6. CONSERVATION STRATEGIES: AN AGRO-ECOLOGIST'S VIEWPOINT

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6.1 Introduction

The estimate of the number of species on earth varies from 5 to 30 million; in any case, no one doubts that the numbers are far higher than was thought until recently (World Resources Institute 1988). With an estimated 15 to 33% loss out of the total wildlife by 2 000 AD, the extinction rate is becoming critical (Lovejoy 1986). It is in this context that conservation biology assumes considerable significance. Apart from a number of biological problems such a community equilibrium and fragility of ecosystems, there are many social challenges that impinge upon people's perception of environment and development. It is, therefore, only in recent times that efforts are directed to build up the obvious contacts between social and natural sciences. What is it that we wish to conserve? Is it possible or even necessary to conserve all the species that are likely to be lost and about which we may or may not even be aware of? How do we ensure that our conservation strategies are effective? What is sustainable development in the context of biological conservation? This paper considers some of these issues and attempts to answer them using experiences in linking conservation with development.

6.2 Agro-ecosystem concept and conservation

6.2.1 *Lesser-known plants of food value*

Of all the 3 000 plant species used as food at some time during human civilization, less than 20 provide over 90% of the food needs (N.R.C. 1982). In fact, just about 3 species (wheat, rice and maize) meet over half of the human energy needs (Wilkes 1981). Reliance on such a small number of plants carries great risks, for monocultures are extremely vulnerable to catastrophic failures brought about by diseases or climatic stresses.

Over large areas of the humid tropics, genetic uniformity of a few varieties is displacing many local varieties traditionally cultivated by the farmers (Wilkes 1977). As the produce of technology displaces the source upon which the technology itself is based, namely the genetic diversity, short-term solutions often become long-term irreversible liabilities. In fact, 75% of the world's lesser-known crops are grown and consumed in tropical countries (N.R.C. 1975). With depletion of genetic diversity of crop plants (Sasson 1987) there is considerable interest in lesser-known plants of food value for meeting the needs of the increasing population, particularly in the developing world (N.R.C. 1975; Raven 1981). There is a need not only to conserve

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them but also to improve upon the economic yield of the more promising ones. Such a diversification of the agro-ecosystem base would go a long way to meet the nutritional needs of people and for the stability of agro-ecosystems.

Some important under exploited food plants are the grain chenopods (N.R.C. 1975; Risi & Galwey 1984; Partap & Kapoor 1985), with a high protein value. These plants are presently cultivated in the Andes or in the Himalayas. Greater emphasis on cultivation, improvement and consumption by the local communities would contribute to enhancement of the quality of life of the people concerned. With considerable similarity in the preparations made out of many chenopods by the Himalayan communities and their counterparts (Risi & Galwey 1984; Partap & Kapoor 1985) possibilities exist for preparation of marketable products. Needless to say that there is much scope for improvement of the grain chenopods.

The people in the humid tropics, such as in the north-eastern hill region of India endowed with rich natural resources and from a variety of socio-economic and socio-cultural conditions, depend upon under exploited food plants. In a recent study in north-eastern India (Gangwar & Ramakrishnan 1989a) over 70 such plant species and 12 animal species were identified for four tribes, namely, the Nishis, the Hill Miris, the Sulungs and the Apatanis. The plant species often come in handy during the lean season of the year when traditional food items are in short supply. With over 200 tribes in a small geographic area, each being highly insulated due to language barriers and socio-cultural differences, north-eastern India is a veritable ethnobiological treasure.

The Khasi tribe of Meghalaya in north-eastern India, practising slash and burn agriculture (jhum) (Ramakrishnan 1985) and having sedentary agriculture under short fallow systems (FAO/SIDA 1974; Ganwar & Ramakrishnan 1989b) cultivate a variety of lesser-known plants for food, such as *Digitaria cruciata* var. *esculenta, Perilla ocimoides* and *Flemingia vestita.* Many tribes in Arunachal Pradesh also cultivate *Dioscorea* species for tubers, *Amaranthus viridis* for leaves, *Chenopodium ambrosioides, Panicum miliaceum, Setaria italica* and *Coix lacryma-jobi* for seeds, apart from others (Gangwar & Ramakrishnan 1989a). Though the contribution of energy and protein through lesser-known plants was only a small fraction of the total food consumed by the Khasis (Table 6.1), the seasonal pattern of consumption varied so that more was consumed during the monsoon season (Figure 6.1). Apparently the lesser-known crops play a more important role when traditional food items are in short supply.

