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Mapping of forests based on biological diversity to identify conservation sites: A case study from Udupi and South Canara districts of Karnataka

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Abstract

Forest classification is traditionally based on the structure and composition of vegetation, which in turn is strongly linked with the climatic profile of the area. Forest maps thus prepared cannot appropriately meet the needs of the managers whose renewed mandate is to conserve the biological richness of the forests. The emerging need for protecting the forests is to understand the spatial distribution of the conservation value of the forests besides knowing their vegetation types. In other words, we need maps that depict the spatial distribution of biological diversity of the forests. In this paper, we report on our attempt to develop such biodiversity maps for the forest ranges of Udupi and South Canara districts of Karnataka state. Utilizing the data from the vegetation sampling of the Forest Survey of India, we developed a terrain view of the density and diversity of tree species and have attempted to identify the sites with the highest conservation value. We propose that such maps be developed for the entire country and discuss the potentialities and problems associated with this protocol.

Keywords: Forest mapping, biodiversity conservation, tree diversity.

1. Introduction

The prevalent methods of mapping forest vegetation are a relic of the past.[1, 2] The maps prepared by adopting these techniques are mostly based on the structure and composition of forest vegetation. Nevertheless, they have been serving a great deal in the management of forests. In the recent past with the realization of the need to conserve our biological resources, most of which is located in the natural forests, there has been a significant shift in the philosophy of managing forests. It is now realized that the major task of forest management is to conserve our biological riches. This shift in the management perspective has led to a new requirement of forest classificatory procedures. We need to construct the forest maps such that they depict biological diversity and conservation value of the forests in addition to structure, composition and economic value.

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Further, there are several problems associated with the existing methods of classifying the forests. First, they all assume that the forests are mosaics of discrete but homogenous patches of vegetation with distinct boundaries between them. The ground reality however does not justify this assumption. In fact, ecologists and forest managers invariably agree that forests are spatially not uniform and that their vegetation exhibits heterogeneity at different spatial scales. Thus forests are not a mosaic of discrete categories of vegetation types;[3] rather they are a continuously changing fabric of biota. Unfortunately, the prevalent methods of forest classification do not reflect this continuum picture.

In other words, there is a need for a fresh set of protocols of forest classification that account for the continuity of vegetation composition and at the same time incorporate biodiversity (and hence conservation) value of the forests.

2. Forest mapping for conservation

Recently, Murali *et al.*,[3] and Ganeshaiah and Uma Shaanker[4] have suggested two different protocols of mapping the forest vegetation. One of them relies on a multivariate classification of different patches of forests into a number (user defined) of categories based on the frequencies of different species and mapping them thematically using GIS techniques. These categories can be hierarchically merged into fewer numbers of classes based on the similarity in their vegetation composition to arrive at simplified vegetation maps. Thus, the maps can be prepared with different levels of detail based on the need and end user. These thematic maps do not assume the discreteness among forest patches though it does eventually emerge as the number of vegetation classes is crunched.

The second method proposed by them however is more relevant for conservationists as it attempts to depict forest as a terrain of biological diversity. In this method, the forest is sampled in a sufficient number of sites and the diversity of the sites is estimated and mapped. Using certain algorithms, the diversity contours are constructed and a three-dimensional view or a terrain of biological diversity mapped. Such maps obviously are continuous, and also incorporate the conservation value of the forest patches. This method also helps in identifying the 'hot spots' of diversity as well for a given forest.

In this paper, we report our attempts to map the forests of Udupi and South Canara districts based on the second protocol proposed by Murali *et al.*[3] and Ganeshaiah and Uma Shaanker.[4] We discuss the potentiality of using such methods by the Forest Survey of India (FSI) in its future programs and their possible utility for forest managers. We also discuss the problems and demerits of such maps and offer suggestions to overcome them.

3. Districtwise data collection program of FSI

FSI has been periodically collecting systematic data in the forested areas of most districts all over the country with a sampling intensity of 0.01%. These data are presently being used for a number of purposes including micro-level planning and estimating the production potentials of forests. It can also be used for estimating the conservation value of the forest and mapping their vegetation richness and to locate areas for conservation. In this paper we have attempted mapping the biodiversity of the forests of Udupi and South Canara districts of Karnataka.

