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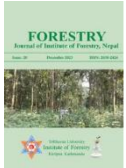


# Diversity and Distribution of 100 Plant Species of a Community Managed Forest from the Mid-Hills of Nepal: A Phytosociological Approach

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**KEYWORDS**

*Diversity indices*
*Subtropical Forest*
*Vegetation*
*Vegetation analysis*

**ABSTRACT**

Phytosociology is the study of interrelationship among plant species which classifies the vegetation in a meaningful manner. The aim of this study was to study diversity and distribution of plant species in Gobankholi Community Forest in the Mid-Hills of Nepal which is dominated by *Pinus roxburghii*. Trees were enumerated in a 400 sq. m. plot, shrubs and climber in a 100 sq. m plot and herbs in a 4 sq. m. plot. Density, frequency, abundance, and important value index of individual species were calculated. Similarly, Simpson's diversity index, Shannon's diversity index, and Pielou's evenness index were also calculated, based on life form viz. herbs, shrubs and trees. 66 herbs, 8 Pteridophytes, 8 shrubs, 3 climbers and 15 trees were found, among a total of 100 species. The rare orchid, *Satyrium nepalense*, was found at an altitude of 1275 m a.s.l. Herbs were more diverse and even than trees, shrubs and climbers. *Aleuritopteris bicolor*, *Colebrookea oppositifolia* and *Pinus roxburghii* were the most dominant herb, shrub and tree respectively.

## INTRODUCTION

Phytosociology is the study of interrelationship among plant species (Lambert & Dale, 1964). It classifies vegetation in a meaningful manner (Odum & Barrett, 1971), providing a foundation for the ecological study of plants and provides an understanding of how plant communities function (Warger & Morrell, 1976). The classification of species is one of the tools to interpret complex ecosystems and simplify existing temporal and spatial complexity (Brown et al., 2013). Vegetation is quantitatively analyzed in phytosociology (Braun-Blanquet, 1932), where parameters such as density, frequency, abundance, important value index (IVI), and diversity indices are measured (Mandal & Joshi, 2014; Joshi et al., 2019).

Phytosociology, also referred as vegetation analysis, has evolved over time, introducing new theories and methodologies. The history of phytosociology dates back to the early 19th century, which can be divided into two phases: the physiognomic approach of the 19th century and the floristic approach of the 20th century (Pott, 2011). The former phase dealt with the classification of vegetation in

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larger geographical areas, such as, savannas, deserts, steppes, tropical rainforests, etc. based on microclimate; whereas, the latter phase dealt with more precise classification (Pott, 2011). In the former part of the 20th century, between 1920s and 1950s, phytosociology revolved around the development and systematization of the methods of describing the plant community, where, Braun-Blanquet system played an important role (Poore, 1955). The phytosociologists played a significant role in the birth of ecology in that period (Acot, 1988) and the descriptive phytosociology, that explains natural plant community and its dynamic aspects was considered the best (Cain, 1932). After the 1950s, multivariate method (classification and ordination) was used in phytosociology, where both numerical and ordinal tools were considered successful (Van der Maarel, 1975). With the evolution of technology, the use of software and computerized databases in phytosociology and ecological explanation expanded significantly (Schaminée & Stortelder, 1996) making it much easier for documentation and explanation.

Phytosociology offers a number of scientific and systematic ways, more or less homogeneous, for enumerating plant species resulting in consistent data that can be compared on a larger scale (Loidi, 2004). The data collection, storage, and interpretation methods suggested by phytosociology are time-efficient and economical (Loidi, 2004), aiding the proper understanding of the forest structure as well as successional pathways, especially when the forest is studied according to different stratum, such as, herbs, shrubs and trees (van Rooyen et al., 2019). A systematic inventory of a plant species of a region provides data about the species of that region (Simpson, 2006), based on which available resources can be efficiently allocated and species can be conserved in situ (Jayakumar et al., 2011). Additionally, the findings of phytosociological analysis can also be used while implementing forest management as it provides the comprehensive details about the plant community available in a region. Furthermore, Phytosociological data serve as a foundation for managing and conserving biodiversity (Dutta & Devi, 2013) and can be used to plan for monitoring rare or endangered habitats, plant species, or plant communities (Edge et al., 2008). The data also describe the physiographic condition of an area (Bhattarai et al., 2018).

Although many researches on phytosociology have been carried out in recent decades around the world, there is still a lack of study in the context of Nepal. Ghimire et al. (2008) have conducted the studies in the Himlayan region whereas Joshi et al. (2019) conducted in the Terai Region. Only a few researches have been carried out in the Hilly region, by a handful of researchers, viz. Bhandari (2003), Bhatt & Khanal (2010), and Rawal & Subedi (2022). However, none of the studies have distinctly studied herbs, shrubs, climbers, and trees, which primarily focused on tree species. Although Bhatt & Khanal (2010) recorded data on shrubs, they did not distinguish between trees and shrubs during data analysis. This paper, however, separately studies the phytosociology of herbs, shrubs, and tree species.

