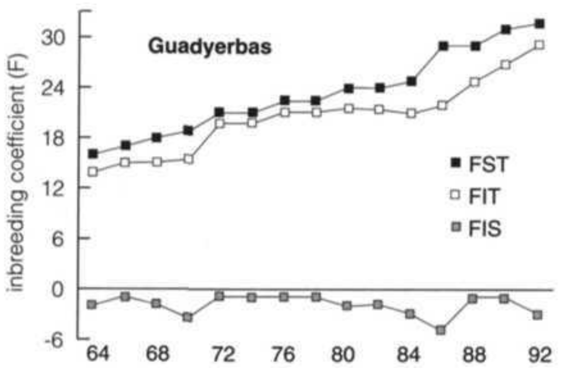
The inbreeding rate per generation is inversely proportional to the number of animals. The population may be increased using the greatest possible number of males and adopting a family structure which minimizes the variance in the size of the family. One way to control the increase of inbreeding is to delay the age at which parents bear young. Adequate mating design can also reduce the rate of inbreeding (Figure 1).

Conserving these strains has always been combined with their propagation among breeders. Torbiscal is valued for its fast growth and crossbreeding abilities. Guadyerbas, traditionally rejected because of its extreme fattiness, is now in demand to improve the quality of meat when crossbreeding with Duroc.

Figure 1.
Effects of mating tactics on Iberian pigs

Non-randomness of mating (FIS), evolution of relationship (FST) and inbreeding (FIT), from 1964 to 1992
Source: Wright (1951)





Selection of Iberian pigs

In order to obtain new lines with better reproduction and production, it is vital to establish genetic and environmental parameters and to make use of appropriate evaluation models. These allow for more precise estimates of breeding values and a corresponding increase in selection response. Information for Iberian pig populations comes from El Dehesón del Encinar. Tables 2a and 2b summarize the estimates obtained for heritability (h^2) and for the effect of the dam's permanent environment (m^2) on reproduction (Rodriguez et al. 1994) and for the common environment coefficient (c^2) of diverse growth characteristics (García-Casco and Béjar 1993).

Table 2. Genetic and environmental parameters in Iberian pigs

Values are quotients of variances; standard error in brackets

a. litter traits	**sows**	**litters**	**h^2**	**m^2**
born alive	1,371	4,883	0.06 (0.02)	0.06 (0.02)
litter weight at 21 days	1,004	2,049	0.12 (0.04)	0.08 (0.04)

b. growth traits	**pigs**	**h^1**	**c^2**
weight at 50 days	26,913	0.10 (0.01)	0.27 (0.01)
weight at 120 days	1,809	0.17 (0.07)	0.27 (0.03)
weight at 240 days	2,682	0.27 (0.05)	0.15 (0.03)
backfat thickness	1,809	0.28 (0.05)	0.16 (0.02)

Among the possible selection objectives in Iberian pigs, obtaining leaner growth is the synthesis of various aspects: reduction of excess body fat, improvement in the conversion index and increase in lean meat in the butchered animal. The limitations of the Iberian pig in these respects has led to crossbreeding that at times has been excessive. Bearing this in mind, a sub-line of Torbiscal with leaner growth, called Torbiscal-S, was selected in 1989.

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How traditional agro-ecosystems can contribute to conserving biodiversity

Jeffrey A. McNeely

Introduction

For rural people, wild plants and animals provide food, medicine, building materials, income and a source of inspiration. Rivers and lakes provide transportation, water, and fish; the coastal zone provides a permanent source of sustenance and building materials. But, instead of producing a sustainable flow of renewable resources provided by nature with little input from people, recent patterns of agricultural development are depleting soils, genetic diversity, and species diversity both in managed fields and surrounding habitats.

Agriculture, grazing, forestry and other human-managed ecosystems cover at least two-thirds of the terrestrial surface of the planet, while protected areas cover only about five per cent (the remaining area is wilderness, urban lands, etc.). Thus the domesticated "ecosystems" can make an important contribution to global biodiversity if they are managed in appropriate ways.

A high diversity of plants is maintained on farms, which cover just over 10 per cent of the planet. In Java, for example, farmers cultivate 607 crop species in their gardens, with an overall species diversity comparable to deciduous tropical forest (Dover and Talbot, 1987). In Norway, permanent old pastures managed without fertilizers may have 45 species of vascular plants per square metre; compared to 27 in abandoned old pastures that are no longer grazed, and 14 in fertilized old pastures (Götmark, 1992). Under one square metre of pasture in Denmark, the soil was found to contain as many as 40,000 small earthworms and their relatives, nearly 10 million roundworms and over 40,000 insects and mites. A gram of fertile agricultural soil may contain over 2.5 billion bacteria, 40,000 fungi, 50,000 algae, and 30,000 protozoa. Thus agriculture has much to contribute to biodiversity.

But all is not well on the agricultural front. The impressive productivity gains of recent decades — including a 20 per cent global increase in average yields of cereals since 1980 — have been attained only through the injection of energy, fertilizers, pesticides, irrigation systems and a great simplification of genetic diversity. Some of the losses of genetic resources, disruption of hydraulic systems, and erosion of topsoil may be essentially irreversible, passing on a significant cost to future generations. At least one-third of Java's cultivated mountainous areas are seriously eroding. In Indonesia in general, 1500 local rice varieties have become extinct in the last 15 years (Ministry of Population and Environment of the Government of Indonesia, 1989). In India, 175 million hectares — half the country's area — requires special treatment to restore the land to productive and profitable use, according to the country's National Wastelands Development Board. In Bangladesh, some 62 per cent of rice varieties come from a single paternal plant; in Indonesia, the figure is 74 per cent; in Sri Lanka it is 75 per cent. This makes these regions particularly vulnerable to changes in growing conditions.

Technological solutions to agricultural problems have also left a legacy of concentrated land ownership, marginalized indigenous people and small farmers, rural impoverishment and other social problems. In many current agricultural development programmes, the traditional knowledge of farmers is ignored or lost, along with crop varieties and food plants that are often far more suited to local conditions and dietary preferences than are modern varieties.

Since the beginning of this century alone, about 75 per cent of the genetic diversity of the most important crops has disappeared from farmers' fields. This has increased agricultural vulnerability and reduced the essential variety of peoples' diets. Many traditional and local species, vital to the diet and nutrition of the poorest people, are under-utilized or neglected. In fisheries and aquaculture, the introduction and transfer of exotic organisms has helped local economies, but sometimes at the expense of ecological resilience.

Farmers and producers are responding to global market forces and specializing in the relatively few crops that provide an edge in the world economy. As the number of crop species declines, there is a dying-out of local nitrogen-fixing bacteria, mycorrhizae, predators, pollinators, seed dispersers, and other species that co-evolved over centuries with traditional agricultural systems. This loss is exacerbated by the use of fertilizers, pesticides, and high-yield varieties to maximize production and profits over the short term.

In forest areas, the rapid and total conversion to mono-cultural plantation cash crops is widespread. When the price of coffee, cocoa, or palm oil drops so that the plantation is no longer an economically viable proposition, it cannot quickly revert to the biologically diverse forest that preceded it. This diverse forest may actually be more economically attractive when hidden subsidies to the commodities are removed (WRI, et al. 1992).

Maintaining biological diversity is essential for productive agriculture, and ecologically sustainable agriculture is in turn essential for maintaining biological diversity (Pimentel, et al. 1992). Diversity of crop species and diversity of varieties within species have traditionally strengthened the resilience of agriculture, a strengthening that can be enhanced through improved agricultural research. This paper will highlight several major issues that governments might consider in seeking to ensure that their agricultural policies and practices help conserve biodiversity rather than deplete it.

Agriculture and the conservation of biological diversity

Each agricultural village is part of an ecosystem. Types of ecosystems range from the broad expanses of river deltas where year-round irrigation is possible, to areas where seasonally-irrigated fields are interspersed among forests, to areas where rain-fed crops dominate. Legumes, medicinal plants, cereals, tubers, tree crops, livestock, fish and wild animals (such as pigs, monkeys, and rats) all play important roles in most agricultural villages, so agricultural development projects need to consider all these factors. Further, each agricultural community has ecological relationships far beyond the village. For example, Sattaur (1987) points out that in the hills of Nepal, each hectare of farmland needs 3.48 hectares of forest to support it. Many Nepalese forests are ecologically sensitive, requiring expert management if they are to continue providing benefits in terms of fodder, firewood, construction materials, fruit, and medicinal plants.

More generally, areas that harbour populations of wild relatives of domestic plants and animals are extremely important to agriculture. An example is the location in India which supported the population of the wild rice *Oryza nivara* that is the only known source of resistance to grassy stunt virus. And, wild populations of rice that are salt-tolerant could help adapt to saline soils or brackish irrigation water, and long-stemmed populations of floating rice may help adapt to the deeper waters that may come with rising sea levels.

Agricultural systems will alter dramatically over the coming decades as a result of global climate change, efforts to achieve sustainability through new technologies based on genetic engineering and agro-ecology, and changes in international agricultural markets. Governments and farmers need to decide how to adapt to these changes. Indicative planning — a system of dynamic planning informed by and constantly adjusting to changes in leading indicators — could be modified to include agricultural and biodiversity indicators. Indicative planning could help assure that agricultural systems will robustly resist mere transitory changes, adapt to desirable technologies and social changes more rapidly, and resist undesirable changes. Research should be initiated now on the most effective indicators and the way that monitoring systems should be enhanced. This research should probably be in conjunction with ongoing efforts to develop environmental accounting systems for use by planners (Ahmad, El-Sarafy and Lutz, 1989).

Exchanges of genetic material among developing countries are particularly important in view of the economic importance of such perennial crops as rubber, oil palm, and cocoa, and of annuals such as cassava and sugarcane. Such crops are often far more productive outside their native habitats, but are also subject to attacks from various pests and diseases. These can in turn be counter-attacked by fresh infusions of genetic material from populations harbouring high genetic diversity.

With only two exceptions — wheat and tomatoes — the wild relatives of crops are extremely poorly represented in *ex situ* collections, constituting only about two per cent of the varieties stored in seed banks. While wild relatives of domesticated plants have traditionally been considered a last resort of plant breeders, they have nonetheless played an important role in sustaining agricultural productivity. In the case of potatoes, for example, over 20 wild species have contributed genes. The difficulty of inter-specific crosses has restricted the role of wild relatives, but this role may be substantially increased in the future given recent developments in biotechnology.

Much of the stored genetic material is of only limited use. Of the two million accessions of plant germ plasm in seed banks worldwide, 65 per cent lack even basic data on source; 80 per cent are missing data on useful characteristics, including methods of propagation; and 95 per cent lack any evaluation data such as responses to germinability tests. Extensive data are available on only one per cent of the specimens, and it is feared that a substantial proportion of those accessions not tested for germinability may be dead (Peeters and Williams, 1984). Gene banks are often plant mausoleums, isolated from the evolutionary pressures of the real world. Working farms are far more effective at conserving genetic diversity.

In conclusion, traditional agriculture can make important contributions to research on changing agricultural conditions, help conserve biological diversity, and maintain healthy relationships between rural people and the land. For example, in traditional systems of shifting cultivation, a wide range of crops — often over 100 at one time — can be grown, essentially transforming a natural forest into a harvestable one. Species grown in the swiddens are in a state of continuous adaptation to the environment; in many places, crops are enriched by gene exchange with wild or weedy relatives. Altieri and Merrick (1987) contend that "maintenance of traditional agro-ecosystems is the only sensible strategy to preserve *in situ* repositories of crop germ plasm".

The contributions of traditional agriculture to conserving biodiversity

Traditional agriculture has adapted to a wide variety of local environments, producing diversity and reliable food supplies, reducing the incidence of disease and insect problems, using labour efficiently, intensifying production with limited resources, and earning maximum returns with low levels of technology. It utilizes a very wide range of species and land races which vary in their reaction to diseases and insect pests, and to different conditions of soil, rainfall and sunlight. It provides sustainable yields by drawing on centuries of accumulated experience by farmers who did not depend on scientific information, external inputs, capital, credit, or markets.

Energy return for energy input is quite high in traditional agriculture, in some cases approaching a ratio of 20:1 (Rappaport, 1972). Industrialized agriculture, in comparison, typically consumes as much as ten times more energy than it produces; in other words, it achieves a ratio of only 1:10. Many of these energy inputs — including fertilizers, pesticides, transportation systems, and so forth — are heavily subsidized, either directly or indirectly. If a calorie of energy produces up to twenty calories of food in traditional agricultural systems characterized by high biological diversity, and ten calories of energy produce one calorie of food in a far more homogenous industrial agricultural system, it is clearly not efficiency and productivity that gives modern agriculture its advantage.

But with growing populations, steps need to be taken to enhance the productivity of lands under traditional agriculture. In the forested uplands, modern agricultural development should take existing swidden systems as starting points and use modern agricultural science to improve on the productivity of the system. The essential element is the design of self-sustaining agro-ecosystems. These ensure the maintenance of local genetic diversity available to farmers, thereby enabling rural communities to manipulate production systems to best suit local conditions. In addition, the ability to maintain a stable and permanent system with forested land enables some swidden farmers to invest time and effort in other permanent assets like fruit trees, fenced gardens, terraces, and irrigation canals. In the most suitable areas, swiddens are supplemented by irrigated rice fields, thus allowing a considerably higher population density than under swidden conditions alone. Such mixed systems will often enable modern agricultural techniques to be wedded to traditional ones, and lead to the establishment of more permanent villages (McNeely, 1989).

Agricultural ecologists have learned to respect the wisdom inherent in many traditional practices. If traditional farming is developed as part of an overall system of conservation-oriented management, it can continue to make a valuable input into the total agricultural productivity of a region and can contribute to the biological diversity of rural ecosystems.

It should be noted that "protection" does not always lead to more biodiversity. Nabhan, et al. (1982) carried out a study of two oases in the Sonoran Desert on either side of the Mexico-United States border. The study indicated that the customary land-use practices of Papago farmers on the Mexican side contributed to the biodiversity of the oases. In turn, the protective land-use of an oasis 54 kilometres to the northwest, within the US Organpipe Cactus National Monument, resulted in a decline in species diversity over 25 years.

On the other hand, some conservation measures can help preserve traditional agro-ecosystems. Rock Coral Canyon Reserve, covering 2000 hectares, is owned by the US Department of Agriculture. It is one of just a handful of places in North America where wild varieties of chili peppers grow naturally. It is the focus of the first proposed government-sponsored *in situ* conservation plan for wild native crops. The project is run by Native Seeds/SEARCH, a non-governmental organization (NGO) that aims to preserve and exploit some of the wild crops in the region. Apart from peppers, the reserve is home to four other important wild varieties of native crops: tepary beans, cotton, squashes, and the tequila plant. These have traditionally been gathered by the local Tohono O'Odham people. As recently as 70 years ago, the Tohono O'Odham cultivated 4000-hectare farms in Arizona without having to pump ground water, an impossible dream for most farms in that state today. The Tohono O'Odham had an extremely healthy diet, based on tepary and lima beans, pods from mesquite trees, acorns, and corn.

Threats to traditional agro-ecosystems

Western technology is now shifting innovation from the farm to the laboratory. The uniform varieties from research centres, with their dependence on chemical fertilizers and pesticides, are displacing farm-bred varieties. Once these traditional varieties are gone, the knowledge of their cultivation and use is also essentially lost. Nor is the "museum" approach to conservation sufficient. Fencing off valued ecosystems, keeping plants in botanic gardens, and storing germ plasm in seed banks is hardly an adaptive approach. It seems apparent that there is little point in preserving a variety unless the farming system that produced it is also preserved, along with its particular climate and soils and the accumulated knowledge about its cultivation and use.

Traditional agro-ecosystems are under threat in virtually all parts of the world. These threats come above all from government agricultural policies that favour centralized control and the use of subsidies as a primary instrument to achieve central policies. While this has undoubtedly increased total agricultural productivity, it has also led to considerable economic inefficiencies and vulnerabilities. Solutions must be found to correct such inappropriate agricultural policies.

Despite impressive increases in agricultural productivity in recent decades, many agricultural policies are economically inefficient and environmentally unsound. They benefit farmers with large land holdings and few crops, while penalizing farmers cultivating smaller holdings, who often have many crops. In developing countries food price controls and subsidies for agricultural inputs have helped to meet short-term consumer demand but have removed incentives to increase agricultural production and have tended to undermine long-term food security. Such policies have also decreased the diversity of species used by farmers, increased the uniformity of crops and livestock breeds, and made farmers dependent on expensive and often unreliable sources of agricultural inputs. Many agronomists will argue that uniformity in agricultural practices and variety can improve productivity. But the Global Biodiversity Strategy (WRI, et al. 1992) points out five current policies which are likely to be contrary to the interests of long-term agricultural productivity. These are:

1. **Agricultural input subsidies.** Reducing the cost of inputs such as water, pesticides, and chemical fertilizers leads to the growth of "industrial" agriculture. This is based on a small number of highly uniform crops at the expense of farming systems based on a wider variety of crops. Subsidized inputs can also replace natural processes based on biodiversity that are equally effective at lower cost to people and to the environment. The growing use of pesticides, for example, has displaced agricultural pests' natural enemies such as micro-organisms and invertebrates.

2. **Food price subsidies.** Policies to reduce food prices for urban consumers can cut into farm profits. Combined with subsidies for inputs, such price controls can greatly discourage agricultural diversity. Some farmers, by using modern crop varieties that require irrigation and heavy inputs of chemicals, can neutralize the impact of food price controls by increasing production, but farmers using low-input systems and traditional varieties receive no such offsetting benefit. This discourages low-input farmers from developing new varieties of their own and leads indirectly to the erosion of knowledge of traditional varieties.

3. Over-valued exchange rates. Governments in many developing countries have over-valued their currencies as a means to subsidize imported capital goods for industry and lower the costs of imported food. Such policies basically "tax" all agriculture, but farmers who use fewer manufactured inputs benefit less than those who use more. Like the combination of subsidies and food price controls, these policies favour industrial agriculture, with its attendant reduction in diversity.

4. Research bias toward high-input agriculture. Much national agricultural research has been directed to increase production of a few major crops through technological change. This research model has been exported from the industrialized to the developing world through CGIAR (Consultative Group for International Agricultural Research) and may have provided much-needed breathing room in the race between production and population. But to meet future production needs, national governments must support agriculture systems that meet food needs while maintaining important components of diversity.

5. Credit policies that discriminate against "minor" crops and traditional varieties. All too often, governments fail to extend agricultural credit to farmers planting traditional crop varieties or growing crops for local consumption. This results in reduced productivity and accelerated loss of crop diversity, particularly in developing countries, where the benefits of "improved" varieties may be negligible in marginal agriculture.

It is apparent that the development of plantations and rubber estates, for example, often suits a general government imperative of centralized control and extraction of resources. Traditional agriculture frustrates this imperative, partly because it is more individualistic. In Indonesia, the colonial government tended to monopolize valuable forest resources, leading Dove (1993) to conclude that, when forest people develop a resource for the market, and when this market attains sufficient importance, central economic and political interests assume control of it, based on self-interest rhetorically disguised as the common good. The cycle is as follows: forest dwellers develop resource; economic boom; external political and economic interests attracted; external interests assume control; forest dwellers marginalized.

Therefore, efforts to develop alternative resources, such as butterfly farms, crocodile farms, fish farms, and medicinal plants have tended to ignore the resources that are of greatest interest to external society, including trees for timber or pulp, valuable hardwoods, plant genetic resources, and smallholder export crops. In other words, these "new" resources are actually the ones that the broader society is likely to allow the forest peoples to keep. Even this will only happen so long as some twist of fate does not suddenly render one of these products more valuable than is deemed appropriate for a forest dweller. Dove (1993) concludes that "for an environment as rich in resources as Southeast Asia's tropical forests, a list of potential income sources that cannot transcend butterfly and crocodile farms is a recommendation, however unintentional, not for the empowerment of the forest peoples but for their impoverishment. In the context of heightened competition for access to tropical forest resources, this 'sin of omission' — which strengthens the position of outside interests and weakens the position of the forest dwellers — is no accident: it is a product of the idealogy and rhetoric of the dominant political-economic interests".

Traditional agro-ecosystems are characterized by a limited reliance on artificial inputs like chemicals, pesticides, and energy-consumptive machines. However, once these external inputs of energy begin to be applied in larger amounts to increase production, then the traditional qualities of the region will almost always decline. As Phillips (1994) points out, "Even if the appearance of the landscape maintains — for a while at least — a superficial similarity to that which was produced through less intensive farming methods, its value from the perspective of biodiversity conservation will be eroded. A similar process will occur where rural populations may persist in traditional land use practices but be forced by increasing human numbers to seek to work the land more intensively, removing remaining pockets of natural vegetation or adopting shorter cycles of fallow or forest regrowth. Herein lies the central dilemma of conserving cultural landscapes. Since they are by definition the product of a particular human society living in a particular way at a particular population density, changes in that society (and especially in the land-use practices which it follows) will inevitably bring about changes in the landscape itself, and thus often affect its value for biodiversity. It is therefore not enough to attempt to protect the landscape as such: attention must be given instead to the ways of life of those who are the architects of the landscape, and upon whom the survival of the biodiversity within it depends. This is not an argument for seeking to fossilize the way in which communities use the land. Rather the aim should be to encourage them to adopt more sustainable patterns of living so that rural communities can both improve their prospects of economic and social progress, and continue to maintain the landscape that they have created. There can be little doubt that this will be the challenge facing many of the cultural landscapes recognized under the World Heritage Convention, especially those which are living, dynamic and organically evolving landscapes".

Traditional agriculture is now threatened by the global consumer culture, which is spreading by means of television, trade and other means. A few examples will indicate the range of factors driving this process.

Land-use management throughout much of sub-Saharan Africa has been evolving from a pre-colonial communal land system to more formal and individualistic land title systems. Most traditional communities do not have effective title or control of their land systems, or any effective way to make their views felt at the national policy level. The colonial period was marked by a taking of many of the most desirable lands from long-term resident communities. The post-colonial period of nationhood brought further ways to take land and resources from local communities in the national interest. Added to this are population pressures on the land, contributing to a breakdown of traditional methods of control. For the Shona of Zimbabwe this divestiture of land has been all too evident. Traditionally, the Shona managed their lands communally based on ancestral relationships. Sacred sites and sites of historical importance were preserved throughout the Shona domain, though outsiders were generally unaware of these areas or of the values attached to them. Consequently, the breakup of Shona lands into small parcels under individualistic ownership schemes has failed to maintain traditional land use protection and management systems, and has resulted in a loss of cultural heritage and associated sustainable farming practices (IUCN, 1993).

Robinson (1994) describes how colonists have been moving into the territory of the Yuqui Indians in Peru, primarily for the purpose of harvesting coca. These colonists tend to remain on their farms only during the planting and harvesting of the coca, and return to their highland settlements at other times of the year. Their activities appear to have had a major impact on the fish and game available to the Yuqui, involving technology (such as dynamite fishing) that leads to considerable over-exploitation of resources. This is just one of many examples that could be provided of how new colonists have moved into traditional lands and disrupted traditional systems which had worked for many generations. Crosby (1986) describes the impacts of Europeans on both cultures and ecosystems during the thousand years of what he calls "ecological imperialism".

In the Moluccas of eastern Indonesia, rapidly rising consumer desires, stimulated by television images of a growing Indonesian middle class, are pushing local government and customary officials to shorten the interval between traditionally-controlled harvests (Zerner, 1994). Increased population densities on isolated islands lead to a greater need for alternative sources of income. Despite evidence that shortened intervals result in drastically decreased stocks of resources, local government officials claim that they are being forced to extend the period of harvest by the villagers' need for income to conduct religious rituals, pay school fees, or acquire consumer goods.

On the island of Sumbawa, in the eastern part of the Indonesian archipelago, hunting has long been an important part of the economy. Because most of the villagers are Muslims, pigs are not a particularly sought-after game animal, but feral buffalo and cattle, as well as the local species of deer (Cervus *timorensis*) are popular. These animals are grazers and do far better in grasslands than in the forest that would normally cover the island.

Today, grassland covers 17 per cent of Sumbawa's land area. This grassland is hundreds of years old and has been used for grazing and hunting for at least that long. Grasslands are maintained by annual fires which replace older and less edible grasses with younger and more edible ones. The fires also eliminate dead plant material and thereby increase overall herbaceous productivity as well as prevent reforestation.

The creation of grasslands by people is a sensible initiative in habitat management, bringing about conditions that favour grazing animals at the expense of pigs (which prefer the forest). Furthermore, replacing forest with grassland has been of net benefit to the wild herbivores that are hunted, whose populations are kept at such a high level that they could be harvested virtually at will. The hunters accepted communal control on hunting methods, proscribing hunting from November to May when the deer give birth and rear their young.

Government conservation programmes prohibited burning the savannas and hunting the main game animals (ironically, pigs were excluded, the only species the Islamic islanders avoided). This broke down a genuine symbiosis which had proved sustainable over long periods of time. Because of the programmes' insensitivity to the local reality, they not only failed to win acceptance among peasant hunters but also undermined traditional conservation measures, thus achieving the worst possible results (Dove, 1984).

The evidence suggests that over-exploitation is to be expected in times of very rapid cultural change, as traditional controls break down and people learn to exploit resources in new ways. The movement of Europeans into the Americas is the most dramatic example of this process (Crosby 1987) — it is estimated that colonizers since Columbus have wiped out two-thirds of North America's native crop varieties — but similar factors appear to affect the entire globe (Roychowdhury, 1992). Technological innovations, such as plantation agriculture or industrial logging, tend to favour exploitation of biological resources and the weakening of traditional approaches to conservation, especially when a new group moves into a region occupied by groups with less complex levels of technology. The dominant society has the option of moving on to fresh resources when an area is exhausted and would derive no particular advantage from adopting the traditions of sustainable, conservative use that characterized the groups it has overwhelmed. It is able to enjoy virtually all the cash benefits of the forest, but pay almost none of the long-term environmental costs. These costs remain with the indigenous peoples, who must live with the consequences of the outsiders' resource management decisions.

At the same time, the indigenous groups lose any advantage of traditions of conservative use that were effective when they could exclude other groups from their territory. These traditions evolved when costs and benefits were internalized in the decisions made by communities, but when local people have to pay the far higher environmental costs of resource degradation, their only rational response is to copy the exploiters and seek greater benefits as well, thereby contributing to the undermining of their culture.

Finally, the dominant economic forces in the world have relied on a vast government machinery to facilitate foreign exchange earnings through international trade. This economic expansion has the implicit (and sometimes explicit) goal of promoting more complete exploitation of biological resources. As an inevitable result, cultural diversity is also reduced, for two main reasons (Gadgil, 1987). First, a significant component of cultural diversity, which enables people to earn a living from the local biological environment, is no longer functional; second, subordinated groups begin to imitate the culture of the dominant group, thereby losing a major portion of their cultural diversity.

This is the real tragedy of the commons: traditional management systems that were effective for thousands of years become obsolete in a few decades, replaced by systems of exploitation which bring short-term profits for a few and long-term costs for many. This leads to the loss of both biological diversity and cultural diversity.

Tenure: the key issue

Responsibility over resources is a major element in traditional relationships between indigenous cultures and the natural world. Tenure systems — upon which responsibility is built — are based on legitimacy drawn from the community in which they operate rather than from the nation or state in which they are located (Lynche and Alcorn, 1994). Indigenous systems of resource tenure are extremely variable, complex mixtures of individual and community rights, enforced by the local culture. These systems are flexible and constantly evolving, often in response to changing environmental conditions. Such systems invariably end up being disrupted by nation-states claiming ownership of the most environmentally important areas.

Institutional control of resources by local peoples tends to be strongest when such groups are very independent. Once they become integrated into larger systems, the social and economic centre of gravity shifts away from the community and rural institutions become increasingly marginalized (Murphree, 1994).

Local people need the right to self-determination, and to set their own development agenda. This is no guarantee of success, but it does put responsibility firmly in the hands of those who will earn the benefits and pay the costs. We might reasonably expect that communities will behave in their enlightened self-interest, if empowered to do so.

Although security of tenure offers opportunities for communities to gain benefits from their resources, at least some market forces tend to exist exclusively outside local communities. As a result, resources are perceived differently at national and community levels, and their benefits are derived differently. Governments should therefore consider returning at least some nationalized resources, such as forests and wildlife, to community-based tenure systems, which can often be more cost-effective. Putting resource management back in the hands of local communities also helps governments divest themselves of responsibilities for functions they have proven incapable of providing adequately. The legitimacy of community-based tenure systems can be recognized through cadastral surveys, assessments of wildlife populations, demarcation, registration, and community infrastructure.

The full implications of such an indigenous privatization scheme need to be considered. Transferring the control of access rights from national to local level gives power to those making local decisions. As Murphree (1994) points out, the way that natural resources are used in a particular place and time is the result of conflicting interests between groups of people having different objectives. Seldom does any one group dominate, and resources can be used in a number of different ways at the same time and place. So the variation in resource management is part of an ongoing process to which the different interests and struggles of the various participants contribute. Some local participants are likely to benefit more than others, thereby creating new tensions in the community.

It is clear to all farmers living in such systems, says Rappaport (1972), that "their survival is contingent upon the maintenance, rather than the mere exploitation, of the larger community of which they know themselves to be only parts."

Agricultural research

Agricultural research can help contribute to biodiversity. It needs to find a balance between high-tech, international approaches and more on-the-ground, farm-based research. Involving the ultimate clients of agricultural research in both the design and testing of improved technology will allow specialists to make use of some of the practical knowledge about agro-ecosystems. Such involvement will also offer greater assurance that new methods will be more widely adopted once their effectiveness has been demonstrated.

Greater diversity in crops should be promoted by strengthening and decentralizing national agricultural research and breeding programmes, and by building on farmer-based research. Agricultural production gains in most developing countries are likely to be far more cost-effective and equitable if traditional breeding techniques are strengthened rather than if modern biotechnology is adapted unreservedly. Indeed, the benefits of biotechnology cannot be realized without a strong public programme in crop breeding: one that meets the needs of marginal farmers as well as those of farmers on better quality land.

Research aimed at benefitting the poorest farmers — who, ironically, often live in the areas with greatest biodiversity — should be based on an ecological approach and on existing traditional agriculture. This might include the development of more efficient low-input agricultural systems based on biological recycling of energy and chemical nutrients. It could also include relying primarily on naturally-occurring control mechanisms for crop protection. Research should seek to develop new agricultural systems, building where possible on rediscovered or newly-appreciated traditional systems. A wide spectrum of agricultural crops should be considered, including many that might be viewed as non-traditional. Restoring, maintaining, and improving the natural resource base should be the basis for offering farmers a reasonable chance for economic betterment.

Agricultural ecologists, anthropologists, and ethnobiologists are documenting the biological adaptability of traditional agricultural systems and the importance of traditional knowledge systems for their maintenance (Altieri, Anderson, and Merrick, 1987). The findings of these researchers need to be linked to agricultural development programmes. This is necessary to legitimize the knowledge of traditional farmers so that they can more fully participate in the development process and to apply the strengths of traditional techniques to the design of modern agricultural systems.

The Convention on Biological Diversity

The new Convention on Biological Diversity came into force at the end of 1993 and had 117 ratifications by mid-March 1995. Biological diversity has been one of the most powerful new terms in the conservation lexicon in recent years. As defined in the Convention, it means "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems" (UNEP, 1992).

The convention offers a new approach to biodiversity, recognizing that conservation requires action at all levels and in all habitats. Although the convention provides few if any specific means of implementation, it does provide a framework which will enable each government to decide for itself how best to conserve biodiversity. In the convention, governments affirm that they have sovereign rights over their own biological resources, but are responsible for conserving biodiversity and for using their biological resources in a sustainable manner.

Governments agree that it is vital to address the causes of biodiversity loss at their source, and that *in situ* maintenance of ecosystems and habitats is the foundation for conserving biodiversity. Further, the convention recognizes the traditional dependence of many indigenous and local communities on biological resources, and the desirability of enabling local communities to share equitably in the benefits arising from the use of indigenous knowledge. As a framework convention which is universal in scope, it will require governments to interpret and apply its provisions in ways that are nationally appropriate.

It is apparent that the importance of biodiversity has struck a responsive chord in politicians and decision-makers, even though the full implications of the convention remain to be explored. But a number of the elements of the convention suggest a greater recognition of the contribution of traditional agro-ecosystems, offering another tool for helping to ensure that the maximum international support possible is brought to bear for conserving them.

The preamble of the convention recognizes "the close and traditional dependence of many indigenous and local communities embodying traditional lifestyles on biological resources, and the desirability of sharing equitably benefits arising from the use of traditional knowledge, innovations, and practices relevant to the conservation of biological diversity and the sustainable use of its components."

Article 8, on *in situ* conservation, says that each contracting party shall regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to assuring their conservation and sustainable use (8c); promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas (8e); respect, preserve, and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices (8j).

Article 10, on sustainable use of components of biological diversity, says that each contracting party shall integrate consideration of the conservation and sustainable use of biological resources into national decision-making (10a); and protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements (10c).

Article 15, on access to genetic resources, supersedes the 1983 FAO undertaking on plant genetic resources, which recognized the principle of free access, by asserting that "the authority to determine access to genetic resources rests with the national governments and is subject to national legislation" (15.1). One perhaps inevitable byproduct of the assertion of national sovereignty over biodiversity is that it may not recognize the differential distribution of legitimate rights in genetic resources among social groups within a country. Specific farmers, communities, or ethnic/tribal groups are associated closely with the production, reproduction, and protection of specific complexes of genetic materials in many countries. This close association may not be respected and national sovereignty might simply become a mechanism by which political or scientific elites channel the benefits of compensation for the extraction of genetic resources to the satisfaction of their own interests, rather than to farmers and indigenous peoples. It is apparent that, as the value of genetic materials is recognized, struggles will increase over the equity of the social arrangements currently in place to regulate access to and ownership of those materials.

Article 17, on exchange of information, includes promoting the exchange of results of technical, scientific and socio-economic research (17.1), as well as information on training and surveying programmes, specialized knowledge, indigenous and traditional knowledge (17.2). And Article 18, on technical and scientific cooperation, states that contracting parties shall encourage and develop methods of cooperation for the development and use of technologies, including indigenous and traditional technologies, in pursuance of the objectives of the convention (18.1). For this purpose, the contracting parties shall also promote cooperation in the training of personnel and exchange of experts (18.4).

It is apparent from this brief summary of certain articles that ample opportunity exists for using the convention to support traditional agriculture, and for modifying it to make it more relevant to modern conditions.

Conclusions

Agricultural development projects that incorporate the protection of the larger ecosystem within which agricultural communities survive and flourish are far more likely to succeed than those which are too narrowly-based. Establishing such protection will often involve ensuring that the relevant communities are given management responsibility for the natural areas upon which their continued prosperity depends. In other cases, responsibility for protecting areas which harbour populations of wild relatives of domestic plants may need to be assigned to the appropriate arm of the Ministry of Agriculture.

Natural areas important for wild relatives of domestic plants or animals, or for protecting wild populations of insects useful in integrated pest control, should be established and managed by agriculture ministries. This will help ensure that all wild relatives of domestic plants are conserved as a basis for adapting to the changes that are certain to come.

Governments should therefore seek ways of promoting a closer collaboration between agriculture and conservation, building on the common interest in maintaining the diversity and productivity of biological resources. In assessing their policies and practices in dealing with agricultural issues as they relate to biodiversity, governments should consider the following:

- have the necessary policy steps been taken to ensure that traditonal farming systems are able to prosper as part of the national agricultural development process;
- has a consistent and meaningful process been established for identifying environmental concerns during project and programme formulation, implementation, and evaluation;
- is environmental mitigation or compensation required as part of each agricultural development project;
- do agricultural development projects give full consideration to the larger ecosystem within which the project is based;
- are agricultural development projects based on principles of sustainability, or do they build dependency on outside sources of essential inputs; and

- will appropriate market prices be paid for the agricultural commodities being produced, and do the projects support the production of commodities which provide the recipient with a comparative advantage?

New directions in agricultural development support low-impact strategies such as integrated pest management and biological control. These may well require that crop germ plasm will need to be restructured, making the traditionally-adapted varieties once again an important part of a nation's adaptive strategy.

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Perceptions on forest conservation in Tropical America

Gerardo Budowski

When it comes to managing tropical rainforests on a sustainable basis, an immediate feeling of frustration becomes evident, particularly on the part of the scientific community. There is a concern about the loss of an invaluable resource, estimated to include more than 50 per cent of the world's total species of trees. Despite this importance, tropical rainforests have been left in relatively unaltered condition on only five per cent or less of the world's land surface.

Although management of the tropical rainforests is admittedly complicated, the obvious starting point is to save them from destruction. It is vital to preserve some representative large samples of relatively unaltered forests.

Many efforts have been made in the past, are now underway or are planned for the future, but the experience of the past provides few reasons to believe that forthcoming actions will be successful. Admittedly, great strides have been made to increase the area of different categories of protected areas. Unfortunately, many legally protected areas exist mostly on paper and not in practice.

Besides efforts to conserve rainforests as parts of legally protected areas (different types of parks, reserves, sanctuaries, etc.) many attempts have been made to provide added value to the forest by various types of exploitation of its products, notably:

- sustainable exploitation of timber, firewood and other woody products; and
- sustainable exploitation of non-timber products and services.

Non-timber products include goods such as latex, resins, nuts, fibers (such as rattan), wax, medicines, honey, fodder, fungi, and game animals. Services include infiltration of rainwater, erosion control, biodiversity (with a number of theoretical and real benefits), ecotourism, beneficial climatic influences and sequestration of carbon dioxide. The results so far have not been encouraging.

It is argued here that the key to sustainable management does not lie in technical aspects alone but in realistic approaches. These must be based on an understanding of the diverse perceptions of the value of tropical forests by the various sectors of the population that determine their fate. A better understanding of these perceptions will provide a much greater chance of success in implementing steps towards effective conservation measures.

The historical legacy

It should not be forgotten that for the majority of population groups in tropical countries, forests were usually a hindrance to "progress". Many books, tales and legends depicted the forest as a dangerous and inhospitable environment. In the past, rainforests were obstacles to clearing land for crops or pastures or for building roads. For many people, tropical rainforests were considered dangerous environments where wild animals, mosquitoes or hostile aborigines made life unpleasant or dangerous. Clearing the forest was — and in many places still is — a symbol of progress. Except for aboriginal populations or others established for several generations, the forest was the enemy. It encroached with weeds (including pioneer trees) on the cultivated fields, while forest animals decimated crops or preyed on domestic livestock and fowl. Moreover forests seemed endless and inexhaustible; it didn't seem possible that they could one day disappear.

In addition to this, the law actually favours and provides incentives for deforestation in many countries. Land covered with forests is considered to have less value than land that includes "improvements". Rainforests were sometimes identified on old maps as "forests and other non-productive lands".

It is against this background that many of the local groups who influence the tropical rainforests must be examined. An attempt will be made to try to understand the perception of such groups. The following actors will be studied as to their perception of tropical rainforests:

1. forest dwellers (or ecosystem people);
2. local farmers, both long-established and recent arrivals, living in isolation or in small villages;
3. rural-urban dwellers, in settlements such as large villages or cities close to the forests;
4. high-level government employees, decision-makers and others living in the capital and large cities;
5. groups with special interests in the rainforest, such as timber exploiters or mining companies;
6. the legal system, involving judges, legislators and others who influence the law and its enforcement; and
7. foreign groups.

These groupings are obviously not homogeneous and there is also considerable overlapping among them.

Forest dwellers

Forest dwellers include indigenous populations or settlers living in the forest for a long time, often for several generations. Their lifestyle, and even their survival, depends in large part on the continuous existence of the forests; their culture is also closely linked with the forest. This has led to their being called "ecosystem people". Usually they introduce few changes in the forest, particularly when their numbers remain low. But in recent times their customs have changed rapidly because of increased contact with the outside world. They have been exposed to a market economy and wish to acquire material goods. They rarely have legal property rights; in fact, the whole concept of land title is usually unknown to them.

The men often work for logging companies; opening tracks or performing other tasks. Sometimes they move for certain periods to large cattle ranches or plantations for wage work as handymen, leaving women and family behind. They are becoming loosely organized and have recently attracted considerable sympathy from the outside world. Certain groups have achieved some legal protection, at least in theory, but often there is a large gap between the intent of the law and its implementation.

Forest dwellers need the forests for their material and spiritual welfare and have valuable ecological, medicinal and other knowledge. Compared to other groups, their influence on the fate of the forests is generally insignificant, although this has changed somewhat in some countries in recent times. Generally, the forest dwellers — and their knowledge — have become a dwindling resource. They need much more effective support from outside sources.

Local farmers

Local farmers living in or close to the forest depend on it a great deal, particularly if they practice shifting cultivation and have lived in the area for long periods. They derive much of their livelihood directly from the forest, both immediately after clearing, when it provides a fertile soil for crops; and after abandonment of the field, when the forest encroaches again and restores fertility. Farmers have developed a good understanding of the ecology of the forest and often derive commercial benefits from hunting, fishing and exploiting commercial nuts, rattans, honey and other products. Changes in exploitation from older to younger generations tend to affect lifestyles, often to a considerable extent.

Local farmers' influence on the forest can range from negligible to very broad, even destructive. Destructive practices can often be the result of exogenous influences, including population increases resulting from improved health facilities and lack of family planning. Local people rarely have property rights and are subject to eviction by the legal owners or submission to their terms. These terms can include having to provide labour or a percentage of their crops in return for the right to stay on the property.

An important sub-group is recently-arrived farmers. They usually come from ecologically different life zones (i.e. drier and colder) and bring with them the only technologies they know. These practices, such as cultivating certain familiar crops or raising cattle, may work well in drier areas but not in areas of high rainfall. Newly-arrived farmers can be very destructive since their knowledge of the area, let alone their concept of sustainability, is practically nil. They frequently use lands on steep slopes or subject to flooding and many do not stay long in the same area. They rarely see the settled area as their "home". Their numbers have increased considerably in recent times because of internal and external migrations caused by wars, violence, droughts, degradation of the land and decrease of human carrying-capacity due to poor land-use practices and population increases. This sub-group, on a worldwide scale, is probably the single most significant factor contributing to rainforest destruction.

Special mention must be made of people who arrive in rainforest areas with a culture based on raising cattle. Throughout the humid tropics it is not common to find successful cattle-rearing in areas of high rainfall, except possibly on the few good alluvial or recent volcanic soils, where other crops can also be successfully grown. Soil compaction and other physical and chemical degradation processes, coupled with ever-encroaching pernicious weeds, make cattle-raising a very hazardous venture. Initially, after clearing the forest and taking advantage of the accumulated fertility (and frequently with an initial period of one to two years of food crops before grass is introduced) the results look promising. Depending on soil, slope, fencing and other management techniques, however, the situation is less hopeful 6-20 years later. In fact, in areas of high rainfall and poor soils many cattle enterprises are gradually abandoned and some kind of scrubby vegetation takes over, followed by secondary forests.

