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Structural Diversity, Distribution Pattern and Regeneration of Forest communities in Shivalik Hills, Himachal Pradesh, North Western Himalaya

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ABSTRACT: Shivalik hills of the Himachal Pradesh are blessed with divine floral and faunal wealth. Forests of these hills provide life support not only to the people of Himachal Pradesh, but also to those in the plains. The present study has been conducted in the seven districts of Himachal Pradesh, to evaluate the diversity and distribution of vegetation in different forest types and their regeneration pattern. Surveys were conducted between 300-1500 m amsl in all districts of Shivalik in all the seasons of the years from 2015-2018. Standard ecological methods were followed for collection and processing of field data. Total 33 communities have been identified based on Importance Value Index and relative density. Out of 33 communities, 32 were tree communities while 01 community was of shrub. Maximum sites were represented by *Pinus roxburghii* (40 sites), followed by *Acacia catechu* (13 sites), *Eucalyptus tereticornis* (11 sites) and *Shorea robusta* (10 sites). From the identified tree communities, total tree density was ranged from 160-1015 Ind ha^{-1}; total basal area ranged from 0.54-105.17 m^2 ha^{-1}; total shrubs density from 570-2180 Ind ha^{-1}; total herbs density from 25.06-61.1 Ind m^{-2}; total saplings density from 140-1375 Ind ha^{-1} and total seedings density from 150-1035 Ind ha^{-1}. Species richness among all the identified communities ranged from 30-262. Species diversity (H´) for trees ranged from 0.48-2.41, saplings, 0.98-3.36, seedlings, 0.06-2.31, shrubs, 1.26-3.65 and herbs, 2.14-3.43. Concentration of dominance for trees ranged from 0.10-0.80, saplings, 0.06-0.66, seedlings, 0.09-0.68, shrubs, 0.05-0.44 and herbs, 0.02-.015. Seven (07) communities were identified with highest regeneration of dominant species, 05 communities were identified under highest regeneration of co-dominant species, 07 communities were identified under poor regeneration of dominant and co-dominant species and rest 14 communities were identified under mixed forest communities with highest regeneration of one species. Of the total species, recorded 151 were found native to Indian Himalayan Region. Natural and anthropogenic activities, habitat degradation and biological invasion across Shivalik hills are major causes for the loss of floristic diversity. Continuing degradation of floristic diversity in the region has led to a demand of growing concern and a sense of urgency in the context of seeking strategies, which can ensure the sustainability management and conservation of forests.

Keywords: Shivalik, Invasive, Monitoring, Management, Species diversity.

INTRODUCTION

The Himalaya is one of the largest mountain system in India and believed to be only 40 million years old (Balokhra, 2015). The Indian Himalayan region occupy a special place in the mountain ecosystems of the world. These geodynamical young mountains are not only important from the standpoint of climate but also a provider of life, giving water to a large part of the Indian subcontinent, but they also harbour a rich variety of flora, fauna, human communities and cultural diversity. Himalayan region represents unique tropical, sub-tropical, temperate, sub-alpine, alpine and tundra vegetation. The Indian Himalayan Region (IHR) spreads over 2 Union territories (UTs) and 11 states namely Jammu and Kashmir and Laddakh Union territories and Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram and hilly regions of Assam and West Bengal states, and contributes about 16.2% of India's total geographical area. The IHR comprises of 1,748 medicinal plants (Samant *et al.*, 1998), 675 wild edibles (Samant and Dhar 1997), 155 plants of sacred belief (Samant and Pant 2003), 118 essential oil yielding

medicinal plants (Samant and Palani 2000) and <400 fodder plants (Samant, 1998).