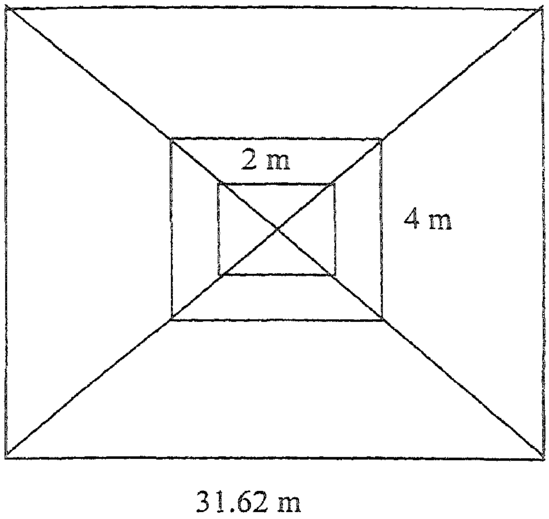

FIG. 1. Sampling protocol followed for enumerating the vegetation. A square grid of 31.62 × 31.62 m was diagonally divided into four triangular quartets and trees sampled in it. The shrub and herb layers were enumerated in the subplots as shown in the diagram; the data on herbs and shrubs however are not presented here.

3.1. *Sampling regime of FSI*

In each of the grids of 2.5° × 2.5° of a 1:50,000 topo sheet of the study area, two sites were chosen. One of them was selected by choosing randomly the latitude and longitude and the other as the mirror image of the first such that the two plots were equidistant from the centre of the grid but on the opposite directions. At each site, a grid (0.1 ha) was marked (Fig. 1) and all the tree species (>10 cm dbh) were enumerated, their dbh measured and the sapling regeneration of the area assessed by ranking from 1 (low) to 10 (high).

3.2. *Diversity estimation and mapping*

The tree species diversity was computed using Shannon diversity index for each sampling site and the density of trees as number of standing trees in the 0.1 ha sampling site. Using Mapinfo GIS software, the sites were digitized as points and their diversity estimates, tree density and other data sets were linked to these points. The roads, towns and forest areas were digitized as different layers for each of the district using FSI maps. Using the Vertical Mapper module of Mapinfo, the contours of diversity were derived from the point data and hypsographic diagrams developed to represent the diversity terrain of the district.

4. Results and discussion

The tree species richness of the forest is represented using two parameters: a) the species diversity as reflected by the Shannon diversity index (Fig. 2) and b) the density of species in the sample sites (Fig. 3). High tree diversity was found concentrated on the northeastern part of Udupi district. In fact, some of the highly species-rich areas are found near Kollur and the forests of this area. The density of trees was also found higher on the northeastern parts (Fig. 3).

However, certain parts on the southeastern range of South Canara were also rich in diversity. The tree density was specifically higher at forest patches east of Belthangadi around the Charmady ghats of the district. Besides these, other areas with highest diversity and density are available at Subramanya ghats of the district.

