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Analysis of Potential Outcome-based Indicators for assessing the Biodiversity status of Managed Forests: A case study of Delawari Range, Ratapani Wildlife Sanctuary, MP, India

Sharma Ravi[1] and Bhattacharya A.K.[2]
[1]Indian Institute of Forest Management, PO Box 357, Nehru Nagar, Bhopal, MP, INDIA
[2]Madhya Pradesh State Bamboo and Bamboo Crafts Development Board, Madhya Pradesh Government, Forest Department, Khel Parisar, 74 Bungalows, Bhopal, MP, INDIA

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Abstract

The paper deals with the application and analysis of the potential outcome-based indicators of biodiversity in Delawari Range under Ratapani Wildlife Sanctuary (WLS). The work examines the feasibility of identifying appropriate indicators to monitor and assess biodiversity, focusing on the usefulness of selected biotic parameters as surrogate measures of different aspects of biodiversity in managed forests, especially the protected areas, where external pressures like illicit grazing, forest fires, tourism, mechanical disturbances etc., have a combined effect on the persistence of biodiversity. A combination of structural (physiognomy and associated structures) and compositional indicators (indicator species or species group) is selected which is appropriate to the aims of management and to the present scenario of forests. For each outcome, relevant key biodiversity surrogates like vegetation cover, vegetation diversity, structural complexity and naturalness were identified and were assessed the ecological functions of those surrogates along with the panel of experts. Set of field -based indicators were used for assessing the condition of biodiversity in the Delawari range along with the usual biodiversity measuring techniques like survey and sampling techniques and biotic survey forms for the listing of IVI-, Plant Species richness and composition, Faunal status etc. Questionnaire method, group discussion and Noise level determination (Decibel meter) were extensively used for assessing present scenario of the range which will help in obtaining existing biodiversity data for the region, identify the significant biodiversity components and significant measures. These indicators will provide a benchmark so that if future conditions are projected, they can be related to alternative management scenarios and an appropriate system for monitoring can be put in place to detect any changes or trends in biodiversity.

Keywords*:* Biodiversity assessment, indicator, surrogate, biodiversity management.

Introduction

Biodiversity and sustainable management have become central events in forest policy and management. Researchers and forest managers are more aware of the sustainable management of the forests and also by the complexity of this task, the need to identify biodiversity 'indicators' has become a research priority in recent years[1-3]. The challenge confronting the land and biodiversity conservation managers is knowledge about what biodiversity to assess, how to evaluate it and how to interpret complex ecological data to inform policy and management decisions. The monitoring of biodiversity is an outcome –based activity that is meant to positively improve the condition of biodiversity at risk[4].

An indicator may be defined as the product of environmental measurement that is intended to signal something in the environment that is not measured but is of interest[5]. The auditing of biodiversity will involve using scientifically credible indicators as measurements of biodiversity surrogate[6]. Estimate surrogates estimate true biodiversity by using environmental or disturbance attributes (*e.g.,* grazing pressure, fires and tourism influx). A true surrogate represents actual biodiversity (e.g., the physiognomy of the area) most of the studies on biodiversity monitoring have devoted attention to producing sets of indicators[7,8,4]. The biotic indicators can be used as surrogate measures of other components of biodiversity, and these may provide a shortcut in a survey or monitoring program[3]. Considerable research has been undertaken in this area[5,9-14] as a means of assessing conditions for making management decisions. But notwithstanding, the challenge of taking a realistic and believable set of indicators for monitoring biodiversity remains[3] and also a limitation of using many indicators at a time of valuing. But a pompous system to determine and scrutinize the effects of an operation on biodiversity will allow the stakeholders to more easily understand and predict, minimize and avert the negative influence; enhance positive impacts; manage activities; and develop, monitor and refine policies. This means that indicators must be developed in response to necessitate that a risk assessment approach should be central to their development,

and that envisaged significant impacts rather than potential impacts should be the focus of the process leading to their generation.

As from the various sources of literature, the three key components of biodiversity can be recognized which provides a framework for the study[15] are: i. Composition, ii. Structure (e.g., Physiognomy and associated habitat), and iii. Function (Processes).

The structure and compositional elements may also be surrogate functional indicators, e.g., deadwood (a structural indicator) may be a good indicator of decomposition processes[3]. By implication, indicators must be spliced into management objectives and need to conform to a number of standards: i. They necessitate to be easy to measure, even for non-specialists; ii. They must be repeatable (often using different observers) and subject to minimal observer bias; iii. They must be cost –efficient, generating reliable data for acceptable prices; iv. They must be ecologically meaningful, providing data which are easy to interpret.

