

Floristic and structure of the herbaceous vegetation of four recovering forest stands in the Eastern Ghats of India

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Received 6 April 2004; accepted in revised form 27 December 2004

Key words: Diversity index, Dominance index, Eastern Ghats, Floristic composition, Herb, Importance value index, Recovering forest, Similarity index

Abstract. Floral composition and structural parameters of the herbaceous vegetation of four recovering tropical dry deciduous forest stands protected for 2, 4, 6 and 10-year periods, on the Eastern Ghats of India, situated at Kandhamal district of Orissa, India were investigated. More than 1 ha of recovering forest stands of each of the four stages was selected and fifteen sample quadrats of 1 m × 1 m were randomly placed at each stand for vegetation analysis. Floristic analysis revealed highest number of species (69) in 2-year recovering stand, which declined with increase in age. A total of 87 species, 71 genera and 32 families were recorded in the forest stands. Total number of herbaceous species encountered in the stands was 44, 28, 30 and 24 in 2, 4, 6 and 10-year stands, respectively. Total individuals of all herb species were 114, 70, 88 and 68 plant m⁻² in 2, 4, 6 and 10-year stands, respectively. Herbaceous stand basal areas were 7.84, 3.66, 4.77 and 5.23 cm² m⁻² in 2, 4, 6, and 10-year stands, respectively. Importance value index (IVI) revealed that *Heteropogon contortus* was predominant in 2 and 4-year stands, *Andrographis paniculatus* in 6-year stand and *Elephantopus scaber* in 10-year stand. Diversity-dominance curve revealed log-normal distribution in all the four stands. Simpson's dominance index (C) was highest in 2-year stand which decreased in other stands, while Shannon's diversity index (H¹) was almost the same in all the stands. Biomass of herbaceous vegetation was 83.2 g m⁻² in 2 year, 62.2 g m⁻² in 4 year, 58.0 g m⁻² in 6 year and 64.0 g m⁻² in 10-year stand.

Introduction

Biodiversity is essential for human survival and economic well-being, and for the ecosystem function and stability (Singh 2002). In India, habitat destruction, over exploitation, pollution and species introduction are identified as major causes of biodiversity loss (UNEP 2001). These disturbances have been considered important factors structuring communities (Sumina 1994). Forest degradation is considered one of the most serious environmental and economic problems for many countries in the tropical and sub-tropical regions of the globe (Sharma 1996; Hare et al. 1997). The anthropogenic disturbances greatly affect the biodiversity and structural characteristics of a community (Mishra et al. 2004). About 72.1% of existing Indian forest has lost the capacity for regeneration (Rai and Saxena 1997). Therefore, in many areas reconstruction

of disturbed ecosystems is being taken up on a priority basis, both for biodiversity conservation and for maintaining landscape productivity (Solbrig 1991). Analysis of stand structure basing on age and size is very useful for a thorough reconstruction of the history of stand development and assessment of tree population, besides prediction of succession trends (Veblen 1986).

Detailed information on species composition, species distribution and forest stand structure in the regenerating dry tropical forests on temporal scale is lacking. Therefore, survey and documentation of biodiversity and other structural characters of the disturbed as well as regenerating forests at different stages of development are necessary for understanding the ecosystem function and its conservation.

The Eastern Ghats, one of the important mountain systems of India, comprises disconnected hill ranges, extending along NE–SW direction in the east coast. The Eastern Ghats starts from Tamil Nadu in the south and extends up to Orissa through Andhra Pradesh in the north. Dry deciduous forest is the major biome of the Eastern Ghats of Orissa.

In India, ecological work on *Shorea robusta* dominated forests in the Himalayas and nearby places like Doon Valley and parts of Uttar Pradesh (Pande 1999; Rawat and Bhainsora 1999) as well as other forests (Garkoti and Singh 1997; Hare et al. 1997; Parthasarathy and Karthikeyan, 1997a, b; Shrestha et al. 2000; Khera et al. 2001; Devi and Behera 2003; Edward and Sah 2003; Lodhiyal and Lodhiyal 2003; Sagar et al. 2003; Singh 2003; Mishra et al. 2004; Tripathi et al. 2004) has been done to some extent but work on phytosociology and biomass of ground vegetation of natural and disturbed forests of the northern part of the Eastern Ghats is scanty. The objective of the present study was to assess the impact of varying periods of protection of degraded forest stands on species composition, phytosociological characters and biomass of the herbaceous vegetation.

Study area

The study site is situated in the Phulbani Forest Division of Kandhamal district of Orissa, India (Figure 1). In the past, the whole district was covered with tropical dry/moist deciduous forests dominated by sal (*Shorea robusta*). In some areas in the district the forest still exists with little disturbance. The tropical dry deciduous forest of the district exhibits a three-tiered profile (Legris and Meher-Homji 1984). The plants of the upper storey with a height ranging from 15 to 25 m are *Anogeissus latifolia*, *Albizia procera*, *Bombax ceiba*, *Buchanania lanzan*, *Chloroxylon swietiana*, *Dalbergia latifolia*, *Diospyros melanoxylon*, *Haldinia cordifolia*, *Lanea coromandelica*, *Madhuca indica*, *Pterocarpus marsupium*, *Semecarpus anacardium*, *Shorea robusta*, *Syzygium cumini*, *Terminalia alata* and *Terminalia chebula*. The under storey trees (height 10–15 m) include *Acacia catechu*, *Bauhinia variegata*, *Bridelia retusa*, *Casearia graveolens*, *Cleistanthus collinus* and *Cassia fistula*. The undergrowth includes

shrub species such as *Clerodendrum viscosum*, *Holarrhena pubescens*, *Ixora pavetta*, *Grewia hirsuta*, *Helicteres isora*, *Indigofera cassioides*, *Dendrocalamus strictus*, *Phoenix loureirii* and *Woodfordia fruticosa*, and herb species are *Andrographis paniculatus*, *Curculigo orchioides*, *Curcuma angustifolia*, *Curcuma aromatica*, *Elephantopus scaber* and *Vernonia cinera*. The common climbers in the vegetation are *Acacia pennata*, *Asparagus racemosus*, *Bauhinia vahlii*, *Aristolochia indica*, *Butea superba*, *Combretum decandrum*, *Dioscorea bulbifera*, *Hemidesmus indicus*, *Ichnocarpus frutescens* and *Smilax zeylanica*.

