Effect of Felling Top Dying Affected Sundari (*Heritiera fomes*) Trees on the Abundance of Regeneration in the Sundarban of Bangladesh

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Abstract

A study was conducted from 1997 to 2000 to determine the effect of felling top dying affected sundari (*Heritiera fomes*) trees on the regeneration status in those areas of the Sundarban. The newly recruited seedlings of sundari (*H. fomes*), gewa (*Excoecaria agallocha*) and kankra (*Bruguiera sexangula*) were significantly higher in the felled areas compared to unfelled areas almost all the years. But seedlings of passur (*Xylocarpus mekongensis*) and goran (*Ceriops decandra*) were found significantly higher only in 1997 and 2000 respectively and amur (*Amoora cucullata*) in 1997 and 1998 in the felled areas. Moreover, seedlings recruitment of all species together was significantly higher in the felled areas. Among the recruited seedlings, *H. fomes* and *E. agallocha* constituted the highest numbers both in the felled and unfelled areas. Therefore, salvage felling of the top dying affected sundari trees is recommended to avoid wastage of wood and to improve regeneration status.

সারসংক্ষেপ

বাংলাদেশের সুন্দরবনের সুন্দরী আগামরা রোগে আক্রান্ত এলাকায় আগামরা রোগাক্রান্ত সুন্দরী (*Heritiera fomes*) বৃক্ষ কর্তনের ফলে প্রাকৃতিকভাবে গজানো নতুন চারাসমূহের অবস্থা নিরূপণের জন্য ১৯৯৭ হতে ২০০০ সন পর্যন্ত একটি নিরীক্ষা চালানো হয়। উল্লেখিত প্রায় সবগুলো বছরে সুন্দরী (*H. fomes*), গেওয়া (*Excoecaria agallocha*) ও কাকড়া (*Bruguiera sexangula*) প্রজাতির নতুনভাবে গজানো চারার সংখ্যা কর্তনবিহীন এলাকার চেয়ে কর্তনকৃত এলাকায় তাৎপর্যপূর্ণভাবে বেশী পরিলক্ষিত হয়। শুধুমাত্র ১৯৯৭ সনে পশুর (*Xylocarpus mekongensis*), ২০০০ সনে গরান (*Ceriops decandra*) এবং ১৯৯৭ ও ১৯৯৮ সনে আমুর (*Amoora cucullata*) প্রজাতির নতুন চারা কর্তনকৃত এলাকায় তাৎপর্যপূর্ণভাবে বেশী পাওয়া যায়। অধিকন্তু, সব বছরেই সকল প্রজাতির সামষ্টিক চারার সংখ্যা কর্তনকৃত এলাকায় তাৎপর্যপূর্ণভাবে বেশী পাওয়া যায়। কর্তন এবং কর্তনবিহীন উভয় এলাকায় অন্যান্য প্রজাতির মধ্যে সুন্দরী (*H. fomes*) এবং গেওয়া (*E. agallocha*) প্রজাতির চারার সংখ্যা বেশী দেখা যায়। সুতরাং, কাঠের অপচয় এড়ানো এবং নতুন চারার সংখ্যা বৃদ্ধির জন্য পরিকল্পিতভাবে আগামরা রোগাক্রান্ত সুন্দরী বৃক্ষের অপসারণ (কর্তন) করা যেতে পারে।

Key words : Mangrove species, salvage felling, seedlings regeneration, *Heritiera fomes*, Sundarban, top dying.

Introduction

The Sundarban, situated in the southwestern part of Bangladesh, is the largest continuous mangrove forests in the world. The floral biodiversity of the Sundarban is very rich which plays an important role in the national economy and environment of Bangladesh. Sundari (*Heritiera fomes*) is the most valuable and dominant species in the forests. It alone constitutes 63.8% of the merchantable timber of the forests (Rahman 1995). According to Canonizado and Hossain (1998), more than 95% of the Sundarban lands (411,234 hectares) is vegetated with profuse natural stands of two timber species; sundari (*H. fomes*) and gewa (*Excoecaria agallocha)* in almost pure stands by themselves or in association with each other and with some lesser abundant species. The merchantable growing stock of this major mangrove species- sundari (*H. fomes*) has been depleted by 40% within a period from 1969 to 1984 (Chaffey *et al.* 1985).

