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Assigning Conservation Value: A Case Study from India

R J RANJIT DANIELS
Centre for Ecological Sciences
Indian Institute of Science
Bangalore
India 560 012

MALATI HEGDE
Centre for Ecological Sciences
Indian Institute of Science
Bangalore
India 560 012

N. V. JOSHI
Centre for Ecological Sciences
Indian Institute of Science
Bangalore
India 560 012

MADHAV GADGIL
Centre for Ecological Sciences
Indian Institute of Science
Bangalore
India 560 012

Abstract: *We assign conservation ualues to ecological zones, habitat types, and specific localities of tbe south Indian district of Uttara Kannada on the basis of occurrence of bird taxa This is a two-step process, assigning values first to individual bird taxa and ,second to .spatial elements based on the occurrence of birds. The attributes of bird tara considered are geographical distribution at four levels, habitat preference, taxonomic position, and degree of endangerment. Tbe criteria translating the attributes into values are based on the assumption that the rarer, more taxonomically unique, or more endangered the taxon, the more valuable it is. The conservation value of a given bird taxon is thus a point in a seven-dimensional space. We reduce this to three dimensions by using internal correlation and clumping of values Each spatial element may then be assigned a conservation value based on number of taxa and the total and mean comervation value along the three dimensions. The*

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Resumen: *Hemos asignado valores de conservacion a zonas ecologicas, tipos de hábitat, y localidades específicas de Uttara Kannada, que es un distrito sureño de la India, en base a la preaencia de los grupos taxonomicos de aves, Este es un procedimiento en dos etapas. Primero se le asignan valores a taxa individuates de aves y segundo a los elementos espaciales basados en la presencia de las aves. Las caracteristicas de los grupos taxonómicos de aves considerados so)?)a distribución geográfica en cuatro niveles, hábitat preferido, posición en la taxonomia, y nivel de riesgo. Para transformar estas caracteristicas en cifras, se parte de la base de que los grupos taxonómicos más valiosos son los más raros, los que tienen caracteristicas taxonómicas más especiales, o los que corren mayor riesgo. El valor de conservación de un grupo tarondmico dado es, por lo tanto, un punto en un espacio de siete dim-nsiones. Hemos reducido estas dimensiones a tres, mediante el uso de correlaciones internas y agrupamientos de valores. Cada elemento espacial recibe un valor de conservación basado en el número de taxa, y el valor total y promedio del valor de conservación a lo largo de los tres ejes. Los valores totales están altamente corre-*

total values are highly correlated with number of taxa, permitting a simplification of the problem at the level of spatial elements to four dimensions The analysis provides a basis for assigning specific conservation values to five ecological zones of the district, to fifteen natural quasinatural, and manmade hahitat types; and to 107 specific localities Our analysis shows that degraded evergreen forests, exotic tree plantations, and urban settlements have low conservation value; the other habitat types considered rank high along one or more dimension We also identify 12 different sets of 20 localities each that would maximize either the diversity of bird taxa or conservation value along the different dimensions. We thus attempt to synthesize diversity and quality of taxa to generate conservation prescriptions, whereas the existing methods tend to emphasize either rare or endangered taxa or total diversity. Such prescriptions would be one useful input into working out an overall conservation strategy for a geographical region

lacionados con el número de grupos taxonómicos, lo cual permite una simplificación del problema de los elementos espaciales a cuatro dimensiones. El análisis sirve para asignar valores específicos de conservacidn a cinco zonas ecológicas del distrito, a 15 tipos de hahitat naturales, seminaturales y artificiales, y a 107 localidades específicas. Nuestro análisis demuestra que los bosques perennes degradados, las plantaciones de árboles exóticos, y las colectividades urbanas tienen un valor de conservacidn bajo; los otros tipos de hahitat considerados tienen un valor alto en una o más dimensiónes. También hemos identificado 12 juegos diferentes de 20 localidades cada uno quepodrian incremental ya sea la diversidad de los grupos taxondmicos de aves o el valor de conservacidn a lo largo de distintas dimemiones Asi hemos tratado de sintetizar la diversidad y la calidad de los grupos taxonómicos para generar recomendaciones sobre la conservacidn En contraste, los métodos actuales tienden a enfatizar los grupos taxonómicos raros o de alto riesgo, o la diversidad total Dichas recomendaciones podrian ser útiles al elaborar una estrategia de conservación general para una regidn geográfica

Introduction

Conservation action demands value judgments because such action often involves a choice among a set of alternatives Some alternatives must therefore he considered to be of higher priority than others It is useful to make explicit such a process of forming value judgments to help reduce the chance that arbitrary actions will be based on some momentary emotional appeal or compromise This is the motivation underlying a number of recent attempts to assign specific conservation values to biological and landscape elements The elements in consideration may vary from an isolated population of a plant species to a major biome such as the tropical rain forest (Nature Conservancy 1983, Usher 1986) We present here an attempt to assign conservation values, and we describe their use in deriving specific conservation prescriptions, Our work pertains to valuation of ecological zones, habitats, and specific localities in the Uttara Kannada district of the state of Karnataka in South India based on the presence and absence of bird taxa

Study Area and Methods

The Uttara Kannada district along with the adjoining taluk (=county) of Hangal from Dharwad district (13" 55'–15" 32' N 74° 05′–75° 05′ E) is located centrally on the Malabar biogeographic province Ibe Malabar, c 160,000 km^2 in extent, comprises of a narrow coastal strip 5 to 100 km in width along with the hill chain of Western Ghats running north-south parallel to the west coast between 8" and 20° N lat (Fig, 1) The hill chain is a long band 50–100 km in width ranging in altitude between 400 and 2680 m It is broken by just one narrow gap, the Palghat gap, over its entire length of 1600 km. The annual rainfall in this province averages 2000 mm, but it is as high as 6000 mm on the crest and as low as 600 mm in the eastern rain-shadow region Its range of habitats includes beaches; estuaries; low-, medium-, and high elevation tropical wet evergreen forests; and moist and dry deciduous forests and scrub (Subramanyam & Nayar 1974) There are a number of manmade habitats too Ali and Ripley (1983) and Daniels (1989) record 586 taxa of birds (which includes 515 full species, some of which exist as two or more distinct subspecies in the Malabar) and broadly distinguish 24 major habitat types for the Malabar province

The study area (Fig 2) of 11,000 km^2, characterized by low hills with only a few peaks above 600 m, has a great diversity of habitats, including 21 of the 24 habitat types described for the Malabar province (Daniels 1989) Based on rainfall, vegetation, the extent of human interference, and the pattern of diversity and distribution of birds, the district may be divided into five ecological zones: the coast, the northern less-disturbed evergreen forest, the southern more-disturbed ever. gseen forest, the moist deciduous forest, and the dry deciduous forest and scrub (Pascal 1982, 1984, 1986; Daniels 1989)