The Kandhamal district was covered with virgin forest till early 1950s. After 1950s, the age old practice of shifting cultivation and other anthropogenic activities such as clear felling of trees for timber and fuel wood, overgrazing and surface burning led to the destruction of the climax tropical dry deciduous forest. This was especially so because of interference of plains people, who migrated from the coastal areas to the interior areas. In the last several decades most of these forests have been degraded gradually leaving some coppices of

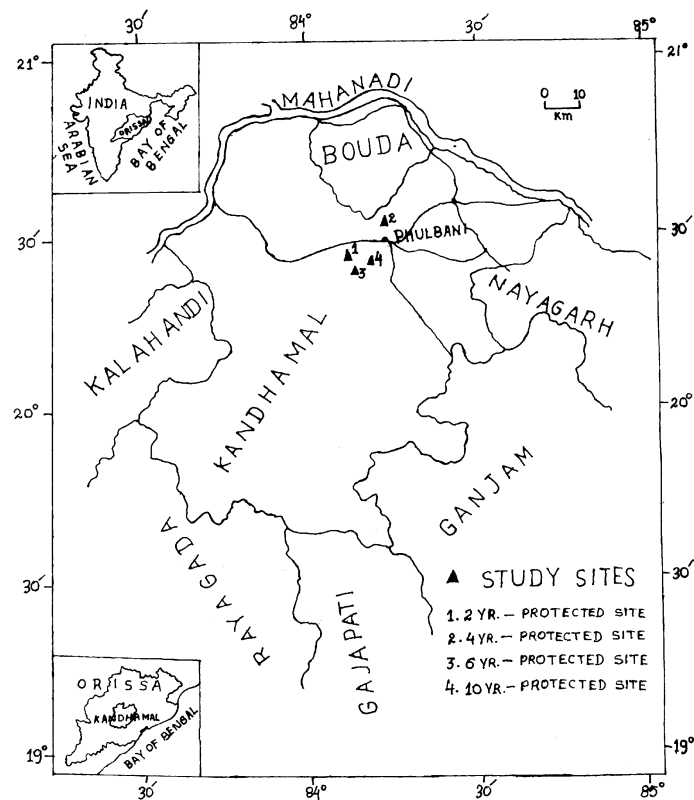


Figure 1. Map showing the study area in the Kandhamal district, Orissa. Inset is the India and Orissa map.

trees and shrubs. The state forest department in collaboration with the local villagers under the Joint Forest Management Programme protected some of these degraded forest stands. The local people protected these village forests by not allowing cutting and grazing. However, some disturbance was observed in the form of cutting, lopping and grazing by way of pilferage.

Four such stands protected for 2, 4, 6, and 10 years for stand regeneration were undertaken for the present study. The study area is situated at an altitude of 750 m. Out of the four stands, the 4-year protected stand is situated near Datapaju under Tudipaju Reserve Forest and the other three sites are situated near Alami under Dakapala Reserve Forest of Phulbani forest division. The former stand is about 4–5 km and the latter stands about 8–12 km from Phulbani town (84° 12' E, 20°29' N), the headquarters of Kandhamal district, Orissa.

The climate of the area is monsoonal and, on the basis of temperature and rainfall, the year can broadly be divided into three distinct seasons, viz. rainy (Mid-June–September), winter (October–February) and summer (March–mid-June). The area experiences a longer winter compared to the other two seasons.

Total annual rainfall of the area during June 2001 to May 2002 was 1407 mm (Figure 2). Out of the total rainfall, rainy season accounted for the maximum (1153.5 mm, 82%) while the winter (131 mm, 9.3%) and summer (122 mm, 8.7%) received nearly the same rainfall. During the year, July received the highest precipitation in the area (473.6 mm) (Figure 2).

During the study year, the minimum and maximum temperatures were -1.8°C and 40°C , respectively. The mean monthly minimum temperature ranged from 3.2°C to 21.1°C , while the maximum fluctuated between 20.7°C and 35.5°C (Figure 2). Relative humidity during the year ranged between 41 and 83%.

Soil textural analysis revealed that sand percentage ranged from 47 to 60 in various stands and slopes (Behera 2003). The pH of the soils of different stands varied between 4.5 and 6.3, indicating that the soils were acidic.

Methods

The study was conducted during July 2001 to July 2002. More than one hectare of recovering forest stands of each stage was selected for the present study. The size and number of quadrats needed were determined using the species area-curve (Misra 1968). Fifteen sample quadrats of $1\text{ m} \times 1\text{ m}$ size were placed randomly at each stand for the ground vegetation analysis (Misra 1968; Muller-Dombois and Ellenberg 1974). Seedlings of tree and shrub species were also considered under herb. Floristic composition of trees and shrubs along with herbs were also recorded. Plant samples were collected from the sites, dried and poisoned with saturated mercuric chloride solution with ethyl alcohol (Jain and Rao 1977). Specimens were identified with the help of the

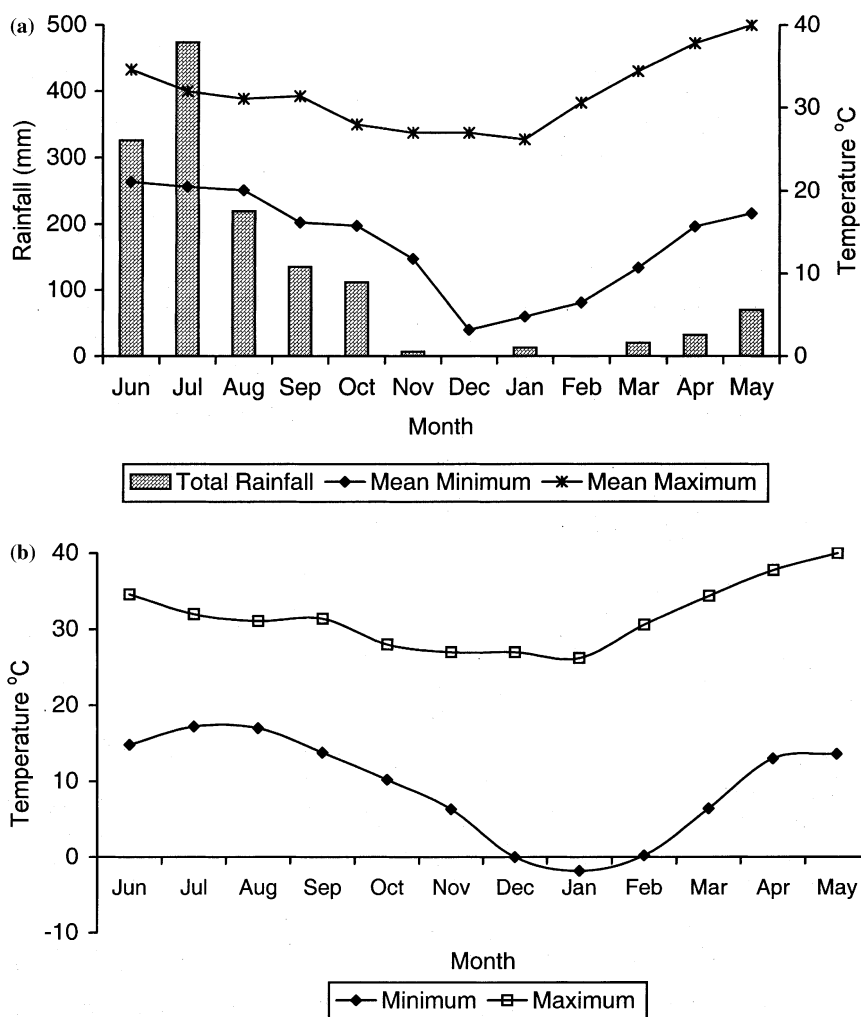


Figure 2. Monthly rainfall, monthly mean minimum and mean maximum temperature (a), and monthly minimum and maximum temperature (b), during June 2001–May 2002 at Phulbani, Kandhamal, Orissa.

local standard Floras (Haines 1921–1924; Saxena and Brahmam 1994–1996) and the voucher specimens were deposited in the Herbarium of the Department of Botany, Berhampur University (BOTB), Orissa, India. Similarity index between the forest stands were calculated using the community coefficient (Jaccard 1928, cited in MuellerDombois and Ellenburg 1974). Community Coefficient or Index of Similarity (IS) indicates the percentage of the species common to both the stands out of the total species in the two stands. Thus Index of Similarity (IS) was calculated as follows:

$$IS = \frac{c}{a + b + c} \times 100$$

where c is the number of species common to both the forest stands; a the number of species unique to forest stand 1; b is the number of species unique to forest stand 2.

