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STUDY OF PLANT REGENERATION POTENTIAL IN TROPICAL MOIST DECIDUOUS FOREST IN NORTHERN INDIA

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Abstract

Regeneration patterns of species population can address climate change by adaptive evolution or by migrating association to survive in their favorable climate and finally decided to particular forest future. In this paper we examined the status of regeneration potential of tree species in tropical moist deciduous forest at Katerniaghat Wildlife Sanctuary, Northern India. To investigate tree, sapling and seedling population distribution, we examine regeneration status in 145 random plots in study area. Total 74 plant species of 60 genera belonging to 32 families out of which 71 species of trees, 56 of seedlings and 60 of saplings were found in the forest. On the basis of importance value index *Mallotus philippensis, Tectona grandis, Shorea robusta*, *Syzygium cumini* and *Bombax ceiba* have been found as dominant species in the study area. As far as the regeneration status is concerned, the maximum tree species (64%) have been found in good regeneration category**.** Significant variations in species richness and population density, between three life form (i. e. tree, sapling and seedling) have been found. In which only three new tree species *Prosopis juliflora*, *Psidium guajava* and *Morus alba* were added in sapling and seedling stage. It is major ecological concern that about 19 % economically important plant species like *Madhuca longifolia, Terminalia elliptica, Buchanania cochinchinensis,* some *Ficus* species etc. have been found in poor regeneration phage, whereas about 7% species found in no regeneration categories.

Keywords: Katerniaghat Wildlife Sanctuary, Protected area, Importance value index, Population density, Regeneration status

Introduction

Lack of adequate forest regeneration is an issue recognized by both foresters and ecologists (Khurana and Singh, 2001; Ceccon *et al.,* 2004). Forest services are renewable because they have regeneration potential (Tripathi and Khan, 2007) but now the repeatedly looped and affected forest regeneration is most common worldwide problem for the economically important plant species. Invasive species change forest composition of northern India (Sharma and Raghubanshi, 2010). Not only forest area but also the species rich communities of moist deciduous tropical forests of India are altering towards the poor and less diverse systems due to rapid deforestation and forest fragmentation (Mishra *et al.,* 2012; Bajpai *et al.,* 2012a). Viability of forest population rapidly changed due to environmental changes (Condit *et al.,* 1996; Stork, 2010), local habitat characters (Chaturvedi *et al.,* 2012), community composition (Sagar *et. al.,* 2008), while insects, disease, herbivores, competing vegetation will also influence forest regeneration (Ward *et al.,* 2006).

Majorly regeneration mechanism of a forest directly depends on their biotic and abiotic characteristics (McDonald *et al.,* 2010) and its geographic distribution (Grubb, 1977). It is important to understand how evolution and ecological potential of different life forms help them to adapt climate change and survivorship in the tropical forests (Woodward and Kelly, 2008), because these forests are greatly affected by climate change, water availability and temperature (Breckle, 2002). Tree population structure and diversity status of tropical forests from developing countries are often insufficient for extensive management (Appiah, 2013). For this purpose the phytosociological assessment is very helpful and provides the information about the status of tree population and its' future diversity (Bajpai *et al.,* 2012a). The population of the forest ecosystems and its' future health is dependent on the tree regeneration potential which has been observed by the presence of sufficient population of different life phages (*i.e.* tree, sapling and seedling) in the plants (Pokhariyal *et al.,* 2010). The density of species regeneration is expected to vary special due to forest structure and phytogeographical condition (Ward *et al.,* 2006). The regeneration status of a tree species in a forest community can be accessed from their population counts in different life phages i.e. tree, sapling and seedling (Uma Shankar, 2001; Pokhriyal *et al.,* 2010).