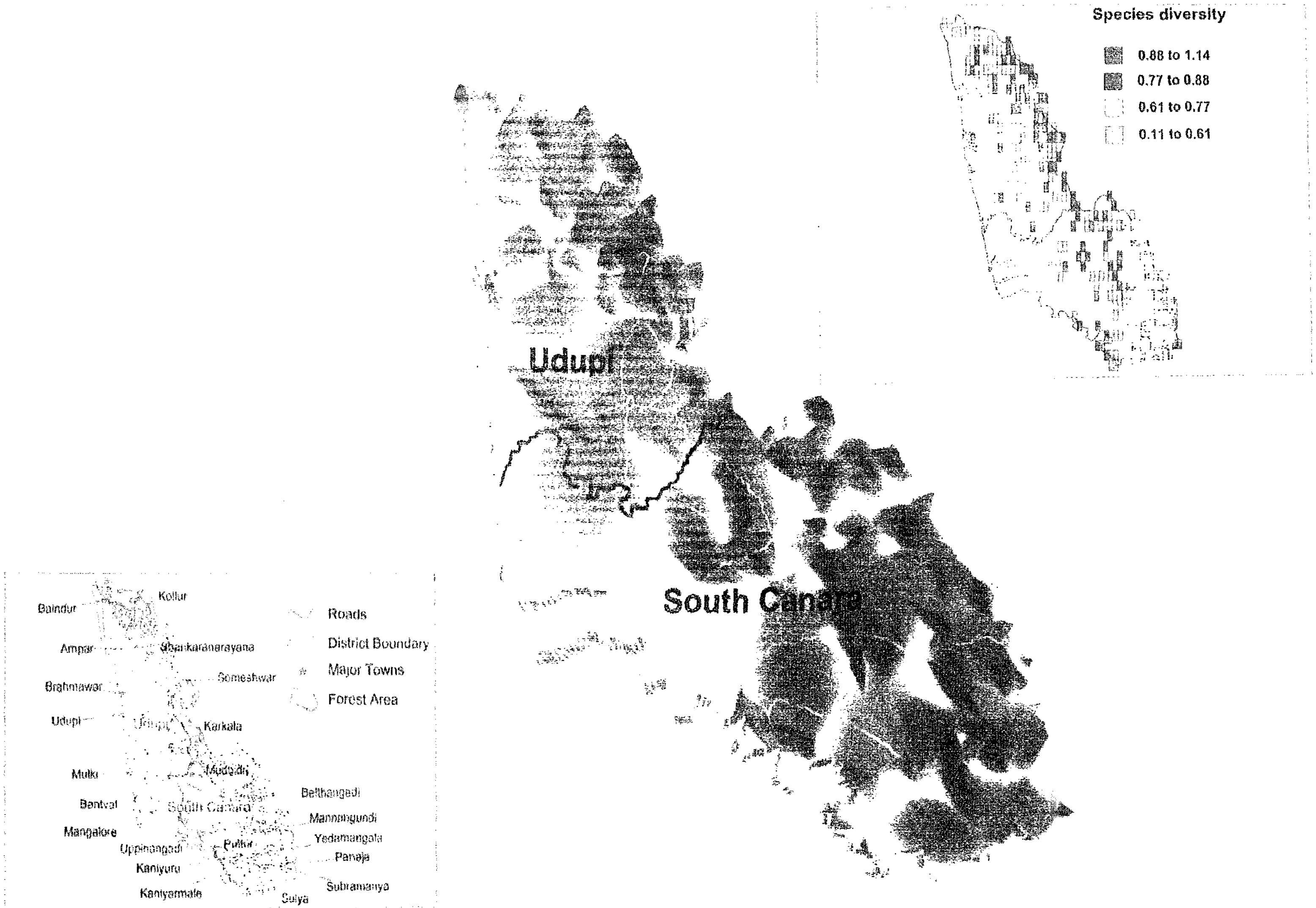

FIG. 2. Map showing the tree species diversity as an hypsographic view. The peaks represent the highest points of tree species diversity measured as Shannon diversity index. The lines represent the major roads. The inset at the top right corner depicts the Shannon diversity index for grids corresponding to sample sites. The inset at the left bottom corner depicts the forest area, roads and major towns.