The bird fauna of Uttara Kannada is relatively well known Davidson (1898a,b) published detailed notes on distribution and habitat preference of birds of the disuict based on collections from 1888 to 1896 Subsequently Koelz (1942) published a supplementary list based on a 3-month survey Daniels (1989) maintained detailed notes on bird taxa throughout the disuict over

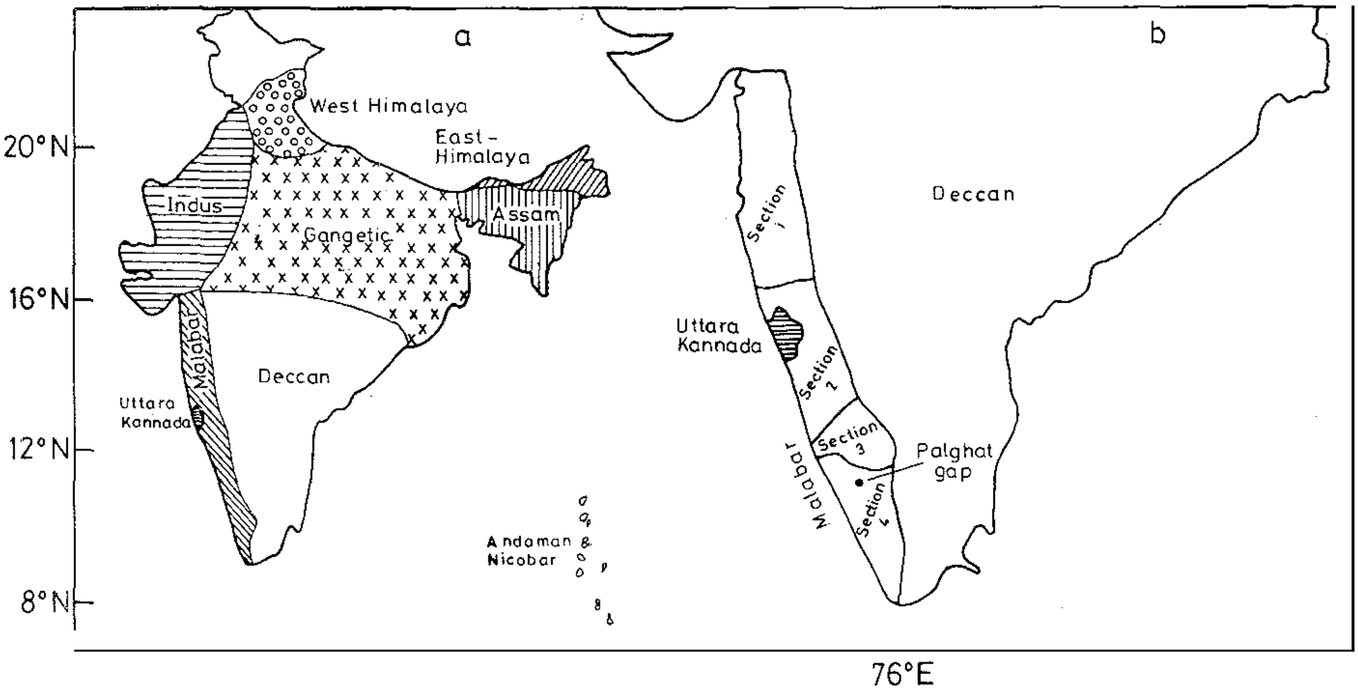

Figure 1 The Uttara Kannada district in relation to the major biogeographic provinces of the Indian subregion (a) and the four sections in the Malabar province (b)

a 5-year period involving 1018 days of field observation During this period he visited 237 localities scattered over the district and recorded the presence and absence of bird taxa For the sake of mapping the spatial distribution of each taxon of bird, the district was divided into 498 grids of 5 km × 5 km Using the vegetation maps (1:250,000; Pascal 1982, 1984) and the Survey of India toposheets (1:250,000 & 1:50,000), the distribution of the major habitats of thr district was mapped onto these grids Notes were maintained on the presence or absence of each taxon by grids and by habitat types during the 5 years of field work This information was used to assign the different taxa of birds to the respective zones and habitats These data have been supplemented by systematic 2-hour, 600-×-200-m strip transect samples from 107 localities These localities were chosen to encompass the total range of variation in climate, topography, and habitat types over the district The transects were covered on foot between 8 00 and 10 00 hours in forests and associated habitats and between 7 30 and 9 30 hours in nonforest and open habitats such as marshes during the nonrainy seasons (November–May) of 1986–1988. Additional information made available by three amateur naturalists on birds in this district has also been utilized The total was 420 taxa of birds (402 full species and more than one subspecies of some of these species) recorded over the century from this district Daniels et al (1990*a*) analyze the changes in the bird fauna over the time span that these records reveal

Assigning Conservation Values

Conservation value is assigned to an element such as a taxon or a locality with reference to an ***attribute,*** for instance, the extent of geographical distribution of a given bird taxon or the number of resident bird taxa in a given locality The different states of such attributes are then assigned values based on a *criterion*. Thus, we may decide that the more restricted the geographical distribution of a taxon, the greater the ***value*** of the taxon, or the larger the number of taxa present in a locality, the more valuable the locality is The actual values may either be ranks along a scale or a ***specific*** number (Nature Conservancy €983; Usher 1986).

In the endeavor contemplated here the conservation values would be one of the inputs for identifying a set of protected localities The values are computed on the basis of the presence and absence of different bird taxa in particular localities, habitats, or ecological zones We set this up as a 2-step process, assigning values to (1) individual bird taxa, and (2) localities, habitats, or zones based on the values of the bird taxa occurring therein

Step One: Bird Taxa

The attributes of bird taxa of the Malabar considered are the extent of their geographical distribution, their habitat preference, their taxonomic position, and their degree of endangerment The criteria translating the attributes into values are based on the assumption that the