Compositional diversity is usually assessed by calculating the number of plants and animal species present in a dedicated area[16], or relative abundance and evenness as part of some diversity indices[17]. The breadth of ecological relationships accounted by three components: heterogeneity, complexity and scale[18]. The complexity is of most importance as it refers to the variation resulting from the absolute abundance of individual structural components and also an aspect of habitat structure. It is possible that for some associated species, total abundance of a particular structural feature may be a reliable indicator; while for others, its relative abundance may be a better predictor[3]. Measuring variables such as the diameter of the median tree in the stand; the range of sampled diameters, and the number of tree species, allowed stand structure variation to be determined for virgin and managed forests in Finnish and Russian Karelia[19]. From these data it is possible to make predictions concerning habitat suitability for dependent taxa.

The study of plant communities and their relationships with environmental factors is important in devising successful management strategies. The added pressures in the managed forest areas are also of major concern. Some of the pressures are illicit grazing, tourism and recreational impacts on vegetation, soil or wildlife are most likely to occur[20,21], along with the dependency of native livestock's on the forest resources for fulfilling their daily needs. Assessing and monitoring the conditions and situations of these visitors concentrated sites is essential for both the protection of recreational resources and the provision of quality recreational experiences[22]. Both points and quadrates can be determined either at a fixed interval along a trail or in accordance with the various strata such as level of use or vegetation type[21]. In contrast to the sampling scheme discussed above, an impacted area could also be evaluated purposively[23]. The parameters like plant height and forms, growth forms[24,22] and Index of Vegetation Impact[25] are commonly used for impact studies due to recreational activities. These data if obtained from any managed forest areas will not only provide the managers with benchmark data, but also can be used for assaying the current situation of the biodiversity of the area.

Methodology

The major objective for implementing the study includes the identification of potential indicators, which reflects information about significant biodiversity, stressors and the environmental properties that are relevant to the relationship between stress and the receptors (the impact attribute). Identification of these indicators and related biodiversity values refer to the desired results of management arising from the judgment.

The set of indicators was identified, based on the number of criteria met by each indicator to select the final set of indicators. The criteria, balanced a set of desirable characteristics against the practicalities of choosing a realistic number of indicators that can be measured on the ground or can be derived from the secondary data available. The estimator surrogates were given preference over the true surrogates of biodiversity as it is easier and less costly to measure. The remote indicators do not take into consideration in the present work as it has its own limitations. The method applied to select field indicators for measuring the biodiversity condition involved undertaking following steps[26]:

Identifying significant biodiversity pressure/ disturbing areas of major concern for the PA mangers. i. Identifying potential outcome –based indicators for assessing through the panel of experts involving eminent scholars and academicians from multidisciplinary fields. ii. Selecting a credible and realistic set of outcome –based indicators. iii. Elements of Biodiversity (as measured by surrogates) to monitor and the best indicators to measure them. iv. Performance Analysis and Evaluation.

Two characters of data inputs were applied: i. Biological data based on well –planned, systematic field surveys, and ii. Secondary source of information available from the management officials and stakeholders of the area.

The computation of vegetation indicators as surrogates of biodiversity was exploratory in nature and vegetation survey method was drawn where the required data on species and their composition were collected from the selected points of the Delawari Range through resource inventory forms. Likewise the same was implemented at the other spots of the selected destination point where tourist activity is prevalent. The methodology used in the present study for vegetation data collection has been adopted from the ITTO- NTFP Project, Maharashtra executed by Indian Institute of Forest Management (IIFM). The inventory Design for Resource Assessment was done in the randomly distributed clusters. Each cluster had nine

plots arranged around a central plot in such a way that each of the four directions- North, South, East and west- had two plots in a row. Each plot was square 10-meter plot (10 X 10 Mt.) separated from the adjoining plots by 10 Mt. All the tree woody climbers (Liana) and saplings were counted in these 10 x 10 Mt. Plots. The saplings at least 1.37 Mt. In height but less than 15 cm GBH (Girth at Breast Height) was counted and shown in the column for 0- 15 cm girth class. The tree count was tabulated in 15 cm GBH classes. Trees above 150 cm GBH were grouped in one category ">150 cm" GBH. The plot layout with the central 10 Mt. Baseline and 5 Mt. Offsets on the selected sites on the base line works faster.

In addition, a line at 2.50 Mt. parallel to the baseline defines a subplot of 25 square mt. for measurement of shrubs, climbers, rhizomes and tubers. Ocular estimation of an average height of each species should be entered into the inventory forms. 1 x 1 Mt plots in the center of each half are laid down for the counting of herbs and grasses. A species need not be counted if the number of individual plants is more than 20. It should be recorded as ">20". If more 10% area of the plot is occupied by a single species, its occurrence should be estimated to the nearest five percent and recorded as such on the inventory forms. It may be possible that some of the shrubs, herbs and other species may not be recorded because of the plot layout. In addition to the quantitative data, it is required that all the remaining species should be listed out and appended to the inventory form. Besides it, the general site characteristics such as slope, aspect, topography, soil conditions, etc., had been described in the inventory forms.

