MONITORING BIODIVERSITY

- INVENTORY / PROSPECTING
  ONE TIME – EXHAUSTIVE

- MONITORING / CONSERVATION
  ONGOING – SELECTIVE

FOR E & W GHATS
MONITORING CALLS FOR
CONSTRUCTION OF A MATRIX OF
(0.65×10^5) SPECIES $\times$ (3×10^7) LOCALES
EVERY 1 – 5 YEARS

AVAILABLE INFORMATION
FLORAS, FAUNAS, CHECKLISTS
VEGETATION MAPS
FSI MAPS
SATELLITE IMAGERY

A PRACTICABLE APPROACH WOULD INVOLVE A TWO-PHASE SAMPLING

- OCCURENCE OF ~100 ESE ON BASIS OF SATELLITE IMAGERY & GROUND TRUTH

- OCCURENCE / ABUNDANCE OF A SET OF FOCAL TAXA IN SELECTED LOCALITIES

P1: IDENTIFY AN APPROPRIATE SET OF ESEs, FIELD GUIDE TO THEIR IDENTIFICATION, GUIDE TO THEIR ASSIGNMENT USING SATELLITE IMAGERY, CHARACTERISTIC TAXA PRESENT IN DIFFERENT TYPES OF ESE'S.

- SELECT LOCALITIES FOR SAMPLING

P2: STRATIFY REGION ON BASIS OF BIOCLIMATE MAPS, VEGETATION MAPS, NORMALISED VEGTTN INDEX MAPS BASED ON SATELLITE IMAGERY

DECIDE ON A SET OF FOCAL TAXA FOR MONITORING TAKING INTO CONSIDERATION

- EVOLUTIONARY LINEAGES
- HABITAT PREFERENCE
- HUMAN SIGNIFICANCE
- ECOLOGICAL ROLE
- FACILITY OF OBSERVATION, AVAILABILITY OF EXPERTISE

P3: IDENITIFY FOCAL TAXA, ~~RESOLVE~~ STANDARDISE NOMENCLATURE, CREATE A DATA BASE BASED ON LITERATURE SURVEY

P4: PREPARE FOR FOCAL TAXA ILLUSTRATED KEYS, FIELD GUIDES, ILLUSTRATED DESCRIPTIONS

P5: PREPARE MANUALS OF STANDARDISED ECOLOGICAL SURVEY METHODS FOR FOCAL TAXA

P6: INVESTIGATE PATTERNS OF DISTRIBUTION OF DIVERSITY FOR FOCAL TAXA ON BASIS OF INFORMATION EXTRACTED FROM LITERATURE

- INVESTIGATIONS MAY BE ORGANISED AT DIFFERENT LEVELS OF DETAIL
- QUANTITATIVE CENSUSES FOR KARANJ, MAHUA, SAL, KOKAM, UPPAGE
- OCCURENCES OF IDENTIFIED SPECIES OF BIRDS
- ESTIMATION OF NUMBER OF BEETLE OTU'S AMONGST 1000 INDIVIDUALS CAUGHT IN LIGHT TRAPS

FOCAL TAXA COULD INCLUDE

MEDICINAL PLANTS
OIL SEEDS
WEEDS
TREES
LICHENS
INSECT PESTS OF CROPS
FUNGAL DISEASES OF CROPS
BEES
BUTTERFLIES
FRESHWATER MOLLUSCS, CRABS
FRESHWATER FISH
PODOSTOMACEAE
DRAGONFLIES
ORABITID MITES
SCORPIONS
SOIL NEMATODES
PLATYHELMINTHS

- INFORMATION COLLECTED SHOULD BE ORGANISED IN A PROPER DATA BASE

POSSIBLE COLLABORATION WITH ARIS, IGCMC

P7 PROJECT TO DESIGN AN INFORMATION SYSTEM

- PROGRAMME SHOULD BE A COLLABORATIVE EFFORT OF

BSI, ZSI
IIRS, NRSA
DST : NRDMS, SCST
KFRI, TBGRI, IISc, ISI
FD : RESEARCH, WILDLIFE WINGS
UNIVERSITIES, AG UNIV, COLLEGES

P8 PROJECT TO DEVELOP HUMAN RESOURCES

EXPERIENCE OF WGBN PROGRAM

~ ABOUT 20 COLLEGES UNDERTOOK

1. SELECT AREA OF ~ 25 KM2
2. MAP LANDSCAPE AS A MOSAIC OF ESEs IN FIELD
3. CHECK AGAINST FCCs
4. PREPARE A MAP ON BASIS OF SUPERVISED CLASSIFICATION
5. SAMPLE REPRESENTATIVE ESE's FOR ANGIOSPERMS, BIRDS, FW INSECTS ETC
6. PREPARE ECOLOGICAL HISTORIES AND FORCES DRIVING ECOLOGICAL CHANGE
7. RECORD PEOPLE'S KLOWLEDGE OF BIODIVERSITY AND THEIR ATTITUDES TO CONSERVATION
8. PREPARE A PEOPLE'S PLAN FOR CONSERVING BD & FEED IT INTO PANCHAYAT LEVEL PLANNING PROCESS

P9 PROJECT TO RELATE RESEARCH OUTPUTS TO DEVELOPMENT PLANNING PROCESS THRU INTERACTION WITH CONCERNED OFFICIAL AGENCIES, ZPs

eg. KERALA, ORISSA

P10 : PROJECTS TO INITIATE FIELD STUDIES ON SELECTED TAXA, E.G. MEDICINAL PLANTS IN A FEW STUDY SITES

P11 : PROJECT TO LIASE WITH INDUSTRY IN MONITORING GROUPS LIKE MEDICINAL PLANTS

P12 : PROJECT TO LIASE WITH AGRICULTURE DEPTS IN MONITORING PESTS, WEEDS

P13 : PROJECT TO LIASE WITH PUBLIC HEALTH AUTHORITIES IN MONITORING MOSQUITOES, FLEAS, RATS

P14 : PROJECT TO LIASE WITH POLLUTION CONTROL AUTHORITIES IN MONITORING FRESH WATER FISH, MOLLUSCS

P15 : PROJECT TO LIASE WITH COLLEGES, UNIVERSITIES TO EXPLORE POSSIBILITIES OF CURRICULAR REFORM

MONITORING BIODIVERSITY OF EASTERN AND WESTERN GHATS :

FORMULATING AN ACTION PLAN

Madhav Gadgil

CENTRE FOR ECOLOGICAL SCIENCES
INDIAN INSTITUTE OF SCIENCE
BANGALORE 560 012 INDIA

Telephone: (91-80) 3315453, 3340985, 3092507
Cable: `Science' Malleswaram, Bangalore, India
Telex: 0845-8349; FAX: 91-80- 3315428, 3341683
E-Mail: madhav@ces.iisc.ernet.in

SUMMARY

As a party to the Convention on Biological Diversity, India is committed to inventory and to monitor throughout the country levels of biodiversity so as to assess the efficacy of conservation measures. The vital task of inventorying, or one time listing of India's biological diversity of over 1,25,000 described and perhaps another 400,000 undescribed species and requires urgent attention. But the task of monitoring, or periodic assessment, cannot wait for inventorying to be completed and must proceed side by side. Monitoring at the species level, leaving aside the much larger challenge of genetic variation, would then imply assessing changes over time in populations of more than 1,25,000 species over 320 million ha of land and 200 million ha of exclusive economic zone in the sea. This is obviously too large a task and it is necessary to scale it down to periodically assessing changes in occurrence/abundance of a selected subset of species in sample localities. This can be couple to monitoring changes at grosser levels of land cover in terms of vegetation types, or earthscape element types, with the help of satellite imagery. Even then it is a massive task which could be undertaken only through a network of institutions distributed throughout the country. Undergraduate science colleges are an appropriate choice for such a decentralized effort; they would have to work in collaboration with more sophisticated agencies such as Botanical and Zoological Surveys, National Bureaus of Plant, Animal and Fish Genetic Resources, research institutions such as Kerala Forest Research

Institute and Universities as well as managers such as forest, agriculture, fisheries departments. If college biology teachers and students are to serve as the major scientific human resources at the field level, they would have to be supported with literature and training. The information generated by them would have to be properly organized in computerized data bases, synthesized and used as inputs for planning for conservation and sustainable use.

