Forest Management for Conservation

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Introduction

Forest management for conservation is in practice different from management of forest for optimizing economic returns. It refers to the preservation of forest for the explicit functions of conserving the constituent biodiversity elements and ecosystem processes. The concept of managing forest for conservation is very old and was practiced by many traditional cultures and societies across the world. The resurgence however of the concept in the nineteenth century followed the European colonization events and thereafter more recently owing to the disproportionately large human pressure on the forest resources. Several models of forest management for conservation have emerged, both globally and locally. From very formal models such as the protected area network to completely informal models of grassroots people's movements, managing forests for conservation has gained an unparalleled momentum in the last couple of decades. In this article we trace the development of the concept of managing forests for conservation with a critique on the various models of management for conservation.

Historical Developments

Historically, forest management for conservation can be traced to two major schools, the first embedded in traditional cultures and the second emerging subsequent to European colonization of the tropical world. In both, the motive seems to have emerged from the need to prevent the overexploitation of natural resources, be it waterfowl hunting by the Egyptians or timber felling by the British in India. Ashoka, one of the illustrious Emperors of India (274–232 BC) was known for his great diligence in conserving forests. He not only passed an official promulgation forbidding the killing of a set of animals, but also decreed that forests must not be burnt. A large number of civilizations across the world, including the Greeks, Romans, Mongols, Aztecs, and Incas, developed such decrees from time to time. With the wave of exploitation of natural resources by the European powers during the eighteenth and nineteenth centuries, the need for conserving the natural resources, if only to build up the growing stocks, was acutely realized. This resulted in a number of promulgations in the European colonies from the Ivory Coast in Western Africa to Indonesia in Eastern Asia. In India, for example, the British established the Imperial Forest Department in 1864 to oversee the utilization of timber for railway crossties. By another legislation, in 1874, the British classified forests in India into three categories, viz., the reserved forests (where extraction of timber was permitted), protected forests (which were under state control and protected against extraction pressures from the local people), and village forests (apparently open to the village settlements for sourcing their needs).

In the recent past, a significant shift in the conservation ethos occurred when attention was paid to conserving or preserving species other than those that were merely economically useful. Thus, perhaps for the first time in recent history, attention was paid to the conservation of invertebrates, small plants, amphibians, and reptiles. One of the earliest milestones in this movement can be traced to the 1960s and 1970s when several countries including the USA passed national legislation on endangered species. Thus from a predominantly economic approach to forest management there was a shift in emphasis to forest management for conservation.

Models of Forest Management for Conservation

Among global models of forest management for conservation, three types can be readily identified: (1) formal models that include protected areas; (2) semiformal models that includes conservation through community participation with the state, such as sacred groves, joint forest management and extractive reserves; and (3) informal models arising from grassroots people's movements (**Figure 1**). The formal models are almost invariably controlled by the state while the semiformal approaches involve varying degrees of state and local community regulations. The informal models are mostly led by individual groups of people or institutions. In the following sections, we describe the salient features of these models with a brief commentary on the relevance of these models to conservation issues and practices.

Formal Model of Forest Management for Conservation: Protected Areas

History

According to the IVth World Congress on National Parks and Protected Areas, 1992, a protected area is