Nepal has abundant biodiversity, with 118 ecosystems and 3.2% of global floristic diversity, despite covering only 0.1% of the Earth's landmass (MoFSC, 2014). Furthermore, Nepal ranks 25th globally and 11th in Asia for biodiversity richness, with 13,027 species of flowering plants (MoFE, 2018). This paper focuses on determining plant species composition, richness, and dominant species, which fill the gaps in phytosociology.

## METHODS AND MATERIALS

### Study area

The study was carried out in Gobankholi Community Forest (CF), which is managed by the local community nearby. It is located at $28^0$07'14"-$28^0$08'10" N and $83^0$02'10"-$83^0$02'56" E in Jhimruk Rural Municipality (RM), Pyuthan district, Nepal (Figure 1). The community forest has an area of 36 ha and ranges from 1,200 -1,300 m a.s.l. in elevation with *Pinus roxburghii* dominated forest. This *Pinus* Forest was due to reforestation program with *Pinus roxburghii* species by the community forest in the mid-hill of Nepal (Jackson, 2015). As a result, it is the most common conifer in the sub-tropical region of Nepal (Tiwari et al., 2020). At Gobankholi CF, it is abundant in eastern, western and southern aspects; whereas, *Schima* and *Castanopsis* were abundant in the northern aspect. Similarly, *Alnus nepalensis* was majorly found along the riverbanks. These species are quite common at the sub-tropical region (Bhattarai et al., 2018). *Pinus* is the third major species in the forest of Nepal (DFRS, 2015) and has high economic value; hence, silviculture-based forest management techniques have been implemented in Gobankholi CF focusing in *Pinus* Forest. The forest receives more rainfall in summer than in winter with an average annual rainfall of 2,200 mm.

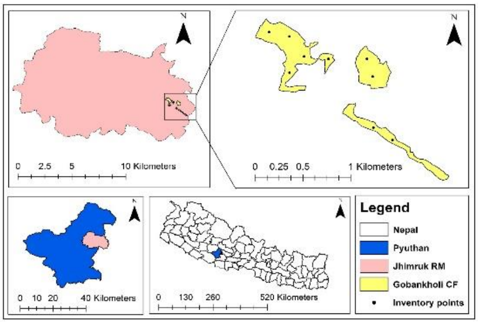


**Figure 1: Location map of study area and stratification of the Community Forest with inventory points**

## Sampling and data collection

The community forest was divided into three blocks which were considered as three strata (Figure 1). The stratum towards the North East was dominated by *P. roxburghii.* Similarly, the stratum in the South East was dominated by *A. nepalensis* and the stratum in the West was dominated by *P. roxburghii* as well as *Schima* and *Castanopsis* sp.

For the inventory of species, stratified random sampling was followed; proportionately allocating the inventory plots. Quadrat method (Curtis & McIntosh, 1950) was used for enumeration. Even though different shapes of plots are used in the enumeration of plant species of a region, square plot, generally, is considered superior (Ferreira and Rankin-de-Mérona, 1998), and is the most famous in Nepal (Dhaulkhandi et al., 2008). A total of 9 square composite plots with 20 m × 20 m area were established randomly in the strata, maintaining a sampling intensity of 1%, where the trees were enumerated. Two sub-plots of area 10 m × 10 m were nested in the composite plot for the inventory of climbers and shrubs, with an intensity of 0.5% (totaling 18 plots). While the standard practice for shrub studies is establishing a 5 m × 5 m plot area (Rout et al., 2018; Kunwar et al., 2020), the area was extended due to their scarcity. Similarly, 5 micro plots of an area of 2 m × 2 m were