The Ministry of Environment and Forests Expert Group on Eastern and Western Ghats Co-ordinated Research would like to take up the challenge of formulating a pilot project to eventually develop a programme of biodiversity monitoring for the whole country. To this end it plans to convene a brainstorming session at Bangalore on September 16-17, 1997 to resolve the following issues :

1) Delineation of biogeographic subprovinces and bioclimatic zones to guide the choice of sampling localities. Such choice would also have to reflect the varying levels of human impacts in different parts of the Eastern and Western Ghats. We may decide upon 30-50 strata which should find representation in the final sampling programme.

2) Choice of focal taxa, at least at the level of phyla and classes and if possible in finer detail for the sampling programme. Plan for generating the requisite resource material promote reliable sampling of these taxa.

3) Plan for finalizing a system of classification of landscape and waterscape elements and preparation of requisite resource material to promote reliable identification of these elements.

4) Choice of sampling methods appropriate to different focal taxa and earthscape elements and plans for preparation of requisite resource material to promote reliable sampling at the field level.

5) Plans for developing a network of institutions to undertake a programme of monitoring the biodiversity of Eastern and Western Ghats.

1. INTRODUCTION

Ministry of Environment and Forests, Government of India sponsors scientific research relevant to its own mandate of addressing the variety of environmental issues facing the country. One of the most significant of such issues to have emerged in recent years is conservation and sustainable use of country's rich heritage of biological diversity (WCMC 1992; Heywood 1995).

Diversity of all, even the seemingly most insignificant, life forms has today acquired the potential for commercial application. At the same time this diversity is being eroded rapidly with fears that at least 10% of all species will become extinct over the next few decades. These twin developments have led to the adoption of an International Convention on Biological Diversity by India and most other countries of the world. This Convention obliges us to inventory the country's biodiversity, make all attempts to conserve these resources and monitor the efficacy of the conservation measures adopted (UNEP 1991). These are important scientific challenges, challenges that India's scientific community must turn into a major opportunity to chalk out a programme of original research of genuine applied value (Gadgil 1994).

These challenges are especially pertinent to biodiversity rich regions of the country, such as the Western and Eastern Ghats, the northeastern hill tracts, Andaman and Nicobar or Lakshadweep islands. The Ministry's Expert Group overseeing the co-ordinated research programmes in the Eastern and Western Ghats has therefore very appropriately identified biodiversity monitoring as one of the thrust areas in which to promote an interdisciplinary - interinstitutional programme.

It might be useful to point out at this juncture that periodic monitoring should be distinguished from inventory or a one time listing of the entire diversity of India's living organisms at the species as well as intraspecific genetic levels. With over 1,25,000 described and perhaps another 400,000 undescribed species of plants, animals and microorganism, and enormous variation at intraspecific genetic level this inventorying is a large task which would keep sophisticated technical agencies like Botanical and

Zoological Surveys of India and National Bureaus of Plant, Animal and Fish Genetic Resources busy for decades to come. Thus, of the projected 30 volumes of Flora of India, only 5 have been completed over the last few years; the task of documenting animal species, especially small forest canopy or soil dwelling insects and mites or the sea bottom dwelling invertebrates will similarly take decades to approach completion. This task of inventorying is a most vital task. We cannot however afford to wait for it to be completed before initiating a programme of monitoring.

2. MAGNITUDE OF THE TASK

The challenge of biodiversity monitoring is also enormous, for our known diversity of over a lakh species is distributed over the country's 320 million ha of land and 200 million ha of exclusive economic zone in the sea. Covering 10% of the country's land area, the Eastern and Western Ghats are expected to harbour about 55% of India's terrestrial and freshwater biodiversity. Since the interest is no longer confined to flagship species, such as a few hundred Nilgiri tahr in the higher reaches of Western Ghats, monitoring the efficacy of conservation measures calls for monitoring the abundances of the entire spectrum of organisms over the whole landscape and waterscape of the region. Even then this leaves out the question of maintenance of intraspecific genetic variation. If then the appropriate spatial scale for monitoring is that of a hectare, we want to construct for the region a matrix of $(0.65 \times 10^5) \times (3 \times 10^7)$ species by locales, with each element in the matrix being the abundance of a given species, in a particular hectare at some specified time. Monitoring would involve assessing changes in this matrix over time.

This exercise of monitoring which must proceed side by side with inventorying, cannot obviously attempt to look at all species, and all genes, over every hectare of our land and waters. So this would have to be an exercise of periodic assessment of selected taxa in some sample localities, intelligently chosen so as to provide an indication of what is happening to overall biodiversity, everywhere. This is still a massive task which can only be attempted as a co-ordinated but decentralised effort.

3. BACKGROUND INFORMATION

It may be appropriate to begin by reviewing the nature of information already available with us to guide in this task. The main form in which such information occurs is as floras, faunas and checklists. These are reports of occurrences of particular species in particular localities. The localities are most often specified broadly as biogeographic provinces, such as Malabar or Gangetic plains or in terms of districts or states and occasionally a little more specifically, for instance, Nellamalai hills. The checklists often refer to more circumscribed localities, e.g., birds and mammals of Bandipur Tiger Reserve. Such publications often contain another kind of information as well, namely on habitats of organisms of interest; thus Daniels (1997) mentions some 24 distinct habitats for Western Ghats bird species. Such habitat categories necessarily pertain to those appropriate for focal organisms under consideration, be they birds, dung beetles or bracket fungi.

Ecological and biogeographic investigations constitute another important source of information. At the level of community ecology, the plant assemblages have been assigned to a series of forest or vegetation types. The French Institute classification, for instance, employs 43 vegetation types, each with 5-6 series of degradation stages. For each of these the accounts specify characteristic species, mostly trees (Puri et.al. 1983). The incidence of these stages has been mapped to the accuracy of sq. kilometers for some parts of the country the most detailed maps being available for the Western Ghats region (Pascal 1986). Ecological investigations may also focus on individual species, such as the Indian elephant, or anopheline mosquitoes specifying their abundances and distribution in detail of variable level.

All of this information is scattered with inadequate standardization of either scientific nomenclature, or ecological categories such as vegetation types or habitats. The specification of geographical localities is also very variable and often insufficient. An important first step is then to standardize and achieve some common understanding in use of scientific names, geographical localities and vegetation types or habitats.

4. REMOTE SENSING

Another most significant source of information on the land cover of the country is the satellite imagery. IRS 3 produces information on reflectances on a scale of 128 values for blue, green, red and near infrared wavebands for picture elements or pixels on a scale as fine as 0.1 ha every 20 days. This information on reflectances can yield many clues as to the coverage of assemblages of plants at canopy level, information that has been used to map occurrences of vegetation types. The availability of aerial photographs and satellite imagery has led to the development of a new discipline, landscape ecology, focussing on the interrelationship of different types of biological communities defined on scales of ha in a locality at a scale of tens of sq. kms. Landscape ecology views a locality as a landscape comprising a mosaic of different types of landscape (or waterscape or more generally earthscape) elements. These earthscape element (ESE) types are identified on scales of 0.1 ha, or so, the scale of pixels in a satellite imagery (Forman and Godron 1986). They are thus generally identified on a scale finer than that of vegetation maps. They do largely correspond, however, to the vegetation types and their degradation stages, or habitats as defined for large mobile animals like birds. A preliminary investigation for the Western Ghats suggests that around 100 types of landscape and waterscape elements, may be an appropriate device for standardizing the categories of vegetation types or habitats to be used in a Eastern and Western Ghats region-wide exercise for monitoring biodiversity (Gadgil 1996b).

The total task at hand was defined above as that of determining the matrix of abundances of 0.65×10^5 species for 3×10^7 locales. This may usefully be broken down into a two step process, namely (1) determining the matrix of occurrences of hundred or so ESE types for the 3×10^7 locales, and (2) determining the range of abundances of species in each of these hundred or so ESE types, and then inferring likely abundances of species in the actual locales (Nagendra and Gadgil 1997).

