

## Vegetation analysis of natural and degraded forests in Chitrepani in Siwalik region of Central Nepal

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Nepal has around 4.27 million hectares of forests representing about 29% of total land area. The high annual rate of deforestation (ca. 1.7%) in the last 16 years has been attributed mainly to human population growth leading to greater demand for farming land, fuel wood, fodder, timber, etc. As a result there has been encroachment into the forests, and to supplement their needs people are cutting trees and clearing the forests with such a rate that forest degradation has become a serious issue. Particularly in the Siwalik range in Nepal, where forest degradation rate was 2.3% per year, more plant species are being endangered. The vegetation of the Siwalik region is dominated by *Shorea robusta*. Other important associated species in the region are: *Bombax ceiba*, *Trewia nudiflora*, *Dalbergia sissoo*, *Acacia catechu*, *Syzygium cumini*, *Ficus* sp. and *Pinus roxburghii*. Studies on vegetation analysis are highly limited in the Siwalik region. The present study was undertaken to determine status of forests and trends of species loss in degraded, natural and regenerating forests in the Siwalik region of central Nepal.

The study site, Chitrepani, about 8 km east of Hetauda municipality lies in Churiamai Village Development Committee of Makawanpur District in Narayani Zone in Central Nepal (27°22' N to 27°23' N latitude, 85°04' E to 85°03' E longitude 420-720 m elevation). Based on the data recorded in Hetauda, the nearest meteorological station, during 1985-1992 the average maximum temperature was 33.5°C in April and average minimum temperature was 8°C in January. Total annual rainfall was 2357 mm and the monsoon rainfall

was 1899 mm. Average relative humidity was 75%.

Four sites were selected for the present study: Site I, Chitrepani Community Forest (Sal regenerating forest); Site II, Chitrepani Community Forest (mixed regenerating forest); Site III, Karne Forest (natural forest), and Site IV, Chitrepani Leasehold Forest (degraded forest).

Density of tree saplings were recorded in three seasons, *i.e.*, Monsoon (September 1994), Winter (December 1994) and Summer (March 1995). Tree density was recorded once in a year. The vegetation analysis was done by using circular plots based on IFRI (International Forestry Resources and Institutions Research Program, Indiana University) methodology (1994). The plots consisted of three concentric rings of 10 m, 3 m and 1 m radius. Tree density was recorded in 10 m radius plots, and dbh and height of each tree (> 10 cm dbh) were measured. Sapling and shrub densities were noted in 3 m radius plots, and basal diameter (bd) and height of each plant (bd > 2.5 cm) were measured. In 1 m radius plots, all herbs were clipped above ground, oven dried at 80°C for 24 h and weighed. Leaf litter was collected in 1 m radius plots and its dry weight estimated. Density, Frequency, Dominance, Importance Value Index, Volume, Biomass of herbs and leaf litter were calculated according to Mueller-Dombois & Ellenberg (1974), and Zobel *et al.* (1987).

Volume of tree stems was computed as

$$\text{Volume} = \frac{\text{BA} \times \text{H}}{2}$$

where, BA = basal area, H = plant height

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The aboveground biomass of tree species (< 10 cm dbh) was estimated following Brown & Iverson (1992) :

$$Y = 1.276 + 0.034 (D^2H)$$

where, Y = biomass (kg tree<sup>-1</sup>), D = diameter at breast height, H = height in meter.

There were total 46 woody species (28 tree and 18 shrub) belonging to 27 different families. Site III had the highest number (39) of species while Site IV, degraded site, had the lowest number (10) of species (Table 1). Sites I, II and IV each had five shrub species. Site IV, degraded forest, had the highest value for species loss (78.2% species), followed by Site I regenerating forest which lost 71.7% species (Table 1). Shrestha *et al.* (1998) have reported 68% loss of plant species in degraded forest as compared to natural forest in midhills of Nepal.

Distinctly, greater tree dbh was recorded at Sites I and IV than at other sites except Site III where *Shorea robusta* showed maximum dbh range (10-189 cm) while the other species exhibited smaller dbh range. All plants at Site II showed lower dbh range which indicate the regenerating state of the site (7 years old). The total

density of trees was found highest in Site II (1326 plants ha<sup>-1</sup>) and lowest in Site IV (23.9 plants ha<sup>-1</sup>) (Table 1). All the three natural and regenerating forest sites had a much higher tree density values than the degraded forest site. *Shorea robusta* had 23.9 trees ha<sup>-1</sup> in degraded forest while 141 trees ha<sup>-1</sup> occurred in natural forest. Aryal *et al.* (1999) have reported 152 trees of *S. robusta* per hectare in the Royal Bardia National Park of Nepal. Sites I and IV were dominated by *Shorea robusta* and at Site III (natural forest) it contributed more than 50% of the total density. At site II *Terminalia bellirica* and *Wrightia arborea* showed about three fourth of the total density. Degraded forest had lost 90.9% tree density whereas regenerating forest Site II gained density because of protection and smaller size tree of *Terminalia bellirica*.

Total basal area of trees was highest in Site III, natural forest (59.6 m<sup>2</sup> ha<sup>-1</sup>) and lowest in Site IV, degraded site (11.4 m<sup>2</sup> ha<sup>-1</sup>) (Table 1). All the three natural and regenerating sites showed much higher values than the degraded site. Here again *Shorea robusta* accounted for the greater portion of total basal area in Site III. While in Site II, *Ter-*

**Table 1.** Occurrence of plant species, plant density, total basal area, plant biomass and species loss in different forests of Nepal.