In present scenario the regeneration studies are in need for forest restoration and their conservation (Vieira and Scariot, 2006; Wale *et al.,* 2012), thus it may be helpful in the forest management because a large area of northern India has been converted into a mosaic of patches of forest, savanna and crop-land which desires to manage sustainably (Singh, 2002). Katerniaghat Wildlife Sanctuary (KWS) directly supports a rich diversity of high biological value animals, plants and ethnic groups, whereas indirectly supports ecological resource and regeneration. We have already studied taxonomic and ecological study of different forests, their microclimate, and some phonological study (Kumar *et al.,* 2011; Behera *et al.,* 2012; Bajpai *et al.,* 2012a,b) and found this regeneration study is need to discuss the effectiveness of biodiversity conservation status in protected area.

Methodology

Study area

The study was carried out in tropical moist deciduous forest of Terai region which considered as foot hills of Himalaya (Figure 1). Terai landscape is most famous eco-regions of the world, for their great biodiversity and high productivity. We have selected Katerniaghat wildlife sanctuary (KWS) a protected area for this purpose. KWS situated between latitude 28° 6' to 28° 24' N and longitude 81° 24' to 81°19' E in district Bahraich Uttar Pradesh, India. It comes under tropical monsoon type of climate with three distinct season’s viz., summer (April–June), monsoon (July–September) and winter (November–February). January is the coldest month with lowest temperature of ranging from 8–22^{O}C, while May and June are the hottest months with the mean maximum temperature rising over 40^{O}C with average monsoon precipitation around 1450 mm (Bajpai *et al.*, 2012b). The soil of the sanctuary area is alluvial made by Kaudiyala and Saryu rivers. (Bajpai *et al.*, 2012b).