5. EARTHSCAPE ELEMENT TYPES

The first scientific challenge then is to choose an appropriate set of ESE types considered on the spatial scale of a hectare for the region. On land these elements may best be determined on basis of the dominant plant form. In case of aquatic habitats, the depth and flow regime of water and substratum would be the main criteria. Terrestrial habitats on this scale have been defined as vegetation types in the UNESCO classification on the basis of structure and seasonal changes (Muller-Dumbois and Ellenberg, 1974); an appropriate modification of this world-wide system may be the best choice for India.

On land this could relate to the structure and seasonality of dominant plant form whether trees, scrub or grasses. Where managed, often single species dominated ecosystems such as paddy fields are concerned, it may be based on the composition of the vegetation. While defining landscape element types one must also take into account the occurrence of structures like buildings and roads. It may be noted that this typology of ESE types would cut across the systems of classification on larger spatial scale such as biogeographic provinces or agroclimatic regions. Thus scrub savanna or paddy fields may be elements present in many different biogeographic provinces or agro-climatic regions. These may also be secondarily derived from distinct vegetation types such as evergreen or deciduous forests. The classification of earthscape elements types may themselves be arranged in a nested hierarchy, e.g. forest - evergreen - open canopy evergreen. Our aim should then be to try and arrive at a countrywide system of earthscape element classification that would be broadly acceptable to ecologists, agricultural scientists and remote sensing experts.

This set of earthscape elements should fulfill the following requirements :

1. An observer in the field should be in a position to assign any particular locale to a particular ESE type on the basis of a set of criteria such that inter-observer variation in such assignment is within some acceptable level.

2. It should be possible to assign a pixel characterized by certain spectral signature (i.e., reflectance values in the four bands) to a particular ESE type on the basis of either visual interpretation of a false colour composite, a supervised

classification, or an unsupervised classification within some acceptable level of error in relation to the ground truth.

3. The different ESE types should differ from each other significantly enough in the set of biological species they harbour, so that assignment of an ESE type to a given locale carries useful information on the likely occurrences of plant, animal or microbial species.

To operationalize such a research programme, we need material to help in the identification of earthscape element types at the whole hierarchy of classification Such material should include keys and descriptions of diagnostic features such that interobserver variation in assigning a given locale to a particular earthscape element type would be minimized. The accounts should include illustrations of vegetation profiles or stream or pond cross-sections and lists of characteristic plant and animal species present. They should also provide clues to spectral signatures and appearance in false colour composites of the elements under normal conditions without complications such as slope or shadows with respect to satellite imagery.

This resource material would facilitate assigning different spatial elements of study localities to types of earthscape elements in a replicable fashion for investigators in different parts of the Eastern and Western Ghats. Mapping the earthscape of the study locality in this fashion on basis of field work aided by topographic maps would then be an important step in biodiversity monitoring (Palat 1997). As far as possible such mapping should be further facilitated by use of satellite imagery, through visual interpretation of false colour composites, or supervised classification. As a bonus, such a programme would serve yet another valuable function, namely to promote remote sensing literacy.

6. SELECTING LOCALITIES

The next step in the process would be to determine the distribution of occurrences/abundances of different species over the region in the whole range of ESE types. To this end, we would have to assess occurrences/abundances of some sample subset of species in a sample subset of localities in specific individual elements or patches of the different ESE types. We may first take up the second question of how to select the localities for such an investigation. The choice would be guided by the many sources of variation in the abundances/occurrences of species in different parts of the Eastern and Western Ghats. Such variation could be viewed at a number of different spatial scales. At the largest scale it is captured by the differences amongst the various biogeographic subprovinces. Thus the Palghat gap is an important geographical barrier to the distribution of living organisms, with a number of species being restricted to the Western Ghats south of the Palghat gap. At the next lower spatial scale, bioclimatic conditions determine the distribution of living organisms. Thus Rhododendrons and Nilgiri tahr are confined to higher elevation plateaus of the Western Ghats subprovince south of Palghat gap. At a finer scale still the distribution of particular species is governed by the distribution of different types of landscape elements. Thus Nilgiri tahr is confined to high elevation grasslands of this biogeographic province. Furthermore, Nilgiri tahr do not occur on all such high elevation grasslands. Their occurrence as that of other species, is dependent on a number of factors such as :

1. Size and shape of the earthscape element. Thus smaller elements may exclude species requiring large areas for their territory; and elements shaped so as to possess a high edge to interior ratio may favour certain ecotone species.

2. Distance from other elements of the same type. Very isolated elements may have lower abundances of many species than elements in vicinity of several others of the same type.

3. Identity of neighbouring elements. Thus species characteristic of neighbouring ESE types may occur in greater abundance than those of ESE types present only at a distance.

Ideally then the sampling localities and within them the subset of landscape (or waterscape) elements to be sampled for abundances should be picked out on the basis of some stratified random sampling design, with sampling effort being related to the extent of pertinent variation. Of course the relative magnitude of variation in these different contexts may differ from one group of organism to another. Thus abundances of frog species may vary much more than those of bird species from one biogeographic province to another, but may vary much less than those of bird species in relation to the identity of adjacent earthscape elements.

The choice of the subset of earthscape elements to be investigated should also serve one more function namely, to generate information on the extent of spatial autocorrelation in the abundance of particular species. This information would be important in determining the disposition of earthscape elements to be sampled to actually assess the abundances of the various species for the purpose of monitoring. So the elements selected for sampling should also be separated from each other over a whole range of distances.

7. SELECTING SPECIES

The next issue is that of the subset of the species to be censused in these sampling locales. It is impossible to cover the full subset of 65,000 or so described species, that are estimated to be present in the Western and Eastern Ghats region. A subset would have to be selected based on the following considerations :

1. Representation of all evolutionary lineages
2. Representation of groups preferring the whole range of ESE types
3. Human significance, such as pollinators, medicinal plants or vectors of human diseases
4. Possible role as keystone resources, as indicators etc.
5. Facility of censusing, availability of taxonomic expertise.

These choices should permit us to generate maximum information of value given the inevitable limitations on the effort that can be deployed. So the focus would be on species or groups such as birds or flowering plants that can be easily tackled. It would also be on species or groups of more immediate conservation importance such as wild relatives of cultivated plants. But along with this an important issue is to generate a fuller understanding of patterns of co-variation in abundances of different taxa. With this in view, the sampling effort may be so deployed as to simultaneously investigate the occurrences of large numbers of different taxonomic groups such as lichens, mosses, flowering plants, ants, butterflies, freshwater molluscs, fishes, birds and mammals, at least in a subset of the total set of locales selected for investigation.

8. CENSUSING TECHNIQUES

The third set of questions to be addressed is that of choice of censusing techniques. There are a variety of methods available, demanding different levels of effort and providing different levels of information. The gigantic task of monitoring the whole spectrum of biodiversity over the entire region would not permit the luxury of very careful determination of the abundances of a large number of species. It may then be appropriate to record presence / absence of most focal species selected for investigation with more careful sampling of just a small number of species of special significance such as medicinal plants, vectors of human diseases or large mammals on verge of extinction. It may be impossible to identify all taxa by their correct scientific name and they may simply be sorted out into operational taxonomic units. Another possible approach may be to confine attention to a higher taxonomic category, such as an order, e.g., beetles and record the number of OTU's in some defined sample, such as 500 individual beetles collected in a light trap.

Assessment of abundances (or simply presence / absence) of focal taxa within study localities would have to be based on transects, quadrats, or plotless methods. Decisions need to be made on placing of such sampling units with respect to patches of different types of earthscape elements. The sampling units may wholly lie within such individuals patches, cut across two or more patches, or lie on the ecotone. They have to be allocated to different types of earthscape elements randomly, or in proportion to the area covered by them or with higher weightage for types exhibiting higher levels of species packing (alpha diversity) or turnover (beta diversity). There may be fewer larger or many more smaller sampling units.

Our ultimate objective is to monitor change over time; it is therefore also necessary to assess the appropriate intensity of sampling and the appropriate frequency of censusing in time. For many species the season of flowering, or of emergence as adults is short and censusing has to coincide with these important events. The population levels of different species may show very different levels of correlation from one generation to next, and therefore call for different frequencies of sampling. The sampling programme should be so structured as to generate considerable information on co-variation in time for at least a subset of species under investigation.