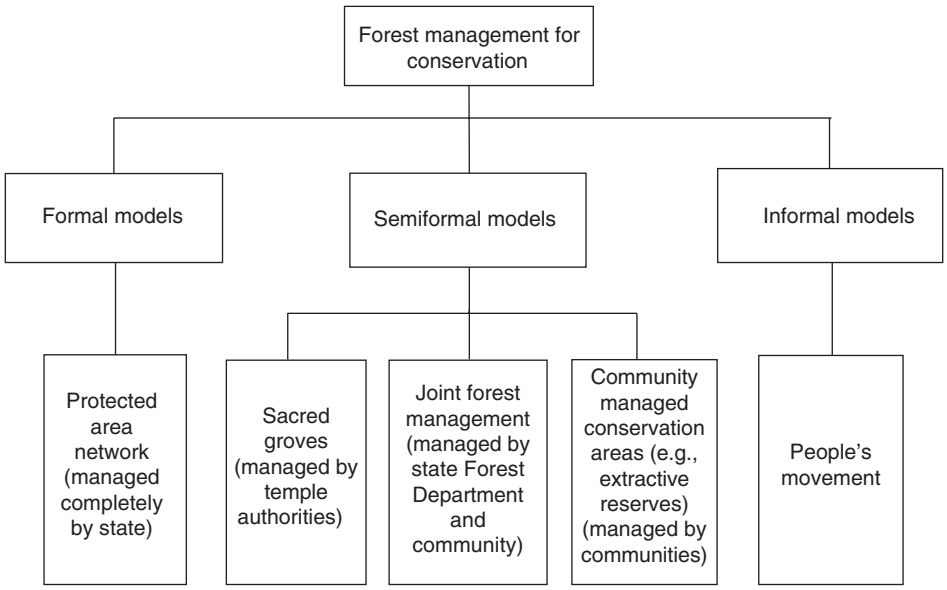


Figure 1 Schematic diagram of the various models of forest management for conservation.

defined as: An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means. The designated protected areas are usually accorded protection by the state authorities and often exclude local people and institutions from decision-making processes or procurement of direct economic benefits. By enforced exclusion of all forms of dependence, the protected area is supposed to serve the conservation goals in its purest form. Delimiting a protected area was historically used by rulers to exclude people from parks to conserve, primarily, a healthy population of wild animals for purposes of hunting. Thus among the first 'conservation areas' in Europe were the medieval hunting parks such as the New Forest established in 1079 by William I of England. In recent history, the first area protected specifically for 'the preservation of' its biodiversity and 'for the enjoyment of the people' was Yellowstone National Park, established by the US Congress in 1872, and later followed by the creation of the National Park Service in 1916. The latter was instrumental in the establishment of the network of protected areas across the USA.

Classically the protected area concept involves setting aside natural or seminatural areas with high conservation value in which genes, species, communities and even habitats are conserved. Based on the emphasis of conservation, the IUCN has categorized protected areas into several groups (**Figure 2**). With increasing international efforts to preserve biological diversity, protected areas have become central to any global strategy for conservation.

Global Network of Protected Areas

Globally there are currently 9869 protected areas (>1000 ha) covering an area of about 9 317 874 km^2, about 6.29% of the earth's land surface area (**Figure 3**). Protected area networks vary considerably from one country to another, depending on needs and priorities, and on differences in legislative, institutional, and financial support. Europe has the maximum area under protection (about 16.4% of the continent's land area) while Asia has the least, accounting for only 4.29% of the land area (**Figure 4**). The global distribution of protected areas does not necessarily reflect the underlying patterns in species richness and biological diversity. For example, in the world's 25 biodiversity hotspots, which harbour 30–40% of all earth's biodiversity, an average of less than 10% of land area is protected. Partly to rectify this discrepancy, a number of protected areas have been established in the framework of international instruments include the World Heritage Sites, designated under the 1972 Convention for the Protection of the World Cultural and Natural Heritage and the World Network of Biosphere Reserves, operated under the UNESCO's Man and Biosphere (MAB) program.

Effectiveness of Protected Areas

Critics claim that protected areas cannot serve as effective means of conservation, because often these forests are vulnerable to anthropogenic pressures. The World Bank/World Wildlife Fund (WWF) Alliance have shown that less than one-quarter of declared national parks, wildlife refuges, and other

IUCN has defined a series of eight protected area management categories, based on primary management objective. These are:

1. Strict Nature Reserve/Scientific Reserve. To protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education, and for the maintenance of genetic resources in a dynamic and evolutionary state.

2. National Park. To protect outstanding natural and scenic areas of national or international significance for scientific, educational, and recreational use. These are relatively large natural areas not materially altered by human activity where extractive resource uses are not allowed.

3. Natural Monument/Natural Landmark. To protect and preserve nationally significant natural features because of their special interest or unique characteristics.These are relatively small areas focused on protection of specific features.

4. Managed Nature Reserve/Wildlife Sanctuary. To assure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities, or physical features of the environment where these may require specific human manipulation for their perpetuation. Controlled harvesting of some resources can be permitted.

5. Protected Landscapes and Seascapes. To maintain nationally significant natural landscapes which are characteristic of the harmonious interaction of humans and land while providing opportunities for public enjoyment through recreation and tourism within the normal lifestyle and economic activity of these areas. These are mixed cultural/natural landscapes of high scenic value where traditional land uses are maintained.