Improved management techniques, using cut grass or even protein-rich trees for fodder, have been suggested as well as a number of silvo-pastoral practices. But it will take considerable time before these techniques reach the poor farmers who migrate to rainforest areas. Clearly for these local farmers, forests are the enemy: an obstacle to their way of life.

Rural-urban dwellers

Rural-urban dwellers live in settlements such as large villages or small cities close to the forests. These are the same centres where local authorities and local entrepreneurs live. Although rural-urban dwellers exert power over the forests, as legal owners or through other devices, most of them have little knowledge of the importance of keeping the forest intact. Logging enterprises and sawmills are also often located close to the forest. Business owners and entrepreneurs usually take full advantage of their status to subjugate the forest dwellers and farmers living in or close to the forest. They may, for instance, lend money and tools to clear forest for crops or pastures, making prohibitive arrangements about benefit-sharing, with farmers providing the labour. In Latin America and the Caribbean only seven per cent of land owners control 93 per cent of private property.

Land-owners benefit from the forest because it supplies timber, poles, posts, rattan, thatch, food, fuel, game animals, etc. They do not feel strongly about the survival of the forest, however, because of their lack of understanding of its full value, and their attitude to it. In addition, it should not be forgotten that logging is commonly perceived as a mining operation.

Although the problems associated with loss of the rainforest are not sufficiently clear to most of the population, they are understood on a basic level by an increasing number of people. Lately some improvements have been made but they are spotty. Forests that provide water for villages or towns are often protected, but rarely involve large areas. Tree planting is often advocated but is costly and is no substitute for the existence of a highly heterogenous natural forest.

Rural-urban dwellers have a significant negative influence on the rainforests but changes are beginning to appear in different parts of the tropics. These are the people, together with farmers, who exert the greatest influence on the fate of the forests. Positive change will not come easily or swiftly.

Decision-makers

High-level government employees, decision-makers and others living in the capital and large cities often hold the view — backed by local statistics — that forests contribute little to economic development. This misconception is compounded by archaic policies and legislation that does not favour forests. Even where legislation does exist, enforcement is weak. Planning policies generally extend over very short periods, with goals rarely extending beyond the next election. Moreover, the education of decision-makers concerning the real value of the remaining rainforests is often very poor. There is an immense gap between intentions as witnessed in political speeches, and actual actions.

This attitude is quite different at university centres, scientific institutions and many of the non-government organizations (NGOs) that are mushrooming in tropical countries. But usually such organizations have little power to change the present deforestation rate. In addition, some NGOs have taken up highly emotional and controversial issues to fight against a variety of development initiatives, sometimes with a lack of data to support their campaign. With few exceptions very little money is spent on applied research within the country. Also, funds are often spent on projects that have little chance of achieving sustainability or having practical application for rural populations.

For many government entities, economic growth at any cost, creating more jobs — and avoiding the loss of existing ones — remains the top priority. With few exceptions conservation of the rainforests ranks low.

This situation may change as the result of a combination of enlightened leadership, success stories (for instance, the surge of ecotourism in Costa Rica based in large part to visitation of rainforests), and the influence of foreign funding to support local conservation efforts and better education programs. Conversely, catastrophes such as floods or droughts perceived to be caused by deforestation of watersheds may also trigger remedial action.

Special-interest groups

At present, many timber companies derive large amounts of their raw material from natural forests. Very few of them operate on a sustainable basis. It is estimated that, worldwide, only about 0.12 per cent of all natural forests exploited for timber have a basis of sustainable management practices (Poore, 1985). The reasons for this are many, but principally because in the past, trees were plentiful, freely available, or relatively so, and hence were considered to have little if any value.

This perception is quickly changing because of the increasing scarcity of natural commercial forests in relatively accessible areas. In addition, an increasing number of timber companies wish to own and manage their own forests rather than harvest from government concessions, which are usually granted for only one or a few years. There is also an increasing harvest of timber from plantations, as well as from accessible secondary forests or from formerly logged forests. In these forests, new species, neglected until recently, are now entering the market. This activity is accompanied by a significant increase of the value of timber in recent years. It seems unavoidable that more sustainable management will be required. The questions are: how, how soon, and how effective?

Logging companies undoubtedly contribute to the destruction of the rainforest. Heavy machinery causes enormous damage to open roads, even if, as is sometimes the case, only one or a few trees per hectare are harvested. Logging itself fells or kills several trees for each tree that reaches the mill. Moreover, logging roads open the area to invasion by farming (including cattle raising). In fact there is often an alliance between forest land-owners and the logging industry. The logging industry opens roads, paying a royalty to the owner who, with the support of landless farmers, destroys the remaining forests and cultivates staple crops for one or two years before grass follows. After a few years the pasture is itself abandoned and the process is repeated elsewhere.

The prevailing attitude is one of getting at the timber while it lasts, with no thought for the future. When forest becomes scarce, pressure on the remaining patches increases. Dwindling forest resources also bring increased pressure on legally protected forest areas, such as parks and reserves. Many "paper parks", created by decrees but with little funds for protection or other management practices, have been devastated or destroyed.

The hope in some countries is that sustainable management schemes will relieve the pressure on the relatively timber-poor natural primary forests. Such schemes include the production of timber or chips from plantations and harvesting from secondary forests or even certain types of swamp forests with a high percentage of merchantable timber. But this may be wishful thinking, since there are many competing economic and policy issues and, perhaps more important, a weakness on the part of government in implementing adequate policies.

Other groups with an interest in the conservation of rainforests include rubber and chicle tappers, Brazil nut gatherers and rattan gatherers. Conflicts about land use have arisen, as in Brazil, where the leader of the rubber-tappers and nut-gatherers, Chico Mendes, was killed. The case attracted worldwide sympathy to the cause of forest preservation and triggered the creation of legal "extractive reserves".

Mining interests have caused considerable damage to specific forest areas, a trend which is likely to increase in the future. Not only is the mined area affected, but the opening of roads or railroads also attracts a considerable number of migrants. Together with the miners, they practice shifting cultivation, hunt or otherwise affect the forest. Moreover, mining may pollute rivers. Regulations in this case, as in other cases, are poorly enforced or non-existant.

Road opening through forest areas by public works projects is another factor which affects the remaining forest. Those who plan and build the roads have little concern for the land use along the road, even if there is hope of converting the newly-accessible area to sustainable cropping or grazing.

The legal system

Developing and enforcing laws is very much influenced by precedents. Often archaic legal measures prevail, many of them actually acting as incentives to deforestation. An enormous amount of tree cutting — often over 50 per cent — is done illegally, but enforcement is difficult and often not willingly implemented. Local judges are virtually uneducated about the conservation of rainforests. Even if they were highly motivated, it is extremely difficult to promote changes given the prevailing legal system and its loopholes, the adverse precedents and the general perception of the population.

Foreign groups

Many foreign groups have had an undeniable influence on local decisions favouring rainforest conservation. They provide technical assistance or funding mechanisms, or call for a recognition of the biodiversity of tropical rainforests. Foreign groups have been promoting changes in local perceptions and legal measures by bringing hard currency and by supporting the various education and training programs. Various international and regional organizations, bilateral assistance programs and a number of international NGOs have all contributed to promoting favourable changes in perceptions. In contrast, some profit-oriented multinationals have been accused of undermining conservation efforts by promoting forest conversion to industrial crops such as palm oil, rubber, banana and citrus plantations.

There is enormous potential to increase such groups' influence on a more positive perception of rainforests. But the various pressure groups have to operate carefully in order not to interfere with local sensibilities or the government's intent to "develop" the forest-covered areas and create jobs. As has been shown by numerous case studies, pressure needs to be carefully designed, coordinated and implemented to bring about the desired results.

Conclusion and follow-up

From this analysis — admittedly based on generalizations in many aspects — it can be concluded that the current perception of the rainforest, now mostly negative, is likely to continue for some time. The most favourable attitudes come from forest dwellers or from highly-educated people, including scientists, people living in cities and foreign representatives. Unfortunately, they have a relatively minor impact on those with influence; that is, the people living close to or in the forest, the decision-makers in the government and elsewhere, and groups with large commercial interests in the rainforest.

This implies that drastic changes need to be promoted. While coming up with recommendations was not within the scope of this essay, an analysis of what appear to be promising follow-up activities will be briefly explored.

A critical mass of enlightened leaders seems essential. This demands a considerable increase in training and education programs at all levels, including extension activities that reach the people near the forests, decision-makers, legislators and land-use planners. The matters of land tenure, law enforcement and applied research also appear critical.

Success stories, when well-publicized, can be powerful instruments to change perceptions. So too can the catastrophes resulting from mismanagement of rainforest resources.

Appropiate documentation of past experience — both negative and positive — should help lead to the preparation of guidelines for proper land use in rainforest areas. Such guidelines should of course indicate what is needed, what actions are to be implemented and why. But they also need to indicate clearly what should not be done, mistakes to be avoided and why. They should receive the greatest possible publicity and provide the basis for workshops and extension and other education activities.

The preparations of these guidelines may be one of the most important tasks the scientific community can carry out to bring about the required changes in perceptions and activities. These must be part of a concerted world effort to safeguard the remnants of our endangered rainforests.

Traditional farming systems and biodiversity in the High Andes of Bolivia

The case of Ayllu Mujlli

Marco Sotomayor, AGRUCO

Introduction

The structure of traditional farming systems in the Andes is inherent in the forms of organization that constitute the basis of the maintenance and validity of these systems. Andean agro-ecosystems have developed in response to the high variability of the natural environment. The rural economy is an expression of this high variability and of the cultural components of the society. In order to understand the rural economy, it is important that these cultural components be understood.

This is the highest elevation in the world where agriculture is practised. It has resulted in a bank of germ plasm, the management and conservation of which is in strict accordance with the forms of productive organization, the quality of productive resources, the management of agroclimatic risks, the size of the family, the destination of farming, social relations (Tables 3, 4 and 5), rituals, etc. The ultimate objective of agriculture in this region is to function at minimum cost, with control of risks, and with manageable levels of production. This ensures social and biological sustainability.

This paper synthesizes and analyzes the results of research carried out by the AGRUCO[1] Programme in the last five years in the Province of Tapacari in the Department of Cochabamba, Bolivia.

Due to the nature of this document, it is not possible to include the political, economic or social background of the country that provides a framework for the rural communities and their practices.

The Ayllu Mujlli

Bolivia's rural population constitutes 42 per cent of the national total. The urban population, currently at 58 per cent, has increased during the last two decades. In 1970, for example, the rural population was 59 per cent and the urban 41 per cent, almost the exact reverse of present figures. This phenomenon is common in many other countries of the South.

Table 3. Territorial organization

The Ayllu Mujlli community is organized into four sectors that farm four sub-valleys. The lands in the four valleys are different sizes and different ecological conditions prevail.

sub valleys	ecological characteristics
1. Mujlli, Uyuni, Mujlliwayllas	most extensive land in the Ayllu, with very regular ranges of altitude and climate.
2. Japo, Pastogrande	smallest lands in area with greater climatic and altitudinal ranges than the above (coldest zone).
3. Yarwitotora	less demographic pressure on the land, altidudinal and climatic ranges less than both the above (roughly a temperate zone).
4. Chullpani, Huayllani, Huayllatambo, Tayalaka and Kañawapulca	situated in the valley of the Rivers Chullpani and Calaya. Warmer land than those above.

Source: T. Blanco, 1992: AGRUCO.

Table 4. Number of families

Estimated population of Mujlli.

group	number of affiliates	group	number of affiliates
Mujlli	250	Kañawapalca	30
Uyuni	141	Yarwitotora	72
Chullpani	80	Japo	85
Huayllatambo	41	Pastogrande	40
Tavalaka	30		

Total: 769

Source: T. Blanco, 1990

Affiliates are those people who are appointed and/or registered in the group as representing a family unit. Each family therefore has a representative in the group. As is generally the case in the Mid-Andes, the family houses are dispersed in "rancheríos" or farming settlements and in "sayañas" or individual or private lands.

Table 5. Settlement pattern

group	rancheríos	family	per cent
Mujlli	Mujlli	2	2.50
	JachaPampa	5	6.25
	Estro Kochi	2	2.50
	Vaca Jibata	3	3.75
	Choque Chiwani	1	1.25
	Jacha Jaraña	3	3.75
	Jirirani	1	1.25
	Chullunkhayani	1	1.25
	Khellanhayani	1	1.25
	Jachoqo	4	5.00
K'ollpaña	K'ollpaña	5	6.25
	Muyu Khochi	3	3.75
	Hacienda Pampa	4	5.00
	Quesuta	4	5.00
	Chacalabani	5	3.75
	Khatakahtani	2	2.50
	Murmuntaña	2	2.50
	Kalachocuta	2	2.50
	Vinto	2	2.50
	Vaquería	3	3.75
	Calakhota	1	1.25
	Cóndor babacha	5	6.25
Estroni	Estroni	6	7.50
	Picotani	4	5.00
	Kochillanta	4	5.00
	Palca Khochi	4	5.00
	Phuchuni	3	3.75
Total		**80**	**100.00**

Source: Thesis, Chila M. 1992, AGRUCO

Organization of territory and production

The Ayllu Mujlli is located in the canton of Challa in the Department of Cochabamba, which is situated in the Puna zone. This is an area more than 3660 metres above sea level.

The organization of territory in the Andean Zone of Bolivia and other Andean countries functions under a traditional system called aynokas [1] in Bolivia and Suertes Laimis and Muyuy in Peru. This system of territorial organization is reflected in the process of decision-making at a communal (collective) and family level. The communal role is to exercise well-managed control over collective resources: land, water, flora and fauna, infrastructure etc. This territorial organization also implicitly influences forms of social organization at the family and inter-family level with reciprocal relations that guarantee and influence the cycle of family life.

The aynokas

Aynokas are traditional systems of territorial organization of production with the following characteristics:

- They form the axis for communal productive organization and, above all, for the planning of family/communal production.
- They regulate the access of a family to different types of lands with specific types of production; for example, production of bitter potatoes, ocas, ollucus [3] and others. This stems from the fact that not all parcels of land are equal and that each aynoka is different from another.
- The diversification of soils, micro-topography etc. also allows diverse management of varieties of crops and breeding in an area which, due to its high altitude, would not normally offer such diversity.
- Due to their management structure, the aynokas directly influence decision-making within the family; for example, decisions over their distance from the family residence, their size, or quality of the soils. In the case of a remote location, this will influence, for example, the proportion of estiércol [4] used on a plot of potatoes. Some of the peasants use chemical fertilizer in minimum doses in place of estiércol, but this happens only occasionally.
- The system allows soils to recuperate in long periods of fallow, allowing them to form communal pasture. There are inter-changing cycles of cultivation and pasture.
- The aynokas represent a synchronization, structured in the form of cycles of production. The cycle givies a family access to 100 per cent of the aynokas in a first turn. In a community of 10 aynokas, a peasant family will likely gain access to four cycles during the whole sequence. This process is carefully managed by the family and the community.
- The system of aynokas regulates and organizes the most typical farming activities through pre-established norms. This orders the productive activity of the family in the form of a flexible calendar devised for each year and each aynoka.

- The system allows for the redistribution of communal resources through the setting of standards and decision-making in a communal framework.

Figure 2 illustrates the simple manner of rotation of crops in the complete aynokas cycle. It shows the case of the community of Mujlli, in which the aynokas rotate from the bottom to the top, that is to say from the most sheltered zones to the coldest.

In some cases, during a year or a season, some communities will manage two aytas [5] with the aim of securing production and controlling risks through diverse managment of the aynokas.

Figure 2. Crop rotation cycle

aynoka	**year**													
	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Karogo/Huaylla Tambo	√											•	x	√
Levitami/Lupara	x	√											•	x
Llajma Chiar Cala	•	x	√											•
Titin Uma/Huaylal Pata		•	x	√										
Uyuni			•	x	√									
Patoqo/Jalturi				•	x	√								
Mujlli					•	x	√							
Jachoqo/Jacha Jaraña						•	x	√						
Jirirani							•	x	√					
Kollpaña/Quesu Uta								•	x	√				
Chacalabani/Muyu Khochi									•	x	√			
Iru Uta										•	x	√		
Lak'olak'oni											•	x	√	

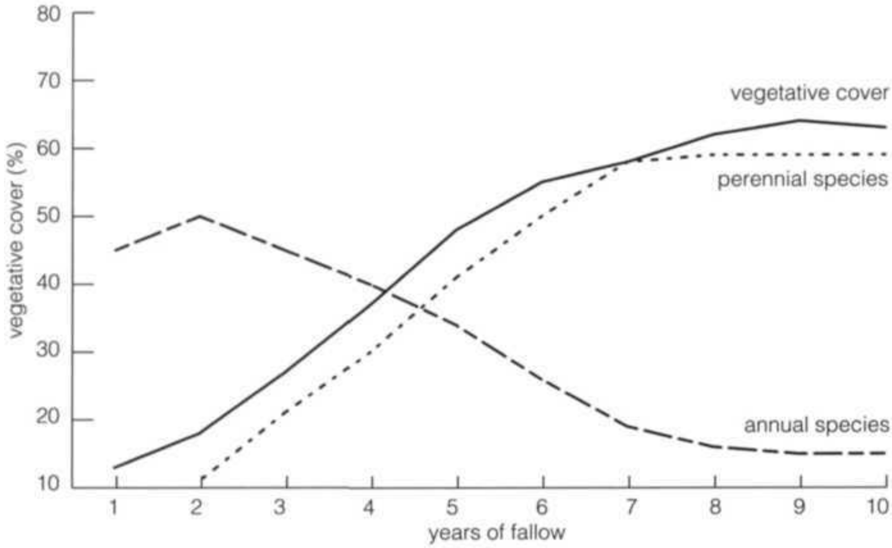
• potato x quinua-kañawa √ barley-oats

Source: Sotomayor, M., AGRUCO: based on Degregori and Golte, 1973 and Chila, M. 1992

Figure 3 shows the evolution of the vegetation of the aynokas during periods of rest under conditions of pasture and the relationship to the recomposition of soil fertility with organic material. This is very important because some areas with only a thin layer of arable soil are degrading. It also

Figure 3. Evolution of vegetation

Estimated evolution of vegetation in aynokas during periods of fallow under conditions of pasture and in relation to the recomposition of the fertility of the soils in organic material.



aims to show the process by which vegetation acts as an indicator of recuperation in the aynokas cycles. Many of these processes tend to be regressive, which has great importance in terms of sustainability.

The rotation of crops (Table 6) in the aynokas is strongly linked to their ecological characteristics. The management of biodiversity is a function of these characterisitics. This management is remarkable for way it allows the variability of the ecosystem to be maintained, thus providing food security in the long term.

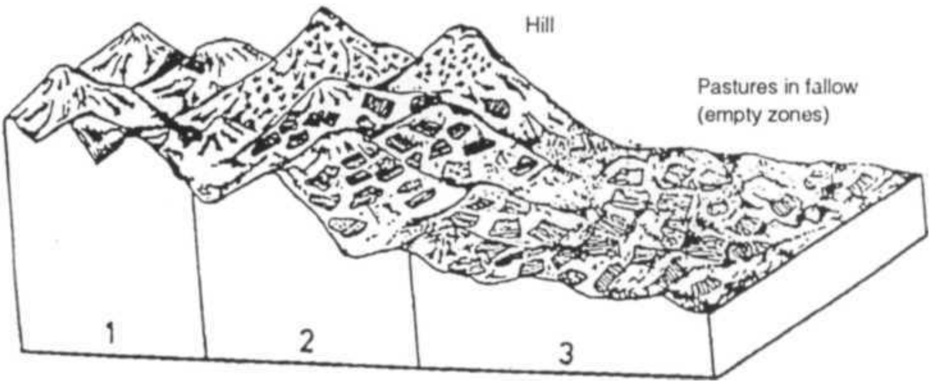
Figure 4 is a visual representation of the plots in a specific aynoka and of crop rotation. The system sustains itself by creating a dynamic integration between livestock and agriculture.

Table 6: Rotation of crops

	rotation of crops		
	R1	R2	R3
Pampas with high frost risk	hitter potatoes	kañawa	barley
Slope and ravine with less risk	non-bitter potatoes	quinua	oats

Figure 4. Cultivation in Puna, Bolivia

Figure 4 illustrates the location of the plots of a specific aynoka. This is a system which secures a dynamic integration between livestock and agriculture, ensuring the continuation of the system.



1 Aynoka in fallow zone of common pasture
2. 3 Aynoka with crops
2 Zone of predominantly non-bitter potatoes, quinua and oats, according to rotation/season.

Traditional production and biodiversity

In the Andes, systems of production have developed in which the process of andesation [6] of some crops and breeding is an important factor in their improvement and sustainability. The resulting increase in biodiversity and its management brings food security, which is the main concern of local families. These systems of agro-pastoral production, sustained by a dynamic inter-dependence of crops and livestock, mean that:

- production systems are closely interdependent;
- the level of productivity of one of these components directly affects the productivity levels of the others — a bad year for livestock, for example, will mean less manure for the potato plots, and will affect the working ability and carrying capacity of the animals, especially llamas — while one bad year in agriculture will directly affect the availability of food for the livestock; and
- the system is based on management of risk, diversification of crops, breeding and other resources, and reciprocal social relations in a way which inter-connects family needs with communal needs.

Figure 5 shows the most important interdependencies of crops and herds, based on studies carried out by AGRUCO. These studies revealed, for example, that yuntas [7] are used to provide energy (traction) for between 60 and 90 days per year.

Managing and conserving biodiversity

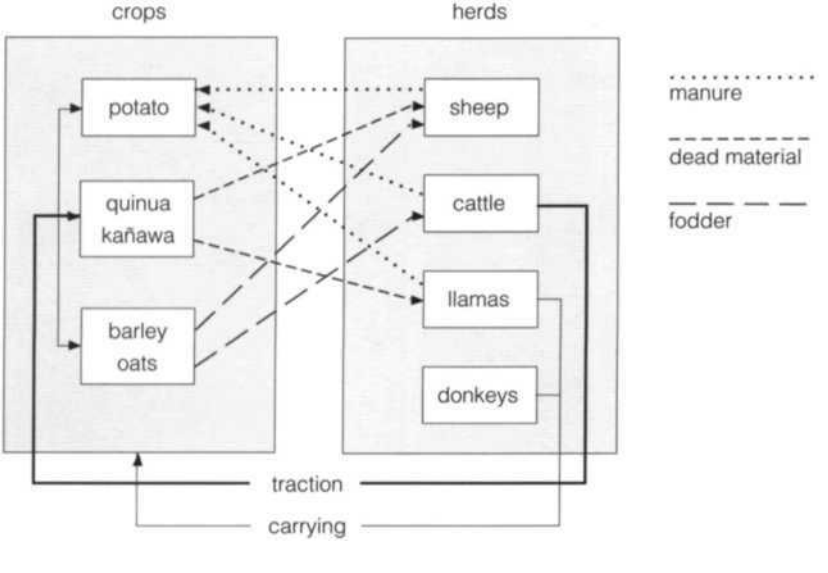
Biodiversity in the agro-pastoral systems of the Andes constitutes a strategy for food security. The management of climatic, bio-geographic and altitudinal systems has brought diversification not only in terms of use and production, but also in the success and the varied adaptation of many species of crops and animals in greater altitudinal ranges.

Because of this, the Andes has a store of rich and diversified germ plasm, which is the basis of the future nutritional system. In order to maintain this situation, greater emphasis must be placed on the biodiversity of agriculture, livestock and the pastures which form the basis of the farming systems.

Maintaining the biodiversity of the Andes means maintaining a variable ecological system that can provide long-term food security. Studies by AGRUCO during the last five years inventoried and categorized the biodiversity of Ayllu Mujlli. There is a high biodiversity of domestic cultivars, which gives farmers great flexibility in adapting to different conditions. Table 7

Figure 5. Some inter-relations of the Puna-Mujlli

Source: Sotomayor, M. 1993, AGRUCO.



lists 26 varieties of potatoes; Table 8 shows 34 varieties. According to reports from AGRUCO, around 50 varieties of potatoes, with various uses (Table 9), are managed in the area.

Table 7. Varieties of potatoes sown

Table 7 is an inventory of potatoes according to type. The quantities and varieties used per season are a function of the characteristics of each aynoka and each plot.

local name	scientific name	cycle
bitter potatoes (lukis)		
Wila luki	*Solarium curtilobum*	long(< 150 days)
Peraza	*Solarium juzepczukii*	
Q'etu	*Solarium juzepczukii*	
Bola luki	*Solarium juzepczukii*	
Uma luru	*Solarium sp.*	
Wila peraza	*Solarium juzepczukii*	
Moqo toro	*Solarium juzepczukii*	
Moroq'o luki	*Solarium juzepczukii*	
Chhoqe pito	*Solarium sp.*	
Kaysalli	*Solarium juzepczukii*	
Wila qollu	*Solarium sp.*	
semi-bitter potatoes (ajawiris)		
Wila ajawiri	*Solarium ajawiri*	long (< 150 days)
Larama ajamiri	*Solarium ajawiri*	
Ch'añu ajamiri	*Solarium ajawiri*	
Pitumayaqa	*Solatium ajawiri*	
Janq'o ajamiri	*Solarium ajawiri*	
Sotamari	*Solarium sp.*	
Llunk'u ajawiri	*Solarium ajawiri*	
non-bitter potatoes (qollus)		
Waycha	*S. tub. sp. andigenum*	medium (125 - 1 50 days)
Yana imilla	*S. tub. sp. andigenum*	
Sani imilla	*S. tub. sp. andigenum*	
Khuchisullu	*S. tub. sp. andigenum*	
Janq'o imilla	*S. tub. sp. andigenum*	
Wawachara	*S. tub. sp. andigenum*	
Alka imilla	*S. tub. sp. andigenum*	
Qoyu qoyu	*S. tub. sp. andigenum*	

Source: Chila, M., 1992. AGRUCO

Table 8. Varieties of potato grown in Japo

bitter potatoes	semi-bitter potatoes	non-bitter potatoes
Chojlla Luki	Larama ajawiri	Llunk'uimilla
Wile Luki	Janqo ajawiri	Alqaimilla
Yana Luki	Llunk'u ajawiri	Jank'o imilla
Moroqo	Ch'añu ajawiri wila	Khurchisullu
Perasa	K'ala ajawiri	Wanwachana
Q'etu	Pituwayaqe	Qoyoqoyo
Torillo wajra	Alphachuchuli	Taka
Sotamari	Chuillo	Sani imilla *
Kaysalli (3 var.)	T'antahualura	Yana imilla *
Moqotum *	Laru ajashu	Yurag imilla *
Polonia	Jowayaqe	Waycha *
Bola Luki *		

Source: Blanco, T. and Saravia, G. (1989); * introduced variety

Table 9. Uses and types of potatoes

type	use	cycle	characteristics
Lukis	• used to make chuño	• long cycle	• sown in more temperate locations • sown on level land • tolerant to frost and droughts • sensitive to *Sinchyt-rium endobioticum* (Jank'a o verruga)
Ajawiri (semi-bitter) and *Solarium ajawiri*	• used to make chuño[7] and in wayqo	• long cycle	• sown in more sheltered locations than Lukis with some slope • drought resistant, susceptible to floods or excessive damp
Qoyllus (non-hitter) *Solarium Tuberosum sp. andigenum*	• broken down, used in soups • eaten in wayqo (cooked with skins on)	• shorter than Ajawiri	• sown in sheltered and sloping locations • little tolerance of cold • most important variety is waycha (marcada)

Source: Blanco, T. AGRUCO 1992

In the case of other crops like quinua (*Chenopodium quinoa*), kañawa (*Chenopodium pallidicaulle*) and others, the diversity is also high. It has been calculated that, in Puna, for each of these crops there are around ten varieties, all of which have very particular characteristics.

Similarly, the diversity in the varied management of cultivated fodder like oats (*Avena sativa*) and barley (*Hordeum vulgare*), is also very high. There is a certain amount of specialization oriented to the production of green fodder (berza) for consumption and for making hay.

Biodiversity in the native meadows

It is important to consider both the permanent native meadows (non aynokas) and the native meadows with their cyclical fallows (aynokas). The diversity of the vegetative cover is a result of these two land uses coexisting.

Table 10 shows the results of an evaluation carried out in the community of Mujlli during the rainy season of 1992. Local assessment of the use of resources is not only useful, but can also be combined with other criteria of a more scientific type. There is a fairly wide range of usage of local species. This can be seen with animal fodder, species used in human and animal medicine, soil protection etc. It is important to assess additional characteristics as well as those studied for fodder, which has been predominant in the evaluations and investigations carried out to date.

Table 10. Grazing preference of sheep

local name	scientific name	family	
		annual: 35%	perennial: 65%
high palatability			
Chiji negro	*Mulhenbergia fastigiata*	*Gramineae*	
Chillihua	*Festuca dolychophylla*		*Gramineae*
Condorchinoka	*Alchemilla pinnata*	*Rosaceae*	
Sik'e	*Hipochoeristaraxacoides*	*Compositeae*	
Marancilla	*Caltha saginata*	*Ranunculacea*	
Altea	*Nototriche azorella Hill*	*Malvaceae*	
Malva silvest.	*Malvastrum silvestris*	*Malvaceae*	
Zapatilla	*Calceolaria flava*		*Calceolaria*
K'ita cebolla	*Nothoscordum andícola*	*Liliaceas*	
Cebadilla	Bromus *lanathus*	*Gramineae*	*Gramineae*
Layo	*Trifolium amabile*	*Leguminosae*	
Sultaj sulta	*Geranium sessiliflorum*	*Geraniaceae*	
P'enkapenka	*Gentiana postrata*	*Gentianaceas*	
Anuk'ara	*Lepidium bonaeriensis*	*Cruciferas*	
Vira vira	*Gnaphalium minuta*		*Compositae*
Appharuma	*Solanum curtilobum*	*Solanaceas*	

local name	scientific name	family annual: 35%	family perennial: 65%
low palatability			
Pacu pacu	*Calamagrostis curvula*		*Gramineae*
Pacu pacu	*Calamagrostis vincurarum Wedd P.*		*Gramineae*
Ichu sicoya	*Stipa ichu*		*Gramineae*
Cawra ichu	*Stipa smithi Hitch sp.*		*Gramineae*
Annu ichu	*Stipa inconspicua Presl.*		*Gramineae*
Ch'ankoruma	*Perezia multiphora HBK*	*Compositae*	
Pacu llapa	*Acciachne pulvinata*		*Gramineae*
Aña wiya	*Adesmia spinossisima Meyen*		*Leguminosae*
Llapa llapa	*Paronichiachilensis*	*Caryofilacea*	
Muni	*Bidens pilosa L.*	*Compositae*	
K'ela	*Lupinus condensiflorus C. P.*	*Legwninosae*	
Sanu sanu	*Ephedra americana HBK*		*Gnetaceae*
Wari chiji	*Stellaria sp.*		*Gariofilaceas*
Wari chapi	*Adesmia schickendantazii*		*Leguminosae*
Torarilla	*Cheilanthes myriophyla*		*Polipodiaceas*
Kanlli	*Tetraglochin cristatum*		*Rosaceae*
undesirable			
Choq'e canlla	*Margiricarpus pinnatus*		*Rosaceae*
Chinchircoma	*Salviaopositiflora*	*Bromelaceas*	
Waraq'o	*Opuntia pentlandii Salm. D.*		*Cactaceas*
Khota	*Azorella sp.*		*Compositae*
Muña	*Minthostachys setosa*	*Labiadas*	
Airampu	*Opuntia soechrensii* B. R.		*Cactaceas*
Cacto	*Cactus Opuntia*		*Cactaceas*
Yareta	*Azorella compacta*		*Umbelíferas*
Itapallu	*Cajophora horrida*		*Urticaceae*
Iruya	*Festuca orthophylla*		*Gramineae*
Ñak'athcila	*Fabiana denudata Niers*		*Solanaceas*
T'antathola	*Baccharis obtusifolia HBk*		*Asteraceas*
Violeta	*Astragalus sp.*		*Leguminosae*
Macha macha	*Oxalis corallecoides Knutn*		*Oxalidaceas*
Chillca	*Senecio sp.*		*Compositae*
Garbancillo	Astragalus *garbancillo*		*Leguminosae*

Source: Chila, M. 1992, AGRUCO

It is not possible to expand more on this theme within the scope of this document. To summarize: in the Andes, biodiversity, its management, conservation and characteristics are important to the context of the traditional organization of production and of existing agro-pastoral systems.

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Connectivity: key in maintaining tropical rainforest landscape diversity

A case study in Los Tuxtlas, Mexico

Sergio Guevara

Introduction

Mexico is facing a profound crisis in the conservation of its biological diversity. Simplistic single species tactics and confinement approaches to protecting wildlife are not sufficient. Individual species protection is certainly still critical, but is essentially useless without directing efforts to habitat protection as well. Habitat loss, fragmentation and isolation are the most common causes of species extinction (Hudson, 1991).

Although the establishment of protected areas is beneficial and necessary, it is clearly insufficient. This strategy by itself is not going to succeed in the preservation of Mexico's remarkable biodiversity.

Mexico is a country with some of the highest biological diversity in the world (Toledo, 1988). This diversity is linked to the country's geological history and geographic location. The two biogeographic regions of the American continent: the neoarctic and neotropical, merge in Mexico. This, together with the country's complex topography, produces an intricate mosaic of environmental conditions. The heterogeneity, variation in extension and isolation of habitats explains the endemic richness in Mexico's local flora and fauna.

Furthermore, Mexico has a huge number of indigenous groups, each with its own system of natural resource use and management. The myriad cultural traditions and lifestyles imposed on the natural world implies a substantial fragmentation of habitats. Actually, the extent of fragmentation and the degree of isolation vary greatly, as do the types of management systems. In addition, current land tenure laws produce problems and conflicts where ancestral or traditional views confront modern ones. The task of biological conservation, already difficult, is especially problematic in Mexico.

Less than three per cent of the country's almost two million square kilometres is protected (SEDUE, 1989). In addition, protected areas do not operate adequately. This results from a shortage in funding and personnel for adequate care and maintenance, and from the lack of a management plan, and is why protected areas don't achieve their objectives. Natural reserves in Mexico administrated or linked to academic or research institutions function better.

There is an urgent need to examine the remaining biological diversity and the semi-natural and transformed landscapes that cover most than two-thirds of the surface of the country.

The humid tropics in Mexico

The territory of Mexico can be classified in ecogeographic regions based on geomorphology and climate characteristics. This study refers to the region known as the humid tropics. In this ecogeographic region the mean annual precipitation exceeds 2000 mm, and the mean annual temperature is higher than 20°C (Toledo, 1994). The region comprises 20.5 million hectares, almost ten per cent of Mexico's total land mass, and is the most diverse of the country's regions. Ecosystems in this regions are tropical evergreen rainforests, mangroves, savannas and swamps.

The humid tropics of Mexico have the country's longest history of human occupation. There are many archaeological sites, including those of the Olmec and Maya. For more than 3000 years, natural resources of the humid tropics have been intensively used and managed by indigenous groups. Some very well-preserved Mexican tropical rainforest coincides with the location of ancestral indigenous groups. This is the case of the Lacandona rainforest in Chiapas and Chimalapas in Oaxaca.

Protected areas in the Mexican humid tropic comprise 500,000 hectares, less than 2.5 per cent of the country's total area. The Biosphere Reserve of Montes Azules has 331,200 hectares, and is the only reserve in the humid tropics so recognized by UNESCO and IUCN. The rest are smaller areas mostly administrated by academic institutions or NGOs.

Human activities in Mexico's humid tropic landscape have been such that it is not possible to conserve biodiversity solely within protected areas. The need to preserve the immense biodiversity of this region compels us to find a way to maintain native species in areas transformed and used by humans. The question is whether rainforest remnants can be preserved for a long time within productive agro-systems.

Consequences of forest fragmentation

Habitat fragmentation is the greatest threat to biological diversity. It is well-known that the establishment of pastures and crops has caused an alarming reduction in the area originally covered by tropical forest in the Americas. However, the fragmentation of these forests and its ecological consequences have not been sufficiently studied and are poorly understood.

Forest fragmentation affects indigenous populations in two ways. First there is a reduction of the total habitat area, which reduces population size, and increases local extinction rates. Second, the remaining area is fragmented, which limits dissemination and immigration rates (Wilcove, et al. 1986). Thus, there is a reduction in the effective population size, which could be smaller than the total count of surviving individuals by a factor of ten. If effective population sizes persists at a minimum level over several generations, there would be a considerable loss of genetic variation and an increase of genetic drift (Forman and Godron, 1986; Turner, 1989).

In the tropical rainforest (TRF) there is an outstanding richness of trees per unit area. Most tree species have a low density. In addition, many plant species depend on animals for reproduction (insects, birds or mammals for pollination and frugivorous species for seed dispersal). Small and isolated TRF fragments could not be maintained as such if isolation precluded the immigration of animals or seeds of rainforest species. If isolation is complete, then by the next tree generation these fragments would have vanished without cutting a single tree.

Remnant habitats of TRF within landscapes affected by human activity are fragments whose size varies widely, from dozens to hundreds of thousands of hectares. In Mexico, as in the rest of South and Central America, these remnants are part of a human-made matrix dominated by pastures. The current view is that tropical pastures are considered to be deleterious and inhospitable for TRF species.

TRF plants suffer from hampered seed germination or seedling establishment due to environmental conditions in these areas; they also face competition from heliophytic ruderal herbs of pastures (Uhl, et al. 1988). More than 80 per cent of TRF woody species depend on frugivorous vertebrates for seed dispersal (Howe and Smallwood, 1982). Animal seed dispersers avoid pastures and remain in large remnants of natural TRF habitat. The extent and non-cyclical nature of tropical pasture, its inhospitability for seed dispersers and for the establishment of TRF plants are the main impediments to the regeneration and preservation of TRF (Gómez-Pompa, et al. 1972). Assessing the degree of isolation or the extent of any connection between TRF remnants is badly needed, as is the identification of elements that influence the relationship.

These are the main objectives of the research being conducted at Los Tuxtlas. Results show that rainforest habitats, species and populations were still found, even in severely fragmented landscapes devoted to raising cattle. It is proposed that connectivity is a key landscape process in the maintenance of TRF diversity in human-modified agro-systems.

Case study: Los Tuxtlas

Los Tuxtlas is a volcanic range isolated in the coastal plain of the Gulf of Mexico in the state of Veracruz. It is in the humid tropic region, and originally was mostly covered by tropical rainforest. The mountain range of Los Tuxtlas extends approximately 90 kilometres in a NW-SE direction and 50 kilometres in a SW-NE direction. There are two main volcanoes, the San Martin (NE) and Santa Martha (SW), which are, respectively, 1650 and 1700 metres above sea level. Mean annual precipitation varies from 4000 to 5000 mm at the Gulf slope (north), and between 3000 and 4000 mm at the inland slope (south). The mean annual temperature varies from 23 to 27°C.

By 1980 there had been a huge transformation of the Los Tuxtlas landscape. The extent of vegetation and land-use types in an area of 696,771 hectares, which included the mountain range of Los Tuxtlas, was analyzed in its entirety.

In 1980 there were 89,142 hectares of well-preserved TRF (12.8 per cent of total area), 48,853 hectares of disturbed TRF (7 per cent), and 35,959 hectares (5.2 per cent) of other types of natural vegetation (mangroves, dune vegetation, oak-pine forests, cloud forest, others). The rest of the area included 319,755 hectares of pastures (46 per cent) and 203,062 hectares of different kinds of crop-fields (29 per cent). Of the approximately 500,000 hectares of TRF that originally covered the study area, there were close to 138,000 hectares of TRF in 1980. However, if just the well-preserved TRF is considered, only 89,000 hectares remained by 1980, which is less than 18 per cent of its original extent.

Deforestation and fragmentation of TRF at Los Tuxtlas is linked with the spatial arrangement of settlements, the best preserved areas being those less populated. The pattern of fragmentation at Los Tuxtlas is the same as in other areas of the neotropics (Guevara, in press).

This is an oversimplification of the actual situation, however. Crop-fields and pastures are much more complex and heterogeneous than commonly thought. In Los Tuxtlas, cleared areas are crossed by two-lined corridors of TRF trees at the riversides, and single-lined corridors of planted trees which serve as posts for barbed wire (living fences). Fields are heavily dotted with isolated trees, remnant TRF trees of the canopy or subcanopy.

All these elements suggest a role as biological corridors, linking the landscape, and, in particular, connecting TRF fragments. It is crucial to pay attention to the function of a corridor or connection which could act as a selective conductor. Each one works to promote the movement of some organisms and obstruct others. The problem is evaluating which corridor is letting species in, and which is keeping species out.

In our study we have concentrated on one arboreal component of the landscape: isolated TRF trees, which are frequently present in actively managed pastures. These trees are mainly used as a source of shade for cattle, and sometimes as complementary fodder, but they also supply firewood, lumber and edible fruit (Guevara, 1986).

Isolated spared trees in pastures

When a patch of TRF is felled for agricultural reasons, some portions of the canopy or subcanopy trees are purposely left standing *in situ*. These isolated spared trees (IST), scattered in cleared plots, are common features of today's agricultural landscape throughout the tropics. IST are more common in fields cultivated by old and traditional cultures, however, than in those under modern exploitation systems.

Sparing and protecting selected trees of valuable species during forest clearing and burning is an integral part of cyclic agro-forestry systems. The practice of leaving IST in crop fields was widely and intensively carried out by TRF inhabitants, who used these ecosystems sustainably for centuries (Guevara, 1986).

The type of species present as IST and their frequency and dispersion in the fields depends on the composition of the original forest canopy and on the farmers' selective cutting or tree-felling. Leaving IST has served to protect some useful and venerated species and has met some necessities of present-day inhabitants (i.e. shade-trees for cattle and trees for supporting barbed wired as living fences).

In 13 pastures at Los Tuxtlas, totalling more than 80 hectares, 265 isolated trees were counted. Density among pastures varied between 0.3 and 39.1 isolated trees per hectare; the most common being two to eight trees per hectare. In total there were 57 different species of trees. Of this total, 61 per cent were primary TRF species, 25 per cent were late secondary species, 11 per cent were gap colonizers and 3 per cent had no clear affiliation (Guevara, et al. 1992).

At four isolated fig trees (Ficus *yoponensis* and *F. aurea*) in pastures, we monitored bird visits and seed deposition. Over a year, visiting birds were registered monthly by direct observation during three-day periods totalling 247 observation hours. Seed-traps were located under the canopy of the same trees for six months, and seeds were collected monthly (Guevara and Laborde, 1993).

There were 73 species of birds perched in the trees studied; of these, 47 were frugivorous (close to one third of total frugivorous avifauna reported for the area). In total, 3344 visits were made by frugivorous birds to ISTs, with highly variable visitation rates during the year. These rates varied from 5 to 18 visits per hour in 14 of 15 observation periods. During the 15th observation period an extraordinary visitation rate of 80 visits/hour was recorded (Guevara and Laborde op. cit.).

The direction of arrival of frugivorous birds is not random, but depends on the location of arboreal vegetation around each IST. The flight paths followed by birds also varied in relation to fruit available in neighboring trees of the same or different species, and in relation to the location of nests (Guevara and Laborde op. cit., Bronstein and Hoffman, 1987). As is the case in orchards of temperate regions (Wegner and Merriam, 1979) the movement of frugivorous birds in tropical pastures is governed by the spatial arrangement of arboreal elements in riparian corridors, living fences or ISTs.

