BIODIVERSITY

A Biology of Numbers and Difference

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13: Managing biodiversity

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13.1 Introduction

Managing the Earth's heritage of biodiversity is an immense challenge. It is a twofold challenge; the magnitude of biological diversity is staggering, with tens of millions of species, each with many variants of thousands to millions of genes, constituting an intricate mosaic of biological communities distributed from the depths of the seas to the tops of the mountains. Equally staggering are present day human impacts on the biosphere, with mobilization of perhaps 40% of all primary production towards human ends, and with man-made entities ranging from molecules of dichlorodiphenyltrichloroethane (DDT) and chlorofluorocarbons (CFCs) to buildings and transport vehicles affecting all parts of the atmosphere, hydrosphere, and surface of the lithosphere (Vitousek *et al*., 1986; Gadgil, 1993a). Humans are, therefore, bringing about ever more drastic changes in the magnitude and distribution of biological diversity on the Earth, on many different space and time scales. Yet we remain largely ignorant of the magnitude and distribution of biological diversity, as also of the driving forces behind and the precise course of impacts of human activities on the stock of biodiversity.

Confronted with this challenge, people have sought to focus biodiversity management action by looking for conservation priorities. Taxa at the level of species have tended to provide the point of departure for arriving at these. Thus species which are taxonomically distinctive, species that have a restricted geographical range, and species that are endangered have been assigned high priorities. So have species with economic potential such as wild relatives of cultivated plants. Management plans have then been drawn up for such high priority taxa as the spotted owl *Strix occidentalis* and its habitat of old growth coniferous forest in the northwestern United States. Developing the management plans for just this one species has entailed enormous efforts, while winning social acceptance for the implementation of these plans has run into serious difficulties. Evidently, extending such a species-based approach to managing all of Earth's biological diversity is not a practical proposition. A somewhat different approach has led to the identification of biomes, which are at once rich in species and under severe pressures of

depletion of biodiversity, such as the 18 hotspots identified by Myers (1988, 1990). Focusing attention more directly on the broader issues of biological diversity, this approach forces us to confront the social and economic realities that must be addressed if the biological diversity of Amazonia, Madagascar or the Eastern Himalayas is to be managed.

13.2 Of people and resources

There are few answers available as to how one may set about this task, and the purpose of this chapter is to explore this challenge. A key consideration in such an approach has to be people, and how they relate to biological resources. Dasmann's (1988) classification of humanity into ecosystem people and biosphere people provides an appropriate starting point (Fig. 13.1). The category of ecosystem people refers to many forest dwellers, peasants, herders, and fishers of the non-industrial world who primarily depend on biological resources of a circumscribed ecosystem to meet the bulk of their material requirements – through gathering, grazing, or low input agriculture. These are people with limited capabilities of purchasing from the market substitutes for what they acquire with their own labour. Their well-being is closely tied to that of the ecosystems of which they themselves

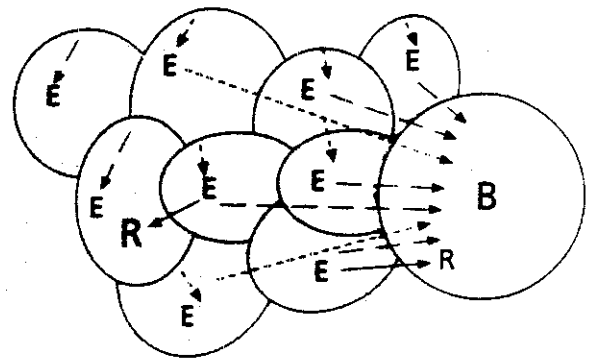

Fig. 13.1 People may be classified on the basis of their patterns of resource use as ecosystem people (E), biosphere people (B) and ecological refugees (R). Ecosystem people derive resources from a relatively limited catchment through fluxes that are either strong (— — →) or weak (- - - - - →). Biosphere people derive resources from much larger catchments through strong fluxes (— — →) from nearby catchments of ecosystem people, or weaker fluxes (- - - - - →) from further afield. Ecosystem people who can derive only very low levels of resources from their own catchments may then move to other areas as ecological refugees (——→). These movements may bring ecological refugees to areas from which biosphere people are deriving only weak fluxes as, for instance, encroachers on forests. Alternatively, ecological refugees may join biosphere people in urban shanty towns.

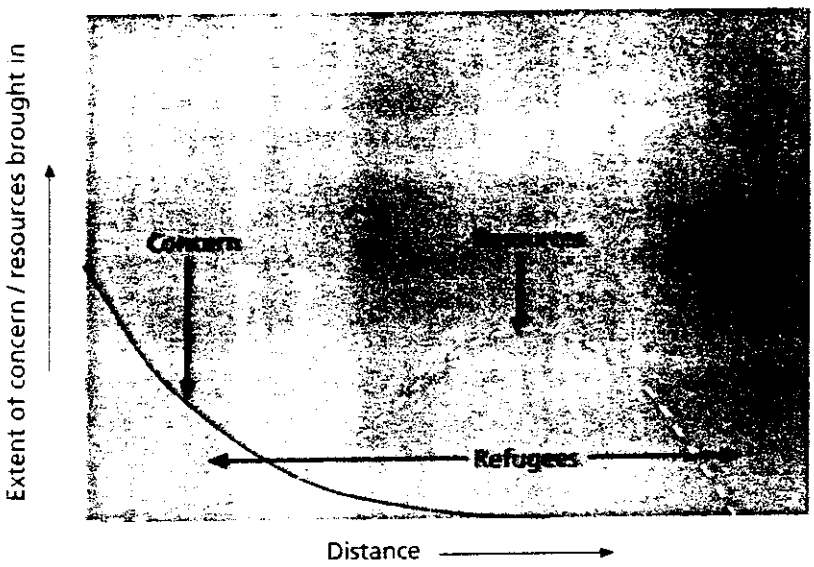

Fig. 13.2 Biosphere people's concern for maintenance of a healthy environment declines with distance from their own habitation. They therefore prefer to bring in resources from areas at some distance. Since the costs of obtaining resources increase with distance, the pressure of resource exploitation is heaviest on localities at some intermediate distance from the habitation of biosphere people. The ecosystem people living in the localities subject to heavy resource exploitation are converted to ecological refugees who may move either further away to localities less subject to resource exploitation pressures of biosphere people or to areas of concentrations of biosphere people