Making these decisions requires us to define some criterion/ criteria that the sampling design must optimize. Maximizing the number of species encountered for a given level of effort may be one such criterion. In any case little good information exists to permit us to decide on the level of sampling effort that would be required to detect a certain level of change in the composition of the biological community over time. The relevant parameters would have to be estimated on the basis of initial sampling and the sampling design progressively improved as the monitoring programme progresses.

Actual surveys of specific taxonomic groups in specific earthscape element types would follow these decisions on study localities and sampling units. These methods, e.g. of assessing abundance of lichens in forest habitats or alpine pastures, or of freshwater fish in ponds or streams need to be standardized for application in the field throughout the Eastern and Western Ghats region by different investigators (Sunderland 1996). We should facilitate this by identifying investigator - friendly, practical methods that do not require high levels of investment in equipment or time.

Apart from assessing abundance/ occurrence of specific taxa the surveys should also include recording of ancillary environmental parameters such as pH of water or basal area of woody plants in a forest. To operationalize such a research programme, we should provide simple, clear descriptions of survey methods. We should also pay particular attention to the need to minimize disturbance to the habitat or destructive sampling of organisms in all these efforts. Nevertheless some collections would be essential. We should develop guidelines on how to keep these to minimal levels, as well as provide to the investigators descriptions of methods of collection and preservation. Proper links between such field collections and maintenance, curation and identification of material in centres of systematic biology such as Botanical or

Zoological Surveys of India or Bombay Natural History Society would also have to be organized as a part of the overall programme of monitoring biodiversity.

9. PEOPLE AND BIODIVERSITY

These strictly ecological and systematic studies need to be complemented by studies of how humans - village communities, resource managers, traders, industry - relate to living resources and how they transform the earthscape. This is important since we cannot provide useful inputs for conservation and sustainable use (or control) without an understanding of this whole dynamic. Standardized methods need therefore to be devised for this purpose. People's Biodiversity Registers is one such methodology focussing on village communities (Gadgil 1996c). This register documents local knowledge of living resources and earthscape, their locally known uses, local understanding of harvest and other influences including habitat transformations leading to changes in abundances, their perceptions of forces driving these changes, their own development aspirations and perceptions of how to go about conservation of biodiversity. As a part of a pilot project several such registers have already been compiled. The Kannada version of one of these, for village Mala in Karkala Taluk of Dakshina Kannada in Karnataka was formally handed over to the village community on World Environment Day, June 5, 1997 by Dr. Shivaram Karanth (Achar 1997). We need further work along these lines to develop methodologies for investigations of commercial harvests and trade, as well as perceptions and prescriptions for biodiversity management by other components of the society.

Changes in the earthscape are an important cause of changes in biodiversity. These may be assessed on basis of satellite imagery taken at different times, topographical maps prepared at different times, official records such as Project Reports for river valley projects or Forest Department Working Plans, or on the basis of oral histories recounted by local people. It would be worthwhile developing standard methodologies for recording earthscape changes, as well as evidence relating to forces driving such changes from different sources (Prabhakar and Gadgil 1995; Chandran, 1997).

10. INFORMATION MANAGEMENT

The large amount of information that such a programme would generate needs to be synthesized, digested and then made available to promote a process of more biodiversity friendly development planning. Ideally this synthesis should take place at a hierarchy of levels; district, state, region and involve not only educational and research institutions, but organizations like the district and state units of Natural Resource Data Management System of Department of Science and Technology, as well as Zilla Parishats and State Governments. The data should be generated on the basis of comparable methodology and should be computerized and made accessible to all interested parties subject to the guidelines that need to be developed by the Ministry of Environment and Forests, Government of India. The responsibility for computerization, synthesis and management should be assigned to some appropriate ENVIS centres with a focus on Eastern and Western Ghats, or on biodiversity.

11. ORGANIZING THE EFFORT

This obviously needs to be a multi-disciplinary, multi- institutional effort involving the disciplines of systematics, ecology, biogeography, remote sensing, statistics and informatics. The actual monitoring in the field would best be carried out as a decentralized effort by a network of institutions available in all parts of the Western Ghats - Eastern Ghats region. Undergraduate science colleges are obviously the most appropriate choice, there are an estimated 1000 or so of these in the 75 districts of Western and Eastern Ghats region. Together this would mean a human resource of 2500 or more M.Sc or Ph.D degree holders serving as teachers of biology and some 50,000 or more students majoring in botany, zoology or microbiology at the B.Sc. level. A pilot project to assess the potential of deploying this student and teacher power to the task of monitoring biodiversity of the Western Ghats has met with an excellent response (Gadgil 1996b). It has involved 18 colleges in the states of Maharashtra, Karnataka, Tamilnadu and Kerala and was also supported by the Indian Institute of Science, Bangalore, Dr. M.S. Swaminathan Research Foundation, Chennai, Foundation for Revitalization of Local Health Traditions, Bangalore and

Regional Remote Sensing Services Centre, ISRO in Bangalore. These institutions have provided considerable support in terms of methodology manuals, training programmes and data analysis and interpretation. This experience and this package of resource material can now be developed further for supporting a broader programme for Western and Eastern Ghats region.

Thus visualized the monitoring effort will proceed as a networked, co-ordinated activity comprising:

1) Mapping of the ecological setting or the habitat mosaic of the study locality.

2) Assessment of population densities of a focal set of species in the different habitats or earthscape elements of the study locality.

3) Assessment of various factors affecting the pattern of existing habitats in the study locality, (e.g. conversion of scrub into monoculture of Eucalyptus, conversion of a clear water into eutrophic lake by release of sewage into water).

4) Assessment of factors affecting populations levels of focal species in the study locality (e.g. harvest as fuelwood, fish kills following eutrophication).

5) Assessment of responses of various segments of society to ongoing changes in diversity of living resources (e.g. forest produce collectors, forest officials, forest produce supply contractors, pharmaceutical companies to depletion of medicinal plant resources), and their prescriptions for conservation and sustainable use of biodiversity.

A major shortcoming of decentralised efforts is the difficulty of standardizing methodologies and generating comparable data. The success of the proposed system of monitoring biodiversity will therefore be crucially dependent upon devising standard methods which can be suitably adapted to local situations by generating resource material for investigators and providing them with appropriate training. Lifescape, a project launched by the Indian Academy of Sciences in November 1996 to commemorate the birth centenary of Salim Ali, aims to meet this challenge (Gadgil 1996a). Its objectives include:

1) Identifying an appropriate set of focal species whose abundance would be assessed in study localities in all parts of the country.

2) Generating material to aid in reliable identification of these taxa.

3) Devising a standardized system of classification of ecological habitat types that could cover all parts of the country.

4) Generating material to aid in reliable classification of ecological habitat types.

5) Devising standardized survey methods to assess abundance and utilization of the focal taxa in the various habitat types.

6) Devising methodologies for recording changes in habitats and focal species abundances in recent past.

7) Devising a set of student projects appropriate to the focal set of species, so as to advance the understanding of various topics in ecology, evolutionary biology, behaviour and biogeography.

8) Designing a computerized biodiversity information system to organize the data generated through the activities of the biodiversity monitoring network.

9) Field testing of the programme outlined above through pilot projects in selected high schools, colleges and universities.

Such a programme can be accomplished only as a co-operative effort of people knowledgeable in a variety of fields; systematics of different groups of organisms, ecology, biogeography, remote sensing, biostatistics and informatics as well as people with experience in natural history, and in teaching of biology and environmental sciences at all levels under different situations in different parts of the country. Project Lifescape has begun to develop a network of such resource persons throughout India by intimating interested people of the participatory nature of the project through the medium of journals, periodicals and newsletters such as Current Science, Hornbill, Resonance, WWF and CEE newsletter and Newsletter for Bird Watchers. Over 1000 people have as a result expressed an interest in participating in the project; their help will be sought in a variety of ways as the project develops (Annexure 1).

Project Lifescape has simultaneously developed a network of biology teachers from the Western Ghats, states of Maharashtra, Karnataka, Tamil Nadu and Kerala, who have over the last three years participated in programmes of field monitoring of biodiversity as an extracurricular activity. A group of such teachers from autonomous colleges in Tamil Nadu have now come forward to incorporate such activities as a part of biology curricula in their colleges (Gadgil 1997).