In recent years, sundari trees have been affected by a serious disease syndrome called top dying and a substantive depletion of the growing stock of the species has been observed (Karim 1995). This disorder causes death from top to downward. Chaffey *et al.* (1985) reported that 17% of the main forest types of the Sundarban are affected by top dying. Chowdhury (1988) reported that 13-17% sundari trees were affected, of which 81% belongs to 5-9 cm dbh class. Now it has become a threat to the existence of the species and sustainable productivity of the Sundarban forests. This may further worsen if regeneration is inadequate in the forests.

Siddiqi (1994) and Faizuddin e*t al.* (1996) studied the abundance of natural regeneration in the Sundarban. Inadequate seedling recruitment or failure of establishment of seedling is the main cause for the low density stocking in some parts of the Sundarban (Das and Siddiqi 1985; Siddiqi 1989; Siddiqi 1992; Siddiqi 2001). A number of factors may be responsible for inadequate seedling recruitment and their successful establishment. The physical and chemical factors such as increasing of soil water salinity, rainfall, temperature, wind, fresh water flush, tidal surge, duration of inundation, siltation, water logging etc. influence natural regeneration of the Sundarban (Hutchings and Saenger 1987; Siddiqi 1989; Zabala 1990). Light also influences germination, growth and distribution of the vegetation (Aksornkoae 1993). Besides, inadequate regeneration is caused by lack of mother trees in some areas of the Sundarban (Faizuddin 2001).

The Sundarban mangrove forest is managed for timber, firewood and pulpwood production on a sustained yield basis under a selection system with a 20 years felling cycle (Choudhury 1968). Besides, a few years back top dying affected sundari trees were harvested through salvage felling from some compartments. The canopy cover became partially open as a result of felling. Regeneration pattern may be different due to felling of those top dying affected trees. Therefore, the present study was conducted with an objective to determine the effect of felling of top dying sundari trees on seedling recruitment and regeneration status in the top dying areas of the Sundarban.

Materials and Methods

Top dying affected sundari trees were commercially harvested by the Forest Department from 1990-91 to 1997-98 from some severely top dying affected compartments of the Sundarban. The standing trees having $\geq$ 50% crown affected and one foot girth were marked and then extracted. Among those, four compartments *viz.* 39, 20, 26 and 19 were selected for laying out experimental Temporary Sample Plots (TSP) for this study in 1997. TSPs were established in those areas which were felled from compartment nos. 39 and 20 in 1995-96 and from 19 and 26 in 1996-97. Another 4 sites for unfelled areas such as compartment nos. 18, 29, 28, and 41 were selected for laying out TSPs (Fig. 1). In each site, 10 plots of size 4.0m x 2.5m = $10.0m^2$ were laid out 10m apart from every plot in a