constitute a part. The biosphere people, in contrast, have access to the resources of much of the biosphere—resources that are brought to them through increasingly integrated global markets. They are largely city dwellers involved in the organized industries-services sector, or practise high input industrialized agriculture or animal husbandry. Most citizens of the developed world belong to this category, as do the elite of the non-industrial world. The biosphere people do not depend on the biological resources of any particular locality; if the resources of a given locality are exhausted, they always have the option of drawing resources from others. The biosphere people also have options of substituting exhausted resources with alternatives through technological innovation. They, therefore, have little stake in the health of the biological resource base of any given locality for their own material well-being. However, they do have an interest in maintaining a healthy, pleasing ambience in their immediate vicinity, and therefore prefer to shift the pressure of their resource demands, or generation of pollutants, to geographically distant localities (Fig. 13.2). The biosphere people therefore tend to generate pressures for exhaustion of biological resources in distant localities, principally in the non-industrial world countryside, in which are concentrated the ecosystem people. Given the far greater per capita

resource demands of the biosphere people, these demands play a significant role in determining the fate of biological resources of the non-industrial world countryside, often exceeding in magnitude the role of localized resource demands of ecosystem people. Such resource exhaustion through combined action of the growing resource appetite of the biosphere people and growing populations of the ecosystem people creates a third category of humanity, that of ecological refugees (Gadgil, 1995). These are ecosystem people deprived of traditional access to biological resources in their immediate vicinity, who are forced to migrate in search of a fresh resource base. Such are the poor peasants who move into the Amazonian forest to clear it and eke out a living for a few years before they move on to another patch of forest. Such are the basket weavers of India deprived of access to bamboo resources exhausted by the pressures of the paper industry, who flock to shantytowns of cities like Bombay in search of livelihood. Footloose as they are, the ecological refugees too have little stake in sustainable use of biological resources of the localities to which they are forced to migrate (Gadgil & Guha, 1992).

The level of motivation for maintaining a healthy biological environment in their immediate vicinity is then rather strong for the biosphere people. The biosphere people are also in a position to accomplish this, since they have fairly firm control over not only their own resource base, but access to resources from elsewhere. This is how Japanese are able to maintain 60% of their country under forest cover, while importing timber from southeast Asia, Brazil, or the northwestern United States. In a way, therefore, problems of managing biodiversity in the industrially developed countries are simpler. But the biodiversity-rich countries tend to be largely developing countries, who have large populations of ecosystem people and ecological refugees. Of these, the ecosystem people do have a stake in the health of the biological resources of their immediate vicinity, they also have rich traditions of conservation of biodiversity (Gadgil *et al.*, 1993). Today they have little control over their biological resource base, and therefore little motivation or capability of prudent use of their environment. The ecological refugees of the non-industrial world are in the worst plight of all, and are today significant agents of erosion of biodiversity. The problem of management of biodiversity is therefore above all a human problem of how to involve the ecosystem people of the world in a positive fashion in managing biodiversity and how to help ecological refugees to settle down to a reasonable subsistence and thereby also come to play a positive role in this endeavour. Of course, this could only be brought about through the active cooperation and support of the biosphere people (Gadgil, 1995).

13.3 Small-scale societies

In seeking answers to this question, it may be useful to review how human

societies in different parts of the world have approached the problem of managing biodiversity at various periods in their historical development (Gadgil, 1987). An interest in conservation of biodiversity is by no means a post-Rio Summit phenomenon. Indeed, the small-scale, egalitarian societies of hunter-gatherers, shifting cultivators and horticulturalists which encompass much of human history exhibit a number of practices of restraint in the use of biological resources that promote conservation of biodiversity (Gadgil & Berkes, 1991). Such societies view the world around them as a community of beings. To them rocks and rivers, trees and birds are fellow beings, often viewed as kin or as benefactors. These may then be accorded respect and protection in several ways. The restraints so motivated include regulation of two main kinds of processes that could erode biodiversity, namely harvests of biological populations and transformation of habitats. Regulation of harvests may range all the way from occasional lowering of hunting pressure to complete protection (McNeely & Pitt, 1985). Thus, several Pacific islanders give up fishing from particular lagoons if the catches from these lagoons decline. Some New Guinea tribes stop hunting birds-of-paradise when their populations have declined. In modern terminology these are instances of adaptive management (Walters, 1986). In southern India, storks and pelicans breeding at a heronry may be given full protection, although they may be hunted at other times of the year. Also in southern India, the large fruit bat *Pteropus giganteus* may be protected at the day time roost, although it will be hunted at night away from the roost. Other plants and animals may be totally protected at all times, for instance as kin accorded totemic status. Thus a farming community called the Bishnois of Rajasthan in northwestern India will never cut a Khejari *Prosopis cinerarea* tree even if it grows in the midst of a field. They also give total protection to all antelope species and peafowl around their villages. Amongst the more notable of such instances of total protection is that accorded to many tree species of the genus *Ficus* in many parts of Africa and Asia. Because of this, *Ficus* trees are often left standing when forests are clear-cut in India, and huge trees of *Ficus religiosa* dot India's thickly settled rural countryside, and persist even in city centres. *Ficus* is considered a keystone resource of tropical forests since it often fruits in months when none of the other plants are in fruit and therefore promotes the persistence of frugivorous birds and primates (Terborgh, 1986). Today many forest dwellers of India appear to be aware of this role of *Ficus* trees, and it is quite plausible that the widespread protection to *Ficus* came to be accorded in the interest of maintaining populations of favoured prey species of humans such as fruit-eating pigeons.

Small-scale societies regulate habitat transformation by protecting samples of natural communities on sacred sites (e.g. sacred groves, sacred ponds). These sacred sites may be associated with nature spirits resident in trees or pools of water or with more formalized worship as with Buddhist temple groves of Thailand or groves associated with Shinto shrines in Japan. Sacred

groves, ponds and lagoons persist to this day in many parts of Asia, Africa and some of the Pacific islands, a sacred cacao grove has also been described from Mexico (Gomez-Pompa *et al.*, 1990). Brandis, the first Inspector General of Forests in India, noted over a century ago that a network of sacred groves once covered much of the subcontinent, but that it had dwindled considerably under the forest management system introduced by the British. Indeed in 1801, just after the British conquest of southern India, Francis Buchanan (1870), a surgeon in the employ of the British East India Company, wrote of a sacred grove near the town of Karwar:

> The forests are property of the gods of the villages in which they are situated, and the trees ought not to be cut without having obtained leave from the . . . headman of the village, whose office is hereditary, and who here also is priest to . . . the village god. The idol receives nothing for granting this permission; but the neglect of this ceremony of asking his leave brings his vengeance on the guilty person. This seems, therefore, merely a contrivance to prevent the government from claiming the property.