6. Resource Reserve. To protect the natural resources of the area for future use and prevent or contain development activities that could affect the resource pending the establishment of objectives which are based upon appropriate knowledge and planning. This is a "holding" category used until a permanent classification can be determined.

7. Anthropological Reserve/Natural Biotic Area. To allow the way of life of societies living in harmony with the environment to continue undisturbed by modern technology. This category is appropriate where resource extraction by indigenous people is conducted in a traditional manner.

8. Multiple Use Management Area/Managed Resource Area. To provide for the sustained production of water, timber, wildlife, pasture, and tourism, with the conservation of nature primarily oriented to the support of the economic activities (although specific zones may also be designated within these areas to achieve specific conservation objectives).

Figure 2 IUCN system of classification of Protected Area Management Categories.

protected areas in 10 key forested countries were well managed, and many had no management at all. In other words, only 1% of the protected land area is secure from serious threats such as human settlement, agriculture, logging, hunting, mining, pollution, war, and tourism, among other pressures. However, officially designated conservation areas have been shown to be successful at reducing forest clearance and, to a lesser degree, effective at mitigating the effects of logging, hunting, fire, and grazing (**Figure 5**). Even modest increases in funding to the parks are likely to increase the ability of the parks to protect biodiversity.

Despite their shortcomings, protected areas do provide the last refugia for many species threatened with extinction. About 40 critically endangered trees are found almost exclusively within the protected areas across the world. These include *Hibisicadelphus woodii* (Malvaceae) with population fewer than 10 in the Napali Coast State Park, Hawaii; *Parsania formonsana* (Fagaceae) in the Kenting National Park, Taiwan; and *Shorea bakoensis*, in Sarawak, Malaysia. In Thailand, a large number of important timber species, which have been extensively harvested from the native forests, are today found only in protected areas. The last remaining population of the white rhinoceros (*Diceros simus*) is found in the Garamba National Park in the Democratic Republic of Congo as much as the remaining population of the Asiatic lion (*Panthera leo*) in the Gir National Park, Gujarat, India (**Table 1**).

Protected areas also serve as repositories of intraspecific genetic diversity for economically important forest species. For example, populations of sandal (*Santalum* spp.), a tree treasured for its heartwood oil in India and that has been extensively felled as a result, have higher genetic diversity in national parks and sanctuaries than outside. Protected areas also afford higher population genetic diversity for several species of bamboos and rattans. Thus in addition to species conservation, protected areas fulfil an important function in the conservation of intraspecific genetic diversity.

Deficiencies of Protected Areas

Critics also point to the fact that protected areas tend (1) to be biased towards conserving charismatic taxa