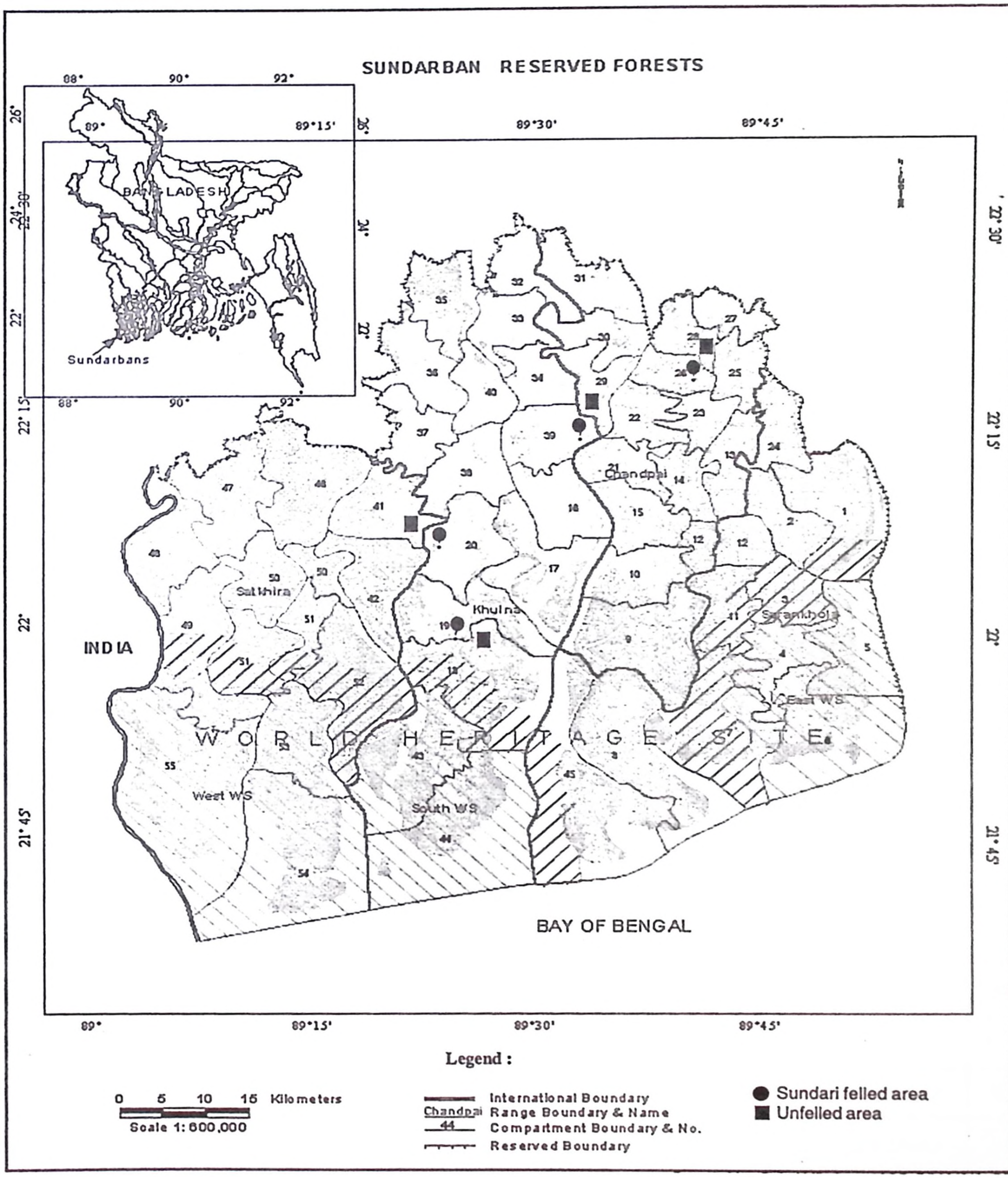

Figure 1. Map of the Sundarban showing the location of experimental plots.

transect line. Thus a total of 40 plots in the harvested areas and 40 plots in the unharvested areas were established. Boundary areas of these plots were demarcated with painted goran posts and bordering trees.

Data on the number of newly recruited seedlings of different mangrove species were collected in the month of November each year from 1997 to 2000. Seedlings survival were also recorded one year after recruitment from 1998 to 2000. The new seedlings were tagged with colour tapes to separate them from the old ones. Recorded data for each year were analyzed separately using the MINITAB statistical package. Analysis of variance (ANOVA) was done to determine the variations on the number of seedling recruitment in the felled and unfelled areas.