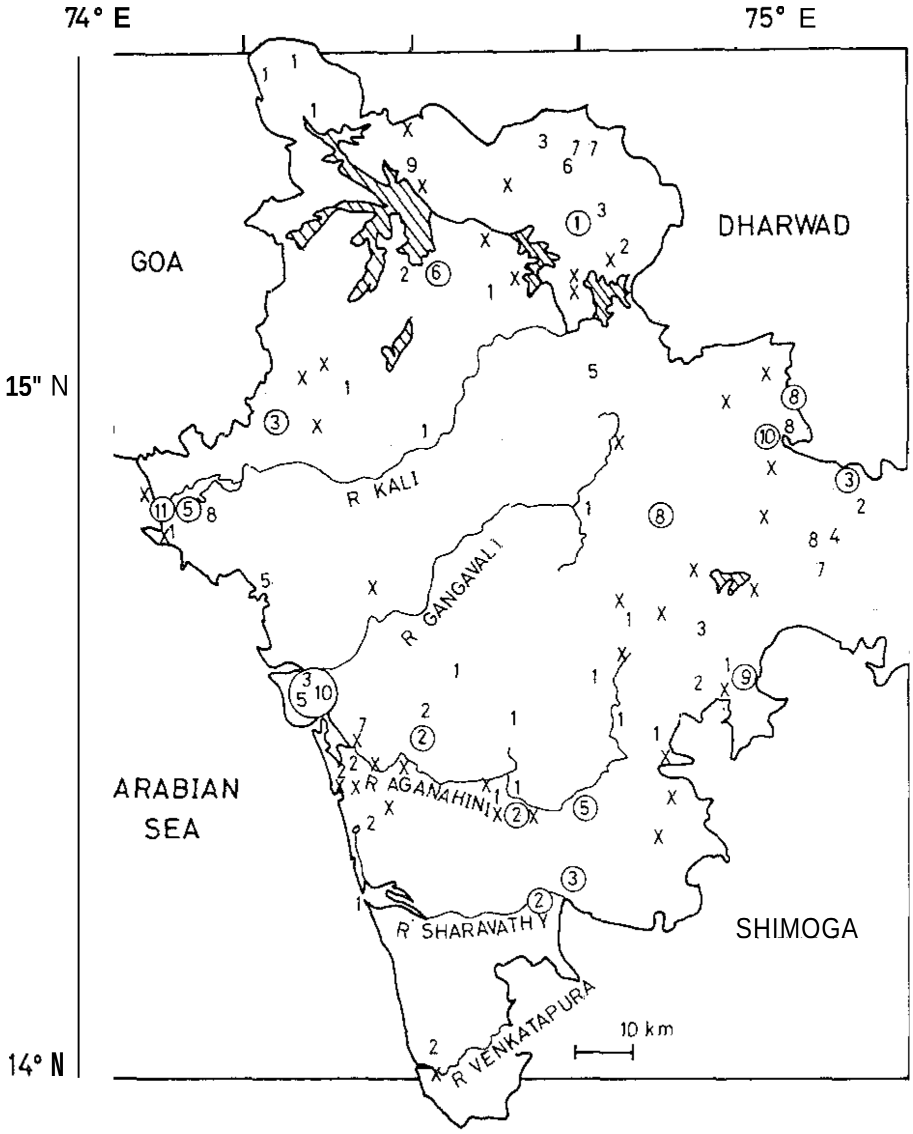

Figure 2. Uttara Kannada district and the adjacent Hangal taluk of Dharwad district, showing the 107 localities sampled and the 18 localities of conservation interest. The numbers indicate the number of times a locality was represented in the 12 approaches attempted in this analysis. "X" indicates localities sampled that never occurred within the first 20 in any of the approaches Circled localities are those recommended for conservation. Hatched areas are major reservoirs

rarer or more restricted a taxon the more valuable it is, and the more taxonomically unique or endangered a taxon the more valuable it is (Nature Conservancy 1983; Dony & Denholm 1985; Miller et al 1987; Wheeler 1988; May 1990). The measures proposed below ensure that all the values lie in the range 0 to 1

We have selected for this analysis seven attributes of bird taxa Four of these relate to the geographic range of the bud taxa; G_1, over the entire world (divided into six zoogeographic regions); G_2, over the oriental region (divided into nine subregions); G_3, over the Indian subregion (divided into eight provinces); and G_4, over the Malabar province (divided into four sections) (Chatterjee 1939; Subramanyam & Nayar 1974; Cox & Moore 1980; Ali & Ripley 1983) The conservation value for a taxon by geographic range is given as

$$G = (N - a)/(N - 1),$$

where N is the number of subdivisions at a given geographic level and a is the number of subdivisions from which the taxon is known. We treat the four levels of geographic distribution as separate dimensions in view of the distinctive patterns of distribution along each level For instance, a taxon restricted to the Malabar may be widespread within the province Similarly, a taxon may be found only in the Malabar in India but may be widespread elsewhere in Southeast Asia The data on geographical distribution used in this analysis are based on Howard and Moore (1980) and Ali & Ripley (1983)

The conservation value of each taxon by habitat preference was computed using the index

$$H = (N - a)/(N - 1);$$

where a is the numbet of habitats in which the taxon is known to occur and N is 24, the total number of habitats for the Malabar province; thus, birds with more restricted habitat preference are assigned higher values This appears appropriate as birds utilizing more habitats also tend to use the more man-modified ones in the Malabar (Daniels 1989)

The conservation value of a taxon reflecting its taxonomic distinctness was calculated using the index

$$7 = 1/(a \times b),$$

where a is the number of species known in the family to which the taxon belongs and b is the number of races under the species to which it belongs based on the information provided by Wallace (1963) and Howard and Moore (1980) The rationale behind such a treatment is that the races or subspecies are the lowest distinct taxonomic units below the level of species and that they indicate the totality of the genes contained in any species (Chambers and Bayless 1983) It would certainly he better to measure taxonomic distinctness on the basis of detailed information contained in the pbylogenetic tree of birds, with a taxon having fewer existing relatives taking a higher conservation value than another with more relatives (May 1990) Since we do not have access to such complete information, we have used a simpler index

The conservation value by degree of endangerment for each taxon was assigned by

$$E = p,$$

where p is the proportion of endangered taxa in the family to which the taxon belongs We prefer this to using the available lists of threatened birds, because only three bird taxa of Uttara Kannada figure in such a list and our field studies strongly suggest that this choice is arbitrary and does not reflect the true situation The Peafowl (*Pavo cristatus*), the Nilgiri Wood Pigeon (*Columba elphinstonii*), the Lesser Adjutant Stork (*Leptoptilus javanicus*), and the Redfaced Malkoha (***Phaenicophaeus pyrrocephalus***) are the only Malabar birds among those listed as endangered in India (World Conservation Monitoring Centre 1988) The Redfaced Malkoha, however, dors not occur in Vttara Kannada The wood pigeon and the stork are locally rather common in appropriate habitats over the Malabar (Daniels, personal observation) and the Peafowl is widely cistrih uted in India with many pockets of local abundance thanks to strict religious protection,

