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Identifying conservation priority zones for effective management of tropical forests in Eastern Ghats of India

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Abstract. There are thousands of protected forest areas existing on earth, yet the deforestation rate continues unabated both inside and outside the protected areas especially in the tropical forests. It identifies the less effectiveness of the current conservation strategies, which is normally oriented around the forest area cover rather than the quality of the protected areas. This calls for realistic and effective management strategies for forests. Based on the drawbacks the present study aims at identifying conservation priority sites within the protected areas (Reserved Forests) of Shervarayan hills, Eastern Ghats of Tamil Nadu, India. The remnant forest patches having less effective management/protection is identified and analysed for its qualitative contribution to the ecosystem. Quadrats of 20 × 20 m were laid in different vegetation based on the percentage of forest cover and assess the species diversity pertaining the richness, Endemism and Red list categories. Thematic layers (maps) such as vegetation type, floristic species richness, floristic endemism, and red list flora are created and categorized according to their weightage classes and overlaid in GIS domain to demarcate the Conservation Priority Zones (CPZ). The CPZ are classified according to the priority status i.e., high, moderate and low based on the contributing species richness, levels of endemism and concentration of Red listed plants.

Introduction

The present global biodiversity is diminishing at an accelerated pace (Myers 1980; Wilson 1988) especially in the tropical countries (Hamilton 1984; Bowles et al. 1998; Malcolm and Ray 2000) where the biodiversity is concentrated. The current status of our forest resources has called for conservation planning (Mooney and Chapin 1994; Western and Wright 1994; Calridge and O'Callaghan 1997; O'Neill et al. 1997; Bawa and Seidler 1998) which seeks to identify spatial options for the preservation of biodiversity (Williams et al. 1996). The ultimate purpose of conservation is to inform and affect the conservation policy (Robertson and Hull 2001). Within the realm of conservation measures, the forest strategists have identified and conserved large tracts of vegetation as protected areas (Gaston et al. 2002; Margules et al. 2002). Still the deforestation rate has markedly increased (Downton 1995) and has spread to the protected areas of tropical region too (Hamilton 1984; Howard 1991; Redford 1992) rendering ineffectiveness in arresting it. Ecologists nowadays are on the consensus that biological diversity is not effectively conserved by reserves alone (Wilcove 1989). Various quantitative methods that allow relatively expeditious identification of conservation-priority areas have been proposed in recent years and these approaches include identification of hotspots of biodiversity (Myers 1988, 1990; Dobson et al. 1997), rapid biodiversity assessment (Oliver and Beattie, 1993 and 1996), identification of indicator and surrogate species (Curnutt et al. 1994), development or rarity and complementary sets (Williams et al. 1996), identification of key eco-region (Olson and Dinerstein 1998), and cost-minimizing or land-values analyses (Ando et al. 1998).

This may be due to the very size of the forest tract whereby the porosity of the protected forest will lead to its ineffective management. Now, it is better to identify the quality of the vegetation in the protected and non protected areas, rather than the area size for effective conservation management (Sheil 2001). Most often we had adopted the conventional approach to maintain biological diversity by following a protocol based on species by species and threat-by-threat approach, but it too has its own detriments i.e., the financial drawbacks, inaccurate complicated database of the forest community (Hutto et al. 1987; Scott et al. 1987, 1991; Margules 1989, Noss 1991) etc.