Results and discussion

The number of newly recruited seedlings of mangrove species such as sundari, gewa, passur (*X. mekongensis*), goran (*C. decandra*), kankra (*B. sexangula*), amur (*A. cucullata*) including other minor species such as shingra (*Cynometra ramiflora*), hantal (*Phoenix paludosa*), khalshi (*Aegiceras corniculatum*) etc. were recorded each year from 1997 to 2000. Table 1 provides total number of recruited seedlings in the felled and unfelled plots in each study years.

The results of ANOVA for the number of seedlings between treatments (felled and unfelled plots) are shown in Table 2.

The number of recruited seedlings regeneration of sundari showed significant differences between felled and unfelled plots in 1998, 1999 and 2000. Although seedling recruitment was higher in the felled plots in 1997 but difference was non-significant. Similarly, there were significant variations in seedlings regeneration of gewa between felled and unfelled plots in 1997, 1998 and 2000. Although difference was non-significant in 1999 but number of seedlings was greater in the felled plots than in the unfelled plots (Fig. 2, Fig. 3, Fig. 4, & Fig. 5). This indicates that salvage felling of sundari trees can enhance seedling recruitment of theses two major mangrove species.

Table 1. Total number of seedlings in 40 TSPs each in the felled and unfelled areas of the Sundarban.

Year	Treatment	No. of seedlings regeneration							Total
		Sundari	Gewa	Passur	Goran	Kankra	Amur	Others	
1997	Felled	605	4300	192	36	44	37	18	5232
	Unfelled	266	1049	37	52	8	6	9	1427
1998	Felled	150	310	9	17	9	15	2	512
	Unfelled	72	75	5	35	2	5	1	195
1999	Felled	3448	487	8	40	19	26	9	4037
	Unfelled	1335	263	14	56	4	20	3	1695
2000	Felled	2816	403	8	40	13	13	3	3295
	Unfelled	1180	77	4	9	0	19	0	1289

Table 2. Variation of the number of seedlings recruited per 10 m² plot from 1997 to 2000 from ANOVA.

Species	Differences (Between treatments)			
	1997	1998	1999	2000
Heritiera fomes	n. s.	*	**	*
Excoecaria agallocha	**	*	n. s.	**
Xylocarpus mekongensis	***	n. s.	n. s.	n. s.
Ceriops decandra	n. s.	n. s.	n. s.	***
Bruguiera sexangula	***	*	**	***
Amoora cucullata	***	*	n. s.	n. s.
Other species	n. s.	n. s.	n. s.	*
Total	**	**	**	**

* Significant at P= <0.05, ** P= <0.01 and *** P= <0.001 level and n.s = non-significant.

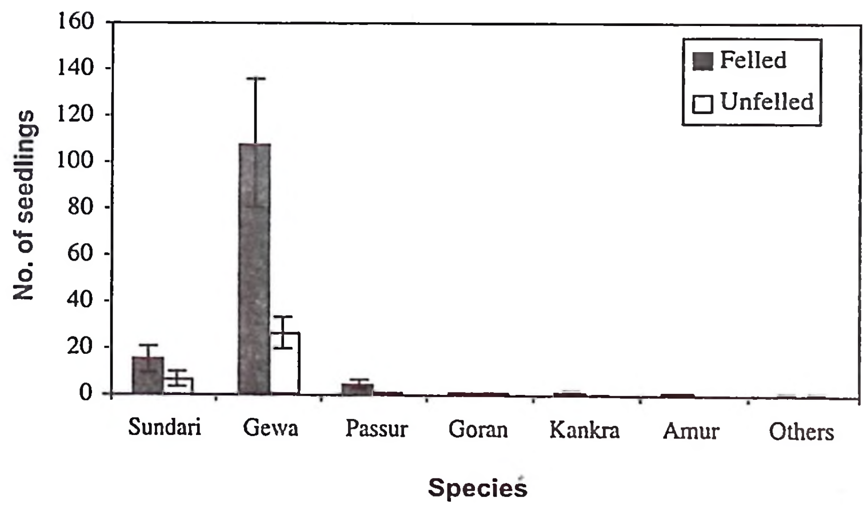

Figure 2. Average number of seedlings/plot (± SE) recruited in 1997.