In Himachal Pradesh, out of the total geographical area, 68.16% is recorded forest area in which 5.68% is categorized as Very dense forest, 12.75% as Moderate dense forest and 9.30% as Open Forest while 0.58% as scrub (ISFR, 2021). Protected Area Network of the state includes 20.45% area of the forest cover and 3.41% area under Reserve Forests. State supports 32 Wildlife Sanctuaries, 05 National Parks, 01 Biosphere (Source: ENVIS Centre on Wildlife and Protected Areas, Wildlife Institute of India, Dehradun, India; Samant *et al*., 2012). Himachal Pradesh possesses a representative, natural, unique and socio-economically important biodiversity (Samant *et al*., 2007a) as parts of IHR. The floral diversity of the state accounts for about 3476 species, belonging to 1038 genera and 180 families (Chowdhery and Wadhwa 1984). Structural diversity of some parts of the IHR specially in Himachal Pradesh has been evaluated by some workers (Chowdhery and Wadhwa 1984; Negi 1985; Singh and Singh 1987; Dhar *et al.*, 1997; Samant *et al.*,1998; Samant *et al.*, 2001, 2002; Arya 2002; Samant *et al.*, 2006; Samant *et al.*, 2007; Rana and Samant 2009; Pant and Samant 2012; Sharma and Samant 2013; Arya and Samant 2017; Devi *et al.*, 2019; Paul *et al.*, 2019; Sharrma and Samant 2019; Lal *et al.*, 2020; Barman *et al.*, 2021; Dasila *et al.*, 2021; Singh *et al.*, 2021a; Singh, 2022 etc.). However detailed study on floristic diversity by considering various ecological factors in such vast area of Shivalik hills of Himachal Pradesh has not been carried out so far. Hence, current study is focused on detailed ecological assessment of floristic diversity in different forest types of Shivalik hills along with regeneration potential.

MATERIAL AND METHODS

Study area. Topographically, Himachal's territory from South to North can be divided into three zones i.e. "The Shivalik or Outer Himalaya, Inner Himalaya and the Greater Himalaya". In Himachal Pradesh, Shivalik hills comprises of lower hills of district Kangra, Hamirpur, Una, Bilaspur, Mandi, Solan and Sirmaur. Climate is sub-tropical and annual rainfall in this zone ranged from 1500 to 1800 mm. The altitude of this zone ranged from 350 to 1500mamsl (Fig. 1). Shivalik ranges are the youngest of Himalayan ranges and mostly made up of tertiary sediments consisting of sand and clay. In the Shivalik hills, alluvial soil with local red loams were found along the river courses while in other parts, soil mainly consists of deposits of gravel and coarse sand. Common minerals in this zone are Limestone, Shale, Slate, Rock salt, Sand, Stones, Silica, Gypsum, etc. Shivalik hills are suitable for the cultivation of maize, wheat, ginger, sugarcane, paddy, table potatoes and citrus fruits.

In Shivalik belt, around 12 forest types are found viz., Bhabar-dun sal forest, Dry Shiwaliksal forest, Northern dry mixed deciduous forest, Dry deciduous scrub, *Euphorbia* scrub, Dry bamboo brakes, Khair-sissu Forest, Lower or Shiwalik pine forest, Upper of Himalayan chir pine forest, Himalayan subtropical scrub, Moist deodar forest, and Ban oak forest (FSI Atlas, 2020). Common floristic composition in these forest types are: *Shorea robusta, Mallotus philippensis, Acacia catechu, Anogeissus latifolia, Flacourtia indica, Carissa spinarum, Woodfordia fruticosa, Justicia adhatoda, Murraya koenighii, Bauhinia variegata, Ageratina adenophora, Urena lobata, Lannea coromandelica, Diospyros montana, Dalbergia sissoo, Pinus roxburghii, Quercus oblongata, Pistacia chinensis, Rhododendron arboreum, Lyonia ovalifolia, Holoptelea integrifolia, Eucalyptus citriodora* etc. Shivalik hills are blessed with abundant resources for daily needs of local people. Unfortunately, increasing anthropogenic disturbances, tourism, pollution levels, rapid industrialization, urbanization, introduction of exotics, have put a great stress on the native vegetation.

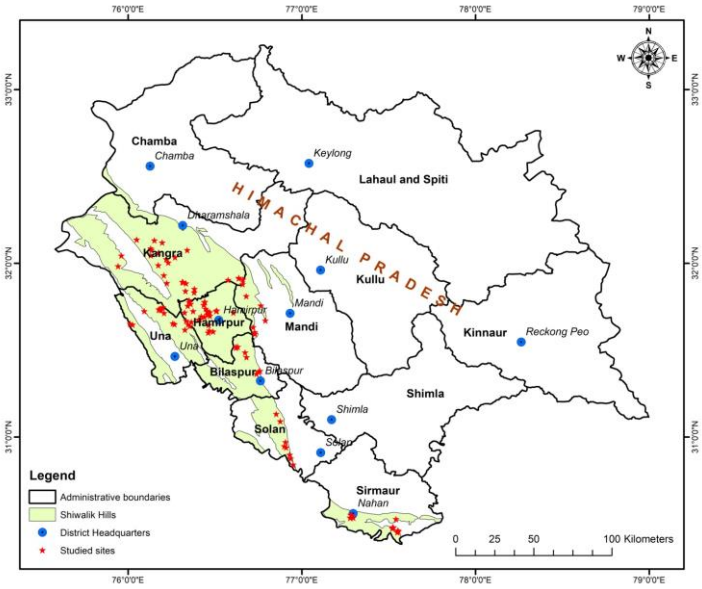


Fig. 1. Location map of the study area.