Frequency, density and basal area were calculated following Misra (1968). Relative frequency, relative density, relative dominance and importance value index (IVI) for individual species were calculated according to the formula of Cottam and Curtis (1956). Species diversity and evenness, Shannon–Wiener index (H^1) (Magurran 1988), Simpson's dominance index (C) (Simpson 1949), and Hill diversity numbers $N1$ and $N2$ (Hill 1973) were computed.

The dominance–diversity curve was drawn by plotting the co-ordinate points of its relative importance index (IVI) on the Y -axis and its position in the sequence of species from highest to lowest IVI on the X -axis (Whittaker 1970) for the herbs.

For aboveground biomass estimation six sample quadrats of 1 m \times 1 m size were harvested randomly from each stand. Clipping of the herbaceous vegetation was done with the help of scissors at the ground level. The plants were separated into monocotyledons and dicotyledons, and dicotyledons were again divided into leguminous and non-leguminous species. The samples were dried to a constant weight in a hot air oven at 90 °C.

Results

Floristic composition

Plant species encountered in the four recovering stands are presented in Table 1. Number of tree species recorded in the individual stands ranged from 20 to 22 with a total number of 29 species in all the four sites (Table 2).

Shrubs in the four stands ranged between 3 and 4, the pooled number of shrub species being 4, excluding the tree species in shrub stage. This shows that shrub species were less important in the stands (Table 2).

In the 2-year recovering stand 40 herb species were observed. In addition, 4 tree species that were in seedling stage were also considered under herbs. Total number of herbs observed in the 4-year stand was 28 while the 6-year protected stand exhibited 30 species, out of which four tree and shrub species were in seedling stage. The lowest number of herb species was observed in the 10-year stand and out of the 24 species recorded, 2 were of tree species in seedling stage (Table 2).

A maximum of 69 plant species was observed in the 2-year recovering forest stand, while the 4- and 6-year stands exhibited same number of species (55). The 10-year recovering stand exhibited 51 species (Table 3). Numbers of

Table 1. Floristic composition of the recovering forest stands in the Kandhamal district of Orissa, India.

Sl No.	Name of the plant species	Habit	Family	Stand age (year)					
				2	4	6	10		
1	<i>Anogeissus latifolia</i> (Roxb.ex DC.) Wall. ex Guill. & Perr.; Behera 121	T	Combrataceae	+	+	+	+		
2	<i>Antidesma acidum</i> Retz.; Behera 133	T	Euphorbiaceae	+	+	+	+		
3	<i>Bridelia retusa</i> (L) Spreng.; Behera 116	T	Euphorbiaceae	+	+	+	-		
4	<i>Buchanania lanzan</i> Spreng.; Behera 177	T	Anacardiaceae	+	+	+	+		
5	<i>Casuarina graveolens</i> Dalz.; Behera 53	T	Flacourtiaceae	+	-	+	+		
6	<i>Cassia fistula</i> L.; Behera 47	T	Caesalpiniaceae	+	+	+	+		
7	<i>Cleistanthus collinus</i> (Roxb.) Benth. ex Hook.f.; Behera 11	T	Euphorbiaceae	-	+	+	+		
8	<i>Desmodium ojeinensis</i> (Roxb.) Ohashi; Behera 163	T	Fabaceae	+	+	+	+		
9	<i>Diospyros malabarica</i> (Desr.) Kostel. (<i>D. macrophylla</i> L.); Behera 50	T	Ebenaceae	+	-	-	+		
10	<i>Diospyros melanoxylon</i> Roxb.; Behera 117	T	Ebenaceae	+	+	+	+		
11	<i>Flacourtia indica</i> (Burm.f.) Merr.; Behera 173	T	Flacourtiaceae	-	-	-	+		
12	<i>Ficus benghalensis</i> L.; Behera 4	T	Moraceae	-	-	+	-		
13	<i>Flacourtia jangomas</i> (Lour.) Raeusch (<i>F. cataphracta</i> Roxb. ex Willd.); Behera 43	T	Flacourtiaceae	-	+	+	-		
14	<i>Gardenia gummifera</i> L. f.; Behera 124	T	Rubiaceae	+	-	-	-		
15	<i>Gardenia latifolia</i> Ait.; Behera 156	T	Rubiaceae	-	+	+	-		
16	<i>Grewia hirsuta</i> Vahl; Behera 136	T	Tiliaceae	+	+	+	+		
17	<i>Holarrhena pubescens</i> (Buch-Ham.) Wall. ex G. Don; Behera 12	T	Apocyanaceae	+	+	+	+		
18	<i>Indigofera cassioides</i> Rottl.ex DC.; Behera 157	T	Fabaceae	+	+	+	+		
19	<i>Ixora pavetta</i> Andr. (<i>I. arborea</i> Roxb. ex Sm.); Behera 119	T	Rubiaceae	+	+	+	+		
20	<i>Lannea coronandolica</i> (Houtt.) Merr.; Behera 125	T	Anacardiaceae	+	+	+	+		
21	<i>Madhuca indica</i> Gmel.; Behera 138	T	Sapotaceae	+	+	+	+		
22	<i>Mallotus philippensis</i> (Lam.) Muell.-Arg.; Behera 126	T	Euphorbiaceae	-	-	-	+		
23	<i>Nyctanthes arbor-tristis</i> L.; Behera 108	T	Oleaceae	-	-	-	+		
24	<i>Phyllanthus emblica</i> L. (<i>Embllica officinalis</i> Gaertn.); Behera 142	T	Euphorbiaceae	+	+	+	+		
25	<i>Protium serratum</i> (Wall.ex Colebr.) Engl.; Behera 127	T	Burseraceae	+	+	+	+		
26	<i>Senecarpus anacardium</i> L.f.; Behera 148	T	Anacardiaceae	+	+	+	+		
27	<i>Shorea robusta</i> Gaertn. f.; Behera 99	T	Dipterocarpaceae	+	+	+	+		

Table 1. (Continued)