This hostile attitude towards sacred groves has continued in independent India with the forest department taking over and clear-cutting groves as extensive as 400 ha to raise eucalyptus plantations in the 1970s (Subash Chandran & Gadgil, 1993).

It is, however, possible to reconstruct the system of sacred sites that might have once prevailed amongst the small-scale gatherer–horticulturalist societies in many parts of the world. We have attempted one such reconstruction for a 5 km × 5 km area in Siddapur taluk of Western Ghats of southern India, based on the local names of the landscape elements. This exercise suggests that as much as 9.3% of the land was originally maintained under sacred groves, which occurred in 10 patches ranging in size from 1 ha to 134 ha (Fig. 13.3). Gangtes, a group of shifting cultivators in the Churchandapur district of the state of Manipur in northeastern India, report that between 10 and 30% of the land was left completely inviolate as sacred groves during their shifting cultivation cycles prior to their conversion to Christianity in the 1950s (N.S. Hemam & M. Gadgil, pers. comm., 1993). Following religious conversion many of the groves were clear-cut. This led to a series of difficulties, in particular the spread to their hamlets of fires set during the slash and burn cycle, which led to the burning down of houses. In response many Christian shifting cultivator groups have revived protection to some of the erstwhile sacred groves, in particular those forming a ring around the villages. Of course, these groves are no longer considered abodes of deities, instead they are termed 'safety forests' (Malhotra, 1990). Nevertheless, the social sanctions ensuring protection to the groves are of the same form as those prevalent in pre-Christian times. Such protection to sacred groves is paralleled by protection to sacred ponds, or pools along rivers. Indeed, the only surviving population of a freshwater turtle *Trionyx nigricans*

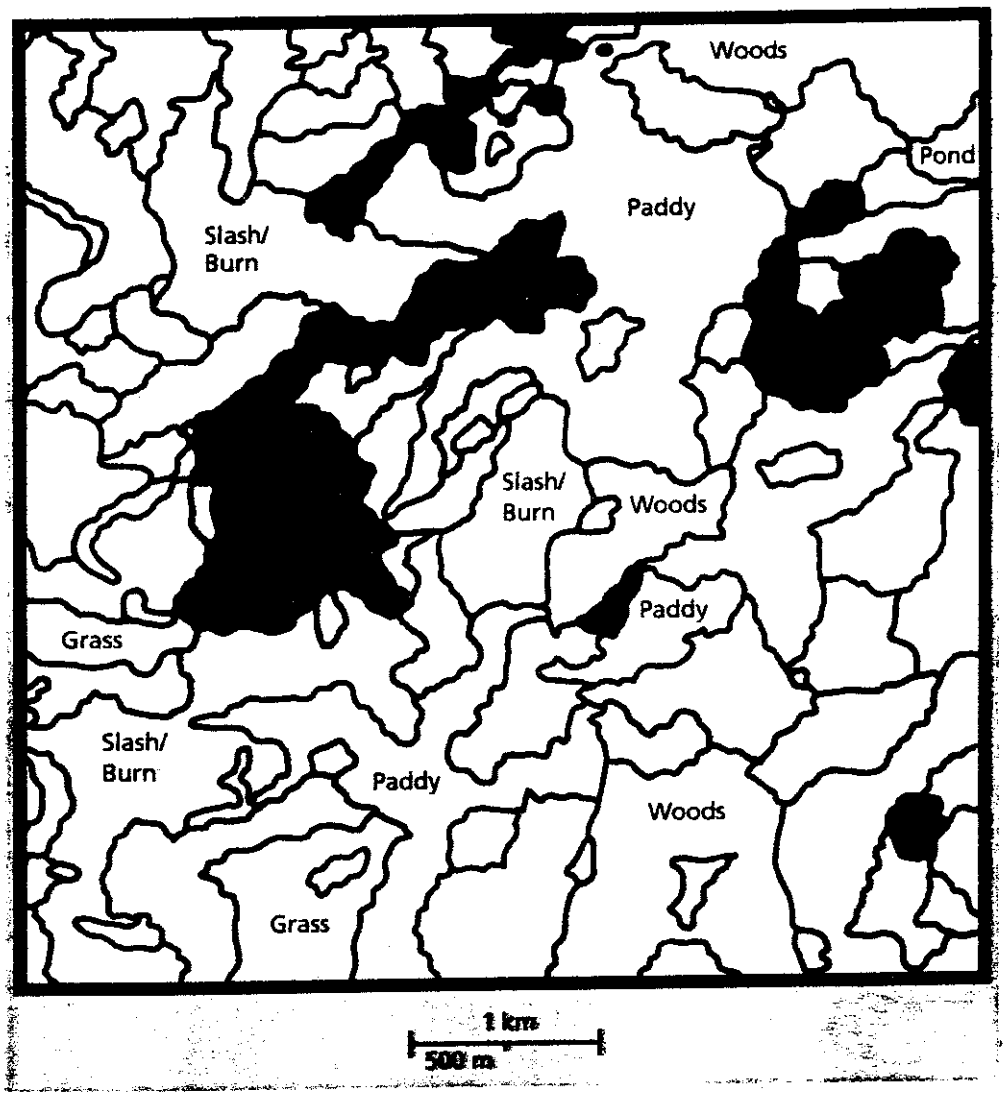

Fig. 13.3 Presumed patterns of land-use prior to British occupation in the early 19th century in a 5 km × 5 km area of Siddapur taluk in Karnataka Western Ghats (14°16'N lat. and 74°54'E long.) The land-use was reconstructed on the basis of local names of individual landscape elements. The black areas were sacred groves, remnants of which persist to this day. The identity of a few other representative elements has also been indicated

now occurs in a sacred pond dedicated to a Moslem saint in Bangladesh (Daniel, 1983). Many coastal and island communities also afford protection to mangrove swamps, lagoons and other coastal ecosystems (Ruddle & Johannes, 1985).