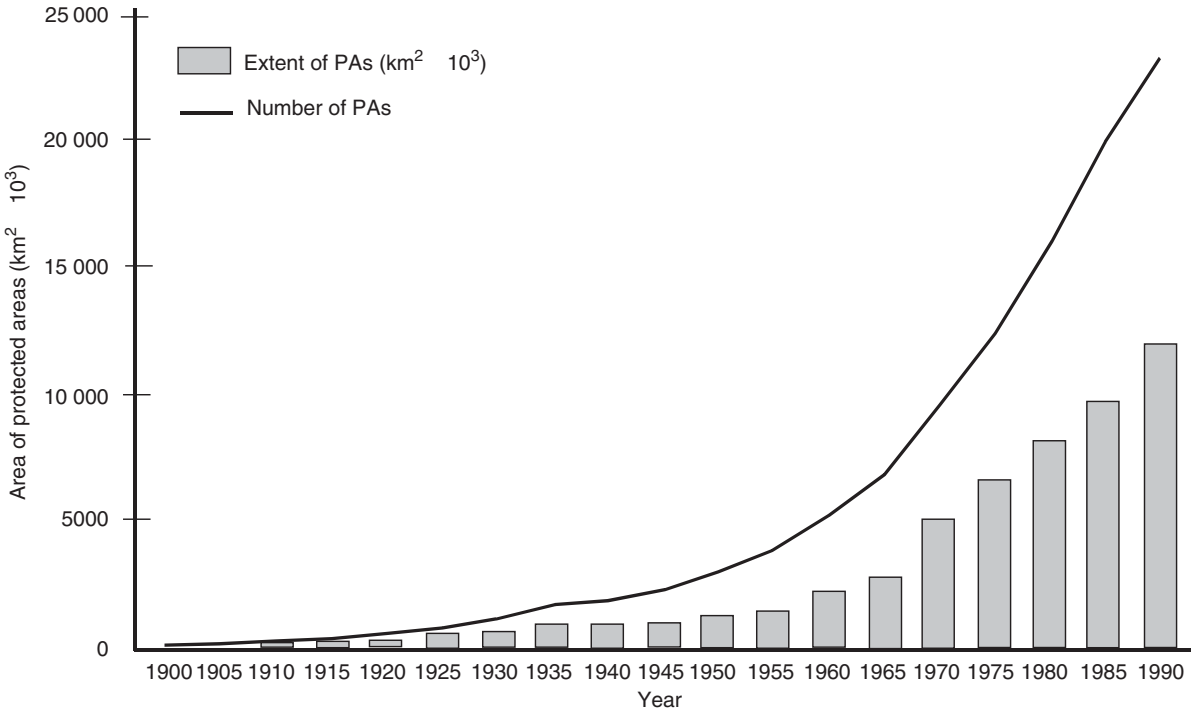


Figure 3 Cumulative area (bars) and cumulative number (line) of protected areas in the world since 1900. About 59% of the protected areas are less than 1000 ha. Redrawn from Michael JBG and Paine J (1997) State of the world's protected areas at the end of the twentieth century. In IUCN World Commission on Protected Areas *Symposium on Protected Areas in the 21st Century: From Islands to Networks*, 24–29 November 1997, Albany, Australia.

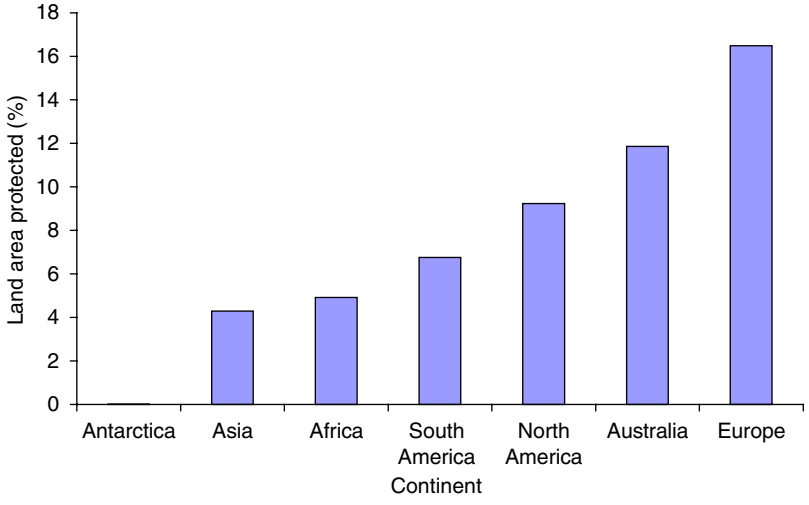


Figure 4 Percentage of land area protected in different continents.

at the expense of lesser known taxa, (2) to be too small to host viable populations, (3) to act as insular and isolated habitats that do not allow for genetic mixing across populations, and (4) to be costly and demanding in terms of logistics to secure the protected area from extraneous pressures.

Among the commonest of criticisms is that protected areas do not necessarily address the conservation needs of nontarget taxa. This is because protected areas have been generally designated on the basis of geomorphical or phytogeographic considerations or, frequently, due to the presence of charismatic large mammals (tiger and elephants in India, panda in China, grizzly bear in British Columbia, wolf in the USA, gorilla, white rhinoceros, and okapi in the Congo Basin, etc.) and not on

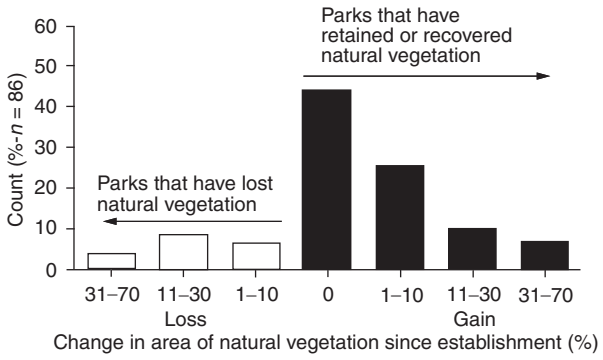


Figure 5 Effectiveness of protected areas in the world. The figure describes the change in the area of natural vegetation for 86 tropical parks. The majority of the parks have either experienced no net clearing or have actually increased natural vegetation cover. Reproduced with permission from Bruner AG, Raymond EG, Rice RE, and da Fonseca GAB (2001). Effectiveness of parks in protecting tropical biodiversity. *Science* 291: 125–128.

