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Plant species diversity and crown cover response to vegetation regeneration in community-managed forest in Makawanpur District, Nepal

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Abstract. *Ghimire P, Lamichhane U. 2020. Plant species diversity and crown cover response to vegetation regeneration in community-managed forest in Makawanpur District, Nepal. Asian J For 5: 36-41.* Community forestry is considered as a win-win solution for forest conservation and livelihood provision of forest-based communities. Yet, limited knowledge is available regarding the status of vegetation regeneration in community forests. The study was carried out to assess plant species diversity and crown cover response to regeneration composition in Nawalpur Saraswati (Basamadi) Community Forest of Hetauda Municipality, Makawanpur District, Nepal in November 2020 to December 2020. A stratified random sampling method with a total of 94 sample plots was applied in the study. In total, 44 species belonging to 26 families were recorded in the study site, of which 23 species were represented in tree category, 14 in shrub, and 7 in herb category. Both Shannon-Weiner and Simpson's diversity indices indicated good floral species diversity in the study area. The forest was dominated by *Shorea robusta* with 396 stem ha^{-1}, followed by *Terminalia bellerica* 29 stem ha^{-1}, *Lagerstroemia parviflora* 25 stem ha^{-1}, and *Terminalia tomentosa* 21 stem ha^{-1}, respectively. Both seedling and sapling were found in good numbers with seedlings 11,583 number ha^{-1}and saplings were 1,896 number ha^{-1}. Both seedling and sapling density was recorded higher in open crown coverage (seedlings=32625 number ha^{-1}; saplings=5033 number ha^{-1}) than in close crown coverage (seedlings=13,708 number ha^{-1}; saplings=2,550 number ha^{-1}). Therefore, the study concluded that crown opening facilitates the growth and development of regeneration density in *Shorea robusta* and its associated forests. Furthermore, the information generated could be useful to predict future trends in species composition and stand structure in order to optimize the possible forest management strategies.

Keywords: Community forest, crown cover, diversity, regeneration

INTRODUCTION

Biodiversity or biological diversity refers to the variety of life forms on Earth, or to the property of living systems to be distinct. It includes plants, animals, microorganisms, ecosystems, and ecological processes associated with them. (CBD 2010; MoFSC 2014). Biodiversity is a central theme of ecological theory and has been the topic of many discussions. The Convention on Biological Diversity (1992) states that the assessment and documentation of biodiversity as one of the most prioritized tasks by the world (CBD 2010). The documentation of biological resources is possible through extensive exploration of biological resources including in-depth floristic and faunal studies (Chalise et al. 2018; Ghimire 2019). Floristic study refers to the identification and documentation of all plant species in a given geographical area (Simpson 2006). Such study helps in botanical inventory and adds herbarium specimens in the existing herbaria which can facilitate the updating of taxonomical nomenclature (Chalise et al. 2018). Moreover, it could provide the basis for protection and wise use of floristic resources and to evaluate the effectiveness of conservation measures.

Floristic diversity refers to the variety of plants occurring in a specific geographical region (Simpson 2006). It is strongly associated with forest crown cover which can be described as the proportion of the forest floor covered by the vertical projection of the crowns of live trees (Jennings et al. 1999). The structure, composition, and vegetative functions are the most significant ecological features of a particular ecosystem, which show variations in response to environmental as well as human-induced variables (Shaheen et al. 2012; Timilsina et al. 2007). Likewise, analyses of diversity of forest components, natural regeneration, and crown cover are important variables in the assessment of forest status in terms of growing stock, dynamics, forest, and sustainable management. Such information would help facilitate the development of a forest management strategy (Spies 1998; Sarkar and Devi 2014). Therefore, timely and accurate assessment of floral diversity dynamics is important for their sustainable management, utilization, and biodiversity conservation.

Natural regeneration of forests is the most important process to maintain and expand the population of plant species in a community with time and space (Bharali et al. 2012). A healthy forest ensures good future regeneration (Awasthi et al. 2015). The regenerating and productive character of a forest is determined by various age groups of seedlings, saplings, and trees (Chauhan et al. 2008). Floral structure in a forest can convey its regeneration behavior, particularly the reproductive strategy (Singh and Singh

1992) which in turn demonstrates the development trend of the community (Zhang et al. 2007), species composition and stability in the future (Napit 2015). Crown cover also influences plant regeneration and survival, thus governing the nature of the vegetation (Zollner and Crane 2003; Baral and Ghimire 2020). Therefore, it is considered an important ecological parameter of forest ecosystem for its relationship with natural regeneration and species richness (Ganey and Block 1994; Zollner and Crane 2003; Baral and Ghimire 2020).