These systems of regulation of harvests and of habitat transformations were most probably motivated by the interest of small-scale societies in ensuring the availability of a diversity of biological materials from within a limited area to which they were largely confined. The systems of shifting cultivation that many of these societies followed create a mosaic of different successional stages of vegetation. When coupled to maintenance of patches of climax vegetation as sacred groves, and populations of keystone resources–

such as *Ficus* protected as sacred trees—these management systems would have created high levels of diversity at the ecosystem and landscape scales. While such a system may fail to conserve populations of a small proportion of species requiring very large areas of primaeval habitats, the dispersed system of plentiful, patchy refugia may still have promoted the maintenance of the bulk of diversity at the species level as well (Fig. 13.4).

Remnants of many of these regulatory practices of ecosystem people persist to this day in Papua New Guinea, India, Ghana, Mexico, on several Polynesian islands and elsewhere in the world. It is then possible that such management practices did in an earlier era perform a valuable function of conservation of biodiversity; indeed a function that they continue to perform to this date, albeit in an attenuated form (Gadgil *et al.*, 1993). This view may appear to contradict much evidence marshalled by Diamond (1994) and others that the first colonizers of the Americas, Madagascar, New Guinea, and many Polynesian islands were probably responsible for large scale extinctions. It would, however, appear that on first colonizing new environments people are unlikely to be concerned with sustainable use of seemingly unlimited resources. Equally, they would have little understanding of the

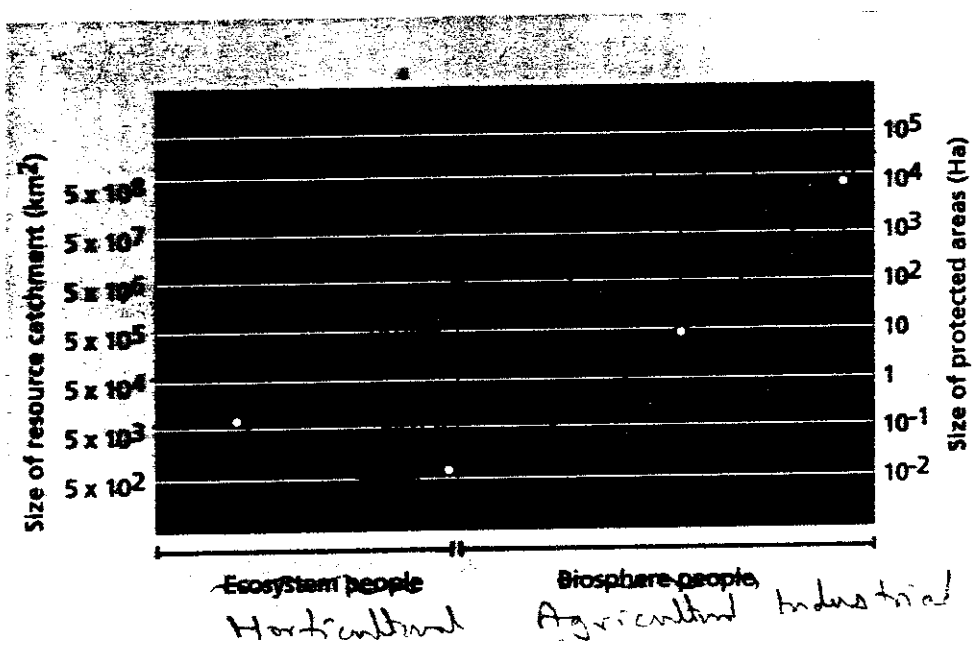

Fig. 13.4 Relation between sizes of resource catchments and sizes of protected areas. Pure hunter-gatherer societies have catchments of the order of 5×10^3 km^2. It is not certain if they maintain any protected areas. Slash-and-burn and low input settled cultivators have somewhat smaller resource catchments around 10^3 km^2 and maintain protected areas ranging in size from around 0.01 to 100 ha. More advanced agrarian societies have larger resource catchments of the order of 10^5 km^2, and they maintain hunting preserves of the order of 100 to 1000 ha in size. The modern industrial societies have resource catchments spanning the whole biosphere and concentrate on protected areas of a thousand to a million hectares.

ongoing ecological processes on which to devise effective regulatory measures. It is only after human populations have settled in a locality for a length of time, perhaps some generations, that they may become motivated to work towards sustainable use of the biological resources. On becoming so rooted, the societies may also acquire sufficient understanding of the ongoing ecological processes to be able to devise simple rules of thumb for regulation of harvests and habitat transformations that could promote sustainable use of biological resources coupled to conservation, indeed local enhancement of diversity on species, ecosystem, and landscape scales (Gadgil & Berkes, 1991).

While in the long-term interests of the group, such restraint is often likely to be against the immediate, short-term interest of individual group members. Small-scale societies of ecosystem people achieve acceptance of such restraint largely through attribution of sacred qualities to the individual plants, animals or whole biological communities to be protected, coupled to social sanctions against violation of the regulations. Thus, in southern India many sacred groves are dedicated to cobras. People believe that they will be safe from death due to snake bite so long as they respect protection of the serpent grove, but will incur the wrath of cobras, or some associated deities, if they violate it. However, the protection of the sacred groves need not always be absolute; in the case of a special calamity such as a fire consuming houses in the village, the deity, through the agency of the priest, may permit selective harvesting of the trees (Gadgil & Vartak, 1976). Of course, the sanctions may become entirely social sanctions divorced from religious context as in the case of the revival of sacred groves as safety forests in Manipur and Mizoram (Malhotra, 1990). In all cases, however, regulation is enforced primarily on the basis of fear of undesirable repercussions visited either by supernatural forces, or one's own social group.

13.4 Agrarian societies

As small-scale gatherer-horticulturalist societies gave way to larger agrarian societies, regimes of regulation of the use of the biological resource base underwent a transformation. The agrarian societies are characterized by far greater levels of social stratification, with an elite supported by the surplus generated by the peasantry (Lenski & Lenski, 1978). The elite has access to surplus produced from many different localities, it therefore has little motivation to promote sustainable resource use in any particular locality. They in fact belong to Dasmann's (1988) category of biosphere people. While the ecosystem people may hold on to some of their traditions of sustainable resource use and conservation of biodiversity, many such traditions may be weakened. The elite of agrarian societies, however, have their own new conservation techniques; particularly the hunting preserves where game is strictly protected for hunting by the aristocracy. Such hunting preserves

played an important role in biodiversity conservation in medieval Europe and Asia. The Mughal emperors of India, for instance, maintained large areas of several hundreds of square kilometres each as hunting preserves in northern India; in fact, these hunting preserves have served as the nuclei of India's modern system of wildlife sanctuaries and national parks (Gadgil, 1991). Again it was fear of punishment that maintained the protection to these hunting preserves; fear of punishment at the hand of the aristocracy and their armed forces, rather than the wrath of deities or sanctions of one's own social group.