Parameters	Regenerating Forest		Natural Forest	Degraded Forest
	Site I	Site II	Site III	Site IV
Total number of species	13	15	39	10
Trees	8	10	23	5
Shrubs	5	5	16	5
Density (plants ha <sup>-1</sup> )	57	1326	264	23
dbh range (cm)	46-184	10-41	10-189	30-135
Total basal area (m <sup>2</sup> ha <sup>-1</sup> )	52.2	37.2	59.6	11.4
Sapling density	11099	8154	8649	1830
Litterfall (kg ha <sup>-1</sup> )				
March	795	827	848	238
December	1114	1114	2238	795
Bole volume (m <sup>3</sup> ha <sup>-1</sup> )	365	214	467	132
Tree biomass (t ha <sup>-1</sup> )	698	337	807	160
Herb biomass (kg ha <sup>-1</sup> )				
September	1154	805	144	2735
December	818	488	210	635
March	237	148	88	354
Species loss (%)	71.7	67.4	15.2	78.2
Tree density loss/gain (%)	78.4	+105.1	-	90.9
Basal area loss (%)	4.36	37.6	-	80.0
Volume loss (%)	21.9	54.1	-	71.7
Tree biomass loss (%)	13.5	58.2	-	80.1

*minalia bellirica* and *Wrightia arborea* accounted for greater portion of total basal area. Aryal *et al.* (1999) found 36.3 m<sup>2</sup> ha<sup>-1</sup> basal area in the Royal Bardia National Park forest, out of that about 50% was occupied by *S. robusta*.

*Shorea robusta* showed the highest importance value index among the trees in all sites studied except in Site II where *Terminalia bellirica* showed highest IVI. Broadly IVI followed the pattern similar to that of density and basal area. Thus, it shows that though there are many species of trees growing in this forest, sal is the dominant component and other species are associated and still need to be established.

Aryal *et al.* (1999) reported greater density of seedling-sapling compared to trees in *Shorea robusta*-*Terminalia* forest than in *Shorea robusta* forest. The *Shorea robusta* seedling-sapling density was 13166 individual per hectare in the Royal Bardia National Park, and 11099 in natural forest at Chitrepani. However, the density of seedling-sapling was drastically reduced in destructed forest (Table 1). In Sites I and IV *Cleistocalyx operculatus* also showed increasing dominance, while *Wrightia arborea* and *Terminalia bellirica* showed similar trend in Site II. In Site III, *Lagerstroemia parviflora*, *Schima wallichii*, *Semecarpus anacardium* and *Wrightia arborea* showed an increasing dominance while all the remaining species showed decreasing trend.

The biomass of herbaceous plants was highest in September and lowest in March in all the sites except natural forest where it was highest in December (Table 1). But the values in the degraded site was much higher than in natural sites because of open canopy allowing greater light to reach the understorey and herbs had to compete less for light and water (Gupta & Shukla 1991). Regenerating Site I had the highest value and natural forest Site III had the lowest value which may be because there were bigger plants so herbs had to compete more in Site III. It can be seen that higher the number and size of larger plants in forests, lower would be the biomass of herbs.

Leaf litter is considered a dominant component of litterfall in sal forests (Singh & Singh 1992). The leaf litter values were higher in March than in December (Table 1) showing the semi-deciduous nature and that maximum leaf fall occur from the end of dry season (Herbohn & Congdom 1993). The degraded site showed very low litter than the natural sites.

Total tree volume was higher in the natural forest (467 m<sup>3</sup> ha<sup>-1</sup>) (Site III) which decreased to 132 m<sup>3</sup>ha<sup>-1</sup> in degraded site. Thus the loss of 70.1% volume was recorded in degraded site compared to natural forest. However, the tree volume values were 214 in another natural forest site and 365 m<sup>3</sup> ha<sup>-1</sup> in regenerating forest. The tree volume values in the present study were broadly similar to that of the values calculated by different methods (Dawkins 1961)

The aboveground live biomass (AGB) of trees (Table 1) was also highest in natural forest Site III (807 t ha<sup>-1</sup>) while Site IV, degraded site, had the lowest value (160 t ha<sup>-1</sup>). *Shorea robusta* accounted for greater portion of AGB in both types of forest except in Site II where *Terminalia bellirica*, *Wrightia arborea*, *Cleistocalyx operculatus* and *Gmelina arborea* had higher value. The value for total aboveground biomass in present study was in the mid of the range reported by Sejuwal (1994) (1038 t ha<sup>-1</sup>) in sal forest of Royal Chitwan National Park, and Giri *et al.* (1999).

*Shorea robusta* was found to be the dominant species of the plant community except in regenerating forest where *Cleistocalyx operculatus*, *Terminalia bellirica* and *Wrightia arborea* were found dominant. *Shorea robusta* saplings were found increasing in the forests where there were less number of other species. Total volume and biomass of trees were higher in natural forests. It is noted that degraded forest had lost 78.2% species, 90.9% loss of plant density, 80.0% basal area, 71.7% tree volume and 80.1% tree biomass compared to natural forest (Table 1).

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