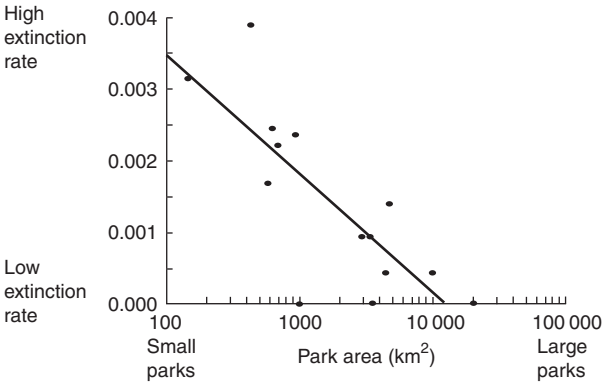


Figure 6 Extinction rates of mammals versus park size. Each dot represents the extinction rates of animal populations for a particular US national park. Mammals have higher extinction rates in smaller parks than larger ones. Reproduced with permission from Newmark WD (1995) Extinction of mammal populations in western North American national parks. *Conservation Biology* 9: 512–526.

Table 1 Protected areas as refugia for critically endangered species; the examples illustrated are those in which the concerned species is not present outside the protected areas

Species	*Protected area*
Animals	
Asiatic lion (*Panthera leo*)	Gir National Park, Gujrat, India
Javan rhinoceros (*Rhinoceros sondaicus*)	Udjung Kulon National Park, Java (Indonesia) and the Cat Tien National Park in Vietnam; it may also still exist in other locations
Hangul or Kasmir stag (*Cervus elaphus hanglu*)	Dachigam National Park, Jammu and Kasmir, India
Orangutan (*Pongo pygmaeus*)	Sepilok Forest Reserve, Malaysia
Straight-horned markhor (*Capra falconeri*)	Sheikh Buddin National Park, Pakistan
Plants	
Dypsis ovobontsira (Palmae)	Mananara Biosphere Reserve, Madagascar
Rhododendron protistum var. *giganteum* (Ericaceae)	Nature Reserve, Gaoligongshan, Yunnan Province, China
Maillardia pendula (Moraceae)	Aldabara Strict Nature Reserve, Seychelles
Hibisicadelphus woodii (Malvaceae)	Napali Coast State Park, Hawaii, USA
Parsania formonsana (Fagaceae)	Kenting National Park, Taiwan
Shorea bakoensis	Sarawak, Malaysia

a holistic basis. The disproportionate emphasis on few large mammals may divert attention from other similarly endangered taxa. Thus it is suggested that the boundaries of protected areas need to be revised to fulfil the conservation requirements of a more representative range of taxa.

The trade-off of size with number of protected areas has been the subject of considerable debate. A single large reserve allows for a wider habitat heterogeneity that is more representative of landscape complexity, and larger population sizes, particularly important for maintaining viable populations of wide ranging low-density species such as carnivores (**Figure 6**). On the other hand, several small reserves offer a degree of protection from large-scale catastrophic events, such as disease, fire, or extreme weather events that may destroy populations confined to a single reserve.

Protected areas could be made more effective by establishing them in sites known to harbor exceptionally high species diversity and/or endemism. Efforts should be made to optimize the selection of new protected areas by iterative processes that maximize the biological diversity conserved in a given area.