Several species of avian frugivores actively visit ISTs throughout the year, when meteorological conditions are favourable for bird activity. Consequently, many seeds of zoochorous species are deposited under the canopy of ISTs in the middle of cultivated pastures. During six months we captured 8268 seeds of 107 species under the four IST studied. Of these, 6,726 seeds (81 per cent) were those of the 56 species dispersed by frugivorous vertebrates. Seeds of tree species (primary, secondary and gap species) were most abundant, accounting for 62 per cent of total seeds. Seed deposition included mature forest tree species such as *Cymbopetalum baillonii, Dendropanax arboreus* and *Guarea glabra.*

Seeds of different species are discharged by frugivorous birds at the canopy of ISTs. In addition, these birds ingest fruits and seeds of ISTs, carrying them to other trees in pastures or even into nearby TRF fragments (Guevara and Laborde op. cit.). At the study site birds disperse plant species over distances greater than 300 metres from the seed source, across the actively managed pastures (Laborde, unpublished data). In the fragmented landscape, remaining TRF fragments are important seed sources of TRF species. Outside these fragments, isolated remnant trees are also seed sources and attract birds and animals to TRF species in pastures.

In the same 13 pastures where ISTs were counted, 50 isolated trees of the most abundant species were chosen (30 fig trees and 20 *Nectandra ambigens).* Vegetation was sampled as follows:

- at each tree three quadrats of four square metres were placed, one under its canopy, another at the perimeter of the canopy, and the last one five metres outside the canopy;

- total richness per site type was 191 species for under-canopy, 111 for perimeter and 106 for pasture sites; and
- the mean number of species per quadrat was 17.8 (±4.3 s.d.), 11.2 (±3.4) and 10.6 (±3.6), respectively, which were significantly different (ANOVA; $F (2,147) = 53.07$; $p<0.001$).

Quadrats under the canopy of ISTs were significantly richer than the other two sampling sites (Zar, 1974). The difference was explained by a higher number of woody species (trees, shrubs, vines) as well as endozoochorous species at canopy sites. Another noticeable difference among sampling sites was the abundance of trees: 278 individuals for all canopy quadrats, 69 and 48 for the perimeter and pasture sites, respectively. Most registered trees were seedlings or saplings (Guevara, et al. 1992).

The composition and structure of vegetation under the canopy of ISTs are clearly distinct from surrounding vegetation. Directly under most ISTs there are several native rainforest species and late secondary succession species, which are uncommon in unshaded pasture sites. Of the 191 species registered in canopy quadrats, 53 were primary forest trees and 51 primary forest climbers, hemi-epiphytes or herbs. Many of them were found exclusively under the canopy of ISTs. The rest of the species have significantly higher densities at canopy sites than outside in open pasture (Guevara, et al. op. cit.). In the fragmented landscape of Los Tuxtlas, vegetation under the canopy of ISTs is more related to TRF vegetation than to perimeter and open pasture sites, as measured by attributes such as species composition, richness and tree density (Figure 6).

Seed deposition data showed significantly higher numbers of colonizing (pioneer) and secondary tree species with small seeds and dormancy (e.g. *Cecropia obtusifolia)*, than mature forest species with larger seeds. However, established woody plants under ISTs are mainly mature forest species with large seeds lacking dormancy (e.g. *Cymbopetalum baillonii)*, and only a few individuals of gap colonizer and secondary species were registered (Table 11). Rainforest species with large seeds germinate and establish successfully under ISTs (Guevara and Laborde, 1993; Guevara, et al. 1992).

Table 11. Seed deposition and plant establishment

This table illustrates the comparison between seed deposition and plant establishment under the canopy of trees isolated in pastures (IST). Only zoochorous woody species are shown; species with small seeds (less than 3 mm) are compared with others with large seeds (greater than 7 mm).

species	seed deposition under 4 IST* (seeds/m^2)	establishment under 50 IST** (plants/400m^2)
with small seeds < 3mm		
Cecropia obtusifolia	231.4	3
Piper hispidum	79.1	35
Piper auritum	34.4	—
Conostegia xaiapensis	42.6	8
Trema micrantha	3.1	—
with large seeds > 7mm		
Cupania glabra	0.5	14
Rollinia jimenezii	0.3	9
Stemmadenia donnell-smithii	0.7	17
Cymbopetalum baillonii	0.2	8
Psychotria chiapensis	0.2	5
Dussia mexicana	—	2
Pseudolmedia oxyphyllaria	—	2

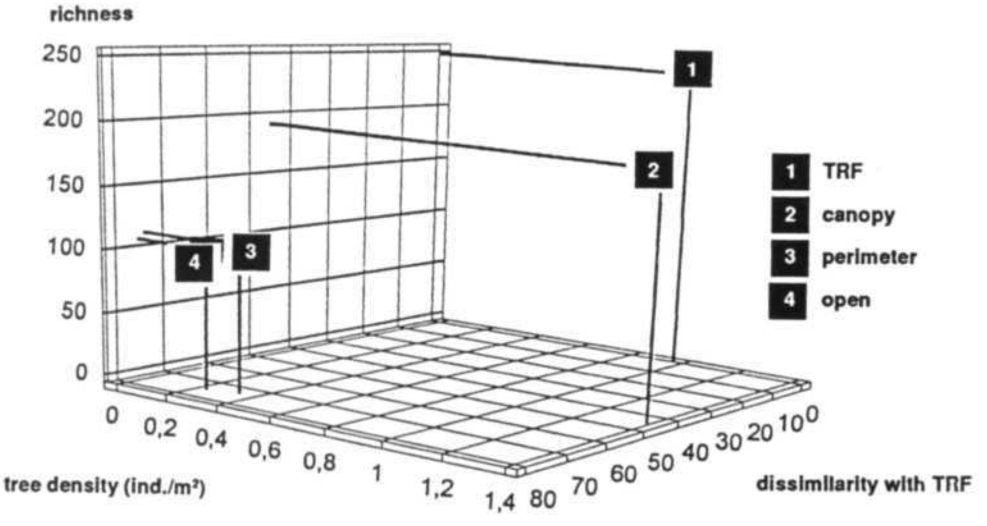
* Seed deposition over six months, under the canopies of four isolated trees of two fig species (Ficus), with 15 seed traps per tree. Total of 60 traps with 11.8 square metres of sample surface (Guevara and Laborde, 1993).

** Number of individuals (mainly seedlings or saplings) recorded under the canopy of 50 isolated trees (30 Ficus spp. and 20 Nectandra ambigens). At each tree one 2 by 2 m quadrat was placed near the trunk and another under the canopy perimeter, totaling 100 quadrat with a sample surface of 400 square metres (Guevara et al. 1992).

Anthropogenic landscapes

Throughout the world, avian and mammalian fruit-eaters have lower taxonomic diversity than other feeding guilds. In despite of this fact, vertebrate fruit-eaters play extremely important roles as seed dispersers in the humid tropics. Many species of fruit-eaters operate in very large territories. Ephemeral patchy resources encourage high mobility, which can in turn profoundly affect many aspects of the lives of frugivores. Because of their daily and seasonal movements these species serve as mobile links between plant populations, communities and habitats over large geographic areas (Fleming, 1992).

Figure 6. Comparison of vegetation attributes



Comparison of vegetation attributes between one hectare of tropical rainforest (TRF) and three sampling sites related to 50 isolated trees in pastures of Los Tuxtlas (see text for definition of canopy, perimeter and open sites; sampling area for each one was 200 square metres). For the TRF-plot all individuals with dbh >= 1.0 cm were registered (Bongers et al. 1988). For the calculations of dissimilarity values (1-Ss) in species composition, only fully identified species were included, and 44 obligate epiphyte species registered at the TRF were excluded.

We still have limited knowledge of how barriers and corridors work. Neither do we have adequate models for dispersal of animals or plants through heterogeneous environments. Most of the models of dispersion assume a homogeneous environment and a random walk (Lubina and Levin, 1988).

Corridors may increase the odds of persistence by providing fresh individuals. Immigrants can rescue a population from a crisis of too few individuals (Brown and Kodric-Brown, 1977) or from inbreeding (Frankel and Soule, 1981). Immigrants can also recolonize an empty habitat patch, where the target species was locally extinct.

A corridor must be tailored to the needs of the species it is designed to serve. In certain circumstances a corridor may have a negative effect on a target species. For example, a species could be exposed to higher rates of predation in the corridor, which would then become a sink corridor (Soule, 1991). The optimal scale for planning and managing habitat connectivity depends on the biota under consideration and the goals of the conservation strategy (Noss, 1991).

Studying the role of isolated trees in pastures is one step in the design of landscapes, where the main goal is a profitable and sustainable exploitation of natural resources in human-modified ecosystems without threatening their native biodiversity.

Spared TRF trees, standing in crop-fields or pastures, are a common feature of today's fragmented landscapes in the tropical Americas. They form living fences, growing in domestic orchards (home-gardens), along rivers and roads or isolated in fields or pastures. They are important in the regeneration of forest vegetation after plot abandonment or during fallow period in old fields (Guevara et al. 1992) and are important in traditional and modern agro-forestry.

Preserving TRF trees during crop cultivation or pasture exploitation helps increase the connectivity of TRF fragments. In the transformed landscape, there would be greater possibilities of long-term maintenance of populations of TRF species which survive deforestation. The latter will help preserve the native animal and plant diversity in fragmented landscapes.

Care should be taken with the design of human-transformed landscapes; in particular the nature, location and functionality of possible corridors for native local populations. The presence of isolated remnant TRF trees is highly promising, since they operate as efficient connecting devices. This observation is based on results from the Los Tuxtlas pastures, where a high proportion of the local flora under ISTs was found, particularly those linked to TRF. Apparently, the ruderal and heliophytic plants of pastures are discouraged or their cover reduced under the canopy of isolated trees (as with Mimosa *pudica,* for example). Early succession and gap colonizer trees with small and abundantly dispersed seeds had low densities of established individuals in comparison with large-seeded primary tree species, in spite of their higher seed deposition.

Isolated TRF trees in pastures are a remnant diffuse corridor highly efficient for conservation purposes. They selectively favour the connectivity of TRF plants, increasing the degree of functioning into a demographic unit for their split individuals, which remain in the landscape after fragmentation.

Conclusions

Even if Mexico's protected areas in the humid tropics were to triple, more than 90 per cent of this region (approximately 19 million hectares) would be outside protected areas. The future, if any, of Mexican tropical rainforests relies on what will or won't be done.

A minimum natural habitat as well as target species must be protected in order to conserve Mexico's biodiversity. It is vital to include areas of indigenous settlements, which possess a representative and stable proportion of the region's biodiversity.

Human presence alone is not the cause of biodiversity depletion; current exploitation systems are to blame. It is possible to use and manage humid tropical areas, even raise cattle, without threatening biodiversity. Landscape patterns and processes (sensu Turner, 1989) have to underlie the design of human-dominated landscapes, where preservation of TRF diversity and sustainable development meet. Connectivity must be one of the main guidelines in decision-making.

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Agropastoralism and biodiversity conservation in East Africa

The case of Maasailand, Tanzania

Raphael B. B. Mwalyosi

Abstract

The arid and semi-arid areas of East Africa are known for their spectacular local diversity and an abundance of large wild herbivores. For many years these areas have also been inhabited by nomadic pastoralists. Particularly of note are the Maasai who, to a large degree, have co-existed with wildlife.

These marginal areas are too dry for rain-fed agriculture, although extensive areas have recently been converted to cropland, thus reducing the amount of grazing land. This is a result of increased human population pressure and the subsequent increased demand for land to grow food crops. Many of the pastoral communities have been forced into agro-pastoralism.

The traditional and sustainable Maasai system of rangeland resource management was supplanted by new power structures following villagization in the 1970s. This trend has imposed a new pattern of settlement and land use that is difficult to reconcile with pastoral values. The new pattern of land use has led to habitat loss, resource degradation and extinction of both plant and animal species.

In this paper, it is recommended that traditional pastoral communities like those of the Maasai should be allocated specific areas for rotational grazing to allow livestock raising. This will entail a change in the existing land tenure policy to allow for communal property ownership and institution of grazing control measures. It is also recommended that efforts be made to study traditional management systems and improve upon them to ensure their sustainability. In addition, it is argued that development policies and strategies should be re-focused in order to bring about the most benefits.

Introduction

The term agro-pastoralist stems from the Latin word for farmer, "agricola", and from the word "pastor" which means shepherd. The word describes someone who is a farmer and who also keeps freely-grazing livestock.

The East African arid and semi-arid areas are characterized by a short rainy season (less than 500 mm annually) with irregular intense showers, a long dry season with no precipitation and high evapo-transpiration. These conditions make the area too dry to sustain rain-fed agriculture. Originally, such marginal areas had low human populations because of their low and unpredictable primary production.

In recent years, however, human population has increased in these areas and rangelands are being opened up for crop cultivation. Many previously pastoral communities now base their livelihood on settled agriculture and semi-pastoralism, i.e. agro-pastoralism. This change in land use may affect the ecology of the rangelands in various ways. It may reduce biological diversity, which will accelerate environmental degradation and so threaten the future of both human and non-human life.

This paper addresses the problem of introduction of crop production in Tanzania's Maasailand and its effect on biodiversity conservation.

Environmental description

The area encompasses some 35,000 square kilometres. It is surrounded by the Serengeti and Ambroseli national parks, Mount Meru and Kilimanjaro and some ecosystems to the south, the boundaries of which are unclear (Figure 7). The Maasai ecosystem described here is the area defined by watershed boundaries centred on Lakes Manyara and Burunge, and by boundaries between populations of migratory/nomadic large mammals.

To the north, east, and south, the boundaries of the ecosystem are rather vague; watersheds are ill-defined in these arid regions, and, in this area with few roads, animals have not been studied in depth.

Biodiversity aspects

The arid and semi-arid areas of East Africa have high local diversity and large numbers of large wild herbivores and livestock. Such diversity and abundance is maintained by ecological segregation through size, habitat and food preferences, as well as migration.

The ecosystem is rich in habitat and ecosystem biodiversity. The area below 1300 metres above sea level is arid, while the area above this line — the Mbulu Plateau and the Crater Highlands — ranges from semi-arid to humid (Pratt and Gwynne, 1997). Rainfall varies with altitude, ranging from 434 mm per annum at about 820 metres above sea level to 99 mm per annum at 2285 metres above sea level (Prins, 1987).

In the arid lowlands there are small moist enclaves, including Lake Manyara, ground-water forest, rivers etc. More typically, however, the lowlands (1000 metres above sea level) are covered by grasslands, where drainage is poor, and by volcanic thickets and acacia woodlands. The escarpment of the

Rift Valley is covered by Commiphora bushland and bush thicket, while the natural vegetation of the Mnbulu Plateau (1400 metres above sea level) is broad-leafed wooded bushland. *Podocarpus* and *Olea* forest occur naturally in the highest parts (2000-3200 metres above sea level). The Maasai ecosystem has very high plant species bicxJiversity compared to similar environments, such as the Serengeti (Mwalyosi, 1992a).

Figure 7. The Maasai ecosystem

Redrawn from Prins, 1987

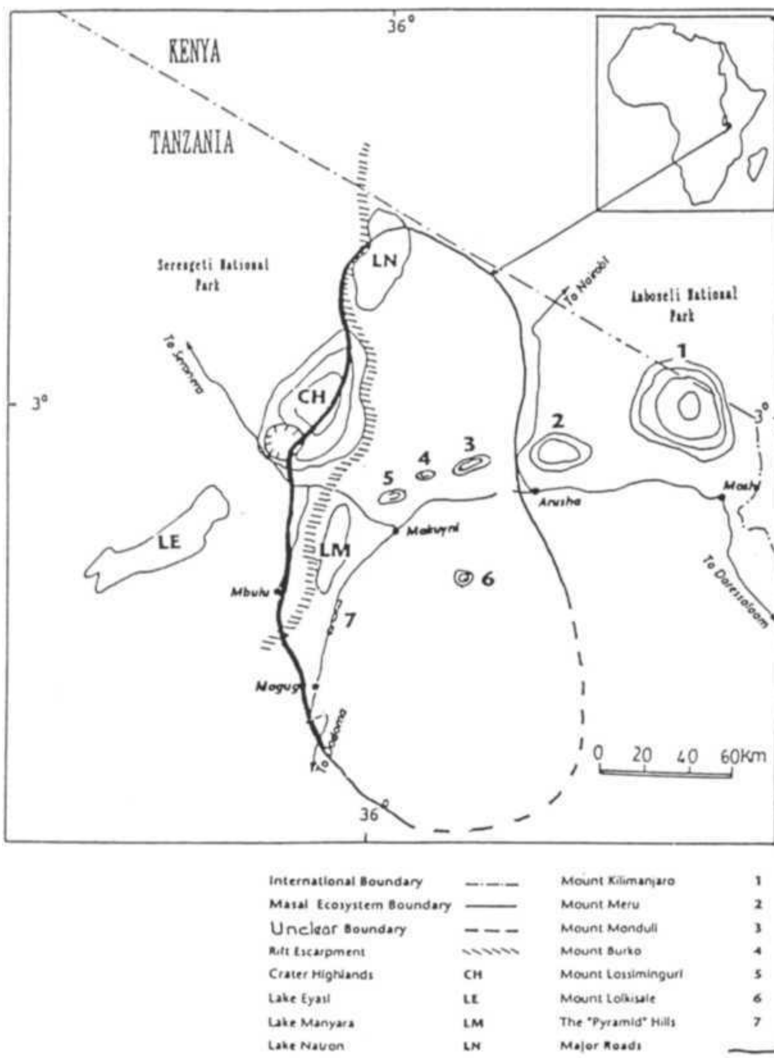
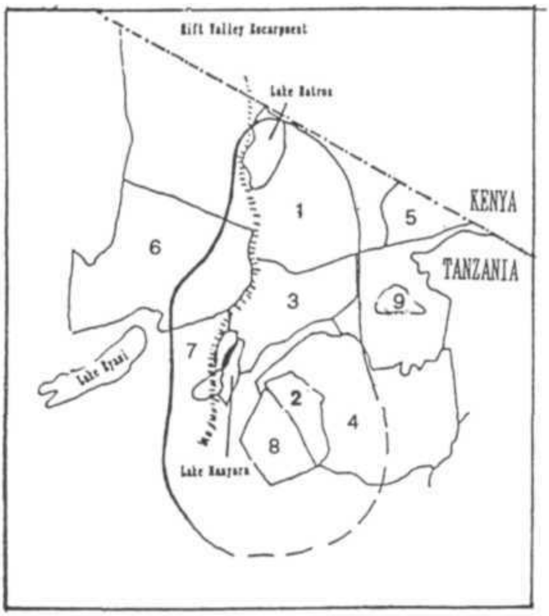


Figure 8. Conservation status within the Maasai ecosystem



1 L. Natron Game Controlled Area
2 Losiminguri Game Controlled Area
3 Mtowambu Game Controlled Area
4 Simanjiro Game Controlled Area
5 Longido Game Controlled Area
6 Ngorongoro Conservation Area
7 Lake Manyara National Park
8 Tarangire National Park
9 Arusha National Park

The Maasai ecosystem supports some of the biggest large-mammal migrations in Tanzania. During the peak dry season wildebeest (*Connoc/uzetus taurinus*), zebra (*Equus burchelli*), Thompson's gazelle (*Gazella thompsoni*) and Grant's gazelle (*G. granti*) concentrate in Tarangire and Manyara National Parks and the Simanjiro Plains. Other species include buffalo (*Syncerus caffer*), impala (*Aepyceros melampus*), Coke's hartebeest (*Alcelaphus buselaphus coki*) and cheetah (*Acinonyx jubatus*). The Rift escarpment forms a genetic separation between the Serengeti wildebeest (*C.t. albojubatus*) and the Rift Valley wildebeest (*C.t. hecki*) as well as between the eastern and western Thompson's gazelle (Prins, 1987).

The ecosystem is also heavily utilized by Maasai livestock. During the dry season Maasai cattle (*Bos taurus Linn.*) constitute about 90 per cent of the grazing biomass (500 kilograms per square kilometre) of the Simanjiro Plains. Other livestock species include goats (*Cappra hircus Linn.*), sheep (Ovis *aries Linn.*) and donkeys (*Equus asinus Linn.*).

Functional aspects

Biodiversity conservation in the Maasai ecosystem has mainly been confined to the protected areas (Figure 8). It is now realized that there is significant biodiversity in the non-protected development areas. These lands are subject to increasing degradation and resultant biodiversity loss because of human population pressures. Degradation of natural resources has an adverse effect on the conservation of biodiversity, and so endangers species in two distinct ways:

- land degradation directly affects protected areas (PAs) or triggers the dispersal of game populations into adjacent public or private lands, which often results in direct encroachment and reduction of productivity; and
- land degradation leads to reduced returns for local communities and industries, so causing a further demand on resources of other non-degraded lands, including PAs.

Apart from biological and ecological importance, the biodiversity of Maasailand has consumptive values that include commercial harvesting and sale of resources such as meat, leather, honey, timber, and aviary birds. Such resources are found in private/public lands and game controlled areas. These varied products make a substantial contribution to both the local and export economy of Tanzania.

Other consumptive values of biodiversity include the use of wood and dung (accounting for over 90 per cent of total domestic energy needs) and the use of wildlife products for everything from medicines to house construction. In most cases these uses occur without the products being formally marketed; therefore their value does not appear in the national income accounts.

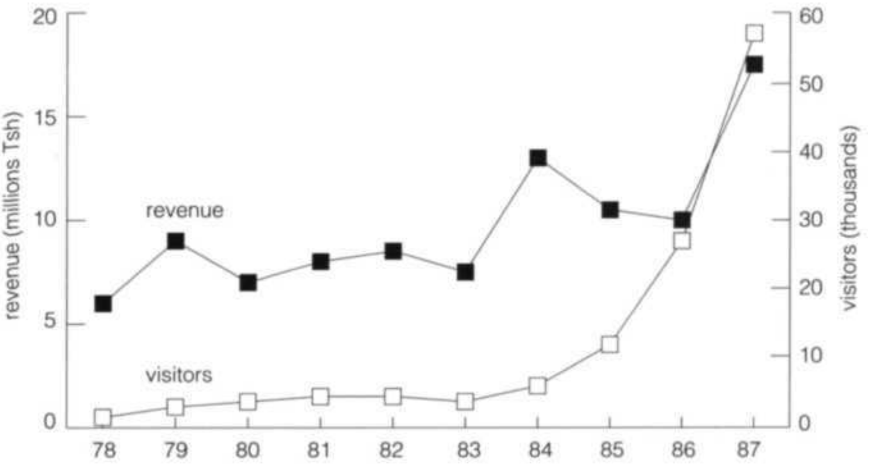
Tourism and the pursuit of activities such as hunting for pleasure are based on the rich biodiversity of the area. The geography and abundant wildlife of the Maasai ecosystem attracts many visitors from within the country and around the world. Tourism is an important source of foreign exchange for Tanzania. Lake Manyara National Park ranks third after Ngorongoro Conservation Area and Serengeti National Park in terms of average number of visitors (Figure 9). It has about 288 visitors per square kilometre, the highest ratio among the Tanzanian parks (Prins, 1987). It ranks second after Kilimanjaro National Park in terms of revenue (Mmari, 1989). Activities like big-game hunting, photographic safaris and camping depend on the continued existence of the species and their habitats.

Management practices

The majority of the people who live in the ecosystem are Maasai, although other tribes are also represented. Traditionally, the survival of the Maasai was based to a large degree on a wide spectrum of adaptive livestock grazing strategies designed to minimize the effects of drought. These strategies included rotational grazing, organized management of communal grazing, diversification of livestock herds and redistribution of stocks. In general, it was a sustainable and ecologically sound system (Arhem, 1986).

Figure 9. Visitors and revenue, Lake Manyara National Park

From 1978 to 1987; After Gamassa. 1988



One of the ecosystem's basic tenets was that it was not aimed at providing a marketahle surplus, hut producing a good, regular supply of food for families to enable them to survive physically and socially and to maximize the chances of their surviving prolonged droughts and other risks. Traditional Maasai management strategies ensured that families had the right type of livestock at any given point in time and that the size and maturity of the family had a hearing on herd size and composition. Thus, younger families tended to have herds which produced more milk for children (Ole-Kuney, 1992).

Traditionally, the Maasai were grouped into geographically-bound sections (Olosho), which were self-contained ecological units with well-defined boundaries. These boundaries constituted the limits of livestock movements and of control for pasture and water in the same territories. These were overlain by clans and age-set systems that provided support for both the household and the communal relationship.

Within the network there were various customary rights and obligations related to grazing and water use, which defined clearly the ownership of property. Each territory, clan, and/or age-set had traditionally nominated leaders with varied authorities and judgement powers. The Maasai had rules and regulations which governed the use of water, pasture, animal movement and control of vegetation and trees. They had institutions, in the form of schedules for watering, for controlling communal use of the scarce water (Figure 10). The strategy was hased on the availability of water as a determining factor for the extent of grazing during both the dry and wet seasons. It also determined the concentration of animals and pattern of settlement within the same rangeland (Ole-Kuney, 1993).

The recent history of Maasailand is one of land loss and marginalization. During the colonial period (1940s and 1950s), extensive areas of Maasailand were alienated for estate farms and game reserves (Kjekshus, 1997), squeezing the Maasai into a smaller land area. At the same time, local agriculturalists from the best highland areas were moved to Maasailand, giving way to European farmers. Thus, population growth rate in Maasailand grew rapidly to 42 per cent per year during the 1980s. This was higher than regional and national rates (3.8 per cent and 2.8 per cent, respectively) and was attributed to immigration and natural growth (Mlay, 1981; Mwalyosi, 1992b).

In the mid-1970s introduction of the Tanzanian Villagization Programme led to the partial settlement of the nomadic Maasai and their subsequent change in life-style to agropastoralism. As a result, the traditional Maasai system has been supplanted by new power structures. These involve village chairmen and secretaries, who are often young men appointed by the government from anywhere in the country. Such people are usually not motivated by matters of local resource management or conservation. This creates a power struggle with traditional elders in the village.

In effect, villagization represented a step towards the imposition of a new settlement and land-use pattern that is difficult to reconcile with pastoral

Figure 10. Traditional water conservation practices

Schematic presentation of Maasai traditional institutions for controlling scarce communal water (modified from Ole-Kuney, 1993)

values. By 1987, about 10.5 per cent of the land in southwest Maasailand was under cultivation, mostly commercial farms. Although over 89 per cent of the land was still available for grazing, effective extensive grazing was restricted by tsetse fly infestation. The tightly-knit and sedentary settlement pattern, together with increased commercial farming, has restricted the nomadic life style of the Maasai and game animal migration. The result has been a reduction of dry season pastures, a decline in pasture quality due to overgrazing, an intensified competition between wildlife and livestock for pasture and water, and a restriction of individual livestock holdings and herds.

The current livestock biomass per household is only 6.4 units, which is 74 per cent less than the minimum estimated biomass requirement for a Maasailand household. In order to meet household requirements, pastoralists have been forced to grow crops (Mwalyosi, 1992b).

Most peasants and commercial farmers in Maasailand do not use fertilizers and/or manure in agriculture (Mwalyosi, 1991), but are actually agrico-pastoralists (Fukui, 1968). Because yields are relatively low, production is improved by expanding cropland at the expense of grazing. This is evidenced by the dramatic increase in ox-drawn ploughs and tractors during the 1980s (Mwalyosi, 1992b). More and more of Maasailand is coming under the plough and with this, biodiversity is being eroded.

Between 1957 and 1987, cultivation in southwest Maasailand increased by about 450 per cent, while woody cover decreased by 77 per cent, contributing to a 16 per cent increase in grassland and 33 per cent increase in bare ground (Mwalyosi, 1992b). The carrying capacity of cropland (0.4 hectares per capita) is already exceeded by about 86.5 per cent, while that of grazing land (2.9 hectare per capita) is below requirement levels by at least 87 per cent. These developments are likely to have profound effect on the management of the pasture resources and biodiversity in general.

Social context

In the past the Maasai did not hunt game animals for food; literally ignoring wildlife, they actually considered it a "non-resource". They obtained all their subsistence from domestic animals (flesh, milk, blood, or sale of animal products). Today, the Maasai are known to kill wild animals for food as well as for the sale of animal products. This is due to changes in the economic environment of the area.

It is estimated that a family size equivalent to 6.5 adults needs 21 kilograms of milk a day, which requires at least 35 to 40 head of cattle (Widstrand, 1975). The dwindling livestock units per household suggests that subsistence requirements cannot be fully met from livestock. Milk yields of local zebu cows is below 250 kilograms per annum; considering the high calving rate (60-70 per cent) and short lactation period (155 days), it seems difficult to expect more than 180 kilograms of milk to be available for human consumption from one cow in one year. To produce one litre of milk, a cow needs more than nine kilograms of fodder (Stile 1998). With the diminishing rangelands, decline in livestock productivity is inescapable.

Environmental consequences

In Tanzania, natural woody vegetation is receding at about 300,000 to 400,000 hectares (0.9 per cent) per annum (MLNRT, 1989). The rate in Maasailand (2.1 per cent) is therefore excessively high. The existing area of woody resource per capita in the study area is only 0.2 hectares (Mwalyosi, 1991). As this resource base is needed to provide building materials and fuel, the population in the area already exceeds sustainable density in terms of woody resource requirements.

Previous studies (Heady, 1960; Peterson and Peterson, 1980) suggest that in the past, Maasailand was dominated by *Themeda-Hyparrhenia* grasslands. Peterson and Peterson (1980) reported the disappearance in the late 1970s of *Themeda triandra* throughout Maasailand. The change was attributed to the lack of burning and to overgrazing by livestock and wildlife. In the absence of fire this species declines, which might be the case in the Maasai ecosystem. The absence of fire is mainly due to low fuel loads; high grazing pressure keeps grass cover low. The short grass stage in East Africa is considered by Heady (1966) to be a retrogression from the original climax formation. Further evidence of retrogression in Maasailand is shown by the higher incidence of annuals than perennials, and of unpalatable grasses (Mwalyosi, 1992a).

Soil erosion is the clearest manifestation of declining range condition (Wilson and Tupper, 1982). The soils of the study area are highly susceptible to erosion (Ecosystems, 1980; Hathout, 1983). The lack of vegetation cover in overgrazed areas resulted in excessive surface run-off and gully erosion during the rainy season. Gullies were also initiated by human tracking, and more often by cattle tracking to and from grazing and water sources.

Problems and pressures

In recent years, overstocking in localized areas has been caused by the settlement of pastoral people into permanent villages, the abolition of traditional land tenure system, the adoption of agricultural policies favouring crop production, the rapid growth in human population and the resultant increase in the demand for land to produce food. In such areas continuation of traditional range management practices (extensive grazing) has led to severe loss of vegetation and environmental degradation. Elsewhere, overgrazing has led to deterioration of the range condition in the form of soil erosion and fewer palatable grazing grass species (Mwalyosi, 1992a).

The gradual reduction of grazing in Maasailand has led to such extensive commercialization of the pastoral economy that milk, once the main diet of the Maasai, is giving way to a mixed diet. A wide range of agricultural products is becoming important. So far, the only technological input that has gone into livestock operations has taken the form of water and veterinary programmes, both of which have been aimed at containing pastoralists, or protecting others from them. There has been little input in such areas as grazing and/or grass improvement, seeding and fertilizing pastoral land, insect pest eradication, anti-erosion measures, organization of viable marketing systems or provision of mobile slaughter facilities. As a result, livestock management has become a dwindling industry.

Expansion of agricultural settlement is not compatible with wildlife conservation. Game migration in the area has gradually been restricted (Figure 11) and several animal species have become extinct. Results from field research by Newmark (pers. comm.), indicate that Lake Manyara National Park has already lost four species of large mammals; Arusha National Park and Kilimanjaro National Park have each lost two species and Tarangire National Park one species. Game migration after the long rains (May-June) coincides with crop ripening in the area. Crop destruction by livestock and migrating wild animals create conflicts among pastoralists, conservation authorities and farmers. As human population pressure increases, pressure on the parks and the remaining grazing also increases, threatening the survival of the remaining biodiversity centres.

Possible opportunities

Group ranches

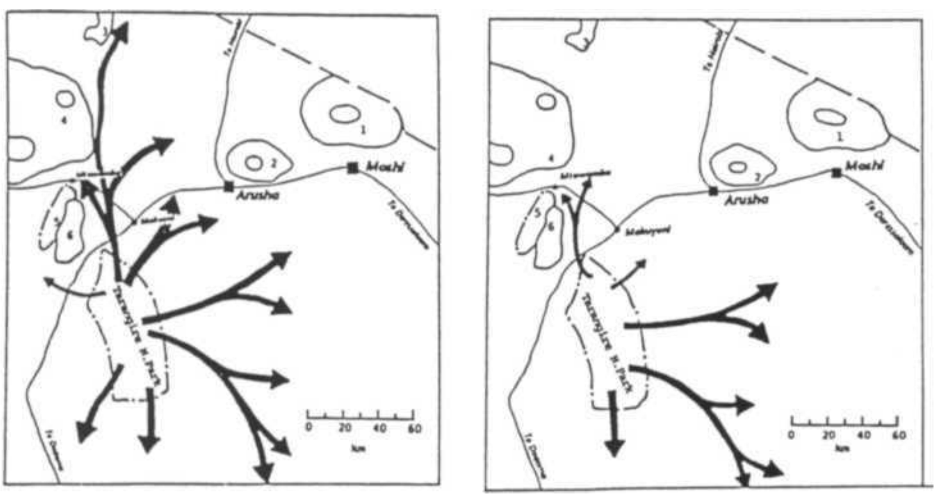
Group ranches or ranching associations were introduced in Maasailand in the early 1970s in an attempt to constrain pastoral migrations to smaller land areas. The associations were open to voluntary membership and were to be controlled by committees. They were incompatible with the established traditional structure. The group ranch system did not last long enough to be tested, being overtaken by the villagization programme in 1975.

A major disadvantage of ranching associations is the lack of flexibility among the groups that jointly exploit a range at a given time. Moreover, the system is not based on stable arrangements, nor on structural units. Ranches cannot be built around social units that do not exist. The experience in Kenya with ranching associations has been partly negative because vested private interests are subdividing the group ranches and selling them, leaving some of the Maasai destitute (Graham, 1989).

Despite the many problems associated with the ranching concept, it is still a viable way of utilizing land in a sustainable manner and could save the pastoralist from marginalization in the face of existing statutory regulations. The concept should be reviewed so that pastoralists receive exclusive leasehold right of occupancy in consideration of their traditional or communal land rights. The government should actively collaborate with traditional institutions, and try to facilitate the evolution of such responsive resource management systems from a grass roots level.

Figure 11. Changes in game migration

Migration routes in 1964 (left) and 1985 (right): redrawn from Borner. 1985



Rotational grazing

The Maasai are capable of maintaining large flocks and herds on arid or semi-arid lands; land with persistent vegetation cover favours ticks, flies and worms. The unaided peasant is helpless against the ravages of these pests. Because overstocking tends to produce aridity and to reduce the incidence of parasitic diseases, native stock owners favour it. They prefer seasonal losses from starvation, which they can understand, to continual and greater losses from disease, the nature of which is beyond their comprehension.

It is recommended that truly pastoral villagers who live nomadic or semi-nomadic lives should be allocated specific areas that are suitable for livestock raising. They should then be allowed to practice rotational grazing in those areas instead of using unsystematic ways of moving their animals in search of pasture and water. This will involve evacuating land around watering points during the whole of the growing season. People would move to allocated tsetse-free land which has no stock and go back to the watering points during the dry season. This will mean instituting grazing control measures by government. The government should also provide well-planned watering points and veterinary services.

The most important principle of such a scheme is the complete resting of more than half the grazing land during the entire growing season. In compliance with the demands of the scheme, alien squatters should not be allowed to cultivate near permanent water in fly-free areas. They should move their stock out of the area except for a few milking cows if required.

Lessons for the future

Current resource use in Maasailand is not sustainable. At the present rate of population growth, both human and non-human inhabitants of the area face a severe threat to their existence. The primary management objective in this area should be to ensure the long-term maintenance of livelihood of the local people.

The immediate measure needed to achieve this objective is to correct the inadequacies of existing land tenure policy to allow for communal property ownership in Tanzania. Existing laws regulating land tenure are both confusing and outdated. It is encouraging that some laws are being reviewed and rationalized, including the Villagization Act, 1975; Range Development and Management Act, 1964; Land Use Commission Act, 1984; and the Grazing Ordinance Cap. 155 (Masaki, 1992). Traditional pastoral practices are capable of effective regulation of land use when blended with modern techniques, and may lead to development of sustainable pastoral systems and conservation of biodiversity.

Although traditional land husbandry systems are now believed to be sustainable (Repetto and Holmes, 1983; Eden, 1987), they are not being assisted or given the opportunity to evolve to higher technological levels. They are instead an over-taxed, impoverished and neglected sector. Efforts should be made to study traditional management systems and improve upon them to ensure their effectiveness.

It is particularly notable that in East Africa the vast majority of natural resources users are artisanal. But despite the role played by these smallholders in the economy of the region, development policies, especially in Tanzania, have mainly focused on macro-economic issues, which are expressed in a monetary context. Smallholders are left to over-exploit the dwindling natural resources. There is a need to refocus development policies in order to benefit the right targets: the grass roots.

Despite the potential of semi-arid areas to contribute to the national economy, no proper systems for resource management have been developed. Management systems have instead been borrowed wholesale from other regions of the world. If these are not appropriate to local conditions, environmental degradation and loss of biodiversity can result. There is a need for a concerted search for policies and strategies which take into account innovative approaches to natural resource conservation and development. Biodiversity can be sustained and enhanced by encouraging the regeneration of traditional indigenous systems.

Thus, it seems that some form of nomadism remains the best way of utilizing semi-arid and arid rangelands. To make these traditional systems work, there is need for on-farm research into pastoral range/livestock production systems as well as rangelands research and extension services. Research should concentrate on smallholder systems and community needs. Research and development programmes should include those plants and animals now neglected but traditionally valued by local communities. Participatory approaches could be of great use to this end and would help ensure effective management of rangelands and conservation of biodiversity.

Integration of livestock keeping and crop production, micro-climate management and water and soil conservation can be incorporated in traditional methods of agriculture and livestock management to improve productivity. This improved productivity will minimize pressure on natural resources and enhance biodiversity.

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The Indonesian agro-forest model

Forest resource management and biodiversity conservation

Geneviève Michon and Hubert de Foresta

Abstract

Rural life in Indonesia is still greatly dependent on forests, although resource use by local populations often tends to be exploitative. While predation of *in situ* resources does exist, there are also interesting examples of conservative resource management outside natural forests by local populations throughout the archipelago. As native populations' traditional access to natural forests becomes more and more limited, forest resources are often managed through an agro-forestry reconstruction of the ecosystem: the agro-forest. In the present context of degradation of natural ecosystems and of generalized dilapidation of their resources, indigenous agro-forests reaffirm traditional responsibility over natural resources by native farmers and societies. Besides management of useful species, these agro-forests also allow conservation of a good part of animal and plant diversity. In Sumatra, results of a comparative study on biodiversity levels between natural forests, several agro-forests and monospecific plantations show the high potential of this original type of resource management system in conserving forest biodiversity in agricultural lands.

Introduction

In Indonesia, disagreements between the forestry sector and the peasant world have become common. As is usually the case, foresters see farmers as forest destoyers, totally unable to manage forest resources or protect biodiversity. Successive powers in Indonesia, from the Dutch colonial administration to the modern Indonesian Republic, have constantly tried to relocate and assimilate forest people in order to achieve total appropriation of the forest. At the same time, however, the forest's appeal for peasants has been increasing. Beside providing foods and material for daily life and being a reserve of fertility for agricultural fields, the forest has served as a reservoir of potentially cultivable species, from fruit trees to latex and resin species, and presently timber. But, above all, the forest has been the basis of economic exchange between forest dwellers — farmers more than hunter-gatherers, or at least part-time farmers — and the outside world. The age-old involvement of forest dwellers in the trade of forest products has continually gained in importance with the development of communication facilities between the outer islands and export market centres.

Until the 1960s, natural forest covered around 170 million hectares, representing the second largest tropical forest block after Amazonia. Most of this original forest area — 70 per cent of the country — is national forest land under the administration of the Forestry Department, and access to its resources is strictly controlled. Local populations are pushed by economic incentives to extract forest resources or to open forest land, while being restricted from exerting any long-term control over forest lands and resources by administrative and legislative constraints.

In spite of the massive loss of natural forests in the immediate environment of villages, forest resources still contribute to the economy of peasant households. In Indonesia, it is through agro-forestry associations that forest resources are presently managed by local farmers. An important part of the original biodiversity is preserved by means of this original management of useful resources (Michon, 1985; Mary, 1986; Michon and Bompard, 1987).

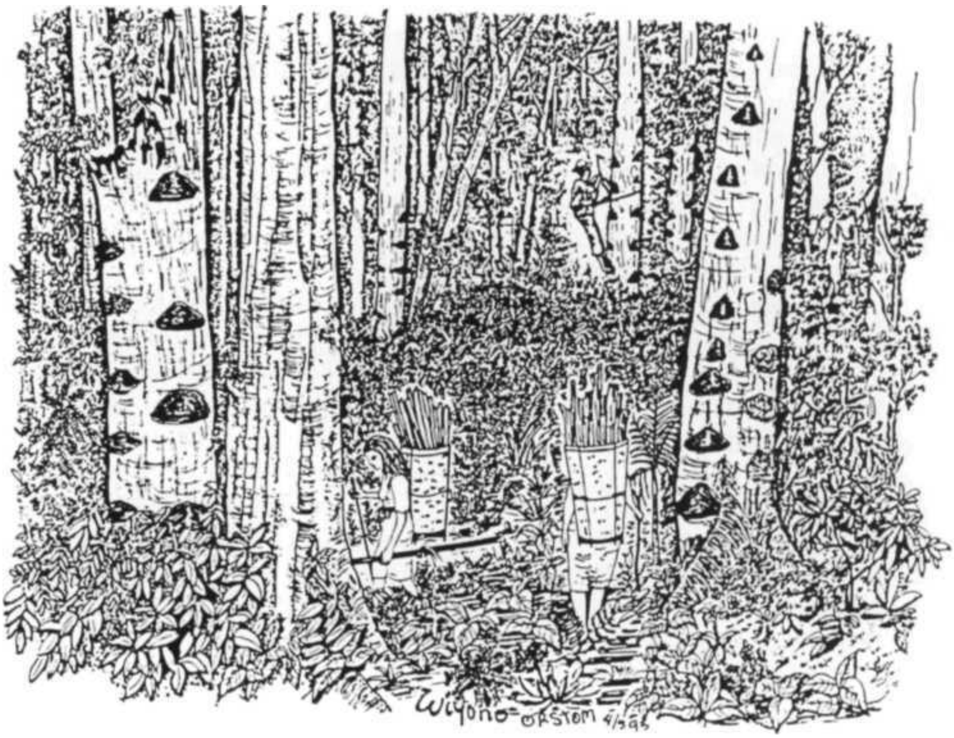
The traditional duality of the forest in the economy of the forest peoples has been an important facet of Indonesian smallholder agriculture. Supplementing staple-producing systems, but always parallel to them, original agroforestry systems have developed which have gradually replaced natural forests in the village landscapes and economies.