Flemingia vestita, in particular, has a dual role in the agro-ecosystem. Apart from the value of the tuber as a protein source, this legume considerably improves the nitrogen status of the soil through nodular fixation (Table 6.2). While in the developed countries nitrogen level in the soil is maintained through intense use of nitrogen fertilizers, attempts to transfer this technology to the humid tropics have been unsuccessful (Greenland 1977). Nitrogen is a highly mobile element in the soil of the humid tropics. Through our earlier studies on nitrogen budgeting under jhum, we have shown that the loss during one cropping season may be as much as 600kg ha^{-1} $year^{-1}$ (Mishra and Ramakrishnan 1984; Swamy & Ramakrishnan 1987b). Under shorter jhum cycles of 5 years, not more than half of what is lost is put back into the system (Table 6.3). Therefore, the role of nitrogen-fixing legume species such as *Flemingia vestita* offers possibilities of improving yield under sedentary agriculture, through appropriately managed crop rotation.

Table 6.1 Per capita annual consumption of lesser-known crops in relation to other food item of the Khasis of Meghalaya in north-eastern India (after Gangwar & Ramakrishnan 1989b).

Food items	Quantity (kg)	Energy (MJ)	Protein (kg)
Traditional crops	216.8	3187.2	17.3
Lesser-known crops	17.7	217.9	1.3
Animal products	15.7	325.9	12.5
Total	250.2	3731.0	31.1
Standard requirements		3665.3	20.1

Table 6.2 Nitrogen economy (kg ha^{-1} yr^{-1}) under *Flemingia vestit* cultivated in pure or mixed stands by the Khasis at higher elevations in north-eastern India (after Gangwar & Ramakrishnan 1989).

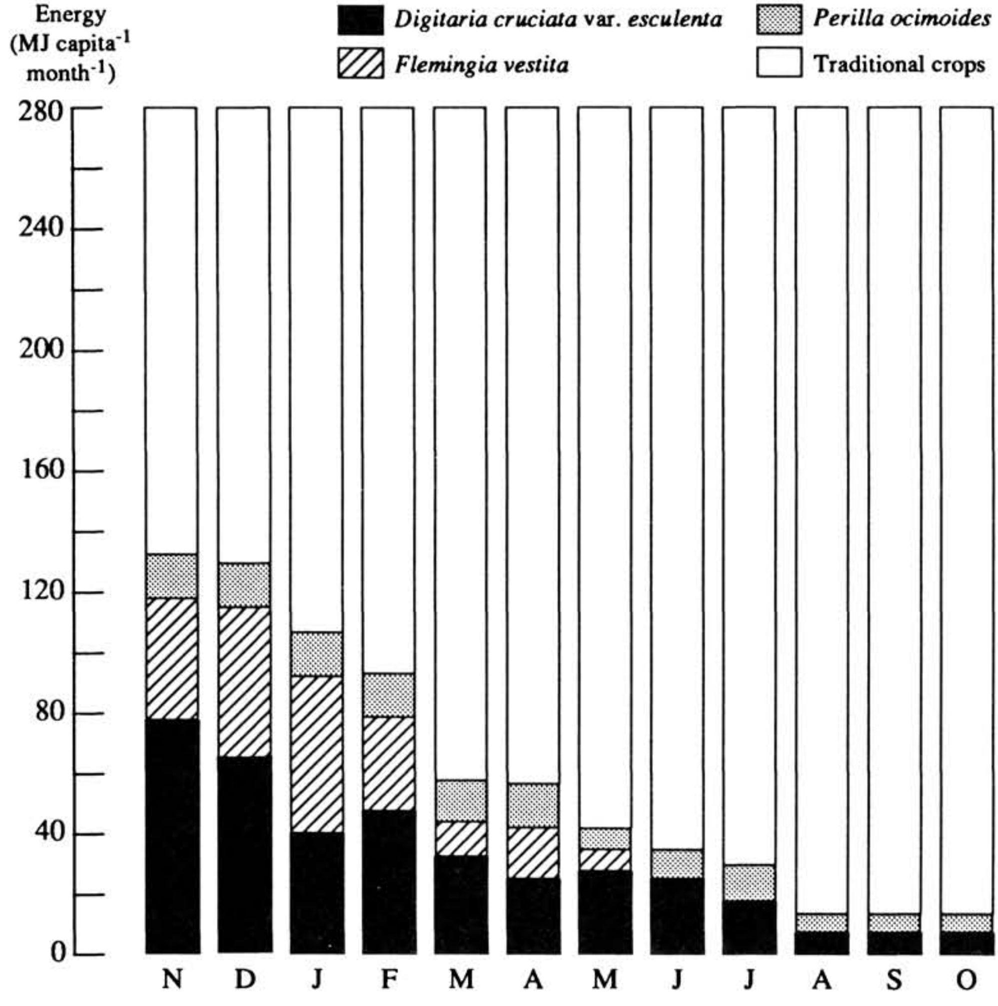
	Pure	Mixed with cabbage	
Accumulation in the crop biomass			
Shoot	19± 0.7	16± 0.6	(3± 0.1)[1]
Root	10± 0.5	10± 0.3	(2± 0.1)
Economic yield removed	31± 0.5	23± 1.0	(10± 0.1)
Crop biomass recycled	29± 1.7	26± 1.5	
Weed biomass recycled	9± 0.6	13± 0.9	
Nitrogen fixation	207± 7.2	154± 5.5	
Net gain in soil	245±18.3	193±15.6	

