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INTEGRATING ECOSYSTEM CONSERVATION AND PLANT SYSTEMATICS– NEW APPROACHES FOR BIODIVERSITY CONSERVATION

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ABSTRACT

This paper reviews the effect of ecosystem degradation on species occurrences and distribution in the Himalayan region and how ecosystem restoration can help in species migration and recruitment. The author is of the opinion that plant systematics as a science has to be integrated with the study of various ecosystems as they exist in the hilly regions and studying how ecosystem functioning helps in the survival of species. Impact assessment studies are required if most of the endangered species are to be protected for the future.

Due to constraints of time and resources, a rapid inventory technique is suggested, in which information from various sources can be dove tailed into a data base and selected centers identified for species conservation. A list of a few selected locations are suggested as starting points for conservation of both species and ecosystems.

INTRODUCTION

The Himalayan region occupies an area of 53.7 million ha which constitutes 16.4% of the total geographical area of the country. Extending for 2500 km east to west, the belt covers more than 10^{o} of latitudinal expanse between 27^{o}- 38^{o}N. This dimension encompasses ecological ranges corresponding to a latitudinal displacement of over 5000 km. Tropical and alpine communities may occur within a distance of 200-300 km. Two significant gradients are recognizable, one of decreasing temperatures from low to high elevations and the other of decreasing moisture from east to west. Depending upon the elevation, average temperatures in the Himalayas may be subtropical (17^{o}-24^{o} C) below 2000 msl, temperate (7^{o}-17^{o} C) above 2000 msl and alpine ($<10^{o}$C) above 3300 msl. Temperature and rainfall gradients have resulted in the formation of a variety of vegetation covers in the region, each of which differs in structure, physiognomy and species diversity and occupies its own ecological 'niche' in the mountainous region.

Extreme topographical features of the Himalayan region have given rise to a vast spectrum of plant and animal biodiversity. Ecosystem diversity in nature favours specialization of living organisms to a fairly narrow set of environmental conditions. The mosaic of smaller subsets (soils, water, microbes, plants and animals) and their interactions can only be maintained under limited aberrations in a given environment. Several interlinked factors like climate, soils have led to the development of vegetation in the Himalayas and it is difficult to express the relationships of forest formations to environment in a simple framework. Out of the 17,000 flowering plants in India, about 8000 grow in the Himalayas, with 5000 species growing in the North East alone. According to Chatterjee (1939), the number of flowering plants endemic in the Himalayas is 3165, out of a total of 6550 endemics in India. The Himalayas are a mega centre of diversity of higher fungi, as has been reported by Sharma and Kamal (1993), Rawla (1993). Bir (1993) estimated that there are atleast 114 species of endemic ferns in the eastern (82 species) and western (18) Himalayas and 14 are common to both regions. There are atleast 18 genera of primitive angiosperms growing wild in the eastern Himalayas (Takhtajan, 1969).

Over the past four decades four major factors viz. habitat deterioration, poaching, pollution and introduction of exotics, have contributed to widespread destruction and loss of India's biodiversity at all levels. It is estimated that 20% of this country's wild flora and fauna may be facing threat of varying degrees. Climate change and global warming will aggravate this attrition problem by disrupting the delicate relationship within ecosystem. Mountain ecosystems are projected to shift to higher elevations, with species migrating to conducive habitats, if possible. This rate of vegetational change will be slow and colonization rates will depend on local geographic and 'people' factors.

Natural and man made disturbances affect species populations, community dynamics and ecosystem structure (Paine and Levin, 1981). Wali (1987) defines ecosystem disturbance as an event or a series of events that result in altering, both spatially and temporally, the relationships of organisms and their habitats from their natural state. Environmental stresses, brought about by human activities, specially in vulnerable areas like the Himalayas, change the pattern of primary productivity, nutrient cycling, food chains and size distribution of biota in natural ecosystems. Deforestation and grazing in forest areas and consequent soil erosion have already caused significant alterations in the functioning of the Himalayan ecosystem, and has led to the exodus of many disturbance sensitive species and their replacement by invasive weeds that are now all pervasive. Loss of habitat (forests, grasslands, wetlands) due to various man made reasons, has directly affected the survival of many vulnerable species of animals (Table 1).