Semiformal Model of Forest Management for Conservation

Protected areas that exclude humans alienate local people who may have traditionally depended on forest resources. A recent study estimated that 54% of protected areas considered had residents who contested the ownership of some percentage of the park area. In India, with about 572 protected areas occupying 4.58% of the geographical area, an estimated 3 million people live within the protected areas with several million more living adjacent to the parks. Rather than evicting people traditionally dependent upon forests a more pragmatic and sympathetic approach is to manage forest use and

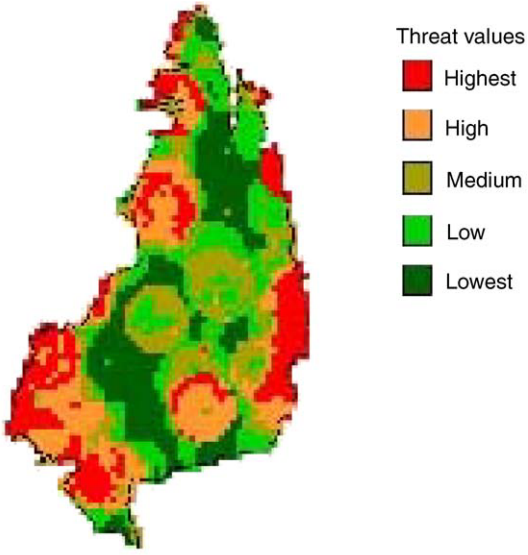
impacts in a way that maximizes conservation gains while realizing economic benefits (**Figure 7**). Community involvement in the management of protected areas, where the state and the local inhabitants work together for both conservation and basic livelihood security, is seen as a positive and necessary strategy for successful conservation programs in both tropical and temperate regions.

Semiformal methods of forest management for conservation are predominantly located in tropical countries that have a long history of association of people with the forests and that retain sufficiently large areas of forest such that these associations persist. The origin of these models can often be traced to the codification of the use of forest resources. Among the semiformal models, the predominant are the temple forest or sacred forests, joint forest management (*see* **Social and Collaborative Forestry**: Joint and Collaborative Forest Management), and extractive reserves.

Sacred Groves

Probably begun as manifestations of nature worship, sacred groves have played an important role in conserving the forest and its constituent biodiversity elements. This unique community-linked forest conservation concept is practiced in several tribal and agrarian regions of the world. A number of societies in Asia, Africa, Europe, America, and Australia have long preserved sections of their natural environment as sacred groves. The practice of sacred groves is widespread in India (**Figure 8**). About 4215 sacred groves covering an area of 39 063 ha are estimated to

In India a number of protected areas (PAs) continue to be inhabited by the tribal and indigenous communities who depend almost completely on the forests for their livelihoods and thus constitute direct threats to the PAs. It is clear that unless attempts are made to reduce these threats, the protected areas in succumb to the increasing human pressures. Unfortunately most of the threats arising from anthropogenic activities in the protected areas are not easily quantifiable as they are very dynamic and heterogeneous. Effective conservation of such protected areas demands that we evaluate the threats and accordingly formulate appropriate management plans to mitigate them. However, there is hardly any standardized methodology to evaluate the complex threats that protected areas might face.



Threat map of BRT wildlife sanctuary, south India

Ganeshaiah and his coworkers developed a protocol for measuring and mapping threats in a protected area, a wildlife sanctuary, in South India. They computed three threat values viz:

1. Settlement associated threat from human, cattle, and sheep.
2. Developmental activity associated threats due to major and minor roads.
3. Accessibility-related threats due the steepness of the terrain.

Combining all the three threat values, they derived a composite threat index for each grid over the sanctuary. The composite threat index clearly reflected the pressures on the sanctuary as evident from the strong correlation between the threat levels and the human related disturbance activities and a strong negative relation between the composite threat index of a grid andits tree diversity. Periphery of the sanctuary (in deep red) is more threatened than those in the core (green). Based on the composite threat index, Ganeshaiah and coworkers have proposed strategies to manage the forest to maximize the conservation gains.

Figure 7 Measuring, mapping and managing threats in a protected area. Reproduced with permission from Ganeshaiah KN and Uma Shaanker R (2003) *A Decade of Diversity*. Bangalore, India: Ashoka Trust for Research in Ecology and the Environment and University of Agricultural Sciences, Bangalore.

Figure 8 A typical sacred grove in Coorg District, Western Ghats, India. Photograph by courtesy of G. Ravikanth.