Identification and selection of sites. The sites were selected and surveyed based on each and every accessible aspects and habitats between 300-1500mamsl. The habitats were identified based on the physical characteristics and dominance of the vegetation. Plots having closed canopy with high percentage of humus and moisture were considered as moist habitats, whereas low percent of the same as dry habitats. The plots having >50% boulders of the ground cover were classified as bouldery habitat. The plots near to water bodies (streams) were considered as riverine. The plot which has a slope ≥ 50º and maximum vegetation is on the rocks were considered as rocky habitat and those facing high anthropogenic pressures were classified as degraded habitat. Mapping of the sites were done with the help of Global Positioning System (GPS). Slope was measured with the help of Abney's Level.

Surveys, samplings, identification and analysis of data. For the qualitative assessment of the floristic diversity, rapid sampling of the species from each and every aspect and habitat was done. Information regarding, local name, habitat, life form, phenological characters, etc. for each and every species were gathered. Global positioning system (GPS), Abney level and Compass were used to record latitude, longitude, altitude, aspect and slope of each site. Specimens from each site were collected and identified with the help of local and regional flora (Chowdhery and Wadhwa1984; Aswal and Mehrotra 1994; Dhaliwal and Sharma 1999; Singh and Rawat 2000). Sites were selected from each habitat based on altitude, aspect, slope and type of vegetation. In each site, a plot of 50 × 50m was laid. For trees, saplings and seedlings randomly 10 quadrats of 10 × 10m, for shrubs, 20 quadrats of 5 × 5m and for herbs 20 quadrats of 1 × 1m were laid. For the collection of data from these quadrats, standard ecological methods (Saxena and Singh 1982; Singh and Singh 1992; Dhar *et al.*, 1997; Joshi and Samant 2004; Samant and Joshi 2004) were followed. The circumference at breast height (CBH), at 1.37m from the ground for each individual tree was recorded. The individuals were considered as tree (cbh ≥ 31.5 cm), sapling (cbh 10.5-31.4 cm) and seedling (cbh<10.5 cm) based on cbh. The data were analyzed for species richness, frequency, density, abundance, Basal Area (BA), Total Basal Area (TBA), Important Value Index (IVI) and regeneration of tree species by following (Curtis and McIntosh 1950; Kersaw 1973; Dombois and Ellenberge 1974; Dhar *et al.*,1997; Samant *et al.*, 2002; Joshi and Samant 2004). The abundance data of different sites were pooled to get community averages in terms of density, total basal area and IVI.

RESULTS AND DISCUSSION

Site and habitat characteristics. Total 148 sites were randomly sampled in the seven districts of Shivalik hills between 300-1500 m amsl, and 30.45°N to 32.16°N latitudes and 75.90°E to77.6°E longitudes for the assessment of forest vegetation and to understand the regeneration trend in the forest communities. Maximum sites have been represented by shady moist habitats (49 sites), followed by dry habitat (91 sites), rocky (02sites), riverine (04 sites) and bouldry (02 sites) habitats. Northeast aspect was represented by maximum number of sites (29 sites), followed by West (27 sites), North (18 sites), East and South East (17 sites, each), Northwest (16 sites), Southwest (14 sites), South (09 sites) and South east (01) aspects. Slope ranged from 5°-45°.