Ecosystem degradation and reduction in forest area

The Himalayan biota is very disturbed particularly in the western and central flanks, the eastern part being comparatively less disturbed due to the tropical humid climate and less biotic pressure. The effect of forest cover depletion and loss of biodiversity is relatively less known in developing countries than in developed ones. This may be due to poor impact assessment studies combined with rehabilitation by monocultures of few species. It may therefore be difficult to quantify how many species of ferns and orchids are made rare or become extinct by *jhuming* or when moist temperate broad leaved forests are replaced by exotic conifers.

Table 1 : Threatened animal species due to habitat degradation in different parts of the country.

Name	Location	Population remaining	Threat
Sangai deer	Loktak Lake, Manipur	1000	Loss of habitat
Cheer pheasant	Hills of UP, HP, J&K	*	Habitat destruction and hunting.
Snow leopard	Ladakh and high hills of UP, HP	*	Poaching and loss of prey.
Himalayan musk deer	High hills of J&K, HP	7000	Poaching for musk, grazing by livestock, hunting by snow leopard and disease.
Hangul	Endemic to the Dachi-gam sanctuary in J&K	300	Poaching, deforestation.
Leopard	Garhwal hills, HP, NE regions,MP	7000	Shrinking habitat, disturbed food chain.
Oriental small clawed otter	Lower slopes of the Himalayas, West Bengal plains	*	River pollution, drying up of wetlands, marshes, poaching.
Pigymy hog	Manas biosphere reserve	150	Habitat destruction,poaching.

* numbers not known

Over the past decade there has been a significant decline in the forest cover in practically all the hill states (Table 2), except Arunachal Pradesh, Sikkim and Uttar Pradesh (now the newly carved out hill state Uttaranchal), much of which has been due to new plantations and very little recovery of the original degraded forest. By 1993, in the hill districts of Uttaranchal, though statistics show an overall gain in forest cover, the state actually lost 5100 ha of dense forest and gained 6800 ha of open forest (FSI, 1999). This degradation of habitats has placed India in the top ten countries with threat to their flora (Walter and Gillett, 1997).

Deforestation and increasing bio-uniformity

Disturbed ecosystems provide a harsh condition for plant and microbial growth because of low organic matter, nutrient supply or compact structure (Meyer, 1973). Deforestation increases loss of nutrients like C, N, P and sulphur by 'leakage' from the ecosystem leading to reduc-tion in soil fertility, carbon fixation and organic matter accumulation. Under these conditions only a few non demanding but aggressive species invade open areas and establish themselves.

Opening of canopy followed by increased insolation of the soil surface, slowed rate of organic matter decomposition and increased dryness of the soil has resulted

Table - 2 : Comparative changes in dense forest cover (sq.km) in the Indian Himalayas

States	1987	1997 (%)	Annual growth rate
North Eastern India			
Arunachal Pradesh	51,096	54,155	0.60
Assam	18,415	15,548	-1.56
Manipur	4670	4937	0.57
Meghalaya	5749	4044	-2.97
Mizoram	2938	4348	4.80
Nagaland	637	3487	-4.50
Sikkim	1867	2423	3.00
Tripura	340	1819	43.50
Western Himalayas			
Himachal Pradesh	9908	9560	-0.35
Jammu & Kashmir	12970	11020	-1.51
Uttaranchal	10506	16622	5.82
Total Himalayan states	124846	126163	0.11

Source : FSI - 1987,1997.