In a taxonomic survey of endangered birds, Temple (1986) distinguished four types of birds: (1) taxa that are endemic to islands, (2) taxa that are narrowly confined to scarce habitats, (3) taxa that are particularly sought-after by human consumers, and (4) taxa that depend on easily-disturbed food chains The first category is irrelevant to this analysis, hut the other three are pertinent Birds of prey and those in families such as Podicipedidae, Haematopodidae, Gruidae, Rallidae, Phasianidae, and Psittacidae are more threatened than others because they share some common trait (more palatable flesh, ground- or bole-nesting, poorly developed dispersal abilities) Temple argues that families in which 10% or more of the constituent birds are endangered should be considered especially sensitive Our assignment of conservation values reflects this notion, and birds in families with more endangered taxa are assigned a higher conservation value on the basis of the proportion of endangered taxa in a family (Temple 1986)

We thus arrive at a conservation value for each of the 586 bird taxa of the Malabar as a pcint in a seven-dimensional space (Figs 3 & 4) The set of bird taxa of interest to us is those occurring in one of the provinces, the Malabar Fully 40% of these are restricted to the Oriental region, and within the Orient, 29% are restricted to the Indian subregion The distributions of conservation values at global arid regional levels are therefore unimodal, with the mode occuring at the higher extreme of the conservation value Within the subregion, however, a much smaller proportion, 17%, are confined to the Malabar province, many being shared with two other provinces Hence this distribution is bimodal Finally, a high proportion of taxa (41%) are distributed over all the four sections of Malabar Hence this distribution is unimodal, but with the mode occuring at the lower extreme of the frequency distribution Taxa restricted to India are necessarily restricted to the Oriental region; many of these are also confined to the Malabar Hence the conservation values along these axes are highly positively correlated

The frequency distributions of values along the other three axes are unimodal; those for taxonomic value and degree of endangerment are confined within a very narrow range at the lower extreme This implies that most bird taxa belong to families with several species or species with several subspecies, the only monotypic family in the Malabar being the Dromadidae represented by *Dromas ardeola* Similarly most taxa of birds in the Malabar belong to families in which only a very small proportion of species are listed as endangered

REDUCING THE DIMENSIONALITY

The conservation value of a bird taxon can thus be represented as a point in the seven-dimensional space, Because it is difficult to visualize and inconvenient to ham

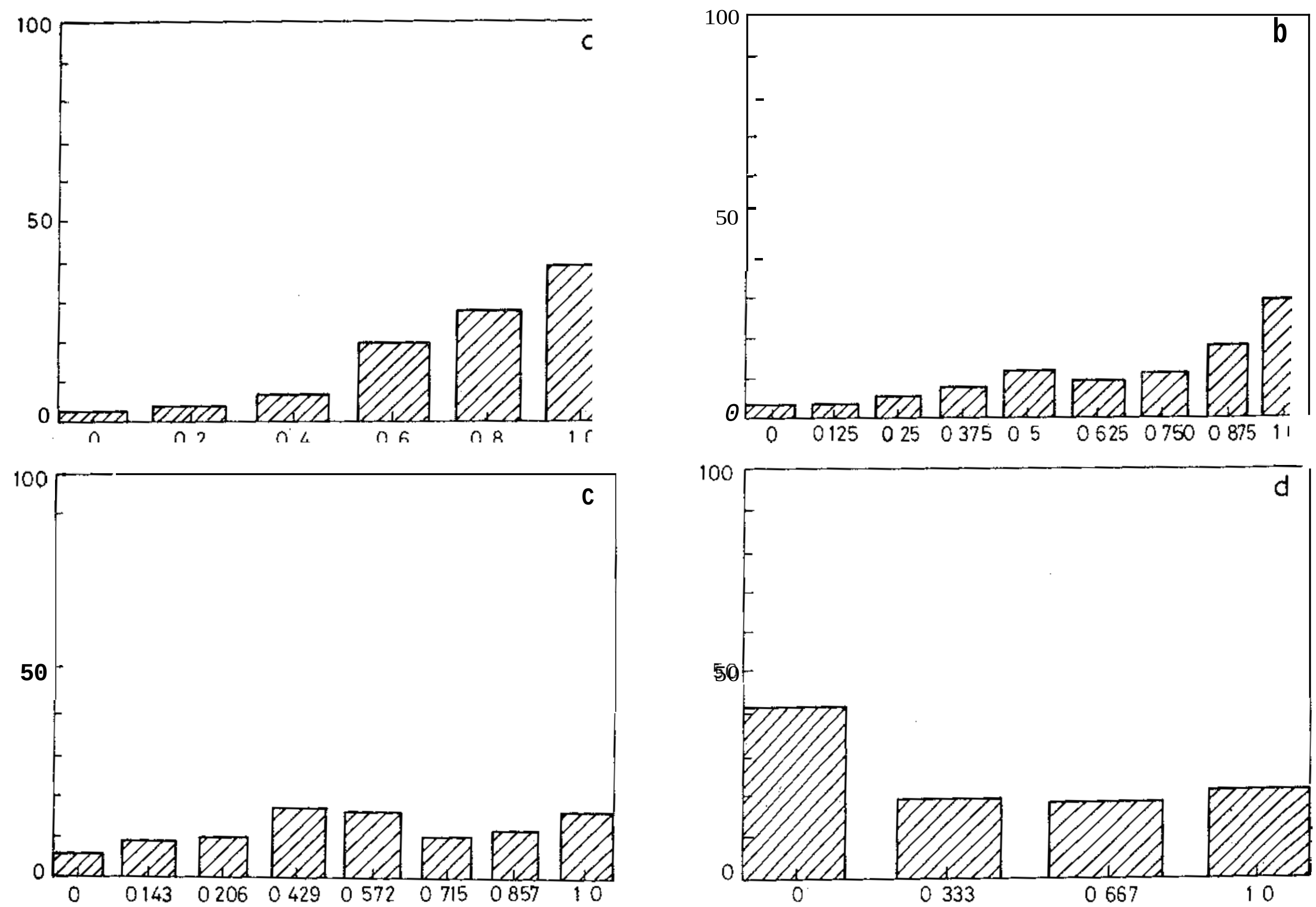

Figure 3 Frequency dishibution of conservation values based on geographical distribution for the 586 taxa of Malabar birds. (a) G_1: Global; (b) G_2: Regional, (c) G_3: Subregional; and (d) G_4: Provincial

dle the distribution of points in space of such dimensionality, it would be useful to reduce it We may do this in two ways First, if the conservation values in two or more dimensions are highly positively correlated, it would be enough to retain only one of those dimensions, To explore this possibility we have computed the correlation matrix in the 7 × 7 dimensional space for the 586 bird taxa of the Malabar (Iable **1**) **As** discussed above, the Conservation values in dimensions G_1, G_2, and G_3 are significantly correlated among each other, and it should be sufficient to choose just one of these ?he dimension to be **so** chosen should be minimally positively correlated to the other six, **An** inspection of the matrix shows that G_1 satisfies this condition We therefore propose to leave **G,** and G_3 out of further consideration in this presentation We did, however, **look** at the implications of continuing to take **G,** and G_3 into account and found that they do not change our subsequent conclusions We have also considered the use of techniques such as principal components analysis; this does not affect the final conclusions in any way either It thesefore appears justifiable to leave out the **di**mensions G_2 and G_3 and thereby further simplify analysis