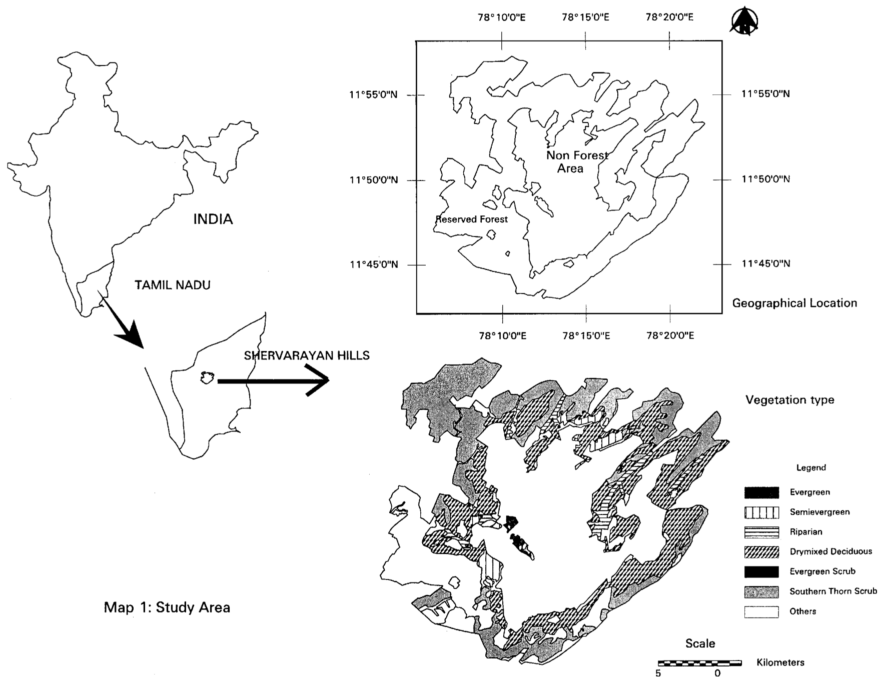
In recent years the focus for conservation has shifted from single species management approach to protection of biodiversity in the aggregate i.e., to maintain the native plant species in extensive natural landscapes (habitats) restricting to a minimal size factor, that are sufficiently linked (i.e. corridors) to allow interaction and genetic interchange among distinct populations (Noss 1983). This approach requires a cohesive and representative system of areas to be managed for the maintenance of biodiversity. Hence there is a need to prioritize only those areas, which are considered most essential for conservation, which are termed as biodiversity priority areas (Olson and Dinerstein 1998). The procedures involve scoring and ranking, which make priority setting more systematic and explicit (Margules et al. 2002). Prioritization of strategies is essential to ensure that efforts at conservation yield best possible results and undesirable side effects, such as the alienation and impoverishment of local communities can be avoided (Singh and Taneja 2000). Prioritization of sites for conservation also needs to be done with reference to the (often least studied) vegetation type (Williams et al. 2002), species richness (Terborgh and Winter 1983; Scott et al. 1987), endemism based on Kier and Barthlott (2001) and concentration of red listed plants (Ahmedullah 2000; Kumar et al. 2000).

The methods for identifying priority areas vary with the entity selected for the overall biological conservation planning and management (Margules et al. 2002; Gaston et al. 2002) and for example Ramesh et al. (1997) have suggested conservation priority based on the biodiversity gaps by considering the vegetation uniqueness, species richness, endemic flora and endemic fauna in Western Ghats, whereas on the other hand Menon et al. (2001) and Amarnath et al. (2003) have identified conservation priority zones based on the land use changes, vegetation patch characteristics, phytosociological data, topographic, bioclimatic and disturbance level in wet evergreen forests of Western Ghats in Tamil Nadu.

Thus the present study has deviated from the approaches described above and have considered a new concept with the vegetation type, species richness, endemic and IUCN red listed plants as base for identifying Conservation Priority Zones (CPZ) in GIS (Geographical Information System) domain.

Study area

The Shervarayan hills (a part of Eastern Ghats) are located in the northern part of Salem city, Tamil Nadu, South India and with an area of 469.9 km^2. The study area lies between latitudes 11°43′00″ to 12°00′00″ N and longitudes of 78°00′00″ to 78°22′30″ E (Map 1) and falls in the Survey of India toposheets (SOI) 581/1, 2, 5 and 6 (i.e., 1: 50,000 scales). The mean annual rainfall at the upper hill reaches is 1638 mm and 850 mm at the foothills. The temperature



Map 1. Study area.

ranges from 13–29°C on the hill plateau to 25°C and 40°C at the foothills. The soil is red loamy and lateritic. The area is made up of Archaean crystalline rock like amphibolites, leptinites, garnetiferous granites and charnockites. Bauxite and Magnesite are the chief mineral resources in the Shervarayan hills. There are 71 villages, which are administrated by two taluks (political unit equivalent of an English county) i.e., Yercaud and Omalur. Most of the hill plateau is in private ownership, which includes coffee estates, villages and their agricultural lands. Colonial planters had been maintaining and harvesting the coffee estates till the time of independence of the country and later, the ownership has been entrusted to the natives. There are 45 reserved forests, which are administered by the Salem Forest Division. Almost all the reserved forest area is on the outer slopes of the hill tract facing the human habitats on the fringing foothills thereby enhancing the proneness to deforestation and very much is the evident fact.