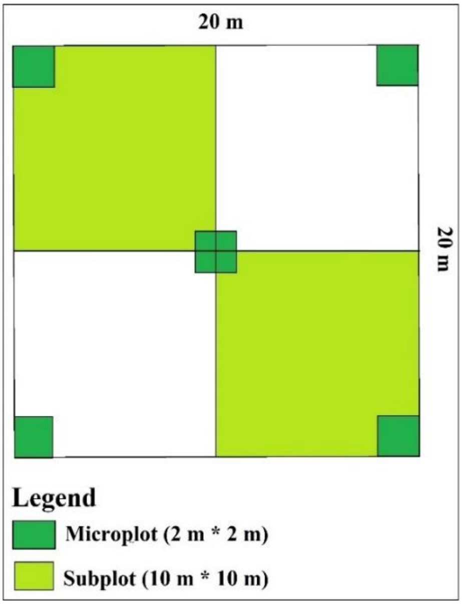


**Figure 2: Graphical representation of inventory plot**

nested in each composite plot, one in the center and the remaining four in the four corners, for the inventory of grasses, herbs and pteridophytes, with an intensity of 0.05%. The representation of the plot is given in Figure 2. This rectangular quadrat method has been followed by a number of studies (e.g., Bhatt & Khanal, 2010; Mishra et al., 2013; Mandal & Joshi, 2015: Gupta et al., 2015); however, the area of plots for these studies varies. During the inventory, plant species, their number in the respective plots, and basal diameter for herbs, shrubs, and climbers, whereas, diameter at breast height (DBH at 1.3 m) for trees were noted. As the enumeration of tree species was only done in the 20 m * 20 m plot, only the tree species with diameter greater than 10 cm (DBH > 10) cm were measured. Vernier caliper was used for measuring diameters less than 10 cm, while diameter tape was used for diameters greater than 10 cm. The species were identified in the field by their vernacular as well as scientific names with the help of locals and the experts. Unidentified species were later identified with the help of photos taken in the field; cross-checked with relevant literature (e.g., Polunin and Stainton, 1984; Press et al., 2000; Bista et al., 2001; Watson et al., 2011; Shrestha et al., 2018), websites (www.efloraofindia.com, www.efloras.org, www.floraofnepal.org, and https://powo.science.kew.org/), and by consultation with the experts.

## Data analysis

Vegetation analysis parameters, including frequency, density, abundance was calculated based on the formulae given by Curtis & McIntosh (1950). Relative frequency, relative density and relative basal area were calculated based on the formulae by Cottam & Curtis (1956); whereas, important value index (IVI) was calculated by adding these parameters (Phillips, 1959). Similarly, Simpson's (1949) diversity index and Shannon's (1948) diversity index, and Pielou's (1966) Evenness Index were also calculated.

$$Frequency = \frac{Number\ of\ sample\ plots\ in\ which\ the\ species\ occured}{Total\ number\ of\ sample\ plots} * 100$$

$$Relative\ frequency = \frac{Frequency\ of\ individual\ species}{Total\ frequency\ of\ all\ the\ species} * 100$$

$$Density = \frac{Total\ number\ of\ plants\ of\ any\ species}{Total\ number\ of\ plots\ taken}$$

$$Relative\ density = \frac{Density\ of\ individual\ species}{Total\ density\ of\ all\ speceis} * 100$$

$Basal\ area = \frac{\pi d^2}{4}$; where $d$ = basal diameter for herbs, shrubs and climbers, and DBH for trees.

$$Relative\ basal\ area = \frac{Basal\ area\ of\ individual\ species}{Basal\ area\ of\ all\ species} * 100$$

$$Abundance = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ plots\ in\ which\ species\ occurred}$$

$$Important\ value\ index\ (IVI) = Relative\ frequency + Relative\ density + Relative\ basal\ area$$

Simpson's diversity index $= \frac{N(N-1)}{\Sigma n(n-1)}$ ; where $N$ is the total number of species counted and $n$ is the number of individual species.

Shannon's divesity index $= \sum_{i=1}^{S} pi * lnpi$; where, $i$ = 1, 2, 3, ...., $S$; $S$ is the total number of species (species richness); $pi$ is the proportion of the number of $i^{th}$ species ($pi = \frac{ni}{N}$; $n_i$ is the number of $i^{th}$ species) and $lnpi$ is the natural logarithm ($\log_n$) of $pi$.

Pielou's Evenness Index $= \frac{H'}{H'max}$; where $H'$ is the Shannon-Wiener index and $H'max$ is the maximum Shannon-wiener index ($H'max = ln(S)$; $ln(S)$ is the natural logarithm of species richness ($S$). Species richness ($S$) is the number of species documented).

## RESULTS AND DISCUSSION

A total of 100 plant species were recorded during the study, of which 66 were herbs, 8 were ferns, 8 were shrubs, 3 were climbers and 15 were trees (Figure 3). This result aligns to the findings by Masoodi & Sundriyal (2020) in Himanchal Pradesh, India where herbs comprised the highest percentage (64.61%), followed by shrubs (19.61%) and trees (13.93%).

The total number of species recorded in the present study is higher than those in various other studies in tropical and subtropical regions [Fox et al., 1997 (n=94); Chowdhury et al., 2000 (n=85); Kadavul & Parthasarathy, 1999 (n=80); Pande, 1999 (n=52); Khera et al., 2001 (n=92); Shankar, 2001 (n=87); Gurarni et al., 2010 (n=27); Mandal & Joshi, 2014 (n=66, 59 and 85 respectively)] but less than the findings by Ohlson et al. (1997), Devi & Yadava (2006), and Rout et al. (2018), who recorded 148, 123 and 108 species respectively.