in failure of natural regeneration in many originally forested areas. Such areas undergo more damage due to annual lopping patterns, removal of woody biomass for fuelwood and trampling by free grazing animals that effectively destroys any natural regeneration (Table 3). Due to these uncontrolled factors, forest cover on a majority of Himalayan slopes, has retrogressed back to early successional stages, light demanding species and even aged species dominate, with all aged populations becoming rare to observe. In recent studies carried out by the author in *Quercus leucotrichophora* dominated forests in N.W. Himalayas, it was observed that the continued exploitation had led to the absence of regeneration of oak, with the density of trees in stands between 1300 - 1900 msl being low (Fig.1) while those of shrubs in the same elevation is high. Thus between 1300-1900 msl, the luxuriance of vegetation as reflected by the higher basal cover is maintained by individuals of large sizes rather than by the presence of numerous individuals of low stem girths, that is old trees. These areas have been replaced by numerous shrub species

Table 3 : Extent of grazing and its effect on regeneration of forest species in the Himalayas.

States	Forest areas affected with grazing (%)				Regeneration % of important species
	High	Medium	Light	Total	
North Eastern India					
Arunachal Pradesh	3.0	17.9	31.9	52.8	2.0
Assam	6.7	13.7	29.1	49.5	15.2
Manipur	5.0	11.0	30.0	46.0	10.0
Meghalaya	4.1	17.8	42.2	64.1	6.0
Sikkim	4.8	20.1	29.6	54.5	53.0
Tripura	13.5	30.0	37.0	80.5	31.0
Mean	6.2	18.4	33.3	57.0	19.5
Western Himalayas					
Himachal Pradesh	31.6	27.4	25.7	84.7	10.0
Jammu & Kashmir	17.4	53.2	25.4	96.0	9.8
Uttaranchal	13.0	35.4	33.3	81.7	16.0
Mean	20.7	38.7	28.1	87.4	11.9
All India	18.3	31.0	28.2	77.6	26.4

Source: F.S.I. (1995)

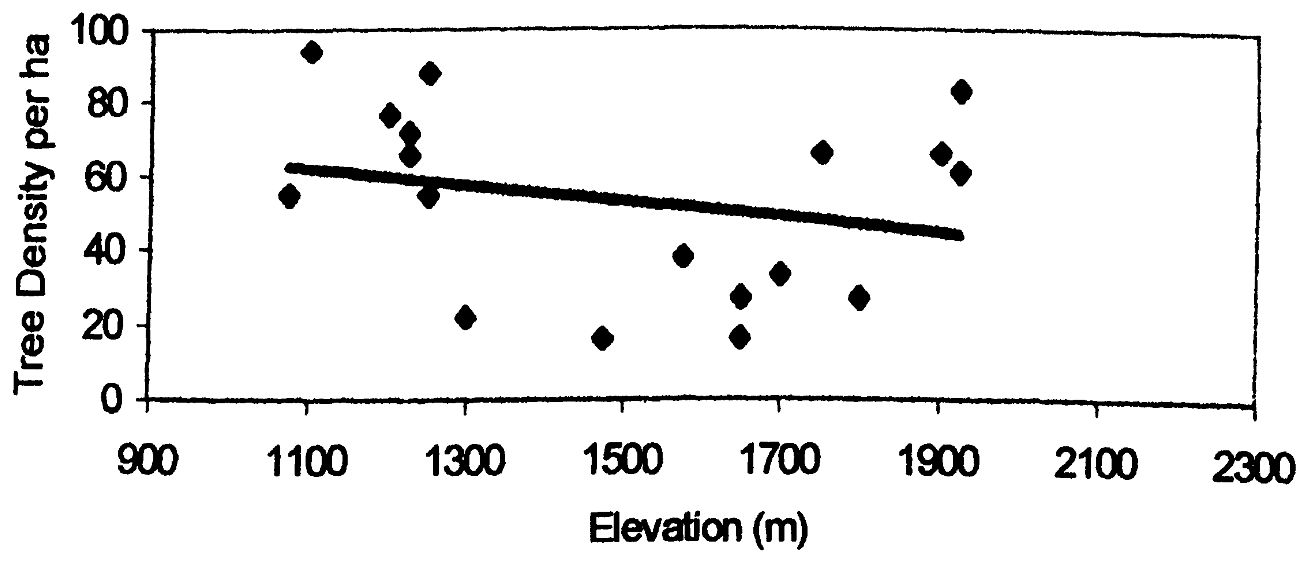

Fig.1. Total tree density in 18 forest stands along an elevation gradient in a Himalayan watershed.