12. TAXONOMIC ACCOUNTS

Biodiversity monitoring would have to be based on assessing population levels of a focal subset of reliably identified species. A study locality covering an area of 32 Km^2, constituting one hundred thousandth of the total area of the country, is expected to harbour between 2% to 5% of the total number of Indian species. This is equivalent to 2,500 to 6,250 of the 1,25,000 described species. Obviously this is too large a number for school or college students and teachers to handle. Something of the order of 100 to 300 is on the other hand reasonable. Many barefoot ecologists, shepherds, fisherfolk, forest produce collectors do know these many different species of plants and animals (Achar 1997). It is then reasonable to expect biology students and teachers to know a similar level of diversity from their own localities. Since the total number of species over all of India would be between 20 to 50 times the number of species in a study locality, we may reasonably aim at a focal subset of 6,000 species at the all-India level, and a subset of around 3300 species for the Eastern and Western Ghats region.

The programme of monitoring biodiversity of the Eastern and Western Ghats should then aim to make available accurate yet user friendly illustrated descriptions of 3300 focal species and the pertinent higher taxonomic categories such as genera, families, orders, classes and phyla. These descriptions should be accompanied by pictorial keys in the form of flow charts to aid in identification down the taxonomic hierarchy. Thus the account of the malarial vector mosquito Anopheles stephensi should include as supporting material accounts of phylum Arthropoda, class Insecta, order Diptera, family Culicidae and genus Anopheles. It should also have an illustrated key guiding the investigators to Anopheles.

Each species (or higher taxon) account should include a statement of diagnostic characters relevant for identification and descriptions of other similar taxa with which it may be confused. This would differ from a taxonomic account in being focussed on facilitating identification rather than furnishing a complete description. The account should also include a description of the habitat preference, geographical range, and habits and behaviour. It should discuss possible human significance of the taxon from perspectives of utility or harm it may cause, as well as from aesthetic, cultural or religious perspectives. It would include local names in regional Indian languages, and material such as mention of the taxon in folklore or literature. It would describe current threats to its persistence or possible dangers of excessive growth of its population. Annexure 2 provides an illustrative example of one such account (Gadgil 1996a). Since our focus is on monitoring abundance we should aim at simple, practical methods of field surveys which could be adapted throughout the Eastern and Western Ghats region to yield comparable data. We should leave out any more complex methods, or methods requiring equipment or effort beyond the capabilities of college students and teachers. The taxon accounts should also include material to facilitate students taking up other projects of interest from the perspective of teaching different aspects of ecology, biogeography, behaviour or evolutionary biology. The accounts should aim to use simple language and more commonly understood words in preference to technical terms to the extent possible. All technical terms should be explained, as far as possible with help of illustrations, either in the text or in an accompanying illustrated glossary.

13. STUDENT PROJECTS

As argued above, B.Sc. level students and teachers of biology might be the best human resource to undertake biodiversity monitoring at a large number of sites spread throughout the country. Such monitoring could be conducted through student projects, either as extra-curricular or curricular activity, and as individual or group projects. Students of subjects other than biology may also be involved. The members of the Western Ghats Biodiversity Network involving B.Sc. level biology teachers and students of biology and other subjects from 18 colleges have carried out several such exercises over a three year period from 1994-96 as extra-curricular group projects (Palat 1997).

Integrating such activities in the regular curricula of environmental studies or biology could greatly facilitate organizing such monitoring on a wider scale. Such changes in curriculum are easiest for autonomous colleges and a group of 7 autonomous colleges of Tamil Nadu, two of which were a part of the earlier Western Ghats Biodiversity Network Project have taken such an initiative. Annexure 3 provides an example of the curriculum developed with this perspective by one of the colleges.

Such curricular change has broader implications beyond organizing monitoring of biodiversity. The change would promote observations of living organisms under natural condition in the vicinity of the educational institution as an integral part of teaching, especially of systematics ecology, evolution, biogeography and behaviour (Gadgil 1997). It is then appropriate that apart from biodiversity monitoring students be encouraged to take up other such projects as well. To illustrate the possibilities, assume that the Indian Myna (Acridotheres tristis) is one of the focal species selected for biodiversity monitoring. A very good way of assessing abundance of this species is to count the birds at their large night time gatherings or communal roosts. Such censuses could be easily combined with behavioural observations. These could lead to interesting projects on the sleep-wake-activity rhythms of the birds in relation to changing times of sunrise and sunset, or on the variety of calls used at the roosts. Similarly, trees of genus Ficus may be selected as a focal group for biodiversity monitoring. In that case studies of fig wasps that both help pollinate and feed on ovules of these plants would provide an excellent subject material for projects relating to evolutionary biology. The teachers would of course have to tackle the tricky problems of evaluating such individual or group project work and ensuring that students receive fair credit for the effort put in.

14. ORGANIZING DATA BASES

Over last three years The Western Ghats Biodiversity Network has already generated a certain amount of base data on the abundances of flowering plants, butterflies, ants, freshwater molluscs, aquatic insects, caecilians and birds in different types of earthscape elements in some 18 localities (Gadgil 1996b). The study localities have also been mapped in terms of earthscape elements, and matrices of how they are being transformed determined (Palat 1997). All this data has been computerized. At the same time considerable amount of data on the distribution and habitat preference of flowering plant and bird species of India has been extracted from literature and computerized. All this is being organized as a Biodiversity Information System. It would be necessary to build on this and other experiences and create for the Eastern and Western Ghats programme a flexible biodiversity information system which would take in, synthesize the information being generated through the field exercises and then make it available to all interested parties for a variety of purposes; to promote conservation measures, suggest strategies to sustain use and to control in an effective fashion.

It would be important to ensure that we take full advantage of modern information technologies and the availability of computers and electronic mail to reach this information to all users, be they forest departments, educational institutions or forest produce collectors' co-operatives.

15. RESEARCH PROJECTS

Information thus generated could not only be applied to its central purpose of biodiversity monitoring, it could have several spin-offs. It could, for instance, promote a great deal of interesting ecological, biogeographic, evolutionary or behavioural research. Pramod et.al. (1997a and b), Utkarsh et. al., (in prep.) Kunte et.al. (in prep.) provide examples of such research flowing out of the Western Ghats Biodiversity Network. These are examples of research for which scientists working in the biologically rich tropics are at a natural advantage because of the ready accessibility of interesting research material. Such research does not require sophisticated instrumentation or expensive chemicals and is therefore within easy reach of most Indian scientists, even those working in small colleges in muffosil places. Such investigators are primarily handicapped by access to scientific literature. This handicap is now greatly reduced because of the possibilities of easy access to information through electronic media. Our Eastern and Western Ghats Biodiversity Monitoring project ought to capitalize on this tremendous potential by organizing a network of such investigators and by making accessible to them basic resource material and training.

16. AN ACTION PLAN

The programme thus visualized would involve the collaboration of a whole range of actors. An indicative (not exhaustive) list of such actors includes :

1. Botanical, Zoological and Forest Surveys of India, National Remote Sensing Agency.
2. Research Institutions such as Kerala Forest Research Institute, Tropical Botanical Garden and Research institute.
3. University departments of Botany, Zoology, Statistics, Life Sciences.
4. Undergraduate colleges
5. Research and Wildlife wings of State Forest Departments

A first step in formulating such a programme was taken at a one-day brain storming session, in conjunction with the second meeting of the Expert Group on Eastern and Western Ghats on June 18, 1997 hosted by the Statistics Department of Pune University which has had a major long term interest in Statistical Ecology. This meeting attracted over 50 participants from amongst botanists and zoologists of BSI and ZSI, officials of forest departmetns, teachers from colleges and universities and researchers from variety of disciplines ranging over remote sensing, ecology, taxonomy and statistics. The proposed meeting on September 16-17, 1997 at Bangalore would be a follow up of this discussion to arrive at a number of detailed decisions. The detailed decisions that we must take include :

1) Delineation of biogeographic subprovinces and bioclimatic zones to guide the choice of sampling locaties. Such choice would also have to reflect the varying levels of human impacts in different parts of the Eastern and Western Ghats. We may

decide upon 30-50 strata which should find representation in the final sampling programme.

2) Choice of focal taxa, at least at the level of phyla and classes and if possible in finer detail for the sampling programme. Plans for generating the requisite resource material to promote reliable sampling of these taxa.