[1] *Values for cabbage are in parenthesis.*

Table 6.3 Net change of nitrogen (103kg ha^{-1} yr^{-1}) (after Mishra & Ramakrishnan 1984).

	Fallow cycle (yr)			
	15	10	5	
			I yr crop	II yr crop
Soil pool before burning	7.68	7.74	6.40	5.98
Soil pool at the end of cropping	7.04	7.15	5.98	5.60
Net difference	0.64	0.59	0.42	0.18

Figure 6.1 Consumption patterns of lesser-known and traditional crops by the Khasis of Meghalaya in north-eastern India (after Gangwar & Ramakrishnan 1989b).



6.2.2 *Shifting agriculture in north-eastern India – a case study*

Shifting agricultural farmers throughout the humid tropics cultivate a variety of traditional crops. The stability and sustainability of this and other traditional agro-ecosystems are based on crop diversity (Altierri 1983; Ramakrishnan 1984). The important consideration in their multiple cropping systems is related to optimal use of nutrient resources from the soil by appropriate changes in crop mixtures and/or through manipulation of their placement, depending upon soil fertility. Thus in north-eastern India, the shifting agriculture farmers often shift to tuber and perennial crops when soil fertility is low under a short agricultural cycle (Toky & Ramakrishnan 1981a).

Under shifting agriculture in north-eastern India, the cropping system involves a number of local varieties of traditional and non-traditional species. The number in the mixture may vary from 4 or 5 to over 35 (Ramakrishnan 1985). The species mixture consisting of pulses, cucurbits, vegetables, legumes, cereals, tuber and fruit crops, both annuals and perennials, are planted and often harvested sequentially. The crop mixture and the varieties used are location-specific, differing depending upon ecological conditions and socio-economic and socio-cultural factors of the people who are involved in the activities.

The shift in crop mixtures is often linked with soil fertility characteristics and related optimisation of production. Thus, in a recent study (Gangwar & Ramakrishnan 1987), 17 different cropping patterns were identified over a small area within 20km radius around Shillong. These cropping patterns gave economic returns ranging from about INR 15 000 to as high an over INR 35 000 ha^{-1} yr^{-1}.

In many areas on the humid tropics where shifting agriculture is the chief land use system, attempts have been made to develop alternate land use strategies. This has been necessitated because of drastic shortening of the shifting agricultural cycle from a reasonably long 10-20 years to a rather short 5 years or less. Among the different strategies suggested, sedentary terrace agriculture on hill slopes has been one of them. These sedentary systems are often energy intensive and ecologically inefficient. This apart, such alternatives are conceived more as intensive production systems, with emphasis on monoculture of a high yielding crop variety.

These are often rejected by the traditional farmers. The tendency of the farmers to hold on to traditional land use practices has to some extent contributed towards conservation of traditional varieties. Even sedentary agriculture, for example in valley land with wet cultivation of rice, traditional varieties are often not totally dispensed with. Thus rice farmers in Thailand combine traditional varieties of rice during the dry season optimising production and at the same time maintaining stability of the system (Grigg 1974). Some potato cultivation has a mixture of both native and modern bred varieties perhaps because of the risk and expense involved in sustaining production under the modern system.

The renewed interest of recent times in traditional agro-ecosystems has contributed towards their adaption to the modern age wherever possible. The concept of 'home garden', which is well developed in the humid tropics, offers possibilities of maximising the production per unit area through tight vertical packing of species, as is done by many tribes in north-eastern India (Maikhuri 1987). An extreme example of this is the te'lom plots of about 6 ha maintained by Huastec Indian farmers of north-eastern Mexico. With over 300 species in a te'lom plot, the Huastec system is not only an alternative to land management in the humid tropics but provides protection for wild genetic conservation and contributes towards a combination of commercial and subsistence agriculture (Alcorn 1984).