that are well distributed. In other words it is apparent that if indiscriminate lopping and biomass extraction from these oak forests continue, the oaks would be replaced by hardy coniferous species like *Pinus roxburghii.*

The resulting forest fragmentation is associated with plant and animal extinction, damage to the ecosystem and loss of biodiversity. This is due to firstly a reduction in the net area of natural habitat available and secondly creation of forest patches that are at a distance from each other that prevents movement of plant propagules and animals through forest corridors.

Invasion of *Lantana camara* (up to 1500 msl) and *Arundinaria falcata* (at 1800-2800 msl) a dwarf bamboo commonly called 'ringal' has led to complete absence of species regeneration in sal and oak forests, respectively. *Chromolaena odorata,* another exotic weed occupies mesic sites in oak forests and forms dense thickets, preventing their natural regeneration.

Studies carried out in the Kumaon region (1830 - 2200 msl) revealed (Tripathi *et al.,* 1991) that *Quercus floribunda* prefers mesic hill slopes and *Arundinaria falcata, Daphne cannabina* and *Myrsine africana* which are the most common dominant shrubs in undisturbed oak forest fail to withstand strong sunlight due to canopy openings created by annual lopping and may vanish from the region. All oaks are quite resilient and being good coppicers may regenerate rapidly if no disturbance occurs. Similarly *Quercus leucotrichophora,* a common oak in the central Himalayas is able to regenerate from old stumps if no disturbance occurs.

Collection of medicinal plants

Within the Himalayas, the western flank is richest in terms of number of medicinal plants found and commercially exploited but it is also the most disturbed. Deforestation and fragmentation of forested areas have broken the natural chain species migration, seed dispersal and establishment and consequently medicinal plants face greater threat of extinction (Table 4).

Indiscriminate exploitation of medicinal plants by unscrupulous traders and 'herbal' companies during the last three decades has led to the disappearance of many plants from those locations where they were easily available earlier. Digging up of roots and rhizomes, removal of bark from living trees and complete harvest has broken the chain of regeneration of many of these species, even in the most difficult terrain conditions and the availability of many of these plants in the future may be doubtful (Table 5).

Ecosystem restoration and species migration

Due to its varying geological structure and upheavals during its formation, the region is rich in minerals, like limestone, dolomite, phosphosite, magnesite, gypsum, copper, silica, quartz, bauxite and sapphire. Unscientific mining by open cast mines, forest removal and dumping of soil, mine debris and consequent erosion, came severe disturbances in the downstream. Beside visible impacts on water yields, water quality, decline in food production and deforestation, the invisible effects have more serious

Table 4: Some important medicinal plants facing threat of extinction in different parts of the Himalayas.

Region	Species
a) **Western Himalayas**	
Lower sub-tropical zone (<1800 msl)	*Datura stramonium, Datura metel, Urginea indica, Holarrhena pubescens, Plumbago zeylanica, Alpinia galanga, Ocimum basilicum.*
Temperate zone (1800 2600 msl)	*Atropha acuminata, Swertia chirayita, Thymus serphyllum, Angelica glauca, Gentiana* sp.
Higher temperate zone (>2600 msl)	*Saussurea* sp., *Aconitum* sp., *Rheum* sp., *Ephedra gerardiana, Artemisia maritima, Nardostachys jatamansi.*
b) **Central and Eastern Himalayas**	*Aconitum* sp., *Polygonum* sp., *Iris* sp., *Alpinia galanga, Croton tiglium, Nepenthes khasiana, Curcuma aromatica, Coptis teeta, Hydnocarpus kurzii.*