3) Plans for finalizing a system of classification of landscape and waterscape elements and preparation of requisite resource material to promote reliable identification of these elements.

4) Choice of sampling methods appropriate to different focal taxa and earthscape elements and plans for preparation of requisite resource material to promote reliable sampling at the field level.

5) Plans for developing a network of institutions to undertake a programme of monitoring the biodiversity of Eastern and Western Ghats.

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ANNEXURE - 1

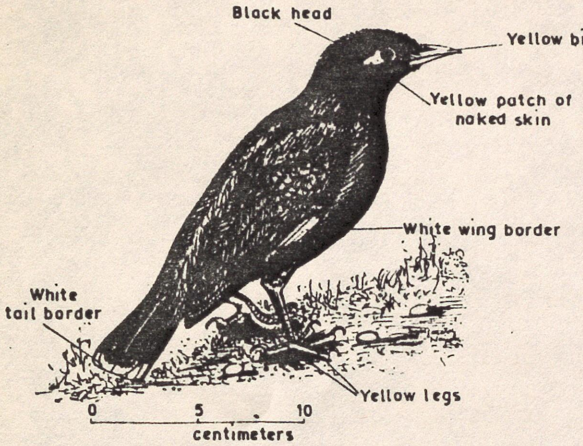
(As on 15th August 1997)

GEOGRAPHICAL DISTRIBUTION OF PEOPLE WHO HAVE EXPRESSED AN INTEREST IN PARTICIPATING IN PROJECT LIFESCAPE

STATE	NUMBER OF RESPONSES
Andaman and Nicobar	5
Andhra Pradesh	35
Arunachal Pradesh	8
Assam	36
Bihar	25
Chandigarh Union Terri.	3
Delhi	37
Goa	32
Gujarat	63
Haryana	16
Himachal Pradesh	15
Jammu and Kashmir	13
Karnataka	167
Kerala	81
Madhya Pradesh	20
Maharashtra	172

STATE	NUMBER OF RESPONSES
Manipur	11
Meghalaya	8
Mizoram	2
Nagaland	1
Orissa	40
Punjab	17
Rajasthan	31
Sikkim	2
Tamil Nadu	161
Tripura	2
Uttar Pradesh	72
West Bengal	45
Unclassified	84
Total (Indian response)	1204
Bangladesh	1
Taiwan	1
U.S.A.	1
West Indies	1
Grand Total response	1208

ANNEXURE - 2



Indian Myna

Acridotheres tristis (Class Aves, Order Passeriformes, Family Sturnidae).

Size: 23 cm in length, about 110 gm in weight, a little smaller than a dove, bigger than a bulbul.

Field character: With its plump body, short tail and straight, sharp bill, the Indian Myna is a characteristic feature of Indian life. It is dark brown in colour with a glossy black head and bright yellow legs, bill and a naked patch below and behind eye. When in flight a white bar opens out on the wing; its tail is also bordered with white. Males and females are indistinguishable, the young are a little duller in colour with the heads ashy brown rather than black.

Related species. Indian Myna most resembles the Jungle Myna (*Acridotheres fuscus*) which lacks the yellow patch of skin behind the eye, is greyer in colour and has a little tuft of black feathers at the base of its bill on the forehead. The Bank Myna (*Acridotheres ginginianus*) is slightly smaller and pale bluish grey in colour, with a brick red patch of naked skin below and behind the eye.

Habits. Indian Myna follows people everywhere in the country, quick to colonize even far out in the desert. It is to be seen in town and villages, fields and gardens, sometimes walking after cattle, other times hunting insects on its own. It has a direct, business like flight in the air and a parade step on the ground. Mynas go in pairs or small parties, chattering a great deal. They sleep in large aggregations at communal roosts in large leafy trees, coconut groves, sugarcane fields, or in warehouses or railway stations. Such communal roosts are often mixed with those of crows, sparrows, parakeets or rosy pastors.

Nesting. The breeding season is primarily between April and July, but may commence as early as mid-January in Kerala and extend to September in parts of the country. Mynas nest in holes in trees or in walls and roofs of buildings. Usually there is considerable competition for nesting sites with violent fights between members of prospective pairs. Each partner grapples with its opposite number in a noisy rough and tumble, often dropping to ground. Mynas generally raise two successive broods over the breeding season laying clutches of 4 or 5 blue eggs.

Food. Indian Mynas have a broad range of diet, chiefly fruit, grain, insect and grubs but also small animals like baby mice, lizards and crabs and kitchen scraps form garbage dumps. They are also fond of nectar from bird flowers like silk cotton.

Distribution. Indian Mynas are resident, staying in a given locality year after year, probably coming to the same communal roost evening after evening. They occur throughout the subcontinent including Pakistan, Bangladesh, Nepal, Bhutan and Sri Lanka, going up to 3000 m in Himalayas. They have also been introduced to Andaman, Nicobars and Lakshadweep, as well as other parts of the world such as New Zealand.

Human significance. Indian Mynas are a companion of man all over the country amusing people with their chirpy chatter. To an extent they damage crops and orchards, but also help by destroying insects.

Population assessment. Indian Mynas are quite conspicuous and may be easily recorded on bird counts along straight transects. Their large noisy communal roosts with several hundred to thousands of birds may also be located and mapped, and birds counted fairly accurately as they gather at the roosts just before the sunset in the evenings. It is also possible to locate their nests and estimate their breeding populations in a given area.

Suggestions for student projects

(1) Mapping of communal roosts of mynas, crows, parakeets and populations censuses; (2) Role of mynas in pollination of trees like silk cotton and coral trees; (3) Role of mynas as pests of crops like jowar; (4) Biological clock of Mynas in terms of time at which they return to the roosts in the evening; (5) Nesting success of Mynas; (6) Variety of calls used by Mynas in different situations.

Local names: Desi myna (Hindi); Hor (Kashmiri); Salik, Bhat salik (Bengali); Salik sorai, Salika, Ghor salika (Assamese); Dao myna (Cachari); Bemni, Saloo (Chota Nagpur); Gulgul (Madhya Pradesh); Shale, Salonki (Marathi); Kabar (Gujarati); Gorwantera (Kannada); Nahanavai (Tamil); Goranka (Telugu); Kavalamkili, Matatta (Malayalam).

ANNEXURE - 3

AMERICAN COLLEGE
POST GRADUATE BOTANY

M.Sc. BOTANY (Spl. in Microbiology)
(Effective from 1997 June Onwards)

Sem.	C.No.	C. Title	Hr/Wk	C.Total
I PGB	441	Plant Diversity - I	6+1	120
	443	Plant Diversity - I Lab	3	30
	445	Genetics and Plant Breeding	5+1	100
	447	Principles of Microbiology	5+1	100
	449	Principles of Microbiology Lab	3	30
	451	Quantitative Biology	4+1	80
			30	460
II PGB	442	Plant Diversity - II	6+1	120
	444	Plant Diversity - II Lab	3	30
	446	Plant Disease Management	6+1	120
	448	Plant Disease Management Lab	3	30
	450	Physiological Biochemistry	6+1	120
	452	Physiological Biochemistry Lab	3	30
			30	450

III PGB	541	Macromolecules	6+1	120
	543	Macromolecules Lab	3	30
	545	Plant Morphogenesis	6+1	120
	547	Plant Morphogenesis Lab	3	30
	549	Molecular Biology	6+1	120
	551	Project	3	30
			30	450
IV PGB	542	Plant Tissue Culture	6+1	120
	544	Agricultural Microbiology and Plant Genetic Engineering	6+1	120
	546	Plant Tissue Culture Lab	3	30
	548	Agricultural Microbiology and Plant Genetic Engineering Lab	3	30
	550	Projects	10	100
			30	400

PLANT DIVERSITY - I

6 Hrs./ Wk.

Seminar 1 Hr.

This course has been designated to project the diversity observed among lower non-vascular and vascular plants. The course incorporates evolutionary trends, status of biological diversity and recent trends in biodiversity studies. The student will hardly ever miss the underlying principle unity in diversity.

On the whole, the course will provide a balanced overall view of all aspects of different groups of plants.