Sl No.	Name of the plant species	Habit	Family	Stand age (year)					
				2	4	6	10		
28	<i>Syzygium cumini</i> (L.) Skeels; Behera 128	T	Myrtaceae	+	+	+	+	+	
29	<i>Terminalia alata</i> Heyne ex Roth; Behera 40	T	Combretaceae	+	+	+	+	+	
30	<i>Terminalia chebula</i> Retz.; Behera 51	T	Combretaceae	+	+	+	+	+	
31	<i>Wendlandia heynei</i> (Roem.& Schult.) Sant.& Merch. (<i>W. exserta</i> (Roxb.) DC.); Behera 41	T	Rubiaceae	+	+	+	+	+	
32	<i>Chromolaena odorata</i> (L.) R. King & H. Robins.; Behera 122	S	Asteraceae	+	+	+	+	+	
33	<i>Phoenix laurentii</i> Kunth (<i>P. humilis</i> Royle); Behera 88	S	Arecaceae	+	+	+	+	+	
34	<i>Woodfordia fruticosa</i> (L.) Kurz; Behera 20	S	Lythraceae	+	+	+	+	+	
35	<i>Ziziphora nummularia</i> (Burm.f.) Wight & Arn.; Behera 153	S	Rhamnaceae	+	-	-	-	-	
36	<i>Andropogonis paniculata</i> (Burm.f.) Wall. ex Nees; Behera 13	H	Acanthaceae	+	+	+	+	+	
37	<i>Anisomeles indica</i> (L.) Kuntz; Behera 115	H	Lamiaceae	+	+	+	+	+	
38	<i>Aristida setacea</i> Retz.; Behera 154.	H	Poaceae	-	-	+	+	-	
39	<i>Arthraxon lancifolius</i> (Trin.) Hochst.; Behera 224	H	Poaceae	+	-	+	+	+	
40	<i>Bothriochloa bladhii</i> (Retz.) Blake (<i>B. odorata</i> (Lisboa) A. Camus); Behera 175	H	Poaceae	-	+	-	-	-	
41	<i>Bothriochloa pertusa</i> (L.) A. Camus; Behera 207	H	Poaceae	+	-	+	-	-	
42	<i>Cenotheca lappacea</i> (L.) Desv. (<i>Cenchrus lappaceus</i> L.); Behera 174	H	Poaceae	-	+	-	-	-	
43	<i>Chrysopogon aciculatus</i> (Retz.) Trin.; Behera 179	H	Poaceae	+	+	+	+	+	
44	<i>Corchorus aestuans</i> L.; Behera 131	H	Tiliaceae	+	-	+	-	-	
45	<i>Crotalaria hirsuta</i> Willd.; Behera 132	H	Fabaceae	+	-	-	-	-	
46	<i>Crotalaria retusa</i> L.; Behera 223	H	Fabaceae	+	+	-	-	-	
47	<i>Curculigo orchiooides</i> Gaertn.; Behera 35	H	Hypoxidaceae	-	-	-	+	+	
48	<i>Cynodon dactylon</i> (L.) Pers.; Behera 79	H	Poaceae	-	-	+	-	-	
49	<i>Cyperus niveus</i> Retz.; Behera 155	H	Cyperaceae	+	-	+	-	-	
50	<i>Cyperus rotundus</i> L.; Behera 112	H	Cyperaceae	+	-	+	-	-	
51	<i>Dactyloctenium aegyptium</i> (L.) P. Beauv.; Behera 114	H	Cyperaceae	+	+	+	+	+	
52	<i>Desmodium triflorum</i> (L.) Dc.; Behera 219	H	Fabaceae	+	+	-	+	+	
53	<i>Digitaria ciliaris</i> (Retz.) Koeler (<i>D. adscendens</i> (Kunth) Henrard); Behera 134	H	Poaceae	+	+	+	+	+	

54	<i>Elephantopus scaber</i> L.; Behera 34	H	Asteraceae	+	-	+	+
55	<i>Eragrostis ciliaris</i> (L.) R. Br.; Behera 118	H	Poaceae	+	+	-	+
56	<i>Eragrostis coarctata</i> Stapf; Behera 201	H	Poaceae	+	-	+	-
57	<i>Eragrostis tenella</i> (L.) P. Beauv.; Behera 213	H	Poaceae	+	-	+	-
58	<i>Eremopogon foveolatus</i> (Del.) Stapf.; Behera 123	H	Poaceae	+	-	+	+
59	<i>Fimbristylis complanata</i> (Retz.) Link; Behera 214	H	Cyperaceae	-	+	-	-
60	<i>Fimbristylis ferruginea</i> (L.) Vahl; Behera 135	H	Cyperaceae	+	+	+	-
61	<i>Glossogyne bidentis</i> (Retz.) Alston (<i>G. pinnatifida</i> DC.); Behera 212	H	Asteraceae	+	+	-	-
62	<i>Hedyotis corymbosa</i> (L.) Lam. (<i>Oldenlandia corymbosa</i> L.); Behera 162	H	Rubiaceae	-	+	-	-
63	<i>Heteropogon contortus</i> (L.) P. Beauv.; Behera 203	H	Poaceae	+	+	+	+
64	<i>Indigofera linifolia</i> (L.f.) Retz.; Behera 216	H	Fabaceae	+	+	-	-
65	<i>Ischaemum indicum</i> (Houtt.) Merr.; Behera 204	H	Poaceae	+	+	+	-
66	<i>Launaea asplenifolia</i> (Willd.) Hook.f.; Behera 208	H	Asteraceae	+	+	+	+
67	<i>Mitracarpus villosus</i> (Sw.) DC. (<i>M. verticillatus</i> (Schum. & Thonn.) Vatke); Behera 217	H	Rubiaceae	+	+	-	-
68	<i>Oplismenus compositus</i> (L.) P. Beauv.; Behera 205	H	Poaceae	+	+	+	+
69	<i>Oxalis corniculata</i> L.; Behera 211	H	Oxalidaceae	-	-	+	+
70	<i>Perotis indica</i> (L.) Kuntze; Behera 206	H	Poaceae	+	+	+	-
71	<i>Phyllanthus virgatus</i> Forst.f. (<i>P. simplex</i> Retz.); Behera 120	H	Euphorbiaceae	-	+	-	-
72	<i>Polygala arvensis</i> Willd. (<i>P. chinensis</i> auct. non L.); Behera 151	H	Polygalaceae	+	-	-	-
73	<i>Sida cordifolia</i> L.; Behera 215	H	Malvaceae	+	-	+	+
74	<i>Spermatocoe articularis</i> L. f. (<i>Borreria articularis</i> (L. f.) Will.); Behera 152	H	Rubiaceae	-	+	-	-
75	<i>Spermatocoe hispida</i> L.; Behera 218	H	Rubiaceae	+	-	-	+
76	<i>Sporobolus indicus</i> (L.) R. Br. var. <i>dianther</i> (Retz.) Jovet & Guedes (<i>S. dianther</i> (Retz.) P. Beauv.); Behera 202	H	Poaceae	+	-	+	-
77	<i>Thysanolaena maxima</i> (Roxb.) Kuntze; Behera 129	H	Poaceae	-	-	-	+
78	<i>Tritumfetta rhomboidea</i> Jacq.; Behera 210	H	Tiliaceae	+	+	+	-
79	<i>Vernonia aspera</i> Buch-Ham. (<i>V. roxburghii</i> Less.); Behera 221	H	Asteraceae	+	+	-	-
80	<i>Vernonia cinerea</i> (L.) Less.; Behera 130	H	Asteraceae	+	+	+	+
81	<i>Asparagus racemosus</i> Willd.; Behera 19	C	Liliaceae	+	-	-	-

Table 1. (Continued)

Sl No.	Name of the plant species	Habit	Family	Stand age (year)				
				2	4	6	10	10
82	<i>Atylosia volubilis</i> (Blanco) Gamble; Behera 222	C	Fabaceae	+	+	-	-	-
83	<i>Bauhinia vahiti</i> Wight & A.; Behera 178	C	Caesalpinaceae	+	-	-	-	-
84	<i>Evolvulus alsinoides</i> (L.) L.; Behera 209	C	Convolvulaceae	+	-	+	+	+
85	<i>Evolvulus nummularis</i> (L.) L.; Behera 220	C	Convolvulaceae	+	+	+	-	-
86	<i>Hemidesmus indicus</i> (L.) R. Br; Behera 17	C	Periplocaceae	+	+	-	-	-
87	<i>Smitax zeylanica</i> L.; Behera 84	C	Smilacaceae	+	-	-	-	+
	Total			69	55	55	55	51

+ Indicates presence of the species; - Indicates absence of the species; C – climber/creeper; H – herbs; S – shrubs; T – trees.