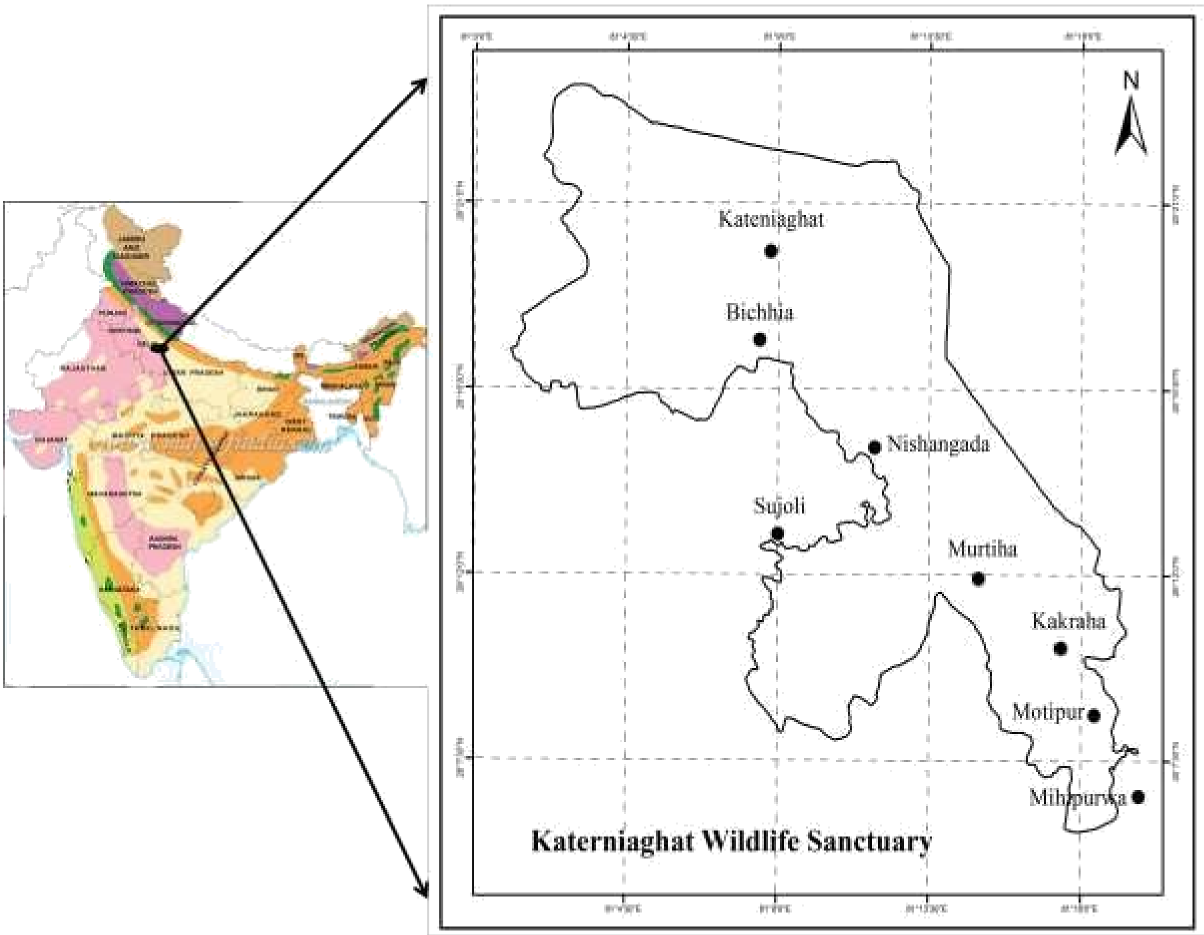

Figure 1: Study site Katerniaghat Wildlife Sanctuary, India

Experimental plan

Regeneration status of tree species in forest was studied during year 2010-2011. To study the regeneration pattern three life forms of plant species (tree, tree sapling and seedling) have been used here. Phytosociological studies were carried out systematically using nested random quadrat sampling technique to reduce bias caused by within site difference in structure and composition, whereas quadrats were laid down randomly minimum 100 m distance in each other. The size of quadrats was decided on the basis of species area curve (Mueller-Dombois and Ellenberg, 1974). For tree species 20 × 20 m, fore sapling 5 × 5 m and for seedling 1 × 1 m size quadrates have been done. In forest 145 quadrats for tree species, 290 for sapling and 580 for seedling have been studied. CBH (Circumference at Breast Height, *i.e.* 1.37 m above the ground) has been used to simply categories the life forms of the plants into three classes (*i.e.* tree ≥ 30 cm, sapling 10-30cm and seedling ≤ 10 cm). Individuals having ≥ 30 cm CBH were considered trees, individuals having ≤ 10 cm circumference were considered as seedlings and those having the intermediate position with respect to these circumferences were considered as saplings (Knight, 1963). Phytosociological parameters of tree, sapling and seedling were calculated as given by Mishra (1968). Importance value index (IVI) for the tree species was determined as the sum of the relative frequency, relative density and relative dominance (Cottam and Curtis, 1956).

In five forests mean stem density (100 m^{-1}) of tree, saplings and seedlings is considered to calculate regeneration potential. We follow (Uma Shankar, 2001) to calculate regeneration status with in different categories of tree life form stages like (i) good regeneration (GR): if number of seedlings > saplings > adults regeneration, (ii) fair regeneration (FR): if number of seedlings > or < saplings < adults, (iii) poor regeneration (PR): if the species occupy only at sapling life forms, there are no seedlings (Number of saplings may be more, less or equal that of adults), (iv) no regeneration (NR): if individuals of species are present only in adult form and (v) new regeneration or not abundant (NA): individuals of species have no adults only occupy in seedlings or saplings.

Results and Discussion

We use three life stages (trees, saplings and seedlings) of different tree species in our regeneration study to represent their possible future species composition. The status of the regeneration of tree species showed important difference in the demography of seedling and sapling in KWS. The overall structure of the forest in the study area comprises of 74 plant species of 60 genera in 32 families. Plant biodiversity richness, population density (ha^{-1}), number of genus and families in three different stages has been shown in figure 2.