The data so collected from the field through the resource inventory form is then used to describe it into the quantitative manner. The parameter that is used to calculate the intensity of the disturbance is an Importance Value Index (IVI). The distance methods yield three quantitative parameters- density, abundance and frequency. Any one of these parameters can be interpreted as an 'Importance Value'. This depends on which of the values the investigator considers most important for a particular species, group of species of community. This 'importance value' also known as 'Importance Value Index (IVI)', is defined as the sum of relative density, relative frequency and relative abundance. These are calculated as:

Relative Density = [Number of individuals of a species / Total No. of all Individuals] *100
Relative Dominance = [Dominance of a species/ Dominance of all species] * 100
Relative Frequency = [Frequency of species/ Frequency of all species] *100
IVI = Relative density + Relative Dominance + Relative Frequency

Comparing the values of IVI of important species from different sites, the differing intensity of biotic disturbance can be calculated[27]. Although the IVI gives no idea of species biomass or cover, but still for comparing the impact at two sites and assessing the present condition of the area, IVI is a suitable method because the value so obtained gives the intensity of biotic disturbances, which is the major objective of implementing this study. Only it does not express significant aspects of biodiversity, only in combination with other variables or by comparing the two sites on the basis of disturbance / activities may give significant data about the present status of the field. In spite of all, the exploratory data collection of this variable provides a benchmark data for further use, both for analysis and management purpose.

Shannon-Wiener Diversity Index: This method is used to compare diversity between different community and habitats. Both the species richness and equitability of the data set may be summarized by a single number- a diversity index. The value of Shannon-Wiener Index usually falls between 1.5 and 3.5 and rarely surpasses 4.5.

$$H= \; - \sum_{i=1}^{Sobs} [P_i \log_e (P)]$$

Where $P_i = (n_i/N)$ = Proportion of individuals in the *i*th species; H = Shannon Wiener Diversity Index.

'H' tends to increase with the number of species in the sample so it often gives a little more insight than the species number. Also the 'H' value allows us to know not only the number of species, but how the abundance of the species is distributed among all the species in the community. Shannon Diversity is the very widely used index for comparing diversity between various habitats[28].

For preparation and description of existing visual resources in the study area along with the prediction of activities of disturbance and human interference, Visual Assessment methodology[29] has been used. In addition to the visual assessment methodology as stated above, the Biotic Assessment Forms are also filled up by the extensive visits to the site and observations in consultations with the local ground staff and local residents. The Biotic assessment forms often give more evaluative and realism, but qualitative insight into the type of changes that might occur at the site along with the characteristic of the site, which plays an important role from the point of visual assessment and further comparisons of the destination sites in the near future if so. The information garnered by this can lead to useful predictions of biotic impact as easily as to the establishment of baseline conditions and population numbers[30]. The major advantage of this instrument of the survey is that this standard of impact assessment should be used whenever possible. The site features that relate to the biota and that may be impacted by the activities should be noted. This may be accomplished quickly with the aid of a site features checklist assessment form. The data collected through these forms helps in the preliminary assessment of the site as well as provide a record of researcher's first hand observation from the field, as it describes the natural assets of the field. The key threats and pressures to biodiversity specific to the Delawari Range were

identified through this approach. The records of wildlife were obtained from the concern forest department.

Study Area: Cradled in a portion of *Vindhyan* Ranges passing through Raisen and Sehore Districts of Madhya Pradesh, Ratapani Wildlife Sanctuary is one of the good abodes for a variety of wildlife. The sanctuary runs parallel on the northern side of the Narmada River, the "life line of Madhya Pradesh". *Kolar* River forms the western boundary of the Sanctuary. The sanctuary was first notified in 1976 and then extended in 1983. The sanctuary extends over an area of 530.67 sq. km. of forests out of which the 260.66 sq. km. is reserved forests and 270.01 sq. km. is protected forest area and also 57.54 sq. km. In the non - forest area of 18 villages is included in the Sanctuary. Most of the area is hilly comprising of *Vindhyans* hill ranges spreading East-west. One can enjoy witnessing four types of forests: i. Southern Tropical Dry Deciduous Dry Teak Forests, ii. Southern Tropical dry deciduous Mixed Forests, iii. Tropical Dry Deciduous Scrub, iv. Tropical Dry Deciduous Forest Dry Grassland.

The main constraint of management is illicit grazing by the cattle of surrounding villages. About 20, 000 heads of cattle from in and around villages graze in the area. Illicit felling of timber, firewood and bamboo, poaching and encroachment in the forest area are other problems. Forest fire is a major problem in the summer. Ratapani WLS is about 70 km long and about 15 km wide; at places width is only about 10 km which makes the WLS susceptible to intensive biotic pressure in most of its area. Due to this, a large number of wild animals frequently enter human habitats.

Ratapani WLS includes four ranges- Dahod range, Delawari Range, Berkheda Range and Bineka Range. Among the four ranges, Delawari is the most famous tourist spot and an important Eco-tourism destination is also situated in the sanctuary. As per official sources, 50000 tourists visited the sanctuary in the year 2009. Land uses are cattle grazing by the local residents in the range, ecotourism and other picnicking activities, protected area management being the most widespread. Biodiversity is important for the region's production and for its natural and cultural heritage values.