In north-eastern India, the shifting agriculture shown to be a system based on sound scientific principles (Ramakrishnan 1984), has been distorted due to rapid shortening of the jhum cycle. The overall conclusion is that the low production costs and high energy efficiency make the shifting agriculture system more viable than terrace cropping (Ramakrishnan 1984). Mixed cropping with sequential harvesting of crops (Table 6.4) is efficient in light capture for photosynthesis, meets the varied needs of the community and ensures self sufficiency of the village (Mishra & Ramakrishnan 1982; Ganwar & Ramakrishnan 1987). During the rainy season, it provides closed plant cover and checks rapid nutrient loses (Toky & Ramakrishnan 1981b) and enables weeds to be kept under control (Saxena & Ramakrishnan 1984). The entire shifting agriculture operations involves efficient recycling of resources for optimising yield through the use of crop and weed residue as organic manure (Swamy & Ramakrishnan 1988) and as feed in swine husbandry (Mishra & Ramakrishnan 1982).

However, the studies of Ramakrishnan and his co-workers (Ramakrishnan 1988; Mishra & Ramakrishnan 1981, 1984) has led to a number of practical guidelines for redeveloping shifting agriculture in north-eastern India under very short agricultural cycles. The ten guidelines noted below would also contribute to effective resource management and conservation in north-eastern India.

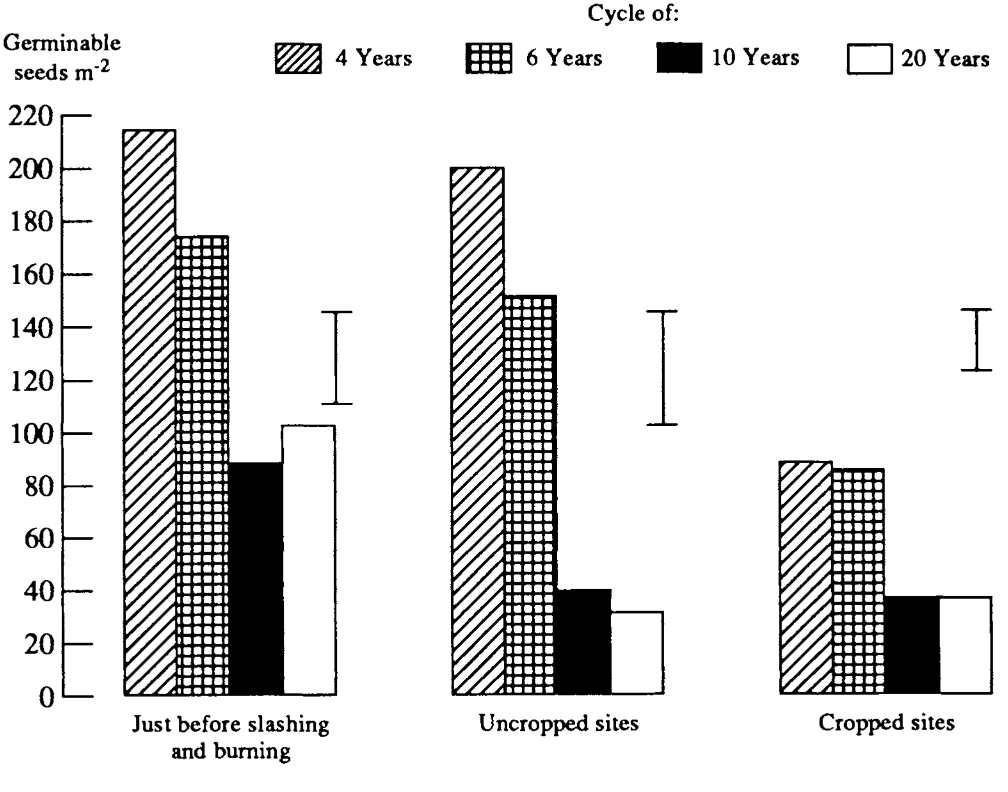
Table 6.4 Sequential harvesting of crops on jhum plots under 30 year cycle at lower elevation of Meghalaya (after Ramakrishnan *et al.* 1981a). All the seeds were sown in April.