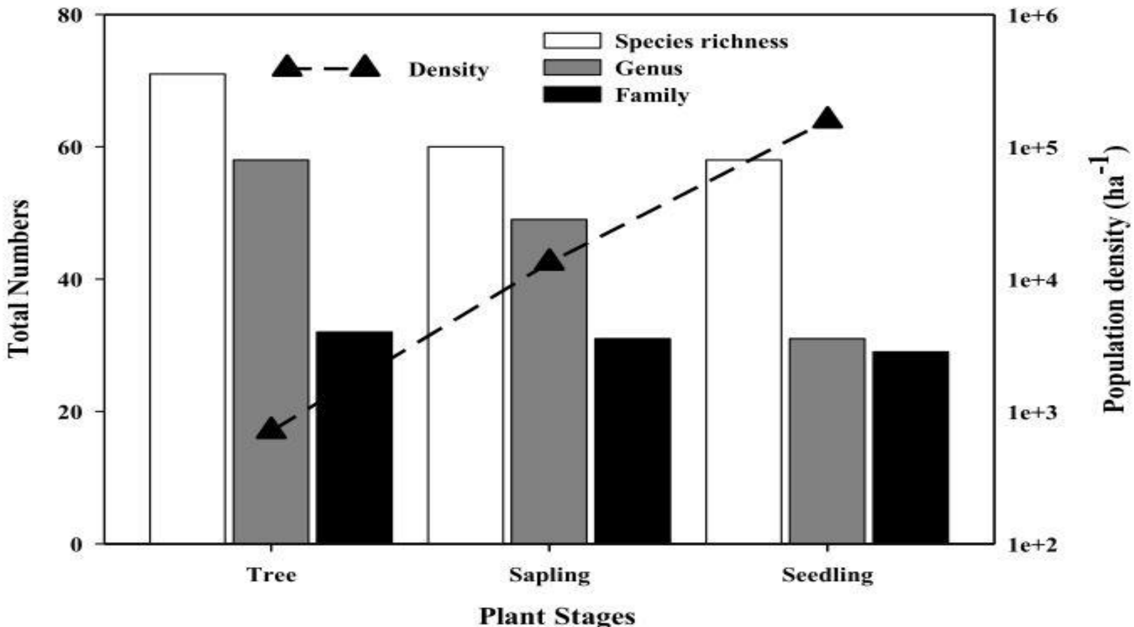

Figure 2: Species composition and population density in different life stages

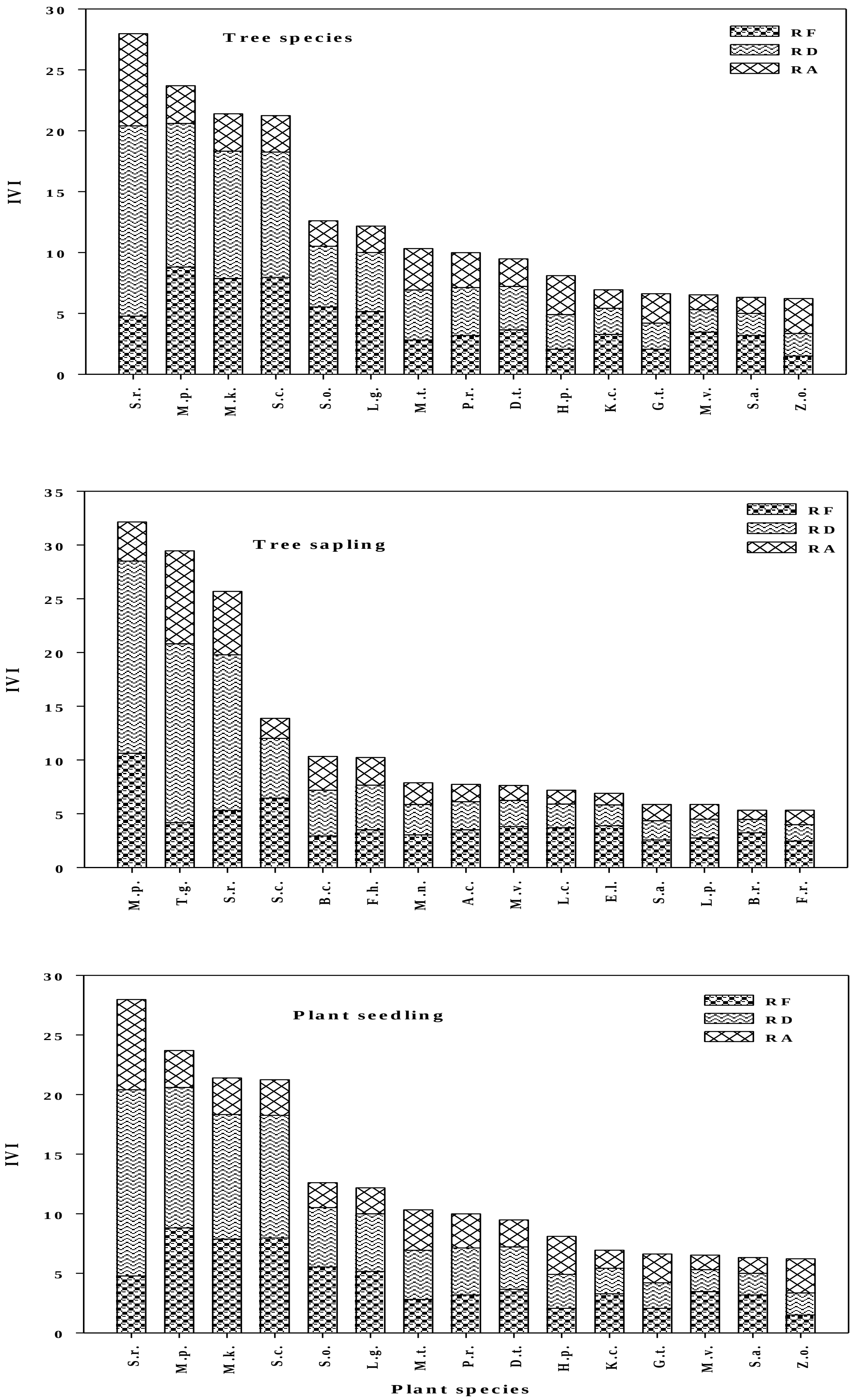

Figure 3: Importance value index of different plant life forms in Katerniaghat Wildlife Sanctuary. Species abbreviations are given in regeneration status table

Tree species richness and species densities were more or less similar with previous phytosociological study of KWS (Chauhan *et al.*, 2008; Tripathi and Singh, 2009; Bajpai *et al.*, 2012a). We have found 71 tree species of 58 genus in 32 families, 56 seedlings of 51 genus in 29 families and 60 saplings occupied by 49 genus in 31 families.

The most important tree species, sapling and seedling with the highest IVI have been shown in decreasing order (Figure 3). In sapling and in seedling stage *Shorea robusta* lead to *Mallotus philippensis*. *Mallotus philippensis, Tectona grandis, Shorea robusta, Syzygium cumini* and *Bombax ceiba* were found as dominant tree species of study area but in sapling and seedling stage this sequence gradually change and *Shorea robusta, Syzygium cumini* and *Murraya koenighii* replace *Mallotus philippensis, Tectona grandis* and *Bombax ceiba.*