Table 5 : Trends in the availability of some medicinal plants from the Himalayas

Species	Price (Rs/kg)	Availability trend	Demand trend	Future trend
Aconitum heterophyllum	2690	D	I	D
A. ferox	208	C	I	D
Commiphora wightii	142	I	I	C
Coptis teeta	222	D	C	D
Gloriosa superba	35.5	I	I	D
Podophyllum hexandrum	57.5	D	C	C
Saussurea costus	58.5	I	I	D
Taxus wallichiana	29.5	I	C	C

D- decreasing; I increasing; C constant.

repercussions. Mining of limestone in the Doon Valley from 60 odd mines yielding 1.1 million tonnes annually of ore, led to a decline of 50% in water resources, 28% in food production (due to destruction of *ghools* and debris overflow into agricultural fields) and livestock production by 35% (Anonymous, 1988). Saxena *et al.*, (1979) reported that 60% of water resources in the Doon Valley had dried up due to deforestation and mining.

Bio-engineering measures carried out for rehabilitating the Sahastradhara mines, besides being cost effective led to reduction in runoff, channel slope, debris load but an increase in lean period flow and vegetation cover (Table 6). Similarly in 2, 3, and 5 year old reclaimed rock phosphate mines at Maldeota (Dehradun) the relative contribution of herbs and grasses increased with age (Soni *et al.*, 1989 b).

Table 6 : Effect of bio-engineering measures on mine rehabilitation in the Doon Valley.

Particulars	Before treatment (1983)	After treatment (1996)
Channel slope	38	20
Monsoon runoff (%)	57	37
Debris outflow (t/ha/yr)	550	6
Lean period flow (days)	60	240
Vegetation cover (%)	10	80
Cost of debris clearance (Rs/yr)	1,00,000	0

In limestone mines at Sahastradhara species succession after bioengineering measures were executed, was slow and species occurrences clearly followed an edaphic gradient, with rehabilitated mines showing lower diversity values (Table 7) than natural forests, inspite of being richer in terms of number of species (Raizada and Samra, 2000).

Table - 7: Diversity indices for two locations in an abandoned limestone mine in the lower western Himalayas.

Index	Site I		Site II		
	Trees	Shrubs	Trees	Shrubs	Grasses
No. of species	9	6	13	11	5
Richness	0.943	0.60	2.221	2.222	0.868
Concentration of Dominance	0.266	0.326	0.318	0.200	0.436
Diversity (H')	1.668	1.267	1.511	1.880	1.014
Abundant species	5	3	4	6	2
Very abundant species	3	3	3	4	2
Equitability of species	0.76	0.70	0.58	0.78	0.63

Site I - Adjoining unmined forest area; Site II - rehabilitated mine area.

Fragility of the Himalayas makes it very prone to landslides and these cause serious problems for agriculture, communication, tourism and water resources. A massive landslide may revert forest ecosystems to the earliest successional stage. This provide an opportunity for annuals to occupy 1 year to 6 year old landslide sites, after which a number of perennials slowly begin to appear and edge out the annuals by niche pre-emption. Soil nutrient pools begin to stabilize in forty years and release of nutrients gets regulated by the developing vegetation. Climax oak forests have been reported (Singh and Singh, 1986) to rejuvenate rapidly from old stumps by coppicing, provided disturbance is restricted after the landslide has taken place.

Soil nutrient buildup in oak forests took about 45 years to reach level equal to undisturbed sites, while in pine forests soil nutrient levels in twenty five years were lower than those in oak forests (Reddy, 1989) although recovery is fast in the surface soil layer. These changes in soil proportion influence the arrival of annuals in large number and their gradual replacement with slow growing perennials leading to a decrease in species diversity but the development of a highly stable vegetation community.