Such stratified agrarian societies gave rise to several organized religions. Those of the east, such as Buddhism, absorbed some elements of the conservation traditions of the ecosystem people, as witness the temple groves of Thailand. On the other hand, religions of the Middle East. Christianity and Islam, rejected the attribution of any sacred quality to nature. As Christianity spread to Europe, churches were built by cutting down sacred groves of oak trees. Indeed medieval Europe saw rejection of the so-called pagan traditions of conservation and rather wholesale liquidation of the region's natural stock of biodiversity, except in the game parks of the aristocracy (Whyte, 1967).

13.5 European expansion

Much of the European expansion beginning in the fifteenth century carried this spirit of rejection of any attempts at restraints on the harvest of biological resources or transformation of natural habitats. It was this ethic which promoted large-scale felling of forests in the northeastern United States and the massacre of hundreds of thousands of buffaloes *Bison bison* of the prairies. It led to the fur trade by the Hudson Bay Company dramatically increasing the hunting pressure on Canadian wildlife (Crosby, 1986). Berkes (1989) has documented the response of Amerindians drawn into this trade as commercial suppliers of pelt; this involvement led to a breakdown in their traditional hunting practices which rejected killing except for consumption as food or pelt for their own use. They did, however, develop new sets of yardsticks coupled to the demarcation of territories that promoted more sustainable use even under pressures of commercial harvests.

The European impacts also related to large-scale introduction of exotic plants and animals on the many continents and islands newly colonized by them. Domesticated animals such as cattle and sheep, and rabbits running wild, were responsible for a significant decline in Australia's indigenous marsupial fauna (Wilson, 1990). Interestingly enough, one of the few placental mammals that had reached Australia ahead of Europeans, the dog dingo *Canis familiaris* became a major pest for the European ranchers. Dingo then attracted bounty, a reward paid on presentation of its tail as evidence of having killed one. The indigenous people of Australia took to this as a welcome source of income, but while hunting dingos they ensured that they

would not kill lactating females or disturb the dens, so that the dingo population would continue to thrive! The Australian aborigines had thus arrived at a simple yardstick for ensuring sustainable harvests of a biological resource that supported them (Meggitt, 1965).

Notions of conservation arose amongst Europeans only in the second half of the nineteenth century as frontiers of new lands to be colonized seemed to be closing and deforestation led to serious negative consequences in parts of Europe such as Switzerland. These led to protection of forests for their watershed function in colonial possessions, and the revival of forest cover under communal management in Switzerland (Grove, 1992). This also led to the National Park movement in the United States with the setting aside of large scenic areas such as Yellowstone National Park (Koppes, 1988). Notably enough, these areas were thought of as primeval nature untouched by man. In reality, they were humanized landscapes where nature was lightly trodden upon and much of its diversity protected over thousands of years of use by indigenous people. So in the National Park system the emphasis was on regulating human access by deploying a bureaucratic machinery. For the first half of the twentieth century there was little interest in the conservation of biodiversity for its own sake in Europe, in neoEuropes like the United States or Australia, or in the state-sponsored efforts which came to be influenced by the European world view in all countries of the world.

13.6 Of guns and guards

The nature conservation effort that developed in India following independence in 1947 illustrates well the strengths and weaknesses of this approach. Prior to independence India had its aristocratic hunting preserves, such as the wetland of Keoldeo Ghana at Bharatpur visited by hundreds of thousands of wintering waterfowl, or the Gir lion hunting preserve of the Nawab of Junagarh. It also had equivalent shooting preserves for the European planters, such as those of the Nilgiri Game Association in the upper Nilgiris with its Nilgiri tahr *Hemitragus hylocrius*. Broader, state-sponsored conservation efforts started only in the 1950s, led principally by erstwhile princes, with the Maharaja of Mysore being the first president of the Indian Board for Wild Life and the Maharaja of Baroda the first president of the Indian branch of the World Wildlife Fund. The whole nature conservation approach has tended to focus on protection of a few flagship species such as the Indian elephant *Elephas maximus*, rhinoceros *Rhinoceros unicornis* or lion *Panthera leo*, with the firm belief that such protection can be achieved primarily through elimination of the subsistence demands of India's ecosystem people by the force of guns and guards.

Consider as an example Gir National Park, dedicated to the conservation of the lion. At the time of British conquest, the lion was distributed over much of the northern peninsula. It was a prime hunting trophy and was

eliminated through most of its range during the nineteenth century. In 1920 the Nawab of Junagarh had to pretend that it had become extinct in his hunting preserve of Gir in order to resist the pressure of organizing a lion hunt for the Governor General of India. In fact, just 22 lions still survived in Gir at that time, and by the 1950s their population had grown to over 200 (Seshadri, 1969). When Gir was constituted a National Park, an important measure immediately introduced was removal of Maldharis, buffalo keepers who had coexisted with the lion in the Gir forest for centuries. Maldharis traditionally accepted occasional kills of their livestock by lions as inevitable; their animals were an important source of food, especially for the lazier male lions. Being removed from the Gir forest has meant serious hardships and a decline in living standards for Maldharis. They are currently living on the periphery of the National Park, denied access to the rich grazing within the park. But the lions are addicted to buffaloes and come out at night to feed on them. Now when a buffalo is killed, the impoverished Maldharis are unwilling to tolerate the loss and poison the carcass to kill the lion when it comes to feed on it a second time. So the displacement of Maldharis has served little positive purpose from the perspective of the flagship species in whose interest the National Park is being managed (Gadgil, 1991).

There has been little interest in the broader objective of conserving biodiversity on the part of the state machinery. Indeed the National Commission on Agriculture recommended in 1976 that all mixed species forests of India should be replaced by more productive monoculture plantations (National Commission of Agriculture, 1976). In consequence, the state forest departments have resorted to clear-cutting sacred groves, considering them, as one Chief Conservator of Forests once put it to me, as merely stands of over-mature timber.