Seedling recruitment of kankra was also significantly higher in the felled plots than in the unfelled plots during all the study years from 1997 to 2000. Passur and goran showed significant variations in seedling recruitment only in 1997 and 2000 respectively and amur in 1997 and 1998 (Fig. 2, Fig. 3, Fig. 4, & Fig. 5).

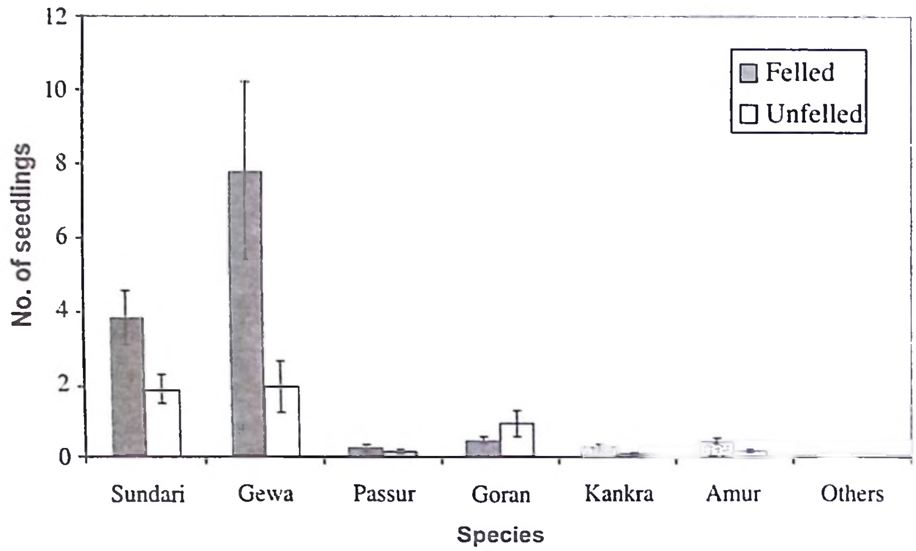

Figure 3. Average number of seedlings/plot (± SE) recruited in 1998.

The total number of seedlings regeneration were found significantly higher in the felled plots than in the unfelled plots in each study year (Fig. 6). It was 130,795/ha and 35,670/ha during 1997, 12,810/ha and 4,875/ha during 1998, 100,915/ha and 42,400/ha during 1999, and 82,380/ha and 32,200/ha during 2000 in the felled and unfelled areas respectively (Table 3). It means that felling the top dying affected sundari trees promotes seedling recruitment in those areas probably due to partially open forest cover.