Species	Harvesting time
Setaria italica	Mid-July
Zea mays	Mid July
Oryza sativa	Early September
Lagenaria species	Early September
Cucumis sativa	Early September
Zingiber officinalis	Early October
Sesamum indicum	Early October
Vigna mungo	Early October
Cucurbita species	Early November
Manihot esculenta	Early November
Colocasia esculenta	Early November
Hibiscus sabdariffa	Early December
Ricinus communis	(Perennial crop)

a) Condense the time span of vegetation succession and reconstitution, through manipulation of species mixture in time and space (Figure 6.2).
b) Accelerate fallow regeneration through introduction of fast growing native shrubs and trees.
c) Redesign agroforestry systems incorporating ecological insights on tree architecture (e.g. the canopy form of tree species should be compatible with crop species at the ground level, by permitting sufficient light penetration and through fast recycling of nutrients).

d) Vary species composition in the crop mixture at different altitudes (e.g. emphasis on potato at higher elevations compared to rice at lower elevations has resulted in a manifold increase in economic yield, in spite of low fertility of the more acidic soils at higher elevations.
e) Improve nitrogen economy through introducing nitrogen fixing legumes and non-legumes such as Nepalese alder (*Alnus nepalensis*).
f) Use bamboo and other fast growing trees as windbreaks, to check wind blown losses of ash and nutrient losses in water.
g) Incorporate cash crops such as black pepper and cardamom into the agroforestry system.
h) Introduce improved breeds of swine and poultry.
i) Introduce improved low level technology into the village units to relieve drudgery and increase energy efficiency (agricultural implements, cooking stoves, micro-hydroelectric projects, biogas systems).
j) Encourage artisan skills and products based on leather, bamboo and other woods and blacksmith work.

Figure 6.2 Germinable soil seed population of herbaceous species under different jhum cycles. Vertical lines represent least significant difference (P=0.01) (after Saxena & Ramakrishnan 1983).



6.3 Rainforest – a critical ecosystem

In recent times, ecologists, evolutionary biologists, and conservationists have focused increasing attention on tropical rain forests. Though they cover only about 7% of the earth's land area, they harbour more than half the species of the world's biota. With rapid conversion of these forests, they will mostly disappear by the turn of the century, resulting in extinction of a large number of species, many of them not even catalogued and understood by the tropical biologists. Besides, the tropical rainforests are among the most fragile of all habitats. Often conversion results in wet deserts (Ramakrishnan 1987; Ramakrishnan & Ram 1988) because of the highly leached infertile soil subjected to wash-out by heavy rains. Most of the soils under rainforests are red and yellow earths which are acidic and nutrient deficient. With high concentration of iron and aluminium, phosphorous availability is restricted because of the formation of insoluble compounds. Potassium is highly mobile (Table 6.5) and therefore is leached quickly (Toky & Ramakrishnan 1981b; Ram & Ramakrishnan 1988). With a weak soil base, a dense forest cover is supported because of a thick fine root mat located on the top of the mineral soil which helps in tight recycling of nutrients released by the quickly decomposing leaf litter, even before the element could seep into the mineral soil (Ramakrishnan 1984). This fine root biomass may be up to about 15 tonne ha^{-1} (Khiewtam 1986). Any large-scale disturbance in this system would make it unstable and make recovery difficult.

In north-eastern India, large scale disturbance to rainforest has resulted in varied levels of degradation, ranging from unproductive grasslands to arrested weedy communities, consisting largely of exotica (Swamy & Ramakrishnan 1987a; Ramakrishnan & Ram 1988). This has resulted in considerable erosion of species diversity.

The concept of succession offers the basis for a meaningful restoration programme for conserving biological diversity. Plant strategies starting with herbaceous weeds of early successional communities and that of bamboos, shrubs and trees of mid and late-successional environment offer the basis for designing strategies for restoration. The dry matter allocation strategy studies on herbaceous weeds (Saxena & Ramakrishnan 1983, 1984) suggest that organisms in more open habitats are selected for greater reproductive capacity (r-strategists), while those in closed habitats are selected for greater ability to compete for resources, though at the cost of lower reproductive potential (K-strategists). Thus species such as *Eupatorium odoratum* which is a r-strategist, is not able to survive in a more competitive environment of a 6-yr old fallow regenerated after shifting agriculture (Saxena & Ramakrishnan 1984). Further, some arterial species such as *E. odoratum* emphasises sexual reproduction and others such as *Imperata cylindrica* reproduce largely through rhizomes. In early successional stages following shifting agriculture in the hill tops of north-eastern India the soil is highly heterogeneous. Availability of nitrogen is uncertain, since that is a highly mobile element. The micro-distribution of C_3 and C_4 plants in early herbaceous communities is designed to exploit nutrients from such a heterogeneous soil. The C_4 species with a high nutrient use efficienty occur in nutrient

Table 6.5 Nutrient losses (kg ha^{-1} yr^{-1}) through run-off and percolation water under 10 yr jhum cycle agro-ecosystem and a 5 yr fallow (after Toky & Ramakrishnan 1981; Mishra & Ramakrishnan 1983).