An original agro-forestry model

Until now, only two indigenous agro-forestry systems were officially recognized. The first is tumpangsari, an Indonesian version of the taungya system. It was first developed at the beginning of this century by the Forestry Services in Java to improve the management of state-owned teak plantations. The second is pekarangan, the javanese home-garden, which is one of the most sophisticated home-garden systems in the world.

Another farming system is the talun/kebun system of western Java. This involves growing perennial crops: bamboos, fast-growing tree crops and fruit trees — which form the talun phase — on the same land as a mixture of annual crops and seedlings of perennials (the kebun phase, which is a rejuvenating phase of the talun). In Java, farmers also practise dry-land farming. This involves almost every parcel of land being planted with a mix of perennials and annuals: most dry fields include trees either as true components (coconut with maize) or as borders (teaks, mahogany, rosewood, in east and central Java). Trees are also commonly associated with irrigated ricefields, either on dikes or along roads. These trees have a real place in the agricultural system.

Figure 12. Dipterocarp agro-forest, Lampung, Sumatra



Most of these systems are obvious agro-forestry combinations; for example trees and agricultural crops. They involve a small number of components, usually one tree species and one to a few annual or short-cycle species, on the same piece of land. Because of the small number of components, these types of agro-forestry associations will be referred to as simple agro-forestry systems.

Outside Java, however, the outer islands are known mainly for their destructive mode of agriculture, particularly pioneer shifting cultivation. To some observers, vegetation bordering agricultural areas — especially those which are still in transition from the primary forest — is often misunderstood to be a mix of virgin and degraded forest.

But experienced agronomists and foresters know that these are not patches of natural unmanaged vegetation, but are in most cases kebun, the Indonesian word for tree garden or tree plantation. They are, in fact, true agro-forestry plots, with a complex mix of trees and herbs. A whole facet of Indonesian agriculture evolved around traditional forest resources: fruits and spices as well as forest material and commercial products. Integrating these resources in agricultural lands has gradually shaped original agro-forestry systems, in which common domesticated tree species of tropical gardening — various fruit trees as well as ruhher, cinnamon, coffee — are associated with forest trees (Michon, 1985).

This kind of agro-forestry combination, which takes the form of a forest, both in appearance and function, is called complex agro-forestry system or agro-forest (de Foresta and Michon, 1990; de Foresta and Michon, 1991). Such systems involve a high number of components (trees as well as tree seedlings, lianas, herbs); their appearance and function are close to those observed for natural ecosystems, either primary or secondary forests.

These complex agro-forestry systems are encountered in most peasant agricultures throughout the humid tropical world, and are highly developed in Indonesia. The Javanese pekarangan is one of many examples of complex agro-forestry systems.

Most complex agro-forestry systems are not home-gardens, but are far more extended tree plantations. They were developed outside Java, sometimes over hundreds of years, within shifting cultivation systems. These complex agro-forestry systems are quite successful, and are developed with either fruit species, local forest species providing timber and other commercial products (rattans, resins, spices) or exotic trees such as rubber. In terms of quantity and production, their diversity, dynamism and importance make them a major element of smallholder agriculture in the great outer islands.

In the hills and lowlands of Kalimantan and eastern Sumatra, the last tracts of mixed dipterocarp forest are being exploited for timber and rapidly converted. But smallholder "jungle rubber" agro-forests, in which rubber trees are associated with numerous tree species providing either fruits or timber, preserve a diverse forest cover for an estimated area of 2.5 million hectares, complementing either irrigated or dry rice cultivation (de Foresta, 1992; Gouyon et al. 1993).

On the western coast of Sumatra, villagers have used an impressive model of complex agro-forestry for more than 100 years (Figure 12). It is based on a dipterocarp tree exploited for its resin (Torquebiau 984; Mary and Michon, 1987; Michon and Bompard, 1987; Michon and Jafarsidik, 1989; de Foresta, 1992). The illipe nut gardens of west and central Kalimantan are also examples of complex agro-forestry systems integrating dipterocarps (Momberg, 1992).

All over Sumatra, various types of complex agro-forestry systems make use of numerous fruit species as well as economic spices (cinnamon, nutmeg, clove) and timber species (Michon, 1985; Mary, 1986) under a canopy of durian or kemiri trees.

In eastern Kalimantan, impressive fruit forests called lembo have developed, which seem to be among the richest systems as far as tree species are concerned (Sardjono, 1987; Sardjono, 1988; Sardjono, 1992). In Lombok, north Sulawesi, agro-forests are centered around a sugar-producing palm. In the Moluccas, agro-forests associate fruit or nut trees with the traditional spice trees, clove and nutmeg.

In terms of production these agro-forestry systems are of the utmost importance, at regional as well as national levels. They provide 80 per cent of the rubber latex consumed and exported by Indonesia, roughly 95 per cent of the various fruits marketed in the country, between 75 and 80 per cent of the dipterocarp resins traded in and outside the country, a significant part of rattans and bamboos, an immense part of the firewood used in the country, and the majority of such items as medicinal plants and handicraft material. Moreover, they ensure the self-sufficiency of most rural households in complementary foods, fuelwood and light and heavy construction material.

It is important to note that most of these systems are definitely not home-gardens, but more extended systems which have evolved from previous clearings in natural forests. They belong more to the world of plantation agriculture than to subsistence agriculture, as the main reason for their establishment is providing monetary income for rural households.

A forest and its ecological integrity

Agro-forests are extremely close to natural forest formations in their dominance, diversity and origin of most of their species. Some of them have the structural as well as functional characteristics of a primary forest ecosystem, with high specific richness, great ecological complexity and closed mineral circulation systems. As with natural forests, agro-forests can be considered sustainable in the long term. But agro-forests are more than a biological copy of the forest. They represent a totally original form of appropriation of forest resources by indigenous people. More than natural forests, which are at present a highly threatened public domain, agro-forests represent a viable space for sustainable management of forest resources and forest biodiversity by indigenous people.

Indigenous management of forest resources

From the beginning, the age-old involvement of forest farmers in the trade of forest products has shaped the structure and evolution of indigenous agro-forests. It was the need for sustainable management of commercial forest resources that led to the first development of agro-forests. Economic species, such as benzoin or cinnamon trees in Sumatra, were introduced into native tree gardens or swiddens as far back as the 16th century (Marsden, 1783). The Dayak people in western Borneo have built their agro-forests around illipe nut-producing dipterocarps. Villages in Mollucas are surrounded by agro-forests which combine traditional local spice trees: nutmeg and clove, with forest nut trees. More recently, farmers in the southwestern part of Sumatra cultivated a resin-producing dipterocarp, resulting in an agro-forest tens of thousands of hectares in size.

Agro-forests have gained in importance with the introduction of colonial tree crops. The case of rubber is an example: rubber, a forest species — though not native to the area — has totally replaced native forest species in the local economies of forest villages. Less than 50 years after its introduction and rapid acceptance by farmers, Brazilian rubber dominated the non-fertile lowlands of Sumatra and Borneo in agro-forests. Since 1945 they have produced more than 80 per cent of the latex exported by Indonesia.

The composition of agro-forests continues to change. Formerly abundant forest products are becoming scarce; several of these resources, such as rattan in Kalimantan, gain in importance in agro-forests. The most promising forest resource of the 21st century is probably timber. Some farmers in south Sumatra have introduced dipterocarps in their rubber agro-forests, while farmers on the west coast of Sumatra have developed systematic commercial exploitation of traditional timber species into the durian/cinnamon agro-forests.

Biodiversity in agro-forests

The successive integration of commercial tree crops did not fundamentally change the actual form of agro-forests. Today, in spite of a common marked specialization, dominant tree crops are still associated with large primary forest trees or with tree species of secondary vegetation. Apart from major species, either cultivated or selected and protected, which form the frame of the agro-forest, vegetation includes an important spontaneous component — the "weed" of modern agriculture — which is not eradicated but managed according to its usefulness. This may represent up to 50 per cent of the tree stand alone, not taking into account lianas, epiphytes or undergrowth species. Near Padang, in west Sumatra, which is one of the most populated and intensively managed areas on the island, agro-forests include more than 30 commonly-managed tree species. There are several hundred additional species, which establish naturally and are utilised often. Qualitative analyses of plant diversity in Indonesian agro-forests have been discussed elsewhere (Bompard and

Michon, 1985; Michon and Bompard, 1987; Michon and de Foresta, 1990). What is stressed here is a more quantitative assessment of biodiversity levels in agro-forests, and critical comparisons of biodiversity levels between natural forests, agro-forests and other types of agricultural management. This will help define the capacity of complex agro-forestry systems to allow the conservation of animal and plant forest species.

Table 12. Comparison of diversity in Collembola

		n spp. per sample	frequency per sample	total n spp.	total frequency
leaf litter	primary forest	20.6	117.4	47	587
(mean values)	rubber agro-forest	22.8	161.4	47	807
	rubber estate	11.6	83.2	23	416
soil	primary forest	13.7	48.4	57	1211
(mean values)	rubber agro-forest	16.0	63.2	55	1579
	rubber estate	8.3	36.4	28	364

Biodiversity assessment

In order to assess biodiversity levels, several groups have been studied, including higher plants (from ferns to dicotyledons), birds, mammals and soil mesofauna. Comparative studies have been conducted in three locations on the island of Sumatra, between agro-forests (damar agro-forests in southern Sumatra, rubber agro-forests in eastern Sumatra and durian/cinnamon agro-forests in western Sumatra), related neighbouring natural forests, and, in one location, monospecific (rubber) plantations. This study is in its final phase, and the information must be refined by further analysis. The data does provide preliminary information, however.

For soil fauna (Deharveng, 1991 and 1992), 500 soil and litter samples were analyzed, including more than 50,000 arthropod samples and 20,000 *Collembola* samples, 80 per cent of which are new species. Results show that diversity levels are quite similar between forest and agro-forest (Table 12 and Figure 13), but far lower in plantations. None of the most common species of the forest populations are absent in the related agro-forest; however, many rare species exist, and results do not prove that rare species in the forest also exist in the agro-forest. It is obvious that, for soil fauna, agro-forest is a much preferred option to industrial plantations as far as diversity is concerned.

Table 13. Comparison of bird diversity

	primary forest Mua/Krui/Man	rubber agrof. Muarabungo	damar agrof. Krui	durian agrof. Maninjau
observed richness	179	105	92	69
average richness per sample (n. spp.)	26.4	18.5	15.4	15.1
rare species (%)	79.9	72.3	75	62.3

Source: Thiollay, 1994
Rare species are those which account for less than 1% of the total population

In terms of birds (Thiollay, in press), diversity in the agroforest is reduced to about 60 per cent of that in primary forest. Plantations have only five per cent of the diversity in primary forest (Table 13). About 41 per cent of bird species found in the forest have not been encountered in the agro-forest, whereas 25 per cent of the agro-forest species were not present in the forest surveys. It is interesting to note that the three surveyed areas are significatively different. The rubber agro-forest is the closest to natural forest in terms of bird species richness, while diversity levels are lowest in the durian agro-forest. This could be explained by both the composition of plant species and the influence of villages and constant human disturbance, which is much higher here than in the other agro-forests.

Large birds (weighing more than 80 grams) are significatively more abundant in primary forests; more than 50 per cent of species of this group do not appear in the agro-forests. The cause of this can be related to biological factors (simplification of composition and vertical structure from forest to agro-forest), but is probably due mostly to hunting pressures. Birds are shot for sport or food; in addition, bird keeping is extremely popular in Indonesia, and birds are often caught to be kept in cages in villages.

As far as mammals (Sibuea and Herdimansyah, 1993) are concerned, almost all forest mammals are present in the agro-forest (Table 14), but population densities have still to be studied. Results available for primates (macaques, leaf monkeys, gibbons and siamang) show that densities in the agro-forest are quite similar to those observed for natural forests. An interesting fact to note is the record of Sumatran rhino footprints in the damar agro-forest, less than two kilometres from villages. This represents the first record of rhino in this part of Sumatra and suggests that the conservation of endangered animals might possibly be an important adjunct to the use of agro-forests.

Table 14. Mammal families and species in three agro-forests

	agro-forests					
	Mn (durian)		Mb (hevea)		Kr (damar)	
	Sp.	Fam.	Sp.	Fam.	Sp.	Fam.
Insectivora	0	0	0	0	1	1
Dermoptera	0	0	1	1	1	1
Chiroptera	6	2	3	2	9	5
Primata	5	4	7	4	7	4
Pholidota	1	1	1	1	1	1
Rodentia	7	3	11	3	14	3
Carnivora	9	4	9	4	6	4
Perissodactyla	1	1	1	1	1	1
Artiodactyla	4	4	6	3	6	4
Total	**33**	**19**	**39**	**19**	**46**	**24**
Protected by Indonesian law (Ordinance no. 5, 1990)	14		15		17	
IUCN red list	9		6		7	
CITES	4		3		4	

Results of flora studies (de Foresta, Bompard, Molino, Michon) are taken from exhaustive observations along several 100-metre transect lines, completed by random collection in each of the three locations. For each location, more than 1000 herbarium samples are being analyzed. Global diversity is reduced to approximately 50 per cent in the agro-forest, and to 0.5 per cent in plantations. However, results have to be categorized by biological type, as they can be very different from one group to another. The biggest loss of diversity occurs for trees (30 per cent of the original diversity levels for agro-forests, 0 per cent for plantations). This is quite understandable since economic requirements, and therefore selection, relate mainly to trees.

Diversity of epiphytes in the agro-forest should be at least 50 per cent of the forest diversity in agro-forests (one to five per cent for plantations). Analyses of orchids (92 identified species, representing 50 per cent of the collected orchid matter) include seven new records for Sumatra, whereas 42 species are reported exclusively from old-growth forests. Diversity in undergrowth plants in agro-forests is twice as high as in natural forest, which is related to the richness of this group in old secondary forests compared to primary forests. Diversity for lianas is close to 95 per cent in rubber agro-forests, but is much lower in the damar agro-forests.

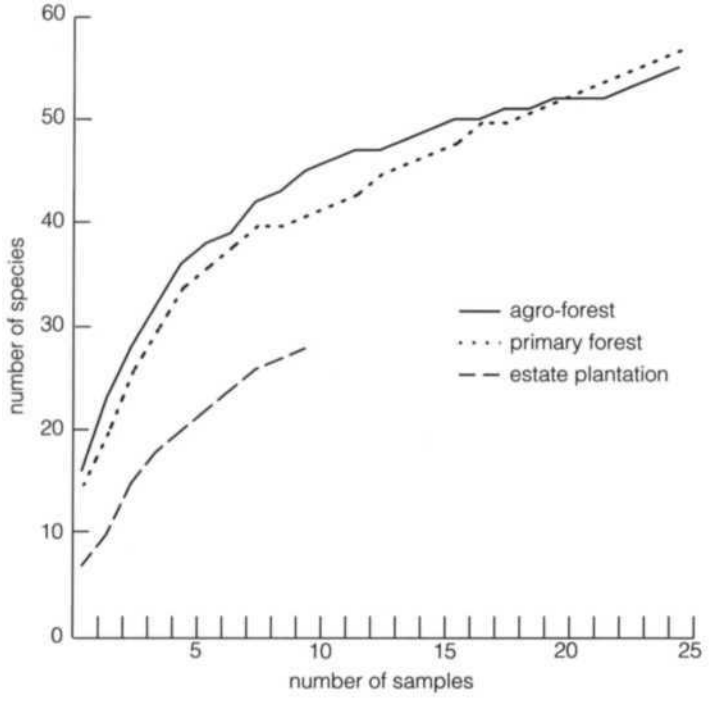
A critical analysis of biodiversity levels

The sample technique used for plant surveys (comparative quantitative collections on transects of a given length) does not provide definitive data on the overall presence or absence of a given species. Many relatively rare forest species in the agro-forest would not be revealed by this technique, which emphasizes numerically important species. The mammal census, which made use of observations as well as discussions with farmers, revealed a great diversity of mammals, but provided very little information about the frequency or abundance of individual species.

A wider census for useful plants in the agro-forests (plants with a positive selection pressure from the farmers) has revealed important numbers of species producing fruits and nuts, spices and flavourings, exudates, fibers, etc. Observations have shown the low density of many of these resources, which means that they are probably not included in our quantitative surveys. The same is probably true for plants which have no harvesting value and which are not affected by positive selection.

Figure 13. Comparison: Collembola diversity

Comparison of diversity in the soil of primary forest, rubber agro-forest and rubber estate plantation, Rantau Pandan area, Kabupaten Muara Bungo, Jambi Province (from Deharveng, 1992)



It should be stressed that biodiversity in the agro-forest does not result from a deliberate choice of farmers to conserve biodiversity *per se*. Rather, it is the logical consequence of structural features of the agro-forest and of associated management practices. The main incentive for establishing an agro-forest is economic, and is closely linked to the market economy. The search for marketable tree products is not a new trend. However, commercial tree gardening is not conceived as an exclusive enterprise, but is combined with other functions, for example subsistence. In so doing, farmers are following an age-old model of multi-purpose forest use.

Biodiversity results, therefore, from two types of dynamics. One is semi-intentional and exclusively concerns plants, combining the planting of useful species — which recreates the frame of a forest system — with selection of spontaneously occuring resources. The other is accidental, resulting from the establishment of a diversified flora and fauna as in any silvigenetic process, and shaping the forest aspect of an agro-forest. This accidental component is not a neutral one; it determines not only the diversified structure of the agro-forest, but its function. As an example, if a selection reduces minor fruit trees in a damar or a rubber agro-forest, there will probably be a reduction in the number of fruit-eating birds, squirrels and bats. There will therefore be a reduction in the number of natural pollinators and dispersors. This could possibly endanger the reproduction of many species, a trend which human intervention may not be able to reverse.

Changing the habits of farmers through education or agricultural extension can bring about important changes in biodiversity levels. One farmer in the durian/cinnamon agro-forest recently chose to use herbicides in his garden to get rid of weeds (an exogenous concept in indigenous farmers' societies). This will have an effect on animal populations and soil fauna as well as on the higher plants and seedlings that are killed in the process.

Managing biodiversity and its economic consequences

Agro-forests are more than a collection of forest resources. They also represent an admirable system of resource management, entirely developed and administered by indigenous populations.

The Indonesian examples show the value of ecological and technical control of resources as well as the socio-cultural control over these resources. This is accomplished not through the conventional domestication of species, which usually involves modification of plant characteristics to adapt to the cultivated ecosystem, but through total reconstruction of the original ecosystem.

Exclusive and homogenized management of stands, characteristic of conventional silvicultures and tree plantations, is not found in indigenous agro-forests. Agro-forests cannot be used for a single purpose. They are characterized by multiple use of resources, multiple use of individual species, an individualized manipulation of plants and maximal use of natural processes of production and reproduction. Agro-forest management achieves truly integrated management of a complex ecosystem.

The integrity of agro-forest structures is ensured through a dominant private tenure system complemented by an overall control by enlarged families or clans. Radical transformations, clear-felling and sale of individual agro-forest plots have to be approved by these superior councils, who ensure a respect for tradition as well as for future generations.

The success of agro-forests lies in their proven ecological reproductive capacity over the long term as well as in their immediate economic benefits. They provide the main source of monetary income for families, contributing to reasonable levels of life quality (including schooling of children), and are an important and valuable heritage. They also contribute to the nation's welfare through the production of important goods, including export crops, fruits, material and firewood.

Table 15. Comparison: species richness and abundance

	number of species			**frequency**		
	rubber estate	rubber agro-forest	primary forest	rubber estate	rubber agro-forest	primary forest
trees	1	92	171	28	247	258
lianas	1	97	89	5	2.28	219
tree seedlings	0	26	45	0	170	72
epiphytes	2	28	63	2	51	261
herbs	1	25	12	*2000	217	84
total	6	266	382	2035	913	897
trees (except rubber)	0	91	171	0	189	258
total (except rubber)	**5**	**265**	**382**	**2007**	**855**	**897**

samples: 100 m transect-line; all plants past seedling stage recorded
* estimated number of herbs: about 1000 individuals for each species

The future of indigenous agro-forests

It is more and more apparent that sustainable management and protection of natural forests, usually exclusively administrated by national institutions, would benefit from the integration of local populations able to use and manage resources in an optimal way. Instead of displacing local people from forest areas, it would be judicious to give more forest land to those shifting cultivators who have mastered the techniques and strategies of a true integrated agro-silviculture. Agro-forests in Sumatra and Kalimantan achieve much more sustainable management of forest resources, together with conservation of biodiversity, than most of the forest plantations developed by the government as the solution to exhaustion of timber resoures.

On the other hand, the future of agriculture in forest areas will have to integrate forest components into food producing systems in order to achieve both ecological sustainability and economic viability. Small-scale agriculture has evolved with the forest and should not depart from it.

Why not agro-forests?

Preliminary study results reveal the importance of agro-forests in the conservation of biodiversity. This importance has to be considered in the context of forest transformation for agriculture or timber plantation: global levels of 50 per cent of preserved diversity could be considered low by conservationists. But statistics have to be compared with biodiversity levels in other types of agricultural/silvicultural systems. Agro-forests are not devised for conservation, but for production; biodiversity conservation is just a derived benefit, not an aim *per se*. Many areas of forest land will have to be transformed to give way to intensive production, and the current agro-forest strategy apparently allows the highest levels of biodiversity conservation.

In Sumatra, deforestation rates between 1982 and 1989 have reached 300,000 hectares per year. Most of the lowland dryland forests (between 15 and 150 metres elevation) have been logged; much of this logged-over forest has been replaced by estates, either oil palm plantations, accacia forests or monocrop rubber plantations. In 1985, intact lowland forest covered less than 1.5 million hectares. This means that, by 1994, only a few hundred thousand hectares of this forest were left. With some two million hectares of rubber agro-forests in the eastern lowlands of Sumatra, approximately 1.5 million hectares of fruit agro-forests in the alluvial lowlands, and about 10,000 hectares of productive damar agro-forest in the western lowlands; agro-forests, and not natural forests, are presently the widest reservoir of forest biodiversity at low elevations in Sumatra.

A threatened future

Agro-forests have survived until now thanks to the constant integration of technical and strategic innovations, agro-forests and societies evolving in parallel ways. But a gap is widening between peasant societies, which modernize through uniformity, and an agro-forestry model that is perceived by both agricultural and forestry authorities — and often by the farmers themselves — as backward and inefficient. Farmers' access to development is perceived exclusively through the extension of plantations. Agro-forests are probably the most endangered agro-ecosystem in Indonesia.

All over Indonesia many beautiful examples of age-old agro-forests are being drastically modified or even destroyed. This happens for many reasons, ranging from institutional, legislative and administrative impediments to socio-economic mutations occuring in production systems and changes in rural societies. Agro-forests are viable only so far as they can meet peasants' needs. They are sustainable only in a well-structured and coherent social context.

Biodiversity within agro-forests is directly threatened by the emergence of new elements in the peasant world. Fulfilling short-term monetary needs leads to the replacement of slow growth or secondary species by fast-growing, high yielding species. Uncertainty about the future restrains long-term investment, and agricultural extensionists and agricultural information through television promotes monocropping, the weed concept in tree gardening, and an increase in gross yields per unit of land for individual crops. Agro-forests can be affected by the same range of factors if they do not provide enough immediate income; this can be due to lack of inadequate marketing channels for the products.

This was the case in the Tembawang system in west Kalimantan, where local markets for tengkawang nuts are so undeveloped and monopolistic that people prefer to sell their trees for timber, at the derisory price of US $3-5 per tree. The trees are not prized by local people, who prefer — and are pushed by agricultural extensionists — to adopt more modern agricultural systems, mainly monocrop and input-consuming plantations. Agro-forests are also threatened by non-economic factors, such as the weakening of traditional regulators (family or clan heads, custom representatives). This places more importance on individual initiatives, which are often unsuccessful.

Last, as agro-forests are seen as being natural formations and are found in territories that are not officially acknowledged as agricultural lands, they fall under the chainsaws of timber companies. This happened to damar agro-forests in Bengkulu and is happening to lembo in east Kalimantan. Agro-forests are cleared for transmigration projects, as in Ipuh, Bengkulu, or they are felled to give way to fast-growing timber estates, as illustrated by the loss of the sophisticated rattan agro-forests in east Kalimantan. The unfavourable administrative and legal framework is the first thing that must be changed to provide better prospects for the future.

The role of scientists

Indonesian agro-forests can indeed provide the base for a totally original model of sustainable development. This could benefit not only Indonesia, but many forest lands all over the humid tropics. The value of the agro-forest still has to be acknowledged to balance the commonly negative perception. Strengthening the agro-forest model needs several types of action, including further experimentations and improvements to existing models as well as extension through integration of new systems in future development programs.

But what the agro-forest model needs most urgently is innovation able to carry it into the 21st century. It might otherwise disappear in the same modernization movement that fells natural forests and assimilates indigenous forest societies. Outside institutions, and above all scientific institutions, have to support vanishing local institutions to ensure a bright future for an age-old model of original resource management.

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Dehesa systems in the western Mediterranean

Biological diversity in traditional land use systems

Francisco D. Pineda and Javier Montalvo

Introduction

The landscape of the Iberian peninsula results from the interaction between its geoclimate and its rich cultural heritage. The former is expressed in areas of siliceous and limestone lithology, divided from east to west into two large regions and four main interspersed sedimentary depressions. In both regions, geomorphology is an important environmental factor. This determines a high variability of habitat (Bemáldez, et al. 1976; Pineda, et al. 1981a; Bernáldez, 1981) and a large number of rural uses (Bernáldez, 1991; Montserrat, 1964; Rescia, et al. 1994). There is a marked inconsistency in weather patterns from one year to the next (Pineda, et al. 1987; Peco, 1989; Arroyo and Marañón, 1990; Figueroa and Davy, 1991; Ortega and Fernandez Ales, 1988) but in general, the agro-climate is characterised by severe summer and winter rainfall (Allúe, 1990).

This environmental framework is affected by a genetic and cultural adaptation to a specific climate with highly variable geomorphology and historical processes. Such adaptation has allowed optimum exploitation of the land. A link between agricultural land and forest has resulted in the maintenance of high biological diversity (Bernáldez, 1991, 1992).

Traditional rural practices, especially the dehesa system, have also been important in maintaining biological diversity. Dehesa systems are open savanna-like woodlands used as pastures, with sclerophyllous trees, mainly Quercus *rotundifolia* Lam., and a therophytic herb layer (MaB, 1989). Dehesas cover some two million hectares in the central, west and southeast territories of the Iberian peninsula. They are important in terms of food production, preservation of tradition and scientific interest (Vacher, et al. 1985; Ruiz, 1986).

Research on the dehesa system in the past decades has covered several aspects and ecological processes (Gomez-Guttierrez, 1992; Pineda, 1990; Pienda and Peco, 1988; Pineda, et al. 1994):

- the effect of climate, weather and soil on ecological structure and function;
- the different types of herbivore behaviour and pasture management;
- woodland-herbaceous vegetation interaction;
- the variability of biological diversity and species distribution; and
- land management practices, by traditional users and others.

Conserving biological diversity

Biological diversity in the dehesa is very high (Bernáldez, 1991; Pineda, et al. 1981b; Montalvo, et al. 1993), which has an impact on agriculture, forestry and other land uses. Biological diversity can be understood to have several meanings (Table 16):

- an essential component of human heritage, recognizable on worldwide, regional and local levels (Bernáldez 1991; Wilson 1989; Sandlund et al. 1992);
- the expression of biological species and communities and the variety of types of domesticated life forms (Bernáldez 1991 and 1992; Gómez-Gutierrez 1992);
- an indicator of changes in ecosystems (De Pablo et al. 1982; Pineda et al. 1981b; Margalef 1990, 1994).

Species represented in traditional systems of agro-pastoralism are kept relatively free from a destabilizing human influence, which helps to maintain biological diversity (Table 17). Traditional land-use systems also allow many natural processes to flourish, including soil conservation. The semi-natural system that is created by means of traditional land management also brings aesthetic and cultural benefits.

Table 16. Species and frequency

Biological diversity expressed as the variety of species (a) and their relative frequency (b).

a	b
variety of life forms: organisms, morphologies, colours, textures	expression *of* ecological organization: the concept of information in ecology
richness of species: the most ahundant prevent appreciation of variety	result of a historical process: colonization, intet-specific relationships
presence of emhlematic, rare or wild species: value of the habitat	change indicator: perturhation and succession

Table 17. Emblematic species of the dehesa system

Emblematic species found in dehesas and other similar Spanish woodland-pasture systems

	monte: high slope zone trees	pastures	middle and low slope zones wetlands and streams
herbivores			
hoar *Sus scrofa*	dormouse *Eliomys quercinus* ◊	fallow deer *Dama dama*	salamander *Salamandra salamandra*
Roe buck *Capreolus capreolus*	wood pigeon *Columba palumbus*	little bustard *Tetrax tetrax* ◊	Iberian newt *Triturus boscai*
red deer Cervus *elaphus*	warbler *Sylvia spp.*	crane Grus *grus* •	lapwing *Vanellus vanellus*
carnivores and carrion eaters			
wild car Felis *sylvestris* ◊	Bonelli's eagle *Hyeraetus fasciatus* √	black-winged kite *Elanus caeruleus* •	kingfisher *Alcedo atthis*
genet *Genetta genetta*	eagle owl *Bubo bubo* ◊	hobby *Falco subbuteo*	plover *Charadrius spp.*
booted eagle *Hyeraecus pennatus*	ocellated lizard *Lacerta lepida*	black stork *Ciconia nigra* √	grey heron *Areda cinerea*
Iberian lynx *Lynx pardina* √	imperial eagle *Aquila adalberti* √	Egyptian vulture *Neophoron pernopterus* √	osprey *Pandion haliaetus* √
lammergeier *Gypaetus barbatus* √	golden eagle *Aquila chrysaetos* Δ	raven *Corvus corax*	pike *Esox lucius*
black vulture *Aegypius monachus* √	griffon vulture *Gyps fulvus* •	rook *Corvus frujilegus* •	

• rare ◊ vulnerable
√ in danger of extinction Δ sensitive

The conservation of biodiversity in these areas helps to maintain the ecosystem and its functions (Margalef, 1970; Montalvo, 1992). Although biodiversity is not the only issue in conservation, it is an important one. Also important is recognizing the relationships and dependencies within the ecosystem; relationships which are an important part of these woodland-pasture systems. Studying these relationships can help avoid some of the problems caused when inappropriate or inadequate technologies are applied.

Most dehesa systems are found in areas thought to be marginal in terms of soil productivity. Production is at optimal levels for this type of soil, however, considering the prevailing environmental conditions. It is also important to consider more than productivity when determining a system's true worth.

In these marginal areas, estates are commonly divided into high (los altos) and low (los bajos) slope zones. High zones often contain scrub and greater tree density, although their relatively low levels of biomass accumulation reduces the possibility of fires. The high zones provide shelter for livestock and for the wild fauna that feed in nearby pasture areas. Runoff water from the high zones, with its comparatively richer soil, also fertilizes the low zones, increasing fertility from high to low areas. In winter and early spring the high zones have no scrub vegetation and thus maintain greater pasture growth, which supports livestock grazing (Casado, et al. 1985). As spring advances, productivity advances towards the middle and low zones, and the livestock moves progressively down the slopes. In the summer, livestock exclusively graze the pasture — known as "agostaderos" or August pastures — in the low damp zones (Table 18).

There are important ethical and cultural reasons to keep environments free from destabilizing influences and to protect species and habitats. Other reasons may also become apparent, as in the case of relict populations such as the Iberian Imperial eagle, *Aquila (heliaca) adalberti* C. L. Brehm or the lammergeier, *Gypaetus barbatus L.* It is also important to consider not just species obvious by their size or significance, such as trees, large mammals or birds of prey, but the full range of life forms, including insects, algae and bacteria.

Table 18. Plants and terrain types of the dehesa

mountainside hills		los altos		los bajos
shade	**sun**	**cerillos upper zone**	**baén lower zone**	**trampadal wetland**
Arrenaterum album	*Stipa gigantea*	*Stipa lagascae*	Cynodon *dactylon*	*Alopecurus arundinaceous*
Trifolium phleoides	*Dactylis glomerata*	*Trifolium cherleri*	*Trifolium cernuum*	*Trifolium michaelianum*
Koeleria crassipes	*Trifolium campestre*	*Trifolium arvense*	*Festuca rubra*	*Trifolium resupinatum*
Aim praecox	*Agrostis castellana*	*Anthyllis lotoides*	*Gaudinia fragilis*	
	Avenula marginata	*Bromus tectorum*	*Biserrula pelecinus*	
	Corinephorus canescens	*Poa bulbosa*	*Vulpia bromoides*	

Table 19. Biological richness of the Iberian Peninsula

	approximate number of species		
group	actual number	endemic number	% found in dehesas
vascular plants	8,000	1,300	10
lichens	2,000	—	—
ferns	111	—	10
mammals	1	14	(114)
birds	460	1	40
reptiles	4	5	(33)
amphibians	2	4	(24)
insects	40,000	—	—
fishes	61	—	—
butterflies	5,000	400	—

Although technology can bring great advances, it can also have negative repercussions. New irrigation systems, changes in exploitation practices, construction of roads and reservoirs and urban expansion are generating serious local and glohal changes, which can result in a loss of biological diversity (Rescia, et al. 1994; PSOE, 1979; Gomez-Gutierrez, 1992).

Recognizing biological richness as one of the meanings of biodiversity also constitutes an approach to biodiversity and is a strong argument for conservation of the dehesa system. The number of species found in the Iberian peninsula is quite high (Table 19): of the plant species found, plant richness is estimated at 30 per cent, mainly represented by therophytic species. Animal species richness is also important: 60 per cent of the mammals, 40 per cent of the birds, 60 per cent of the reptiles and 30 per cent of the amphibians are also present in dehesa systems. Plant diversity is also one of the highest recorded in the world (Pineda, et al. 1981b; Montalvo, 1992).

This extraordinary wealth of diversity is due to the characteristics of the Mediterranean climate, the history of the hiological populations and the traditional land-use systems (Bernáldez, 1991 and 1992). It should be a source of inspiration for modern agricultural technology and an example to follow.

Species and communities

Before and after the Pliocene the Iberian Peninsula formed a land bridge between Europe and Africa. During that time in the biogeographical history, a sub-tropical climate of dry summers began to appear in the Mediterranean basin (Di Castri and Mooney, 1973). This doubtlessly laid the structure for today's biological diversity. In the present day the Mediterranean climate offers a certain selective advantage to annual plant species, which make up a significant proportion of the peninsula's flora.

The dehesa's high diversity values also seem somewhat related to the distribution of species. Pasture vegetation is not evenly distributed in the dehesa (Pineda and Peco, 1988). Its presence depends mainly on the dynamics of the slope (Table 18) and on the influence of dispersed trees (González Bernáldez, et al. 1969; Table 20). Periodic ploughing is sometimes carried out to eliminate shrubs, which promote ecological succession and maintain spatial heterogeneity. Native livestock breeds — still very well represented here — move along the slopes daily; they, as well as the variable intensity of their grazing, could also contribute to heterogeneity and biodiversity (Casado, et al. 1985).

Pasture in its early stages is characterized by a uniform distribution of plant communities (Pineda, et al. 1981a; De Pablo, et al. 1982) and low diversity (Pineda, et al. 1981a). In the first stages of succession, rainwater draining into the spongy soil tends to homogenize the substratum along the slope. In time, this drainage is reduced, the ground becomes compact and the difference between the upper and lower areas becomes more pronounced (Pineda and Peco, 1988). A heterogenous distribution of vegetation is favoured, which remains relatively stable in later succession stages. Other ecological relationships, such as inter-specific competition, probably also have an effect on this heterogeneity (De Pablo, et al. 1982; Galiano, 1983; Galiano, et al. 1987).

In the advanced stages of succession, record diversity levels are found. Pastures with high levels and quality of production are called "majadales". The pastures' mosaic pattern is a heterogenous structure and coincides with high diversity values (Grubb, 1985; Maarel, 1988; Glenn-Lewin and Ver Hoef, 1988; Rescia, et al. 1994). These high values are partly due to the spatial organization and to the flow of material, energy and information among the mosaics.

Boundaries and corridors

In the last 30 years, the transformation of the Spanish landscape has had an effect on both rural and urban life. This transformation has followed the imperatives of modern agriculture: early crops, products with high commercial value; and of tree plantations: the disappearance of a great part of the large sclerophyllous leafy woodlands and pasture and rural abandonment (PSOE, 1979; Rescia, et al. 1994; Groome, 1990).

Table 20. Tree dispersion: *Quercus rotundifolia*

microclimate	soil	pasture composition
Tree dispersion carries out efficient rain interception; the greatest rainfall recorded next to tree trunks and on the ground surrounding the profile. Radiation from the sun is modified, with the tree acting as shade during the day; used by animals for shade in area's hot summers. During the night the tree radiates heat, forming a group of these dispersed elements in the pasture and helping lessen the effects of freezing in Fehruary-March. The effects of wind are also substantially modified.	The tree has been called a "nutrient bomb" since it gives the soil surface cations, which are rare in siliceous soils, especially calcium and phosphorous. The effect of this can be seen at great distances. The deposit of forest litter describes a gradient from the base of the tree to the middle of the pasture, where it stops, and begins again near another tree. In the dehesas, where the soil is ploughed to ward off scrub invasion, trees act as islands of undisturbed pastute, due to the barrier created for the plough.	The influence of tree dispersion causes variation tendencies in the pasture's flora. Diversity is greatest near the edge of the tree top. Variation of both aspects is more obvious along the slopes, showing species characteristics of the different positions (Table 18). The direction of prevailing winds generates variation tendencies from the trunk outwatds. In central Spain, different types of similar communities are differentiated south and east and also north and west. Species found close to trees include *Geranium molle, Stellaria media* and *Bromus matritensis*; those found at a greater distance include *Trifolium suffocatum, Tuberaria guttata, Vulpia ciliata, Cerastium semidecandrum* and *Aphanes microcarpa.*

On a large scale, biodiversity also concerns agro-silvo-pastoral uses and their effect on the landscape. Diversity is also an important consideration in wilderness and rural lands. These can be simple (agrarian) or complex (woodlands and other mature formations). In most Spanish rural areas, the landscape was shaped from the 15th to 17th centuries (Bernáldez, 1991) and contains:

- forestry areas with large accumulation of biomass and low productivity called "monte" (Humbert 1980);
- mixed forestry-pasture systems — dehesas — created from cleared forests, with the remaining trees carefully selected and pasture lands used in accordance with the suitability of plants and the availability of groundwater (Gomez-Gutierrez 1992; Montserrat 1964);

- extensive agricultural areas, based on a more complex technology and enriched by successive cultures (Bernáldez 1991 and 1992; Saenz 1990) occupied by dry-land cereals and legumes (Baldock et al. 1993), mainly occupying tertiary sediments, and irrigation systems in quaternary valleys.

There has been recent interest in the importance of maintaining corridors or links between wild areas. Dehesas can also be considered in this context. The idea of a European ecological network, or EECONET (Bennett, 1991) is based, in the case of Iberia, on promoting conservation of wild nuclei and corridors of different types, including paths, thickets, edges and mountain ranges. The European Centre for Nature Conservation, ECNC, based in Tilburg, Holland, and Soto del Real, Spain, is promoting this idea. Such a network would lose a great deal of its effectiveness if modern land management practices lose sight of the lessons of traditional land use. Spatial heterogeneity, boundaries between different types of ecosystems and the presence of livestock all contribute to sustaining biodiversity in this landscape (Rescia, et al. 1994).

There are good examples of the way dehesas act as corridors. These corridors can be vital in the movement of species in danger of extinction, such as the Iberian lynx, *Lynx pardina* Temm., or vulnerable species, such as the badger, Meles *meles* L., the wild cat, *Felis sylvestris* Sch., the Iberian mole, *Microtus cabrerae* Th. or the wolf, *Canis lupus* L. Dehesas also act as a corridor between the mountains of the Hispano-Portugese Cordillera Central and the mountains of Toledo. They are also essential areas for many types of birds, including many birds of prey, the crane, *Grus grus* L., the black stork, *Ciconia nigra* L. and the little bustard, *Tetrax tetrax* L. In addition, corridors are used by hibernating and sedentary small birds dependent on the fruits available in the Mediterranean mountains in winter, when their usual diet of insects is not available.

Very close to Madrid is one well-known corridor, which connects the Guadarrama Range with the El Pardo area. This latter area has been kept wild since time immemorial and is now a forest nucleus with mountains and dehesa, the only well-conserved remnant of the once wooded area of central Spain. More than 50,000 hectares in size, it was recently declared a national park by the autonomous government of Madrid. Although this is a positive initiative, a much greater challenge lies in promoting forms of agricultural economies that will keep such systems productive.

Transhumance is another tradition still being practised (Ruiz and Valero, 1990). It is an ancient tradition in a precarious state and in need of state and international protection. Historically, transhumance has played an important role along the pasture routes of large territories. Drovers' roads or "cañadas" can connect climatically different systems far from each other.

The dehesas make up the winter pastures of the west-central and southwest of the Iberian Peninsula. They are connected with the Cañada Real Leonesa, now used by approximately 300 drovers and their 30,000 cows, sheep and goats. There are other drovers' roads in the central peninsula (Cañada Real Segoviana) and in the east (Cañada Real Murciana), which cover the peninsula from north to south and which are in varying states of conservation and use. The European Nature Heritage Fund is one of the sponsors of Project 2001, the aim of which is to restore these roads and to promote transhumance and extensive traditional stock breeding.

The movement of livestock, from these areas to other areas farther north, is an example of how territorial connectors can work. The drovers' roads act as corridors and the dehesas are used as overnight pastures. Summer pastures act as intersections in the system of corridors. As well as providing routes for livestock, corridors allow for the movement of plant species.

It is important to study the ecological phenomena associated with the existence of corridors in order to understand and conserve biological diversity. It is as important to develop this natural territorial infrastructure as it is to develop the more technological infrastructure of roads, canals and reservoirs. There are complex scientific issues to be considered; on the one hand, natural corridors need to be promoted, while on the other hand, there must be enough knowledge of the processes and organisms affected by corridors to establish priorities for conservation policy. It is vital to consider not only the conservation of isolated habitats but the corridors that connect them and the barriers that divide them.

Diversity as an ecological parameter

In studying biodiversity outside protected areas, it is important to consider the ways that traditional land management practices have imitated natural processes. In order to do so, there is a need to establish scientific as well as empirical guidelines. Several aspects can be studied to this end:

- adequate indices to indicate diversity variation;
- natural control mechanisms (Magurran, 1988; Montalvo, 1992; Margalef, 1991);
- organizational and regulatory mechanisms of ecological systems (Margalef, 1963; Odum, 1969);
- analysis of the degree to which human activity affects these mechanisms (Montalvo, 1992);
- study of relicts of wild environments (Rescia, et al. 1994).