Community forestry (CF) has been accorded the highest priority of Nepal's forestry sector and has been widely acclaimed as a successful forest management approach. The program successfully rehabilitates degraded hills and thereby increases biodiversity (Shrestha et al. 2010; Gilmour 2016; Ghimire and Lamichhane 2020). During the last 40 years of community forestry implementation, about 40% of the national forest area has been handed over to more than 22,266 community forest user groups (Ghimire and Lamichhane 2020). While forest user groups have been protecting community forests for about the last 40 years, yet studies on the assessment of regeneration and growth performance of forest species in community-managed forests have not received much attention, except few similar studies (Paudyal 2016; Cedamon et al. 2018). In this regard, this study was conducted to assess plant species diversity and crown cover response to forest regeneration in community-managed forest of Makawanpur District, Nepal.

MATERIALS AND METHODS

Study area

The study was carried out in the Nawalpur Saraswati (Basamadi) Community Forest (27°25'N, 85°02' E) of Hetauda Municipality, Makawanpur District, Nepal, covering an area of 234.21 ha which was handed over in July 1995. The study area is characterized by upper tropical climate with average temperature ranging from 18° C to 28° C and rainfall of 220 mm. It is situated at an altitude between 510-950 m above mean sea level. It has good forest condition with the dominant stage of forest is tree and has 80 percent coverage of *Shorea robusta* forest. Other associated plant species are *Terminalia alata, Terminalia bellerica, Terminalia chebula, Syzygium cumini, Lagerstroemia parviflora,* etc. (NSBCFUG 2015).