Results and Discussion

A set of potential field indicators for assessing the present condition of the biodiversity in the Delawari Range was identified and priorities for its management in the area in lieu of anthropological activities. The Delawari Range is rich in assets and has many significant biodiversity values, which are: i. Richness of natural ecological attributes. ii. Rich in those species for which the central region of the state is known for its importance. iii. Connectedness and the existence of natural supporting attributes along with the local resources and stakeholders in spite of the existence of external pressure and disturbances (both natural and anthropogenic). iv. Rich in wildlife, flora and fauna.

The desired outcomes and the biodiversity surrogates associated with those outcomes were identified based on the management priorities. The list of key threats and pressure that leads to the identification of indicators is listed in table 1.

Therefore, from the initial assessment of the biodiversity value of the site and associated area as listed in the table 1, establishes in general term the nature of any biodiversity values that may be present and potentially impacted. Stakeholder analysis and subsequent engagement (e.g., with local communities, forest department ground, officials and concerned agencies) were used to assist in understanding the context within which potential impacts may occur. This also helps to develop the reasoning behind the indicators should be developed and used. And an additional output of such engagement of the study also revealed as the priority outcome –based indicators as per management perspectives.

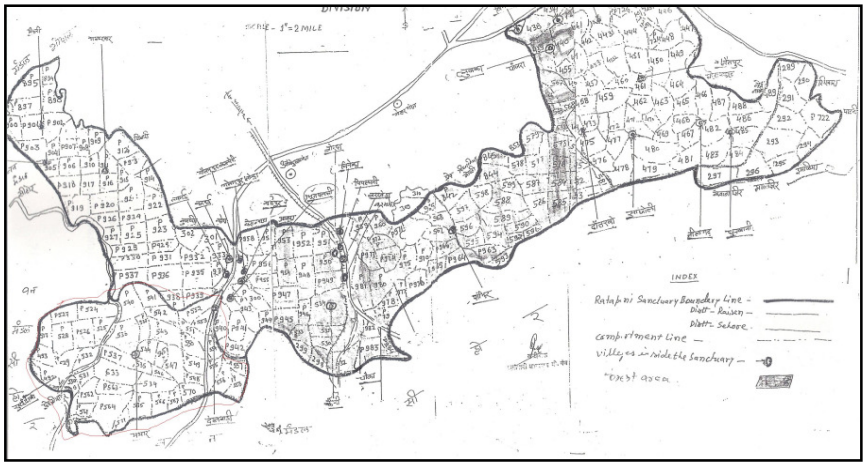

Figure-1
Map of Ratapni Wildlife Sanctuary (Obedullahgunj) Delawari marked with red circle

Table-1
List of identifying added pressures, reasons and key points for management concern (as from the experts' panel)

List of added Pressures on the Range	Description	Effects / Disturbances (concerned for management Practitioners)
Tourism and Recreational activities	-Concentration of visitors in the forest area (during peak area), and also activities in the forest area. -Introduction of left over and polythene in the forest area.	*Accumulation of Debris and waste substances in the area. *Disturbance to wildlife, natural habitats and pressure on the resources. *Degradation of Ecosystem functioning over time. Impact due to pollution (Noise and Air). * Change in land use pattern. * Loss of Aesthetic appeal of the area.
Forest Fires	Common concern for the forest officials and managers.	* Decline/ Loss of local species. * Decline in invertebrate fauna. *Decline in habitat value and depletion/scarcity of resources within dependent communities.
Infrastructure	Road, highway, construction within the area through the range, scarcity of water, Natural resource of water bodies.	Cumulative effects on the ecology and present status of the area.
Noise Generation	Due to visitors' concentration on the specific area and due to transportation through the range. - Visitors' interference in forest area for picnicking activities.	*Shift in the location of habitat and its quality. * Change in wildlife behavior.

In lieu of the above and the result stated in table 1, the key list of added pressures in the managed area and the issues of concern for the managers have been emerged. On the basis of the potential outcome –base indicators has been identified on the basis of applicability, relevance to each desired management outcome. The key Biodiversity surrogates used for assessing biodiversity were: i. Plant Diversity (for current status of plant species associated communities), and vegetation status. ii. Structural Complexity, iii. Naturalness (Wildlife, habitat relation and ecosystem attractions).

The most common tree species were selected on the basis of highest relative dominance percentage obtained after the analysis of resource inventory form from the Controlled site (*i.e.,* area of No tourist interference) and Uncontrolled site (*i.e.,* site of visitors' interference area) of Delawari range. The list of the main tree species has been elucidated in table 2.