The plant population density in three stages varied greatly as 713.96 ha^{-1} in trees, 13387.59 ha^{-1} in sapling and 158706.89 ha^{-1} in seedling. Plant population densities in three different life forms (tree, sapling and seedling) at KWS were shown in table 1. Trends of population density in KWS was much similar to northern Eastern Ghat (Panda *et al.*, 2013), where they found high seedlings and saplings to adult ratio. The highest tree density in KWS were recorded for *Mallotus philippensis* (127.59 plants ha^{-1}) followed by *Tectona grandis* (118.79 plants ha^{-1}), *Shorea robusta* (103.28 plants ha^{-1}) and *Syzygium cumini* (39.66 plants ha^{-1}) whereas in sapling stage highest sapling density was recorded for *Shorea robusta* (2091.03 sapling ha^{-1}) followed by *Mallotus philippensis* (1577.93 sapling ha^{-1}), *Murraya koenighii* (1398.62 sapling ha^{-1}) and *Syzygium cumini* (1376.55 sapling ha^{-1}) and in seedling stage highest seedling density was recorded for *Shorea robusta* (24258.62 seedling ha^{-1}) followed by *Syzygium cumini* (1376.55 seedling ha^{-1}), *Murraya koenighii* (1398.62 seedling ha^{-1}) and *Mallotus philippensis* (1577.93 seedling ha^{-1}).