Community diversity and distribution pattern. Total 33 communities were identified based on Importance Value Index and relative density. Thirty two (32) were of tree communities while 01 community was of shrub. *Pinus roxburghii* community was found maximum in (40 sites), followed by *Acacia catechu* community (13 sites), *Eucalyptus tereticornis* (11 sites), *Shorea robusta* (10 sites), *Eucalyptus citriodora*(8 sites), *Dalbergia sissoo*, *Quercus oblongata* (5 sites, each), *Acacia catechu-Mallotus philippensis* mixed, *Dalbergia sissoo-Acacia catechu* mixed, *Shorea robusta-Acacia catechu* mixed (4 sites, each), *Chamaerops humilis, Eucalyptus tereticornis-Pinus roxburghii* mixed, *Pinus roxburghii-Quercus oblongata* mixed, *Mallotus philippensis*, *Shorea robusta-Eucalyptus citriodora* mixed, *Tectona grandis, Mallotus philippensis-Pinus roxburghii* mixed (3 sites each), *Acacia catechu-Cassia fistula* mixed, *Acacia catechu-Chamaerops humilis* mixed, *Myrica esculenta - Quercus oblongata* mixed, *Pinus roxburghii-Chamaerops humilis* mixed, *Terminalia elliptica* (2 sites each); while remaining all communities were represented by single site. The community types, altitudinal distribution, sites and habitat representation and major tree associates are presented in Table 1.

Species richness. Among all the identified communities, total species richness ranged from 30-262. In the shrub community of *Lantana camara,* total 26 species (Shrubs: 7; Herbs;19) were recorded. Highest species richness was reported in *Pinus roxburghii* community (262 sp.), followed by *Shorea robusta* (183 sp.), *Eucalyptus citriodora* (167 sp.), *Quercus oblongata* (164 sp.), *Eucalyptus tereticornis* (160sp.), *Acacia catechu* (142sp.), *Shorea robusta-Acacia catechu* mixed(140sp.), *Mallotus philippensis-Pinus roxburghii* mixed(138sp.) and *Acacia catechu-Mallotus philippensis* mixed (129sp.) communities (Fig. 2).

Structural Pattern. In the identified tree communities, total tree density was ranged from 160-1015 Ind ha^{-1}; total basal area from 0.54-105.17 m^2 ha^{-1}. Total saplings density varied from 140-1375 Ind ha^{-1} and total seedings density from 150-1035 Ind ha^{-1}. Total shrubs density ranged from 570-2180 Ind ha^{-1} and total herbs density from 25.06-61.1 Ind m^2 (Table 2). Maximum tree density was shown by *Myrica esculenta-Quercus oblongata* mixed community (1015 Ind ha^{-1}), followed by *Quercus oblongata-Quercus glauca* mixed community (950 Ind ha^{-1}) (Fig. 3). Maximum trees

TBA was shown by *Terminalia elliptica* community (105.17m^2ha^{-1}), followed by *Shorea robusta-Eucalyptus citriodora* mixed community (61.23m^2ha^{-1}) (Fig. 4).

Maximum saplings density was shown by *Pinus roxburghii-Chamaerops humilis* mixed community (1375 Ind ha^{-1}), followed by *Shorea robusta-Eucalyptus citriodora* mixed community (1060.01Ind ha^{-1}) (Fig.5). Maximum seedlings density was shown by *Pinus roxburghii-Chamaerops humilis* mixed community (1035 Ind ha^{-1}), followed by *Terminalia elliptica* community (1030Ind ha^{-1}) (Fig. 6). Maximum shrub density was shown by *Mallotus philippensis-Syzygium nervosum-Celtis australis* mixed community (2180 Ind ha^{-1}) followed by *Mallotus philippensis-Pyrus pashia - Salix tetrasperma* mixed community (1960Ind ha^{-1}) (Fig. 7). Maximum herb density was shown by *Eucalyptus tereticornis-Acacia catechu-Dalbergia sissoo* mixed community (61.1 Ind m^{-2}), followed by *Chamaerops humilis* community (57.73 Ind m^{-2}). (Fig. 8).

Species diversity and Concentration of dominance

Species diversity (H´) for trees ranged from 0.48-2.41; saplings, 0.98-3.36; seedlings, 0.06-2.31; shrubs, 1.26-3.65 and herbs, 2.14-3.43 (Table 3). Highest diversity of trees was reported in *Mallotus philippensis-Chamaerops humilis-Dalbergia sissoo* mixed community (2.41), followed by *Mallotus philippensis-Pyrus pashia -Salix tetrasperma* mixed community (2.35) (Fig. 9).

