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Ecological Restoration of Rainforest Through Aided Natural Regeneration in the Denuded Hills of Sitakunda, Chittagong, Bangladesh

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ABSTRACT

Bangladesh Forest Department attempted ecological restoration of its denuded natural forests by establishing the first eco-park at Sitakunda in the South-eastern Chittagong hills in 2000. The semi-evergreen sub-tropical forest has been lying denuded of trees for years. The present study was conducted in December 2003 by taking a systematic sample of 50 circular plots each of 5.05 m in radius from a 20 ha patch of the eco-park, where non-woody vegetation has been routinely removed since 2000 in order to favor natural regeneration. The objective was to examine coppices and sprouts coming from stumps and root-suckers, respectively. In each plot regeneration were identified to species and their height measured. A total of 1401 individuals were found that represented 63 species. Most of the individuals were in the height classes 1 - 2 m (617) and < 1 m (529). It appeared that native forest ecosystem could be restored in denuded areas even when seed-bearing trees are almost absent.

Key Words: Bangladesh; Coppices; Root-suckers; Natural regeneration; Native forest ecosystem

INTRODUCTION

Bangladesh is one of the densely populated countries in the world. The total forest area in Bangladesh is estimated at 2.53 million ha corresponding to 17.50% of the surface area of the country. However, only 0.84 million ha (about 5.8%) of the state forest land has acceptable forest vegetation (Mondal *et al*., 2004). An indiscriminate felling of trees mainly from the hill forests have resulted in a serious depletion of tropical forest tree species causing a serious degradation of native ecosystems. Most of the hill forests areas have been lying denuded of forest cover for decades. Although Bangladesh Forest Department has undertaken reforestation programmes in some of these degraded hill forests through the World Bank and Asian Development Bank aided projects (Misbahuzzaman, 2004), no satisfactory results have so far been achieved either in respect of a successful establishment of plantation or in terms of the area brought under tree cover. The poor biophysical condition of the degraded hill soils and a severe seasonal moisture stress remain to be the major hindrances for survival of plantations. Investing in reforestation projects in those hilly areas may become prohibitive because of the threats of plantation failures. Steep slopes and deep gorges in some of those barren hills may further add to the difficulties of carrying out activities for establishment of plantations. However, though belatedly the government has recognized the importance of restoration of its native forest ecosystems mainly, because of its concerns for biodiversity conservation and climate change issues. Therefore, concentrated efforts have recently been made in an attempt to restore the unique conditions of the native forest ecosystems in some critical forest areas of the country. One of such initiatives was to establish eco-parks for ecological restoration of native hill forest ecosystems and development of eco-tourism for education and research on nature conservation. Forest Department launched its first ever project on ecological restoration of denuded natural forests by establishing the first eco-park of the country, named the Sitakunda Botanical Garden and Eco-park, in the South-eastern Chittagong hills in 2000. Although the hills mostly lack seed bearing trees, many of them have stumps from the previously felled trees and a system of active root-suckers often covered with thorny bush and climbers and other weeds. Hence, in order to favor natural regeneration in some patches of the Eco-park Forest Department had attempted to remove all non-woody vegetation from around stumps of the felled trees and their root-suckers without and/or with a very controlled use of fire. The cultural operation termed as 'regeneration cut' involves clearing the forest floor by cutting sun-grass, bamboo clumps and all climbers and small shrubs leaving the tree species and major shrub species intact to encourage natural regeneration by coppice, root suckers and seedlings. However in places, where no natural coppices or root-suckers could be seen, seedlings of indigenous tree species were being planted. Before the present study of December 2003, 'regeneration cut' had been started in the three previous years, the first cut on a 20.25 ha (50 acre) patch in January 2000, the second cut on a 30.38 ha (75 acre) patch in February 2001, while the third cut on a 20.24 ha (50 acre) patch in November-December 2002. The present study on survey of regeneration of forest

tree species was conducted in a 20 ha patch that had undergone a routine removal of vegetation around stumps and root-suckers since 2000 with an objective to examine coppices and sprouts that came out from stumps and root-suckers, respectively.