The inevitable consequence has been the ever-growing conflict between the state machinery striving to protect nature reserves by force of arms and the local communities all over the country. Given this hostility, there is little political support for the ongoing conservation effort in India, outside of a narrow circle belonging to part of the urban middle classes. The political leaders are in fact now in the process of dismantling the protected area network of the country (covering some 4% of the land surface) by denotifying some of the wildlife sanctuaries (Nambiar, 1993). There have been similar experiences in other parts of the non-industrial world as well, with management focusing on flagship species, often in the interests of ecotourism, and concentrating on excluding local communities, with little participation or benefit sharing on the part of the latter (Gomez-Pompa & Kaus, 1992). Only in a few exceptional cases, such as Papua New Guinea, has there been some recognition of the traditions and rights of the local communities and attempts to involve them in the conservation of biodiversity.

13.7 The American experience

The 1960s witnessed the beginnings of an interest in biodiversity issues on the part of the developed countries. This interest began with a realization that pesticides persisting in the environment were reaching excessive levels of concentrations in the bodies of animals high up in the food chain, with serious consequences, such as reproductive failure in the case of the peregrine falcon *Falco peregrinus*. The discovery of DDT in the bodies of penguins from Antarctica also highlighted the ubiquity of these substances. The result was the passage of the Endangered Species Act of 1973 in the United States (Primack, 1993). This act committed the United States Federal Government to protect critical habitats of endangered species, thereby promoting conservation of a diversity of natural habitats outside the National Park system. The 1970s also saw the coming on the scene of Nature Conservancy, a Washington-based non-governmental organization (NGO) with considerable influence. The Nature Conservancy initiated the process of systematizing the assignment of conservation priorities to various elements: individual taxa, or populations of particular taxa in a given region, as well as land and water elements supporting populations of one or more species of high conservation priority. The habitats so identified may be of very limited size, of a few hectares or less. The Nature Conservancy has followed up on the identification of such habitats by either their outright purchase or by organizing agreements with the owners, compensating them in some way for giving up the option of developing the property in ways incompatible with the conservation objectives. These developments have brought onto the biodiversity management scene the practice of protecting large numbers of patchy, widely dispersed elements of the landscape (Grove, 1988).

The Nature Conservancy approach also shifted attention from the protection of flagship species and spectacular landscapes to habitats rich in taxa of high conservation value. This habitat focus also obtains in programmes in other countries, such as protection of Sites of Special Scientific Interest (SSSIs) in Great Britain. These programmes have also brought in the new element of paying individual landowners for behaving in ways conducive to the conservation of biodiversity (United Nations Environment Programme, in press).

The 1970s saw the beginning of serious attention being paid not only to protecting specific areas, but also to regulating processes that have an impact on biodiversity levels. Such regulation pertains to the production of harmful substances such as pesticides and a variety of industrial effluents that directly affect living organisms, as well as molecules such as CFCs that have an indirect effect through destruction of ozone and consequent increase in levels of ultraviolet radiation. The regulatory process has also broadened to assessment of environmental impacts of a range of developmental activities, such as

the damming of rivers or extraction of timber. There is, however, as yet little explicit consideration of broader biodiversity issues in the process of environmental impact assessment, with attention remaining focused on endangered species. The list of these endangered species does include many flowering plants and smaller vertebrates as in the famous case of the snail darter—but there is still very inadequate attention paid to invertebrates or microbes.

The efforts at management of biodiversity in the developed countries have thus begun to incorporate a number of new, significant elements. These include: (i) interest in a broader range of living organisms; (ii) focus on a wide range of habitats, often small in extent and widely dispersed; (iii) positive rewards to private landowners for adopting biodiversity-friendly practices; and (iv) overall regulation of processes affecting biodiversity.

13.8 Biosphere reserves

Another major positive initiative to have emerged in the 1970s is the worldwide programme of Biosphere Reserves. The Biosphere Reserves do emphasize the need to manage overall biodiversity, to base such an effort on a scientific understanding of the underlying processes, to recognize people as an integral part of the ecological world, and to involve them positively in the conservation effort. While an impressive worldwide network of biosphere reserves comprising 300 reserves in 77 countries has come into being, most of these are merely old national parks dressed up in new jargon without any fundamental change in the management approach (Groombridge, 1992). An important exception includes some of the biosphere reserves in Mexico, where serious attempts have indeed been launched to involve local people. But in most places such attempts remain restricted to programmes of creating awareness and educating local communities, and of extending state patronage through schemes such as creation of village woodlots or supply of fuel efficient cooking stoves. Nowhere do local communities actually play a role in shaping the programmes. This ignores the important fact that local communities may indeed be more knowledgable about local biodiversity resources and may in fact have a greater stake in their conservation, if only permitted genuinely to participate in the effort.

13.9 Imperatives of biotechnology

By the 1970s the remarkable developments that followed the elucidation of the molecular basis of heredity began to be applied to the manipulation of life-forms to human ends. These, in combination with a number of other technological advances, have led to the developments that go by the generic name of biotechnology. Biotechnological industry is already an important player on the world economic scene; it is expected to play a much bigger role

in the coming decades. Its bag of tricks includes the capability to move genes from one organism to another; from a mouse to a bacterium, from a virus to a tobacco plant. This implies that organisms once believed to be insignificant could turn out to be of considerable commercial value. Industrial concerns are therefore now greatly interested in access to the world's resources of biological diversity. They would also benefit from information on traditional uses of such biodiversity, as drugs, dyes, cosmetics and so on. Much of this biodiversity is outside industrially developed countries, much knowledge of the uses of plants and animals is with the ecosystem people of the non-industrial world. Organizing access to this biodiversity and this information is therefore now a priority of biotechnology industry, and of the industrial nations (Fig. 13.5). These players are also interested in establishing monopolistic control over these resources and this information to the extent possible (Reid *et al.*, 1993). In the meantime, at least until the biotechnological applications are in place and monopolistic control established over biodiversity resources – perhaps held in *ex situ* collections – as well as information on their uses, the industry and industrial nations are