As a second device for reducing the dimensionality of the problem, we looked at the distribution of the conservation values **along** each individual dimension, It turns out that for the dimensions of taxonomic position and degree of endangerment, most of the values ate concentrated in a very narrow range between 0 and 0 05 (Figs *4b* & *4c*) This is because the Malabar bud fauna, as discussed above, includes just one taxon belonging to a monospecific family (Dromadidae) and only a few taxa belonging to families such as Phasianidae, Gruidae, etc, that have a high proportion of threatened taxa We can therefore further reduce the dimensionality of our analysis by leaving **out** these two attributes Again we have carried out the full analysis retaining these dimensions and confirmed that the **con**clusions are not affected in any way

We therefore suggest that it **is** useful to reduce the dimensionality of the valuation procedure by using internal correlations and distribution of the values Over the total range We do not, however, imply that the specific dimensions removed in our analysis would turn out to be the dimensions to be neglected in other such analyses We propose only that all possibilities of reduc-

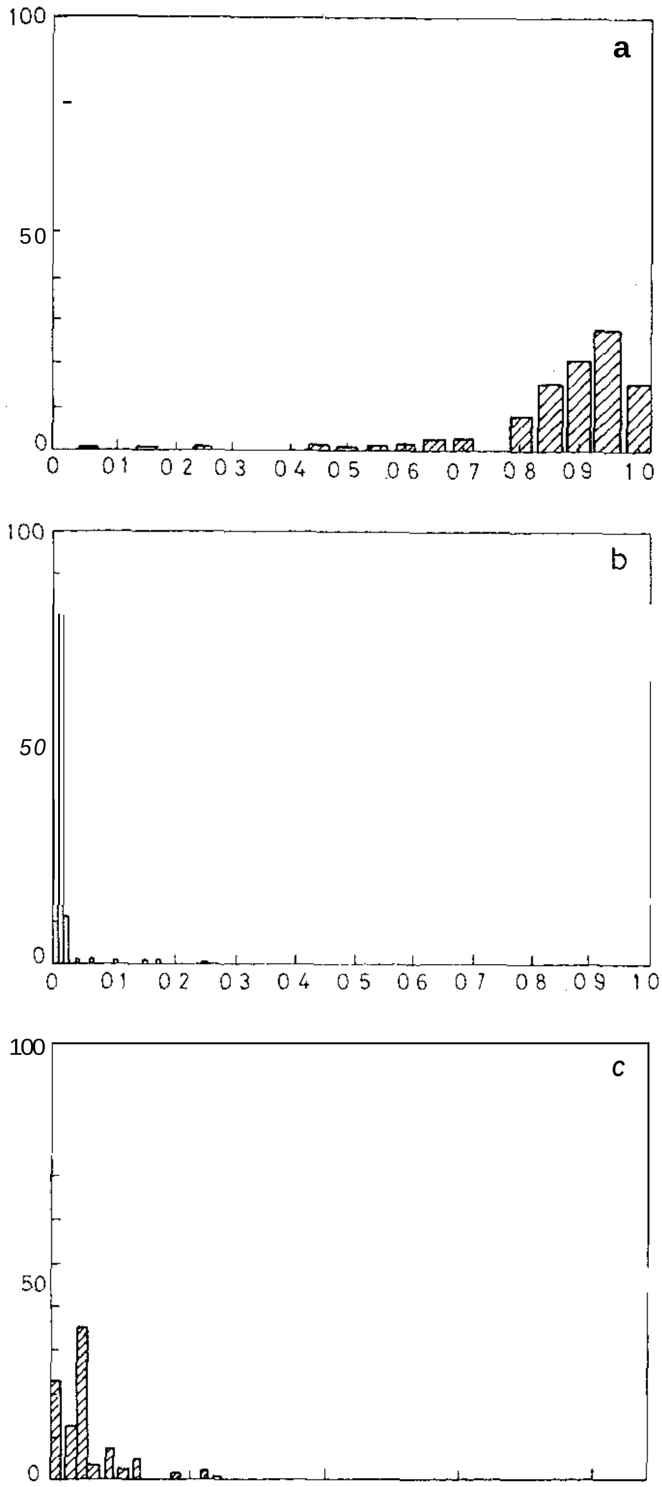

***Figure 4** Frequency distribution of conservation values for the 586 taxa of Malabar birds, (a) H Habitat preference; (b) T: Taxonomic position; and (c) E: Degree of endangerment*

tion of dimensionality should be explored and judged on a case-by-cast basis

Step Two: Geographical Element Level

The second step in the process concerns the occurrence of bird taxa in given localities, habitats, or zones The criterion for assigning conservation value to such geographical elements could be species richness (number of bird taxa) or a measure of diversity (*e*g . the Shannon-Wiener index), the total conservation value summed for all taxa occurring in a given geographical element, or the mean conservation value of a taxon in each geographical element We carry out this analysis with the conservation value being considered as a point in the reduced three-dimensional space of G_1, G_4 and H We do not have adequate data on the relative abundance of taxa to compute an index such as the Shannon Wiener diversity index This means that any given geographical element could be assigned a conservation value along one of the following seven dimensions: richness of taxa and total as well as mean conservation value along the dimensions of G_1, G_4, and H

Again it is possible to reduce the dimensionality of the problem Table 2 presents a 7-×-7 matrix of correlation between the conservation values for the 107 localities It is evident that the total conservation values along all three dimensions are very highly correlated with richness of taxa Indeed, similar analyses for habitats and ecological zones show the same trend We therefore retain just the simplest parameter, number of taxa, for further analysis As before we have gone through the analysis preserving the full dimensionality of the problem and confirmed that deleting these three dimensions does not change our conclusions We thus have reduced the problem of valuation of geographical elements to a four-dimensional problem with values being assigned for (1) number of taxa and mean conservation value in terms of (2) global geographical distribution, (3) distribution within the biogeographic province of Malabar, and (4) habitat preference

Conservation Values

Zones

Table 3 presents the conservation values along these four dimensions for the five ecological zones, the five natural and quasinatural and seven manmade terrestrial habitats and the three aquatic habitats Of the five ecological zones none has the highest conservation value along all four dimensions The coastal zone with its rich aquatic habitats has the highest value for birds with narrow habitat preference and restricted geographical distribution within the Malabar The northern evergreen forest zone scores highest in the global geographical

Table 1 Spearman's correlation coefficient *r* between the Conservation values under the seven attributes for the 586 taxa of the Malabar birds.