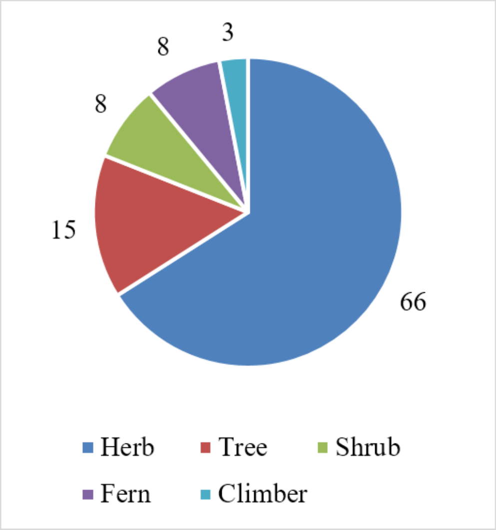


**Figure 3: Number of species for different life form**

The documented species were from 46 families, of which the family Asteraceae had the largest number of species (n =15), followed by Poaceae (n=12), Fabaceae (n=9), Lamiaceae (n=5) and Malvaceae (n=5) (Figure 4). Masoodi & Sundriyal (2020) also obtained similar results where the family Asteraceae had the largest number of species but was followed by Lamiaceae.

Disturbances such as grazing, forest fire and tree felling play an important role in influencing the forest composition (Timilsina et al., 2007), which pose serious threat to the ecosystem and can cause irreversible damage (Archer and Stokes, 2000). Similarly, present vegetation composition reflects the condition of site as well as the disturbances that occurred over time (Bhatt & Khanal, 2010). Hence, phytosociological analysis helps in understanding the disturbance and implying the prevention techniques accordingly. For instance, vegetation analysis helps in determining the diversity of trees, which ultimately assists in restoring the degraded forest by plantation of highly diversified trees (Holl et al., 2013).

### Phytosociological attributes

Phytosociological values are also used in determining the present as well as future impacts of human activities in the plant community (Konatowska & Rutkowski, 2019). Furthermore, IVI represents dominance and ecological succession of any species (Joshi et al., 2019) and also used to specify forest features and it assists in designing different ways to improve forest health (Verma & Jain, 2018).

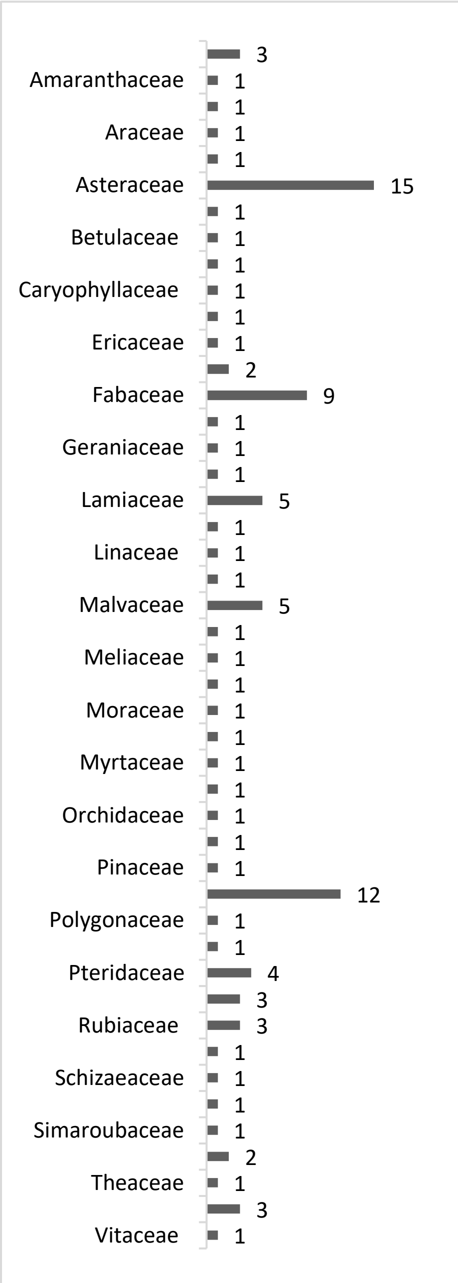


**Figure 4: Number of species in a family**

*Ageratum conyzoides* (IVI=16.01), *Ageratima adenophora* (IVI=15.04) and *Spermacoce latifolia* (IVI=14.27), which are invasive alien species to Nepal (Shrestha, 2016; Shrestha et al., 2019; Pandey et al., 2021), were co-dominant species. The invasive species are considered as one of the greatest threats to the biodiversity (Coutts-Smith and Downey, 2006). The presence of opportunistic invasive plants decreases the plant diversity and these plants are generally seen in the disturbed regions with open canopy (Mandal & Joshi, 2014).

*A. conyzoides* had the highest frequency (F) of 68.89, followed by *A.bicolor* (F=64.44). Similarly, *A. bicolor* was the densest species, with a density (D) of 7.13, which was followed by *S. latifolia* (D=6.18). *Desmotachya bipinnata* was the most abundant among herbs and pteridophytes, with an abundance (A) of 23.22, which was followed by *S. latifolia* (A=19.86).

*Satyrium nepalense*, an orchid with high medicinal value (Kumar & Rawat, 2022), was found at an altitude of 1275 m asl in the study area. While it is mainly distributed in temperate region (Mahendran & Bai, 2009) and higher altitudes ranging as 1,560-3,650 m asl (Vaidya et al., 2000), 4,076 m asl (Shapoo et al., 2014), 2,400-5,000 m asl (Mishra et al., 2018; Babbar & Singh, 2016), 1,600-2,500 (Kumar et al., 2019), and 2,300-2,600 m asl (Prakash & Pathak, 2019) but Wu et al., (2003) recorded it in the lower altitudes ranging from 1,000-4,000 m asl.