Among the saplings, highest diversity was reported in *Chamaerops humilis*) community (3.36, followed by *Bauhinia variegata-Terminalia myriocarpa* mixed community (2.55). Among the seedlings, highest diversity was reported in *Cinnamomum tamala-Quercus glauca* mixed community (2.31), followed by *Mallotus philippensis-Syzygium nervosum-Celtis australis* mixed community (1.98). Amongst shrubs, *Myrica esculenta-Quercus oblongata* mixed community showed highest diversity (3.65), followed by *Mallotus philippensis-Syzygium nervosum-Celtis australis* mixed community (3.22). Amongst herbs, *Eucalyptus tereticornis-Acacia catechu-Dalbergia sissoo* mixed community showed highest diversity (3.44), followed by, *Quercus oblongata* (3.32) community.

Community wise Concentration of Dominance (Cd) for trees was ranged from 0.10-0.80, saplings 0.06-0.66, seedlings 0.09-0.68, shrubs 0.05-0.44 and herbs 0.02-.015 (Table 4). The highest Cd for trees was recorded in *Chamaerops humilis* community (0.80), followed by *Dalbergia sissoo* community (0.77) (Fig.10). Among the saplings, highest Cd was recorded in *Eucalyptus tereticornis* community (0.66), followed *Terminalia elliptica* (0.42). Among the seedlings, highest Cd was reported in *Chamaerops humilis* community (0.68), followed by *Dalbergia sissoo-Cassia fistula* mixed community (0.67). Amongst shrubs, *Dalbergia sissoo-Cassia fistula* mixed community showed highest Cd (0.44), followed by *Terminalia elliptica* community (0.39). Amongst herbs, *Acacia catechu-Cassia fistula* mixed community showed highest Cd (0.15), followed by *Dalbergia sissoo-Cassia fistula* mixed community (0.14).

Nativity. Of the total species, recorded 151 were found native to Indian Himalayan Region. Maximum Native species were reported in *Acacia catechu* (56), followed by *Acacia catechu- Cassia fistula* mixed community (46), *Acacia catechu- Chamaeropshumilis* mixed community (42), *Acacia catechu- Mallotus philippensis* mixed community (39), *Bauhinia variegata-Terminalia myriocarpa* mixed community(35) (Fig. 11).

Discussion

On the basis of density of seedlings and saplings the forest communities have been categorized in to four categories:

Communities with highest regeneration of dominant species: Seven (7) communities were identified under this category. These were *Acacia catechu, Chamaerops humilis, Dalbergia sissoo, Mallotus philippensis, Pinus roxburghii, Quercus oblongata* and *Shorea robusta* community. High regeneration status of these species indicated their dominance in near future too.

Communities with highest regeneration of co-dominant species: Five (5) communities were identified under this category. These were *Acacia catechu-Cassia fistula* mixed, *Bauhinia variegata-Terminalia myriocarpa* mixed, *Eucalyptus tereticornis, Eucalyptus tereticornis-Acacia catechu-Dalbergia sissoo* mixed, *Shorea robusta-Acacia catechu* mixed communities. This indicated that these communities will be replaced by the co-dominant species in near future.

Communities with poor regeneration of dominant and co-dominant species: Seven (7) communities were identified under this category. These were *Eucalyptus citriodora, Dalbergia sissoo-Acacia catechu* mixed, *Eucalyptus tereticornis-Pinus roxburghii* mixed, *Tectona grandis, Terminalia elliptica, Terminalia myriocarpa-Acacia catechu* mixed, *Toona ciliata-Pinus roxburghii* mixed communities. These communities indicate that dominant and co-dominant species will be replaced by other species, and form new community in the area in near future.

Mixed forest communities with highest regeneration of one species: Fourteen **(**14) communities were identified under this category. These were *Acacia catechu-Chamaerops humilis* mixed, *Acacia catechu-Mallotus philippensis* mixed, *Cinnamomum tamala-Quercus glauca* mixed, *Dalbergia sissoo-Cassia fistula* mixed, *Mallotus philippensis-Pyrus pashia- Salix tetrasperma* mixed, *Mallotus philippensis-Bauhinia racemosa-Cassia fistula* mixed, *Mallotus philippensis-Chamaerops humilis-Dalbergia sissoo* mixed,

Mallotus philippensis-Pinus roxburghii mixed, *Mallotus philippensis-Syzygium nervosum-Celtis australis* mixed, *Myrica esculenta-Quercus oblongata* mixed, *Pinus roxburghii-Chamaerops humilis* mixed, *Pinus roxburghii-Quercus oblongata* mixed, *Quercus oblongata-Quercus glauca* mixed and *Shorea robusta-Eucalyptus citriodora* mixed communities. Among these communities, one of the dominant species will replace the community from mixed to dominant type in near future (Fig. 12) (i-xxxiii).