Among the tree species found from the inventory survey, the five most common identified tree species from the controlled and uncontrolled area of Delawari area are: *Terminalia tementosa* (Saaj), *Tectona grandis* (Sagon), *Diospyros melanoxylon* (Tendu), *Lamnea grandis* (Gurjan), *Chloroxylon swietenia* (Giriya). The IVI value of these five common tree species is given in figure 2. The figure shows the pattern of change of five common tree species growing as common associates of other tree species. The mean IVI value for controlled site and of uncontrolled site was found to be 20.48 and 16.64 respectively.

Among the Shrubs, *Marod phalli*, Tamoli (Cassia tora), Van tulsi (*Eranthemum purpurascens*), Dudhai Bel (*Vallaris heynei*) are the species found frequently. Among the grass species identified and present at the survey site includes *Evagostis species,* Doob (*Cynodon species), Andropogon* and *Bambusa* species.

The forests of the WLS belong to slightly moist and dry teak forests and mixed forests with varying proportions of teak. The forests are generally lowly stocked. The density varies from 0.2 to 0.6 and only a few small patches have density more than 0.6 (as per records from the management plan of forest department). Teak (*Tectona grandis*) is the main crop. The associates of the teak forests include Bija (*Pterocarpus marsiupium*), Saja (*Terminalia tomentosa*), Bahera (*Terminalia bellerica*), Dhaora (*Anogeissus latifolia*), and Bhirra (*Chloroxylon swietenia*). Khair (*Acacia catechu*), Kullu (*Sterculia urens*), Tendu (*Diospyros melanoxylon*), Mahua (*Mahduca latifolia*), etc. In mixed forests, teak is almost absent but most other associates predominate. There are some bare patches of Khair (*Acacia catechu*), Bhirra (*Chloroxylon swietenia*) and Saja (*Terminalia tomentosa*). About 55 percent of the area of the WLS bears teak forests and the remaining 45 percent mixed forests. Bamboo (*Dendrocalamus strictus*) is found in about 24 percent area overlapping with the above two types. The forests adjoining villages are degraded while these are better and dense in the interior.

Table-2
List of some major tree species encountered in a vegetation survey through resource inventory method in Delawari Range. (Herbs are not taken into consideration)

S. No.	Local Name	Botanical Name
1.	Achar	*Buchanania latifolia*
2.	Amaltash	*Cassia fistula*
3.	Aonla	*Emblica officinalis*
4.	Astha	*Bahunia racemosa*
5.	Babool	*Acacia arabica*
6.	Bheel	*Aegele marmelos*
7.	Chechla	*Albizzia odoratissima*
8.	Dhaman	*Grewia teliaefolia*
9.	Dudhai	*Wrightia tinctoria*
10.	Ghentar	*Zizyphus xylopyra*
11.	Giriya/ Bhirra	*Chloroxylon swietenia*
12.	Gurjan	*Lamnea grandis*
13.	Jamrashi	*Elaeodendron glaucum*
14.	Karee	*Saccopetalum tomentosum*
15.	Kekadh	*Garuga pinnata*
16.	Kerwara (amaltash)	*Cassia fistula*
17.	Khair	*Acacia ferruginea*
18.	Khejad	*Acacia leucophloea*
19.	Kusum	*Schleichera oleosa*
20.	Lendiya	*Lagerstrocinia paviflora*
21.	Mahua	*Madhuca latifolia*
22.	Mango	*Mangifera indica*
23.	Phasee	*Dalgergia panniculata*
24.	Saaj	*Terminalia tementosa*
25.	Sagon/ Teak	*Tectona grandis*
26.	Tendu	*Diospyros melanoxylon*
27.	Tesu (Paalash)	*Butea monosperma*
28.	Tinsa	*Ougeinia delbergioides*
29.	Dhawda	*Anogeissus latifolia*
30.	Bija	*Pterocarpus marsupium*

The Shannon's diversity of the controlled site as well as uncontrolled site was also obtained. The '$H_{Control.}$' value is 2.25 with $H_{max.(cont)}$ and evenness for the controlled site comes out to be 2.94 and 0.76 respectively. Similarly, the Shannon diversity value, $H_{max.(unct.)}$ and evenness for the uncontrolled site with anthropogenic disturbances were 1.82, 2.48 and 0.73 respectively.

Wildlife: A large variety of wildlife is found in the wildlife sanctuary. Some precipitous hills have cliffs; have large rock blocks and talus at the base. This unique feature provides shelter to various animals like vultures, reptiles and small mammals. The carnivores are tiger, panther, wild dogs, hyena, jackal and fox and the herbivores include chital, Sambhar, blue bull, four horned antelope, languor, rhesus monkey and wild boar. The omnivore bear is also seen often. Smaller animals , like squirrels, mongooses, gerbils, porcupines, hares, etc. are of common occurrence. Among reptiles, important species include different kinds of lizards, chameleon, snakes, etc. Among snakes, cobra, python, viper, Krait etc. is common. More than 150 species of birds are also seen here. A few to mention here are the common babbler, crimson breasted Barbet, Bulbul, bee-eater, baya, cuckoo, kingfisher, kite, lark, Bengal vulture, Sunbird, white wagtail, crow pheasant, jungle crow, egrets, myna, jungle fowl, parakeets, partridges, hoopoe, quails, woodpeckers, blue jay, dove, Black Drongo, flycatcher, flower-pecker, rock pigeon etc.