**Table 1: Frequency, Density, Abundance and Important Value Index of Herbs**

| Scientific Name | Family | F | D | A | IVI |
|---|---|---|---|---|---|
| *Achyranthes aspera* L. | Amaranthaceae | 15.56 | 0.33 | 2.14 | 6.11 |
| *Adiantum philippense* L. | Pteridaceae | 6.67 | 0.40 | 6.00 | 1.42 |
| *Ageratina adenophora* (Spreng.) R.M.King & H.Rob. | Asteraceae | 57.78 | 5.53 | 9.58 | 15.04 |
| *Ageratum conyzoides* L. | Asteraceae | 68.89 | 6.02 | 8.74 | 16.01 |
| *Ageratum houstonianum* Mill. | Asteraceae | 28.89 | 1.20 | 4.15 | 5.22 |
| *Aleuritopteris bicolor* (Roxb.) Fraser-Jenk. | Pteridaceae | 64.44 | 7.13 | 11.07 | 16.80 |
| *Anaphalis contorta* (D.Don) Hook.f. | Asteraceae | 11.11 | 0.42 | 3.80 | 2.19 |
| *Arisaema jacquemontii* Blume | Araceae | 2.22 | 0.02 | 1.00 | 10.16 |
| *Artemisia vulgaris* L. | Asteraceae | 4.44 | 0.11 | 2.50 | 8.80 |
| *Arthraxon hispidus* (Thunb.) Makino | Poaceae | 6.67 | 0.44 | 6.67 | 1.64 |
| *Bidens pilosa* L. | Asteraceae | 33.33 | 2.40 | 7.20 | 8.14 |
| *Capillipedium parviflorum* (R.Br.) Stapf | Poaceae | 8.89 | 0.29 | 3.25 | 1.66 |
| *Cassia occidentalis* L. | Fabaceae | 11.11 | 0.44 | 4.00 | 5.79 |
| *Cirsium arvense* (L.) Scop. | Asteraceae | 4.44 | 0.04 | 1.00 | 8.70 |
| *Conyza angustifolia* Roxb. | Asteraceae | 24.44 | 0.78 | 3.18 | 4.39 |
| *Cotoneaster microphyllus* Wall. ex Lindl. | Rosaceae | 4.44 | 0.04 | 1.00 | 3.47 |
| *Crassocephalum crepidioides* (Benth.) S.Moore | Asteraceae | 20.00 | 0.84 | 4.22 | 7.28 |
| *Crotalaria prostrata* Rottler ex Willd. | Fabaceae | 4.44 | 0.04 | 1.00 | 0.86 |
| *Crotalaria tetragona* Roxb. ex Andrews | Fabaceae | 4.44 | 0.04 | 1.00 | 0.80 |
| *Cynoglossum lanceolatum* Forssk. | Boraginaceae | 28.89 | 1.20 | 4.15 | 5.44 |
| *Cystopteris fragilis* (L.) Bernh. | Aspleniaceae | 6.67 | 0.42 | 6.33 | 1.35 |
| *Desmodium microphyllum* (Thunb.) DC. | Fabaceae | 2.22 | 0.07 | 3.00 | 0.69 |
| *Desmodium triflorum* (L.) DC. | Fabaceae | 8.89 | 0.40 | 4.50 | 2.00 |
| *Desmostachya bipinnata* (L.) Stapf | Poaceae | 6.67 | 1.56 | 23.33 | 3.17 |
| *Dicranopteris linearis* (Burm.f.) Underw. | Gleicheniaceae | 2.22 | 0.02 | 1.00 | 0.78 |
| *Digitaria violascens* Link | Poaceae | 8.89 | 0.60 | 6.75 | 2.13 |
| *Drymaria diandra* Blume | Caryophyllaceae | 15.56 | 2.58 | 16.57 | 5.93 |
| *Dryopteris sparsa* (D.Don) Kuntze | Polypodiaceae | 4.44 | 0.18 | 4.00 | 1.15 |
| *Elephantopus scaber* L. | Asteraceae | 17.78 | 1.00 | 5.63 | 3.81 |
| *Eleusine indica* (L.) Gaertn. | Poaceae | 2.22 | 0.02 | 1.00 | 0.47 |
| *Elymus repens* (L.) Gould | Poaceae | 8.89 | 1.67 | 18.75 | 3.29 |
| *Emilia sonchifolia* var. *sonchifolia* | Asteraceae | 11.11 | 0.24 | 2.20 | 1.78 |
| *Eulaliopsis binata* (Retz.) C.E.Hubb. | Poaceae | 6.67 | 1.24 | 18.67 | 2.60 |
| *Euphorbia hirta* L. | Euphorbiaceae | 6.67 | 0.58 | 8.67 | 1.68 |
| *Flemingia strobilifera* (L.) W.T.Aiton | Fabaceae | 17.78 | 0.47 | 2.63 | 2.85 |
| *Galium hirtiflorum* Req. ex DC. | Rubiaceae | 2.22 | 0.11 | 5.00 | 0.41 |
| *Geranium lamberti* Sweet | Geraniaceae | 2.22 | 0.04 | 2.00 | 0.32 |