	10 year cycle jhum plot		5 year fallow	
	Run-off	Perco-lation	Run-off	Perco-lation
Low elevation jhum				
Nitrate nitrogen	4.2	10.7	0.8	1.1
Available phosphate	1.3	0.1	0.1	0.02
Potassium	91.2	21.2	0.9	0.5
High elevation jhum				
Nitrate nitrogen	1.7	0.5	1.0	0.9
Available phosphate	0.9	0.1	ND	ND
Potassium	80.1	25.8	19.6	ND

ND – Not detectable

rich micro-sites (Saxena & Ramakrishnan 1984). These and other attributes of early successional communities could form the basis for early restoration of desertified landscapes as in north-eastern India. Population dynamics and growth strategies of bamboos (Rao & Ramakrishnan 1987, 1988) could form the basis for management of bamboo forests that come up subsequently.

Realising that light availability in the environment would change during forest succession and that light to a large extent determines the architecture of a tree and consequently allows appropriate leaf display for optimal photosynthesis (Ramakrishnan 1987) under varied light regimes, early successional trees were compared and contrasted with late successional trees. Early successional tree species are characterised by rapid extension growth, more allocation of biomass to the shoot system than to the root system, greater allocation of biomass to the first order branches than to other higher order branches, excurrent (narrow) crown form, larger leaf population and faster leaf turnover rates. This contrasts with the late successional species (Ramakrishnan 1986).

The differential features of early versus late successional tree species could be utilised for restoration of human-impacted ecosystems through mixed plantation programmes. Species characterised for social forestry and agroforestry systems could form the basis for rural development, which in turn would take the human pressure off the land.

Social forestry programmes in a developing country should aim at identification of fast growing, multi-purpose native species for meeting the fodder, fuelwood and timber needs of the rural population. Use of early successional species for social forestry is appropriate because they have a fast growth rate and relatively faster accumulation of biomass. The leaf population of early successionals having a shorter life-span would help in faster turnover of nutrients between the plant and the soil, ensuring their success in nutrient deficient wastelands, so that more fertile land is available for agricultural and other land uses.

With greater realisation that agriculture and forestry could form compatible systems on the same site, identification of trees that could optimise production in a viable agroforestry system is important. The early succession trees have a crown architecture that permits maximum light penetration to the ground layer so that the growth and productivity of crop species would not be limited by light. Besides, a fast turnover of nutrients would ensure a constant and steady supply of nutrients in the surface layers of the soil to be used by crop species. If the root architecture of the tree species used is such that the roots are more uniformly distributed at different depths, rather than being chiefly restricted to surface soil layers, it would make the species mixture in the agroforestry system more compatible. Though early succession trees have superficially placed root systems, some of the mid-successional trees are better suited in this respect. Identification of suitable root architecture from the successional continuum should not be difficult.

Mixed plantation programmes, having distinct ecological advantages over monoculture forestry, could also be economically as productive or even better than the latter, if compatible species are used. Fast growing, light demanding, early successional species could form compatible mixtures with shade tolerant mid or late successional species for exploiting light availability at different canopy levels and thus optimise production per unit area. Such a mixture would also allow optimum use of nutrients from the soil profile, the early successional species exploiting deeper soil layers. It should even be possible to have a "condensed succession" for revegetation of damaged sites by appropriate mixture of different categories of trees that are mutually compatible (Figure 6.3). The applications of tree architecture and growth strategy analysis for forestry management are immense. More work in this emerging area would indeed be rewarding to resolve basic issues and concepts and for designing better forest management strategies and ultimately for better conservation.

6.4 The human factor and the biosphere concept

When the Man and Biosphere (MAB) programme was launched in 1971 by UNESCO, it was also decided to have biosphere reserves as representative ecological areas, as part of an international network. The chief objective was to demonstrate the value of conservation and its relationship both with eco-development and with local participation. The last two components are perhaps the most important, as this would set apart the concept of biosphere reserve from all other conservation strategies.