Table 2. Total number of species in the individual recovering forest stands of the Kandhamal district of Orissa, India.

Taxa	Number of species in the stands				
	2-year	4-year	6-year	10-year	Pooled
Herbs	44	28	30	24	54
Shrubs	03	05	05	06	04
Trees	22	22	20	21	29
Total	69	55	55	51	87

species confined to each of the stands were 6, 6, 3 and 5 in 2-year, 4-year, 6-year and 10-year stands respectively, which adds to a total of 20. Species common to all the stands numbered 30. The number of species common to any two stands was 21 and for any three was 16 (Table 1). When all the four stands were taken together the number of species encountered was 87, out of which monocots represented 27 and dicots 60 (Table 3).

Number of genera was highest (59) in the 2-year stand, while it remained almost the same in the other three stands, i.e. 49, 50 and 48 genera in 4-, 6- and 10-year stands, respectively (Table 3). The total number of genera represented in the four stands was 71, out of which 22 were represented by monocots and 49 by dicots.

Number of families was highest (28) in 2-year stand followed by 10-year (27), 6-year (24) and 4-year (22) stand. The total number of families observed in the four stands was 32 (Table 3).

When all the forest stands were pooled together, the ten dominant families were Poaceae representing 19 species, Rubiaceae representing 8 species, Fabaceae representing 7 species, Asteraceae and Euphorbiaceae representing 6 species each and Cyperaceae representing 4 species, while the remaining four families were represented by 3 species each. However, when the four stands were considered separately, the same ten families with Poaceae at the top also dominated the flora but the order of dominance of these families altered slightly in different stands. For example, in the 2-year stand the most co-dominant families next to Poaceae were Fabaceae (7) followed by Asteraceae (6) and Rubiaceae (5). In the 4-year stand, next to Poaceae the dominant

Table 3. Floral statistics of the recovering forest stands of the Kandhamal district of Orissa, India.

Taxa	2-year	4-year	6-year	10-year	Total (pooled)		
					Monocot	Dicot	Total
Number of species	69	55	55	51	27	60	87
Number of genera	59	49	50	48	22	49	71
Number of families	28	22	24	27	06	26	32

Table 4. The ten dominant families in the recovering forest stands of the Kandhamal district of Orissa, India.

Name of the family	Number of species				Pooled value	
	2-year stand	4-year stand	6-year stand	10-year stand	Genera	Species
Poaceae	14	10	12	9	16	19
Rubiaceae	5	6	3	3	6	8
Fabaceae	7	6	3	3	4	7
Asteraceae	6	5	4	4	5	6
Euphorbiaceae	3	5	4	4	5	6
Cyperaceae	3	2	3	1	2	4
Anacardiaceae	3	3	3	3	3	3
Tiliaceae	3	2	3	1	3	3
Combretaceae	3	3	3	3	2	3
Flacourtiaceae	1	1	2	2	2	3
Total	48	43	40	33	48	62

families were Fabaceae and Rubiaceae, each representing 6 species, followed by Asteraceae and Euphorbiaceae, each representing 5 species. In the case of the 6-year and 10-year stands the trends of dominance of families were the same. In these two stands, next to Poaceae, the co-dominants were Asteraceae and Euphorbiaceae, representing 4 species each, followed by Fabaceae and Rubiaceae representing three species each (Table 4).

The similarity indices calculated between the forest stands are shown in Table 5. It indicated a high degree of similarity between the 2- and 6-year stands (77.4) and between the 2- and 4-year stands (74.2). Among the recovering stands, the 4- and 10-year stands exhibited the lowest similarity index (62.3) (Table 5).

Density and basal area

Total density of species in the 2-year stand was 114 plant m⁻², out of which *Heteropogon contortus* shared 25% followed by *Desmodium triflorum* (21%) and *Andrographis paniculata* (6.6%). These three species together accounted for about 53% of the under story density (Table 6). The remaining 41 species contributed 47% of density. Total basal area occupied by all the species in this

Table 5. Matrix of similarity indices among the recovering forest stands of the Kandhamal district of Orissa, India.

	2-year stand	4-year stand	6- year stand
2-year stand			
4-year stand	74.2		
6-year stand	77.4	70.9	
10-year stand	73.3	62.3	71.7

Table 6. (Continued)