The encounter between the wildlife and domestic killings has enunciated below in table 4, while the population statistics are provided in the table 3.

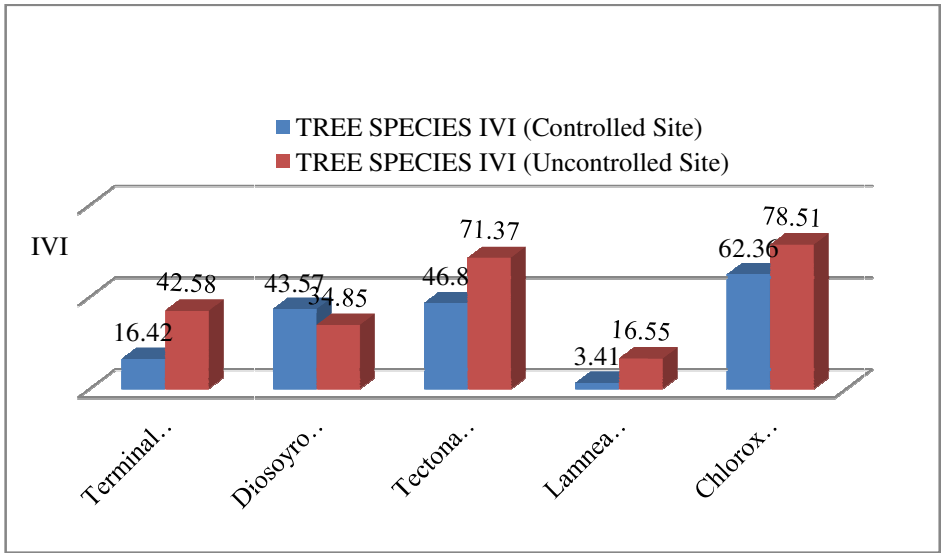

Figure-2
Importance Value Index of five most common tree species growing in common associates of different trees

Noise Level Indicator: The noise level at the site is of the major potential outcome as pinned out desired outcome for management priority. Therefore, from the potential indicator list, an attempt to determine the noise level at the Delawari

range has been conducted, in order to assess the present condition of noise level due to added recreational activity pressure in the area.

The data collected reveal that at present there is no heavy noise generation in the area either in the lean period or the peak period that can result in any serious externally in the future of the wildlife, wilderness or on the visitors' experience. This can be attributed to the reasons of lack of visitors' influx to the area at present and the control of tourism under the forest department. The figure 3, depicts the graphical representation of the data for noise level (in decibel) and its percentage of time of occurrence.

Table-3
Wildlife Population in Ratapani WLS

S. No.	Species	1984	1986	1988	1992	1998	2000
1	Tiger	8	18	15	22	19	19
2	Panther	18	35	39	60	15	11
3	Bear	-	132	140	-	32	49
4	Wild dogs	-	-	100	-	-	48
5	Sambar	682	685	267	320	2541	151
6	Chital	807	798	344	300	378	375
7	Blue Bull	767	768	426	452	353	404
8	Barking Deer	87	-	212	228	-	-
9	Wild Boar	775	1874	1447	-	-	1072

Source: Dwivedi, A. P., (2003): Protected areas of Madhya Pradesh

Table-4
Domestic Killings at Ratapani WLS

Year	No. of Killings of Animals
2008	04 Cattle
2009	20 Cattle
2010	37 Cattle

Source: Divisional Forest Office, Obedullahgunj, Madhya Pradesh.