The unique topography, diverse habitats and large altitudinal range (200-8,000 mamsl) of bio-geographic zones (02) and bio-geographic provinces of the IHR harbours rich biodiversity. The Shivalik hills supports maximum diversity of plant species in Himachal Pradesh as compared to other Himalayan hills. The inhabitants are largely dependent on forest resources for their sustenance in the Shivalik hills. Various anthropogenic and natural activities such as grazing, development of roads, over exploitation, forest fire, invasion by the exotic species, natural calamities and changing environmental conditions have caused the rapid depletion of the floristic diversity in particular and biodiversity in general. These areas are largely infested with invasion of *Lantana camara*. Present study provide first hand information about floristic diversity of 7 districts of Shivalik hills and total 667 species of vascular plants were reported. Kaur and Sharma (2004) also documented the total 898 sp. of vascular plants in Flora of Sirmaur. But this flora covered the temperate, subalpine and alpine regions along with Shivalik zone. Genera wise highest species richness was shown by, *Cyperus* (11 sp.); *Ficus* (10 sp.); *Terminalia*(7sp.); *Desmodium*, *Euphorbia*, *Ipomoea* (6 sp. each); *Acacia*, *Artemisia*, *Indigofera* (5 sp. each); *Bauhinia*, *Chrysopogon*, *Crotalaria*, *Eragrostis*, (4 sp. each), etc.

Comparative analysis. In the identified trees communities, total trees density was ranged from 160-1015 Ind ha^{-1}. Similar trend was observed by Rana (2007) from Manali Wild Life Sanctuary (170.0-1190.0 Ind ha^{-1}); Singh (2022) from GHNP Kullu (160.0-1480.0 Ind ha^{-1}); Lal (2007) from Kais Wild Life Sanctuary (160.00-860.00 Ind ha^{-1}); Kumar (2018) from Kalatop Wild Life Sanctuary Khajjiar (230.0-720.00 Ind ha^{-1}). Similar trend was observed from the high altitude forests of the West Himalaya (Samant *et al.*, 2002; Sharma 2008; Joshi and Samant 2014 etc.). Total tree density value was reported higher in the study area as compared to the values reported earlier Singh and Rawat(2000); Rawat and Singh (2006) reported values (214 Ind ha^{-1}) in the Great Himayan National Park; Sakshi (2009) reported the range in Chailchowk-Rohanda-Kamrunag area of Mandi district (40.0-620.0 Ind ha^{-1}); Marpa (2013) reported the total tree density ranged (190.0-326.67 Ind ha^{-1}) from Rewalsar town; Sharma (2017) reported the density range (210.0-627.0 Ind ha^{-1}) in Nargu Wildlife Sanctuary. Likewise, trends were observed from the high altitude forests of the West Himalaya (Samant *et al.*, 2002; Samant and Joshi 2004; Sharma 2008 and Joshi and Samant 2014, etc.). This lower density of the trees in these areas may be due to the several climatic conditions and large area covered in the Shivalik hills by totally different type of vegetation.