Name of the plant species	2-year stand			4-year stand			6-year stand			10-year stand		
	Density (ind. m ⁻²)	Basal area (mm ² m ⁻²)	IVI (%)	Density (ind. m ⁻²)	Basal area (mm ² m ⁻²)	IVI (%)	Density (ind. m ⁻²)	Basal area (mm ² m ⁻²)	IVI (%)	Density (ind. m ⁻²)	Basal area (mm ² m ⁻²)	IVI (%)
<i>Hemidesmus indicus</i>	2.9 ± 0.4	16.5 ± 2.4	10.4 (3.5)	6.2 ± 1.2	39.8 ± 6.6	26.6 (8.9)	9.7 ± 1.4	68.4 ± 9.7	31.8 (10.6)	1.9 ± 0.7	17.6 ± 4.4	9.1 (3.1)
<i>Heteropogon contortus</i>	29.1 ± 3.3	327.7 ± 51.6	73.1 (24.4)	8.3 ± 1.5	76.3 ± 11.4	39.6 (13.2)	0.3 ± 0.2	3.5 ± 1	2.3 (0.8)	—	—	—
<i>Holarrhena pubescens</i>	—	—	—	—	—	—	—	—	—	—	—	—
<i>Indigofera tinifolia</i>	0.7 ± 0.3	3.7 ± 0.6	3.4 (1.1)	1.5 ± 0.6	6.9 ± 1.4	6.3 (2.1)	—	—	—	—	—	—
<i>Ischaemum indicum</i>	1.1 ± 0.4	3 ± 1.1	3.7 (1.2)	2.3 ± 0.8	11.3 ± 1.9	9.6 (3.2)	1.7 ± 0.5	5.6 ± 1.6	6.6 (2.2)	—	—	—
<i>Lanana asplenifolia</i>	0.9 ± 0.4	4.8 ± 1.1	3.4 (1.1)	2.1 ± 0.9	7 ± 1.7	7.6 (2.6)	1.8 ± 0.6	6.1 ± 1.3	6.3 (2.1)	3.7 ± 0.5	15.6 ± 1.7	16.1 (5.4)
<i>Mitracarpus villosus</i>	0.5 ± 0.4	7 ± 1.9	2.1 (0.7)	1.1 ± 0.4	12.3 ± 2.8	8.2 (2.7)	—	—	—	—	—	—
<i>Oplismenus compositus</i>	0.7 ± 0.4	3 ± 0.7	2.2 (0.7)	3.5 ± 1.5	16 ± 2.5	13.0 (4.3)	3.3 ± 0.6	15.1 ± 1.7	13.3 (4.4)	7.5 ± 1.3	38.1 ± 5.5	26 (8.7)
<i>Oxalis corniculata</i>	—	—	—	—	—	—	0.9 ± 0.6	1.5 ± 0.7	2.7 (0.9)	4.1 ± 1.0	7.6 ± 1.7	12.1 (4.0)
<i>Perotis indica</i>	1.3 ± 0.9	4.2 ± 0	2.9 (1)	3.1 ± 1	3.3 ± 0.8	9.5 (3.2)	3.7 ± 1.3	5.9 ± 1.9	8.0 (2.7)	—	—	—
<i>Phyllanthus virgatus</i>	—	—	—	1 ± 0.3	4.5 ± 0.8	5.4 (1.8)	—	—	—	—	—	—
<i>Polygala arvensis</i>	0.9 ± 0.3	2.8 ± 0.7	4.2 (1.4)	—	—	—	—	—	—	—	—	—
<i>Shorea robusta</i>	0.3 ± 0.2	0.6 ± 0.2	1.1 (0.4)	—	—	—	—	—	—	—	—	—
<i>Sida cordifolia</i>	0.6 ± 0.3	4.2 ± 1.1	3 (1)	—	—	—	—	—	—	2.9 ± 1	26.5 ± 4.7	13.8 (4.6)
<i>Smilax zeylanica</i>	0.2 ± 0.1	1 ± 0.4	1.1 (0.4)	—	—	—	—	—	—	0.5 ± 0.2	2.8 ± 0.5	3.2 (1.1)
<i>Spermacoce articulata</i>	—	—	—	0.9 ± 0.3	4.7 ± 1.4	5.3 (1.8)	—	—	—	—	—	—
<i>Spermacoce hispida</i>	7.2 ± 2	60.8 ± 8.1	19.9 (6.6)	—	—	—	—	—	—	—	—	—
<i>Sporobolus indicus</i>	1.1 ± 0.5	4.5 ± 1.3	3.4 (1.2)	—	—	—	1.9 ± 0.8	9.1 ± 1.9	6.3 (2.1)	—	—	9 (3)
Var. <i>dianther</i>	—	—	—	—	—	—	—	—	—	—	—	—
<i>Thysanolaena maxima</i>	—	—	—	—	—	—	—	—	—	0.3 ± 0.2	12.8 ± 0	3.9 (1.3)
<i>Triumfetta rhomboides</i>	0.6 ± 0.2	5.2 ± 0.9	3.9 (1.3)	0.8 ± 0.3	6.5 ± 1	6.14 (2.0)	0.5 ± 0.2	4.4 ± 1.1	4.6 (1.5)	—	—	—
<i>Vernonia aspera</i>	1.1 ± 0.5	5 ± 0.9	3.9 (1.3)	1.1 ± 0.5	4.7 ± 0.9	5.6 (1.9)	—	—	—	—	—	—
<i>Vernonia cinerea</i>	1.1 ± 0.5	16.2 ± 2.7	4.6 (1.5)	2.2 ± 0.6	30 ± 3.2	15.0 (5.0)	2.7 ± 1.0	31.1 ± 6.4	12.6 (4.2)	2.5 ± 0.5	22.7 ± 3.3	15.6 (5.2)
<i>Wendlandia heynei</i>	—	—	—	—	—	—	0.3 ± 0.2	11.7 ± 5.1	3.7 (1.2)	—	—	—
<i>Woodfordia fruticosa</i>	0.9 ± 0.3	6 ± 0.6	3.9 (1.3)	—	—	—	0.4 ± 0.2	3 ± 1.1	2.4 (1.0)	—	—	—
<i>Ziziphus nummularia</i>	1.1 ± 0.3	15.7 ± 2.4	5.6 (1.9)	—	—	—	—	—	—	—	—	—
Total	113.8	783.8	300 (100)	70.2	365.7	300 (100)	88.3	476.5	300 (100)	67.5	522.8	300 (100)

stand was $7.84 \text{ cm}^2 \text{ m}^{-2}$, out of which *Heteropogon contortus* contributed 42%, *Desmodium triflorum* 10% and *Spermacoce hispida* 8%. These three species together shared nearly 60% of the under storey basal area (Table 6). The other 41 species shared 40% of the basal area.

The density of all species in the 4-year stand was 70 plant m^{-2} . Highest density was shown by *Heteropogon contortus* followed by *Desmodium triflorum* and *Hemidesmus indicus*. These three species together accounted for nearly 29% of the total under storey density (Table 6). Total basal area covered by all the species was $3.66 \text{ cm}^2 \text{ m}^{-2}$, of which the three species *Heteropogon contortus*, *Hemidesmus indicus* and *Vernonia cinera* together contributed 40% of the total basal area (Table 6).

Total density in the 6-year stand was 88 plant m^{-2} , of which *Andrographis paniculata* exhibited highest density. The top three species together contributed 35% of the stand density and 39% of the stand basal area. Total basal area of the stand was $47.65 \text{ cm}^2 \text{ m}^{-2}$ (Table 6).

Total density of all the species in the 10-year stand was $67.5 \text{ plant m}^{-2}$. The three highest contributors together shared 34% of the stand density (Table 6). Total basal area occupied by the herbs was $5.23 \text{ cm}^2 \text{ m}^{-2}$, of which 48% was shared by three species (Table 6).

Importance value index (IVI)

In the 2-year stand, *Heteropogon contortus* had the highest IVI (24.4%), followed by *Desmodium triflorum* (12.3%), *Spermacoce hispida* (6.6%) and *Andrographis paniculata* (5.8%) (Table 6). *Heteropogon contortus* also showed the highest IVI (13.2%) in the 4-year stand followed by *Hemidesmus indicus* (8.9%) and *Desmodium triflorum* (6.6%) (Table 6). In the 6-year stand, *Andrographis paniculata* had the highest IVI of 37.7. The other dominant species were *Heteropogon contortus* with IVI of 31.8, *Desmodium triflorum* with IVI of 22.3 and *Aristida setacea* with IVI of 21.6 (Table 6). In the 10-year stand, *Elephantopus scaber* exhibited the highest IVI (14.8%) followed by *Chromolaena odorata* (9.2%) and *Oplismenus compositus* (8.7%) (Table 6). These species were not dominants in the other stands.

Diversity and dominance indices

Values for species richness, species diversity index and dominance index for the herbaceous vegetation in the four recovering forest stands are shown in Table 7. Shannon–Wiener's diversity index (H^1) was highest in the 6-year stand (2.96) followed by the 4-year (2.92), 10-year (2.9) and 2-year (2.80) stands. Concentration of dominance (C) was lowest (0.06) in the 4-year stand and it was slightly more in the 6-year and 10-year stands (0.07). However, concentration of dominance was highest in the 2-year stand with highest species

Table 7. Some structural attributes of the herbaceous vegetation of the four recovering stand of kandhamal districts of Orissa, India.