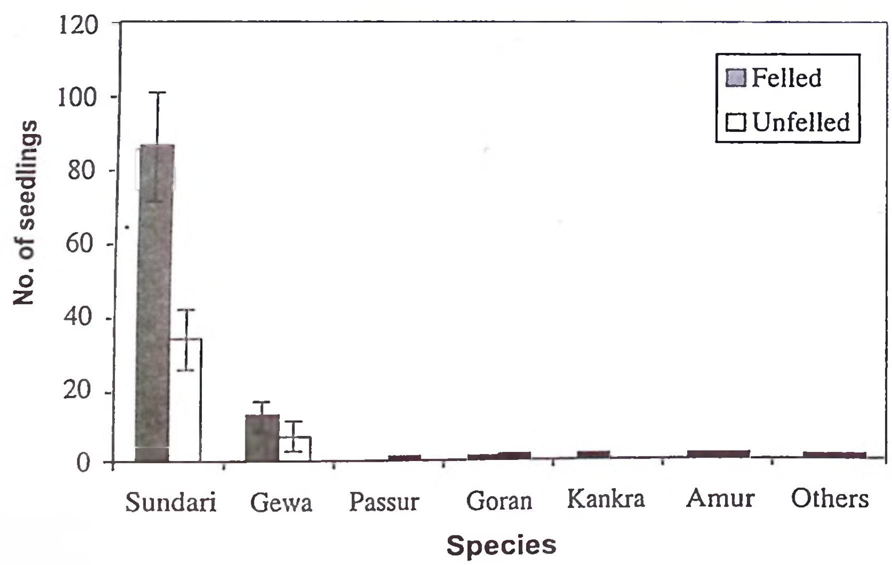

Figure 4. Average number of seedlings/plot (± SE) recruited in 1999.

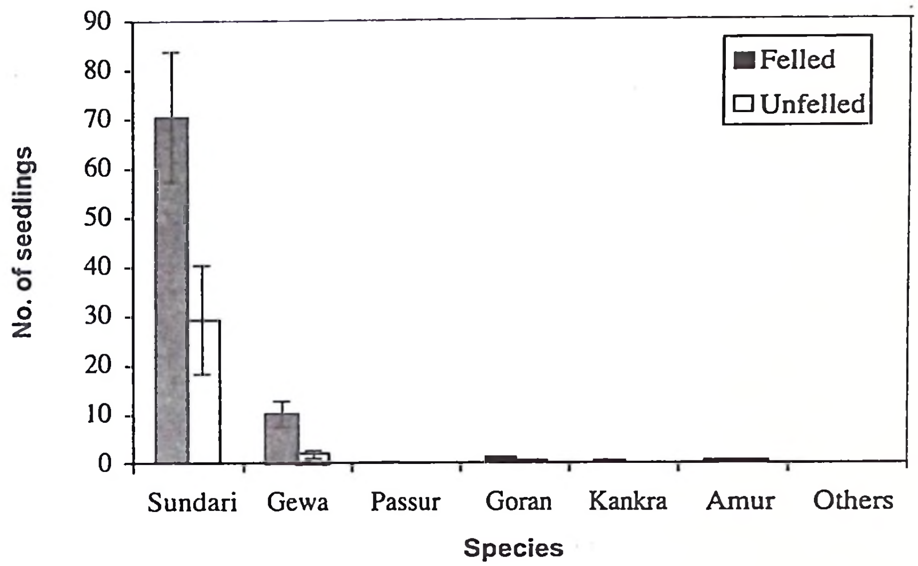

Figure 5. Average number of seedlings/plot (± SE) recruited in 2000.

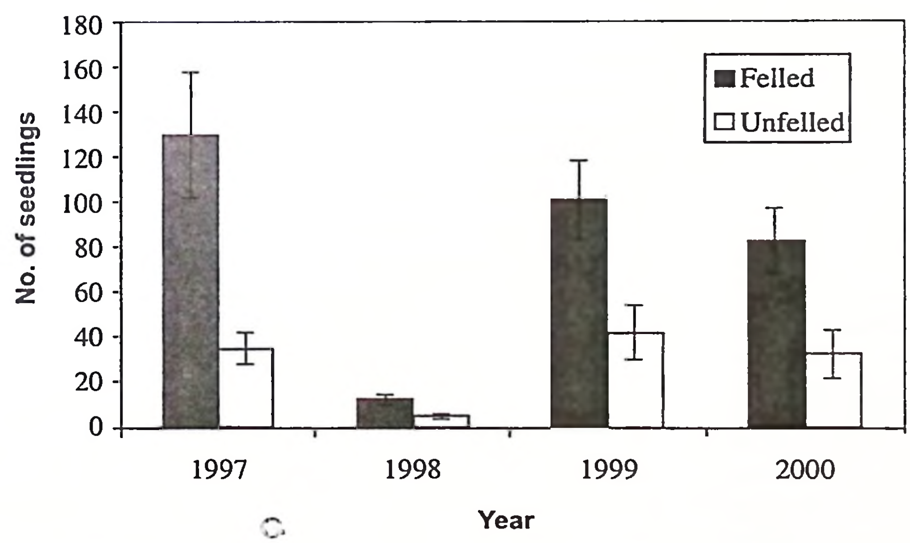

Figure 6. Total number of seedlings of all species/plot (± SE) recruited during 1997 to 2000.