Attributes	G_1	G_2	G_3	G_4	H	7	E
G,: Global	—	0 31''	0 33''	– 12**	– 19''	– 05	– 07
G,: Regional		—	0 72''	0 22''	– 08'	– 06	– 04
G_3: Subregional			—	0 22''	– 07	– 03	– 07
G,: Provincial				—	0.29**	0 08*	0 06
H Habitat preference					—	0 07	0 11*
T: Taxonomic position						—	– 02
E: Degree of endangerment							—

*$p \leqslant 005$
**$p \leqslant 0.01$

distribution, harboring a number of taxa restricted to the Oriental region and Indian subregion The moist deciduous forest zone has the highest number of taxa sheltering a large number of land birds The dry deciduous forest-scrub zone with freshwater lakes shares the highest conservation value for habitat preference with the coastal zone It is only the southern evergreen forest zone with its extensive man-modified habitats, especially hetelnut (*Areca catechu*) orchards, that does not score the highest along any dimension While human interference has not had an adverse effect on the total diversity of birds within the district, it has affected the "quality" of birds, generalist invaders displacing the birds more specialized to utilize the natural forests (Daniels et al 1990*a,b*)

Habitats

Among the natural and quasinatural terrestrial habitats, the evergreen forest scores highest on the dimension of global geographical distribution because many forest bird taxa are restricted to the Indian subregion of the Oriental region The moist deciduous habitat is richest in taxa, the scrub in taxa having narrow habitat preferences, and the scrub and dry deciduous forest in taxa with restricted distribution within the Malabar province, Again it is the degraded evergreen forest that is not among the highest along any of the four dimensions

Of the manmade habitats, eucalypt plantations score high on richness of taxa and on birds with restricted distribution within Malahar This is because in this district the plantations are in small patches and share a number of taxa from the surrounding habitats, mcstly of dry deciduous forest and scrub (Daniels et al 1990*b*) The hetelnut plantations closely resemble the evergreen forest in their structure and microenvironment and share bird taxa characteristic of the latter, such as the Malahar Whistling Thrush (*Myiophonius horsfieldii*) and the Spiderhunter (*Arachnothera longirostris*). Hence they score high on birds restricted to the Indian subregion and Oriental region Finally the cultivation does well for taxa with limited habitat prefetence, resembling the scrub with which it shates a number of taxa Ieak (*Tectona grandis*) follows the betelnut closely with regard to globally resuicted taxa of birds, Other exotic plantations such as *Acacia auriculiformis*, coconut groves, and urban settlements do not score the highest along any of the four dimensions (Table 3)

The three aquatic habitats score quite high along three of the four dimensions Freshwater ponds and lakes have a high richness of taxa, even exceeding that of the moist deciduous forest Estuaties and beaches have taxa scoring high in terms of habitat preference, As expected, aquatic habitats score very poorly in terms of geographic distribution on a global and regional scale, many migratory taxa having a worldwide distribution,

Localities

Ihis assessment of the conservation values of ecological zones and habitats is useful for developing a regional conservation strategy Furthermore, our analysis can

Table 2. Spearman's coefficient *r* for the correlations between the conservation values of birds from the 107 localities.

Attributes	R	Summed values G_1	Summed values G_4	H	Mean values $\bar{G}_1$	Mean values $\bar{G}_4$	$\bar{H}$
R: Richness of taxa	—	0 90**	0 70**	0 99''	0 00	– 07	0 14
G,: Global		—	0 54'''	0 84''	0 42''	– 18	– 09
G_4: Provincial			—	0 74''	– 20'	0 64''	0.33**
H: Habitat prefetence				—	– 09	– 02	0 31''
$\bar{G}$,: Global					—	– 28'	– 46''
$\bar{G}_2$: Provincial						—	0 35''
$\bar{H}$: Habitat preference							—

*$p \leqslant 0.05$
**$p \leqslant 0.01$

Table 3. The number of taxa of birds and the mean conservation value of a taxon in the different zones and habitats of Uttara Kannada.

Zones/Habitats	*R*	$\overline{G}_1$	$\overline{G}_4$	$\overline{H}$
Coastal zone	130	0 70	0 18	0 85
Northern evergreen zone	111	0 89	0 12	0 81
Southern evergreen zone	165	0 84	0 13	0 83
Moist deciduous zone	185	0 83	0 14	0.84
Dry deciduous zone	160	0 77	0 17	0.85
Natural and quasinatural terrestrial habitats				
Evergreen forest"	33	0 97	0 13	0 76
Degraded evergreen forest	36	0 94	0 09	0 71
Moist deciduous forest	43	0 93	0 13	0 72
Dry deciduous forest	28	0 88	0 14	0 70
Scrub	28	0 74	0 14	0 81
Manmade terrestrial habitats				
Eucalypt plantation	41	0 90	0 13	0 71
Teak plantation	37	0 92	0 11	0 72
Betelnut plantation	36	0 93	0 09	0 70
Other exotic plantation	35	0 83	0 09	0 '71
Coastal coconut garden	29	0 80	0 09	0 71
Urban	29	0 74	0 09	0 74
Cultivation	42	0 71	0 12	0 78
Aquatic habitats				
Freshwater ponds or lakes	47	0 76	0 13	0 77
Estuarine	35	0 66	0 15	0 79
Beach	24	0.71	0.15	0.77

[a] Average number of bird taxa per sample has been used for the habitats because 2–20 transects were sampled in each habitat type

help pinpoint localities that merit protection under a nature reserve system on a priority basis In the specific context of Uttara Kannada, the state Forest Department, which is responsible for nature conservation, has set up a network of nature reserves by constituting a large wildlife sanctuary at Dandeli and protecting several freshwater marshes notable for water birds as bird sanctuaries The large wildlife sanctuary functions only on paper, being severely disturbed by the construction of several dams and a paper mill inside its boundaries The official approach thus is of little value (Rodgers & Panwar 1988). The scientific approaches largely focus on identifying localities harboring rare or endangered taxa (Dony & Denholm 1985; Miller et al. 1987; Slater et al 1987; Wheeler 1988) or maximizing the number of taxa protected (Hague et al 1986) Both approaches have serious limitations in the present context First, only three taxa of birds have been considered endangered in Uttara Kannada, and since there is reason to doubt the appropriateness of the choice, this cannot serve as a useful basis Second, as we will see in more detail below, attempts to maximize the number of bird taxa protected would lead to a focus on secondary habitats and buds with wide ranges and habitat preference Our attempt therefore is to bring information on a number of attributes to bear on the choice of localities to be protected