Variable	Stand age (year)			
	2	4	6	10
Numer of individuals (m^2)	114	70	88	68
Basal area ($cm^2 m^{-2}$)	7.84	3.66	4.77	5.23
Simpson's dominance index (C)	0.12	0.06	0.07	0.07
Shannon–Wiener's diversity index (H')	2.81	3.06	2.96	2.90
Hill's diversity number				
(a) N_0 (species richness)	44	28	30	24
(b) N_1	16.59	21.41	19.25	18.09
(c) N_2	8.09	17.28	14.60	14.99

richness (44). Hill diversity numbers (N_1 and N_2) were least for the 2-year stand and highest for the 4-year stand (Table 7). The dominance–diversity curve for the herbaceous layer of the four stands, which showed lognormal distribution, is shown in Figure 3.

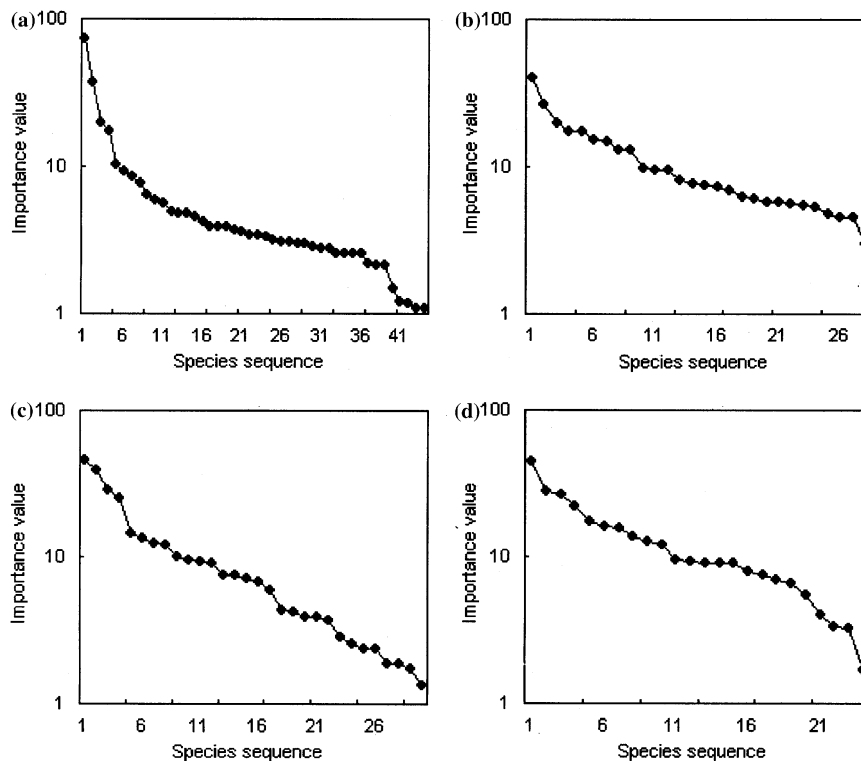


Figure 3. Dominance–diversity curve based on IVI for the herbaceous vegetation in 2-year recovering stand (a), 4-year stand (b), 6-year stand (c), and 10-year stand (d).

Biomass

The biomass of the herbaceous layer was highest in the 2-year stand (83.2 g m^{-2}) and lowest in the 6-year stand (58.0 g m^{-2}) (Table 8). The trend in biomass in the four herbaceous stands was 2-year > 10-year > 4-year > 6-year (Table 8). Monocots contributed 38.6, 31.9, 25.0 and 36.8% in the 2, 4, 6 and 10-year stands, respectively, rest being contributed by dicotyledonous species. Highest contribution of dicots was observed in the 6-year stand (68.1%). Legumes contributed a significant percentage of biomass to the total herbaceous standing biomass, i.e. 36.6, 33.8, 30.7, and 26.4% in the 2-, 4-, 6- and 10-year stands, respectively. Moisture content was 43.7% for the monocotyledons species, 26.7% for legumes and 66% for non-leguminous species. The relationship of biomass to other structural parameters showed that herb biomass had no significant relationship with diversity and density but the relationship with basal area was significant (Table 9).

Table 8. Biomass of herbaceous vegetation by group in the four recovering forest stands of Kandhamal district of Orissa, India.

Stand age	Dry weight (g m^{-2}) ^a				
	Monocot	Dicot			Grand total
		Legume	Non-legume	Total	
2-year	32.14 ± 1.92	29.92 ± 1.28	21.11 ± 0.97	51.03 ± 1.37	83.16 ± 2.3
4-year	19.85 ± 2.12	20.99 ± 3.23	21.31 ± 0.57	42.31 ± 2.93	62.16 ± 5.03
6-year	14.49 ± 1.5	17.8 ± 1.93	25.7 ± 1.05	43.49 ± 0.88	57.98 ± 2.31
10-year	23.57 ± 0.9	16.91 ± 1.27	23.56 ± 0.78	40.47 ± 1.9	64.04 ± 1.36

^aAverage weight \pm SEM.

Note: Moisture contents of monocots, legumes and non-legumes were 43.7, 26.7, and 66%, respectively.

Table 9. Relationship between various structural parameters of the herbaceous vegetation of four recovering forest stands.

Variables	Correlation coefficient (r)	Significant level (p)	Regression equation
Biomass (g m^{-2}) vs. diversity (No. of plants)	0.875	N.S.	–
Biomass (g m^{-2}) vs. density (plants m^{-2})	0.790	N.S.	–
Biomass (g m^{-2}) vs. basal area ($\text{cm}^2 \text{ m}^{-2}$)	0.910	≥ 0.05	$Y = -4.264 + 0.144x$
Diversity (No. of plants) vs. density (plants m^{-2})	0.967	≥ 0.01	$Y = 10.344 + 2.37x$
Diversity (No. of plants) vs. basal area ($\text{cm}^2 \text{ m}^{-2}$)	0.840	N.S.	–
Density (plants m^{-2}) vs. basal area ($\text{cm}^2 \text{ m}^{-2}$)	0.860	N.S.	–

Discussion

Tree species remained almost constant in all the four stands because in most of the stands coppices regenerated from the old stumps. Further, out of the total of 29 species, 21 were recorded in each of the four stands. The low difference in the number of species may be attributed to the history of the stands: these stands were the part of the same forest type before disturbance commenced, and subsequent protection helped regeneration. The number of shrub species was low in the stands because of the dominance of tree species. The presence of *Chromolaena odorata*, an exotic weed, in all the stands indicates that it had probably invaded the forest long ago and had established itself. The decrease in the total number of herb species from the 2-year stand through 4-, 6- and 10-year stands (Table 2) was because in the 2-year stand more space was available compared to other stands and therefore more herbaceous species had invaded. The lower number of herbaceous species in the rest of the stands was due to competition among the species for space, light, soil moisture and nutrients. As annuals and or short-lived perennials were favoured by disturbance (Raizada et al. 1998; Mishra et al. 2004), there was a maximum number of herbaceous species in the 2-year stand, in which the period of protection was the least.

Total density of herbs was highest in the 2-year stand (114 plant m⁻²), followed by the 6-year (88), 4-year (70) and 10-year stands (67). More density of species in the least protected stand, i.e. the 2-year, than in those protected for longer periods, i.e. 4, 6 and 10 years, can be attributed to the invasion and subsequent establishment of many grasses and sedges which propagate mostly through rhizome and spread through wind-dispersed seeds. Moreover, opening of the canopy favoured their invasion (Whittaker and Niering 1965; Devi and Behera 2003). Further, Whittaker (1972) reported a negative relationship between canopy cover and herbaceous density. Tree basal cover and canopy increased with increase in the protection period of the stands (Behera 2003). Thus, there was a decline in the herbaceous plant density from less protected to longer protected stands. This suggests that after the initial establishment period of vegetation in the disturbed stand, the number of herbaceous plants decreased with relation to tree cover in the longer protected stands.