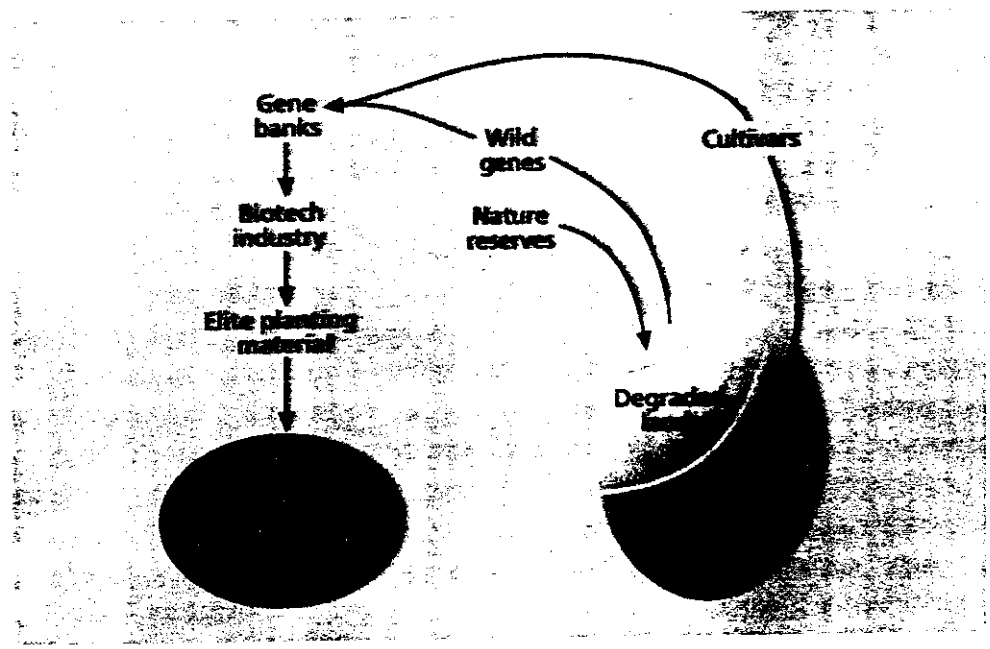

Fig. 13.5 The current strategy of conservation and utilization of biological diversity of biosphere people. This strategy derives genetic diversity of cultivars from low-input–high-diversity subsistence agriculture, and wild biological diversity from nature reserves in developing countries. With little economic rewards flowing into these areas, pressures of poverty are converting extensive tracts of these countries into degraded lands. In consequence, nature reserves are becoming difficult to maintain enclaves of diversity surrounded by degradation from all sides. These genetic resources are being used as raw material for the production of new high yielding plant material, as well as new drugs and other industrial products. The value-added genetic resources support high-input–low-diversity plant production, and other industrial production that brings in handsome economic returns to those with access to advanced technologies.

interested in the conservation of natural biodiversity and knowledge of its uses. It is likely that this interest will be evanescent; to be given up once monopoly over biodiversity resources brought into *ex situ* collection is established (Gadgil, 1993b).

Nevertheless, for the present, there is considerable worldwide concern with managing biodiversity, concern that has led to the signing of the international convention on biological diversity by over one hundred countries. This convention asserts national sovereign rights over the biological diversity of the countries of origin of these resources; encourages all countries to document and conserve biological diversity and to make it available to other countries on the basis of prior, informed consent, and assures countries of origin of some share in the commercial profits that may flow from utilization of biodiversity resources. Additionally, the convention urges nations to recognize the role of local communities in the conservation of biodiversity and to share with them benefits from the utilization of biodiversity. The convention has constructed a radically different framework for the management of biodiversity than what has prevailed so far (Reid *et al.*, 1993).

13.10 Bioregional approach

This is the setting for the current global effort at managing biodiversity. The objective of this management ought to be to conserve, as far as possible, the entire spectrum of genetic diversity in multiple populations of each of the millions of species, in the great variety of ecosystems, both natural and man-made, for the benefit of all of humanity. While potential economic utilization will undoubtedly remain an important motivation for such conservation, it should equally be motivated by the rights of all life to persist and to continue to evolve. In fact, the philosopher Bryan Norton (1987) concludes that the most important reason for conserving biodiversity is its transformative value, its influence in moulding human values to be more friendly towards the natural world. If transformative value is a significant reason for conserving biodiversity, then we must surely strive to ensure that as large a cross-section of humanity as possible has the opportunity to experience a biodiversity-rich world. The inescapable conclusion is that the primary objective of managing the earth's biodiversity should be to maintain a biodiversity-rich milieu over the entire earthscape, and organize people having easy access to this heritage of biodiversity. This is a very different programme from that of guarding a few biodiversity-rich enclaves from which people are totally excluded.

Such a programme is being widely accepted today under what has been termed the bioregional approach (World Resources Institute *et al.*, 1992). This visualizes the earthscape being divided into a number of relatively homogeneous bioregions, each with their characteristic life forms and human cultures; with people feeling an affinity for the well-being of the environment

of their own region. The management of the biodiversity resources of the region would be based on ecologically prudent use of all elements of the landscape, which may of course include total protection of certain representative ecosystems. This regime of ecologically prudent practices would be sought to be arrived at through a democratic, participatory process involving all people. It would attempt to motivate people primarily through positive rewards to behave in a biodiversity-friendly fashion. While the focus of the effort would be a bioregion, it would also consider, and try to appropriately regulate, the impacts of people outside of their specific bioregion.

Such an approach will have to be adapted to the very different human settings of the different parts of the world. These may vary from a region like southern Sweden, with low densities of biosphere people, to one like Papua New Guinea, with low densities of ecosystem people and a region like the African Sahel with large numbers of ecological refugees. Obviously, one can only sketch some broad principles of how a bioregional approach could be implemented under such widely divergent conditions.

13.11 The knowledge base and building motivation

Two questions need to be answered in order to work out a biodiversity management strategy: (i) how is the necessary knowledge base created? and (ii) how is the required motivation generated?