Information about the number of species present in an area does not alone give a clear picture of diversity. A more accurate measurement of diversity would also express the way that a group of organisms is distributed into sub-groups representing the different species present (Margalef, 1991). This measurement could be extended to the sub-groups that do not necessarily represent any species, but do represent sizes, biological functions, morphologies or even types of landscapes. Distribution of a group does not occur by chance but follows a non-linear tendency and indicates the group's form of organization.

There are various diversity indices. Shannon, for example, measures diversity variations in "bits"; the greatest diversity values in the world — in tropical forests and other seemingly less complex environments, such as certain Mediterranean therophytic pastures (Pineda, et al. 1981b) — being approximately 6 bits. A diversity of 0 bits indicates a monospecific group, such as a wheatfield; 1 bit indicates a community with two equiprobable species; 2 bits, a community with four equiprobable species; and so on. In Iberian dehesas, values of 6 bits are normally found in stabilized pasture areas whose specific richness consists of approximately 200 species of therophytes.

It may seem paradoxical to find a high diversity in an exploited ecosystem — the pasture — with a high renovation rate. It is probably due to the fact that the plant species found there are predominantly annual. The reduction in the renovation rate following the suppression of livestock causes a sharp decrease in diversity (Montalvo, et al. 1993 and 1994; Montalvo, 1992); in only four years approximately ten species are lost. This illustrates how a certain exploitation intensity is needed to maintain a high diversity in this agro-system, contrary to the case in natural ecosystems or those with little human influence (Figure 14).

There are ways of measuring diversity that reveal information about the functioning of an ecosystem. Margalef's *k* index (1991) allows for relatively lower quantitative measurements in the pasture. These do not coincide with those of other indices, but are enormously helpful in interpreting the relationships between biological diversity and human influence. In the case of the dehesas, the interaction with domestic herbivores promotes the coexistence of different species of annual plants. The high density of individuals (number per surface unit) with a relatively small size implies that a high biological diversity is maintained.

Diversity can measure the classification of the groups studied in more than one way; not only covering classification into species, but also including the variation of groups in time or space (Pineda, et al. 1988; Margalef, 1975). This allows an area's ecological organization to be studied in more detail, including its spatial complexity (De Pablo, et al. 1982; Rescia, et al. 1994) and helps to quantify the value of rural landscapes, taking into account whether or not they are integrated into natural spatial grids.

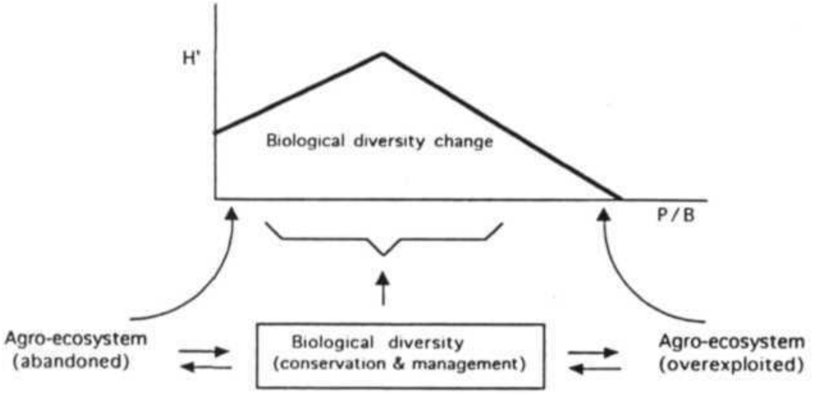
In measuring biodiversity, natural processes must also be studied. These processes are probably affected by the site's physical conditions, history and bio-geography (Margalef, 1963, 1991 and 1994; Odum, 1969; Tilman, 1982; Montalvo, 1992). This is an area of scientific research which still needs development, but which is basic in order to understand the effects of human influence on the landscape.

The intensity of exploitation and the configuration of the traditional rural landscape shows that high diversity values are maintained because of two circumstances: the relationship between diversity and exploitation intensity, and the spatial complexity of the area.

Figure 14 synthesizes the probable relationship between diversity value and its thermo-dynamic significance (Montalvo, et al. 1994; Margalef, 1991 and 1994). Energy flow of an ecosystem can be expressed by its turnover, *r*, or the quotient between primary production, P, and the biomass, *B*, maintained (B: $r=P/B$). If the energy flow is low, the biomass accumulated will allow for strong competition, and, as a consequence, a probable low diversity. This situation occurs in the monte areas, which have a very high level of biomass. Excessive acceleration of energy flow — high exploitation, provided there is water and sufficient nutrients to elevate production — allows the diversity to change over time. Diversity will probably drop (Margalef, 1991), leaving only the species with the greatest turnover which are capable of tolerating this flow. Dehesas are subject to traditional exploitation and so diversity is at its maximum, offering livestock the most varied menu.

Figure 14. Expected biodiversity value

Value between unexploited "wild" systems, unexploited and exploited agro-systems. Biological diversity: H would change in relation to energy flow, expressed by the quotient P/B (see text).



There are two extremes to the gradient related to the conservation of biodiversity: overexploitation on the one hand and rural abandonment on the other (Margalef, 1970). These relate to an energy flow that is either excessively accelerated or greatly depleted; both extremes lead to low biodiversity. Between the two extremes, intermediate levels of exploitation allow high diversity to be maintained in an exploited system.

A high diversity value can be maintained in a rural landscape with a mosaic structure, ecologically mature relicts, agricultural simplicity and a grid of corridors. This is due partly to the greater diversity of habitats offered by these mosaics and partly to the energetic tensions between systems with different renovation rates (De Miguel, et al. 1994). The energy flows mainly from the pasture to the monte; eagles nest in the trees of the monte, but feed on the rabbits bred in the pasture. Deer graze on the pasture and give birth in the monte. Pasture tends to occupy the middle and low slope areas, with an assured supply of water and nutrients, in order to maintain optimum production. Monte occupies the higher, drier and less exploitable areas.

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Upland farming systems of the Northern Apennines

The conservation of biological diversity

Almo Farina

Introduction

There is a common assumption that human activities always deplete natural resources and impoverish biological diversity. When moderate, however, as in traditional farming, human disturbance can create suitable habitats for many species of plants and animals and contribute to conserving biological diversity (Baudry and Bunce, 1991; Naveh, 1991; Farina, 1994d).

International agencies such as IUCN and UNESCO have recently recognized the special value of the traditional agricultural landscape, introducing the concept of the cultural landscape (UNESCO, 1993). During recent decades cultural landscapes in Europe have been threatened by many natural and human-induced causes and survive only as remnant mosaics, especially in uplands or in remote areas. In the Mediterranean region in particular, recent land abandonment is one of the most common causes of cultural landscape degradation and species impoverishment (Farina, 1991 a, d; Lepart and Debussche, 1992; Gomez, et al. 1993; Pinto Correia, 1993).

This paper revisits the role of the upland traditional farming system along the Apennines in Italy as a land system that preserves, and in some case enhances, the biological diversity threatened by changes of land use and by diffuse abandonment.

Figure 15. The study area: Northern Apennines

The study area

The study area is located in the northern Apennines within the Magra River watershed, Massa Carrara province, Tuscany region. The mountains reach 2000 metres above sea level and are approximately 20 kilometres from the Ligurian Sea (Figures 15 and 16).

The region is characterized by a high geo-morphological heterogeneity (Pelletier, 1964; Federici, 1973, 1978). Three mountain chains border the area: the Tosco-Emiliano Apennines in the north-northeast and east, the Ligurian Apennines in the northwest and west and the Alpi Apuane chain in the southwest and south.

The Magra River drains a large valley of tectonic origin (graben), terraced by alluvial sediments uplifted during the quaternary era by sub-crustal tectonic movements.

The presence of high mountains close to the sea causes a variety of microclimates: from Mediterranean along the coast to alpine at the top of mountains (Bigi and Rustici, 1984). Because of this, the vegetation is extremely varied and rich. Ferrarini (1972, 1979, 1982, 1988) has distinguished six vegetation belts along an altitudinal gradient from Mediterranean maqui to the summit *Vaccinium sp.* prairie (Table 21).

Figure 16. The study area: Magra River watershed

The study area has been covered by a Geographic Information System (GIS) (Burrough, 1986) prepared for the Massa Carrara Provincial Government (see Farina, 1992c, for detailed description of the system and the methods used). Morphology, aspect, slope, land-use cover, river network and vegetation belts were transferred from a cartographic basis to separate digital overlays and modeled using macGIS software (Larsen and Hulse, 1989) at a resolution of 200x200 metres. Each land use was estimated for every 200x200 metre cell according to five cover categories: less than 5 per cent; 6-25 per cent; 26-50 per cent; 51-75 per cent and greater than 75 per cent.

The structure of the cultural landscape

One of the emergent characteristics of the upland farming system of the study area is the complexity and heterogeneity of the mosaic patches that can be observed. According to the classification of the Tuscany Regional Government (Giordano, et al. 1986), 51 land uses have been classified (Table 22). Six land uses are dominant (more than five per cent of all categories):

- dense woodlands (29.49 per cent);
- chestnut orchards (8.35);
- scattered woodlands (7.93);
- crop fields (7.54);
- pastures (6.81); and
- degraded woodland (5.26).

The heterogeneity of the natural landscape has enhanced that of the farming system. The complexity of the local morphology has been utilized in most cases as a guide or indicator of the suitability of each type of land use. With a long-term series of trials and errors the human populations that have lived in this area for thousands of years (Ambrosi, 1981) have found the best land use for each local morphological and microclimatic condition. This process, repeated over many years, has shaped the landscape in a matrix of small fields, each different from the other in terms of crop production and quality.

Several different landscapes can be distinguished along an altitudinal gradient. One is lowland landscape, located mainly along riverain terraces and characterized by open fields and herbage.

Another is hill landscape, located in that part of the study area found between 100 and 600 metres in altitude. This landscape is one of the more rich in terms of agricultural practices and biological diversity. Olive orchards mixed with vineyards and scattered fruit trees (cherry, apple, plum, fig), small terraces cultivated with corn and herbage are mixed with woodlot, dense hedgerows and stream corridors. This farming system is locally known as coltura mista.

A third landscape is mountain farmlands, found from 600 to 1200 metres. Although this landscape was intensively worked in the past, today it is completely abandoned. Crop diversity was limited due to the elevation, but the strong connection between this landscape and the high-altitude forests and prairies has created a nutrient flow and a large seasonal resource availability.

Despite the region's historically dense population it has maintained many original characteristics as a good wood cover. Soil erosion has probably been mitigated by the building of terraces, while windstorm effects have been reduced by tree hedgerows. In many cases patches of cultivation were completely surrounded by deciduous woods that functioned as a barrier against the wind. The high structural complexity of this landscape has conserved a high biological diversity along the entire altitudinal gradient.

The complex use of resources, seasonal use of the fields and overlapping of the traditional farming system with a seasonal transhumance and an upland pastoralism have created a puzzle of land patches, each suitable for specific plants and animals.

Although this fine-grained mosaic has favoured small animals and encouraged the presence of a very rich vegetation, agricultural practices have created a habitat for many plants and animals that are of little interest for biogeographers or taxonomists. More details on the structure and dynamic of the cultural landscape are reported elsewhere (Farina, 1991a, 1991d).

Biological diversity

Despite an extremely old human history biological diversity is very high, especially on the mountains above treeline in a belt between 1700 and 2100 metres. At this altitude the flora is rich in species indicating a past colder climate, including arctic-alpine species such as *Salix erbacea, Woodsia alpina, Gentiana purpurea, Lychnis alpina* and endemic species like *Primula apennina* (Ferrarini and Alessandrini, 1988).

There is a great variety of plants everywhere in the area, especially in secondary prairies, temporary clearings or along riverbeds. When domestic livestock grazing is combined with seasonal grass cutting there is a seasonal spreading of many beautiful plants, such as *Orchidaceae* and *Liliaceae.*

In terms of fauna, the vertebrates are especially well-distributed (Table 23), with birds being the group most intensively studied. Since 1981 habitat-oriented investigations were carried out in target habitats such as riparian woodland, farmland chestnut orchard, mountain meadow, olive orchard and woodland (Farina, et al. 1989; Farina, 1990, 1991c, 1992a, 1994 b, c, d; Illner, et al. 1992). Recently birds were studied at landscape scale in an area ten by ten kilometres typical of coltura mista (Farina, 1995) and in the summit prairies (Farina, 1994c).

Evidence indicates that most of the birds are attracted by olive orchards and by open areas such as prairies, meadows and crop fields. Birds prefer cultivated open habitats, particularly out of the breeding season. In these habitats food is available in the form of seeds of cultivated plants or insects. Woodland habitats are not as attractive for birds and only a small number of species can be seen there. The study area receives an important influx of migratory birds in spring and autumn. Open habitats are used as stopover foraging sites by most of the migratory birds and the presence of many species of migrants is conditioned by the local agricultural practices (Farina, 1987, 1988 a, b). Ploughed fields or cut meadows are preferred by many species, such as thrushes and pipits.

The area is particularly rich in small- and medium-size animals (Table 23). Recent investigations have verified the presence of many species of small mammals, especially in cultivated areas (e.g. *Pitymys multiplex*, P. *savii*, *Suncus etruscus*, *Crocidura leucodon*, C. *suaveolens*, *Sorex araneus* and S. *samniticus* (Farina, 1980) and, in mountain prairies above the tree line, the snow vole *Chionomys nivalis* is the dominant species (Farina and Cenni, 1983).

Land abandonment

The long-established relationship between natural processes and human activities has shaped the landscape of this area, creating unique mosaics of fields, woodlot, prairies, orchards, river corridors, hamlets and small villages. The farming system today is severely threatened by the land abandonment of the last 50 years (Farina, 1991a) with a dramatic drop in the number of employers in agriculture (Table 24). The reasons for this human-induced process are complicated and depend largely on the individual history of the property. Land abandonment has strongly influenced the shape of the land mosaic, transforming the fine-grained texture of crop-fields that composed the landscape (sensu Forman and Godron, 1986) into a coarse-grained mosaic dominated by woodlands.

This change occurred so quickly that many parts of the study area completely changed their spatial and functioning patterns within a few decades (Farina, 1991a, b; Vos and Stortelder, 1992; Farina, 1994b; Vos, 1993). Woodland is quickly recolonizing scattered parkland pastures, clearings, submontane pastures and fields; this trend is expected to persist in the near future.

Although there is not yet quantitative data, changes to the ecological processes can be expected as a consequence of this change in human activities. Changes to the mosaic patterns have affected many of the ecological processes of this landscape, such as soil erosion, flow of nutrients and animal movements.

Most of the study area was utilized in terms of natural and human-induced resources, as were many other regions of the Apennines. Crop production, orchards, livestock, timber and charcoal were the main resources utilized by the local communities. Their activities were regulated more by local ecological processes than by human factors such as the economy or management. Until the recent past, in fact, most agro-silvo-pastoral products were used only by family groups and local communities.

Cultivation practices were adapted according to the edaphic conditions; farmers had a true ecological sensibility. Factors like slope, orientation and soil characters were well-understood by the farmers and different types of cultivation were distributed accordingly.

Proposals

Most authorities believe that the upland farming system is a relic of the past without future possibilities because of its lack of economic importance. But, although policy-makers still consider the traditional farming system non-productive and lacking in the capacity to compete with modern mechanized and chemical-fertilized farming, the last decades have brought an increasing appreciation of its inherent value. The upland farming system is valued for its recreational function, scenic amenity and wilderness attributes.

IUCN and the International Association for Landscape Ecology (IALE) have coordinated working groups and organized symposia on many occasions; for example, Farming Landscape and Natural Values, IALE World Congress of Landscape Ecology, Ottawa 1991, to discuss the problems of managing these systems and conserving their biological and ecological diversity.

The main difficulties in maintaining an active farming system in the study area are the increased cost of agricultural practices; the land's consequent abandonment and the recovery of shrubs and mono-specific grass cover, which modify the habitat very quickly. The synanthropic species that disappear after land abandonment are not replaced by new species.

One strategy to recover these areas is encouraging cultivation as a tool to maintain biological and ecological diversity. Public investment should be reconsidered.

The traditional upland farming system can be seen as one component of a source-sink system, indispensable for the survival of many relevant resident and migratory species. This model is common to other European countries as well (Harms and Opdam, 1990).

Broad-based educational action is urgently needed to focus on the ecological value of this landscape and its role in conserving biological diversity; to mitigate the negative effects of the surrounding urbanized areas; to assure vital resources such as fresh water and to preserve its recreational capacity. It is imperative to recognize the landscape's non-economic richness.

A Red Book is a good example of an educational tool to increase public awareness (Naveh and Lieberman, 1984; Farina, 1992b, Naveh, 1993). A Red Book provides a description of the main environmental characteristics of a threatened landscape. It also presents proposals to improve sustainable development and the conservation of the heritage value of natural and human-influenced patterns. Content, methods and strategies to prepare a Red Book have been discussed at different meetings. Recently a detailed report on one case study — West Crete — has been published (Grove et al. 1993); this represents a good example of a way to condense ecological and socio-economical information in order to solicit public concern about a threatened landscape. In the case in question, Crete Island is a significant example of Mediterranean landscape threatened by land-use changes (intensification of agriculture); upland land abandonment, especially pastoralism; and strong tourist impact (urbanization and resource depletion).

Table 21. Vegetation belts: Magra watershed, northern Apennines

vegetation belt	species found
1. Quercus peduncolata wood	*Quercus cerris, Q. peduncolata, Virus torminalis, Acer campestre, Carpinus betulus, Populus tremula*
2. Mediterranean maqui	*Quercus ilex, Arbutus unedo*
3. Querceto-Carpineto	*Quercus pubescens, Q. petraea, Fraxinus ornus, Ostrya carpinifolia*
4. Cerreto-Carpineto	*Quercus cerris, Carpinus betulus, Acer opalus, Laburnum anagyroides, Crataegus monogyna*
5. Beech forest	Fagus *sylvatica, Sorbus aria, S. aucuparia, Laburnum alpinum*
6. Vaccinieto	*Vaccinium myrtillus, V. vitisidaea,* V. *gaultherioides, Empetrum nigrum, Juniperus nana*

According to Ferrarini classification (Ferrarini 1972, 1982, 1988).

Table 22. Land use categories abundance

Abundance of selected categories as number of 200 by 200 metre cells and relative importance

land use	abundance	per cent	* category
urban	1577.51	4.89	2
crop fields	2432.37	7.54	3
crop fields abandoned	597.76	1.85	4
crop fields and olive orchard	683.73	2.12	6
crop fields and vineyard	430.67	1.34	7
crop fields, vineyard and olive orchard	323.53	1.00	8
olive orchard	652.22	2.02	15
thick old conifer stand	475.24	1.47	20
thick old broadleaf wood	398.78	1.24	24
thick conifer and broadleaf wood	559.74	1.74	28
thick woodland	9510.23	29.49	31
sparse woodland	2558.57	7.93	32
degraded woodland	1697.63	5.26	33
mature woodland	415.52	1.29	34
chestnut orchard	2692.89	8.35	38
pastures	2196.68	6.81	42
pasture and scattered trees	1180.78	3.66	43
rock outcrop	899.8	2.79	46
bare soil	469.4	1.46	47
mines	310.87	0.96	49

* Designated categories according to the land use classifications of the Tuscany Regional Govt.

Table 23. Recent vertebrate diversity

freshwater fishes	22
amphibians	6 caudata 8 salienta
reptiles	17
mammals	4 ungulates * 7 carnivores ** 17 rodents *** 15 bats
birds	100 breeders

* wild boar, fallow deer, mouflon and roe deer since 1970

** brown bear is extinct since 1700; wolf is a recolonizing predator; otter is extinct locally since 1960

*** porcupine is an invading southern species since the 1980s; marmot was introduced in the 1960s

Source: Farina

Table 24. Employers in agriculture

Number of employers, from 1951 to 1981, in the communes of Massa Carrara province, expressed as a percentage of total employers.

	1951	1961	1971	1981
Aulla	.35	.18	.11	.06
Bagnone	.37	.27	.24	.16
Carrara	.04	.02	.01	.01
Casola	.50	.32	.29	.13
Comano	.29	.32	.41	.29
Filattiera	.49	.33	.26	.14
Fivizzano	.44	.26	.19	.14
Fosdinovo	.61	.41	.21	.10
Licciana	.50	.28	.17	.11
Massa	.09	.05	.03	.02
Montignoso	.17	.08	.05	.02
Mulazzo	.58	.39	.30	.15
Podenzana	.43	.38	.22	.04
Pontremoli	.42	.23	.17	.09
Tresana	.57	.36	.33	.13
Villafranca	.32	.20	.12	.06
Zeri	.89	.45	.52	.33

Source: ISTAT, Rome

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The date palm grove oasis

A north African agro-system

Hala Barakat

The Sahara is the largest desert on earth. It occupies most of north Africa, from the Atlantic coast on the west to the Red Sea in the east. It is characterized by high temperatures, lack of frost (except high in the mountains) and, except for the coastal margins, by its dryness. The daily temperature can reach more than 35°C; wind is also an important factor. The limits of the desert are not clearly defined; however, the line that best reflects the biological reality is that coinciding with the 100 mm isohyte on the southern margin and 150 mm on the northern one. The 100 mm isohyte corresponds more or less to the southern limit of the agriculture of date palm (*Phoenix dactylifera*) and the northern limit for halfagrass (*Stipa tenacissima*) (White, 1986).

The oases

In the Sahara there are relatively few areas where potable water is found. Sedges (*Typha latifolia, Phragmites australis* or *Scirpus holoschoens*) are present near the places where water is located. These sedges develop progressively into stands of *Tamarix gallica* and T. *nilotica*. The primitive vegetation of the oases, as described from the uninhabited oases in southern Egypt (Boulos, 1966; Bornkamm, 1986 and Kehl, 1987) seems to be composed mainly of Dom palm (*Hyphaene thebaica*), several *Acacia spp., Maerua, Capparis, Calotropis procera* and *Citrullus colocynthis*. Date palm (*Phoenix dactylifera*) is rare in such neglected oases. In inhabited oases, on the other hand, this primitive vegetation has been replaced almost entirely by a date palm grove oasis agro-system. There is archaeo-botanical evidence that such anthropogenic oases already existed in Arabia around 5000 b.p. (Cleuziou and Costantini, 1982). This paper deals with such date palm oases and the traditional agrarian system that has developed over the centuries in such oases.

There are many common features among the date palm grove oases agro-systems all over north Africa, as shown below.

1. The oases are generally found in depressions around naturally flowing artesian water sources. When these sources cease to flow, artesian wells are dug in order to exploit the underground water close to the surface.
2. Water is the principal controlling factor in all Saharan oases, except those where irrigation of the palm groves is not necessary. Sharing water is a

common practice: a well rarely belongs to a single land-owner, but is shared among several land-owners according to rules which differ from one oasis to the other.

3. The structure of the date palm grove oasis could be summarized as follows: the wells determine the site of the oasis; the irrigation system determines the layout; and the rules of water-sharing define the dimensions of the palm groves.

Biodiversity

The biodiversity in the oasis agro-system is related to the date palm population. By far the most important component of the system, it exists in the form of an intra-specific diversity within the *Phoenix dactylifera.* Many free-hybridizing varieties of date palms are cultivated in the oases. In well-organized palm groves, the land-owners make sure they have several varieties of dates of different quality for local consumption and for commerce. This genetic variety of the population is the primary reason for its survival in the long term (Barbault, 1993).

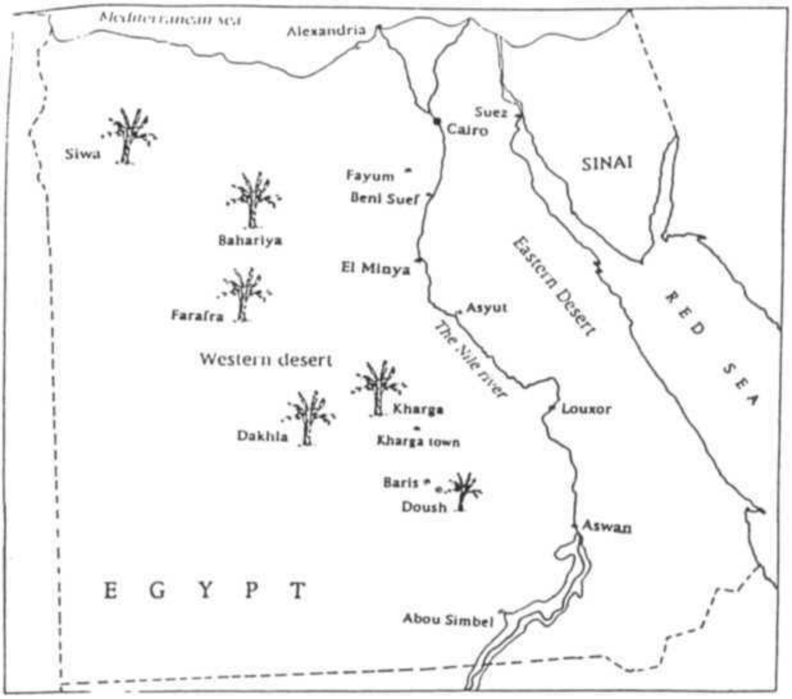
Artificial pollination

This is a common practice all over the date palm empire. The date palm is a diecious plant; wind pollination is not sufficient. Human intervention is required to ensure a good harvest with a large, high-quality fruits and to determine the variety. In the oases this process is of special importance, since the date palm is such an important cultivated tree. Date variety is determined by the female palm.

The male inflorescences are collected in spring before the spathes are completely opened. When the female inflorescence has lost its spathe, a trained worker carefully climbs up the palm, using the carefully pruned leaf-ribs as a ladder. He brings several male branches which he attaches to the female inflorescence with a palm leaflet. Excess female inflorescences are removed, leaving only 20-25 inflorescences per palm. The male inflorescences are left for 15 days; by then the dates are already pea-sized. This practice seems to be quite ancient; it was mentioned by Theophrastus, circa 300 BC, in his Enquiry into Plants (Hort, 1990).

In addition, the multiplication of date palms is carried out using vegetatively produced suckers. The date stones are not used, to save time and to avoid the undesired hybrids.

Figure 17. Map of Egyptian oases



Production of goods

In the life of the inhabitants of the oases, every part of the palm has an important role. The date fruit is their staff of life. It is consumed locally or sold fresh, dried or made into a paste.

The trunk of the palm provides wood for the construction of doors of their houses. In the case of the Ksours, the wood is also used to build galleries, or water recovery shafts, and to make the water-lifting tool known as the khottara. Palm leaves (djerid) are used for ceilings and fences, while the leaflets are plaited into plates and all sorts of basketry. The fibrous leaf base (lif) is used to make ropes and sacks, while the date stones are fed to camels. The palm centre (gfuelb) is edible and much-valued.

Date wine is made from old palms. All the leaves are removed, except in the central part; a vertical cut is made on one side of the crown and a reed pipe is placed inside to collect the exudate in a jar. This jar is emptied from time to time, a process which lasts for eight to ten weeks, after which a large quantity of the drink is collected. It is drunk fresh, when it is sweet and siropy, or is left to ferment, when it becomes intoxicating and worm infested.

Geographical distribution

The date palm grove oasis is a vegetation type which extends all over the Sahara in north Africa and southwestern Asia. In fact, as mentioned earlier, the southern limit of date palm agriculture in oases defines the southern limit of the Sahara. These oases stand out as islands of green; signs of life within a harsh sea of sand. There are many oases on the margins of the desert, in Algeria, Tunisia, Libya and Egypt, but fewer in the southeastern part of Morocco (Joly, 1948), and very few in Mauritania, Mali, Chad or Sudan. Oases are also found farther east in Arabia at the foot of mountains in Saudi Arabia, Yemen and Oman (White, 1986).

The domestication of the date palm (*Phoenix dactylifera*) is evident in its fruits (seeds) which have become larger and sweeter over time. This is directly related to artificial pollination; moreover, the domesticated palms are propagated vegetatively through suckers. The earliest finds of domesticated date palm seeds in archaeological sites date to 6000 b.p. from lower Mesopotamia and somewhat later from Palestine (Zohary and Spiegel-Roy, 1975).

The palm exists in several areas as subspontaneous, producing small tasteless fruits and hybridizing easily with cultivated trees (Duckerby, 1865; Täckholm, 1974 and Boulos, 1966). It is nevertheless difficult to decide whether these trees are genuinely wild or simply derived from neglected cultivated clones.

The other wild *Phoenix spp.* showing close genetic affinities to *Phoenix dactylifera* are found in southwest Asia. *Ph. reclinata* (*Ph. arabica*) is found in Yemen, Eritrea and Somalia (Burret, 1943); *Ph. atlantica* in northwest Africa. Both of these hybridize freely with the local cultivated *Ph. dactylifera* clones. It is again difficult to know which of these wild palms is the progenitor of today's cultivated date palm.

Problems and pressures

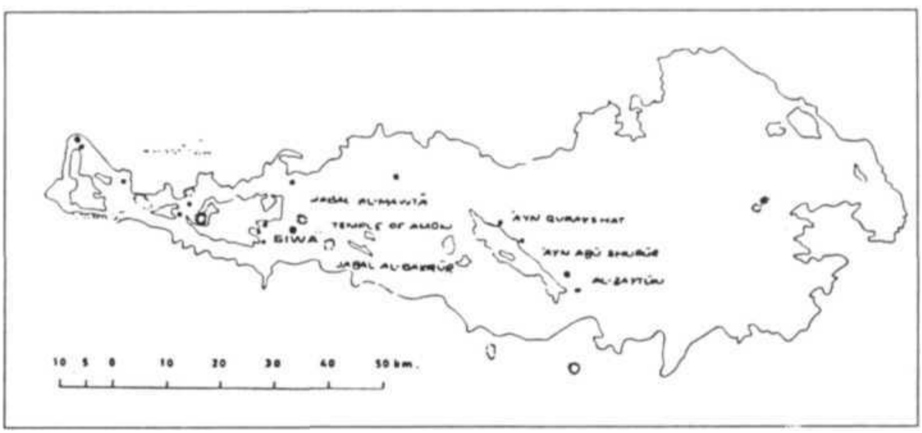
Three countries in North Africa have been chosen as examples: Egypt, Algeria and Chad. Problems and pressures will be discussed for each of the selected countries and for individual study cases. In general, drainage is a threat to agriculture, while sand extension is a major problem in villages.

Egypt

The Egyptian desert lies in the eastern part of the north African Sahara. The desert covers about 96 per cent of the total area of the country; so vast that it could be divided into three sub-deserts: the Sinai, the eastern desert and the western desert. The western desert covers an area of 681,000 square kilometres. Within this great sand sea are found a number of scattered oases; the largest and best known of them being Siwa (Fakhry, 1990), Bahariya, Farafra, Dakhla (Beadnell, 1901) and Kharga (Fakhry, 1950). In addition there are some uninhabited oases farther south.

The oases are found in depressions: Farafra and Bahariya in one, Kharga and Dakhla in another and Siwa in a third. In all the oases, the inhabitants live in villages. There is much in common in the customs and traditions among the first four oases, while Siwa, which lies more to the west, stands apart. The Siwans have their own language, a dialect of Berber, while the inhabitants of the other four oases speak Arabic, as do most Egyptians.

Figure 18. Siwa Oasis



Siwa Oasis

The depression in which the oasis is located averages 18 metres below sea level. It is some 82 kilometres long from east to west, between 25°16'and 26°7'E and 29°7'and 29°21'N. Its western boundary is at Al Maraqi, while its eastern edge is at Al Zaytun. The town of Siwa (Figure 18) is roughly in the centre; in addition, there are few other scarcely populated villages. Most of the 5000-6000 inhabitants of the oasis live in the town of Siwa.

Functional aspects

There were some 281 springs present during the 1970s. The water supply is artesian; water is derived from miocene aquifers 3500-5500 years old. The water is generally warm, with a temperature range of 26-30°C. The springs are found in the midst of the gardens, usually surrounded by a circular stone wall. The cultivated land amounts to 1300 feddans (approximately four square kilometres), 1000 of which are palm groves. The date palm is by far the most important and most common tree cultivated in the oasis, followed by the olive tree (25,000 trees). In addition, many other fruit trees, such as fig, pomegranate, sweet lemons and citrus lemon are cultivated. The Siwans also grow in their gardens almost all of the vegetables known in the Nile Valley. Gardens and palm groves are surrounded by fences, two metres high, made out of date palm ribs held together and fixed to the ground by mud. The gardens look wild and untidy. There are some 240,000 date palms belonging to several varieties, among the most important of which are Saidi (the best quality dates), Frihi, Ghazali, and Azzawi.

The oasis does not suffer from a scarcity of water so much as from the lack of an adequate drainage system. Water from several springs is wasted and flows into the salt lake of Al Zaytun. Thousands of cultivatible hectares are thus turned into karshif. Karshif is mud formed from salt-impregnated soil, which becomes hard as cement upon drying, but dissolves on contact with water. These areas are thought to have been cultivated much earlier, as seen from the remains of ancient monuments in the vicinity.

Socio-economic issues

Siwans depend a great deal on the date palm; not only is the fruit consumed and exported and the principal source of income for the inhabitants, but all parts of the palm are used and valued. When constructing houses the trunk is used for doors, the ribs for the ceiling. In household use the leaves are used for the manufacture of mats, plates and baskets. The palm also provides a favourite drink of the oasis: date wine. The second most important tree is the olive tree, from which a high quality olive oil is produced using a donkey-driven oil press.

The Zaggalah system is part of the management of the oasis. A special class of the inhabitants, 20-40-year-old bachelors, work in the fields and gardens of wealthy land-owners. The land-owner is responsible for all their needs year-round, as well as for giving them 40 bushels of the best variety dates. This resembles the khammés system in north Africa.

As mentioned previously, the Siwan language is a dialect of the Berber language. The original inhabitants were one of the branches of a Berber group from the tribe of Zanatah who mixed with Arab Bedouins from different western tribes during the Middle Ages. Siwa was one of the important stations for caravans, and a market for the slave trade, which explains the negroid blood present among the inhabitants. There are two principal groups: the easterners and the westerners, with a long history both of conflict and of sharing life in the oasis.

Historical context

In spite of its isolation, the oasis held an important place in the history of Egypt during the pharaonic period. This is illustrated by the presence of numerous monuments, such as the two main temples of the oracle (Amoun temple) and that of Um-ubaydah at Aghrumi.

Siwa was built around 800 b.p., when the inhabitants were forced to abandon the ancient town at Aghrumi. It is an example of a fortified town on a hill. The Siwans built their houses inside the strong outer wall; this originally had only one entrance but two others were added later. Until 1820 the Siwans were not allowed to build outside the wall, and had to add storeys to their existing houses when extensions were necessary. This resulted in the characteristic architecture of the town. Additional storeys were built with karshif. Rains were therefore destructive to these houses and nowadays only the ruins of the old town are left, giving a special aspect to the oasis.

Bahariya Oasis

Bahariya oasis is typical of the four main oases in the western desert of Egypt. The depression in which the oasis is found lies at 128 metres above sea level. There is almost no rain (only 14 mm per year) and the mean maximum temperature is 36°C. The oasis is estimated to cover about 2000 square kilometres, only 11 square kilometres of which are cultivated. The cultivated area is thought to have been much larger in the past when many of the ancient wells, now dry, were still flowing. Bahariya has approximately 6000 inhabitants.

Functional aspects

There are two methods of recovering water for irrigation in the oasis.

1. There are more than 200 artesian springs providing water. The water is generally warm, ranging from 26-30°C. Water flows from the bottom of the springs through natural fissures in the rocks of the ridge. Water from several springs might join to form a cataract used for the irrigation of gardens; it is also led from the source to the gardens in underground aqueducts, which are usually concealed under the palm groves. This practice goes back to the Roman period; remains of some of these aqueducts can still be found.

2. Long underground galleries are cut in the water-bearing strata of the rock, in the form of small cylindrical shafts close together (15-40 metres apart). The galleries are cut obliquely to catch water. The water is accumulated and flows out continuously as if it were a natural spring, such as at Ayn Umm al Dabadib. This water recovery method is also common in the three other eastern oases.

The inhabitants of the oasis rarely dig new springs, preferring to use the ancient ones. These are cleaned when they become full of sand. When a new spring is to be opened, a primitive instrument called a doulab is used.

Water-sharing system: Water from a single spring is rarely the property of a single land-owner; instead it is usually the supply for several land-owners. Distribution of water is carried out using a wooden weir. Rectangular notches are cut in the weir's upper edge and each individual is entitled to the water which flows through a certain number of notches. At night the springs are banked up so that the water accumulates in a large pool surrounded by a mud dam. Water is allowed to run into the gardens during the day; during the hot season, water is diverted to irrigate the palm groves rather than other fruit trees. The oasis is home to approximately 100,000 palms of several varieties, including Saidi, Feirehi and Sultani.

Socio-economic issues

As is typical in all oases, the wealth of the inhabitants depends on the date palm and olive. In gardens the principal cultivated tree is the date palm; the dates of the Bahariya are particularly highly valued. Three quarters of the total production of the oasis is exported to the Nile Valley. In contrast to the other oases, agriculture in Bahariya is typically Egyptian oasis agriculture. It is mainly found around villages in the northern part of the oasis.

The architecture of the houses is quite interesting and includes a spacious courtyard which is surrounded by a fence or a wall. The open courtyard provides space to spread the dates to dry before they are exported. Within the courtyard there is usually a well. Water from the well is used to irrigate the small home vegetable gardens, which are looked after by women, and to provide the daily needs for the house. A mulberry tree is planted near the well for shade. The house is usually one or two rooms built out of mud or mud-brick in a corner of the courtyard close to the entrance.

Ezbet Doush

Ezbet Doush was the site of a study in Kharga oasis. Doush — ezbet means village in Egyptian dialect — is located at 24°25'N and 30°45'E. It is a small palm grove oasis located within the Baris Plain in the Kharga depression, south of Kharga town (Figure 17).

Functional aspects

Water is the controlling factor in this oasis agro-system and will be discussed in detail. The water resources in the oasis belong to two distinct water-bearing sandstone strata.

1. An upper stratum, close to the surface, is the source from which artesian flowing wells derive their water supply.
2. A lower stratum is separated from the upper by a 75-metre band of impermeable grey shale. This deep formation is the main source of underground water in the western desert, although only a few wells in Ezbet Doush get their water from it.

In Ezbet Doush, there are about 50 wells belonging to the shallow well category. The wells are 90-120 centimetres deep and are dug in a concentric pattern which more or less corresponds to the consecutive contour lines. This facilitates the irrigation of cultivated land. Many of these wells have been neglected; at the time of this study (1983) there were a dozen functioning wells. These were dug in two parallel series with the houses of the inhabitants in between.

Environmental aspects

While studying the vegetation in the oasis, two principal ecosystems were recognized: farmlands and wastelands (Barakat, 1986). The farmlands show a typical ancient agricultural pattern. There are five main components.

1. Well openings: the opening of each functioning well is usually marked by an elevated mound surrounded by tamarisk (*Tamarix nilotica*).
2. Irrigation canals: water flows through a short main canal that distributes water to a limited area of the farm land through a system of subsidiary canals.
3. Palm grove habitat: This the most conspicuous habitat at Ezbet Doush, occupying the elevated parts of the oasis. Palm groves include both date palm (3000 palms) and dom palm (*Hyphaene thebaica*: 400-500 palms). Dom palm is believed to be a constituent of the natural vegetation of the area; the two types of palms grow together and occupy several hectares.
4. Orchards: The orchards are fenced and occupy the area below and around the palm grove. Trees include olive, apricot, citrus fruit, guava and pomegranate.

5. Crop fields: These occupy the lower and peripheral parts of the oasis, surrounding palm groves and orchards. The main cultivated crops are wheat, barley, clover, broad beans, onion, garlic and lentils as winter crops and maize and vegetables as a summer crop.

Biodiversity issues

Biodiversity in Doush, as in the oasis agro-system, is related to the date palm population. In Doush this includes at least 17 freely hybridizing varieties. This small oasis of 150 inhabitants offers one of the rare extant examples in Egypt's western desert of an earlier, much more extensive agro-system. The history of the area's vegetation is also quite interesting; a reconstruction of the vegetation during the Greco-Roman period (Barakat and Baum, 1992) shows that the oasis was much more prosperous. It is now a typical oasis agro-system. The oasis lies at the end of the asphalt road from Kharga town. The agricultural complex includes date palm groves, orchards, fields and house gardens. Doush's economy is a closed one; the oasis is modestly self-sufficient. The products related to date palm, such as mats, plates, baskets and dried dates, are sufficient for local consumption but are far from being plentiful enough to export. During the study period (1980s) there were only a few electric street lights, no electricity in the houses, and just a small primary school.

There are problems related to exploitation of the cultivable land, as in many other oases in the Sahara. Doush suffers from inadequate drainage as well as a lack of water-resource exploitation, so that previously cultivated areas become wasteland. These areas are either salinized or desertified due to lack of water for irrigation. Traces of the old irrigation canals can still be seen where wells have dried up.

Decrease in population is another problem directly related to environmental issues. Young people leave the oasis, migrating to the closest town and from there to the already over-populated Nile Valley.

Algeria

There are three main regions of oases (Bisson, 1995, Capot-Rey, 1961, Cornet, 1961, Durand and Guyot, 1955, Dybowski, 1889, Estorges, 1964, Lablée, 1958, and Nesson, 1965):

1. the eastern or Irharhar region includes Wadi Righ along the railway from Biskra to Touggort, Ouargla oasis more to the south, Souf to the east and Laghouat in the northwestern margin, which more or less delineates the northern edge of the date palm empire;

2. the western or Saoura region includes Tarhit, Beni Abbes and Gourara oases; and
3. the Tademai plateau includes the southern oases, such as Adrar, Titaf and Taourirt.

Figure 19. Map of Algeria

Functional aspects

The oases (Figure 19) are situated in a very arid region (less than 100 mm mean annual rainfall and 20-30°C mean monthly temperature); moreover, the winds contribute to a high evaporation rate. The date palm grove agro-system is installed in one of several locations:

- in depressions around naturally flowing water sources;
- near wells, which are dug primitively but efficiently; or
- in the lowest part of the depression, where the slightly rising artesian water-table is accessible and no irrigation is necessary.

In the first two regions and, to a certain extent, in the third, water is the principal controlling factor upon which the date palm grove oasis structure and functioning depends.

Water supply: Water flows from artesian springs, forming small circular lakes that allow for easy irrigation of the plantations established below the spring. When these springs cease to flow, the inhabitants of oases dig artesian wells in the same spot. This permits the exploitation of underground water. The borders of the wells are covered by wood logs from palm trunk, the cracks between rocks and the wooden coating are filled with fine loam and fibrous palm leaf. In order to clean sand from the well, special workers called ghettassa remove the sands by diving several times to the bottom of the well.