Total density values of herbs in the present study are much higher than the total herb density (15.9–33.3 plant m⁻²) in the mid elevation forest of Central Himalayas, India (Khera et al. 2001). The minimum individual herb density (0.2 plant m⁻²) reported by Khera et al. (2001) for the forests of central Himalayas is similar to the minimum individual herb density of the present study in the 2-year stand.

The total herb basal cover (cm² m⁻²) was highest for the 2-year stand (7.84), followed by the 10-year (5.23), 6-year (4.77) and 4-year stands (3.66). Maximum basal area in the 2-year stand may be attributed to higher plant density. More basal area in the 10-year stand than in the 4- and 6-year stands was due to shift in dominance and co-dominance of species. These new species occupied more ground area per plant than the dominant and co-dominant species of the

other stands. For example, *Chromolaena odorata*, which had $27 \text{ mm}^2 \text{ m}^{-2}$ in the 6-year stand, contributed $80 \text{ mm}^2 \text{ m}^{-2}$ in the 10-year stand, while *Elephantopus scaber* which occupied less basal area in the 2 and 6-year stands increased to $132 \text{ mm}^2 \text{ m}^{-2}$ in this stand.

Less species diversity (Shannon–Wiener index) in the 2-year stand, which was less protected, may be due to decreased resource availability (Sagar et al. 2003). The present diversity index values are higher than the values (0.64–2.34) reported for the herbaceous layer of the sal (*Shorea robusta*) forest of Doon Valley, India (Pande 1999). Highest dominance in the 2-year protected stand was due to higher disturbance stress that decreased in other stands. A similar result has also been reported by Mishra et al. (2004). The dominance index (*C*) range for herbs in the present study is within the range (0.10–0.54) reported by Pande (1999) for the herbaceous vegetation of sal forests of Doon Valley, India.

Analysis of IVI provides information about social status of a species and can be used to recognize the pattern of association of dominant species in a community (Parthasarathy and Karthikeyan 1997a, b). Analysis of IVI indicated that the four stands studied represented different combinations of species with different dominants and co-dominants. In the 2-year stand, out of the three dominant species, *Heteropogon contortus* and *Desmodium triflorum* continued the dominance in the 4- and 6-year stands. The other dominant species in the 4-year stand was *Hemidesmus indicus* and in 6-year stand *Andrographis paniculata*. *Hemidesmus indicus*, which is a climber with strong root stock, probably took some time to establish itself in the stand. However, this species was not observed in the 6- and 10-year stands. *Andrographis paniculata*, the dominant species in the 6-year stand, is a common species of the ground vegetation of the natural forest in the area, and was recorded from all the four stands. *Heteropogon contortus*, *Desmodium triflorum* and *Spermacoce hispida*, the three dominant species of the 2-year stand which was more open, are commonly found in open disturbed grasslands (Misra 1978) as they require more light for growth. Probably this was the reason for the shift of dominance of species from the 2-year to the 10-year stand, where growth of tree canopy was more, thus reducing light penetration to the ground level (Behera 2003). In the 10-year stand, the dominant species were *Elephantopus scaber*, a shade loving natural species commonly found in the forest ground vegetation in the area, *Oplismenus compositus*, a common grass found in the area and *Chromolaena odorata*, an exotic weed that invaded almost all open forests in the area. The shift in the dominance of species from the 2-year to the 10-year stand indicates that protection for a longer period leads to natural stabilization.

When the importance values (IVI) of the herbaceous species of the four recovering stands were ordinated against the species sequence, the dominant–diversity curves (Whittaker 1965) followed lognormal distribution in all the stands (Figure 3). These lognormal dominance–diversity curves in the stands indicate the heterogeneity of the species (McNaughton and Wolf 1970; May 1975). In other words, these samples indicate a large number of species from a

range of environments and communities which invaded the stands and colonized them. Lognormal hypothesis assumes that species importance is governed by a large number of factors for success in the niche hyperspace (Whittaker 1970). Similar types of curves have been reported by Misra and Misra (1981) for a grassland plant community in Berhampur, India, and Tripathi et al. (2004) for the three herbaceous stands of sub-tropical pine forest in Meghalaya, India.

The highest herbaceous biomass in the 2-year protected stand may be attributed to higher diversity and density of herbaceous species. Moreover, due to thinness of tree species in the stand, more light was available on the ground and there was minimum competition among the herbs for light, nutrient and water (Gupta and Shukla 1991; Shrestha et al. 2000). Moreover, availability of moisture during rainy season was likely to have favoured rapid increase in growth of the herbaceous vegetation in all the stands. Decline in biomass in other stands was due to competition among species for the resources, which increased with increase in protection age. Increase in protection age had reduced the herbaceous biomass up to 6 years with a little increase in the 10-year protected stand. This decrease in biomass was due to increased protection age that helped in the accumulation of biomass in trees and shrubs (Behera 2003), reducing the resource availability to herbs and also due to shade of trees. A little higher biomass in the 10-year stand may be attributed to perennial species like *Chromolaena odorata*, *Elephantopus scaber*, *Oplismenus compositus* and *Vernonia cinera* present in the stand. Further, this may be due to the dominant growth of sal coppices to larger size allowing more space for the growth of herbaceous species.

The herbaceous standing crop biomass reported in this study ($0.58\text{--}0.83\text{ Mg ha}^{-1}$) was lower than the range of biomass values ($0.9\text{--}1.3\text{ Mg ha}^{-1}$) reported for the herbaceous layer of the central Himalayan forests (Garkoti and Singh 1997) and herbaceous layer biomass ($2.0\text{--}2.4\text{ Mg ha}^{-1}$) in planted forests of 5–10 years after clear cutting (Lodhiyal and Lodhiyal 2003) but higher than the values ($0.49\text{--}0.57\text{ Mg ha}^{-1}$) reported for the herbaceous layer of Oak forest in central Himalayas (Rawat and Singh 1988). This present value is towards the lower side of the biomass range reported for forest ground vegetation of northern Wisconsin ($0.38\text{--}1.18\text{ Mg ha}^{-1}$) by Zavitkovski (1976), certain low and mid altitudinal forests of Central Himalayas ($0.7\text{--}1.3\text{ Mg ha}^{-1}$) by Rana et al. (1989) and for certain forest communities in Bratislava ($0.45\text{--}1.37\text{ Mg ha}^{-1}$) by Kubicek and Simonovic (1975).

Conclusion

The present study suggests that natural forests degraded by the cutting of trees for timber, firewood collection for fuel, cattle grazing and surface burning can be restored by providing protection, which helps in the regeneration process. Although species richness decreases with increase in the protection period, it is

only due to herbs, and the shift in dominance of herbaceous species with longer protection age suggests the initiation of the stabilization process of the community allowing colonization and establishment of shade tolerant perennial species. Conservation of these forests will definitely help improve the condition of the environment and the economic status of the local people.

Acknowledgements

We are thankful to the Forest Department, Government of Orissa for the permission and facilities. Thanks are also due to the Head, Department of Botany, Berhampur University for facilities.

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