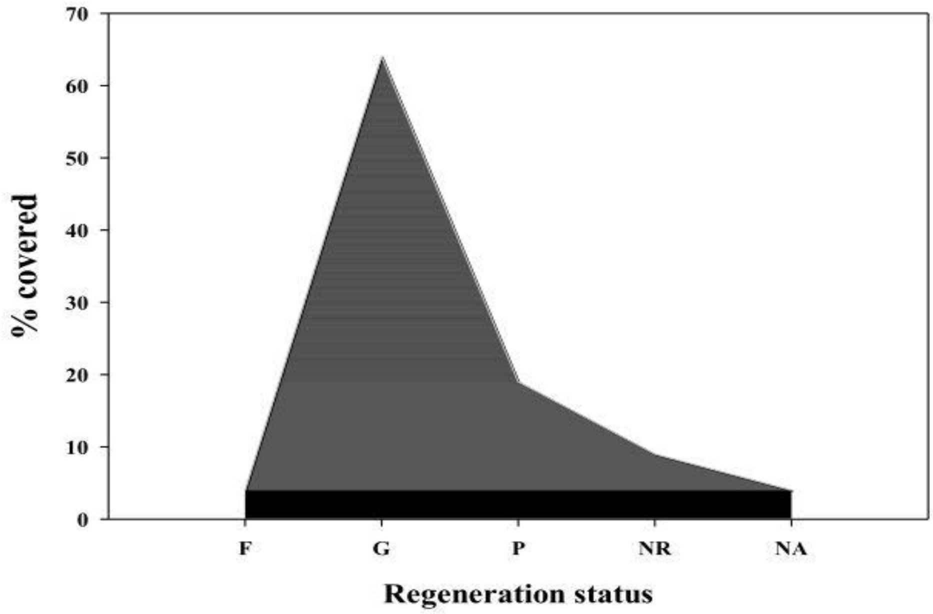

Figure 4: Regeneration status of Katerniaghat Wildlife Sanctuary (F: fair, G: good, P: poor, NR: not regeneration, NA: not abundant)

The success of regeneration can be predicted on the basis of current population structure, growth and fecundity (Guedje *et al.*, 2003). Population structure and regeneration status of tree species in terms of proportions of seedlings, saplings and adults varied greatly

(Table 1). Species regeneration potential was represent to consider their population density in three different life phases. Categories of regeneration good, fair, poor, not regenerated and not abundant used to define regeneration status of the forest. Categories of regeneration status of KWS forest show good regeneration potential may be due to protected area. Good regeneration status (expanding population) of tree species in the different forest indicates effectiveness of protected area and signifies the sustainability of the species for the future. Regeneration status of tree species of any forest is quantified by recruitment potential of saplings and seedlings (Saikia and Khan, 2013). In KWS highest number of species found in good regeneration status 64% (47 species) which shows wealth of forest (Figure 4).

Those species which have nearly equal number of representatives at each of the three life stages are expected to remain dominant in the near future (Bhuyan *et al.*, 2003). In other remaining 36% regeneration part occupied by poor regeneration 14% (19 species) and not regeneration 7% (9 species) whereas number of fair regeneration 4% (3 species) species and not abundant 4% (3 species) are very low. Highly microclimate variability control forest association formation, species recruitment and establishment in KWS (Behera *et al.*, 2012). KWS is a tropical moist deciduous forest (Champian and Seth, 1968), whereas Morgan and Smith (1981) suggested broad-leaved tropical forests receive more light at understory layer as compared to coniferous forests may be the one reason of good regeneration potential of plant species. Based on the regeneration status *i.e.* the proportion of saplings and seedlings in the population, the studied forest have been categorized as follows, as only three species *Prosopis juliflora, Psidium guajava* and *Morus alba* found in not abundant phage (new recruiting species). *Shorea robusta, Mallotus phillipensis, Syzygium cumini, Murraya koenighii, Ficus hispida, Putranjiva roxburghai, Schleichera oliosa, Miliusa tomentosa, Litsea gutinosa, Grewia tiliaefolia* and *Streblus asper* etc. are good regenerating species in KWS. *Buchanania cochinchinensis, Butea monosperma, Madhuca longifolia, Terminalia elliptica* and some *Ficus species* etc. are in poor regeneration phage. *Bambusa spp*., *Ceriscoides turgid, Dalbergia latifolia*, *Eucalyptus tereticornis*, *Haplophragma spp.*, *Toona ciliate* and one unknown spp. are found as not regenerating species. Availability of seeds, which are often limited for many tropical species (Wijdeven and Kuzee, 2000), and competition among species for space, light and water (Holl *et al.*, 2000) may be the reason of not regeneration.