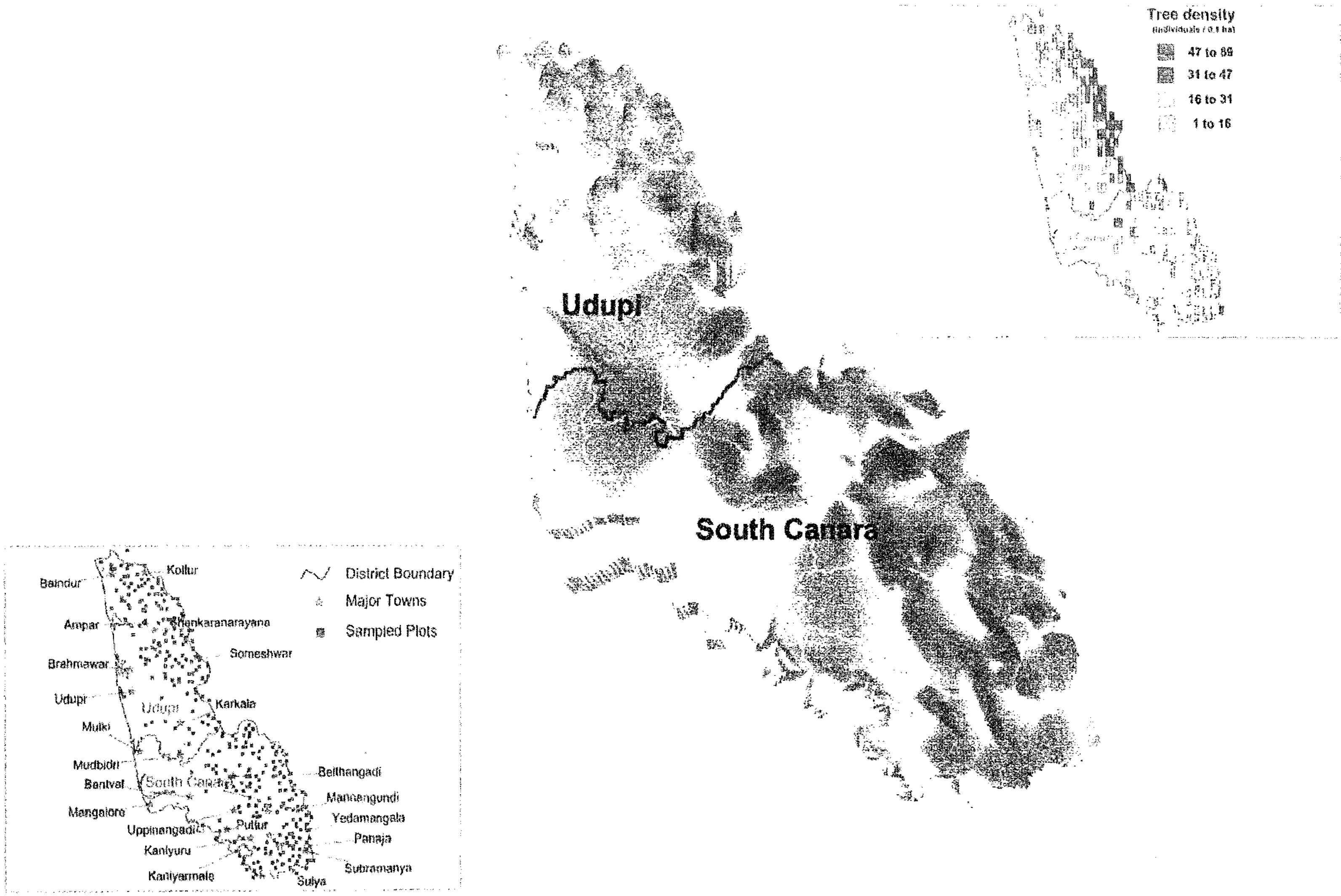

FIG. 3. Map showing the tree density (number of trees with dbh >10 cm in every 0.1 ha area) as an hypsographic view. The peaks represent the highest points of tree density. The lines represent the major roads of the district. The inset at the top right corner depicts the tree density for grids corresponding to sample sites. The inset at the left bottom corner depicts the sampling sites and major towns.

The diversity and density maps also suggest that perhaps the highest diversity and tree density are concentrated in the forests along steep ghats and with less human settlements. For instance, the forests around Kollur, Someshwar reserve near Agumbe, forest along Shiradi and Charmadi known for their steep slopes are the most rich and dense patches. Nevertheless, it is also clear that the forest areas adjoining the human activities such as roads and towns are generally poor in diversity. For instance, though forests on either side of the Shirady ghat section are rich and dense, those along the major highway (Bangalore to Mangalore) exhibit poor health in terms of density and diversity (Figs 2 and 3). This is also true along the other two major roads in the southern part of South Canara district.

However, the low diversity along the highways cannot be attributed to human activity, as it is also likely that the roads are laid primarily in the less dense and low diversity areas of the forests. We are now attempting to evaluate the impact of such developmental activities on forest diversity and density.

These biodiversity maps also help in identifying the hot spots for conservation. This can be accomplished either by identifying the peaks of the diversity and density terrain shown in the maps or by developing contour maps of different levels of tree diversity and density (figure not shown). Interestingly, some of the rich sites (tall peaks) represented by these maps, such as forest patches near Kollur, Someshwar, Shiradi and Charmady, in fact, are already brought under conservation plans by the forest department as sanctuaries (Mookambika sanctuary) and forest reserves.

How perfect are these maps in depicting the conservation or diversity value of the forests? The fineness of the maps is obviously a function of the size, density and distribution of sampling sites in the forest area. Clearly, more the sites sampled, higher will be the reliability of the maps for conservation plans. Besides, the shape of the biodiversity terrain also depends upon the algorithm used in the software while interpolating the values between the sampling sites. Increasing the sampling sites would reduce the role of these algorithms on the shape of the terrain. In other words, the resolution and reliability of these maps are as good as our sampling intensity is. Nevertheless, they offer a continuum picture of the forest, a feature not available in the existing methods of forest mapping.

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