I'he data base for this analysis is the 273 taxa of birds noted during the 2-hour transects over the 107 localities This is only a fraction of the taxa actually present in each locality For the present purpose, however, we want the data to be strictly comparable and hence do not take into account bird taxa sighted at other times in these localities I'hese 107 localities also include 15 of the 21 broad habitats in the district Ibe six habitats left out are insignificant because they occur either as small patches (dimensions less than that of a uansect) or as mosaics, as in the case of a freshwater marsh-paddyfield complex

Given the variety of information available, it is possible to devise several alternative methods of valuing the localities and ranking them in terms of conservation priorities Table 4 lists twelve such alternatives Each involves choice of an initial starting point and a criterion for adding another locality The natural choice for a starting point can be a locality scoring highest on any one of the attributes, for example, the total number of bird taxa, total conservation value, or the average conservation value of a taxon in terms of habitat preference The csiterion for adding a locality may refer to some property of the totality of bird taxa represented when that addition is made Such a property could be total diversity, total conservation value, or average conservation value of bird taxa A decision also needs to he made as to the total number of localities to be selected Following Rodgers and Panwar (1988) we may aim at bringing 6% of the total area under the network of protected localities If this is a highly dispersed network, the minimal size of protected localities may be fixed at 30 km^2, since reserves of this size are considered appropriate for tropical forest buds including some of the raptors (Leck 1979; Thiollay and Meyburg 1988) This

Table 4. **Localities of Conservation Interest in Uttara Kannada.**

S. No.	Procedure followed: Criteria	Starting point	Criteria for subsequent choices	No. of taxa (out of 273), habitats (out of 15), predominant habitats and zones (our of 5) represented in the first 20 localities chosen: Taxa	Habitats	Predominant habitat type	Zones
1	Maximizing number of bird taxa	The locality with the highest no. of taxa	Choosing the next locality with the maximum no of taxa different from those that have already been included	242	6	Marsh beach, and manmade	5
2		The locality taking the highest rank $\overline{G}_1$	As in 1	239	9	Marsh beach, and manmade	5
3		The locality taking the highest rank $\overline{G}_4$	As in 1	244	8	Marsh, beach, and manmade	5
4		The locality taking the highest rank under $\overline{H}$	As in 1	244	8	Marsh, beach, and manmade	5
5		Localities ranking the highest under no. of taxa $\overline{G}_1$, $\overline{G}_4$, and $\overline{H}$	As in 1	238	8	Marsh, beach, and manmade	5
6	Maximizing total conservation value	Locality ranking the highest under $\overline{G}_1$	Next locality chosen such that it maximizes the total conservation value	242	8	Marsh, bench, and manmade	5
7		Locality ranking the highest under $\overline{G}_4$	As in 6	229	9	Marsh, beach, and manmade	5
8		Locality ranking the highest under $\overline{H}$	As in 6	243	7	Marsh, beach, and manmade	5
9	Maximizing the value per taxon protected	Locality ranking the highest under $\overline{G}_1$	Next locality chosen such that the value per taxon remains at the highest level possible	109	5	Evergreen forest	3
10		Locality ranking the highest under $\overline{G}_4$	As in 9	162	5	Beach and marsh	4
11		Locality ranking the highest under $\overline{H}$	As in 9	165	8	Beach and marsh	3
12	Equal representation of all 4 attributes	Localities ranking the highest under no—of taxa, $\overline{G}_1$, $\overline{G}_4$, and H	Those ranking the next and thus up to the first five ranks	207	5	Marsh and evergreen forest	5

suggests that we should identify about 20 localities for this purpose

The first eight alternatives listed in Table 4 all lead to essentially similar results because the total conservation value is highly correlated with the total number of taxa. These procedures all lead to representation of a high proportion of taxa (about 240 out of a possible 273), habitat types (six to nine out of a possible fifteen), and all five ecological zones in the fust 20 localities selected A major drawback of these choices is the emphasis on secondary, manmade habitats and taxa with broader habitat tolerance Such habitats and taxa do not really need special conservation efforts Alternatives 9 through 11 attempt to maximize average conservation value Hence they tend to emphasize taxa with narrow geographical ranges or habitat preference, a relatively small number of total taxa being represented in the top 20 localities The last alternative, 12, attempts to bring together the desirable features of both sets of alternatives It selects the localities with the five highest scores on the four attributes, namely the total number of taxa, average conservation value along two levels of geographic distribution, and average conservation value on habitat preference Because of some common representation this leads to the selection of only 18 instead of 20 localities While with this procedure the total number of taxa and habitats represented is somewhat lower than for the fust eight procedures, it ensures good representation of primary habitats deserving urgent attention, namely the evergreen forests, beaches, estuaries, fresh-water marshes, and dry scrub (Table 5) Figure 2 shows the distribution of all the localities, 66 in all, that were identified as worthy of preservation by any of these 12 procedures and the number of procedures in which each locality was represented. The 18 localities of procedure 12 are specially highlighted as we believe these represent a very good combination of the various attributes that may be employed toward selecting localities for conservation (Table 4)

Discussion

Valuation of localities of high priority for conservation purposes is one of the many significant inputs to a conservation strategy However, most often it is limited by choosing just one set of organisms such as flowering

Table 5. Attributes of 18 localities identified as possessing the five highest conservation values along the four dimensions of total richness of taxa (R), mean value for geographical distribution on a global scale ($\bar{G}_1$), mean value for geographical distribution on the scale of the Malabar ($\bar{G}_4$), and mean value for habitat preference ($\bar{H}$).

Locality	Ecological zone	Habitat	Dimension
Sunkeri	coastal	Estuary	$\bar{H}$
Sanikatta	coastal	Estuary	$\bar{G}_4$
Madnegeri	coastal	Estuary	$\bar{G}_4$
Thenginagundi	coastal	Estuary	$\bar{H}$
Karwar	Coastal	Beach	$\bar{G}_4$
Bacgadda	N evergreen forest	Evergreen forest[a]	R
Patoli	N evergreen forest	Evergreen forest[a]	R
Anegundi	S evergreen forest	Evergreen forest	$\bar{G}_1$
Doddamaneghat	S evergreen forest	Evergreen forest	$\bar{G}_1$
Unchalli	S evergreen forest	Evergreen forest	$\bar{G}_1$
Mastimane	S evergreen forest	Evergreen forest	$\bar{G}_1$
Malamane	S evergreen forest	Evergreen forest	$\bar{G}_1$
Bharatnalli	Moist deciduous forest	Freshwater lake	R
Madurahalli	Moist deciduous forest	Freshwater lake	R
Sambrani	Dry deciduous forest or scrub	Freshwater lake	R
Salgaum	Dry deciduous forest or scrub	Freshwater lake	$\bar{H}$
Nyasergi	Dry deciduous forest or scrub	Freshwater lake	$\bar{G}_4$
Yelavatti	Dry deciduous forest or scrub	Scrub	H