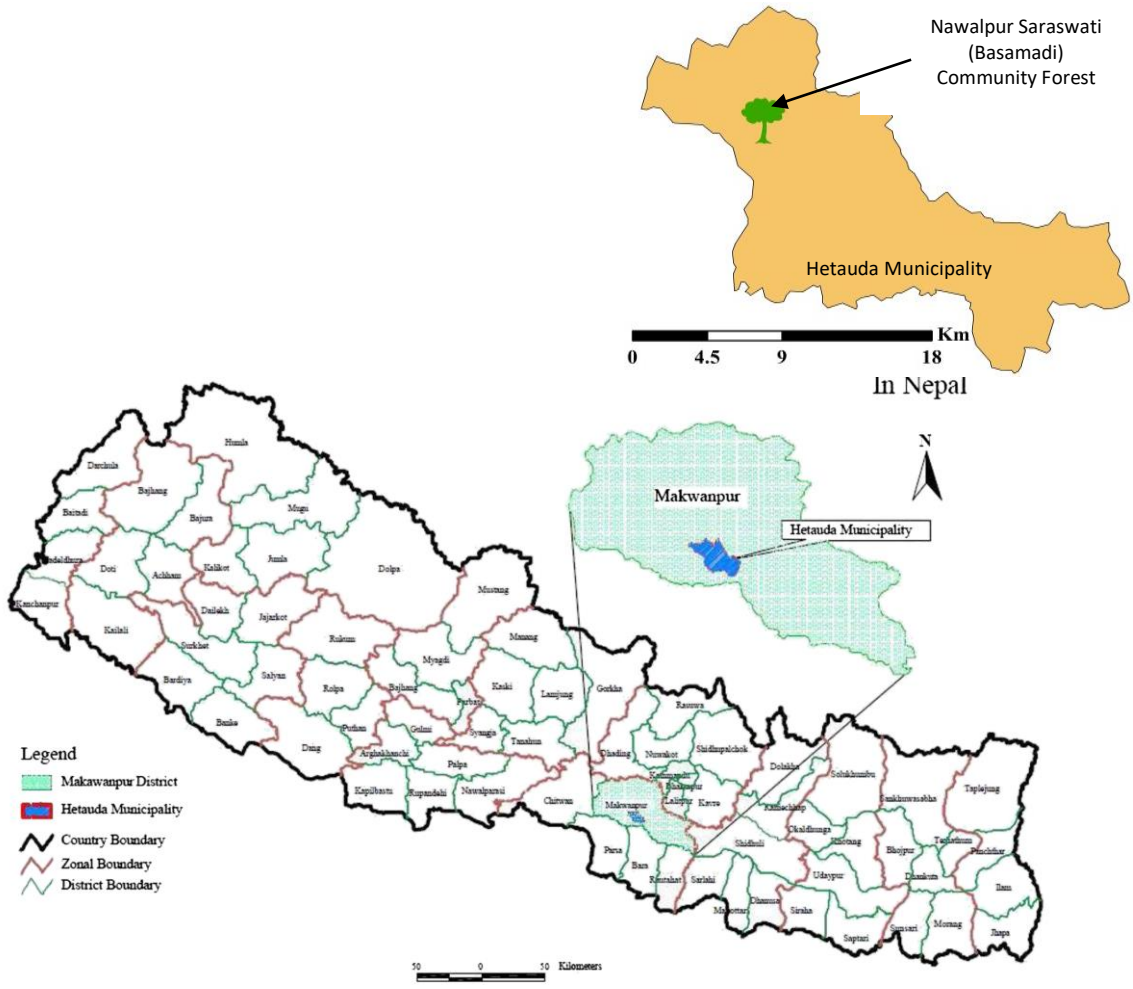

Figure 1. Map of the study area in Nawalpur Saraswati (Basamadi) Community Forest of Hetauda Municipality, Makawanpur District, Nepal

Forest sampling

A stratified random sampling method was applied in the study. Individual plants were categorized into tree (dbh> 30 cm), saplings (dbh < 10 cm and height > 1.0 m) and seedling (height < 1.0 m). A total of 96 sample plots (with 0.5% intensity) were established to collect plant species diversity and regeneration status following the Forest inventory guideline as recommended by Government of Nepal (DoF 2004). The quadrants of 5m x 5m for sapling and 5m x2m for seedling were laid out. Furthermore, of the total 96 plots, as many 24 plots were stratified into four crown cover classes namely: 0-25%, 25050%, 50-75%, and 75-100% to analyze the crown response to regeneration status. Diameter tape and GPS were used for the measurement of plots. Densitometer was used to determine the crown cover percentage.

Data analysis

There are many indices that are available for measurement of species diversity and richness. For this study, diversity indices including Shannon-Wiener's index (H), Simpson's diversity index (D), and Species evenness index (E) were analyzed following Shannon and Wiener (1963) and Simpson's (1949) respectively. Empirical data were analyzed with the help of Statistical Package for Social Science (SPSS). In addition, Correlation analysis was performed to assess the response of crown cover on regeneration composition of the forest.

Density = Total number of a species in all the quadrats/ Total number of quadrats

Shannon-Wiener index (H) (For the analysis of species diversity)

$$H = -\sum pi \ln pi$$

Shannon's measure of evenness (E) (For the analysis of species evenness)

$$E = H / \ln S$$

Simpson's index (D) (For analysis of species diversity)

$$D = 1/ (\sum p^2_i)$$

Where, Pi is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), and S is the total number of species(=species richness), E= evenness, and H= Shannon-Wiener index respectively.

RESULTS AND DISCUSSIONS

Abundance and species composition

In total, 44 plant species belonging to 26 families were reported in the study area, of which 23 species were represented in the tree group, 14 in the shrub group, and 7 in the herb group. *Shorea robusta* was the most dominant species of tree category followed by *Terminalia bellerica*, *Lagerstroemia parviflora*, *Terminalia alata*, *Mallotus philippensis*, *Terminalia chebula*, and *Schima wallichii* (Table 2). *Clerodendron infortunatum*, *Lyonia ovalifolia*, *Woodfordia fruticosa*, and *Eupatorium odorata* were dominant species in the shrub category. Among herbs, *Thysanolaena maxima* and *Eulaliopis binata* were most dominant. Occasionally, *Rauwolfia serpentina*, and *Asparagus officinalis* were also reported in the study area. Paudyal (2011) observed 58 plant species in the *Shorea robusta* dominated Lamindanda Community forest of Tanahu District. The result is in line with Mishra and Garkoti (2014) who reported 51 floral species including 15 tree species, 20 shrub species, and 9 herb species in Sabaiya Collaborative forest in Bara district of central Nepal. Similarly, Paudel (2016) documented 32 plant species in Pragatisil Community forest in Kaski District of western Nepal. In the two *Shorea robusta* Forests in Western Nepal, Gautam (2001) observed 94 and 120 plant species respectively. Pandey and Shukla (2003) also recorded a total of 208 plant species representing 165 genera and 72 families in a *Shorea robusta* forest in Gorakhpur, India.