Methodology

Mapping vegetation type

Vegetation type map of Shervarayan hills (Balaguru et al. 2003) is used which covers nearly half (49.50%) of the hill area (23260.76 ha) under reserved forests comprising about six major forest types - evergreen (111.33 ha), semi evergreen (1057.67 ha), riparian (1145.15 ha), dry mixed deciduous (10179.10 ha), southern thorn scrub (10735.70 ha), and evergreen scrub (31.81 ha), respectively (Map 1). To evolve potential conservation priority elements, the virgin and primary forest patches comprising the evergreen, semi evergreen, riparian, and dry mixed deciduous forests are used as the base, while the evergreen scrub and southern thorn scrub forests are excluded due to their highly degraded nature. The scores for each forest type are attributed according to the species concentration (Figure 1) and substituted to all the representing polygons accordingly.

Mapping floristic richness

Representative polygons for each forest type are analysed for assessing species richness contribution by adopting quadrat method (20×20 m) (CES 1998; Ferreira and Prance 1998). This study has taken optimum sampling quadrats to cover all variations within each type of the vegetation and the number of quadrats for each forest type is based on the area percentage of the forest cover (> 1000 ha area 0.5%; 1000–2000 (0.5%) and > 2000 (0.01%). All living plant species within the quadrat are identified and the number of species in each forest type is summed and represented by species richness values and these

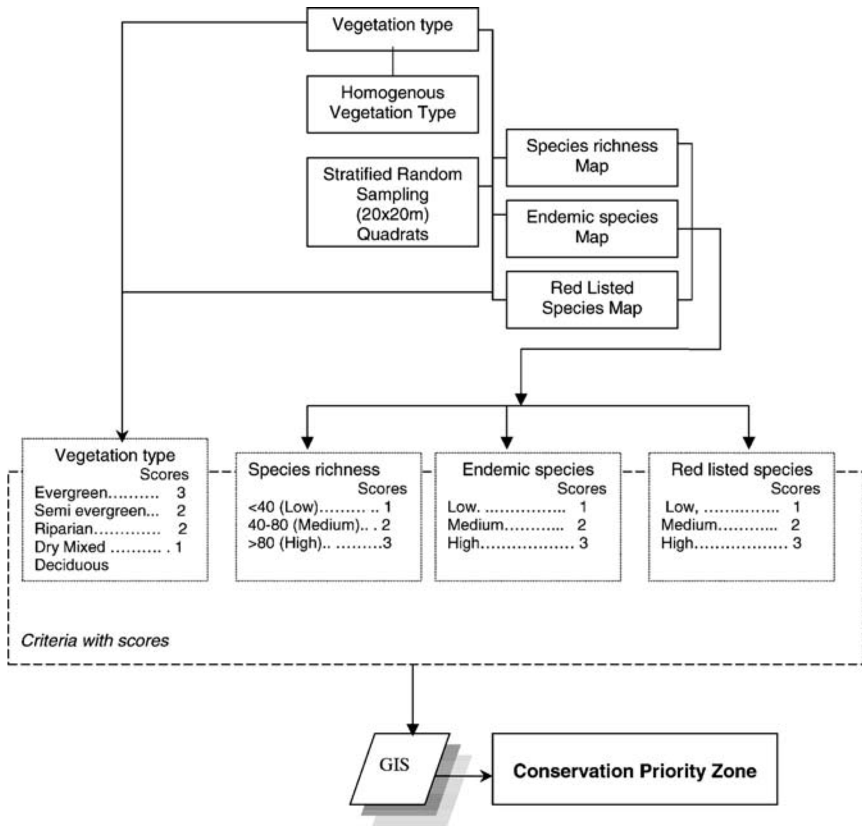


Figure 1. Conceptual diagram illustrating the building identification of conservation priority zone.

values are attributed or extrapolated to all such polygons representing the respective forest type. To produce the species richness maps the ensuing polygons are regrouped and classified into categories of low, medium and high according to the ranges of species richness values.