At the outset, it would be realised that biosphere reserve management, because it demands peoples' participation, cannot be governed by a standardised set of strategies. With differing ecological conditions one may consider only a few generalities related to management; the specifics have to be tailored to the needs of a given situation. The management strategies have to be focused around the human population both within and outside the reserve, taking into account the socio-economic and socio-cultural background of the people concerned, as has been shown for the tribes of north-eastern India (Ramakrishnan 1983). If developmental strategies are based on a value system that the people concerned cherish and with which they can identify, then their participation in development and conservation of resources would be ensured

(Ramakrishnan 1987).

It is well recognised that for the management of a biosphere reserve, two distinct zones, the core zone and buffer zone, have to be considered separately. The basis for such a differential approach is based on the fact that each of these two zones are managed with divergent objectives in view.

In a developing country like India, one needs to consider another zone, outside the buffer zone, that I prefer to call an "interaction zone". This zone would be a zone of gradual transition into the typical rural environment. With a high population pressure, the core zone itself could be subject to human pressure. The buffer zone and the interaction zone would indeed be under intense biotic stresses. In these two zones, eco-development should be aimed at adequately meeting the food, fodder and fuelwood needs of the people. It should then be possible to diversify the economic activities in a phased manner.

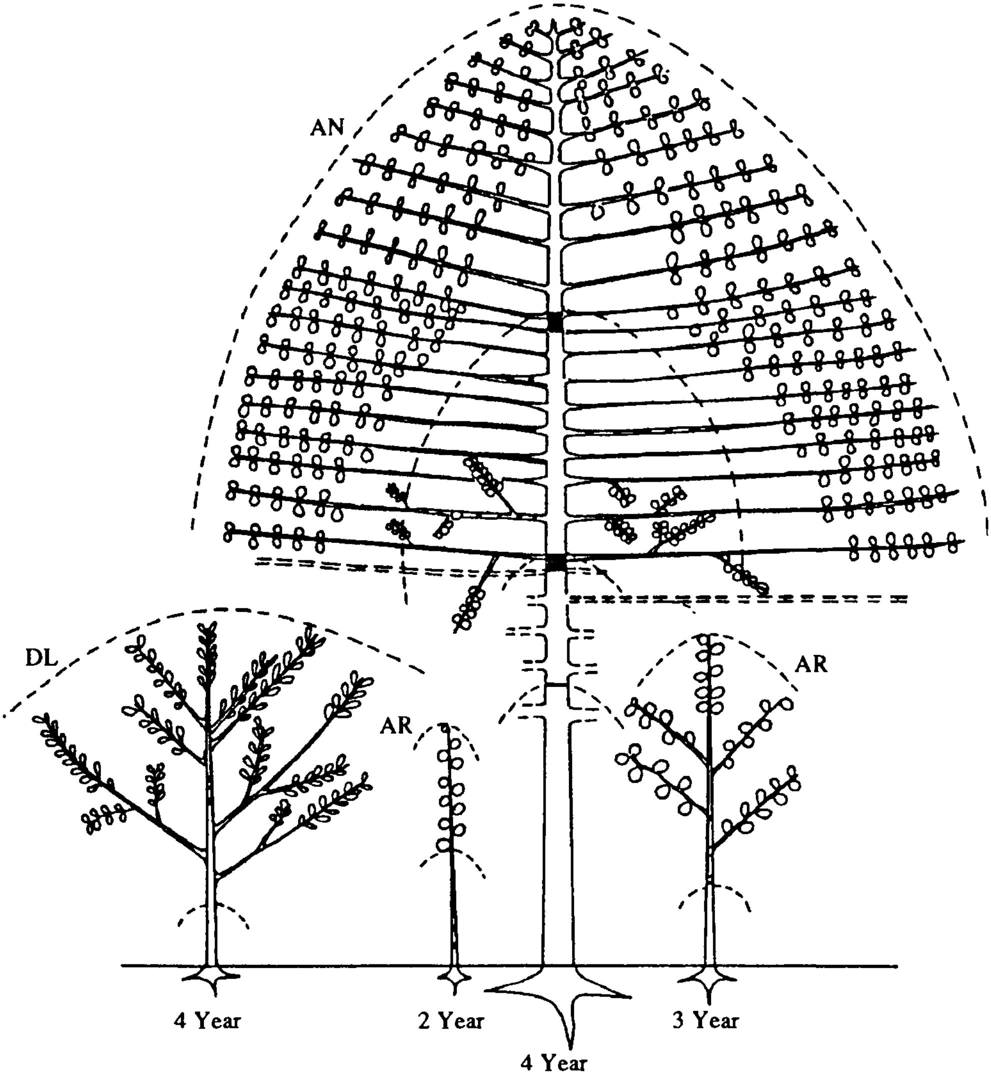
Introduction of technology of a high level but of low magnitude such as small-scale processing units for primary produce of various kinds, solar energy, wind power, energy efficient stoves, etc., are some of the possibilities. Peoples' participation in these activities is important. This is possible only through building on the traditional knowledge and wisdom of the people. Developmental strategies should include health and hygiene of the population and educational facilities through vocation-oriented programmes. What is required is a holistic approach to the development of the rural ecosystem. This alone would lead to effective *in situ* conservation.