This study revealed that the index of dominance was 0.55 (S*horea robusta* representing 55% in the stand). The Shannon Diversity Index (H) for tree, shrub and herb was 1.59, 1.32 and 0.52 respectively, while Simpson's Diversity Index was 0.79, 0.51 and 0.27 for tree, shrub and herb, respectively (Table 1), showing higher floral diversity in the forest. Dhakal et al. (2011) reported Shannon Diversity Index and Simpson's Diversity Index of 3.01 and 0.87, respectively, in Satkanya CF of Chitwan district. Similarly, the result of this study is consistent with Mishra and Garkoti (2014) who documented Shannon Diversity Index for tree, shrub and herb was 1.34, 2.09 and 0.56 respectively and Simpson's Diversity Index of 0.52, 0.57 and 0.21 for tree, shrub and herb, respectively, in Sabaiya Collaborative forest in Bara district of Nepal.

Plant density and regeneration status

In the study area the highest tree density was recorded for *Shorea robusta* (396 stem ha^{-1}), followed by *Terminalia bellerica* (29 stem ha^{-1}), *Lagerstroemia parviflora* (25 stem ha^{-1}), *Terminalia tomentosa* (21 stem ha^{-1}) and *Mallotus philippensis* (20 stem ha^{-1}). Accordingly, in shrub category *Clerodendrum infortunatum* was dominant with density of 25 stem ha^{-1}. In the regeneration composition (both seedling and sapling), the highest density was reported for *Shorea robusta* (10,908 number per ha), followed by *Terminalia bellerica* (950 number per ha), *Terminalia alata* (700 number per ha) and *Terminalia chebula* (279 number per ha) (Table 2). Both, seedlings and saplings of *Shorea robusta* was recorded in good number than other species.

Regeneration status of forests in terms of number per hectare determines the condition of the forest ecosystem. In this study regeneration structure (both seedling and sapling) of *Shorea robusta* (seedling=8,552 ha^{-1} and sapling=1,683 ha^{-1}) shared a major portion in the study

area, which was followed by other 22 different tree species such as *Terminalia bellerica*, *Terminalia*. Compared to *Shorea robusta*, the regeneration status of other species was very poor (less than 1,000 seedling ha^{-1} to even 0). Shrestha (2005) reported 909 trees ha^{-1} in Community forest of Gorkha district, Nepal. Mishra and Garkoti (2014) reported *Shorea robusta* was found to be the dominant tree species with 430 trees ha^{-1} in Sabaiya Collaborative forest of Bara district. The findings of this study are in line with Paudyal (2016) who reported *Shorea robusta* with higher density 291 stems ha^{-1} and with 6,126 seedlings ha^{-1} in the Pragatisil Community forest of Kaski district. Baral and Ghimire (2020) also reported a good number of regeneration (seedling 29,251 ha^{-1} and sapling 4,800 ha^{-1}) in Buddha-Shanti Collaborative forest of Paris district in western Nepal.

Table 1. Plant species diversity and evenness in the Nawalpur Saraswati (Basamadi) Community Forest, Nepal

Biodiversity indicators	Plant category		
	Tree	Shrub	Herb
Species richness (number of species)	23	14	7
Shannon diversity index (H)	1.59	1.32	0.52
Simpsons diversity index (D)	0.79	0.51	0.27
Species Evenness index (E)	1.17	1.15	0.48

Table 2. Density and regeneration per ha of plant species in Nawalpur Saraswati (Basamadi) Community Forest, Nepal

Species/category	Family	Density (trees/ha)	Regeneration (individuals/ha)		
			Seedling	Sapling	Total
Shorea robusta (T)	Dipterocarpaceae	396	8,552	1,683	10,235
Terminalia bellerica (T)	Combretaceae	29	979	13	992
Terminalia alata (T)	Combretaceae	21	677	75	752
Terminalia chebula (T)	Combretaceae	17	271	8	279
Schima wallichii (T)	Theaceae	13	198	29	227
Clerodendrum infortunatum (S)	Lamiaceae	25	125	12	137
Mallotus philippensis (T)	Euphorbiaceae	20	94	17	111
Syzygium operculata (T)	Myrtaceae	4	83	8	91
Lagerstroemia parviflora (T)	Lythraceae	25	73	13	86
Holarrhena antidysenterica (T)	Apocynaceae	6	73	0	73
Syzygium cumini (T)	Myrtaceae	4	62	4	66
Bombax ceiba (T)	Malvaceae	4	0	0	0
Phyllanthus emblica (T)	Phyllanthaceae	12	21	4	25
Miscellaneous		143	315	34	349
Total		719	11,583	1,896	13,479