Conclusion

Based on the present results, it can be concluded that the sanctuary supports a high diversity of tree species. In this way, our study may be used as an important tool to assess possible future structural and compositional changes incensing and upgrading management policies for protected forest. In order to maintain our forests in the face of increasing threats including climate change, energy development, invasive species etc., we should improve our understanding of the causes of poor or no regeneration. Study suggests research and development action is needed to stimulate regeneration of those species which having high importance value indices but showing poor or not regeneration.

Table 1: Floristic composition and plant regeneration status (density/100 m^2) in Katerniaghat Wildlife Sanctuary

S.No.	Species	Abrivation	Tree	Sapling	Seedling	Status
1	*Acacia catechu*	*A.c.*	18.62	77.24	1844.83	Good
2	*Aegle marmelos*	*A.m.*	6.38	16.55	1241.38	Good
3	*Alangium salvifolium*	*A.s.*	3.28	68.97	741.38	Good
4	*Albizia lebbeck*	*A.l.*	0.86	24.83		Poor
5	*Albizia procera*	*A.p.*	3.45		2655.17	Poor
6	*Alstonia scholaris*	*A.sc.*	0.34		206.9	Poor
7	*Bambusa sp.*	*B.s.*	1.03			Not regeneration
8	*Barringtonia acutangula*	*B.a.*	3.1		344.83	Poor
9	*Bauhinia purpurea*	*B.p.*	0.52	55.17	706.9	Good
10	*Bauhinia variegata*	*B.v.*	1.21	137.93	724.14	Good
11	*Bombax ceiba*	*B.c.*	30.34	16.55	793.1	Fair
12	*Bridelia retusa*	*B.r.*	8.97	220.69	1172.41	Good
13	*Buchanania cochinchinensis*	*B.co.*	0.34		172.41	Poor
14	*Butea monosperma*	*B.m.*	0.17		275.86	Poor
15	*Careya arborea*	*C.a.*	0.34	33.1	1931.03	Good
16	*Cassia fistula*	*C.f.*	1.72	41.38	706.9	Good
17	*Catunaregam spinosa*	*C.s.*	1.03	195.86	2241.38	Good
18	*Ceriscoides turgida*	*C.t.*	1.21			Not regeneration
19	*Cordia dichotoma*	*C.d.*	1.72	8.28	379.31	Good
20	*Dalbergia latifolia*	*D.l.*	0.86			Not regeneration
21	*Dalbergia sissoo*	*D.s.*	4.83	8.28	155.17	Good
22	*Desmodium oojeinensis*	*D.o.*	1.21	27.59	293.1	Good
23	*Dillenia pentagyna*	*D.p.*	1.72	93.79	1655.17	Good
24	*Diospyros tomentosa*	*D.t.*	7.41	477.24	2500	Good
25	*Ehretia laevis*	*E.l.*	13.79	124.14	2775.86	Good
26	*Eucalyptus tereticornis*	*E.t.*	1.72			Not regeneration
27	*Ficus benghalensis*	*F.b.*	0.52	19.31	172.41	Good
28	*Ficus hispida*	*F.h.*	29.66	132.41	11965.52	Good
29	*Ficus palmata*	*F.p.*	0.69	63.45		Poor
30	*Ficus racemosa*	*F.r*	10.86	55.17	1448.28	Good
31	*Ficus religiosa*	*F.re.*	0.69	2.76		Poor
32	*Ficus retusa*	*F.rt*	0.52	22.07		Poor
33	*Ficus rumphii*	*F.ru.*	2.07		293.1	Poor
34	*Ficus semicordata*	*F.s.*	0.34	41.38		Poor
35	*Grewia tillifolia*	*G.t.*	8.79	286.9	2827.59	Good
36	*Haldina cordifolia*	*H.c.*	4.14	13.79	1034.48	Good
37	*Haplophragma* sp.	*H.s.*	0.34			Not regeneration
38	*Holarrhena pubescens*	*H.p.*	2.41	380.69	931.03	Good
39	*Holoptelea integrifolia*	*H.i.*	2.76	22.07	551.72	Good
40	*Hymenodictyon orixense*	*H.o.*	1.72	60.69	275.86	Good
41	*Kydia calycina*	*K.c.*	5.52	286.9	1310.34	Good
42	*Lagerstroemia parviflora*	*L.p.*	12.41	35.86	2293.1	Good
43	*Lannea coromandelica*	*L.c.*	15.69	66.21	1120.69	Good
44	*Leucaena leucocephala*	*L.l.*	0.34	16.55	741.38	Good
45	*Litsea glutinosa*	*L.g.*	3.1	648.28	3689.66	Good
46	*Madhuca longifolia*	*M.l.*	4.48	11.03		Poor
47	*Mallotus philippensis*	*M.p.*	127.59	1577.93	13724.14	Good
48	*Mallotus nudiflorus*	*M.n.*	20.17	13.79	5258.62	Fair
49	*Mangifera indica*	*M.i.*	0.17	2.76	637.93	Good