| | | | | | |
|---|---|---|---|---|---|
| Girardinia diversifolia (Link) Friis | Urticaceae | 2.22 | 0.02 | 1.00 | 1.57 |
| *Gnaphalium palustre* Nutt. | Asteraceae | 20.00 | 1.02 | 5.11 | 5.56 |
| *Indigofera dosua* Buch.-Ham. ex D.Don | Fabaceae | 17.78 | 1.76 | 9.88 | 4.77 |
| *Inula cappa* (Buch.-Ham. ex D.Don) DC. | Asteraceae | 2.22 | 0.02 | 1.00 | 0.78 |
| *Justicia pectinata* L. | Acanthaceae | 4.44 | 0.29 | 6.50 | 0.95 |
| *Justicia procumbens* Thiéb.-Bern. ex Nees | Acanthaceae | 13.33 | 0.73 | 5.50 | 2.75 |
| *Laggera alata* (D.Don) Sch.Bip. ex Oliv. | Asteraceae | 2.22 | 0.04 | 2.00 | 2.34 |
| *Lygodium japonicum* (Thunb.) Sw. | Schizaeacea | 2.22 | 0.04 | 2.00 | 0.48 |
| *Onychium japonicum* (Thunb.) Kunze | Pteridaceae | 11.11 | 1.11 | 10.00 | 2.80 |
| *Oplismenus compositus* (L.) P.Beauv. | Poaceae | 28.89 | 4.31 | 14.92 | 9.11 |
| *Orthosiphon incurvus* Benth. | Lamiaceae | 2.22 | 0.16 | 7.00 | 1.18 |
| *Oxalis corniculata* L. | Oxalidaceae | 26.67 | 0.98 | 3.67 | 4.35 |
| *Pogonatherum crinitum* (Thunb.) Kunth | Poaceae | 26.67 | 4.56 | 17.08 | 9.23 |
| *Potentilla indica* (Andrews) Th.Wolf | Rosaceae | 2.22 | 0.02 | 1.00 | 1.57 |
| *Pouzolzia hirta* Hassk. | Urticaceae | 20.00 | 0.93 | 4.67 | 3.66 |
| *Pteris biaurita* L. | Pteridaceae | 17.78 | 0.64 | 3.63 | 8.00 |
| *Pulicaria dysenterica* (L.) Bernh. | Asteraceae | 2.22 | 0.18 | 8.00 | 1.08 |
| *Reinwardtia indica* Dumort. | Linaceae | 6.67 | 0.16 | 2.33 | 1.65 |
| *Rumex hastatus* D.Don | Polygonaceae | 2.22 | 0.07 | 3.00 | 2.37 |
| *Satyrium nepalense* D.Don | Orchidaceae | 2.22 | 0.13 | 6.00 | 8.59 |
| *Scutellaria discolor* Wall. ex Benth. | Lamiaceae | 11.11 | 0.27 | 2.40 | 2.05 |
| *Scutellaria repens* Buch.-Ham. ex D.Don | Lamiaceae | 13.33 | 1.42 | 10.67 | 3.88 |
| *Selaginella tenuifolia* Spring | Selaginellaceae | 8.89 | 1.09 | 12.25 | 2.68 |
| *Setaria pumila* (Poir.) Roem. & Schult. | Poaceae | 24.44 | 1.22 | 5.00 | 4.45 |
| *Sida cordata* (Burm.f.) Borss.Waalk. | Malvaceae | 2.22 | 0.13 | 6.00 | 0.65 |
| *Sida cordifolia* L. | Malvaceae | 6.67 | 0.09 | 1.33 | 1.15 |
| *Sida rhombifolia* L. | Malvaceae | 8.89 | 0.31 | 3.50 | 4.31 |
| *Solanum nigrum* L. | Solanaceae | 2.22 | 0.02 | 1.00 | 1.57 |
| *Solanum xanthocarpum* Schrad. | Solanaceae | 2.22 | 0.04 | 2.00 | 4.30 |
| *Spermacoce latifolia* Aubl. | Rubiaceae | 31.11 | 6.18 | 19.86 | 14.27 |
| *Spermacoce pusilla* Wall. | Rubiaceae | 22.22 | 2.36 | 10.60 | 6.19 |
| *Sporobolus fertilis* (Steud.) Clayton | Poaceae | 4.44 | 0.69 | 15.50 | 1.63 |
| *Strobilanthes pentastemonoides* (Nees) T.Anderson | Acanthaceae | 2.22 | 0.04 | 2.00 | 5.53 |
| *Tadehagi pseudotriquetrum* (DC.) H.Ohashi | Fabaceae | 2.22 | 0.18 | 8.00 | 0.91 |
| *Teucrium quadrifarium* Buch.-Ham. ex D.Don | Lamiaceae | 33.33 | 2.07 | 6.20 | 6.88 |
| *Urena lobata* L. | Malvaceae | 11.11 | 0.24 | 2.20 | 1.75 |
| *Zornia gibbosa* Span. | Fabaceae | 4.44 | 0.09 | 2.00 | 0.71 |