The results showed that sundari and gewa constituted the major numbers of the total recruited seedlings in all the study years and passur, goran, kankra, amur, etc. were found less number in the experimental plots. Seedling recruitment of gewa was higher than sundari and other species in 1997 and 1998 in the felled areas (Fig. 2 & Fig. 3). Due to the top dying of sundari the areas may be replaced by the less valuable gewa, kankra, goran, jhana (*Rhizophora mucronata*) etc. (Faizuddin 2003 and Islam 2003).

Table 3. Number of seedlings/ha recruited in the felled and unfelled areas of the Sundarban.

Year	Treatment	No. of seedlings regeneration							Total
		Sundari	Gewa	Passur	Goran	Kankra	Amur	Others	
1997	Felled	15120	107500	4800	900	1105	930	440	130795
	Unfelled	6650	26230	925	1300	200	150	225	35670
1998	Felled	3740	7760	225	425	235	375	50	12810
	Unfelled	1800	1875	125	875	50	125	25	4875
1999	Felled	86200	12170	200	1010	465	650	220	100915
	Unfelled	33380	6580	350	1400	100	500	75	42400
2000	Felled	70400	10080	195	1010	315	315	65	82380
	Unfelled	29500	1925	100	225	0	475	0	32200

In the same study, seedlings regeneration of sundari was higher than those of gewa and other mangrove species in 1999 and 2000 both in the felled and unfelled areas. Rahman *et al.* (2003) stated that seedlings and samplings of sundari were found significantly in higher proportion than gewa and other species in the top dying felled and unfelled areas. Siddiqi (2001) opined that regeneration status of sundari remained stable and satisfactory over the period from 1970 to 1985. In the present study showed that in most of the cases the number of seedlings of different species was significantly higher in the top dying felled areas than in the unfelled areas.

A significant effect of salvage felling of top dying sundari trees on the seedlings recruitment were found in all the study years from 1997 to 2000 in the Sundarban. It may be due to some environmental factors. In simple terms, sunlight is vital for photosysthesis and growth processes of green plants and has marked influences on the growth, distribution and development of the vegetation (Chandel and Shukla 1987, Negi 1983, Aksornkoae 1993). It is responsible for the production of flowers, maturation of fruits, orientation of leaves, and their form, plant form, etc. (Dutta 1974). In general, mangrove plants are long-day plants and require high intensity of full sunlight (Macnae 1968). The range of light intensity which is optimal for the growth of mangrove species, is 3,000-3,800 Kcal/m^2/day. Apart from this, it also causes changes in other factors such as temperature, soil and water. Therefore, trees retained (growing) in the open places, usually free from competition, have a greater or open photosynthetic surface area and can invest more resources in production of fruits (Arista and Talavera 1996). Opening of crown due to harvest of top dying sundari trees has created changes to allow light to the forest floor penetrating through the canopy and thus germination of seeds can be improved. Zabala (1990) reported that successful regeneration of any sort, natural or artificial could occur only if sufficient amount growing space becomes available for the establishment and growth of the new seedlings. Clarke and Hannon (1971) observed that long hours of shade damage seedlings while inadequate light exposure impedes plant growth and increase the death rate.

Aksornkoae (1975) observed that *Rhizophora mucronata*, *R. apiculata* and *Bruguiera* spp. in shaded areas showed slower growth rates and a higher death rate than in the open areas.