6.5 Conclusion

The concept of biological conservation is closely linked to sustainable development. The launching of the World Conservation Strategy in 1980 was a significant turning point involving an integration of nature conservation with sustainable development of both human and natural resources. This implies that ecological integrity is to be maintained not only to meet human needs but also to achieve equity with social justice and provision for maintenance of cultural diversity (Jacobs *et al.* 1986). Local peoples' participation in conservation is crucial and this could only be achieved by ensuring access to the natural resources developed on a sustainable basis.

Sustaining cultural diversity is an important mechanism to promote conservation. The case study of north-eastern India, inhabited by a large number of tribal societies, is an example to illustrate this point. Shifting agriculture, which is the chief land use system, differs significantly depending upon social and cultural difference of the people. Consequently, the variety of non-conventional crop plants conserved by them is remarkable indeed (Gangwar & Ramakrishnan 1989a). Religion and culture form important factors for promoting conservation in traditional societies. Many tribes of north-eastern India maintain sacred groves protected for cultural reasons. They believe that the spirits of their ancestors and their Gods live in these forests (Boojh & Ramakrishnan 1983; Khiewtam 1986). The fact that these sacred groves once formed part of each village is suggestive of the value attached to conservation by traditional societies. With the advent of modernity, it is unfortunate that these values have been rapidly eroded. There is a need for a revival of these traditions.

Figure 6.3 Model of mixed tree plantation involving early successional *Anthocephalus cadamba* (AN) and late successional *Dillenia pentagyna* (DL) and *Artocarpus chaplasha* (AR) (after Ramakrishnan 1986).



Realising that conservation of all species known or as yet not catalogued is an impossible task, priorities have to be determined. The criticality from a conservation point of view may be defined both in terms of ecosystem fragility and biological diversity. In such a definition, diversity sustained through human activities, such as agriculture, is also significant. The concept of the biosphere reserve where the local human population is integrated with conservation strategies through their sustainable development, offers a unique approach for biological conservation.

What is to be conserved would also depend upon the variety of ways in which the species could be used by the society. Thus a species such as *Flemingia vestita*, cultivated by tribes in north-eastern India (Gangwar & Ramakrishnan 1989b), is not only a lesser-known plant of food value for the use of the village community during the lean season when traditional food items are in short supply, but is also an important component of the shifting agriculture and the fallow systems of agriculture, for building up the nitrogen status of the soil. The germplasm of such multipurpose species needs to be conserved, as they serve a variety of purposes.

Fragility of an ecosystem should be an important criterion for conservation. We have seen how in a tropical rainforest extreme deficiency in soil nutrients leads to the development of an extensive surface root mat system leading to tight cycling of nutrients and therefore contributes to its fragility (Ramakrishnan 1984b). This fragility may lead to total site desertification (Ramakrishnan & Ram 1988) or may lead to biological invasion by exotic weeds (Ramakrishnan & Vitousek 1988). In the western Himalayas, climax oak forests are often irretrievable, or retrievable only at a great cost, from seral pine forests, because of a drastic alteration in site characteristics by the latter (Singh *et al.* 1984). These and many other causative factors contribute towards ecosystem fragility. Obviously, such ecosystem types should receive priority for conservation.

An agro-ecologist's viewpoint is not necessarily confined to agricultural systems alone. Agriculture as a land use system is closely linked with forestry and other land use practices. Therefore, a holistic approach towards a conservation strategy has a distinct advantage over *ex situ* management, in that it not only ensures conservation at the specific level but also enables conservation of natural populations at the subspecific level (Ramakrishnan 1981). This is particularly important because ecotype populations often would be as different amongst themselves as two distinct species of contrasting ecological characteristics. The ultimate objective should be to integrate *ex situ* conservation strategies with the existing or altered life styles of the human population.

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