MATERIALS AND METHODS

The study area. The study area is situated between 22^0 36/- $22^0$39/ North latitude and 91^0 40/- 91^0 42/ East longitude and about 15 - 65 m above mean sea level. The present Eco-park and Botanical Garden is part of the Southern Sitakunda Reserve Forest, which was declared as reserve forest in 1901. Before the constitution of park and garden, it was under Chandranath block of Sitakunda Beat under Baraiadhala Range of Chittagong (North) Forest Division. The total area of Sitakunda Botanical Garden and Eco-park is 808.38 ha (1996 acres). Out of this area 405 ha (1000 acres) are allotted for botanical garden and the rest 403.38 ha (996 acres) for Eco-park (Alam, 2001). The area is composed of a good number of low, medium and high hills with steep slopes and V-shaped valleys, numerous gullies, dangerous gorges and a few waterfalls and many streams originated from the hills. The hills are elongated along the North- South direction, leaving a wide coast of the Bay of Bengal about 6 - 7 km towards the west. The hills are mainly the part of Garo Hill Range, which belongs to the Pliocene and Miocene epoch of the tertiary period. The soil of the area formed in recent and sub-recent alluvial sediments of tidal and river flood plains and of piedmont alluvial plain and valleys. Soils are yellowish brown to yellowish red in color and are sandy loam to clay loam with moderately alkaline to widely acidic in reaction. The climate is sub-tropical. Though the south-west monsoon provides majority of the mean annual rainfall of about 2890 mm, these denuded hill slopes suffer from the moisture stress over a period of about 100 days (January- May).

Previously the hills of the study area were densely covered with a wide number of tropical broad leaved timber species with decorative tropical climbers, shrubs and lianas, canes and bamboo species. The old tree branches were also covered with numerous epiphytes (Alam, 2001). Rahman and Uddin (1997) recorded 203 species under 154 genera and 54 families from the entire Sitakunda Forest Reserve. Some of the big to medium sized tree species that previously occurred abundantly in the study area were *Dipterocarpus costatus, Hopea odorata, Tetrameles nudiflora, Artocarpus chama, Bombax ceiba, Bombax insigne, Albizia chinensis, A. procera, A. odoratissima, Duabanga grandiflora, Quercus gomeziana*, several species of *Castanopsis* such as *Castanopsis lancifolia, C. tribuloides and C. indica, Firmiana colorata, Sterculia villosa, Dillenia pentagyna, Schima wallichii, Artocarpus lacucha, Amoora wallichii, Aphanamixis polystachya, Stereospermum personatum, Terminalia bellirica, Vitex glabrata, V. limonifolia, Lannea coromandelica, Garuga pinnata, Protium serratum*, several species of *Syzigium* such as *S. claviflorum, S grandis, S. formosum and S. macrocarpum, Cassia fistula, Gmelina arborea*. The middle to small sized tree species that occurred abundantly were *Callicarpa tomentosa, Macaranga denticulata, Phyllanthus emblica, Cordia dichotoma, Aporusa dioica, Hollarhena pubescence, Ficus hispida, Haplophragma adenophyllum, Microcos paniculata, Pterospermum semisagittatum, Lagerstroemia speciosa, Excoecaria indica* etc. Species common to near the streams were *Saraca asoca, Vitex negundo, Streblus asper, Trewia nudiflora, Ficus semicordata, Sarcochlamys pulcherrima, Alpinia nigra*, many aroids and ferns. Many species of *Calamus* particularly *C. erectus, Daemonorops jenkinsiana* and bamboos such as *Melocanna baccifera, Schizostachyum dullooa, Gigantochloa andamanica* occurred in the forest. Woody vines such as *Entada phaseoloides* occurs in the drier parts of the forest. Now the scrub forest is composed of shrubby vegetation, sun grass (*Imperata cylindrica*) and other tall grasses such as *Saccharum spontaneum, Narenga fallax, Thrysanolaena maxima.* Over-cut bamboos of the species *Melocanna baccifera* along with sporadic saplings coming as coppices from stumps and the root suckers cover most of the area.

Sampling method and collection of data. The study area is composed of a number of low and high hills having peak slopes and streams covered with thorny bush and climbers. Coppice shoots and root suckers occurred in a scattered manner that apparently had no spatial uniformity. Therefore, systematic sampling method was chosen. Out of the 20.25 ha of 'regeneration cut' area, some places were not accessible and some places were set aside for breeding grounds for animals. Therefore, those areas were avoided, while doing the sampling. 50 equi-distant circular plots each of 5.05 m radius were laid out in the field. Each plot was 80 m^2 and thus 50 plots covered 4000 m^2 or 0.4 ha. The sampling intensity was 1.98%. Regeneration was identified as to whether it was a coppice originating from stump, or a root sucker or a seedling. Height of individuals of each species within a plot was measured from base to the apical bud of the seedling by a marked bamboo pole; however, individuals below 1 m height were not measured for actual height. Each individual tree species was identified by vernacular names in the field. Twigs with leaves were brought to laboratory for identification to family, genera and species levels. Scientific names of the regenerating plant species were obtained using Das and Alam (2001).