50	*Melia azadirach*	*M.a.*	0.52	13.79	344.83	Good
51	*Miliusa tomentosa*	*M.t.*	2.24	551.72	500	Fair
52	*Miliusa velutina*	*M.v.*	17.41	245.52	2637.93	Good
53	*Mitragyna parvifolia*	*M.pa.*	7.41	146.21	3413.79	Good
54	*Murraya koenigii*	*M.k.*	3.79	1398.62	14327.59	Good
55	*Phyllanthus emblica*	*P.e.*	0.52	8.28	655.17	Good
56	*Pongamia pinnata*	*P.p.*	1.9	38.62	827.59	Good
57	*Putranjiva roxburghii*	*P.r.*	4.31	526.9	3258.62	Good
58	*Schleichera oleosa*	*S.o.*	6.72	667.59	4275.86	Good
59	*Semecarpus anacardium*	*S.an*	2.76	27.59	896.55	Good
60	*Shorea robusta*	*S.r.*	103.28	2091.03	24258.62	Good
61	*Sterculia villosa*	*S.v.*	6.38	13.79	396.55	Good
62	*Stereospermum chelonoides*	*S.ch.*	0.86	49.66	1206.9	Good
63	*Streblus asper*	*S.a.*	12.76	242.76	7155.17	Good
64	*Syzygium cumini*	*S.c.*	39.66	1376.55	16844.83	Good
65	*Syzygium heyneanum*	*S.h.*	3.28	38.62	2241.38	Good
66	*Tectona grandis*	*T.g.*	118.79	160	1827.59	Good
67	*Terminalia bellerica*	*T.b.*	1.03	13.79		Poor
68	*Terminalia elliptica*	*T.e.*	7.59	8.28		Poor
69	*Toona ciliata*	*T.c.*	0.17			Not regeneration
70	Unidentified	*U.i.*	0.34			Not regeneration
71	*Zizyphys oenoplia*	*Z.o.*	1.03	248.28	896.55	Good
72	*Prosopis juliflora*	*P.j.*		80	879.31	Not abundant
73	*Psidium guajava*	*J.g.*		52.41		Not abundant
74	*Morus alba*	*M.a.*			68.97	Not abundant

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