Mapping floristic endemism

The plant species thus collected in the quadrats are identified with the endemic flora of Peninsular India as enlisted by Ahmedullah and Nayer (1986). Procedures for deciding on CPZ need more systematic and explicit approach for priority setting wherein multiple criteria are given scores. These scores are then combined and ranked accordingly and priority (high, moderate or low) is given to those areas (Margules et al. 2002). The number of endemic species are allocated to the respective scores/classes based on their significant status in

Indian context (Roy 1999; Ajith Kumar et al. 2000) i.e. individual species endemic to India is considered as 'Indian Endemic' in distribution, hence they received low score (1), similarly individual species endemic to peninsular India is considered as 'Regional Endemic' (2) and species endemic to Eastern Ghats (including Shervarayan hills) is 'Local Endemic' and received the highest score (3). The number of species and their scores in each of the polygon is then summed up and values attributed as described for species richness. To produce endemic species map, the polygons are finally regrouped/reclassified into low, medium and high degree of endemism according to the summed values attributed to each polygon (see Figure 1), the polygon with the highest score had the high degree of endemism and likewise.

Mapping floristic red listed plants

The methodology to map red listed plants is the same as for the endemic plants map or species richness map. The ensuing plant species in the quadrats are evaluated based on version 3.1; IUCN/SSC (1999) criteria and cross checked with Indian Red Data books (Nayer and Sastry 1987–1990) and other relevant literature Kumaravelu and Chaudhuri 1999). The red listed categories and their scores are classified into (a) Critically Endangered (CE) −5; (b) Endangered (En) −4; (c) Vulnerable (VU) −3; (d) Lower risk (LR)/Least Concern (Lc) −2; (e) Data Deficient (DD) −1 (Table 2). To produce the red listed plant species map, the polygons are finally grouped into low, medium and high wherein the scoring is similar to the one adopted for the endemic classification.

Modelling conservation priority zone (CPZ)

The components of various units (classes) from the thematic maps like the vegetation type, floristic richness, endemism and red lists with their respective weightages (Figure 1) are essential to develop conservation priority zones for this study. Considering the conservational importance and status for each class (unit) of the respective thematic maps, the classes are given weightages to designate and identify the CPZ. Overlay or superimposition creates a composite output GIS file by combining a number of input GIS files based on the minimum or maximum values of the input files (Murthy 2000). To prepare the CPZ map, the respective thematic maps (species richness map, red list map and finally endemism map) are overlaid on the vegetation type map, which comprised the lowermost tier (the base map) using a remote sensing and GIS software (ERDAS imagine). The *model maker* (a tool in the ERDAS software) is used to analyse the overlays, wherein the different features of the thematic layers are intersected/extracted and new class values are attributed to the resulting polygons. The polygons are classified according to the conservation priority status and finally integrated (union criteria in *model maker*) to generate the CPZ. The authenticity of the areas/zones proposed for conservation priority is confirmed with ground truthing.

Results

Totally 322 species are recorded from the Shervarayan hills (based on the quadrats studied in the study area), of which 24 species are endemic (Table 1) and 23 species are red listed (Table 2). The floristic richness (Map 2) are regrouped/reclassed into high (> 80 species), medium (40–80 species) and low (> 40 species) rich areas respectively. The endemism and red listed species are grouped into three zones based on the number of contributing species. The CPZ map (Map 3) is generated with three classes according to the criteria described before, based on the combination of scores – high, moderate and low priority zones.

High priority zone

High priority zone is distributed in five sites with moderate to high species richness. This zone accounts for 1582.53 ha (6.80%) of the total hill forest area. The priority sites are authenticated with the presence of select/target species (under different criteria) like *Rubia cordifolia*, *Crotalaria shevaroyensis*, *Litsea oleoides*, *Smilax zeylanica*, *Ixora notoniana*, *Neolitsea scrobiculata*, *Psychotria octosulcata*, *Randia candolleana* var. *candolleana*, *Peperomia dindigulensis*, *Celastrus paniculatus* and *Nothopegia colebrookiana* in the evergreen forests. The riparian forests comprise *Terminalia arjuna*, *Mangifera indica*, *Ficus microcarpa* and *Syzygium cumini* and on the other hand the semi evergreen forests is represented mainly by *Nothopegia colebrookiana*, *Celastrus paniculatus*, *Decalepis hamiltonii*, *Santalum album*, *Naravelia zeylanica*, *Gymnema sylvestre*,

Table 1. Endemic plant species and their distribution status.