RESULTS

Composition of the regenerating tree species. A total of 1401 individual stems (coppice shoots, root-suckers, stems of sapling size originated from coppices & root-suckers, few seedlings) of 63 tree species appeared to have occurred in the 0.4 ha sampled area. Among the 63 regenerating species, only 52 tree species could be identified that represented 44

Table I. Composition and types of regenerating tree species in Sitakunda Botanical Garden and Eco-park, Chittagong

Family No.	Sl	Family	Species Sl. No	Scientific name	Vernacular name	Type of regeneration
1		Anacardiaceae	1	*Lannea coromandelica* (Houtt.) Merr.	Bhadi	coppice
			2	*Spondias pinnata* (L. f.) Kurz	Amra	coppice
2		Apocynaceae	3	Holarrhena pubescence *(Buch.-Ham.) Wall.*	Kuruj	coppice, root-suckers
			4	*Alstonia scholaris* (L.) R. Br.	Chatian	coppice, root-suckers
3		Bigoniacea	5	*Stereospermum personatum* (Hassk.) Chatterjee	Dharmara	coppice, root-suckers
4		Bignoniaceae	6	*Haplophragma adenophyllum* (Wall.) Dop.	Koira- aswal	coppice
			7	*Oroxylum indicum* (L.) Vent.	Sona	coppice, root-suckers, seedlings
5		Bischofiaceae	8	*Bischofia javanica* Bl.	Kainjal	Coppice, seedlings
6		Bombacaceae	9	*Bombax insigne* Wall.	Bon-simul	coppice, root-suckers, seedlings
7		Boraginaceae	10	*Cordia dichotoma* Forst. f.	Buhal	coppice
8		Burseraceae	11	*Protium serratum* (Wall. *ex* Colebr.)	Gutgutya	coppice
			12	*Garuga pinnata* Roxb.	Silbhadi	coppice
9		Caesalpiniaceae	13	*Saraca asoca* (Roxb.) *de* Wilde	Ashok	coppice, root-suckers
			14	*Cassia fistula* L.	Sonalu	coppice
10		Combretaceae	15	*Anogeissus acuminata* (Roxb.) Wall. *ex* Bedd.	Hiori	coppice
			16	*Terminalia bellirica* (Gaertn.) Roxb.	Bahera	coppice
11		Dilleniaceae	17	*Dillenia pentagyna* Roxb.	Hargaza	coppice, root-suckers
12		Ebenaceae	18	*Diospyros nigricans*	Khalta	coppice
13		Ehretiaceae	19	*Ehretia serrata* Roxb.	Kala-huja	coppice
14		Euphorbiaceae	20	*Phyllanthus emblica* L.	Amlaki	coppice
			21	*Macaranga denticulata* (Bl.) Muell. Arg.	Bura	coppice
15		Fabaceae	22	*Derris robusta* Benth.	Jumurja	coppice
			23	*Ormosia robusta* (Roxb.) Baker	Ormosia	coppice
16		Fagaceae	24	*Quercus gomeziana* A. Camus	Sil-batna	coppice
17		Flacourtiaceae	25	*Flacourtia jangomas* (Lour.) Raeusch.	Painnagula	coppice
18		Lauraceae	26	*Litsea glutinosa* (Lour.) C. B. Rob.	Khuz-barela	coppice, root-suckers
			27	*Litsea monopetala* (Roxb.) Pers.	Meda	coppice
19		Lythraceae	28	*Lagerstroemia macrocarpa* Wall.	Mon-jarul	coppice
20		Meliaceae	29	*Toona ciliata* M. J. Roem	Suruj	coppice
21		Mimosaceae	30	*Albizia chinensis* (Osbeck) Merr.	Chakua-koroi	coppice, seedlings
			31	*Albizia procera* (Roxb.) Benth.	Sil-koroi	coppice, seedlings
			32	*Albizia odoratissima* Benth.	Tetuya-koroi	coppice
22		Moraceae	33	*Artocarpus chama* Hamilton	Chapalish	coppice
			34	*Artocarpus lacucha* Buch.-Ham.	Barta	coppice
			35	*Ficus hispida* L. f.	Dumur	coppice, root-suckers
			36	*Ficus racemosa* L.	Jogya-dumur	coppice
			37	*Streblus asper* Lour.	Sheora	coppice, root-suckers
23		Myrtaceae	38	*Syzygium fruticosum* (Roxb.) DC.	Putijam	coppice, seedlings
			39	*Syzygium claviflorum* (Roxb.) Wall. *ex* Cowan & Cowan	Nalijam	coppice, root-suckers
24		Rubiaceae	40	*Nauclea sessilifolia* Roxb.	Kum	coppice
			41	*Mitragyna rotundifolia* (Roxb.) O. Ktze.	Phul-kadam	coppice
			42	*Randia dumetorum* Lamk.	Monkata	coppice
25		Sterculiaceae	43	*Firmiana colorata* (Roxb.) R. Br.	Udal	coppice, root-suckers
			44	*Sterculia villosa* Roxb.	Bansal	coppice
26		Tiliaceae	45	*Grewia tiliaefolia* Vahl.	Dhamin-asar	coppice
			46	*Grewia disperma* Rottle *ex* Spreng.	Dhaman	coppice
			47	*Microcos paniculata* L. *ex* W & A	Assar	coppice
27		Ulmaceae	48	*Trema orientalis* (L.) Bl.	Jibon	coppice, root-suckers
28		Verbenaceae	49	*Gmelina arborea* Roxb.	Gamari	coppice
			50	*Vitex pubescence* Vahl.	Arsol	coppice
			51	*Calicarpa tomentosa* (L.) Murr.	Barmala	coppice
			52	*Tectona grandis* L.	Shaguan	coppice
		Unidentified	53	Unidetified 1		coppice
		species	54	Unidetified 2		coppice
			55	Unidetified 3		coppice, root-suckers
			56	Unidetified 4		coppice
			57	Unidetified 5		coppice, root-suckers
			58	Unidetified 6		coppice
			59	Unidetified 7		coppice
			60	Unidetified 8		coppice, root-suckers
			61	Unidetified 9		coppice
			62	Unidetified 10		coppice
			63	Unidetified 11		coppice