Irrigation network: Water is accumulated in small cemented square or rectangular basins before it flows into the date palm grove and gardens. Once these basins are filled, water flows through two openings supplied with gates into loam canals, each 50-100 centimetres in diameter and 5-10 centimetres deep. These canals cross the grove or garden; each of the principal ones branching into three or four smaller canals. Sometimes a palm grove is constructed on a hillock around a naturally flowing source, making use of the natural slope for the irrigation system. In this case the system is identical to that mentioned above, except that the watering begins with the grove at the downstream end.

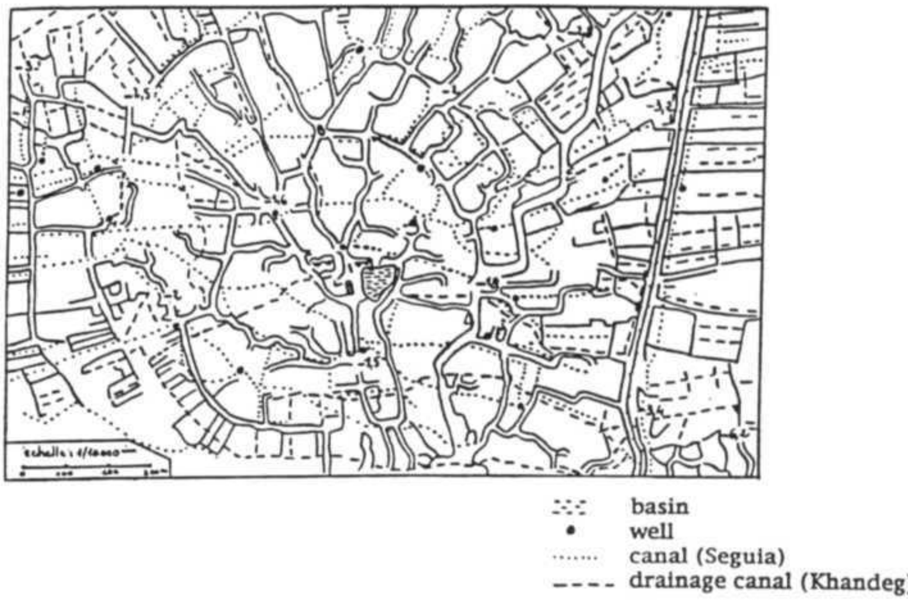
The drainage system consists of khandegs, which are deep canals 10-120 centimetres in diameter and 60-100 centimetres deep. These are dug parallel to the date palm lines, around the squares, to avoid the salinization of lower palm groves. Figure 20 shows an example of an old palm grove in the Wadi Righ.

Water-sharing system: In all oases, artesian well water belongs to those who have contributed to its flow. A well rarely belongs to a single land-owner, and well-digging expenses are shared among several land-owners. In addition, past use often determines whether a well is an individual or a collective one. Water-sharing involves turns, or noubas. Each nouba is 12 hours and can be either day or night. Each person's share is determined by the number of noubas. The water of a single well is usually divided into 28 or 56 noubas, depending on the number of interested land-owners and the flow rate.

In the date palm grove oasis agro-system, irrigation depends on the water-share owned (number of noubas) and the dimensions of the property (number of palm lines). It correspond to the quantity of water available, the water share and the distance from the well.

Figure 20. Ground plan of an old circular palm grove, Wadi Righ

Source: Nesson, 1965



Biodiversity

There is high intra-specific genetic variation in the date palm oasis agro-system. The principal varieties differ from one oasis to another (Table 25). As a general rule, there are more than ten varieties of date palms in each oasis. In a well-organized palm grove, to meet local consumption as well as commercial markets, the owner makes a point of planting different varieties of dry and semi-dry dates that mature in different months.

Socio-economic aspects

Dates are the main commercial product of the date palm, and are sold fresh, dried or made into a paste. Dates of better quality, such as the famous Algerian variety, the Deglet Nour, are sold on the palms. The dates are transported to the closest town where there is a date market. The quality of the dates varies from one region to another. The best are produced in the southern oases, where the high temperatures allow the dates to reach their maturity quickly and achieve a high commercial value.

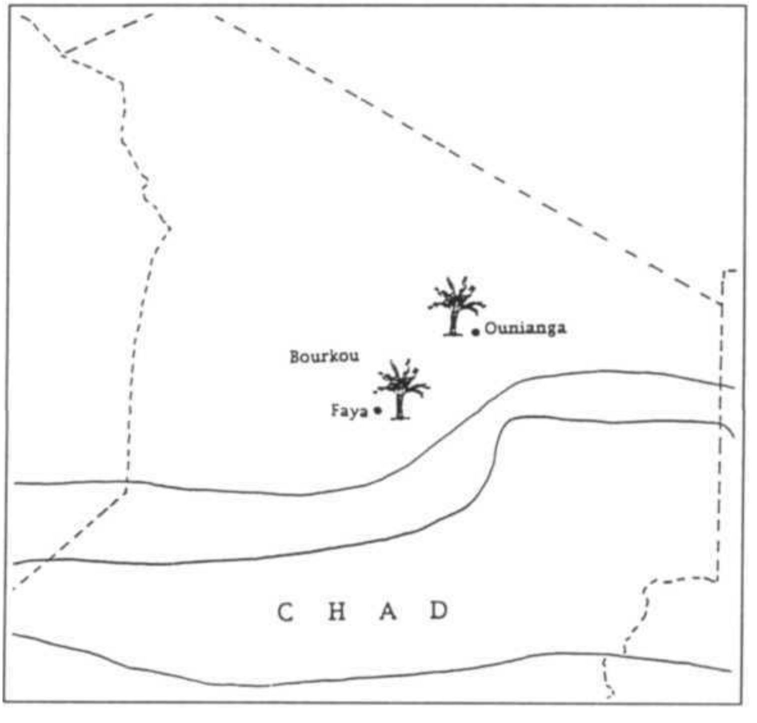
Table 25. Date varieties in Algeria

variety	matures	quantity/quality	observations
Hamari	June-July	large harvest	eaten fresh
Ghars	Aug.-Sept.	large harvest, high quality	eaten semi-dry
Deglet Ache	September	medium quality	earen dry
Tazerzait	September	large fruit, good quality	dried
Bent Ghala	September	good quality	dried
Gosbi	September	large fruit	dried
Tctzaouine	September	good harvest	—
Itime	September	medium quality, oval fruit	dried
Ali or Rached	September	medium quality, oval red fruit	dried
Telacine	September	medium harvest	soft fruit
Deglet Mras	September	—	soft fruit
Tamedjohert	September	good quality	dried
Fezzain	September	large branches, medium quality	long dry fruit
Seba Arous	September	dark red fruit	—
Taourakt	September	dark red fruit	—
Halouala	September	small dry sweet fruit	—
Beid El Hamam	September	round yellow fruit	—
Tameztit	September	small branches	long soft fruit
Tinnecin	September	small soft black fruit	—
Deglet Mamen	September	good quality	dry sweet fruit
El Arichti	September	large branches	soft yellow fruit
Dafar El Gatt	September	small branches, poor quality	very small soft yellow fruit
Bezzoul Khadem	September	good quality	soft brown fruit
Sekria	September	good quality	soft brown fruit
Zog Mongar	September	good quality	soft brown fruit
Hona	September	good quality	soft brown fruit
Messouai	September	very good quality	soft black sweet fruit
Hamraia	September	large branches	semi-soft red fruit
Deglet El Cham	September	large branches	—
Deglet Nour	October	large branches, best quality	transparent amber fruit
Abdelazaz	October	very good quality	transparent amber fruit
Takennoust	October	good quality	round semi-soft fruit
Degla Beida	October	poor quality	large very dry fruit
Taoudant	Nov.-Dec.	medium branches, large fruit	soft yellow fruit
Chettara	January	—	large soft yellow fruit

Inhabitants of the oases are mainly sedentary. The exploitation of the land is either direct — land-owners care for their palm groves themselves with their family members — or paid workers are hired. It can also be indirect; rich land-owners employ khammes (servants), who are given full responsibility for the grove and receive half the production of vegetables cultivated, three litres of dates per palm, or a whole palm. Khammes are also paid to plant suckers and to remove sands.

Most information available about Algeria is at least 30 years old. The country and its oasis agro-system have been the subjects of many publications and studies. While it is interesting to find old publications describing the traditional agro-system, it is not known if there are still any examples extant.

Figure 21. Map of Chad



Chad

Chad's oases are found in the transitional zone between the southern Sahara and the humid tropical northern Sahel (Figure 21). There are environmental differences between the date palm grove oasis agro-systems in the two regions. The date palm groves in Chad take the form of a plantation of palm groves within a forest of acacias and dom palms. The palm groves are not irrigated, since the water table is quite accessible. Water is a much less important limiting factor than in the Sahara; the water-sharing system for the irrigation of gardens is quite simple and there is no control over the quantity of water used by each land-owner. The gardens consist of palm groves and cereal and vegetable crops, but no cultivated fruit trees. The intra-specific biodiversity of the date palm is a common feature in the two agro-systems; there at least 20 varieties of dates in Faya.

In Chad, ownership of cultivated land is managed differently. In the irrigated part of the oasis, ownership of the palm grove can be shared between the initial owner and another who adds palms, fences the land or provides water for the plantation. The exploitation of the palm groves is either familial (the land-owner works the land with the aid of his wife and children) or in collaboration with another inhabitant who gets half the harvest. There are agricultural workers, but not as in the khammés system of north Africa.

The inhabitants of the oases in Chad are sedentary or semi-nomads. The sedentary live in tent-like houses and conserve dates in jars called grinti, which distinguishes them from the semi-nomads, who never use jars.

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Home-garden systems in Vietnam

Nguyen Xuan Quat

In Vietnam, home-garden is one of the traditional and common agro-forestry systems. Home-garden can be found throughout the whole country, especially in the lowlands where the land area is small and the population is large.

In home-gardens the agro-silvo-livestock-fishery systems are combined harmoniously. The nutritional capabilities of the systems are used fully and promoted to the maximum; time and labour are used most effectively to create material wealth and commodities. Home-gardens have thus brought great socio-economic and environmental gains and are actively maintained and developed.

Home-garden models in Vietnam are also numerous and diversified. Depending on climate and soil conditions, traditional practices, combination of elements and main benefits, they can be divided into four main systems:

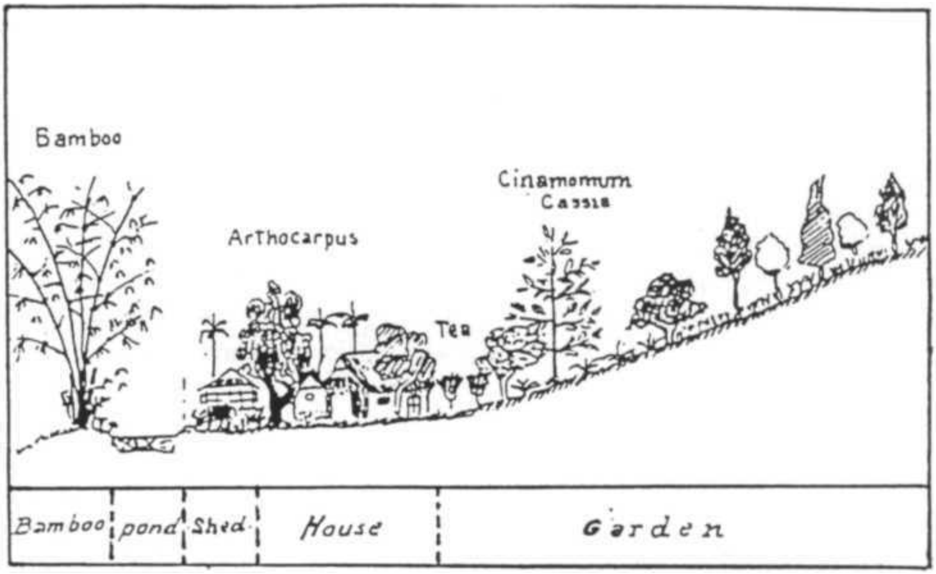
- home-garden with pond and covered livestock areas;
- home-garden with fruit trees (fruit tree garden);
- home-garden with forest trees (forest tree garden); and
- home-garden with industrial trees (industrial tree garden).

Home-garden with covered pond and livestock areas

This type is known as VAC, after the three initial letters of the Vietnamese words for garden, aquatic culture and areas under roof for livestock-keeping. These are the activities that have a long tradition and are very familiar to the families in rural areas of Vietnam. This type of garden helps meet peoples' most essential needs for self sufficiency in several ways.

The VAC model is common in the Red River Delta and in the midland of north Vietnam. Alluvial soil is required that is not prone to flooding. There is a need to avoid waterlogging in the rainy season. Flat land or gentle slopes at the foot of a hill are best, with water available for people's daily life and for agricultural production. The area for each household is usually 300-500 square metres and can be up to 1000-2000 square metres in some places. At times it can be less than 100-200 square metres, depending on the land resources. Usually 50-100 square metres are used for a pond, roofed areas for livestock, and a house with a courtyard. The remaining area is garden(Figure 22).

Figure 22. Home-garden with VAC in mid-hills



Description

Usually the garden has two layers. The upper layer consists of tree species for timber together with fruit or fruit trees. These trees are high with large crowns and require large amounts of light. There are 30-40 such species, the most common ones being grapefruit, *Artocarpus heterophyllus, Litchi* sinensis, *Euphorbia longava* and Canarium *pimelea.*

The under-storey consists of trees and plants yielding fruit, tubers or medicinal materials. They are shade-tolerant and moisture-demanding. There are 20-30 such trees and plants; the most common are pineapple, *Zingiber sp., Zingiber offianale* and *Curcuma longa.* In addition, some small areas are set aside in all home-gardens for hundreds of plants that meet the needs of a family's daily life.

There are commonly three categories of plants:

- vegetables and beans, such as water-lilies, kohlrabi, cabbage, lettuce, tomato and *phyllanthus elegan;*
- plants such as chilis, garlic, onion, basil, *eryngium foetidum, enhydra fructuans, perilla fructescens, schizonepeta tennifolia, capsium unnuum*; and
- medicinal plants such as *Herba ocimi, Mentha pipcrita, Polyscias sp. Ocimum sanctum.*

The **pond** is also composed of many layers. Deep below the surface is where the aquatic creatures are found. Nearly 20 species of fish, frog, shrimp and crab are raised but the most popular are fish species such as *Mylopharyngodon piceus* and *Ctenopharyngodon idellus*. The pond surface is used for water-ferns and water-lilies. Above the pond surface are trellises for pumpkins, gourds, loofah and *Pergularia minor*. Near the edge of the pond are vegetables, such as water lilies, Indian taro, *Araceae* and *Apium graveolens*, that are tolerant to flooded conditions. Sweet potatoes and ground nut are planted on the bank of the pond.

There are two types of roofed areas for livestock-keeping. A sty or stable is commonly used for pigs, buffaloes or cows. There are usually two divisions in each sty and stable: one for the animals and the other for storing feed, fodder and dung. The other type of enclosure is a cage for keeping poultry, commonly roosters, hens, ducks and geese. Cages have two levels; the upper one is for roosters and hens and the lower for ducks. There are live fences serving as protective belts around gardens, ponds and areas for livestock-keeping. Live fences also have two storeys with many multi-purpose trees yielding timber, firewood and other forest products. In the upper storey are found *Melia azendarach*, *Casuarina equisetifolia*, *Mangifera* and bamboo; in the lower storey are rattan, *Leucaena glauca* and *Morus alba*.

Benefits

VAC is a complete and integrated ecological system. Operations and components are inter-related. The garden is planted with trees and plants that meet peoples' consumption needs, as well as feed for livestock and for aquatic creatures reared in the pond. The pond is not only used for aquatic culture but also serves as a water reservoir for watering trees and plants in the garden and cleaning the pigsty and stable.

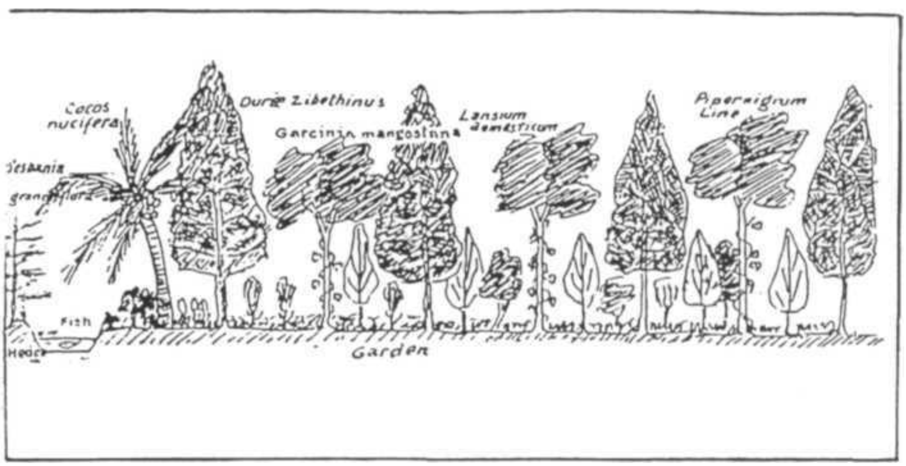
VAC is a very effective agro-forestry system. The land is used fully to bring about higher productivity and yields than those of any other system. It helps each family produce more food, such as meat, fish, vegetables and fruit, which increases protein and vitamin sources and makes meals more versatile and nourishing. It also provides fuel wood and raw materials for traditional handicrafts. It makes full use of the labour force in the family and, through work and contact with nature, increases the quality of life of the family members.

Those products previously discussed are only a number of main products that many families can harvest. These products are also the main commodities that families bring to the markets to sell in exchange for other goods.

- *Artocarpus heterophyllus:* 20 years after planting, the tree attains a stem diameter of 20-30cm and a height of six metres; with a fruit yield of 8-15 kilograms per tree per year (800-1000 kilograms of fruit per hectare).

- *Nephelium lappaceum:* 15 years after planting yields 2-4 kilograms of fruit per tree per year (1000-2000 kilograms fruit per hectare per year).
- Bamboo: 10 years after planting yields 3-4 culms per clump per year (1000 culms per hectare).
- *Thea* sinensis: 5 years after planting yields 0.05 kilograms per square metres per year (500 kilograms per hectare).
- Pineapple: 1 year after planting yields 0.1 kilograms fruit per square metre per year (1000 kilograms per hectare).
- Pigs: provide 100-200 kilograms pork per household per year.

Figure 23. Home-garden with fruit trees, southern Vietnam



Home-garden with fruit trees

Also known as fruit garden, this type of garden is mainly established for fruit trees (Figure 23). In addition, other tree and plant species are also combined, such as in VAC systems, to make full use of the land surface and the area above it.

Fruit gardens or orchards are commonly found in the Mekong River Delta provinces and eastern south Vietnam. The tropical climate has two distinct seasons: rainy and dry. The mean temperature is 26-27°C; the annual rainfall is 1800-1900 mm. The dry season lasts a long time but the soil is usually moist due to a high water table.

Canals are dug to create raised areas of land in order to provide good drainage in rainy season and expedite water supply in the dry season. Grey soil on old alluvium is present with rather flat or undulated surfaces.

Each fruit garden usually covers 0.5 hectares or more. Large fruit gardens have a network of canals and raised bands of land throughout them for water drainage and water supply. In addition, 100-200 square metres is set aside for a house in every garden.

Description

A fruit garden usually has three vertical storeys of fruit-yielding trees to make the maximum use of solar energy.

- Storey I: Tall fruit-yielding trees, highly light-demanding, such as *Durio zibethinus, Cocos nucifera, Mangifera* sp. and *Artocarpus heterophyllus.*
- Storey 2: Medium-sized fruit-yielding trees, moderately light-demanding, with a thick crown, including *Tetramyxis, Psidium guajava, Citrus grandis, Achras zapota, Annona macricata,* and Citrus *sinensis.*
- Storey 3: Low small trees, always found at low storey levels, shade-tolerant, including *Lygodium scandens,* Musa *uranoscopos,* Papaya, Citrus *nobilus* and *Phyllantus acidus.*

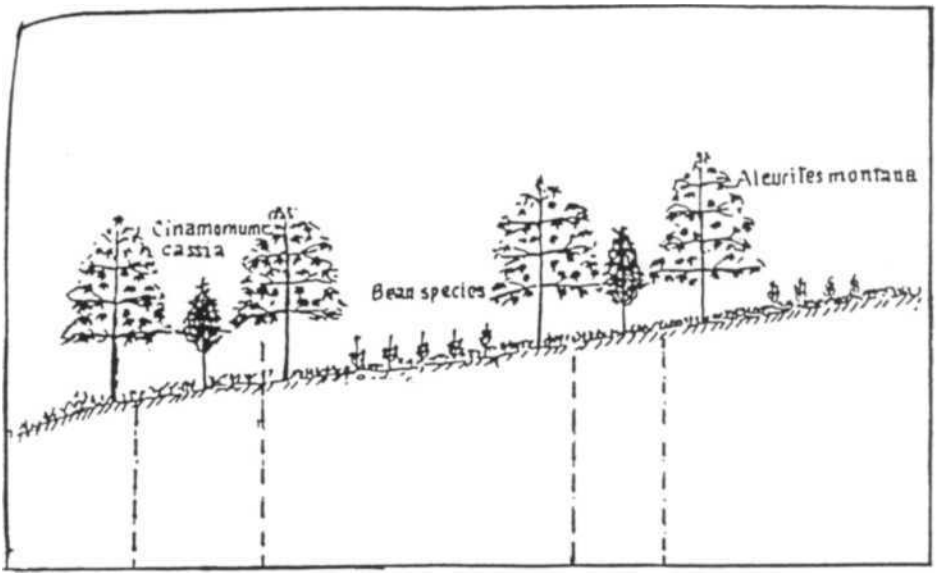
Indian taro and *Colocasia esculenta* are planted in the canals, and polyfagous fish, such as *Pangasius micronemus, Cirrhina molitorella,* and *Oreochronus mossambricus,* are reared.

People in south Vietnam have a long tradition of managing fruit gardens. They are very experienced in tree selection, selection of plant varieties and application of intensive techniques, especially the layout of plants and trees in the gardens. This is done in a way that simulates the multi-storeyed, evergreen, closed and dense rainforests, with many plant and tree species and varieties growing together in an harmonious and stable manner. The wild woody species are replaced by fruit trees of high economic value. In the storey of creepers and ground vegetation, wild species are superseded by others of higher values. Thus fruit gardens give higher productivity and economic value. At the same time, they bring about a better living environment with fine scenery.

The establishment and management of fruit gardens has become a major endeavour with highly-developed techniques that are indispensable to many peasant households in the region. Apart from the fruit trees common in home-gardens in north Vietnam, such as mango, coconut, jackfruit, pineapple, banana, orange, mandarin, grapefruit, papaya, *Psidium guyjava* and Custard apple, there are also endemic tropical species in South Vietnam such as *Durio zebethinus, Tetramyxis bonii, Persea gratissima, Spondias pinnata, Chrysophyllum cainito* and *Nephelium bacsasense.* Many varieties are not only diversified but also produce fruit in very large quantities. Fruit is an important commodity traded in all markets.

Similar to the VAC system, the benefits of fruit gardens cannot be fully and exactly calculated. If the economic value of the fruit alone is considered, however, it is usually higher than any other home-garden system, and can be two to three times that of pure forest or agricultural production.

Figure 24. Home-garden with forest trees



Home-garden with forest trees

This type of home-garden, known as forest garden, involves intensive planting of forest trees in the garden to produce several traditional products of high value (Figure 24). Forest gardens are commonly found in the midland and mountainous provinces of north and central Vietnam. These areas have a tropical climate with two seasons: dry and rainy; and winter, which is cold. The amount of rainfall varies hut usually ranges from 1500-1800 mm.

The dominant terrain is sloping land on different parent rock, mostly acidic volcanic rock, degenerated rock, alluvial stones of various kinds and limestone and sloping land with degraded soil.

Commonly 0.3-0.5 hectares, the smallest forest garden is 0.2-0.3 hectares and the largest is 0.8-1.0 hectares. As in the other systems, 200-300 square metres is also set aside for house building, a courtyard and land for planting vegetables, spices and fruit. This increases the variety and nutrition of daily meals. The remaining area is for forest trees for commodity production.

Description

Forest garden usually has one main storey with mostly a single species. In addition a low storey is planted under the main canopy, or a ground vegetation is maintained for soil protection.

Depending on ecological conditions, traditional practices and experiences in each region and market demands, one of the following tree and plant species is chosen by the peasants for their forest garden.

1. Bamboo species for house construction, utensils and raw materials for a number of handicrafts: *Dendrocalamus sp.* in Vinh Phu, *Dendrocalamus membranaceus* in Thanh Hoa and Nghe An, *Arundinaria spathiflora* in Cao Bang and Bac Thai, and *Bambucoides sp.* and *Bambusa arundinaca* in various locations.
2. Species yielding special products or timber of high economic value, essential oils, resin serving industries and export: *Illicium verum* in Lang Son and Quang Ninh, *Cinamomun cassia* in Yen Bai, Thanh Hoa and Quang Nam-Da Nang, *Canarium nigrum* in Vinh Phu, *Castanopsis boisii* in Hectares Bac and Bac Thai, *Livistona saribus* in Vinh Phu and Tuyen Quang, *Mangletia glauca* in Vinh Phu and Tuyen Quang and *Aleurites montana* and *Camellia sassanqua* in various locations.

A storey of low trees is generally used for making full use of the land area and sunlight to produce more food and other products of economic value or as supplementary crops to the main planted species. Light-demanding species yielding food include cassava, soybean, green bean, black bean and ground nut. Shade-tolerant, moisture-demanding plants yielding medicinal materials or fruit include ginger, turmeric and pineapple. Trees yielding leaves for green manure and soil cover include *Tephosia Candida*, *Cajanus cajan* and *Leucacaena glauca*.

Trenches are dug and planted with live fences around the garden to keep away cattle, domestic animals and poultry. A live fence is established by densely planting multi-purpose plants and trees such as bamboos and rattans that are ecologically suitable, require simple maintenance but give a quick and high yield.

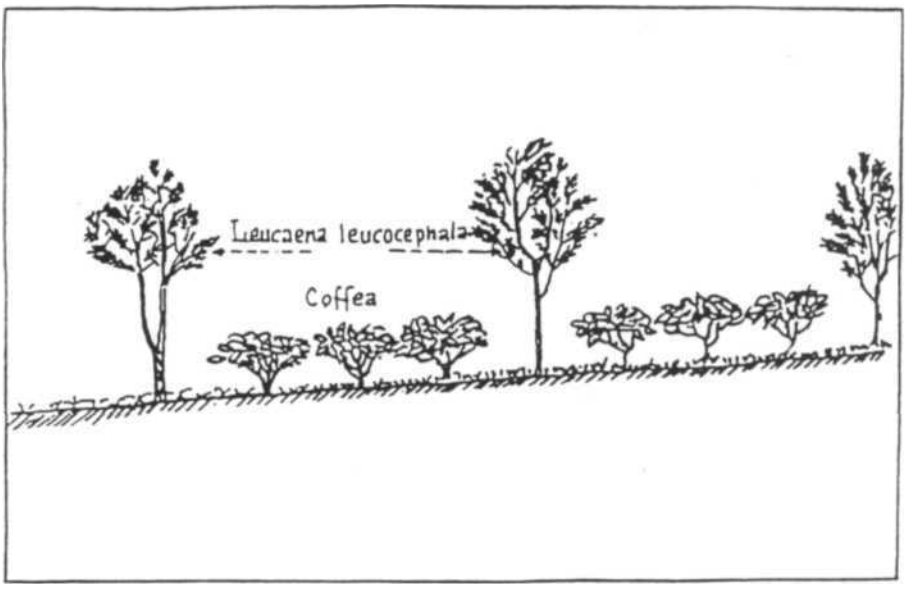
Benefits

Although the structure of forest gardens is simpler than that of fruit gardens, it makes use of many native species that are highly adapted to the location's specific ecological and site conditions. A lower storey is maintained and developed as support for the main storey, creating a stable ecological environment for sustainable development of the planted species. Forest gardens also help each family make full use of the time and labour of family members in tending and protecting the planted trees and create more commodities of high value. This in return helps the household to have a bigger investment in intensive management of the planted trees.

Forest gardens have many benefits, including the following items.

1. *Dendrocalamus sp:* 5 years after planting yields 8-10 culms per clump. Annual harvest is 3-4 culms per clump (600-800 culms per hectare).
2. *Aleurites:* Bears fruit 4-5 years after planting, average annual harvest is 5-7 kilograms of seed per tree (1500-2000 kilograms of seed per hectare per year) equivalent to 50-70 kilograms of rice.
3. Cassava planted with beans: If potassium fertilizer and farmyard manure are applied, productivity can incease by 12-37 per cent to ten tons per hectare. Cassava yield is 20 tons per hectare per year. The yield ot beans is 200-250 kilograms per hectare per year with 5-6 tonnes of leaves for green manure equivalent to 20 kilograms of nitrogen fertilizer applied to soil.
4. *Tephrosia Candida:* apart from providing shade and soil cover, also yields a great quantity of twigs and leaves for soil mulching; produces 20-25 tons per hectare per year, which increases soil moisture and returns nitrogen and organic matter to the soil for use by main crops.

Figure 25. Home-garden with industrial trees, basalt plateau



Home-garden with industrial trees

This type of garden involves planting a number of industrial trees in home-gardens with the same intensive management as that of fruit and vegetables. Industrial gardens are commonly found in the central highland provinces of Vietnam (Figure 25). There is a highland and mountainous tropical climate with two seasons: dry and rainy. The mean temperature is lower than that in the lowland. Red soil on basalt is common and there is also yellow soil on alluvial rock and grey soil on granite. The land is gently sloping and the soil layer is deep.

The average area of a garden is 0.5-1.0 hectares; with the smallest being 0.25-0.30 hectares and the largest 2-3 hectares. Most of the area is for industrial trees. The house, pigsty, stable and vegetable plot can be either near to or distant from the industrial garden. There is a need for convenient water sources and easy access by road for commodity trading.

Description

Industrial gardens are established and managed in the same way as agricultural farms or forest farms. They are designed for industrial tree species that yield products with high export values. The gardens consist of one storey of trees yielding products of economic significance and another storey of trees which are mainly of ecological significance.

- Economic significance: Two species are commonly chosen, coffee and tea. In lower regions there is also pepper, recently some households added cashew and *Morus alba* (mulberry). The trees are planted in rows or wide bands along contour lines. Ditches are dug to hold water; rice, ground nut and beans are planted between rows or bands of trees during the first three years to obtain full use of the land area, suppress weeds and as soil cover.
- Ecological significance: The trees are planted in rows or narrow bands between the industrial trees. They provide soil cover, prevent surface run-off and give shade trees in the early years. The species grown are usually *Cassia siamea, Leucaena glauca* and *Aleurites montana.* Recently some fast-growing leguminous species have been added, such as *Indigofera tseymanii, Acacia auriculiformis,* and *Acacia mangium. A* number of trees that are rather high with straight boles are grown specially in pepper gardens, such as *Wrightia anamensis, Erythrina indica* and *Areca catechu.*

Benefits

The structure of industrial gardens is simple, and depends on the proper choice of species and layout to meet its economic and ecological requirements.

Industrial gardens require a large amount of land and a high investment along with highly intensive management. The owners of the gardens must have adequate knowledge of science and technology and market conditions in Vietnam. These conditions were rarely met in the past but now, with state policies on loans and agricultural extensions, industrial gardens have grown in number and scale in the north as well as the south. Some main economic benefits are as follows:

- tea, which 4-5 years after planting yields an average of 8-10 tons of green young shoots per hectare per year;
- coffee, which 4-5 years after planting gives a mean annual yield of 1000 kilograms of beans per hectare; and
- Cassia *siamea,* which 3-5 years after planting produces trees 6-7 metres high. Thinning can produce firewood, twigs and leaves for soil mulching. After 30-40 years clear- or selective cutting can be made for timber and regenerated by coppice or replanting.

If annual crops are mixed in the first few years, the harvests can average as follows:

- rice, up to 2000 kilograms per hectare per year;
- ground nut, up to 600 kilograms dry pods per hectare per year;
- soybean and green bean, up to 1000 kilograms per hectare per year, excluding tens of tons of stems and leaves for soil mulching in the dry season.

Many gardens gain US$ 500-1000 per hectare per year, excluding soil protection and improvement. With basalt soil on moderate slopes, after the loss of forest, soil erosion is 120-170 tons per hectare, equivalent to one centimetre of surface soil layer per year.

A judicious mix of plants can bring benefits to the garden as a whole. An example is the case of coffee, which requires a large amount of water, especially in the flowering season. Flowering coincides with the dry season in December and January. At 25 per cent humidity the soil dries out, resulting in the coffee wilting and dying. Shade trees increase soil water preservation and air humidity, creating better conditions for growing coffee.

Conclusion

The home-garden system in Vietnam brings about several real benefits in socio-economic and ecological environment aspects:

- meeting the needs of daily life, such as utensils, firewood, food and vitamins;
- making full use of the labour force, including children and elders;

- promoting commodity production to meet market requirements, increasing peoples' income;
- providing expertise in technologies, an understanding of the market and an increase in knowledge;
- making full use of solar energy and land resource, increasing productivity per unit area; and
- maintaining ecological balance to ensure a stable and sustainable development.

Home-garden systems not only contribute to biodiversity conservation of the tropical forest ecosystems with hundreds of tree, plant and animal species, but also reduce the destructive use of the few small nature reserves that are left.

In recent years the State of Vietnam has become aware of this situation and has encouraged households to promote home-garden systems. The government has allocated land for long-term use, provided loans with low interest rates and supported farmers with planting stock and young animals.

The Agricultural and Forest Extension Centres of the gardening association (VACVINA) have been established everywhere, from central goverment to provincial, district, village and hamlet levels. These help peasants establish and develop one of the four traditional home-garden systems.

Many non-traditional tree and plant species and livestock are also effectively used and developed with larger-scale and more intensive management. Snakes, frogs, snails, crabs, shrimp, rabbits and eels are all reared in the VAC system. Prune, apricot and apple are being planted in fruit gardens. Multipurpose and nitrogen-fixing tree and plant species plus species yielding special products are being planted in forest gardens or industrial gardens, contributing to the maintenance and increase of tropical forest biodiversity.

The evolution of Kandyan home-gardens

An indigenous strategy for conservation of biodiversity in Sri Lanka

Anoja Wickramasinghe

Abstract

In the area of biodiversity conservation priority has been given to natural ecosystems, primarily parks and forests. Less attention has been paid to non-forest areas and to the way indigenous communities have promoted biodiversity in their production systems. A series of studies conducted in Sri Lanka during the last eight years reveals a system that has evolved over generations as a strategy to restore some of the fast-depleting resources that forests have provided. The degrading of forests, the detachment of local communities from them, the increasing pressure on quickly-depleting biological resources and the suppression of people's access to forests have forced indigenous people to resort to alternative practices. Kandyan home-gardens (named for the city of Kandy in central Sri Lanka) are a result of all these circumstances. Home-gardens have numerous benefits, from the perspective of production, conservation and aesthetics.

Knowledge and experience have motivated people to manage the lands surrounding their homes as forest gardens. Home-gardens are not identical to forests; in terms of ecological functions and species diversity and richness they are unique systems which have evolved through people's interaction with their environment, including the forest. Endemic and naturalized species make up nearly 40 per cent of home-gardens.

The strength of the structure in which home-gardens have evolved accounts for their stability. A garden gets transferred from one generation to another as family property. It sustains a balance of the country's most complex and species-rich agro-ecosystem. Trees, shrubs, herbs, crops and animals interact and sustain themselves in association with households. Cultural heritage cannot be considered apart from the system because of the strong connection between survival of the household and biodiversity.

Indigenous patterns of land use are examined as a means of managing biological diversity, with genetic resources highlighting the social interactions through which information is transferred and replicated. Results show that strong cultural traditions and indigenous practices are the key to sustainability of home-gardens in Sri Lanka.

Introduction

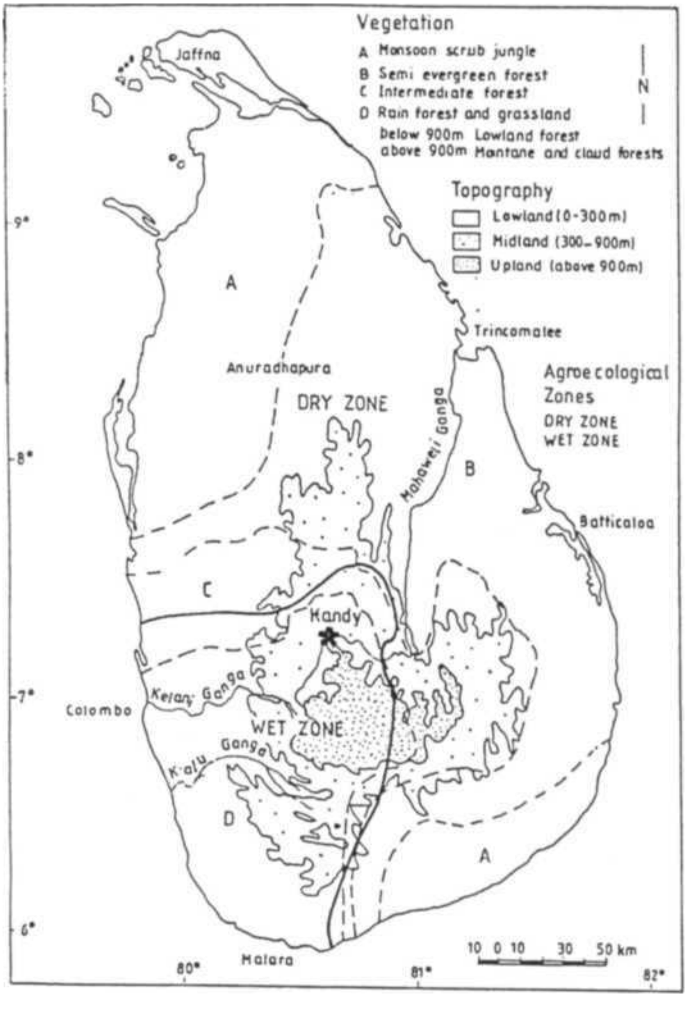
The effects of a natural climax community on the evolution of home-gardens are important, in both biophysical and socio-economic terms. It is vital to understand the anthropogenic causes leading to the loss of forest cover. The importance of forests in sustaining life has led people to make efforts to restore degraded lands. The problems inherent in these processes are numerous; the most difficult ones relating to ways of making intervention efforts acceptable and appropriate. Sri Lanka is favoured with plentiful bio-physical resources and is marked by a strong belief in survival systems related to trees and forests. A strong connection between forest and survival has existed for countless years.

This link has been fragmented as a result of the movement away from the diverse forest ecosystems, and because of forest clearings, modernization and the introduction of substitutes for subsistance goods harvested in the forest. Nevertheless, the evolution of home-gardens reflects the way that people have made adjustments and adapted systems by utilizing limited resources and indigenous knowledge in relation to the functioning and management of forest ecosystems. The mosaic of home-gardens covering Sri Lanka's landscape is indigenous in the sense that home-gardens have evolved from local resources in pace with the culture of local people.

This paper presents a comprehensive overview of Kandyan home-gardens, which represent the most diversified ecosystems located outside the forest. This garden system is similar to the forest, though not identical to it. Kandyan home-gardens exhibit the geometric relationships of trees, light attenuation in canopy layers, multiple functions and interactions that occur in limited areas outside natural forests. The social dimensions and biodiversity of home-gardens are discussed in reference to case studies conducted in the area around Kandy.

There are no home-gardens composed of homogeneous plots of a single species; diversity and frequency are the outstanding features. Most diverse systems are located outside forests, but have evolved in conjunction with the lives of the people. Production and interaction among tree crops and livestock are complex and affect many types of agro-forestry systems. These vary across regions and agro-ecological zones; in certain areas even, to some extent, among households. In Sri Lanka home-gardens include agro-silvicultural systems as well as agro-silvi-pastoral systems.

Figure 26. Agro-ecological map of Sri Lanka



Description

Sri Lanka is located in the tropics between 5°54' and 9°52' N and 79°39' and 81°53' E. It is subject to monsoon rains and is unique in terms of the diversity of its biological resources. One condition that contributes to this is the geomorphology of the country. Topographically Sri Lanka is characterized by central highlands located in the south-central part of the country and surrounding lowlands (Figure 26). In terms of elevation, the country is divided into three zones: lowlands (0-300 metres), midlands (301-900 metres) and uplands (901-2500 metres). This topography has created a radial drainage from the highlands to the coast. Besides the topographic variation, the climate — particularly the amount, intensity and distribution of rainfall — makes the situation more complex. Based on seasonal and spatial patterns of rainfall, Domros (1974) subdivided the country into two zones: wet and dry. Areas with a mean annual rainfall of more than 1900 mm are the wet zone; those receiving less than 1900 mm are considered the dry zone.

Rainfall distribution patterns, combined with the broad geomorphological variations, give rise to a well-marked pattern in the distribution of vegetation zones. According to Mueller-Dombois (1968), the subdivisions are:

- monsoon scrub jungle;
- semi evergreen forests;
- intermediate forests; and
- rainforest and grassland.

Elevation variations have been taken into consideration in differentiating sub-types within rainforest and grassland. Below the elevation of 900 metres is lowland rainforest; between 900 and 1500 metres is lower montane forests; and above 1500 metres is upper montane forest.

Severe deforestation has taken place in the wet zone areas of the country and now only about ten per cent of the country's forest cover is in the wet zone. Out of the country's total land area of nearly 6.5 million hectares, only about 1.3 million is under forests. In the years between 1900 and 1982, the forest cover was reduced from 70 per cent to 23 per cent (Government Land Commission, 1985). The evergreen rainforests in the wet zone of the country are confined to isolated islands. In the midlands, which are broadly designated as Kandyan areas, the lowland forest passes through a wide ecotone into lower montane rainforest.

Significance of home-gardens

Variations in physical setting, as well as in socio-economics and demography, have a direct bearing on the evolution of the home-garden system. Its predominance in Kandyan areas and also its rich composition have been affected by the favourable environmental conditions; particularly the high rainfall, which is more than 3000 mm per year. Another feature is the high proportion of home-gardens in the wet zone areas, where per capita land holding is low. The predominance of domestic agriculture is another factor that influences the extent of home-gardens. Traditional survival systems of Sri Lanka operate on a family basis in small holdings consisting of three units:

home-gardens, paddy lands and highlands. These all contribute to the household maintenance but home-gardens predominate.

In 1982 there were 367,428 hectares recorded as land under home-gardens, which accounts for nearly 26 per cent of the land in the small-holding sector. This statistic indicates the significance of home-gardens in a country where agriculture is the mainstay of the economy. The number of holdings in the country is not uniform throughout the country. The proportional distribution of home-gardens is affected by land availability, population pressure, distribution of other agricultural operations like plantation, agro-ecological conditions, indigenous knowledge and culture.

The percentage of small-holding area under home-garden varies throughout the country from 5.1 to 52.4 per cent. The extent of small-holdings operated as home-gardens is less than 15 per cent in Mannar, Vavuniya, Mullaitivu and Batticaloa. The high percentages in the wet zone areas are associated with population pressure; whereas in some dry zone areas like Moneragala, Polonnaruwa and Anuradhapura, it is related to the allocation of land for colonization and the abundant availability of land. One common factor across the country is the interface between home and gardens.