Table 2 Sacred groves as refugia and sites of relict vegetation; the species listed below are known to occur either exclusively or predominantly in the sacred groves

Species	*Area*
Kunstleria keralensis	Southern Kerala, India
Belpharistemma membranifolia, *Buchanania lanceolata*	Kerala, India
Syzygium travancoricum, *Cinnamomum quilonensis*,	Kerala, India
Philautus sanctisilvaticus	Amarkantak, Madhya Pradesh, India

be distributed in India and are located in habitats ranging from resource-rich forested landscapes, in the Western Ghats, to extremely resource-poor desert conditions, in western and central India. In Ghana, about 1.5% of the land is covered with nearly 2000 groves. Typically the local village temple authority directly manages the groves. However with passage of time, the regulations were extended to the state as well. In India, for instance, the local revenue department and the forest department have joined the temple authorities in managing the groves.

Being bound by taboo, sacred groves have been as effective as modern protected areas in conserving biological diversity and serving as a refugia for endangered species. In Coorg district along the Western Ghats of India, about 14% of tree species, 26% of bird species, and 44% of macrofungi were exclusively found in the groves. Certain species such as *Dysoxylum malabaricum*, *Anacolosa densiflora*, *Holigarna arnottiana*, *Diospyros bourdilloni*, *Poeciloneuron indicum*, and *Vateria indica,* which are in heavy demand for their commercial value, continue to survive and flourish mostly in the sacred groves. The sacred groves called 'orans' managed by the Bishnoi community of Rajasthan, India are well known for their conservation ethos of protecting the khejari trees (*Prosopis cineraria*) and the blackbuck (*Antelope cervicarpa*) (**Table 2**).

Over the years the sacred groves have been threatened from both powers within and outside. In India, from early nineteenth century, the British gained control over the use of forests of the Western Ghats including the vast network of sacred groves. At certain other places, taboos relating to the groves began to weaken. With declining forest resources outside the groves, people began to remove leaf litter and dead wood from the groves to meet the needs of the charcoal industry. Encroachment of the sacred groves, notably by forest-based plantations such as coffee, also took its toll. Between 1905 and 2000, the total area under groves in Coorg, decreased from 6277 to 2550 hectares with about 45% of the groves smaller than 0.4 ha and 80% less than 2 ha. Perhaps in large measure degradation of the groves has been associated with decreased religious rigor among the people over time. The highly fragmentary nature of the groves with their poor insularization in a matrix of grassland and forest makes them very vulnerable.

Maintaining the sacred groves might not only help in conserving the biological diversity in the forests, but also serve to be symbolic of the traditional conservation cultures associated with some of the oldest religions and faiths across the world. In the context of conserving the genetic resources, the groves act as micro-hotspots of biological diversity, and thus merit serious attention. The groves, by their nature, can complement protected areas in forming a network of forest conservation areas in the tropics.

Joint Forest Management Program in India

In a pioneering move, the government of India formulated a National Forest Policy in 1988 where it emphasized the need of people's participation in the management of forests. Specifically the policy urged the need for 'creating a massive people movement with the involvement of women, for achieving these objectives and to minimize pressure on existing forests.' In June 1990, the government of India formally unleashed a new system of forest management involving grass root institutions popularly known as 'Joint Forest Management' (JFM) (*see* **Social and Collaborative Forestry**: Joint and Collaborative Forest Management). The JFM is a tripartite body with the involvement of the Forest Department, local level institutions, and nongovernmental organizations (NGOs). The JFM characterizes a paradigm shift in forest management from a centralized management to decentralized management, from revenue orientation to resource orientation, from a production motive to a sustainability motive, from

target orientation to process orientation, and from restricting people to working with people. By the year 2000, the JFM program had been launched in 22 states in India, covering an area of 10.24 million ha of forest (about 5.5% of the forested area) through 36 130 JFM committees. In the relatively short time of its existence, the JFM has had its impact in regressing the loss of forest cover in a few states such as West Bengal, Madhya Pradesh, and Andhra Pradesh. However, not all the states in the country have shown similar impacts of JFM. The failure of JFM is attributed often to the lack of coordination between state and members of a JFM initiative. More recently, JFM has been introduced in neighboring countries such as Nepal and Pakistan.