Note: T=tree, S=Shrub, H=herb

Table 3. Crown coverage and regeneration density per ha of study area in Nawalpur Saraswati (Basamadi) Community Forest, Nepal

Crown cover (%)	Species	Regeneration count		Regeneration density (per ha)	
		Seedling	Sapling	Seedling	Sapling
0-25	*Shorea robusta*	343	157	14292	2617
	Terminalia alata	22	5	917	83
	Terminalia bellerica	35	1	1458	17
	Others	44	14	1833	233
	Total			18500	2950
25-50	*Shorea robusta*	228	107	9500	1783
	Terminalia alata	26	8	1084	133
	Terminalia bellerica	38	1	1583	17
	Others	47	9	1958	150
	Total			14125	2083
50-75	*Shorea robusta*	146	84	6083	1400
	Terminalia alata	15	5	625	84
	Terminalia bellerica	17	0	708	0
	Others	32	2	1334	33
	Total			8750	1517
75-100	*Shorea robusta*	104	56	4333	933
	Terminalia alata	2		83	0
	Terminalia bellerica	4		167	0
	Others	9	6	375	100
	Total			4958	1033

Response of crown covers to forest regeneration

The study found that crown cover has a notable role in regeneration density of plant species, particularly in regeneration structure of *Shorea robusta* species (Table 3). This study found the regeneration density (both seedling and sapling) was recorded higher in open crown cover strata (i.e. 0-25% and 25-50% crown cover) than in dense crown cover strata (i.e. 50-75% and 75-100% crown cover) (Table 3). Higher regeneration density was recorded in 0–25% crown cover strata with seedlings 18,500 and saplings 2,950 per ha, respectively, and a lesser regeneration number in 75–100 % crown cover strata with seedling 4,958 and sapling 1,033 number per ha respectively.

Opening of crown is one of the important factors in the study of plant growth and development which influences phenology of plant communities (Cook et al. 1995; Zollner and Crane 2003; Baral and Ghimire 2020). This study found that both seedling and sapling density was lower in dense crow cover strata than in open crown cover strata. Baral and Ghimire (2020) also reported higher regeneration density in open crown closure than dense crown closure in community-managed forest in western Terai, Nepal. Comparing the regeneration structure of *Shorea robusta* species with the increasing crown cover, the regeneration number decreased remarkably, which indicates that crown opening and light intensity is important for the regeneration of *Shorea robusta* and other associated species (Table 3). Gautam and Devoe (2006); and Awasthi et al. (2015) reported that the regeneration performance of *Shorea robusta* and other associated species was found better in open space than under shade. Similarly, the finding of this study is consistent with Sapkota and Oden (2009); and Baral and Ghimire (2020) who reported that regenerations of *Shorea robusta* better grow and survive on open canopy as compared to those under dense or closed canopy. This also exemplifies that the regeneration of *Shorea robusta* and its associated species better grow and survive on open canopy or in presence of light intensity. Furthermore, the study shows that the regeneration density has a strong negative correlation (seedling: r=-0.961; sapling: r=-0.935) with dense or close crown coverage. Baral and Ghimire (2020) also reported a negative correlation between regeneration density and increased crown cover in *Shorea robusta*-dominated community managed forest in western Terai, Nepal.

In conclusion, Nawalpur Saraswati (Basamadi) Community Forest supports 23 species of tree, 14 species of shrub and 7 species of herb belonging to 26 families. Both Shannon-Weiner and Simpson's diversity indices indicated good floral species diversity in the study area. Both the seedling and sapling density was recorded for *Shorea robusta* species (seedlings=8,552 number ha^{1}; saplings=1,683 number ha^{-1}). A higher number of both seedling and sapling densities were recorded in the open space than in the indicating crown opening. The presence of light is crucial for growth and development of regeneration of *Shorea robusta* and its associated species. The study also revealed a strong negative correlation between increasing number of regeneration densities and increased crown coverage, i.e. increase in regeneration density with a decrease in crown coverage.

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