Chronosequence of vegetation recovery in a disturbed moist temperate oak forest in Kumaon Himalayas revealed that while the herb layer did not change significantly in 21 years, seedlings of certain pioneer tree species appeared in 1-13 years and climax oak species appeared only when the herb layer was fully developed. This was attributed to increased contribution by the herb layer to soil organic carbon and total N levels which created an ambient medium for the oak acorns to establish themselves (Pandey and Singh, 1984; Table 8).

Table 8: Recovery over time of disturbed oak forest ecosystem through an age sequence of land stabilized after landslides in Kumaon.

Parameter	Age (years)							
	1	3	6	13	21	40	90	Undisturbed site
No. of annual species	11	6	11	17	16	16	23	15
No. of perennial species	6	2	4	11	10	17	13	13
Herb density (shoot m-2)	7	9	19	42	66	68	278	76
Ground surface cover (%)	8	3	12	18	33	40	49	42
Herb + Shrub Biomass (gm-2)	35	45	50	800	850	980	1375	1050
Organic C (%)	1.5	1.6	1.8	2.0	2.5	3.8	3.9	3.9
Soil loss (kg ha-1)			81	62	42	37		26

Source: Modified from Pandey and Singh, 1984.

Why link taxonomy to ecosystems?

Plant taxonomy was until two decades ago, considered a 'dead' science with few teachers and fewer students, accompanied with poor herbariums and absence of forest areas for training students in plant collection, documentation and preservation. After the

Rio conference and the focus on biodiversity conservation, the science of taxonomy got a new breath of life and taxonomists began to be consulted for important conservation programs.

Ecosystems provide several 'services' to mankind like carbon sequestration, purification of air and water, soil formation and renewal of fertility, control over climate, providing recreation and scenic beauty and regulation of water and nutrient movement, to name a few. While taxonomy is a prerequisite for successful species identification and conservation, ecosystem conservation and analysis is equally important. In fact, it would not be incorrect to say that in ecosystem conservation lies the key for the survival of plant taxonomy in the 21st century. Plant taxonomy cannot survive in isolation and dove tailing of ecosystem information and changing habitat factors (ecosystem factors) have to go hand in hand with systematics. The ecosystem approach considers conservation of species poor areas unlike the biodiversity approach where only areas with a high species diversity are the focal points. Thus ecosystem conservation should be a key word for the future of both species conservation and plant taxonomy which would also include ecosystem restoration.

Under the present socio-political setup in India, it is not physically possible to conserve and protect our already stressed biodiversity for future generations. Even our sacred groves in Kerala, Madhya Pradesh, Bundelkhand, Meghalaya, Nagaland and Uttaranchal are under extreme risk of disappearing for ever by both biotic pressure and biophysical factors.

There has recently been a general increase in awareness that no species can exist in isolation and that species must find a conducive environment in which it will grow, multiply and disperse. This can be achieved only by applying an ecosystem approach for biodiversity conservation, specially for fragile ecosystems like the Himalayas, and allow for the continued existence of plant systematics as a science.

Using Ecological approaches for species conservation

Of the total number of species in a community a relatively small per cent are usually abundant (either in numbers, biomass or productivity) and a large per cent are rare or less abundant. While few common species account for the energy flow in each trophic group, it is the large number of rare and less abundant species that determine the species diversity of the community. Species diversity is usually low in physically controlled ecosystems and high in biologically controlled ecosystems and is directly related with the stability of the ecosystem.

Species diversity has a number of components that may respond differently to geographical, developmental or physical factors. One component called species richness is often expressed by simple ratios between total species (S) and total numbers (N). A second component of diversity (J'=H'/H max) which may be uniform, random, random clumped, uniform clumped and aggregated clumped. The widely used Shannon's function (H') combines the variety and evenness components as one overall index of diversity, it is independent of sample size and is normally distributed, so that routine statistical methods can be used to test for significance.

Species conservation, their survival and migration into other similar conducive areas will depend on protecting individuals and communities with a capacity to regenerate, i.e. more of young and middle aged indivisuals and less of old. Ecological tools and techniques can be used successfully in identifying locations of communities that require protection.