Community Managed Conservation Areas

In Brazil, as in many other tropical countries, a large number of indigenous communities continue to live within the forest where they are dependent on the forest resources for their livelihood. Declaration of protected areas and national parks in such countries have resulted in a serious social problem with either the displacement of the indigenous people or restriction of their use of the forest. Partly to address the social conflict and to maintain efforts to conserve the forest, the Brazilian government initiated the establishment of extractive reserves in the Amazon forest. Under this approach, rather than fence people away from the forest, the reserves permitted the people to manage the forest for their subsistence livelihoods, thereby providing incentives for conservation and sustainable management of the forest resources. Thus the extractive reserves have been broadly successful in preventing land clearance or logging. To date about 12 extractive reserves covering over 3 million ha have been established. However, extractive reserves have not always been successful in maintaining the balance desired between meeting the people's dependence and conserving the ecosystem. Close monitoring and reinforcement could perhaps make community managed conservation areas more effective for conservation than they actually are.

Community managed conservation areas might be highly relevant in regions that have very little forest under government control, as is the case in a number of South Pacific countries. The South Pacific Biodiversity program brought together local communities, NGOs, and governments in 14 countries in the south Pacific to conserve the biological diversity in what has been referred to as the community managed conservation area. The program provides for the sustainable use of the resources in these protected areas but ensuring that the important ecological features and processes are maintained.

Informal Model of Forest Management for Conservation: People's Movement

A number of informal people-based approaches for managing forest for conservation has been the cornerstone of conservation in many traditional cultures in the world. These approaches are essentially amorphous and have no formal structures. Often they have emerged in response to local community perceptions about how local natural resources were being exploited.

In India, there have been several important people-based movements that have made significant contributions to the way forests have been managed. One such illustration is the Chipko movement (chipko, to stick or embrace) initiated by the Bishnoi community of Rajasthan in the early eighteenth century. In this movement local people embraced trees, often at grave risk to their own lives, to prevent the trees from being felled by the King of Jodhpur (**Figure 9**). The movement has since spread to many districts of the Himalayas, in Uttar Pradesh, and Himachal Pradesh in the north, Karnataka in the south, and Bihar in the east, and to the Vindhyas in Central India, and is now realized as a popular people-led movement to conserve trees. Another notable people's movement, in the southern state of Kerala, India rescued a major evergreen forest, the Silent Valley, from being destroyed by a hydroelectric

Figure 9 Chipko movement in India (for details see text).

project. The valley was declared a national park in 1985. In Slovakia, an NGO, WOLF, has since 1993 been working to save natural forests that include large predators such as wolves. WOLF is predominantly managed by local tribes, each tribe adopting a mountain range to save the natural forest. Whether practiced in the Australian outback by the Aborigines or in Amazonia by native Indians, these movements have fought, often successfully, unscrupulous exploitation of forest resources by larger interests. Several such movements have, over time, gained sufficient strength and publicity that they have been later adopted into more formal approaches to forest management.

Conclusions and Implications

Prior to the major human settlements and advances tropical forests covered about 17 million km^2 of the earth's surface. Today, less than half of this remains. The forests lie in some of the most economically underdeveloped and heavily populated countries in the world. Consequently even these remnants face extreme pressures due to an increasing demand on the forest resources by the developing economies. It is feared that unless urgent measures are taken to conserve the remaining forest, not only will these forests be lost but there will also be an irreversible loss of the variety and performance of life functions on earth. Awareness of both threats and consequences has stimulated urgent efforts, initiated mostly at the beginning the twentieth century, to develop various approaches to managing forests in a manner that would conserve biological diversity and ecosystem processes. The establishment of protected areas has been central to these efforts, and now about 6.3% of the earth's land surface is under protection. While protected areas have their faults, there is an overriding consensus that they could be the last refugia for several scores of critically endangered species. Besides state-regulated protected areas, several semiformal approaches to managing forest for conservation also exist, such as sacred groves and people-inclusive forest management (e.g., joint forest management and community managed conservation areas). While the reach of these systems has been restricted, they have nevertheless been moderately successful in managing forest for conservation and local benefit in many developing countries. People-led movements have also been a powerful force in lobbying for improved management for conservation and sustainable development in countries such as India and Brazil, and have been precursors to some major conservation movements. It is believed that collectively the various models of conservation, from the very formal protected area networks to the informal but powerful people-led movements, will complement each other to avoid exploitative management in favor of sustainable management.

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Genetic Aspects of Air Pollution and Climate Change

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Introduction

The first incidences of air pollution impacts on the genetic constitution of forest tree populations were those documented near point sources of sulfur dioxide (SO_2), particulates, and heavy metals. Localized extinction of forests around these point sources was documented by ecologists in the past