[a] With a considerable admixture of trees typical of the moist deciduous forests

plants, or as in this case, birds, for the evaluation It would he ideal if other groups of organisms such as insects, amphibians, and mammals are also included in the analysis For instance, if we go by diversity alone in the evaluation procedure, it can be misleading because bird diversity in Uttafa Kannada is negatively correlated with angiosperm diversity (Daniels 1989) and insect species diversity is correlated with neither of these (Gadagkar et al 1989) The analysis discussed above has not, however, emphasized diversity alone, nor does it try to recommend the sole use of birds in a conservation evaluation procedure Buds were chosen primarily because a good deal of data is available on their status and distribution locally, regionally, and even continentally Such data bases are rather incomplete for most other groups of organisms in India A second limitation of this approach is that it leaves out details of the area of each protected locality and the distances separating them Third, it does not specifically look into endangerment due to human pressures, the ecological roles played by birds, and other televant issues such as social acceptability, cultural and aesthetic appeal, and long-range economic benefits (McNeely et al 1990). We are therefore conscious that a whole range of issues would have to be brought in before a conservation strategy is given proper content (Gadgil, 1991). We have already looked at some of these issues in the context of working out an ecodevelopment strategy for Uttara Kannada (Gadgil et al 1985–86) In a companion paper to this study we have elaborated a *first* proposal for a broader conservation strategy that takes into account many of the aspects left out here (Daniels et al , in preparation) However, within this overall context we believe that derivation of conservation prescriptions based on an explicitly stated procedure with all assumptions clearly exposed as has been done above is very useful

Literature Cited

Ali, S., and Ripley, S D *1983* Handbook of the birds of India and Pakistan Compact edition Oxford University Press, Bombay, India

Chambers, S M , and J W Bayless *1983* Systematics, conservation and the measurement of genetic diversity Pages 349–*363* C M Schonewald-Cox,S M Chambers, B MacBryde, and L Thomas, editors. Genetics and Conservation ed Benjamin/Cummings Publishing Co , London, England

Chatterjee, D *1939* Studies on the endemic flora of India and Burma. Joutnal of the Royal Asiatic Society, Bengai (Science) **5:19–67**

Cox, B C , and P D. Moore *1980* Biogeography 3rd ed Blackwell Scientific Publications, Oxford, England

Daniels, R J R *1989* A conservation strategy for the birds of *the* Uttara Kannada district Ph.D thesis Indian Institute *of* Science, Bangalore, India

Daniels, R J R, N V Joshi, and M. Gadgil 1990*a* Changes in the bird **fauna** of Uttara **Kannada,** India, in relation to changes in land use over the past century. Biological Conservation **52:37–48**

Daniels, R J R, M Hegde, and M Gadgil **1990*b*** **Birds** of the manmade ecosystems the plantations. Proceedings of the Indian Academy of Sciences (Animal Science) 99:39–52.

Davidson, J **1898*a*.** Birds of North Kanara Part I Journal of the Bombay Natural History Society **11:652–679**.

Davidson, J **1898*b*** **Birds** of North Kanara Part II Journal of the Bombay Natural History Society **12:43–72**

Dony, J G, and I, Denholm. 1985 Some quantitative methods of assessing the conservation value of ecologically similar sites Journal of Applied Ecology 22:229–238

Gadagkar, R, K Chandrasekar, and P Nair 1989 Insect species diversity in the tropics: sampling methods and a case study 'Technical Report 54 CES, Indian Institute of Science, Bangalore, India

Gadgil, M. 1991, Conserving India's biodiversity: the societal context Evolutionary Trends in Plants 5:3–8

Gadgil, M., K M Hegde, and K A B Shetty 1985–86. Uttara Kannada: a case study in hill area development Pages 155-172 in C J Saldanha, editor. Karnataka State of Environment Report 1985–86. Centre for Taxonomic Studies, Bangalore, India

Hague, P, J. W Terborgh, B Winter, and J Parkinson. 1986. Conservation Priorities in the Philippine Archipelago Forktail 2:83–91

Howard, R, and A Moore. 1980 A complete checklist of the birds of the world Oxford University Press, Oxford, England

Koelz, W 1942. Notes on the birds of the Londa neighbourhood, Bombay Presidency Journal of the Bombay Natural History Society 4311-38

Leck, C F 1979 Avian extinctions in an isolated tropical forest preserve, Ecuador The Auk 96:343–352

May, R M 1990 Taxonomy as destiny Nature 347:129–130

McNeely, J A, K R Miller, W V Reid, R. A Mittermeier, and T B Werner 1990 Conserving the worlds biological diversity IUCN, Gland

Miller, R. I., S. P. Bratton, and P S White 1987 A regional suategy for reserve design and placement based on an analysis of rare and endangered species' distribution patterns Biological Conservation 39:255–268

The Nature Conservancy 1983 Natural Heritage Program, Operations Manual, Virginia

Pascal, J P 1982 Vegetation map of South India Karnataka Forest Department and French Institute, Pondichtrry, India

Pascal, J P 1984. Vegetation map of South India Karnataka Forest Department and French Institute, Pondicherry, India

Pascal, J P 1986 Explanatory booklet on the forest maps of South India French Institute, Pondicherry, India

Rodgers, W A, and H. S Panwar 1988 Planning a wildlife protected area network in India. Repo . of the Wildlife Research Institute of India, Dehra Dun, India

Siater, F M., P Curry, and C Chadwell 1987 h practical approach to the evaluation of the conservation . atus of vegetation in river corridors in Wales Biological Conservation 40:53–68

Subramanyam, K., and M P Nayar 1974 Vegetation and phytogeography of the Western Ghats Pages 178–203 in M S Mani, editor Ecology and Biogeography in India Junk Publishers, The Hague, Netherlands

Temple, S A. 1986. The problem of avian extinctions Pages 453–458 in R F Johnston, editor Current ornithology Vol 3 Plenum Press, New York

Thiollay, J-M, and B U. Meyhurg 1988, Forest fragmentation and the conservation of raptors: a survey on the island of Java Biological Conservation 44:229–250

Usher, M B 1986 Wildlife conservation evaluation: attributes, criteria and values Pages 3–44 in M B Usher, editor Wildlife Conservation Evaluation Chapman and Hall, London, England

Wallace, G J. 1963 An introduction to ornithology 2nd ed Macmillan, New York

Wheeler, B. D 1988 Species richness, species rarity and conservation evaluation of rich-fen vegetation in lowland England and Wales Journal of Applied Ecology 25:331–353

World Conservation Monitoring Centre 1988 India: Conservation of Biological Diversity, IUCN, Cambridge