Distribution	Species Name
Local Endemic (endemic to Eastern Ghats)	*Crotalaria shevaroyensis*
Regional Endemic (endemic to Peninsular India)	*Peperomia dindigulensis*, *Vaccinium neilgherrense* *Miliusa eriocarpa*, *Litsea oleoides*, *Neolitsea scrobiculata*, *Curcuma neilgherrensis*, *Eranthemum capense*, *Dolichandrone arcuata*,
Indian Endemic (endemic to India)	*Neonotonia wightii*, *Elaeagnus indica*, *Decalepis hamiltonii*, *Jasminum trichotomum*, *Ixora notoniana*, *Pavetta blanda*, *Psychotria octosulcata*, *Randia candolleana* var. *candolleana*, *Wendlandia angustifolia*, *Mallotus stenanthus*, *Tetrastigma sulcatum*, *Pamburus missionis*, *Leucas diffusa*, *Shorea roxburghii*, *Chionanthus mala-elengi*.

Table 2. Red listed plant species and their status.

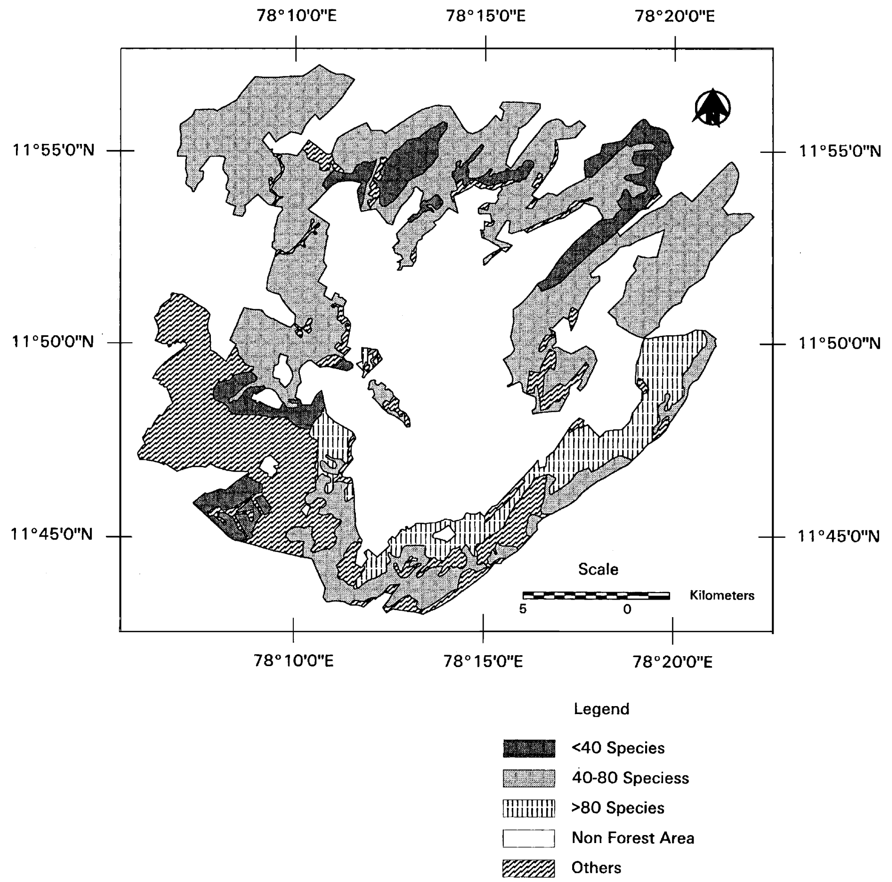
Species Name	Red listed categories
Buchanania lanzan	Lower risk
Celastrus paniculatus	Vulnerable
Cycas circinalis	Threatened
Decalepis hamiltonii	Endangered
Gloriosa superba	Lower risk
Nothopegia colebrookiana	Data Deficient
Pseudarthria viscida	Lower risk
Santalum album	Endangered
Sapindus emarginata	Lower risk/Least concerned
Smilax zeylanica	Vulnerable
Terminalia arjuna	Lower risk
Gardenia gummifera	Endangered
Michelia champaca	Vulnerable
Symplocos cochinchinensis	Lower risk
Rubia cordifolia	Critically endangered
Gnetum edule	Endangered
Naravelia zeylanica	Vulnerable
Hemidesmus indica	Vulnerable
Withania somnifera	Vulnerable
Stephnia japonica	Vulnerable
Evolvulus alsinoides	Lower risk
Gymnema sylvestre	Vulnerable
Vernonia arborea	Endangered
Polystachya concreta	Endangered

Ixora notoniana, *Pseudarthria viscida*, *Buchanania lanzan*, *Hemidesmus indicus* and *Sapindus emarginata*.

The above described forests also are characterized with the occasional presence of some priority species like *Withania somnifera*, *Hemidesmus indicus*, *Celastrus paniculatus*, *Cycas circinalis* and *Symplocos cochinchinensis* with endemic constraints.