Evolution of home-gardens

The importance of Kandyan home-gardens is directly related to their diversity and their distribution in the landscape. This unique system has evolved on steep-sloped terrains that are subjected to severe depletion of forests and land degradation. The two widespread types of land-use in the country were the 'chenas', a form of shifting agriculture, and paddy cultivation. In addition, forest resources were used freely to fulfill a multitude of needs. With the expansion of the British administration into Kandyan areas in 1815, this traditional land use changed drastically and gave rise to the clearing of forests for plantation agriculture, first for coffee and then for tea. This occurred in the highlands, including Kandyan areas.

The drastic changes associated with deforestation had a severe impact on the lives of the indigenous people and their resources. They no longer had rights or access to the multiple resources that they used freely and shared commonly. Ferguson (1903) describes this process very critically: "Money was sent to Ceylon, to fell its forests and plant them with coffee, and it was returned in the shape of copious harvests to some capitalists, leaving in some cases only the bare hillsides from where their rich harvests were drawn". Although colonial administrations marginalized the local peoples' rights and concerns about the biological wealth of lowland rainforest that flourished in the Kandyan areas, they weren't able to completely destroy the tree-related cultures and livelihoods of the indigenous people.

Indigenous people also faced problems because of the lack of availability of land to expand their cultivation, the depletion of forests from their vicinity, and privatization of land to which they once had access. Yet the self-reliance of the local people made it possible to domesticate and conserve a wide range of species. While the narrow valleys of the rivers were used for terraced paddy fields, the sloping lands adjoining the paddy tracts in which dwellings were located were turned into gardens. These home-gardens consist of trees, shrubs, herbs, climbing vegetation and livestock, and contribute significantly to the survival of the dwellers. The balance between home-gardens and paddy tracts, extending from hillslopes to paddy field, reflect the indigenous knowledge that made it possible to maintain a balanced land-use system.

Home-gardens located on the slopes between tea plantations and paddy tracts mitigated the problems of sediment flow and excessive surface run-off by enhancing percolation and filtering of water. The effects of over-use of the areas are also lessened by the functions of home-gardens. Kandyan home-gardens are an agro-forestry system developed by local people to overcome environmental and socio-economic problems that arose in their own mountain terrain because of deforestation, overuse and degradation.

The depletion of forests has not changed peoples' concern for a healthy environment for the forests. Shade, coolness and diversity in species are considered essential for physical and psychological well-being. It is traditional to plant trees around dwellings; in some cases even prior to the construction of houses. Selection of species for planting is in fact governed by Socioeconomics and customs related to trees (Wickramasinghe, 1992a).

The strength of indigenous knowledge in the evolution of home-gardens is demonstrated by their being located in "patana" grasslands, which are classified as non-productive lands. According to the forestry profession nothing other than pine or eucalyptus could be grown in such areas. For the encroachers such lands are considered productive, and the development process began with the planting of trees of multiple uses. The species and their priority uses are known to those who grew up in the area. Investigations conducted in encroachments located in Illuktenna showed that pioneers established by the encroachers are coconut (*Cocus nucifera*), jack (*Artocarpus heterophyllus*), mango (*Mangifera indica*), banana (*Musa sp.*), avocado (*Persea gratissima*) and areca nut (*Areca catechu*). Another case of the power of indigenous agro-forestry practices was observed in Haloya, about 20 kilometres from Kandy, where nearly 48 families have encroached *Pinus* plantations and replaced them with a mixture of tree species.

Evolutionary process

The evolution of home-gardens begins with the establishment of new plots. In most cases the sites are not completely cleared, but are left with a few trees. The recorded history of fairly immature gardens, the age of which varies between 30 and 40 years, includes the following stages.

1. The species retained from the previous vegetation. These include *Madhuca longifolia*, *Tamarindus indica*, *Caryota urens* etc.
2. The planting process, which starts with the growing of a few selected species of high priority. Species of high priority are coconut (*Cocos nucifera*), Jack (*Artocarpus heterophyllus*), mango (*Mangifera indica*) and other food-producing trees. Households integrate priority species into the existing tree system in the areas which are not cleared completely.
3. Development of live hedges for fences. Narrow canopy, single stem, tall-growing trees then enter the system. Gliricidia (*Gliricidia sepium*), teak (*Tectona grandis*), mahogany (*Swietenia mahagoni*), areca nut (*Areca catechu*) are the most prominant (Wickramasinghe, 1989a, 1992b).
4. Enrichment of the system by filling with shade-loving and shade-tolerant species, which thrive under such conditions. These include cocoa (*Theobroma cacao*), nutmeg (*Myristica fragrans*), cloves (*Syzygium aromaticum*), pepper (*Piper nigrum*) on *Gliricidia* and, on other woody stems, mangosteen (*Garcinia mangostana*), avocado pears (*Persea gratissima*) and durian (*Dwrio zibethinus*), depending on the household's choice.
5. The emergence of specific backyard or kitchen gardens with fewer trees but more varieties of shrubs and crops. Gradually the backyard patch is dominated by sera (*Cymbopogon citratus*), rampe (*Pandanus latifolia*), curry-leaves (*Murraya koenigii*), papaya (*Carica papaya*), root crops, chilis and greens.
6. Throughout the development natural processes are also activated. Seed-carriers like bats, birds, wind and water carry planting materials, contributing to increased diversity. The colonization occurring through this process is extremely important. Havari-nuga (*Alstonia macrophylla*), sapu (*Michelia champaca*), kitul (*Caryota urens*), tamarind (*Tamarindus indica*), neem (*Azadirachta indica*) and mahogany (*Swietenia mahogani*) are examples.
7. As the garden gets more dense and diverse some nesting patterns are also established. Some nests emerge through natural regeneration around the species which disperse planting materials. Nests of seedlings emerge under kitul, areca nut, mango, neem and cocoa.

8. While these processes continue the development begun by local residents, the household itself is engaged in eliminating the excess and unwanted while bringing in new members. Livestock is another element integrated into the system. Finally, home-gardens turn into mosaics of village forest.

The evolutionary processes explored in this study raise a number of issues. One is the contribution of households, not only by allocating land, time and labour but by domesticating species native to their heritage. Households also contribute by accommodating new species, nurturing the foreigners brought through natural processes and exploring new practices through trial and error. Local residents act as extension agents by sharing information and by planting new materials, which sometimes convinces others in the region to do the same thing.

Another issue is the involvement of natural processes in sustaining and enriching the system. New species are not only introduced by humans; most are brought by the seed carriers, including birds, animals, wind and water. The stable condition of the home-gardens also attracts many seed-carriers. The maintenance of new species in an established setting increases diversity.

Trends and intervention

This indigenous agro-forestry system is subject to social and economic trends. Changes in the objectives of farming, from household subsistence to commercialization, have a direct impact on home-gardens, particularly by encouraging more intensive practices. There is a growing trend to accommodate species with greater market potential into existing systems, a practice that began in colonial times. Home-gardens have offered a secure place and favourable environmental condition to grow pepper (*Piper nigrum*), cardamom (*Elettavia cardamomum*), cloves (*Syzygium aromaticum*), nutmeg (*Myristica fragrans*), coffee (*Coffea arabica*) and cocoa (*Theobroma cacao*). These species are able to thrive in the home-garden system.

State policies have had an impact by creating subsidies and extension services for the development of home-gardens. The major beneficiaries, however, are not the small holders, but those with fairly large operational units. The practice of adding new species at random has influenced the composition of the home-gardens. Although home-gardens have been developed with indigenous knowledge, new practices may allow new species to dominate indigenous systems.

Some of the research carried out on home-gardens is focused on the economic importance of the gardens located around Kandy. The economic significance of Kandyan home-gardens has been studied (McConnell and

Dharmapala 1973; Jacob and Alles 1987; Perera and Rajapaksa 1991). Everett (1987) compared structure, composition and management while focusing on the sustainability of home-gardens. The system of home-gardening, being an indigenous land-use practice, has comprehensive ecological, socio-economic and cultural perspectives, which have not been covered in studies focused on economic significance. The ecological impact of the farming systems in the hill country was able to draw attention to the multiple significance of home-gardens (Wickramasinghe, 1988, 1989b). Since this agro-forestry system has evolved in conjunction with the livelihood of people, the significance of gender has been investigated (Wickramasinghe, 1991). The conservation interest of the local people involved in home-garden agro-forestry is also a topic requiring further research.

Function

Indigenous people have set out to improve the home-garden system through natural processes as well as management. The function of home-gardens, as with natural forests, is twofold: one function is scientific and environmental, the other cultural and socio-economic. The scientific dimension focuses on ecological, environmental and physical characteristics. The cultural and socio-economic dimensions illustrate the traditions behind its management, which have continued over generations. There is no way of separating its dual functions since in practical and human terms they are closely interrelated. For local people, the stability and richness of the environment reflect the well-being and the smooth functioning of the household. The overwhelming importance of home-gardens is related to a number of facts.

- Given the scarcity of forest resources and forest products, the need for alternatives has become serious. For instance, only 12 per cent of Kandy district has natural forest cover, whereas home-gardens occupy nearly 20 per cent (Anonymous, 1988);
- Where forest resources are unavailable or inaccessible, the rural poor have not had the financial capacity to obtain substitutes for them. Almost all the villagers depend on trees for fuelwood. In addition, 42 per cent of people use tree products as a substitute for rice, the staple diet; 86 per cent consume tree products occasionally. As discussed earlier, the importance of home-garden products rests on the fact that trees are an important source of food.

In this respect Kandyan home-gardens have become a source of multiple products, close in structure to forests (Wickramasinghe, 1992c, 1992d). The multiple functions of forests have been integrated into this non-forest system to improve daily life.

Table 26. Uses of home-gardens by households

use	number of species reported	used by more than 50% of households	used by 30-50% of households
food/fruit	96	82	14
fuelwood	104	104	—
fodder	08	—	08
timber	42	36	06
medieinal products	22	08	14
other (mulch, fencing materials, rafters)	62	41	21

Source: Field inventory in Narampanawa and Alawathugoda.

The main values derived from home-gardens are food, energy for domestic use, fodder for domestic animals, medicinal products, timber for house construction and a pleasant environment for the dwellers (Table 26). These many values show that home-garden agro-forestry is a multiple land management system, where management is based on an extensive indigenous knowledge.

The forces shaping the evolution of home-gardens are peoples' knowledge of environmental interactions, community functions and the physical traits of species. Species with single stems, straight boles and a narrow canopy go to the hedges or demarcation area. Food-producing species are denser and closer to homes; the frequency of non-food species increases towards the outer edge of the gardens (Wickramasinghe, 1994). The ability of species to survive in a complementary manner is the basis of the greater diversity of home-gardens. These Kandyan home-gardens are quite close in structure to natural forests and are ecologically superior to all the other land-use systems located outside forests. Mutual interaction determines how resources like water, nutrients, energy and space are shared and conserved to make the system sustainable.

The ecological superiority of home-gardens is related to their contribution to the conservation of soil, water, nutrients and biodiversity. With regard to soil, fauna and birds, Kandyan home-gardens are comparable to the adjoining natural forest environment (Senanayake, 1987). Home-gardens are also effective in nutrient processing, soil and water conservation, combating erosion, trapping sediment, regulating water and mitigating pollution. These processes in turn slow the degradation of biodiversity.

A comparative analysis of the environmental significance of land-use systems was conducted in the Maha Oya catchment area in the region of Kandy. It showed that home-gardens are quite close to the conditions of the natural forests in terms of annual soil loss, organic matter return, thickness of the humus layer, ground level evaporation, available water capacity and depth of the water-retentive soil layer. All the other land-use systems indicate a greater susceptibility to external processes, leading to land degradation (Wickramasinghe, 1988). Another study focused on comparing forest soils with the soils of non-forest production systems. It revealed that, in the hill country of Sri Lanka, the diverse vegetation cover of home-gardens is significant in maintaining ecological functions (Wickramasinghe, 1992e).

Management

Home-gardens, primarily inherited as family resources, are not generally subject to a great transition in terms of management practices. Transmission of knowledge, along with the transfer of ownership from parents to children, has meant that management has retained continuity. About 68 per cent of the home-gardens located in two neighbouring mosaics in Narampanawa and Alawathugoda are composed of such inherited resources. These are characterized by a long evolution history of two to three generations. The remaining 32 per cent of these mosaics are newly-emerged, but they also have a long history. The aesthetic concerns of the land users make the system diverse and more survival-oriented.

Since home-gardens are adjacent to homes, management activities have been carried out in conjunction with domestic work or during leisure time, particularly by women. These systems are managed by people who live in the same agro-ecological zone. Because of their long history and management, the mosaics have reached a climax stage of development. Although biological fences exist, the mosaics are not fragmented. They are characterized by native trees 40-60 years old as well as by saplings. In terms of well-developed canopy structures, there is an irregular pattern in the distribution of species, seedlings and saplings.

The involvement of households in managing home-gardens is not limited to harvesting outputs. There are specific management practices used to achieve better use of resources, including gaps and favourable inter-actions. Branch pruning, coppicing, clearing excessive seedlings, nurturing of naturally germinated seedlings or species emerging from garbage heaps, enhancing soil nutrients, controlling pests and insects by applying indigenous knowledge are all widespread. The relative position and the density of canopy layers are, to some extent, managed by annual or seasonal pruning and coppicing. Farmers have made it a point that these practices do the following:

- ensure adequate sunlight for growth;
- provide space for leading shoots of the lower strata;
- minimize the oppression of the members of lower strata and of emergent plants; and
- open up space for new growth, not necessarily just woody perennials, but also crops.

The pattern of light attenuation has been taken into consideration in enriching the system. From the level of main canopy down to the ground layer, there is a sharp increase in shade-loving or shade-tolerant species.

An outstanding feature is the management of trees mixed with crops and to a lesser extent with animals. The inter-dependence of its component species allows it to be managed without any external input. The use of organic manure, the control of weeds, pests and insects by spreading plant residues, hearth ash and green biomass of specific trees are practices passed down from ancestors. Their indigenous knowledge led them to grow *Azadirachta indica, Madhuca longifolia* and *Ricinus communis,* either inside the gardens or within fences, to control pests and insects. Over the years women also developed the use of hearth ash to control pests and insects.

Biodiversity conservation

Evidence mounts that current rates of forest loss and degradation are threatening the sustenance of biological wealth. Activities based on forest resources cannot continue without changes in policies related to the conservation of biodiversity outside forests. This requires transition from a dependence on natural forests to forests created by human stewardship.

Biodiversity has been defined differently by different professions. In most circumstances, however, the conservation of biodiversity has been in the context of delineating natural reserves, sanctuaries and natural forests. As a consequence, biodiversity conservation has not been taken into consideration in the case of the systems located outside forests, regardless of the variety of species.

To local people, biodiversity conservation is not new; it refers to the relation between survival maintenance and biological wealth. It reflects the concerns of the people. Indigenous people who have lost their contact with the natural forests have made an effort to maintain biodiversity in their survival systems as a day-to-day practice. The biodiversity integrated in land management practices, as observed in the home-garden agro-forestry systems, are a reflection of human perspectives on biodiversity and its social dimensions. In this respect it is much more than just maintaining rare or endangered species and systems. In the case of Kandyan home-gardens it encompasses many dimensions like variation, richness, composition, frequency and abundance of species and habitats.

Although a full inventory has not been carried out, Kandyan home-gardens are extensively rich from the perspective of species variation and composition. A total of 143 species of woody perennials were identified in 173 gardens in eight villages (Everett, 1993). Everett's 1993 enumeration shown that these perennials belonged to 48 families. *Leguminosae* is highly represented; having 13 families compared to nine *Myrtaceae;* nine *Rutaceae;* seven *Guttiferae;* seven *Moraceae* and six *Euphorbiaceae.* McConnell and Dharmapala (1973) estimated that Kandyan home-gardens have reached a biological maximum, with 29 species per household. Perera and Rajapaksa's enumeration (1991) was much higher, having a mean of 46 and ranging from 37 to 65. The mean of 46 included 23 tree species, 17 herbaceous species, 3 shrub species and 3 climber species of 30 families.

Despite the differences in findings, which could be due to many factors other than species interaction and distribution, an immense diversity is found in the two mosaics of home-gardens, which include 78 individual home-gardens. Field enumeration shows that the feature that makes the gardens comparable to forest is the predominance of woody perennials of different species over all other types, such as herbs and climbers (a selected species composition is given in Table 27).

Each mosaic consists of 72 to 77 tree species and contains five layers (Figure 27), which in turn occupy three canopy layers:

- the emergent layer, which is above 25 metres;
- the main canopy, which occupies a layer between 15 and 25 metres;
- the mid canopy, which is between 8 and 15 metres:
- the shrub layer, consisting of about 15 species, is between 1.5 and 8 metres vertical space; and
- the ground layer, which occupies a layer rising to about 1 to 1.5 metres.

The ground layer includes natural emergents as well as sown crops. The number of species in these two mosaics varies tremendously due to the variation in site locations, micro habitats and nature of home interventions. Species distribution in these layers is rather complex because conditions are not static; stands go through a dynamic process of regeneration. Plants of different ages occur in the vertical strata so they frequently regenerate through natural processes from seeds or root cuttings.

All these strata have distinctly dominant species, although their frequency of occurrence varies. About 61 woody perennials occur most frequently; almost *no* home-gardens are without them. The average number of species is not less than 30 and in some cases goes up to 140. The average number of species per garden varies from 100 to 280 in these mosaics and is affected by the size of the garden.

A greater variation is observed in terms of number of individuals per area. This goes up to 820 per hectare in these mosaics. These small gardens are

Figure 27. Profile diagram: Kandyan home-garden

1. Cocos nucifera
2. Alstonia macrophylla
3. Artocarpus heterophyllus
4. Areca catechu
5. Persea gratissima
6. Atrocarpus altilis
7. Ceiba pentandra
8. Garcinia mangostana
9. Mangifera indica
10. Caryota urens
11. Musa sp.
12. Coffea arabica
13. Psidium guajava
14. Theobroma cacao
15. Syzygium aromaticum
16. Myristica fragrans
17. Carica papaya
18. Averrhoa bilimbi
19. Neolitsea cassia

Table 27. Selected species composition, Kandyan home-gardens

trees	shrubs	herbs
Achras zapota (fw, f,m,)	*Agave vera-ruz (fibre, fence)*	*Achyranthes aspera (m)*
Adennathera pavonina (m, fw)	Annona *muricata (f, fw, m)*	*Ageratum conyzoides (m)*
Aegle marmelos (f, m, fw)	*Atlantia ceylanica (m)*	*Argyreia populifolia (m)*
Albizia falcata (t, fw)	*Averrhoa bilimbi (f, fw, m)*	*Aerva lanata (f, m)*
Albizia odoratissima (t, fw)	*Bambusa vulgaris (t)*	*Alternanthera sessilis (f, m)*
Aleurites moluccana (t)	*Citrus medica (b, f, m)*	*Asparagus falcatus (f, m)*
Alstonia macrophylla (t, fw)	*Coffea arabica (b, fw)*	*Boerhavia diffusa (f, m)*
Ahtonia scholaris (m, t, fw)	*Crown laccifer (m)*	*Brassica juncea (f, m)*
Anacardium occidentale (f, fw, m)	*Cymbopogon citratus (f)*	*Centella asiatica (f, m)*
Annona squamosa (f, fw, m)	*Cynometra cauliflora (f, fw, m)*	*Curcuma domestica (s, m)*
Areca catechu (mas, t, m)	*Erythroxylum moonii (m)*	*Desmodium heterophyllum (m)*
Artocarpus altilis (f, t, fw)	*Manihot esculenta (f)*	*Dolichos biflorus (m, b)*
Artocarpus heterophyllus ***(f, t, fw, fd)***	Musa *sapientum (f)*	*Gloriosa superba (m)*
Artocarpus nobilis (f, fw,t)	*Panax fruticosum (f)*	*Hemidesmus indicus (f, m)*
Averrhoa bilimbi (f, fw, m)	*Pandanus ceylanicus (fibre)*	*lpomoea aquatica (m, f)*
Azadirachta indica (t, fw, m)	Pandanus *latifolia (f)*	*Ipomoea batatas (f)*
Berrya cordifolia (t, fw)	*Paventa indica (m)*	Mentha *viridis (m, f)*
Bridelia retusa (fw)	*Pogostemon heyneanus (m)*	*Oxalis corniculata (m, f)*
Calophylluvn inophyllum (m, fw, t)	*Punica granatum (f, fw, m)*	*Phaseolus mingo (m)*
Cocos nucifera (f, t, fw)	*Psidium cattleianum (f, fw)*	Zingiber officinale (m, s)

b	beverage	m	medicine
f	food/fruit	mas	masticant
fd	fodder	s	spice
fw	fuelwood	t	timber/construction materials

characterized by a high density and diversity. A striking feature is the frequency and abundance of jack (*Artocarpus heterophyllus*), coconut (Cocos *nucifera*), areca nut (*Areca catechu*), mangosteen (*Garcinia mangostana*), *Gliricidia sp.*, avocado (*Persea gratissima*), coffee (*Coffea arabica*), *Gliricidia sepium* and pepper (*Piper nigrum*). The density of individuals in these gardens ranged between 2240 and 3926 per hectare; trees averaged 2800 per hectare. Endemic and naturalized trees make up nearly 40-45 per cent of the garden. Almost 34 per cent of the gardens contain livestock, primarily dairy cattle and poultry, with fewer buffaloes and goats.

No matter what economic trends have taken place, these mosaics of forest gardens have survived in the highlands of Sri Lanka.

Sustainability

There are no hard and fast rules about the development of home-gardens. The variation in the physiology of individual species and the interaction among species are taken into consideration by using indigenous knowledge. Diversification has been achieved by filling gaps or by nurturing the naturally emerged species. This random process varies across the gardens. There are inherent growth dynamics within home-gardens. It is possible to distinguish five canopy layers, consisting of herbs and crops, shrubs and bushes, mid canopy, main canopy trees and emergents (Figure 27). This layering is similar to that identified in the development of dipterocarp forest (Halle et al 1978). The ground cover, consisting of tubers, vegetables, herbs and many other crops, contributes to a further diversity in composition and structure. It is difficult to draw exact boundaries between the layers.

Unlike in industrial forests there is no excessive logging, although timber is considered as the end harvest of a majority of tree species. The sustainability of home-gardens is ensured because of their importance in household survival strategies. Nevertheless, all home-gardens have been subject to timber harvesting. The impact of selectively harvesting a few trees for construction, or to meet family or contingency needs, will not adversely affect the forest structure as a whole. A count revealed that an extremely high proportion of seedlings and saplings become mature trees. Many species vacate the occupied lower canopy spaces and reach the upper canopy layers, which enables them to survive. The continuous transitions occurring in this manner have a direct effect on the sustainability and the maintenance of biodiversity. This implies that intentional planting of perennials becomes rare with the increasing density, which is enhanced by natural regeneration.

Another process that supplements natural enrichment occurs through seed carriers such as bats, crows, dairy animals, polecats and parrots. Wind and water also bring foreign species to the system. While all these natural processes primarily maintain the inter-strata links, the connection with household makes the garden more dynamic and in tune with household needs. This means that dynamism in the home-garden is biological and anthropogenic.

The sustainability of home-gardens is associated with the same ecological functions that are predominant in forest ecosystems. Significant in this sustainability are maintenance of species diversity, a balance between inputs and outputs and the conservation of environment and cultures linked with the system. These indigenous production systems were not developed by adopting experimental models. The diversity in composition, age structure, size and growth habit all inhibit systematic monitoring. The same features govern the functions in conjunction with home-centred operation. The comprehensiveness of the system is linked with that of the household. The smaller the size of the garden, the more comprehensive and diverse the systems. The home-garden's overwhelming importance to the conservation of biodiversity has not as yet been fully taken into consideration.

Conclusion

The conservation of biodiversity outside forest areas is extremely important in Sri Lanka. As deforestation continues, along with the increase of population, it will be extremely difficult to conserve biodiversity in the isolated islands of forests which will be subjected to even greater pressure. The conservation of biodiversity in non-forest areas is a requisite to fulfill the needs of communities. It is significant in relieving pressure on the relict forests. In addition, the prospects for conservation is much greater when use value, particularly socio-economic value, is part of conservation efforts. The micro) ecological conditions are prominent breeding grounds and habitats for some species. Traditional knowledge, experience gained through trial and error, and the self reliance and confidence of the local people should not be dismissed, but instead investigated, recorded and duplicated. The value of such practical knowledge has been already demonstrated and, in some cases, has been scientifically proven. In the past, inappropriate value systems did not incorporate criteria representing cultural, aesthetic, environmental or physical and emotional well-being. There is no need to compartmentalize biodiversity and conservation into sanctuaries which are isolated from human survival. It is diversity that has sustained the lives of indigenous people.

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Community forestry in Nepal

Conserving the biological diversity of Nepal's forests

Andrew W. Ingles

Abstract

Community forestry offers a practicable means to conserve the biodiversity of Nepal's middle-altitude forests. Experience to date has demonstrated that community forestry, through the establishment of plantations and through improved management of natural shrublands and forests by local forest users, can arrest the rate of forest decline and increase the total area of forests. However, there is almost no baseline information available and no monitoring system in place to determine the impact of community forestry on biodiversity. The potential benefits of community forestry to biodiversity conservation are discussed in this paper and a simple rapid methodology for measuring forest condition and biodiversity is described. It is argued that such methodologies are required for managing natural resources in the situation of under-development. It is felt that Nepal's national conservation strategy could be improved if greater emphasis were given to community forestry and to activities that enhance the opportunities to conserve biodiversity through community forestry approaches and methodologies.

Introduction

Nepal is rich in biological diversity as a consequence of its spectacular topography and its central geographic location with respect to Europe and Asia. The land rises from the Gangetic Plain of the Indian subcontinent, at approximately 100 metres above sea level, to the crest of the Himalayan mountain range, whch includes the world's highest point at 8848 metres. This enormous variety of altitudes across a relatively short north-south horizontal distance gives rise to diverse climates, ranging from subtropical to arctic, and creates isolated valleys within which new species have arisen (Gorkhali, 1991).

Stainton (1972) described 35 broad forest ecosystems occurring in Nepal, distributed mainly according to altitude and aspect in the mountainous regions, and by soil type and moisture in the lowlands. In the most recent forest inventory undertaken, using 1977-78 aerial photography, 38 per cent of Nepal's land surface was found to support forests with at least 10 per cent crown cover, while shrublands and grasslands together accounted for another

17 per cent of the total area (HMGN, 1983; Nield, 1985). At the species level, diversity is dominated by a largely unknown number of invertebrates and by about 10,000 species of plants, 5,400 of which have been identified (Upreti, 1985; Shrestha and Gupta, 1993). In addition, almost 850 species of birds, 175 species of mammals (Shrestha and Gupta, 1993), 63 species of reptiles (Majupuria, 1982), 20 species of amphibians (Malla, 1982), and 170 species of fish (Shrestha and Gupta, 1993) have been recorded so far in Nepal. With only 0.15 per cent of the world's forests (FAO, 1993), Nepal has a disproportionate share of biodiversity, having 2.2 per cent of the world's known plants and 9.4 per cent of the world's known birds (Shrestha and Gupta, 1993).

The conservation of this biodiversity is constrained by numerous factors, many of which arise from Nepal's being one of the world's least developed countries, with a large and rapidly growing population (HMGN, 1988a). In terms of available agricultural land, Nepal is also one of the most densely populated countries in the world (Blaikie and Brookfield, 1987). The country faces numerous problems associated with poverty: unemployment and underemployment; food shortage; low levels of infrastructure, health and other social services; and poor institutional credit (Weber et al. 1985). More than 90 per cent of the population lives in the countryside and uses both accessible forests and rangelands intensively to support its households and farming systems. There is a high demand for fuelwood, timber, charcoal, food and medicinal plants from forests. Livestock populations are high, creating a huge demand for both fodder and bedding material, a demand that cannot be met from agricultural land. This results in an additional drain on forest resources (Giri, 1989; Robinson, 1987).

The high demand for forest products lends urgency to the need to establish effective conservation measures. However, Nepal suffers from a dearth of biological information and a lack of resources, institutional capacity and infrastructure with which to coordinate and undertake such measures (HMGN, 1988a).

On the positive side, Nepal's forest policy includes provisions for rural people to manage local forests themselves with guidance from the government's Department of Forests. Experience to date suggests that such arrangements can foster forest conservation. This paper argues the potential for community forestry to conserve the biodiversity of forests in Nepal. Community forestry is a situation where forests are controlled and managed as common property by rural people, who use them to support their subsistence-oriented farms and household economies. The paper also presents a simple, rapid methodology for monitoring the condition and biodiversity of forests managed by rural communities.

Existing and potential conservation reserves

Most countries in the world have initiated conservation programmes by establishing a network of conservation reserves (McNeely et al. 1990). The ultimate intention of these programmes has been to ensure the conservation of a representative sample of the existing biodiversity.

His Majesty's Government of Nepal (HMGN) started to establish a reserve system in the 1970s, in which representative arrays of ecosystems were to be protected from human manipulation as much as possible.

The reserve system currently includes eight national parks and seven other reserves and conservation areas, which together account for 10.8 per cent of Nepal's total land surface (HMGN, 1994a). However, these reserve areas do not adequately represent Nepal's biodiversity, with a major gap in the reserve system apparent in an altitude range of 500 to 3500 metres (Hunter and Yonzon, 1993). Very little area has been reserved in these middle-altitude zones, yet many major forest ecosystems are confined to such zones (Stainton, 1972), as are the exclusive breeding habitats of numerous wildlife species (Hunter and Yonzon, 1993). The majority of existing reserves include extensive areas of either lowland forests and plains, or high mountain environments.

Even if additional reserves were created, this would not necessarily guarantee the conservation of ecosystems, species or genetic diversity. In the absence of complete resource information, the design of a reserve system can be approximate at best. The location of reserves should target representative ecosystems and species populations in an attempt to capture as much of the variability as possible. In the middle-altitude zones, commonly referred to as the Middle Hills, this would require a complex mosaic of small and large reserves, or a number of wide transects running from the lowlands to the mountains. Such a system would be extremely difficult to devise, given the immense complexity of the landscape and the lack of resource information. It is therefore unlikely that forests outside an expanded reserve system would still contain unprotected species and genetic resources.

Establishing additional reserves in the Middle Hills is also problematic because of the high level of human settlement and environmental modification that has occurred there over the last few centuries (Mahat et al. 1986a, 1986b). The accessible forests underpin the household economies of resident farmers and, although substantial areas of forest remain, many have been modified through livestock grazing, intensive harvesting of forest products by villagers, and fire. The opportunities are limited for establishing reserves containing relatively undisturbed forests or modified forests within which further modification would be prohibited. Reservation of representative forest ecosystems in the Middle Hills would require the delineation of large areas to encompass the inherent complexity of the landscape. Within a conventional reserve system this could not be achieved without a massive relocation of communities. Nepal's National Conservation Strategy states that such disruption of communities "...will be avoided to the fullest extent possible, recognising the severe hardship that such relocations impose" (HMGN, 1988a).

Managing conventional reserves

The managing agencies of the existing reserves have not been able to maintain the integrity of so-called protected ecosystems in the face of increasing negative pressures from tourism and nearby agricultural communities. The reserve system in Nepal is now regarded as being in crisis, with major problems in people-park conflicts, almost nonexistent park management and institutional weakness (Upreti, 1985; HMGN, 1988a; Gorkhali, 1991; HMGN, 1994b).

The Department of National Parks and Wildlife Conservation (DNPWC) is responsible for the management of all but two of the reserved areas. The DNPWC is understaffed and lacks the equipment and facilities required to effectively manage the parks and protected areas (HMGN, 1988a; HMGN, 1994b). Current field staff are inadequately trained, insufficiently motivated, and poorly equipped and supported to undertake the tasks required of them (HMGN, 1994b). As a result, field staff do not have a tradition of comprehensive record-keeping, monitoring, or providing reliable reports to decision-makers. Such a situation is common in other line agencies of HMGN, such as the Department of Forests (Gilmour and Fisher, 1991). The lack of appropriate skills and the predominance of a regulatory, top-down approach to park management are major obstacles to achieving the intended goals of biodiversity conservation in the reserve system.

Conservation of biodiversity

Non-reserved land can play a part in conserving the world's biodiversity, depending on the land management practices in place (McNeely et al. 1990). The establishment and/or management of non-reserved forests under Nepal's community forestry programme provides opportunities for conserving valuable residual gene pools, restraining the rate of forest degradation, and preventing further species losses in highly modified rural environments outside the reserve system (Shepherd, 1993).

Illiterate poor farmers in the Middle Hills of Nepal have the capacity to protect, rehabilitate and manage patches of existing forests and to plant new forests with little or no outside assistance (Arnold and Campbell, 1986; Messerschmidt, 1987; Fisher, 1989; Fisher et al. 1989; Gilmour and Fisher, 1991; Chhetri and Pandey, 1992). The recognition that groups of local forest users can undertake such activities on their own initiative has generated great interest in how these practices can be supported and replicated elsewhere. In the late 1970s, HMGN championed farsighted legislation and policies designed to encourage and strengthen community forestry.

Experience with the implementation of community forestry over the past 16 years has so far shown this to be an effective model for encouraging the conservation of forests, and hence of forest biodiversity, in the Middle Hills of Nepal. Community forestry was officially adopted after HMGN recognized that it was impossible for the Department of Forests (DOF) to arrest forest decline and manage all the nation's forests by itself. In 1978, forest legislation and policy were changed radically, requiring the DOF to seek partnerships with rural communities for developing and conserving forests. Initial efforts were concerned with involving villagers in afforestation activities, from which they would benefit at some future time. Later, attention was given to encouraging the improved management of existing forests by local users (Griffin, 1988).

Community forestry now involves DOF field staff gathering information by using participatory rural appraisal techniques. This gives them an understanding of forest management issues from the point of view of forest users, and helps develop solutions in consultation with them (Malla, 1988; Gilmour and Fisher, 1991). Agreed solutions are documented in operational plans, which set out how user groups will protect, regenerate and utilize forests. This is accomplished through mechanisms such as the application of rules and sanctions, the establishment of forest protection systems, decision-making by executive committees and meetings of user groups, the establishment and operation of nurseries, tree planting, and the application of conservative harvesting treatments and schedules.

The government's Master Plan for the Forestry Sector includes a community and private forestry programme which is estimated to require some 47 per cent of the total investment in the forestry sector over the next 20 years (HMGN, 1988b). Much of this investment will be applied to help forest user groups establish plantations and manage forests handed over to them as Community Forests. This is significant for forest conservation in the Middle Hills; over 60 per cent of Nepal's remaining forests (3.4 million hectares) exist there, more than one quarter of these forests are severely degraded (less than 40 per cent cover of trees), and there are extensive areas of shrublands and grasslands

(2 million hectares) that could be protected or planted to increase the total area of forest (HMGN, 1987).

The underlying purpose of community forestry is maintaining or increasing the area and/or productivity of forests to obtain a multiplicity of outputs for rural communities. These outputs include a wide range of forest products for domestic and commercial uses, environmental benefits, and cultural values. This means community forestry has the potential to engage local people in activities that conserve biodiversity, without requiring people to adopt the altruistic conservation motives common to conservation strategies of richer and safer societies. However, the corollary of this "benefit-first" approach is that it will not be reasonable to expect the forest users to conserve a species that is not valued by them. If special measures are required to conserve a species, some form of compensation or subsidy may be needed to ensure that national or international interests in biodiversity conservation are protected.

Potential benefits to biodiversity

Community forestry has the potential to contribute to biodiversity conservation by arresting the rate of land degradation and fostering the return of species to previously degraded habitats. This would be achieved through the protection and regeneration of remnant forests and shrublands and through the establishment of plantations. In these ways community forestry may:

- increase the local representation of different successional stages of forests;
- create habitat corridors;
- increase germ plasm; and,
- prevent local extinction of species.

What evidence is there that community forestry can assist in conserving biodiversity in these ways? The experience of the Nepal-Australia Community Forestry Project (NACFP) has demonstrated that community forestry can help arrest the rate of forest decline and increase the area of forests.

NACFP is a bilateral aid project between the Australian International Development Assistance Bureau and HMGN, operating in two districts of the Middle Hills region: Sindhu Palchok and Kabhre Palanchok. Prior to 1978, the year NACFP began its work, the total area of forest in the project area had not changed significantly during the previous 14 years, but the density of trees in the forests had decreased substantially, indicating that a process of forest degradation was underway (HMGN, 1983; Mahat, et al. 1987).

Since 1978, approximately 18,000 hectares of new community plantations have been established in the NACFP area on grasslands, degraded shrublands and abandoned agricultural land. This is equivalent to 14 per cent of the total forest area as measured in 1978 (HMGN, 1986). Although *Pinus* species were used predominantly in the planting programme, broad-leaf species have re-established naturally in the older stands and, in time, have the potential to dominate stand composition if appropriate management practices are applied (Mohns, et al. 1988; Gilmour, et al. 1990). Most of the plantations will likely be converted to natural forests in the long term as user groups take advantage of species returning to previously degraded sites.

In addition to plantation establishment, 200 patches of natural forest, covering about 5500 hectares, have been brought under improved forest management since 1988 through the joint activities of forest users and NACFP. Table 28 summarizes the results of two studies of recent forest changes in the NACFP area using air-photo interpretation and land-use mapping. The results indicate that the total area of forest has increased mainly due to the plantation programme, and because shrublands protected by local forest users have regenerated to forests.

The combination of NACFP's community forestry activities, and those of other forest users acting independently, appears to have been responsible for a net increase in forests and an improvement in forest condition in the NACFP

Table 28. Recent forest changes in the NACFP area

	IRDC study	**FACTS study**
land area studied (hectares)	11,229	12,290
change period	1972-1990	1978-1992
forests before (hectares)	2,347	1,811
forests after (hectares)	3,396	3,199
area change (hectares)	+ 1,049	+ 1,388
per cent change in forested land	+ 9.3 per cent	+ 11.3 per cent
major sources of change	converted shrubland	converted shrubland
	more plantations	more plantations
		converted agricultural land
other findings	changes statistically significant	changes not statistically significant
		similar or improved densities of shrublands and forests

Results from two comparative studies.
Source: IRDC study, Tamraker, et al. 1991; FACTS study, FACTS, 1993

area between 1978 and 1992 (EDAW, 1994). These findings are encouraging, but provide little information about the current status of the forest ecosystems or species composition or abundance. There is no baseline information which can be used to monitor the impact of current forest management on biodiversity. In the absence of such information, it is not possible to determine how community forestry may be contributing to biodiversity conservation in Nepal.

Measuring and monitoring biodiversity

HMGN, having empowered user groups to manage community forests, has an interest in ensuring that these forests are managed in an ecologically sustainable manner (HMGN, 1988b). There is no monitoring system in place that can provide adequate information about the condition and biodiversity of forests in the Middle Hills. Should HMGN wish to measure forest biodiversity while monitoring the effectiveness of community forestry programmes, the approach should conform with the internationally agreed approach to biodiversity conservation described in Agenda 21 (Robinson, 1993). The issues involved in developing an appropriate monitoring methodology are as follows.

- Information will have to be collected by government field workers, since user groups do not have the technical skills, infrastructure, time, or motivation to undertake periodic measurements or provide sufficient information to HMGN.
- A rapid method is required; the time available for periodic measurement of forests is limited if field workers are to be effective extension agents for several hundred forest user groups.
- The methodology should be simple enough to be done by field workers with minimal training and inexpensive equipment.
- Measurements of selected characteristics must be accurate enough to allow forest changes to be detected within a relatively short period of time; say within five years.

Department of Forest field workers in the NACFP area now undertake participatory community forestry appraisals prior to negotiating operational plans with user groups. The purpose of these appraisals is to obtain and record social and resource information to support planning and facilitate the handing over of grasslands, shrublands and forests to user groups. Information is collected by asking questions of local users and visually estimating some basic land characteristics to prepare a simple forest profile (Ingles and Jackson, 1988, Bartlett and Nurse, 1991). The information collected for forest profiles is summarized in Table 29.

Table 29. Forest profile information

Resource information collected by Department of Forest field staff to prepare a forest profile

topic	items	collection method
location of site	administrative address sketch map	informal discussions [1] participatory mapping [2]
area	estimated area measured area (optional)	ocular estimate [3] chain and compass survey
land type	grassland/shrubland/forest plantation or natural conifer or broad-leaf list of dominant species	rapid assessments [4]
forest condition	average height stocking of shrubs or trees [5] crown cover [6] presence of regeneration	ocular estimate rapid assessments
forest history	plantation history forest condition changes management system	informal discussions

1. Fisher and Malla, 1987
2. Jackson, et al. 1994
3. Nurse, et al. 1992
4. Bartlett and Nurse, 1991
5. number of plants per unit area
6. per cent of the sample site within the vertical projection of the periphery of the tree or shrub crowns (McDonald, et al. 1984)

Although the forest profile provides a useful first glance at the condition of the shrubland or forest, it is not very effective in establishing a baseline description of biodiversity or the condition of the forest as an ecosystem. The profile only gives one estimate for the whole forest and makes no attempt to describe the variation in forest condition or the diversity of species present. The following section describes a strategy for building on current methodologies to develop a simple, rapid appraisal methodology for monitoring the condition and biodiversity of community forests.

Rapid appraisal methodology

A simple, rapid method for monitoring forest condition and biodiversity should include measures of the following:

- area by simple forest types;
- quantity of tree and shrub vegetation;

- abundance of tree and shrub regeneration;
- number of plant species in various growth form categories; and,
- extent of the exposure of soils to accelerated erosion.

In an ideal world, accurate maps of forest ecosystems would be made regularly from aerial photographs or satellite imagery and would provide area estimates for different forest types. Periodic measurements of ecological criteria would also be taken in forests at exactly the same location using a number of permanent plots. However, regular forest mapping is not done in Nepal at a scale appropriate for measuring changes in community forests. Further, permanent plots are not appropriate for Nepal because they are expensive to establish and maintain, difficult to relocate, and there is a considerable risk of their being treated differently by different forest users. An alternative approach is to use a combination of techniques which can be applied by HMGN's field staff. These techniques include:

- sketch mapping;
- estimating forest areas and condition by eye;
- measuring a limited number of ecological criteria within temporary plots; and,
- compiling a list of plant species observed within a forest.

In Nepal, the condition of a community forest can vary considerably even over a short distance. It is important to take account of this variation as much as possible to reduce the standard deviation of estimates of ecological criteria. A simple way to do this is to subdivide the forest into blocks based on major differences in vegetation type and forest condition, delineate these blocks on a sketch map using identifiable natural features, and then estimate the area of each. The blocks become the basic unit for future monitoring. The recommended basis for subdividing and classifying community forests for this purpose is outlined in Table 30.

Once a community forest has been subdivided into blocks based on forest condition categories, then measurements of vegetation and biodiversity can be taken and recorded for each forest block, rather than for the community forest as a whole.