Table II. Height class distribution of naturally regenerating tree species in Sitakunda Botanical Garden and Eco-park, Chittagong

Sl. No.	Scientific name	Height classes (m)					Number of individuals
		0- <1	1- <2	2- <3	3- <4	4- 5	
1	*Lannea coromandelica*	1	12	5			18
2	*Spondias pinnata*	4	6				10
3	*Holarrhena pubescence*	99	111	17			227
4	*Alstonia scholaris*	1	1	1			3
5	*Stereospermum personatum*	62	84	23			169
6	*Haplophragma adenophyllum*	41	27	11			79
7	*Oroxylum indicum*	153	73	24	14		264
8	*Bischofia javanica*	1	1	1			3
9	*Bombax insigne*	3	4	7	2		16
10	*Cordia dichotoma*		2	1			3
11	*Protium serratum*	1	6	2			9
12	*Garuga pinnata*	1	2	1			4
13	*Saraca asoca*	1	4	1			6
14	*Cassia fistula*	3	9	4	1		17
15	*Anogeissus acuminata*	1	2	3			6
16	*Terminalia bellirica*	5	7	2			14
17	*Dillenia pentagyna*	17	21	3			41
18	*Diospyros nigricans*	9	3				12
19	*Ehretia serrata*	1	2				3
20	*Phyllanthus emblica*	1	7	2			10
21	*Macaranga denticulata*	1	4	1			6
22	*Derris robusta*	2	7	3			12
23	*Ormosia robusta*		1	4	1		6
24	*Quercus gomeziana*	1	2				3
25	*Flacourtia jangomas*		3				3
26	*Litsea glutinosa*	1	2				3
27	*Litsea monopetala*	11	33	3			47
28	*Lagerstroemia macrocarpa*	4	9	2			15
29	*Toona ciliata*	3	5				8
30	*Albizia chinensis*		5	7	1	1	14
31	*Albizia procera*	2		8	1		11
32	*Albizia odoratissima*	6	7	1			14
33	*Artocarpus chama* H	2	4	11	3		20
34	*Artocarpus lacucha*	4	11				15
35	*Ficus hispida*	13	12	8			33
36	*Ficus racemosa*		2	4			6
37	*Streblus asper*	1	4	1			6
38	*Syzygium fruticosum*		3	1			4
39	*Syzygium claviflorum*	3	6	1			10
40	*Nauclea sessilifolia*	5	1				6
41	*Mitragyna rotundifolia*	3	7	2			12
42	*Randia dumetorum*	1	1	1			3
43	*Sterculia foetida*		1				1
44	*Sterculia villosa*	7	3				10
45	*Grewia tiliaefolia*	7	7				14
46	*Grewia disperma*		21	7			28
47	*Microcos paniculata*	1	7				8
48	*Trema orientalis*	2	5	6			13
49	*Gmelina arborea*		2	1			3
50	*Vitex pubescence*	3	8	11			22
51	*Calicarpa tomentosa*		2				2
52	*Tectona grandis*		2	2	2		6
53	Unidetified 1	2	15	4			21
54	Unidetified 2	3	2				5
55	Unidetified 3	2	8	1			11
56	Unidetified 4		2				2
57	Unidetified 5	1	1				2
58	Unidetified 6			1			1
59	Unidetified 7		2	1			3
60	Unidetified 8			1			1
61	Unidetified 9		2				2
62	Unidetified 10	31	13	3			47
63	Unidetified 11	2	1	3			6
Total		529	617	207	25	1	1379