Moderate priority zone

The zone occupies an area of about 6282.4 ha (27%) enclosing parts of evergreen forests and dry mixed deciduous forests with species richness ranging from moderate to low. The evergreen forest under this class includes the endemic and red listed species like *Symplocos cochinchinensis*, *Vaccinium neilgherrense*, *Gnetum edule*, *Rubia cordifolia*, *Peperomia dindigulensis*, *Elaeagnus indica* and *Curcuma neilgherrensis*. The endemic and IUCN red listed plant species in the dry mixed deciduous forests has both moderate and high richness and the representing species are *Withania somnifera*, *Naravelia zeylanica*, *Dolichandrone arcuata*, *Hemidesmus indicus*, *Sapindus emarginatus*,

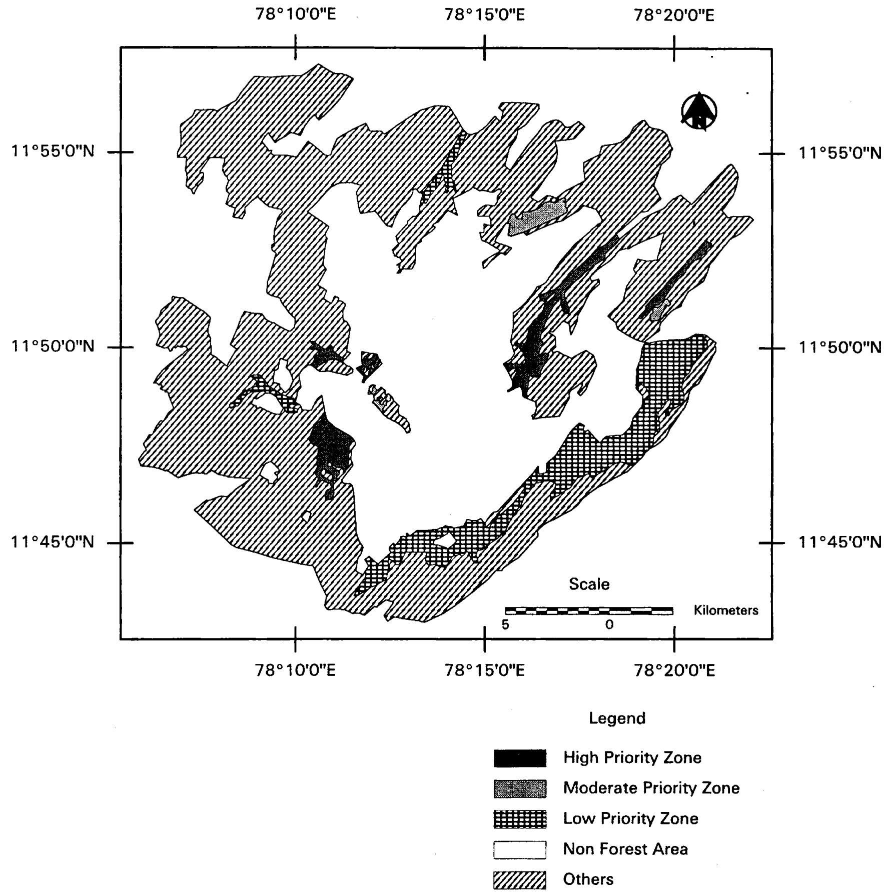


Map 2. Species richness map of Shervarayan hills.

Pseudarthria viscida, *Nothopegia colebrookiana*, *Pamburus missionis* and *Evolvulus alsinoides*.

Low priority zone

This zone with moderate to low species richness occupies an area of about 4524.92 ha (19.45%) of the total forest area and the zone comprises mostly of the dry mixed deciduous types and to a lesser extent the riparian forests. The red listed plant species in dry mixed deciduous forests species are *Celastrus paniculatus*, *Nothopegia colebrookiana*, *Pseudarthria visida* and *Hemidesmus indicus* and the select endemic species like *Mallotus stenanthus*, *Pamburus missionis*, *Shorea roxburghii* and *Pavetta blanda* The riparian forest has only one endemic and endangered plant species i.e. *Cycas circinalis*,



Map 3. Conservation priority zones.