Measurements of ecological criteria

Two separate inventory systems are described in Table 30, one for grasslands and shrublands and another for forests. In shrublands, crown cover should be measured because it is easier than measuring diameters of stems or undertaking destructive sampling of biomass to get a measure of the quantity of vegetation. In forests, the diameter of stems at a standard height above the ground should be measured and total basal area calculated — basal area is the sectional area of a tree stem at breast height — because this is easier to measure than crown cover or biomass.

Table 30. Vegetation type and condition categories

vegetation type	condition class	characteristics
grassland[1]	degraded	very sparse to sparse grass cover (<50 per cent) extensive exposed soils
	stocked	moderate to high grass cover (>50 per cent) soils mostly covered with vegetation
shrubland[2]	very degraded	low stocking of shrubs (< 10,000 per ha) very sparse crown cover (<20 per cent) extensive exposed soils
	degraded	low stocking of shrubs (< 10,000 per ha) sparse crown cover (20-50 per cent) soils mostly covered with vegetation
	stocked	moderate stocking of shrubs (>10,000 per ha) moderate crown cover (50-75 per cent) few or no seed trees present (<100 per ha)
	fully stocked	moderate stocking of shrubs (>10,000 per ha) high crown cover (>75 per cent) adequate seed trees present (>100 per ha)
conifer, broad-leaf or mixed foresr[3]	very degraded	very sparse crown cover (<20 per cent) extensive exposed soils
	degraded	sparse crown cover (20-50 per cent) soils mostly covered with vegetation
	stocked	moderate crown cover (50-75 per cent)
	fully stocked	high crown cover (>75 per cent)

1. Vegetation dominated by sod, tussock, or hummock grasses (McDonald, et al. 1984).
2. Vegetation dominated by woody plants that are multi-stemmed near the ground, or if single stemmed are less than 2 metres tall. An upper stratum of emergent trees may be present and comprise up to 5 per cent of the total crown cover.
3. Vegetation dominated by woody plants more than 2 metres tall and with a single stem or branches well above the base. If 75 per cent or more of trees in a stand are coniferous, the forest is defined as a conifer forest. Similarly, if 75 per cent or more of trees in a stand are of broad-leaf species, the forest is defined as a broad-leaf forest. All other combinations of forest are referred to as mixed.

Table 31. Proposed measures for monitoring community forests

criteria	measurements for: grasslands and shrublands	measurements for: forests
area	ocular estimates of block areas chain and compass boundary survey of whole community forest	ocular estimates of block areas chain and compass boundary survey of whole community forest
quantity of vegetation	stocking counts of shrubs by species crown cover of grass/shrubs total basal area of trees.	stocking counts of trees by species total basal area of trees
regeneration	stocking counts by species (shrubs and trees only)	stocking counts by species (shrubs and trees only)
plant biodiversity	number of species observed in different growth form categories [1]	number of species observed in different growth form categories
exposure of soils to accelerated erosion	ground cover [2]	ground cover

1. Growth form categories used to stratify counts of plant species are: tree, shrub, grass, forb, fern, moss and vine (McDonald, et al. 1984).
2. Ground cover is the percentage of ground surface which does not have exposed mineral soils.

All of the observations, except area and those required to complete the list of plant species, are made on temporary plots located in each forest block using a grid system. The starting point and distance between plots are recorded so that the same grid can be used again in future measurements. The plots should be rectangular, with the long axis aligned along the contour; this layout, compared to circular or square plot layouts, provides the safest and quickest sample area on the slopes, which are often very steep. Plot sizes for each block can range from 5 by 10 metres to 5 by 30 metres, depending on the density of vegetation. Plot boundaries are defined using a ten-metre rope laid along the centre line and a 2.5-metre rope stretched between the enumerators to show the outer limit of the plot as each side is being measured. The total number of plots should yield a minimum sampling intensity of two per cent of the area of each block. The measurements in each plot are simple and can be made rapidly (Table 31). The only equipment required is two lengths of rope, *pro formas*, paper and pens and a tape to measure tree diameters, crown widths and gaps. A measuring party of two or three people is required, consisting of a trained party leader and one or two assistants, who can be relatively unskilled.

Plot results are used to calculate individual estimates of ecological criteria on a per-unit-area basis. These estimates are summarized to give averages and standard deviations of each criteria for each block of vegetation. The plot data and sketch maps should be stored in the nearest field office and summaries sent for inclusion in a district-level management information system.

Participatory planning and implementation

The methodology described above is designed to take account of national interests in monitoring the management of community forests. However, forest user groups also have interests in monitoring the condition of forests they manage. Implementing the monitoring system described above will have to include a participatory approach. Such an approach aims to inform forest users about the government's monitoring plans and to identify which specific interests in monitoring the users might have. There may be opportunities to either build these interests into the government's monitoring system or to encourage and support the user group to undertake additional or complementary monitoring activities.

There is scope to modify the basic system described above, depending on the user group's management objectives and the specific interests of the government. For example, the user group or the government may wish to include the measurement of the habitat of a specific wildlife species for eco-tourism or endangered species management. By using a participatory approach in both the design and implementation of measurements for a particular forest, the monitoring system will become an integral part of the extension activities of community forestry.

This basic methodology is under trial in the NACFP area. The intention is to refine the methodology, prepare appropriate manuals and training curricula and commence their institutionalization within the Department of Forests, This process may take up to two years.

Probable biophysical impacts

The measurements described above have been tried at 34 different sites in the NACFP area. They covered a range of situations, from very degraded shrublands not under community management, to fully stocked conifer plantations and natural broad-leaf forests that have been established and/or protected by user groups. Some results are provided here to illustrate the sort of changes in biodiversity that can be brought about as user groups manage community forests.

Table 32. Vegetation and regeneration: conifer plantations

Differences in quantity of vegetation and abundance of regeneration in conifer plantations.

condition	no. of obs.	stocking of trees (no./hectares)	basal area of trees (m2/hectares)	regeneration (no./hectares)
very degraded	25	280 ± 214	3.28 ± 3.00	472 ± 709
degraded	25	460 ± 231	9.16 ± 6.27	2,690 ± 1,020
fully stocked	25	1,370 ± 331	27.50 ± 9.37	1,020 ± 839

Tables 32 and 33 show the quantity of vegetation that can be established through plantation activities. Both the quantity of vegetation and the abundance of natural regeneration is related to how well the plantation is managed, with very degraded plantations having much less vegetation and regeneration than fully stocked plantations. This demonstrates that planting trees will not in itself lead to substantial improvements in biodiversity. The way plantations are managed has a great influence on vegetation; hence handing over plantations and supporting user groups with management is an important aspect of improving the biodiversity of degraded sites.

These results illustrate the substantial improvements possible in both the quantity and diversity of vegetation through the establishment and management of community plantations by user groups. Similar improvements can be achieved in existing broad-leaf forests through protection and management by user groups. Tables 34 and 35 show how the quantity of vegetation varies in different blocks of broad-leaf shrublands and forests in the NACFP area.

Table 33. Comparative number of plant species

Number of plants species in various growth form categories

site description	no. of obs.	number of trees and shrub species	number of other plant species*	total number of plant species
degraded grassland	3	24 ± 27	32 ± 6	56 ± 27
plantation on degraded grassland	4	30 ± 7	34 ±14	63 ± 21
degraded shrubland	5	16 ± 5	27 ± 10	44 ± 15
plantation on degraded shrubland	3	32 ± 11	63 ± 7	94 ± 16

The number of plant species occurring at a number of degraded sites in the NACFP area can be compared to the number of species occurring in fully stocked plantations that were planted up to 14 years previously on similar degraded sites.

* includes species with the following growth form categories: grass, forb, fern, moss and vine.

Table 34. Vegetation and regeneration: broad-leaf shrublands

Differences ¡n quantity of vegetation and abundance of regeneration in broad-leaf shrublands.

condition	no. of obs.	stocking of shrubs (no./ha)	crown cover (%)	basal area of trees (m^2/ha)	regeneration (no./ha)
very degraded	20	1,510 ± 550	16 ± 8	0.01 ± 0.02	5,590 ± 1,740
degraded	25	6,740 ± 2,290	27 ± 11	2.59 ± 6.15	1,650 ± 1,210
stocked	21	14,950 ± 4,000	93 ± 9	2.96 ± 2.35	1,480 ± 1,370

If user groups improve the condition of community forests from very degraded to fully stocked, large improvements in vegetation cover can be achieved. Table 36 illustrates how the number of plant species in such shrublands and forests can be increased through community forest management.

It is clear that improved management of natural forests can bring gains in forest cover and biodiversity similar to those which can be achieved through plantation programmes. The quantity of plant biomass, structural diversity and diversity of plant species can be increased, which can have direct, positive effects on other aspects of biological conservation such as soil maintenance and the availability of wildlife habitat.

It is not possible to provide examples of ground cover measurements for different forest condition categories at this stage because this was not part of the initially methodology. It became apparent in the trials, however, that a major difference between a very degraded site and a degraded site was the degree to which soils were exposed to accelerated soil erosion processes. The condition of ground cover has since been added to the methodology as one of the prime indicators of forest condition.

Discussion

Community forestry can do more than just complement Nepal's system of conservation reserves. It provides a feasible alternative for conserving large areas of middle-altitude forests rather than expanding the conventional reserve

Table 35. Vegetation and regeneration: broad-leaf forests

Differences in quantity of vegetation and abundance of regeneration in broad-leaf forests.

condition	no. of obs.	stocking of trees (no./ha)	basal area of trees (m^2/ha)	regeneration (no./ha)
very degraded	20	45 ± 201	0.08 ± 0.37	8590 ± 1790
degraded	19	280 ± 132	1.88 ± 1.03	5,580 ± 2,950
stocked	16	1,200 ± 455	10.70 ± 4.19	7,780 ± 1,820
fully stocked	20	1780 ± 527	40.30 ± 14.00	11,080 ± 5,630

Table 36. Differences in species according to site

Differences in the number of plants species in various growth form categories observed on degraded sites and within stocked and fully stocked broad-leaf shrublands and forests.

site description	no. of obs.	no. of tree and shrub species	number of other plant species	total number of plant species
degraded shrubland	5	16 ± 5	27 ± 10	44 ± 15
stocked shrubland	3	33 ± 2	28 ± 17	61 ± 19
degraded forest	4	22 ± 10	32 ± 15	54 ± 15
stocked forest	3	32 ± 8	66 ± 8	98 ± 11

system. Indeed, community forestry may offer the only practicable means to conserve the biodiversity of Nepal's forests in the Middle Hills. Unfortunately, the potential contribution of community forestry has yet to be fully recognized in Nepal's National Conservation Strategy (HMGN, 1988a).

There is some uncertainty about the extent to which community forestry can conserve biodiversity, since community forest management is driven by the need to obtain sustainable outputs of goods and services for forest users, rather than by the need to maximize biodiveristy. How will species diversity and abundance be affected in the long term by the variety of demands made on community forests? Although change and disturbance are natural ecological processes, they must remain within critical boundaries if forests are to retain their capacity to recover from natural or imposed disturbance. We need to determine these boundaries if sustainable management and conservation of biological diversity are to be achieved in community forestry.

In the long term, the monitoring system described in this paper can help to resolve uncertainties and define what the critical boundaries of disturbance might be. In addition, information about forest changes over time can be used to modify the activities of user groups and the government in an attempt to match villagers needs to national and international goals for biodiversity conservation. In the short-term, field staff of the Department of Forests could apply the methodology to all forests in their work area and prepare a simple resource inventory of forest biodiversity. They could then use this information to identify forest types and/or species that are not well represented in their area and give them priority when handing over management responsibility to user groups. Such priorities could also be kept in mind when supporting the implementation of conservation measures through the provisions of operational plans.

Even though the methodology is simple and requires little training and equipment, it will be difficult to apply to all forests in the immediate future because of the limited numbers of literate field staff, the lack of written record-keeping traditions and lack of administrative support within the Department of Forests. These constraints affect the implementation of community forestry in general and are not unique to implementing the monitoring system described in this paper. The rate of identifying forest user groups and handing-over of community forests is slow and there is a poor level of support given to user groups in implementing their operational plans. Assuming that the Department of Forests can increase the rate at which community forestry is implemented, it may be possible to generate a simple inventory of forest biodiversity in the Middle Hills within a few years. Such an inventory could then be used in conjunction with other forest inventories undertaken using remote-sensing techniques to gain an improved understanding of Nepal's biodiversity.

In addition to speeding up the implementation of community forestry, there are a number of other activities that could enhance the opportunities to conserve biodiversity through community forestry. Some of these are:

- provide information and training to HMGN field staff on the distribution and habitat requirements of rare and endangered species in the Middle Hills;
- improve the capacity of the Department of Forests to keep records and support user groups;
- provide information to forest user groups about the advantages of maximizing species diversity and provide training in harvesting and silvicultural treatments to avoid or reverse forest simplification;
- investigate and then communicate the opportunities for user groups to generate income through such initiatives as non-timber forest products and ecotourism, to encourage user groups to diversify the management objectives for community forests; and,
- undertake research, both to determine the utility of measuring biodiversity using simple, rapid methods compared to more comprehensive inventory methods, and to refine the methods as necessary.

Nepal's National Conservation Strategy could be improved by increasing its emphasis on community forestry and identifying activities, such as those listed above, that will increase the potential for community forestry to contribute to the conservation of biodiversity. In addition, there are elements of community forestry that will be of value in developing participatory resource management in the buffer zones of existing conservation reserves. The rapid appraisal methodologies for community forestry, including those described here for measuring forest condition and biodiversity, may be applicable also to managing the existing conservation reserves and their buffer zones.

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Religious beliefs and rituals in Nepal

Their influence on forest conservation

Andrew W. Ingles

Abstract

Religious beliefs and practices affect the way forests are perceived and managed in Nepal. Forests provide a wide range of products used in the performance of religious rituals, and are affected by harvesting by local communities for normal subsistence needs and charitable activities undertaken to obtain religious merit. Forests are also affected by activities such as tree worship, the establishment and maintenance of sacred sites in forests, religious festivals and rituals conducted within forests, and the management of forests as productive assets by religious organizations. These activities and their effect on forest conservation are discussed. The influence of religious beliefs and rituals on forest conservation in Nepal is significant because they give rise to appropriate institutions and organizations for cooperative resource management and provide messages and symbols for forest conservation in Nepalese society. In addition, the presence of religious forests in heavily modified landscapes provide refugia for species which may otherwise have become locally extinct. The systems for managing religious forests can be used to strengthen community forestry activities that further enhance the conservation of forests.

Introduction

"It is a truism worth reiterating that the world-view of a society is what molds its attitude toward, and its actions upon, its surroundings." (Gyawali, 1989a).

This paper examines how the dominant social philosophy of the Indian subcontinent influences the way Nepalese communities perceive their environment, and how religious beliefs and practices affect the way forests are managed. The management and condition of religious forests is considered in detail because the influence of religious beliefs and practices should be at its greatest within forests dedicated for religious purposes. Therefore, the results achieved in religious forests are pertinent when judging the utility of religious beliefs on nature conservation generally.

For the purposes of this paper, religious forests (dharmic ban) are defined as shrublands or forests larger than 0.1 hectares in size, where management is associated with the performance of religious rituals at a sacred site. This includes forests that contain a sacred site, such as the abode of a supernatural being, and forests that do not contain a sacred site but are predominantly managed to provide the resources required for the performance of religious rituals at a sacred site located elsewhere. An example of this second group is a forest managed specifically for the provision of fuelwood for funeral pyres.

Following the discussion of religious forests, some comments are made about how religious beliefs and rituals and the institutions and organizations associated with religious forests can be used in the implementation of community forestry for rural development.

Religion in Nepal

In the 1981 census, about 90 per cent of Nepal's population stated they were adherents of the Hindu religion. The next largest group said they were Buddhists (five per cent), followed by Muslims (two per cent) and other groups such as Jains, Christians and animists (Gyawali, 1989a; citing Central Bureau of Statistics, 1986). However, it should be noted that the statistics on religion may not be a true representation of the situation. Hinduism is the state religion and Hindus dominate national politics and state administration. These factors may encourage people to describe their religious beliefs to officialdom as Hinduism. In addition, a major feature of religion in Nepal is the relative lack of dogma and specific definitions about the supernatural world within Hinduism and Buddhism, compared with religions such as Islam and Christianity (Rieffel, 1987). The adoption of popular Hindu cults by Buddhists may lead to the inclusion of many socio-religious groups within Hinduism while they may not be Hindu in a strict sense (Pant, 1993). This results in a blurring of the boundaries between the two religions.

Perceptions of the environment

Both Hinduism and Buddhism depict a world inhabited by countless supernatural beings who play various roles of destruction, protection and creation. They therefore wield, or are a part of, the forces of nature. Societies holding these religious views relate to the environment by focusing on supernatural explanations of natural processes and events and by directly associating particular elements of the environment with the spiritual world (Berreman, 1972; Shepherd, 1982; Bjønness, 1986; Seeland, 1986; Majupuria and Joshi, 1988; Gyawali, 1989a; Cox, 1989).

Gyawali (1989a) classified the traditional Nepalese world-view as 'oriental' to distinguish it from the more pragmatic 'occidental' or western world-view.

He suggested that the major difference between the two is that the first places a higher value on mastering the spiritual world whereas the second promotes modification of the environment to better suit human-needs.

Adherents of an oriental view of the world may, at the same time, hold another perspective which is more observant, experienced and practical. In a study of the Nepalese Sherpas, the existence of a dualistic world-view meant that the Sherpas would discuss and attempt to minimize certain environmental hazards in both a religious and practical sense (Bjønness, 1986). Gyawali (1989a) also noted that two types of world-view exist in Nepal; although traditionally, the oriental type has had a dominant role in determining the way Nepalese people relate to the environment.

Singh (1986) attributed the origin of a conservation ethic in the Indian subcontinent to the teachings of Hinduism and Buddhism. He drew attention to the fact that India enacted the world's first recorded conservation measures during the third century BC, and is one of the few countries in the world whose constitution makes special reference to protecting the natural environment.

Majupuria and Joshi (1988), Bahl (1979) and Bahaguna (1988) have all provided explanations of why nature is revered in Nepal and India. The natural environment sustains life; plants provide food and medicines for humans; trees and forests provide settings conducive to making sound judgments, contemplating the universe or achieving enlightenment (as they did for Buddha); certain flowers and trees provide supernatural beings with dwellings, favourite resting places and food; and the vegetation protects the land. These attributes are referred to in the teachings of Hinduism and Buddhism and give rise to sacred plants and animals and rituals concerned with the worship of nature (Majupuria and Joshi, 1988).

It is debatable whether religious teachings about the environment, the existence of sacred species, or the rhetoric of India's constitution prove that a conservation ethic is prevalent in India. India's environment has been substantially altered by its huge human and livestock populations. Its national programmes for nature conservation have been deficient in scale and have been characterized by inadequate planning and slow progress in implementation (Singh, 1986). The same can be said of Nepal.

Stracey (1979) believed that the alleged presence of a conservation ethic among the forest dwellers, urban dwellers and forest contractors of modern India is a myth. He dismissed as wishful thinking the contribution of sacred groves and nature worship to nature conservation. Jain (S. K., 1979) postulated that conservation of nature for religious reasons has dwindled greatly in recent history and Chandrakanth et al. (1990) agreed; suggesting that taboos on cutting religious trees became less effective after the early 1960s when shortages in tree products became common.

On the other hand, a number of authors have documented cases where local people claimed to have been moved by a conservation ethic, based on religious principles, to protest against environmental exploitation by the state. A widely-cited example concerns the Bishnoi sect of west-central India. Although there is some confusion regarding the year of the event (probably 1731) it is reported that 363 members of this Hindu sect died while attempting to stop the troops of a local Maharaja from cutting down a grove of trees, near Jodhpur in Rajasthan, because it conflicted with their religious beliefs (Singh S., 1986; Bahuguna, 1988). Fisher (1988b) argued that there is evidence the sect may have used conservation issues as a focus for their political resistance to the Rajput rulers. He also argued that the caste cohesion of the Bishnois, which is useful politically, is largely a result of their religious identity, and that this is heavily grounded in a conservation ethic.

Another example of environmental protest is documented by Guha (1988, 1989). About 100 years ago, the local inhabitants of Kumaun in the central Himalayas waged a long campaign of civil disobedience because of the exploitation of human and forest resources by the British. In this case, the political objectives are more obvious than the environmental objectives.

In recent times the Chipko movement in northern India has received worldwide attention as a significant factor in the protection of India's forests (Jain S., 1984; Bahuguna, 1986, 1988). The basis of this movement, which derives its name from the act of hugging trees to prevent tree-felling by contractors, are attributed to the world-views and values of both the followers of Mahatma Gandhi's disciple, Vinoba Bhave, and the villagers in Uttar Pradesh who were directly affected by government forest policy of the 1970s (Jain S., 1984). Again, the Chipko protests achieved political goals, but it is interesting to note that the movement has spread during the last two decades through the use of religious teachings concerning the environment.

It appears that the traditional, socially shared world-views of the Indian region have had some role in promoting a conservation ethic, even if it has not been shown that such an ethic has been adopted widely and maintained. Several authors have written about the decline in traditional values resulting from the increasing influence of western culture on the populations of South Asian countries (for example, Singh N. N., 1983; Harrison, 1984; His Majesty's Government of Nepal, 1988; Singh M. M., 1989; Dixit, 1989). The National Conservation Strategy for Nepal (His Majesty's Government of Nepal, 1988) identifies the introduction of western culture and lifestyles, through the influences of the media and tourism, as a constraint to conserving Nepal's cultural heritage, which includes sacred sites and religious forests. Unfortunately, the magnitude of the impact of western culture on Nepalese society, including the rate at which traditional values are declining, is unknown.

Despite the erosion of these traditional perceptions, it is possible to explore the conservation significance of socially shared world-views and values by looking at how the current performance of religious rituals influences forest use and management in Nepal.

The performance of religious rituals

Dharma and the Hindu and Buddhist pantheons

To understand the reasons for the performance of religious rituals, it is necessary to define the concept of dharma, which is the basic value system of traditional Nepalese society.

"Dharma" is often mis-translated as "religion" in English. Instead, it implies a correct lifestyle, or living in harmony with one's nature in a world of perpetual change: "...a lifestyle in harmony in the three spheres: the philosophical, the social and the environmental." (Gyawali, 1987).

Nepalese society places a high value on dharma. People can observe their dharma by performing and participating in religious rituals and undertaking social activities to gain religious merit (Berremen, 1972; MacFarlane, 1976; Singh N. N., 1983). The majority of religious rituals are recurrent ceremonies which occur either daily; periodically, according to an annual programme of festivals; or occasionally, when a change in the status of an individual must be observed. During such ceremonies, one or more deities are worshipped using actions and products prescribed by religious texts, religious specialists and local tradition.

The Hindu and Buddhist pantheons include a huge number of different deities. There are tens of thousands of different gods and goddesses worshipped at the household, family, village, regional and national level. Many of the major deities have a number of different forms, each requiring ritual worship at different times and in different ways (Deep, 1982). Some deities have influence in particular spheres, such as education, the acquisition of wealth, agriculture, the occurrence of earthquakes and landslides, rainfall, forest growth, famine and disease. Others can cause a range of problems for villages, families or individuals if they are offended in any way.

Tree worship and religious forests

In Hindu theology, specific plant and tree species are deemed to he incarnations, or symbols, of deities and other supernatural forces, and must be worshipped. Majupuria and Joshi (1988) and Chandrakanth et al. (1990) listed those species that are worshipped in Nepal and India as representations of deities, stars, planets and the zodiac. Some of these species, such as Ficus *religiosa,* are widespread, well-known and widely worshipped; other species are not. It has been argued that the reverence towards these species is strengthened by the fact that most feature in the great Hindu legends; their flowers, fruits and foliage are used in a number of religious rituals; and various parts of the trees are believed to have great medicinal value (Majupuria and Joshi, 1988).

In India, the most common forms of tree worship involve Ficus *religiosa, Acacia ferruginea, Aegle marmelos,* and *Ficus glomerata* (Chandrakanth et al. 1989). In Nepal, the following tree species are worshipped: *Ficus religiosa, Ficus bengalensis, Aegle marmelos, Magnifera indica, Phyllanthus emblica, Elaeocarpus spp., Saraca indica, Butea monosperma, Shorea robusta* and *Anthocephalus cadamba* (Majupuria and Joshi, 1988). Some of these are worshipped mainly by specific groups of people. For example, *Elaeocarpus spp.* is worshipped by many mystics (Majupuria and Joshi, 1988), and *Anthocephalus cadamba* is worshipped by the Dhangar people (Bista, (1987). However, the first five species listed above are worshipped widely. *Ficus religiosa* has widespread popularity as a sacred tree and is worshipped by Buddhists as well as Hindus. Because Buddha's enlightenment is believed to have occurred under one of these trees, it has been adopted by Buddhism as the specific symbol of that event (Mansberger, 1988).

The way trees are worshipped depends on the age and gender of the worshipper; the form of the ritual is prescribed by magico-religious specialists (Chandrakanth et al. 1990). The act of planting a sacred tree species is also a form of worship and a method of attaining religious merit. Religious merit can also be attained by building a temple (Singh N. N., 1983), a rest-house for pilgrims (Gyawali, 1989b), or some other public facility such as a water tap, resting place or footpath (Fiirer-Haimendorf, 1981; Gurung, D. K., 1987); erecting memorials for dead relatives (Bista, 1978; Fiirer-Haimendorf, 1975); donating land to a religious institution (Regmi, 1978); donating land for public grazing (Dhungel, 1987); planting a tree at a water source (Acharya 1984; Gurung, D. K. 1987); establishing a religious forest (Chandrakanth et al. 1990); making donations of food or money to holy men (MacFarlane, 1976); undertaking a pilgrimage to an important sacred site (Messerschmidt, 1989b);

or renouncing physical possessions and living the life of a mystic (Berreman, 1972; Shepherd, 1982).

In some places tree marriage is practiced. This involves the symbolic marriage of one tree to another. A common tree marriage ceremony involves the marriage of a Ficus *religiosa* tree to a nearby *Ocimum sanctum* plant (Majupuria and Joshi, 1988), or to an *Azadirachta indica* tree (Chandrakanth et al. 1990). Tree worship has resulted in the spread of sacred tree species across the landscape as people have planted and protected them for the performance of religious rituals. A detailed description of the spread of Ficus *religiosa* is given by Mansberger (1988). The other result of tree worship has been the establishment and management of religious forests, also known as sacred groves and temple forests.

"Many religious performances and rituals are locally conducted in the forests. Particularly, the lineage god, the forest god and certain evil spirits are worshipped in the forests throughout the hill regions of Nepal" (Acharya 1984).

Many rituals take place within forests. This gives rise to the establishment of religious trees and forests and institutions and organizations concerned with the protection and management of religious forests. Religious trees and forests are identifiable entities in Nepal's rural landscape and range from small groups of several trees to an extensive area of forested land (Ingles, 1990). In addition to the establishment of religious forests, tree worship and the performance of other recurrent rituals create demands for forest products.

Consumption of forest products

Most of the caste and ethnic groups of Nepal cremate their dead in a prescribed manner (Bista, 1978), consuming a great deal of fuelwood each year. In some parts of Nepal, communities have attempted to reduce the quantity of fuelwood consumed during funerals by constructing fuel-efficient fireplaces. Many of the important life-cycle rituals and religious festivals involve feasting, and for many ethnic groups they also involve the consumption of large quantities of alcohol. Fuelwood is used to cook food for participants and to make alcoholic drinks. Fox (1984) reported that Newars used more fuelwood than other castes because of the need to make alcohol for festivals; it is known that Newars observe a greater number of festivals than any other group (Bista, 1987).

The performance of religious rituals and the attainment of religious merit also involves the construction of temples, monasteries, rest-houses for pilgrims, schools, and houses for people in desperate need of charity. The construction and maintenance of such buildings is likely to consume significant quantities of construction timber, although estimates of annual consumption for these purposes are unavailable.

A number of other forest products are used in the performance of religious rituals. Majupuria and Joshi (1988) provided a detailed list of the types of bark, flowers, leaves and fruit used in worship and folk medicine. The number of species involved is substantial. At high altitudes, a minor requirement exists for timber poles, usually of Abies *spectabilis*, to affix prayer flags and for *Juniperus recurva* wood to make incense (Schmidt-Vogt, 1988).

Religious beliefs and practices of the Nepalese have created extra demands on natural resources such as fuelwood and fodder, and this extra demand influences land-use decisions. Bajracharya (1983) pointed out that the caste and ethnic groups in his study area believed that family deities reside in household hearths. As a result, these groups are less inclined to install fuel-efficient stoves. In regard to fodder demand, there was a widely-held view that the livestock population in the Indian subcontinent had reached an alarming size because the cow is sacred and the herd is not managed rationally. Recently, studies have shown that this is no longer a valid argument (Blaikie 1985; Ives and Messerli 1989). It is necessary, however, for a high caste Hindu to have access to cows' milk, urine and dung in order to perform many of the prescribed religious rituals (Uprety, 1986).

Throughout Nepal, organizations exist for the purposes of funding and planning either an important religious festival in a particular area, or a life-cycle ceremony for one of their members. Many of these are modelled on the guthi system. A guthi is a common trust, consisting of assets and an organization charged with managing the resources of the guthi to provide the goods and services required for supporting a particular ritual (Bista, 1987). There are religious guthis for worshipping a particular deity during festivals; functional guthis for conducting funerals and maintaining public places; and social guthis for organising parties and other forms of entertainment (Uprety, 1986).

Therefore, the performance of religious rituals gives rise to institutions and practices that have the potential to create both positive and negative impacts on forests. On the one hand, tree worship, tree planting, the protection of forests containing sacred sites and the social structures created to manage religious forests can contribute to forest conservation. And yet, the use of a wide range of forest products for religious purposes adds to the harvesting pressure on forests which are accessible to the organizers and participants in religious rituals. The outcome of these influences can be examined by looking at the management and condition of religious forests in Nepal.

Management objectives

A primary objective of management for religious forests is to provide a sacred landscape dedicated to the worship of a supernatural being. To facilitate worship, a number of developments, such as temples, rest-houses and paths, may be established inside or adjacent to the forest. Establishing and maintaining these facilities involves, among other things, raising funds and locating building materials such as timber. In addition, a number of activities conducted in these forests, such as cooking food during religious festivals, consume forest products. As a result, a secondary management objective for many religious forests is to provide resources for religious rituals and developments at the sacred site. The primary and secondary objectives are related, and they arise because of the presence of a sacred site and the traditional performance of religious rituals at that site (Ingles, 1990).

On the other hand, there are religious forests that do not contain a sacred site. Allocating management objectives for these forests occurs through a decision-making process that is not influenced by the traditions associated with the presence of a sacred site. Instead it is influenced by the need to supply particular forest products, which are used directly or sold to raise funds. This represents a major difference between religious forests with sacred sites, and those without. The first type of forest gains its management objectives and religious status from the presence of a sacred site. The second type gains its management objectives and religious status from the fact that a decision has been made to sponsor religious rituals and sacred sites, using the forest as an asset.

Several other forest management objectives are shared by both types of religious forests. The objective of providing timber to charitable causes and to schools is one example. As far as it is compatible with other objectives, the forests concerned are treated as a reserve of products for assisting in the provision of social services, such as building an orphanage.

Institutionalized rules and organizations

The presence of institutionalized rules governing resource use is believed to be fundamental to the existence of a local system of managing a forest as common property (Fisher, 1989). Case study material discussed in the literature shows that each of the religious forests studied in detail had a set of institutionalized rules in operation, and many also had some form of organization supporting forest management (Acharya, 1984; Messerschmidt, 1986, 1987; Jackson, 1987; Anon., 1987; Ingles, 1988, 1990; Gilmour, 1988; Fisher et. al., 1989; Gyawali, 1989b; Singh H., 1989a, 1989b).

At this point it is necessary to explain the use of the terms "institution" and "organization". They are often used interchangeably, creating ambiguity and confusion. Uphoff (1986) described institutions as "complexes of norms and behaviours that persist over time by serving collectively valued purposes" whereas organizations are "structures of recognized and accepted roles". This is a useful distinction for discussing local systems of forest management as it separates the locally-agreed rules about forest access and use (institutions) from the roles that may be established from time to time to achieve specific objectives (organizations).

Rules prohibiting the harvesting of products from the overstorey of religious forests are more common than those prohibiting the harvest of products from the understorey. In a survey of 26 forests, felling and pruning trees was prohibited in 81 per cent and 73 per cent of the forests, respectively (Ingles, 1990). In contrast, collecting dry firewood, cutting fodder and collecting dead leaf-material was prohibited in only 4 per cent, 23 per cent and 12 per cent of these forests, respectively. In addition, the results showed that even when the harvest of products from the understorey was prohibited, these rules were not complied with to the same extent as were rules about protecting the overstorey.

There are two possible explanations for this, one or both of which may apply. As discussed above, trees of particular species are worshipped; deities are believed to reside in trees and forests; forests are revered in Hindu and Buddhist theologies; and forests are good environments for making sound judgements and enjoying religious festivals. All of these factors focus attention on the trees. An understorey may not be a necessary element of a sacred landscape. If this is the case, and a fodder and fuelwood shortage exists, trees will be protected and the understorey will be harvested.

Obtaining fodder has became a major problem for farmers in many districts in Nepal (MacFarlane, 1976; Uprety, 1986; Robinson, 1987; Mahat et al. 1987; Dhungel, 1987; Upreti et al. 1989; Riley et al. 1989; Schreier et al. 1989). Therefore, it may be possible for farmers to forgo the timber and wood products tied up in the overstories of religious forests, but more difficult for them to do without the fodder produced in the understoreys of religious forests.

The existence of a forest watcher, who is paid to enforce the agreed rules by contributions of grain from each household, represents a recognized and accepted role in forest management. Other roles exist for making and implementing decisions about sanctions, product distribution, finances and the development of facilities in the religious forest. Such roles are undertaken by one or more of the following: a priest, a community leader, or a committee.

These results show that the social arrangements for managing religious forests conform to the characteristics of local systems for managing forests as common property as described by Fisher (1989). The existence of a set of institutionalized rules is the basic element of the management system; in some cases, organizational structures are built upon the institutionalized rules. Differences between the systems for managing religious forests, as compared to other forests managed as common property, occur in the specific management objectives adopted by the user group; in the involvement of a priest in many of the organizational roles; in the establishment of temples and recreational facilities in the forest; and in the practice of including the forest in a guthi.

The size and condition of religious forests

Most of the religious forests described in the literature are small (Acharya, 1984; Mahat et al. 1986; Anon., 1987; Jackson, 1987; Ingles, 1988, 1990; Fisher et. al., 1989; Singh H., 1989a, 1989b; Messerschmidt, 1989a). In a survey of 26 forests in three districts of central Nepal, 65 per cent of the forests were found to be one hectare or smaller, and only eight per cent were larger than four hectares (Ingles, 1990). In Nepal, it is possible that the expansion of the agricultural land base has occurred at the expense of forested land on the periphery of a sacred site. Where the ratio of forested land to agricultural land is critically low, it is possible that only the core area (surrounding the sacred site) of a larger forest can be allocated as a religious forest because the rest of the forest is required for domestic use. However, at a famous and popular site containing a deity of major significance, a larger area may be required to cater to the demands of visitors and the desires of a powerful god or goddess. One such example is located at Dakshinkali, south of Kathmandu, where the religious forest is 30 hectares in size. The size of a religious forest might depend on the popularity of the site, the significance or status of the deity, the number and size of sacred sites contained in the forest, and the local ratio of forested land to agricultural land.

Many religious forests in Nepal have an open structure, both in the overstorey and understorey, with an absence of a well-established pool of regeneration (Shrestha V. S., 1984; Shrestha A. M. and Shrestha R. B., 1988; Ingles, 1988, 1990; Fisher et. al, 1989). Other religious forests are known to have once been degraded shrublands, and have since regenerated to closed forests after either strong protection measures or reforestation activities were initiated (Jackson, 1987; Ingles, 1988, 1990; Singh H., 1989b). Religious forests may go through cycles of decline and regrowth because the emphasis on protecting trees, rather than protecting the understorey, prevents the development of an uneven age class structure that could provide for the maintenance of a dense overstorey (Fisher et al.1989; Ingles, 1990). The objective of maintaining a sacred landscape of trees may ensure that, at some stage, the decline is halted by a change in the institutionalized rules that aim at restocking the area with trees.

Discussion

The social values of religious forests, their contribution to forest conservation, and the social arrangements for managing them can tell us something about the practical influence of religious beliefs and rituals on nature conservation in general.

Religious forests have a spiritual value, in making a connection by means of trees and forests between worshippers and the supernatural world. Religious forests also have recreational and aesthetic values because people go to them to observe and enjoy religious festivals. They have an educational value because their presence can reinforce the messages about conservation and respect for nature provided by the teachings of Hinduism and Buddhism. The National Conservation Strategy for Nepal (HMGN, 1988) identifies the archaeological and historical values of religious forests, especially those located at long-established sacred sites of international significance, such as at Pashupatinath near Kathmandu.

Clearly, religious forests are part of the cultural heritage of Nepal and provide important sites for spiritual and recreational enjoyment. The cultural value of particular religious forests can be significant at local, regional, national, and international levels. It is therefore likely that religious forests are important to forest conservation in a symbolic sense. Religious forests are necessary for observing a traditional lifestyle. Much of the social life of Nepalese villages occurs in and around religious forests; even urban Nepalese visit religious forests. Generally speaking, this means that religious forests are encountered by Nepalese youth and play some role in their education. The presence of religious forests in the landscape provides a reminder of the conservation messages in Hinduism and Buddhism and of the beauty and environmental benefits of forests. However, the effectiveness of this symbolism in promoting conservation ethics is under threat from the increasing influence of western culture on the Nepalese population.

Some authors have written about the positive value of religious forests in conservation and environmental protection (Gadgill, 1987; Guha, 1989; Chandrakanth et al. 1990). But is the protection and management of religious forests important to forest conservation in Nepal? This question can be addressed by considering two separate questions:

- how do religious forests contribute to the conservation of biological resources and the protection of forest soils; and
- how can the local systems of managing religious forests be utilized in rural development programmes that further the conservation of forests?

It has been shown that religious forests form a special component of the forest resource that underpins the subsistence-oriented farming systems of Nepal (Ingles, 1990). Religious forests are used to provide a wide range of forest products for both domestic and ritual purposes. As a result, religious forests are not sacrosanct. Some religious forests do not have a sacred site; such forests are often managed primarily to provide forest products for religious rituals, the development of sacred sites, community development, and to support charity cases.

Religious forests are exploited for forest products and many have suffered significant modification, especially in the understorey. In addition, most religious forests in Nepal are small and are not established or managed for the purposes of conserving biodiversity or preventing soil erosion. It appears that forest protection is focused mainly on mature trees and on the core areas surrounding sacred sites. Understorey and ground cover species seem to gain little benefit from being located in a religious forest. The poor condition of the understoreys in many of the forests described in the literature also suggests that soils could be subject to accelerated surface erosion.

If, however, a religious forest has been established for a long period of time in a region that has been modified greatly by human and livestock populations, it could constitute an important reserve of the natural vegetation and could play an important role in the local conservation of species (Gadgil, 1987; Dove and Rao, 1986). For the handful of plant species that are worshipped as sacred, there is no doubt that their conservation has been assisted by a deliberate proliferation and protection in the landscape for religious purposes. The direct contribution of religious forests to biological conservation and the protection of forest soils in Nepal may be small, but it is likely that the return of species to degraded sites outside religious forests would be more difficult in modified landscapes if these remnants had not been conserved for religious reasons.

Local systems for managing religious forests contribute to forest conservation because they represent a social capacity for managing resources as common property. One strategy for promoting forest conservation in Nepal is community forestry, which involves the provision of government assistance to groups of local people for establishing new forests or managing existing forests as common property. The key elements in making this strategy work are finding the right people and providing the right assistance. The programme must find a workable user group; the benefits of the programme must suit the needs of this group; and its operation must match the institutional and organizational capacity of the group (Fisher, 1988a, 1989; Jackson and Maharjan, 1988; Fisher et al. 1989).

The existing institutions and organizations for managing both the performance of religious rituals and religious forests provide entry points for implementing community forestry. For example, local people may be interested in creating or improving a religious forest, or they may wish to expand a religious forest under the provisions of a community forestry programme. The user group of a religious forest may wish to establish a new forest as an asset to fund the maintenance or development of a sacred site or to provide products for the performance of religious rituals. In such a case, a user group exists and the needs of the group can be determined and the institutional and organizational capacity of the group can be calculated by looking at which social arrangements for managing the religious forest already exist.

The use of religious organizations and forests as entry points for community forestry may have a number of distinct advantages. Compared to the management of other forests, religious forests may be relatively free of conflict. The model of a religious forest that supplies funeral-wood, timber for schools and charities, and fuelwood for festivals and life-cycle rituals could be promoted to great effect. It could have widespread appeal because of the notions of religious merit, and maintaining harmony with the supernatural world, and because it could take the pressure off private resources. Clearly the benefits of such a forest contribute to the social and spiritual well-being of the village, rather than the material wealth of an individual. For this reason it may provide a starting point for community action in an area where the confidence of user groups is low and where there is little consensus and cooperation in other resource management activities. In this way religious forest management can be used to strengthen community forestry activities that further enhance the conservation of forests.

In summary, the social arrangements established to manage religious forests are valuable for forest conservation and rural development because they represent local capacity for mobilizing resources. The influence of religious beliefs and rituals on forest conservation in Nepal is significant because it gives rise to appropriate institutions and organizations for cooperative resource management and provides messages and symbols for forest conservation in Nepalese society. In addition, the presence of religious forests in heavily modified landscapes provide refugia for species which might otherwise have become locally extinct.

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Endnotes

Budowski

1. Management implies planning, research, and different uses, including total preservation but always maintaining some forest cover with a minimum of alteration. The term tropical rainforests as used here includes non-deciduous forests in areas of relative high rainfall throughout the year.

Sotomayor

1. AGRUCO is Agroecolgia Universidad Cochabamba, an agro-ecology programme of the public University of Cochabamba, supported by Intercooperation and the Swiss Development Corporation.

2. Agricultural land rotated cyclically between crops and pasture meadows with periods of prolonged and variable rest periods. During the cultivation period there are standards of communal control, a system that ensures the socio-economic and cultural well-being of the families and communities (Sotomayor M. Agruco, 1993).

3. Scientific name in Table 6.

4. Organic fertilizer made from the excrement of sheep, llamas and cattle.

5. Group of three aynokas with crops following a specific rotation. The composition by aynoka is potatoes, grains (quinua and kafiawa) and fodder (oats and barley). Each agricultural season consists of three aytas.

6. Process, that began with the Spanish conquest, in which crops such as barley, wheat, oats etc. were introduced as well as livestock such as sheep, cows, goats. Today these form a fundamental part of traditional systems, and are the result of a process of adaptation to local requirements.

7. Pair of bull or oxen, used for farming and threshing in traditional production systems.

8. Potato dehydrated by action of ice and sun; a technology used after harvesting for long-term preservation.

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