Restoring ecosystems and biodiversity conservation

Restoration of ecosystem stability in the Himalayas will have to rely on two major planks converting large patches of degraded forests into viable units that provide direct and indirect benefits using local communities as vehicles to meet the goal and secondly, protecting the remaining patches of forests and related ecosystems by setting up a chain of biosphere reserves and protecting them through JFM plans in different states. Impact assessment studies need to be taken up in vulnerable areas and comprehensive rehabilitation programs taken up in disturbed habitats. Information on species distribution patterns and richness along with information on indigenous knowledge about medicinal and aromatic plants needs to be documented, while vulnerable areas requiring special management need to be demarcated and rehabilitated. If protection to the rejuvenating forest can be ensured, recruitment of new species and secondary succession can begin which will result in increase of species numbers and their equitable distribution in the area.

Biodiversity management requires measurement and the availability of quantitative data in order to compare different sites and identify richer locations. This data could cover several plant forms grasses, herbs, shrubs, trees, climbers, forbs, ferns and liverworts etc, and would need to be collected at regular intervals. Differences in species distribution and richness collected over time will reveal changes and shifts in population structure, the appearance/ disappearance of species and changes in habitat factors. Biodiversity investigations therefore call for extensive field level data collection and its extrapolation over similar habitats so as to demarcate different 'niches' of unique species collection or micro ecosystems in a large area. Field investigations also require a working knowledge of plant taxonomy although India is fortunate to have floras available for a large part of the country and they are of valuable assistance.

Collecting data on abiotic components

No species occurs in isolation, but in an equilebrium with the abiotic components. Conservation of species also means the maintainence of ambient locality factors , specifically of those that are likely to be affected most by human activities like soil, water, air, soil micro flora. Information on these are of equal importance in planning conservation strategies and carrying out environmental impact analysis.

Using Rapid Inventory Techniques for Biodiversity Conservation:

Scientific knowledge of biodiversity in the Himalayan region is still incomplete. The entire system which transcends national boundaries combined with inaccessibility has made it difficult to prepare a complete inventory. It is estimated that there are nine thousand species in the Eastern Himalayas, out of which 3500 are endemic to the region (Myers, 1988). Biodiversity (species) inventories as part of an integrated data base are thus neecessary for documentation of composition and distribution of biodiversity in each ecological zone (Di Castri *et al.*, 1992). Since time and resources are in short supply, it has become necessary to go in for a rapid method by selecting a few known centers and preparing a detailed inventory of all living forms existing in that center.

Type of inventories: There could be three broad inventories

(A) The traditional system of inventory preparation involving inputs from plant and animal taxonomists, phytogeographers and ecologists would require a lot of time and money and would still be considered incomplete. We, in India, are fortunate that a major part of the country and some parts of the Himalayas are well documented in numerous floras and records of the Botanical Survey of India and the Zoological Survey of India, plus other agencies of the Ministry of Environment. The hurdle is their wide distribution and difficulty in collating them at one place for easy retrieval and information dissemination. It is this area of exploring virgin locations that collaborative programs would be helpful, besides saving on precious time and money.

(B) Documentation of species used by humans in the country from selected regions and the various systems of medicines that use these plant products for human and animal health. This is by itself a herculaean task which can be gauged from the fact that the Dictionary of Indian Folk Medicine and Ethnobotany, covering 2500 plants with scientific names and their uses in medicine, food and other cultural practices took about 15 years to be compiled (Jain, 1991).

(C) A data base would need to be created on the wide genetic diversity in farming systems all over the Himalayan region. This would provide a wealth of information on some probable centres of diversity that would need protection. Finally an inventory or updating the existing list of endangered and threatened species, would need to be prepared which shall also include relatively unexplored regions.