genera from 28 families. All of the 63 species appeared to have regeneration in the form of coppices, while 14 of them in the forms of both coppices and root-suckers (Table I). Two tree species such as *Oroxylum indicum* and *Bombax insigne* appeared to have regeneration in all three modes – coppices, root-suckers and seedlings. Four tree species such as *Bischofia javanica*, *Albizia chinensis*, *Albizia procera* and *Syzygium fruticosum* appeared to have both coppice and seedling regeneration. Coppices of a common exotic, *Tectona grandis*, widely planted in the hill forests of Bangladesh, also appeared to occur in a few plots (Table I). Regenerating plants were found to have occurred more densely in nearly leveled hill tops and gentle slopes, moderately densely in medium slopes but sporadically in steep slopes and northern aspect. Among the 1401 individuals, 22 were mature tree individuals, such as, 16 of *Oroxylum indicum*, 2 of *Bombax insigne*, 1 of *Albizia chinensis*, 2 of *Albizia procera* and 1 of *Bischofia javanica*.

Height class distribution of regenerating tree species. Most of the individuals of the regenerating tree species were represented in the height classes 0- < 1 m (529), 1- < 2 m (617) and 2- < 3 m (207), respectively among the 5 height classes; however, in the height class 1- < 2 m occurred the highest number of individuals (617), while in the height class 4 - 5 m only 1 individual of *Albizia chinensis* was found to have occurred (Table II).

Among the identified regenerating tree species, 10 species that appeared to have higher numbers of stems as compared to the other species in 0.4 ha sampled area were *Oroxylum indicum* (264), *Holarrhena pubescence* (227), *Stereospermum personatum* (169), *Haplophragma adenophyllum* (79) *Litsea monopetala* (47), *Dillenia pentagyna* (41), *Ficus hispida* (33), *Grewia disperma* (28), *Vitex pubescence* (22) and *Artocarpus chama* (20) (Table II).

DISCUSSION

It appeared that regeneration mostly occurred in the form of coppices followed by root suckers and only in case of a very few species such as *Oroxylum indicum*, *Bischofia javanica*, *Bombax insigne*, *Albizia chinensis*, *Albizia procera* and *Syzygium fruticosum* regeneration appeared to have occurred in the form of seedlings. Mature trees of these species except of *Syzygium fruticosum* were available on site from which seeds could have contributed to occurrence of regeneration in the form of seedlings in some plots. However, in case of *Syzygium fruticosum* seeds might have come from a distant place away from the eco-park. Occurrence of regeneration of tree species appeared to be 3502.5 per ha, which appears to be more than that can usually be found in plantations with seedlings planted at 2 m X 2 m spacing (2500 seedlings per ha). Moreover, the regenerated plants are mostly coppices and root-suckers, which have better survival potential than seedlings (Dwivedi, 1993). The climatic, edaphic and topographic conditions of the study area are favorable for natural regeneration (Alam, 2001). Therefore, although seed bearing trees may be absent or artificial regeneration may prove difficult, native forest ecosystem of the eco-park could be restored to a significant extent if the present modes of regeneration can be encouraged through routine cultural practices such as removal of non-woody vegetation. However, damages from human interference and animal browsing should be reduced to facilitate survival of the regenerating stems.

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