*F: Frequency, D: Density, A: Abundance, IVI: Importance value index*

**Shrubs and climbers**

The table 2 shows the IVI, density, frequency and abundance of shrubs and climbers, which were combinedly surveyed in a 100 sq. m plot. The most dominant species was *Coleborookea oppositifolia* with an IVI of 71, followed by *Urtica diocia* (IVI=65.58). The least dominant species was *Waltharia indica* (IVI=6.89). *U. diocia* was the densest species (D=2.11), followed by *C. oppositifolia* (D=1.17). *C. oppositifolia* held the highest record in terms of frequency, with a frequency of 44.44, which was followed by *U. diocia* (F=22.22).*U. diocia* (A=9) was the most abundant, followed by *Rubus ellipticus* (A=3).

**Table 2: Frequency, Density, Abundance and Important Value Index of shrubs and climbers**

| Scientific Name | Family | F | D | A | IVI |
|---|---|---|---|---|---|
| *Berberis asiatica* Roxb. ex DC. | Berberidaceae | 5.56 | 0.11 | 2.00 | 22.98 |
| *Cissampelos pareira* L. | Menispermaceae | 5.56 | 0.06 | 1.00 | 18.30 |
| *Colebrookea oppositifolia* Sm. | Lamiaceae | 44.44 | 1.17 | 2.63 | 74.76 |
| *Cryptolepis buchananii* R.Br. ex Roem. & Schult. | Apocynaceae | 5.56 | 0.06 | 1.00 | 17.00 |
| *Dioscorea hamiltonii* Hook.f. | Dioscoreaceae | 5.56 | 0.11 | 2.00 | 9.47 |
| *Leea asiatica* (L.) Ridsdale | Vitaceae | 5.56 | 0.06 | 1.00 | 10.20 |
| *Melastoma malabathricum* L. | Melastomataceae | 22.22 | 0.44 | 2.00 | 26.98 |
| *Rubus ellipticus* Sm. | Rosaceae | 5.56 | 0.17 | 3.00 | 17.48 |
| *Urtica dioica* L. | Urticaceae | 22.22 | 2.11 | 9.50 | 65.58 |
| *Waltheria indica* L. | Malvaceae | 5.56 | 0.11 | 2.00 | 6.98 |
| *Woodfordia fruticosa* (L.) Kurz | Lythraceae | 16.67 | 0.44 | 2.67 | 34.04 |

*F: Frequency, D: Density, A: Abundance, IVI: Importance value index*

**Table 3: Frequency, Density, Abundance and Important Value Index of trees**

| Scientific Name | Family | F | D | A | IVI |
|---|---|---|---|---|---|
| *Alnus nepalensis D.Don* | Betulaceae | 11.11 | 1.667 | 15.00 | 28.51 |
| *Castanopsis indica (Roxb. ex Lindl.) A.DC.* | Fagaceae | 11.11 | 1.111 | 10.00 | 15.34 |
| *Dendrocalamus hamiltonii Nees & Arn. ex Munro* | Poaceae | 11.11 | 0.111 | 1.00 | 6.36 |
| *Ficus subincisa Buch.-Ham. ex Sm.* | Moraceae | 11.11 | 0.111 | 1.00 | 4.72 |
| *Fraxinus floribunda Wall.* | Oleaceae | 11.11 | 0.111 | 1.00 | 13.79 |
| *Heynea trijuga Roxb. ex Sims* | Meliaceae | 11.11 | 0.111 | 1.00 | 5.60 |
| *Litsea monopetala (Roxb.) Pers.* | Lauraceae | 11.11 | 0.111 | 1.00 | 8.28 |
| *Lyonia ovalifolia (Wall.) Drude* | Ericaceae | 33.33 | 0.889 | 2.67 | 18.28 |
| *Madhuca indica J.F.Gmel.* | Sapotaceae | 11.11 | 0.111 | 1.00 | 17.37 |
| *Myrica esculenta Buch.-Ham. ex D.Don* | Myricaceae | 11.11 | 0.111 | 1.00 | 10.76 |
| *Picrasma javanica Blume* | Simaroubaceae | 11.11 | 0.111 | 1.00 | 17.37 |
| *Pinus roxburghii Sarg.* | Pinaceae | 77.78 | 8.889 | 11.43 | 84.78 |
| *Sapium insigne (Royle) Trimen* | Euphorbiaceae | 22.22 | 0.556 | 2.50 | 12.20 |
| *Schima wallichii (DC.) Korth.* | Theaceae | 77.78 | 2.778 | 3.57 | 43.32 |
| *Syzygium cumini (L.) Skeels* | Myrtaceae | 22.22 | 0.222 | 1.00 | 13.33 |