A. PRINCIPLES OF PLANT DIVERSITY

UNIT 1: PALAEOCLIMATIC CHANGES AND EVOLUTION OF ORGANISMS

Primitive earth - components and dynamics. Changes in Atmosphere, Hydrosphere (oceans) and configurations of land. Chemical evolution and origin of life. Theories of evolution and molecular basis of evolution. Megaextinctions and new environmental regimes and its impact on evolution. Natural selection and speciation. Evolutionary trends towards continual increase in simplicity and diversity. The current status of the vital life supporting systems of the earth.

UNIT 2. BIOGEOGRAPHY AND STATUS OF BIOLOGICAL DIVERSITY

Distribution of diversity. Land - along latitudinal and humidity gradient.

Wet lands: area and depth gradient, seas: along the latitudinal depth and productivity gradient island biogeography
- concepts of landscapes - mosaics - habitat sizes - fragmentation and edge effect. Distribution of biodiversity in different biogeographic realms - Biogeographic zones (global and national) - levels of diversity amongst different taxonomic groups. Significance of indicator, unique, rare, endemic, threatened and key stone species in different biogeographic zones of India.

Mapping of landscape.

Concept of classification and nomenclature. Trends in classification of biological organisms with special emphasis on five kingdom classification (Whitaker 1969). Assessment of the current levels of biodiversity on earth.

UNIT 3. RECENT TRENDS IN BIODIVERSITY STUDIES

Convention on biological diversity and its impact - documentation and assessment of the global biodiversity - benefit sharing through sustainable utilisation of global biodiversity - laws and regulations that govern global and local commercial biodiversity centres.

B. REVIEW OF THE MAJOR GROUPS OF PLANT KINGDOM

UNIT 4. ALGAE

History of phycology - contributions of Indian Phycologists. An overview of different kinds of classifications - thallus organisation of algae - fossil algal records. Distribution in different biogeographic zones of India - Life cycle patterns and reproductive biology - ecological significance of phytoplanktons and other forms of algae - methods of identification, nomenclature, collection, preservation, estimation. Inventorying, Monitoring and documentation. Current status of diversity - economic potential of algae.

UNIT 5. BRYOPHYTES

History of bryology and contributions of Indian bryologists. Distribution in India - an overview of different kinds of classification, life cycle patterns and reproductive biology - physiology and phytochemistry of bryophytes - Ecological and human significance of bryophytes. Methods of collection, preservation, estimation, inventorying, monitoring and documentation. Current status of diversity - fossil record of bryophytes - evoluton of land plants and significance of bryophytes.

UNIT 6. PTERIDOPHYTES

History of Pteridophytes - Pteridophytes research in India - chemotaxonomical studies. Distribution in India - An overview on classification and life cycles patterns. Ornamental ferns - ecological and human significance - Methods of collection, preservation, estimation, inventorying, monitoring and documentation - fossil record of Pteridophytes - trends in vascular issue development and origin of seed habit. Establishment of land plants and significance of Pteridophytes.

UNIT 7. GYMNOSPERMS AND ANGIOSPERMS

History of gymnosperms studies - contributions of Indians - distribution in India - classification and life cycles patterns - fossil gymnosperms and evolutionary trends. Ecological and human significance - methods of collection, preservation, estimation, inventorying, monitoring and documentation. Monoculture of conifers and its impact on natural vegetation. Current status of diversity - origin of angiosperms - fossil record of angiosperm - evolutionary trends - distribution in India - A brief account on classification and life cycle patterns.

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16. Kumar, H. D. 1989. Algal Cell Biology.

PLANT DIVERSITY - I LAB

3 Hrs./ Wk.

This course emphasises mainly on field trips to different places where diverse groups of plants can be found. The skill of inventorying. Landscape mapping and preservation will be learnt by the students, with the help of modern techniques. Nursery and vegetative propagation techniques also form an important component of the course - content.

1. A survey of Phytoplanktons ponds and Vaigai river.
2. Collection and characterisation of available Cyanobacteria from the local agricultural fields.
3. Collection identification and preservation of Marine Algae from the local agricultural fields.
4. Inventorying of Bryophytes of Alahar hills.
5. Inventorying of gymnosperms of Kodai hills.
6. Inventorying of Ferns of Alagar Hills and Ornamental ferns.
7. Landscape Mapping.
8. Microbe - Plant Associations - a survey of plants with Nodules/ VAM.
9. Insect - Plant Association in agricultural field.
10. Nursery technique and vegetative propagation technique.

REFERENCE BOOKS/ MANUALS

1. Global Biodiversity Assessment - Heywood, V. H. 1995. Cambridge University Press, Cambridge, U. K.

2. Species Diversity and in space of time. M. Rosenzweig. 1995, Cambridge University Press, Cambridge, U. K.

3. Biodiversity: Sciences and Development. F. d. Caotri and T. Yoynes (eds) 1996. CAB International Walling Fard - U. K.

4. Biological Diversity - Problem and Challenges, S. K. Majundar, F. J. Brenner, J. E. Larch, J. Schalles and E. W. Miller (Eds) 1994. The Pennsynvania Academy of Sciences, U.S.A.

5. Conservation Biology in Theory and Practice. Caughley, Graema and Anna Gunn. 1996. Blackwell Science, Cambridge - Massachusetts.

6. Fundamentals of conservation biology - Hunter Makam, L. Jr. 1996. Blackwell Science, Cambridge - Massachusetts.

7. The Conservation of Plant Diversity. Frankal, Otto, H., Anthony, H. D., Brownt Jeramy, J. Burden. 1995. Cambridge University Press, Cambridge, U. K.

8. Conservation Biology - A Hands on Introduction of Biodiversity, Blain, Rober, B. and Heidi L. Ballard. 1996. Kendall, Hunt Publishing Company, Dubugne - Iowa.

PLANT DIVERSITY - II

6 Hrs./ Wk
Seminar 1 Hr.

This course aims at field oriented studies on the diverse groups of plants. The students are given training in understanding principles and scope of plant systematics through appropriate keys. Modern concepts of biodiversity and its conservation also form part of the course.

A. PLANT DIVERSITY AND HUMAN SIGNIFICANCE

UNIT 1. RELATIONSHIPS BETWEEN PLANTS AND OTHER GROUPS OF ORGANISMS

a) Plants and Microbes/ Animals

Types and degree of relationships, level of dependence and evolutionary significane of th following biological events/ organisms (a) nitrogen fixation (lichens - legumes and other associations) (b) mineral nutrition (VAM) (c) antifeedant and allelopathy (pest resistance) (d) morphogenesis (gall formation) (e) pollination (f) pathogens (g) carnivorous plants.

b) Human, Plant and other groups of organisms

Relationship between cultural diversity and biodiversity - India's rich traditional knowledge systems - degree of dependence on natural ecosystems.

i. Contribution of ethnic communities

Documentation of ethnobotanical/ ethnobiological/ practical ecological knowledge of ethnic communities - methods of documentation and validation - commercilisation of indigenous knowledge - need for community biodiversity registers and legal protection.

ii. Utilisation of biological resources

Conventional methods of sustainable exploitations of bioresources. Impact of urbanisation and consumerism - role of different systems of medicines and expanstion of agriculture - contributions of biotechnology - influence of industry and trade - economic reforms and its significance.

c) Global Climate change and its Influence

Cause and means of global warming and ozone depletion - expected physiological and genetic changes in selected organisms - strategies to meet the challenge in the future.

B. TAXONOMY AND PLANT SYSTEMATICS

UNIT 2. PRINCIPLES AND SCOPE OF PLANT SYSTEMATICS

History and developments of plant systematics in India contributors of various floras of India - modern concept of taxonomy and plant systematics - hierarchy and taxonomic structure - binomial nomenclature, genera, specific epithets, author citation - general and special types of classification. Linnaeus and Bentham and Hooker's system. Phylogenetic system - ICBN - Typification - valid publication.

UNIT 3. TAXONOMIC EVIDENCES

Contributions of morphological anatomical, embryological and chromosomal and palynological evidence towards solving certain taxonomic problems and systematic position of certain genera.

UNIT 4. NUMERICAL TAXONOMY/ PHONETIC SYSTEMS

OTUs character selection, unit characters, coding of characters, data matrix - similarity/ dissimilarity matrices, cluster analysis, phenograms - merits and demerits - future of taxi matrices - punched card systems.