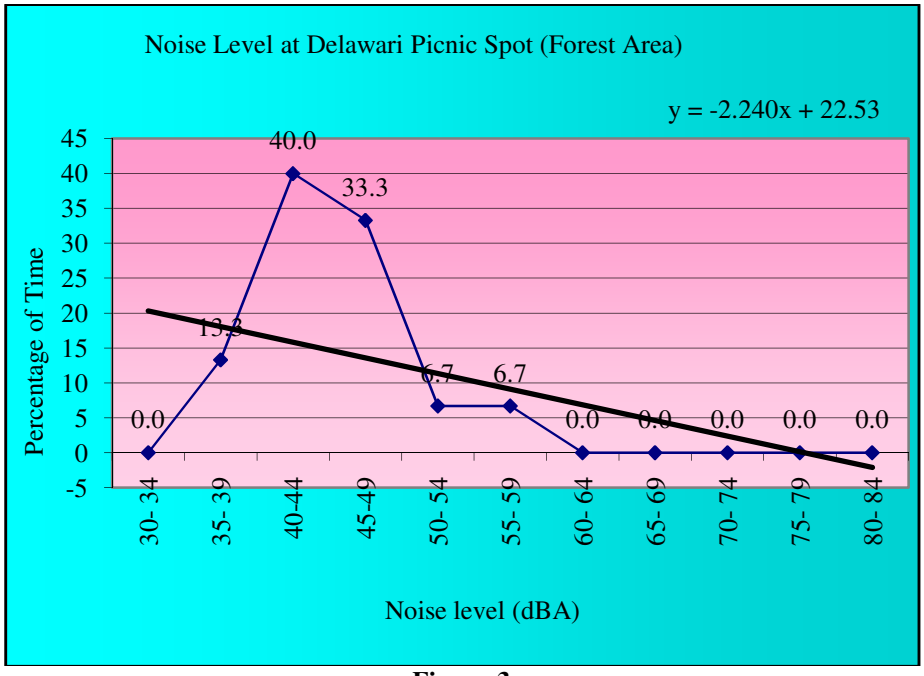

Figure-3
Noise Level as determined from the Delawari Destination site [Ratapani WLS (Delawari Destination site)] in the forest adjacent to the picnic spot

Conclusion

The key surrogates identified and analyzed will result in the desired outcomes as below: i. Native vegetation typical of the

Delawari range of Ratapani wildlife sanctuary. ii. Present wildlife status of the sanctuary. iii. Issues to discuss the maintenance and increase existing native species population and ecological values and sustainable use of resources for the stakeholders. iv. Identification of pressure components and sustainable management in relation to the stakeholders.

The ecological function of the biodiversity surrogates was determined by the participants and exploratory approach through the intervention of stakeholders, expert opinion and literature study. The table 5 below depicts the list of ecological functions (not complete) of each biodiversity surrogates. It is an evolving list that will exchange a new knowledge becomes available.

Table-5
Ecological Functions of the Biodiversity Surrogates

Biodiversity Surrogates	Function (through the participatory approach)
Vegetation pattern Floral Diversity Structural Complexity Wildlife Population	Vegetation provides nutrient source and food chain system in communities. Provides habitat for animals and resource retention in its natural condition. Population records determine the threats and pressure on resources.
Recreational Activities	Revenue sources to the stakeholders Enhances conservation and protection measures. Interaction and awareness towards the environment. Impact on communities (positive and negative both).

Interpreting Biodiversity Indicators And Management Practices: The results revealed that the species diversity of forest area studied has been at a satisfactory level in an undisturbed condition. The key management priority areas and practices that can be concluded through the study and recommended are: i. Continuous registering potential impacts and threats effecting and protection of managed areas. ii. Develop infrastructure to mitigate threats. iii. Introduction of concept "Ecotourism" in the recreation areas of the managed forest area with the main focus of conservation and awareness. iv. Record and survey of vegetation and fauna patterns over a period of time to identify the status of regionally significant terrestrial ecological species, change in abundance, presence or absence of non- native / invasive species. v. Identification of new potential indicators of assessment specific to areas that are capable of measuring the threshold level of disturbance, thus, be determined which can permit the extraction of resources without significant loss to the biodiversity of the region.

The values of the selected individual indicators for each desired outcome were identified and reported using the appropriate ecological techniques. For each desired result, it is urged to continuously monitor and evaluating of these indicators over a point of time. This will show the effects of policy and management actions over time towards achieving biodiversity outcomes in each of the different protected areas in and across Madhya Pradesh. It is also concluded that a formulation of problem and its framework is also required for identification of potential set of indicators in assessing biodiversity. These indicators, though not complete, but their value in terms of covering the complexity of biodiversity as well as their prediction of the relationship between driving forces, status, impact and mitigation measures required are of importance if further data may be available in this context. The remote data, climatic changes and the other factors, no doubt, having a combined impact on the persistence of biodiversity has not been considered here as an indicator because of the threats and pressures required management actions beyond the capacity of the region and therefore remains as a limitation. In addition, new potential indicators are to be identified which are feasible and having a knowledge domain towards the assessment of biodiversity.

Key management objectives: For the Delawari range of WLS, the key management objective was to hold back and preserve the current naturalness, linkages and ecosystem services of the terrestrial ecological system/ habitats across the range and protected area. It has been elucidated in the literatures of biodiversity impact assessment and monitoring, which for the biota sensitive to frequent high grazing pressures and fires can lead to the isolation of biota and habitat loss and/ or decline, all which over time have the potential to reduce biodiversity, production and aesthetic values.