*F: Frequency, D: Density, A: Abundance, IVI: Importance value index*

### Trees

The most dominant tree was *Pinus roxburghii* with an IVI of 84.78. *Schima wallichi* was the co-dominant tree (IVI=43.32), whereas, *Ficus subincisa* was the least dominant (IVI=4.72). *P. roxburghii* is one of the important trees in the subtropical region (Subedi et al., 2018), as it is widely distributed as the natural and pure stand in countries like Nepal, India, Pakistan and Bhutan (Sangye, 2005; Gupta and Dass, 2007; Ghildiyal et al., 2009; Siddiqui et al., 2009). Additionally, *P. roxburghii* can replace broadleaved forest (Bhandari, 2003) and the nitrogen loss during the forest fire aids this phenomenon (Singh et al., 1984). The traces of forest fire were seen during the field visit in. *Pinus roxburghii* is an important tree species in the subtropical region (Subedi et al., 2018) as it is widely distributed as the natural stand in the Himalaya (Applegate, 1988). These statements justify the reasons behind the dominance of *P. roxburghii* in the community forest. Similarly, *P. roxburghii* was more dominant in the southern aspect, which is similar to the findings by Bhandari (2003).

A study by Chapagai et al. (2021) and Gurung et al. (2022) at two different sites reported that *P. roxburghii* and *Schima wallichi* are among dominant species in the mid-hill of Nepal. This finding is also consistent in our study. The important value indices of various species like *A. nepalensis*, *L. ovalifoila*, *S. wallichii*, *Fraxinus floribunda*, and *Sapium insigne*, calculated by Bhatt & Khanal (2010), are different from the current findings as the two types of research were conducted in a different climatic regions with different species composition. Both *P. roxburghii* and *S. wallichii* had the highest frequency with the frequency of 77.78, whereas *Lyonia ovalifolia* had the lowest frequency (F=33.33). In terms of density, *P. roxburghii* (D=8.89) had the highest record, followed by *S. wallichii* (D=2.78). *Alnus nepalensis* was on the top in the list of abundance (A) with an abundance of 15, followed by *P. roxburghii* (A=11.42). Further details about IVI, frequency, density and abundance of trees are given in Table 3.

### Diversity indices

The Simpson's diversity index of herbs, shrubs and climbers, and trees respectively are 21.57, 3.23, 3.14, and the Shannon-wiener index of herbs, shrubs and climbers, and trees are 3.47. 1.67 and 1.59 respectively. Shannon’s Diversity Index ranges from 1.5 to 3.5 (Ortiz-Burgos, 2016), which is also seen in our study. Additionally, the finding is also consistent to the results as documented by Mandal and Joshi (2014), Malik and Bhatt (2015), Gautam and Mandal (2018) Joshi et al. (2019), Kunwar et al. (2020) and Paudel et al. (2022). However, the finding is different from the study by Bhatt & Khanal (2010) as they studied in larger and dispersed area. The microplot has greater diversity index as higher species richness means greater species diversity (Joshi et al., 2019). Diversity, often described by diversity indices, are implemented for objective and clear management of uneven aged forest stands, for which necessary thought and care along with the involvement of forest users and managers is necessary (Heuserr, 1998).

Pielou's evenness index for herbs, shrubs and climbers, and trees are 0.80, 0.69 and 0.60. It is also consistent with the findings of Mandal and Joshi (2014), Joshi et al. (2019).

**Table 4: Different indices according to life form**

| Lifeform /Indices | Simpsons Diversity Index | Shannon-Wiener Index | Pielou's Evenness Index |
|---|---|---|---|
| Herbs | 21.57 | 3.47 | 0.80 |
| Shrubs and Climbers | 3.23 | 1.67 | 0.69 |
| Trees | 3.14 | 1.59 | 0.60 |

## CONCLUSION

As this study was conducted to determine species richness and composition, 100 plant species out of 46 families were document concluding that the Community Forest has good species richness. *A. bicolor*, *C. oppositifolia* and *P. roxburghii* were the most dominant herb, shrub and tree respectively. As *P. roxburghii* has multiple uses viz. use of bark and wood as well as needles for various purposes (Ghosh, 2022), its dominance also concludes that people are willing to grow it, in addition to the restoration program. The herbs are more diverse as well as even than both the trees and shrubs. The documentation of three of the alien invasive species as co-dominant herbs indicates that the ecosystem is disturbed. This further points towards the risk of loss of biodiversity in the near future. Hence, management activities should be implemented by identifying the risk to the biodiversity due to invasive species. Choosing the sites where the best outcome from biodiversity conservation can be ensured is a must (Downey et al., 2010). This study recommends the need for a detailed study of *Satyrium nepalense* as it was also documented in the sub-tropical region, given that most of the literatures have documented it in temperate region.

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