13.11.1 The knowledge base

The knowledge presently available to us on the distribution and dynamics of biological diversity is extremely inadequate. Such knowledge is required on many different spatial and temporal scales. We need to understand global levels of diversity of, say, freshwater fishes; we need information on countrywide distribution of such diversity (especially now that the principle of national sovereignty over genetic resources has been accepted), we need to understand fish diversity levels in particular river basins, and we need knowledge of the fish faunas of particular streams. We also need to understand how such biodiversity levels have been changing over time, on scales of days, for instance, in relation to the discharge of effluents in rivers, over seasons in response to annual rainfall, migration or breeding cycles; over years as river beds may have been gradually silted up; over decades as dams and other human activities may have markedly affected river flow regimes; and over centuries and millenia in response to geological changes. Much of this information is simply not available; some of it is available with professional scientists and fishery managers; much else only with local fisherfolk. Thus in the Nilgiri Biosphere Reserve in south India the fish fauna in most river systems has changed drastically over the last few decades due to the construction of a series of dams and intensification of agriculture in the

upper catchment. There is no formal record of these changes, but local fishermen who have been fishing the rivers for decades can provide a detailed account of the changes, as well as their interpretation of the causes behind them. Today there is little recognition of this knowledge. But such practical ecological knowledge of the ecosystem people would obviously be of considerable value in management of biodiversity at the ground level. In fact, through most of the biodiversity-rich developing countries, levels of formalized scientific information are low. At the same time in these countries, the levels of practical ecological knowledge of the masses of people necessarily living close to the earth are high. The challenge therefore is to put this knowledge to practical use in managing biodiversity (Gadgil *et al*., 1993).

In any event, ecologists must acknowledge that they are as yet not in a position to offer many general guidelines for managing biodiversity that would be of practical value in the field. What is required is to try out various options, monitor the consequences and make corrections as we go along, applying the so-called adaptive approach (Walters, 1986). As Slobodkin (1988) puts it, ecologists at their best remain to some degree naturalists, aided by modern technology and computational devices, but for most practical purposes relying on accumulated experience. Now much accumulated experience of relevance is with the ecosystem people of the non-industrial world, and it is imperative that we develop a new mutually beneficial synthesis of their knowledge with formally organized knowledge especially relevant on larger spatial scales to effectively craft an approach of adaptive management of biodiversity.

Such adaptive management calls for continual monitoring of levels of biodiversity. Again, the ecosystem people of the non-industrial world are engaged in such monitoring day in and day out as a result of their manifold subsistence activities. This level of detailed monitoring can never be organized as a formal scientific effort, in spite of all our advances in remote-sensing instrumentation and informatics. What is then needed is to organize a system of utilizing the information being thus continually gathered by the ecosystem people in the task of adaptive management of biodiversity.

13.11.2 Building motivation

The second important question is that of motivating people to maintain as high a level of distinctive elements of biodiversity in their own bioregion, or in their own localities as possible. This would not only involve protection to specific species, and maintenance of some protected areas, but also management of the entire landscape in a biodiversity-friendly fashion. The last is the more difficult but also the most significant of the tasks from the perspective of the long-term future of global biodiversity. It could best be accomplished through a continual programme of monitoring of biodiversity

levels in the different landscape elements making up the bioregion. The task of identifying the landscape elements and following their fate can be greatly facilitated by the use of remote-sensing techniques and geographical information systems. But this must be complemented by monitoring of selected taxa in a representative sample of the various landscape element types on the ground. Such a programme could be organized through local educational institutions and largely manned by practical ecologists amongst the ecosystem people, be they graziers, fisherfolk or women gathering fuelwood for subsistence use. This would create a network of people continually aware of the impact of the various developments taking place with regard to biodiversity in their bioregion. Mechanisms should then be developed for translating this understanding into inputs for the region's development strategy. In the spirit of adaptive management, the implications of any changes made in the development strategy should be continually monitored from the perspective of biodiversity, and the development plans continually modified in the light of the observations. Similar programmes for monitoring of biodiversity and adaptive management at more intensive levels should be organized for protected areas. The monitoring programmes should have a special focus on protected species (Gadgil, 1994).

The ultimate motivation for people to conserve high levels of distinctive elements of biodiversity must in modern times come not from the age-old negative, but rather from appropriately devised positive incentives. In part, such incentives may derive from people gaining better access to a diversity of biological resources that they value for subsistence as well as a source of income. This is the experience of the joint forest management programmes of West Bengal. In these programmes local communities are assigned the responsibility of protecting patches of regenerating *Shorea robusta* forests with support from the state forest department. They then have much better access to enhanced levels of a great variety of non-wood forest produce such as leaves, fruit, honey and mushrooms (Deb & Malhotra, 1993). The extractive reserves of Amazonia are similar in spirit.

However, such improved access to biological resources is unlikely to be an adequate incentive to maintain high levels of biodiversity everywhere. This could be far better ensured by people being paid service charges for maintenance of biodiversity each in their own bioregion, or some more restricted territory for which they are assigned responsibility. The amount of these service charges would have to be linked firmly to the value of biodiversity maintained within their territory. This valuation would have to be based on some global system of assessment of conservation priorities such as that developed by the Nature Conservancy in the United States, coupled to periodic monitoring of biodiversity levels within each territory or bioregion. The service charges should not be a one-time payment, but paid annually on the basis of performance, so that any failure on the part of the local community to deliver goods would be reflected in a reduction in, or cancellation of service

charges (Gadgil & Rao, 1994). Such a system could easily be made a part of programmes such as the tripartite alliances of the tropical forest action plan of Mexico (SARH, 1994a,b). To be put in practice on a wider scale would of course require the elaboration of a whole series of mechanisms for co-ordination and conflict resolution amongst neighbouring territories within bioregions, amongst neighbouring bioregions within states and so on. Such a system, firmly linking service charges to conservation performance, could be the most effective means of involving local communities in modern times when traditional belief systems are inevitably in decline. Such a system may also be highly cost effective, for alternate systems relying on bureaucracies have proven to be thoroughly inefficient (Gadgil & Rao, 1994).

The system sketched above would be particularly appropriate for parts of the world predominantly inhabited by ecosystem people (i.e. people rooted in a given locality in intimate contact with it). It would not be appropriate to a region predominantly inhabited by biosphere people (i.e. much more mobile people dependent on markets to bring them resources from many different parts of the world). For such regions the more conventional systems of formally protected areas (including many smaller ones), protection of endangered species, control of pollution, assessment of environmental impacts (all largely implemented by professionals), are much more appropriate. But even in these cases, elements of the bioregional approach sketched above may be of value. For instance, residents of northwestern United States paid some special service charges based on the extent of old growth coniferous forests in their locality may feel far more inclined to support the preservation of the spotted owl than they do today.

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