UNIT 5. CHEMOTAXONOMY AND SEROTAXONOMY

Chemical evidences - micro/ macromolecules, proteins, nucleic acids, polysaccharides, phenols, flavonids, anthocynines, betalanins, alkaloids - electrophoretic and chromatographic techniques, serotaxonomy - procedural aspects, antigen/ antibodies, contributions and future role of serotaxonomy.

UNIT 6. SYSTEMATIC INSTITUTIONS

Botanical Gardens house - gene bank and seed banks - botanical libraries - Floras and Floristic Studies. Monographs, Literature, Indexes of plants names, revisions, journals and reprints, herbaria - Rapinad, BSI, FRLHT, TBGRI and other leading ones. Roles of Botanical Survey of India.

C. MANAGEMENT OF BIORESOURCES

UNIT 7. INVENTORYING AND MONITORING OF BIODIVERSITY

Sampling methods appropriate to taxa/ group/ landscape/ wetland/ aquatic system, long-term monitoring methods - diversity indices - similarity indication techniques - Application of geographical information system and remote sensing - mapping of landscapes and biological resources - use of statistical methods if forecasting and decision making - need for computerisation and development of software packages and databases.

UNIT 8. CONSERVATION OF BIODIVERSITY

Indian heritage of biodiversity conservation - modern concepts of conservation biology - assessment of economic values of biodiversity - sharing of benefits of commercial exploitation - Biopiracy - Patent Act - farmers right and plant breeders right - assessment of environmental health - in situ and ex situ conservation methods - contribution of Indian and International Organisations - need for sharing of information and transfer of technology.

UNIT 9. ON GOING CONSERVATION MEASURES AT LOCAL AND GLOBAL LEVEL

Rapid assessment of biodiversity - contributions of IUCN - Biodiversity Conservation Prioritization Project - Man and Biosphere Project - National Parks - Wildlife Sancturies - Reserve Forests - Role of Forest Department - Joining Forest Management - Legislative Protection - Role of NGOs and local people on conservation of biodiversity - need for a community based system to conserve the local biodiversity.

REFERENCE

1. Ananthakrishnan, T. N. 1969. Property Rights, Biotechnology Oxford and IBH Publication.

2. Mohammed, H. Khail et al. 1992. Property Rights, Biotechnology of Genetic Resources, Acts Press, Kenya.

3. Duncen Poones Jessrey Sayer. 1967. The Management of Tropical Moist Forest Lands - Ecological Guidelines, IUCN, U. K.

4. Marten Jet Ald. 1994. Plants, Genes and Agriculture.

5. Lawrence. 1992. Ethnobotany - A Methodology Manual

6. Rajiv. 1995. Ethnobotany - The Renaissance of Traditional Herbal Medicine.

7. Stace, C. H. 1984. Plant Taxonomy and Biosystematics.

8. Sachdeva, S. K. and Mali, C. P. 1986. Experimental Plant Taxonomy.

9. Sivarajan, V. S. 1990. Introduction to Principles of Taxonomy.

PLANT DIVERSITY - II LAB

3 Hrs./ Wk.

In this course, students are given training in identifying plant species with the help of flora and devise appropriate dichotomous keys for the same. Through field trips to nearby hilly and forest areas they learn to appreciate the diverse species among flowering plants, endemic/ exotic/ endangered species. Herbarium technique and documentation of folk medicines also form part of the course.

1. Aquatic plants and pond vegetation.
2. Market survey of commercial flowers, ornamental flowers, fruits and vegetables, spices, condiments, fibre etc.
3. Identification of given plants to their respective families (Polypetalous families any 10, Gamopetalous families any 15, Monochlamydeous families any 10 and Monocotyledons families any 10).
4. Development of dichotomous key and application of computers in classification of plants.
5. Field survey of plants - identification of plants to respective family/ genus/ species level using the available flora.
6. Monitoring of ecological changes in a permanent plot.
7. Indexing of Campus Flora and study of phenology of selected trees of the campus.
8. Documentation of local health traditions and folk medicines.
9. Ex-situ conservation technique - development of a model seed bank.
10. Herbarium technique and submission of herbarium sheets of locally available common plants.
11. Visits to in situ conservation areas and centres committed to conservation of biological diversity.
12. Insect plant associations - *Ficus spp.*.

REFERENCE

1. Fyson, P. F. 1975. The Flora of the Nilgiris and Pulney Hill Tops, Vol. 3.

2. Gamble, J. S. Flora of the Presidency of Madras, Vol. 3.

3. Mathew, K. M. 1981. The Flora of Tamil Nadu and Carnatic, Vol. 5.

MADURA COLLEGE

BIODIVERSITY

UNIT 1. DEFINITION AND SCOPE (8 lectures)

What is biodiversity. Diversity at levels of genes, species, higher taxa; biological communities, ecosystems and landscapes.

Current levels of biodiversity on the earth. Levels of diversity amongst different taxonomic groups. Role of biodiversity in the areas of crop improvement, animal improvement, fish improvement and biocontrol.

Primary threats of biodiversity. Effects of biodiversity erosion.

UNIT 2. DISTRIBUTION OF BIODIVERSITY (10 lectures)

Distribution of diversity in different biogeographic realms and in different biomes. Theory of island biogeography. Geographical patterns of species diversity. Diversity Gradients. Diversity and stability.

Concepts of landscape ecology, matrices, patches, corridors, edges and ecotones and toposcape.

UNIT 3. ECOLOGICAL DETERMINANTS OF BIODIVERSITY (10 lectures)

Distribution of diversity on land along latitudinal and humidity gradients. Distribution of diversity in the sea along latitudinal, depth and productivity gradients. Distribution of diversity in freshwaters - streams, rivers, ponds and lakes. Distribution of diversity amongst different trophic levels.

Causes of species extinction. Threatened species. Threats to species. Concepts of keystone and indicator species. Assignment of conservation priorities in relation to taxonomic uniqueness, rarity, endemicity, threatened status, economic and aesthetic values.

Selection of areas for nature conservation.

UNIT 4. INVENTORYING AND MONITORING BIODIVERSITY (17 lecturers)

The measurement and description of diversity - species richness equitability, alpha (packing), beta (turnover), gamma (accumulation), mue (mosaicity); Shannon - Wiener Index and Simpson Index.

Transects, quadrats and all out searches.

Sampling methodologies to study litter fauna, insects, birds, zooplankton, benthic macroinvertebrates and fishes.

Documentation of practical knowledge of local communities. Community Biodiversity Register, Biodatabases, Geographic information systems and application of remote sensing strategies.

UNIT 5. HUMAN IMPACTS ON BIODIVERSITY (8 lectures)

The history of human impact on biodiversity. The impact of human activity on biodiversity. Biotechnology and Biodiversity : Biotechnology, Patents and Private Property in life forms, Intellectual property rights.

UNIT 6. MANAGING INDIA'S HERITAGE OF BIODIVERSITY (7 lectures)

Erosion of India's natural biodiversity over ages. Ecological history of the subcontinent. History of conservation efforts and traditional conservation practices.

REFERENCES

1. Colinvaux, P. 1986. Ecology, John Willey and Sons, New York, pp. 725.

2. Gadgil, M., Ghate, U. and Pramod, P. 1996. Biodiversity, Resource material for courses, practical exercises and students projects at college and university levels, vol 1-5. Indian Academy of Sciences, Bangalore.

3. Muthkkaruppan, V. R. (Editor) 1991. Biology Education Biodiversity (Special issue), Vol. 8, No. 1, pp. 87.

4. Heywood, V. H. (ed.) 1995. Global Biodiversity Assessment, United Nations Environment Programme, Cambridge University Press, Cambridge, pp. 1140.

5. Stiling, P. D. 1996. Ecology: Theories and Applications, II Edition. Prentice Hall International Inc., pp. 539.

6. Samways, M. J. 1994. Insect Conservation Biology, Chapman and Hall, pp. 358.

7. Shiva, V. 1993. Monocultures of the Mind. Perspectives on Biodiversity and Biotechnology, Zed Books Ltd., London, pp. 184.

8. Spellerberg, I. F. and Hardes, S. R. 1992. Biological Conservation, Cambridge University Press, Cambridge, pp. 123.

9. Magurran, A. E. 1988. Ecological Diversity and its Measurement, Croom Helm, London, pp. 179.