Discussion

Most of the forests on the outer slopes and plateau of Shervarayan hills are still facing the wrath of deforestation in spite of its protected status. There are multidimensional reasons to it and the size of the protected area is the first detriment rendering the very base of protection as ineffective. Secondly it is followed by easy accessibility to the forest patches by the illegal loggers wherein the dense network of the footpaths crisscrossing the forest patches confirm the same. Thirdly the ineffectiveness of the protection status is the poor knowledge of conservation prior sites within the protection realms of the forest.

This study also identifies a similarity in species contribution between the evergreen forests of Shervarayan hills (a part of Eastern Ghats) with that of the evergreen forests of Western Ghats. Species like *Chionanthus ramiflorus*, *Ligustrum perrottetii*, *Olea paniculata*, *Vaccinium neilgherrense*, *Viburnum punctatum*, *Gnetum edule*, *Elaeocarpus serratus*, *Syzygium cumini*, *Memecylon edule*, *Symplocos cochinchinensis* and *Litsea deccanensis* are common only in Western Ghats, but are present in Shervarayan hills too (a trait unique to this hill when compared to other hills in the Eastern Ghats) (Balaguru 2002). The vegetation types like evergreen, riparian and semi-evergreen are potentially most vulnerable owing to their proximity to the surrounding anthropogenic environment (mining, coffee estates and human habitation) and are designated with high conservation value, so as to effectively conserve the remnant forest patches within the realm. These areas as discussed before harbor a number of red listed and endemic species of conservation importance. Some of the evergreen and semi-evergreen forests are inadequately represented on the outer slopes whereas the dry mixed deciduous in the same zone is well represented i.e., rich species diversity. However widespread logging in these areas may deplete (in future) the existing forest cover and add to the deforestation extents. Hence conservation of such areas too is included in conservation priority.

The CPZ map thus generated will help to concentrate the protection strategy to the zones thus demarcated and help the forest department to have an effective approach to conserve and maintain the virgin forests – a positive approach which can be adopted elsewhere in similar forests. This study effectively defends the sole purpose of selecting the virgin forests on Shervarayan hills for conservation priority zone and its mapping for effective conservation strategies. The present study identifies itself with similar studies by Menon et al. (2001) wherein it is discussed that the conservation priorities require the conservation value of an area and its vulnerability (proximity to human interference in this case) towards deforestation. Fixing biodiversity priorities (CPZ in this case) are necessary but in themselves are not sufficient for the long-term maintenance. Biological diversity requires other tools, and approaches such as sustainable development (Peters et al. 1989; Hartshorn 1995) and management prescriptions to minimize the risk of extinction of local plant population, which have to be focused more sharply in such CPZ. More effective strategy involves people's participation, while realizing and ensuring their domestic needs (fuel wood, fodder, minor forest produce including the medicinal plants) (Margules et al. 2002). This will enforce a harmonious facet to the whole process leading to the success of the strategy adopted (Serrao and Homma 1993; Dawson 1996). What is required therefore is an appropriate developmental paradigm that can provide a more relevant perception and an interpretative framework from which such conservation strategies may emerge (Upreti 1994). Such planning for the stabilization of natural ecosystem is essential and this will reduce the pressure on the natural forests and prevent further loss of biodiversity and in the longer run will reestablish the lost forest stand. The development plans with Sustainable forest management would enable the effective management of biodiversity in Tropical forests and is effectively adopted in most revised cases for most of the policies and strategies associated with forest.

The potential utility of remote sensing and GIS to identify the CPZ in this study and culmination of all aspects dealing with the sole purpose of conservation has been effective and reliable (based on the ground truth and field checks). The resultant maps gives a picture of the CPZ providing a birds eye view of the areas thus identified. The accessibility to the zones thus identified can be deciphered and planned, finally paving way for better and effective conservation.

Conclusion

For identifying priority areas, there must be acceptable ways of measuring biological diversity, a way of determining an acceptable level of representation of that diversity in conservation areas. Having set that goal, it is necessary that a cost effective way of allocating limited resources should be a thought of criteria. The methods outlined in this paper have made the most effective use of available field data with the remotely derived satellite data and involves innovative scoring and ranking procedure that is developed and improved in this study. As a result, priority setting has been approached systematically and explicit tolerance. Though the conservation priority areas are geared towards the future, the forest departments should advocate an alternate approach to protected area management that would integrate biodiversity conservation with social development. Such an approach would entail an improved understanding of the local pattern of resource use. As a result, the contemplated conservation strategies would benefit the local population to enable security to their local livelihood and the base of conservation.

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