References

1. Noss R.F., Indicators for monitoring biodiversity: a hierarchical approach, *Conservation Biology,* **4**, 355- 364 **(1990)**

2. Ratcliffe D.A, Biodiversity in Britain's Forests.The Forest Authority, Eidinburgh **(1968)**

3. Ferris R. and Humphrey J.W., A review of potential biodiversity indicators for application in British forests, *Forestry*, **72(4)**, **(1999)**

4. Hunt L., Fisher A., Kutt A. and Mazzer T., Biodiversity monitoring in the rangelands: A way forward, Vol. 1, report to Environment Australia, CSIRO Sustainable Ecosystems, Alice Springs **(2006)**

5. Suter G.W., Applicability of indicator monitoring to ecological risk assessment, *Ecological Indicators,* **1,** 101–112 **(2001)**

6. Sakar S. and Margules C., Operationalising biodiversity for conservation planning, *Bioscience,* **27,** 229–308 **(2002)**

7. Smyth A., James C. and Whiteman G., Biodiversity monitoring in the rangelands: A way forward, Vol. 1, report

to Environment Australia, CSIRO Sustainable Ecosystems, Alice Springs **(2003)**

8. James C.D., Biodiversity monitoring in rangelands. In: Conference papers, Australian Rangeland Society 13th Biennial Conference. (Eds Bastin G, Walsh D and Nicolson S. Alice Springs, NT. July 2004, **(2004)**

9. Karr J.R. and Dudley D.R., Ecological perspectives on water quality goals, *Environmental Management,* **5,** 55–68 **(1981**)

10. Majer J.D. and Beeston G., The biodiversity integrity index: an illustration using ants in Western Australia, *Conservation Biology,* **10,** 65–73 **(1996)**

11. Cornforth I.S., Selecting indicators for assessing sustainable land management, *Jr of Envl Manag.,* **56,** 173-179 **(1999)**

12. Dale V.H. and Beyeler S.C., Challenges in the development and use of ecological indicators, *Ecological Indicators,* **1**, 3–10 **(2001)**

13. Carignan V. and Villard M-A.**,** Selecting indicator species to monitor ecological integrity: A review, *Environmental Monitoring and Assessment,* **78**, 45-61 **(2002)**

14. Read J.L., Kovac K.J. and Fatchen T.J., 'Biohyets': A Holistic method for demonstrating the extent and severity of environmental impacts, *Jr of Envl Manag.,* **77**, 157–164, **(2005)**

15. Schulze E.D. and Mooney H.A., Ecosystem function of biodiversity: a summary, In Biodiversity and Ecosystem Function. E.D. Schulze and H.A. Mooney (eds). Springer-Verlag, Berlin, 497- 510 **(1994)**

16. Groombridge B. (ed.)., Global Biodiversity: Status of the Earth's living Resources, Chapman and Hall, London **(1992)**

17. Magurran M., Ecological Diversity and its Measurement, Croom Helm, London **(1998)**

18. McCoy E.D. and Bell S.S., Habitat structure: the evolution and diversification of a complex topic, In Habitat Structure: the physical Arrangement of Objects in Space. S.S Bell, E.D. McCoy and H.R. Mushinky (eds). Chapman and Hall, London and New York, 3-27 **(1991)**

19. Uttera J., Maltamo M. and Hotanen J.P., The structure of forest stands in virgin and managed peat- lands: a comparison between Finnish and Russioan Karelia, *For. Ecol. Manag.,* **96**, 125-138 **(1997)**

20. Leung Y.F. and Marion J.L., Assessing trail conditions in protected areas: application of a problem assessment method in Great Smoky Mountains National Park, USA, *Env. Conservation,* **26(4),** 270-279 **(1999)**

21. Marion J.L. and Leung Y.F., Trail resource Impacts and an examination of alternative assessment techniques, *Jr of Park and Recr Admin.,* **19(3),** 17-37 **(2001)**

22. Deng J., Qiang S., Walker G.J. and Zhang Y., Assessment on and perception of visitor's environmental impacts of nature tourism: A case study of Zhangjiajie National Forest Park, China, *Jr. of Sust Tourism,* **11(6),** 529-548 **(2003)**

23. Hammitt W.E. and Cole D.N., Wildland recreation-Ecology and Management, 2nd Ed. (New York: John Wiley & Sons, Inc.), **(1998)**

24. Liddle M.J., Recreation Ecology: Effects of trampling on plants and corals, *Trends in Ecol and Evol.,* **6,** 13-17 **(1991)**

25. Liu Y., Studies on the management of Recreational Impacts on Soil and Vegetation, Taiwan: Agriculture Commission (**1996)**

26. Smyth A.K., Brandle R., Brook A., Chewings V., Fleming M. and Read J., Methods for identifying, selecting and interpreting indicators for assessing biodiversity condition in desert Australia, using the Stony Plains bioregion as a case study, DKCRC Research Report 39, Desert Knowledge CRC, Alice Springs **(2009)**

27. Misra R., Ecology workbook. Oxford and IBH Publishing Co. **(1968)**

28. Clarke K.R. and Warwick R.M., A further biodiversity index applicable to species lists: variation in taxonomic distinctness, *Marine Ecology Progress Series,* **216**, 265–278 **(2001)**

29. Morris P. and Therivel R. (*Eds.*), Methods of environmental impact assessment, UCL Press **(1995)**

30. Rau John G. and Wooten David C. (*Eds.)***,** Environmental Impact Analysis handbook. McGraw Hill Book Company, **(1980)**