Conserving species through Preservation Plots

In the present socio-political environment it would be extremely difficult to protect and preserve large areas and hence efforts have to be made to conserve such areas using local level management norms, traditions and cultures. Preservation plots are precise examples of local level management for biodiversity plots. These are " demarcated forest areas set aside in perpetuity for the preservation of the forest with no human interference beyond what is necessary for their protection and management". They also serve as ecological reference centres for studying natural ecological processes in isolation from human interference (Rodgers, 1991).

The concept of preservation plots in India is very old (first plot demarcated in 1905 for Sal in Bihar) and Kaul *et al.*, (1975) reported the existence of 188 plots in India. However, the management of these plots has been very poor, which accompanied with

Table 9: Selected localities and vegetation types for biodiversity conservation in the Himalayan region.

	Vegetation type	Champion's equivalent	Potential area (sq.km)	Area under forests (sq.km)	Total area under nature reserve (sq.km.)	Key Areas for Conservation
1.	Tropical Wet evergreen	Tropical wet evergreen	58600	4043-16056	1950.50	Danseri Kaki- Dasama (Nagaland)
2.	Tropical moist deciduous forest	–	54720	clubbed with 1	1078.53	Intangki wildlife sanctuary Nagaland, (202), Kaziranga National Park, Assam (430),Balphakram National Park, Meghalaya (200)
3.	Sub tropical broad leaved hill forest	–	3000	207-822	nil	none identified
4.	Sub tropical evergreen sclerophyllous forest	–	13400	clubbed with 1	110.3	none identified
5.	Sub tropical *Pinus roxburghii* forests	Sub tropical pine forest formation	49000	clubbed with 3	1092.09	none identified
6.	Temperate mixed oak and coniferous forest	Himalayan moist temperate forest	23600	448.4-14301.6	1555.82	Kishtwar High Alt National Park, dist. Doda, JK (200)

	Vegetation type	Champion's equivalent	Potential area (sq.km)	Area under forests (sq.km)	Total area under nature reserve (sq.km.)	Key Areas for Conservation
7.	Temperate coniferous forest	Himalayan moist temp. forest	9120	clubbed with 6	656.96	Dachigam National Park, JK (141), Gulmarg, Man & Biosphere Reserve, JK (180)
8.	Wet temperate forest	–	28280	clubbed with 6	4105	Namdapha Wildlife Sanctuary, Tirap dist. Arunachal Pradesh (232.66)
9.	Sub alpine montane forest	Alpine forest	50760	101.52-7817	1101.5	Sainj-Tirthan valley, (HP) (140), Kedarnath Wildlife Sanctuary, Chamoli dist, (Utt.) (478.5), Nanda Devi National Park (Utt.) (630)
10.	Alpine scrub and meadows	–	5120	–	408.83	Valley of Flowers (UP) (89.5)
11.	Alpine steppe	Dry alpine scrub	56000	–	1195	Shang Gaui Reserve, Leh, J&K (80), Hemis high altitude National Park, Leh, J&K (150).

Source : Gadgil and Meher Homji (1986). Figures in paranthesis are area (sq.km) of the respective parks/sanctuaries high demographic pressures has sent many of these plots into oblivion. Similarly, the size of these plots is below 10 hectares and cannot serve the purpose of long term biodiversity conservation. Investigations on an optimum plot size for different vegetation types, would therefore be a necessary prerequisite for effective conservation.

Where to get started

Site selection for inventory preparation should be prioritized in the regional context of biodiversity conservation. I have used information published earlier by Gadgil and Meher-Homji (1986) to identify selected localities that may be important for ecosystem conservation in the Himalayan Region (Table 9). Their paper is based on maps prepred by Bellan (1985) and maps of the NRSA, Hyderabad. The vegetation types defined by them are different from those given by Champion and Seth (1968). Although the information provided with regard to the area under different forest types might be at variance with what exists today. This list is by no means complete but these locations may still be useful as starting points.

Inventory preparation of all life forms and abiotic components by an interdisciplinary team needs to be set up with a networking of all Institutions from the concerned disciplines. This data base can then be used to identify richer biodiversity centres and formulate action plans for their conservation.

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