The author opined that light also affects the flowering and germination of mangrove species. Those growing in the outer fringes of the forests were found to produce more flowers and seedlings than those growing inside the forest. Therefore, seeds under full shade and moist conditions are unable to make good germination and thus produce low regeneration. Regeneration under full shade and moist conditions are subjected to damping off disease and seedlings may die. Lugo and Snedaker (1975) observed that the density of seedlings and saplings of some mangrove species increased where the canopy was open and light transmission high. Banik (2003) opined that regeneration success is high under moderate crown cover than heavily opened up and heavy cover on the other hand prevent regeneration. According to Rahman *et al*. (2003), removal of top dying affected sundari trees through salvage felling is not going to affect adversely on the status of regeneration and recruitment of sundari seedlings in the top dying affected areas of the Sundarban. According to ODA inventory in 1985, 65% of the forest land had a crown closure of more than 70%. After removal of top dying affected sundari trees, the canopy cover became partially open and to allow solar radiation through the canopy. There was in fact reasonable number of standing trees to produce sufficient seeds to produce seedlings regeneration.

Yearly variation of seedlings recruitment was noticed in this experiment (Fig. 6 and Table 3). The highest recruited seedlings were 130,795/ha in 1997, 42,400/ha in 1999 and the lowest 12,810/ha in 1998, 4,875/ha in 1998 in the felled an unfelled areas respectively. Siddiqi (1994) also found a remarkable yearly variation of seedling recruitment in the Sundarban. Variation of yearly production of seeds for different mangrove species was observed in the Sundarban due to periodicity (heavy seeding year) or probably other environmental factors. Hocker (1979) stated that there is a significant reduction of seed production following a heavy seed year for different species. Therefore, seedling recruitment varies year to year due to availability of seeds.

Seedlings survival were recorded one year after recruitment from 1998 to 2000. Large proportions of the recruited seedlings disappeared within 12 months. Among the recruited seedlings, sundari, gewa, goran and amur showed the good survivability than passur, kankra and other species. In the felled plots, goran showed the highest survivability (55%) both in 1998 and 2000 and sundari (56%) in 1999. In the unfelled plots, sundari showed the highest survivability (31%) in 1998, goran (63%) in 1999 and amur (30%) in 2000 (Table 4). The survival rate for different species was higher in the felled areas than in the unfelled areas

Table 4. Survival percentage of the seedlings in the felled and unfelled areas one year after recruitment.

Year	Treatment	Survival %						
		Sundari	Gewa	Passur	Goran	Kankra	Amur	Others
1998	Felled	13	24	2	55	0	33	17
	Unfelled	31	23	0	27	0	17	11
1999	Felled	56	51	0	51	0	47	0
	Unfelled	42	20	0	63	0	40	0
2000	Felled	36	13	8	55	7	46	11
	Unfelled	17	6	0	13	0	30	0

in most of the cases. It is probably due to partially open areas in the felled areas, although many other factors are responsible for seedling mortality.

The present findings reveal that removal of top dying affected sundari trees through felling improves seedlings recruitment of sundari, gewa and other mangrove species in the top dying affected areas of the Sundarban. The number of seedlings of sundari and gewa constitute greater part both in the felled and unfelled areas. Although no trends were found in all four-study years in species composition of the seedlings where gewa seedlings were found greater in number for the first two years after felling but sundari was higher for the next two years.

Conclusion

In the Sundarban of Bangladesh, seedling regeneration of sundari, gewa and other mangrove species were found significantly higher in the top dying affected sundari felled areas. Availability of the seed production trees and favourable site conditions are highly responsible for germination of seeds and production of regeneration. Felling of top dying trees enhance seedling recruitment because of creation of favourable environment in the top dying areas. Therefore, top dying affected sundari trees can be felled to improve the regeneration status and to avoid wastage of wood. Otherwise, this shall be the shelter house of many harmful insects, fungi and bacteria.

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