From the study area total basal area ranged from 0.54-105.17 m^2 ha^{-1}. Similar values were reported by Rana (2007) from Manali Wild Life Sanctuary (0.76-103.9 m^2 ha^{-1}); Singh (2022) from GHNP (3.07-131.41m^2 ha^{-1}); Sharma (2017) (5.34-55.4 m^2 ha^{-1}) from Mandi; Marpa (2013) from Rewalsar sacred area; Kumar (2018) from Kalatop Wild Life Sanctuary, Khajjiar (2.06-84.77 m^2 ha^{-1}). Lower reported values may be due to topographical gradient and environmental conditions not suitable for the abundant growth of vegetation. Higher value of basal area compared to study sites (0.20-180.1 m^2 ha^{-1}) were reported from high altitude areas (Kalakoti *et al.*, 1986; Bankoti *et al.*, 1992; Dhar *et al.*, 1997; Joshi 2002; Samantand Joshi 2004; Joshi and Samant 2004; Lal 2007; Sharma 2008, etc.). Total shrubs density of the communities varied (570-2180 Ind ha^{-1}). This range was near to reported earlier Rawat and Singh (2006) (2366.7 Ind ha^{-1}) from Great Himalayan National Park; Sharma (2008) from Hirb and Shojha catchments of Kullu (630.0-2470.0 Ind ha^{-1}); Sakshi (2009) (460.0-2180.0 Ind ha^{-1}) Chailchowk area; Singh (2022) reported (340-2155 Ind ha^{-1}) in GHNP. Totally higher values in comparison to the study site were also reported by Lal (2007)from Kais Wild Life Sanctuary (396.00-4025.00 Ind ha^{-1}); Rana (2007)(190.0-3890.0 Ind ha^{-1}) from Manali; Sharma (2017) from Nargu Wild Life Sanctuary (560.0-3140.0 Ind ha^{-1}); Kumar (2018) reported comparatively lower range from Kalatop Khajjir Wild Life sanctuary(380-1500 Ind ha^{-1}) as compared to current study. Total herb density from the study sites were reported between 25.06-61.1 Ind m^{-2} which is near to earlier reported ones, Kumar (2018) from Kalatop Khajjir Wild Life sanctuary (18.45-59.85 Ind m^{-2}). Higher range as compared to one found from study area were reported earlier too; Joshi and Samant (2004, 2014); Pant (2005) reported values from the temperate and sub-alpine forests of Western Himalaya between 21.0-431.0 Ind m^{-2}; Lal (2007) from Kanawar Wild Life sanctuary (47.35-164.00 Ind m^{-2}); Singh (2022) reported higher total herbs density (21.34-135.2 Ind m^{-2}) from GHNP. This higher and lower difference in densities is due to totally different forest types, environmental conditions from Shivalik hills and especially due to huge impact of invasive species on ground vegetation.

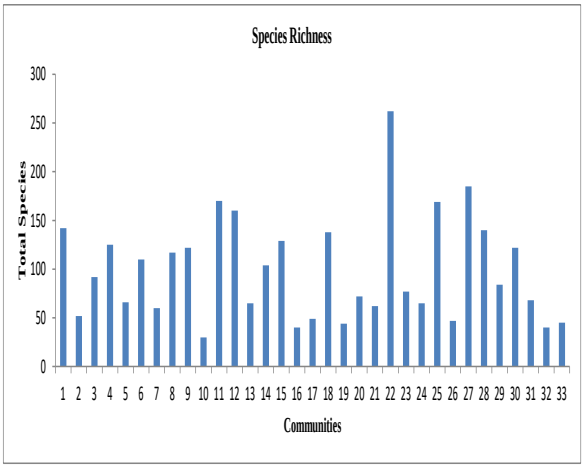


Fig. 2. Communities wise species richness.

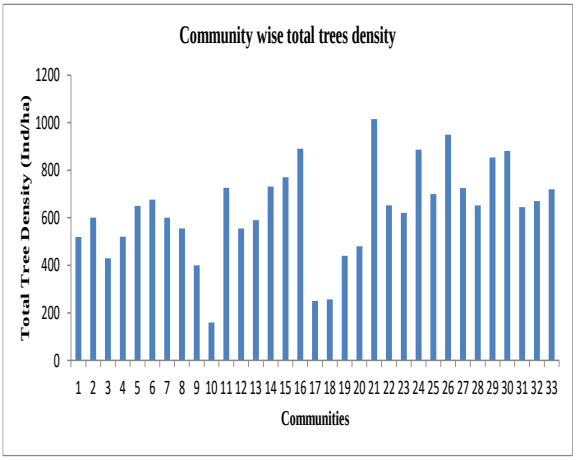


Fig. 3. Communities wise total trees density.

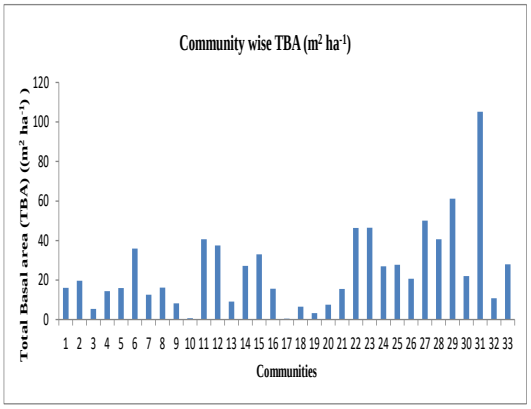


Fig. 4. Communities wise total basal area.

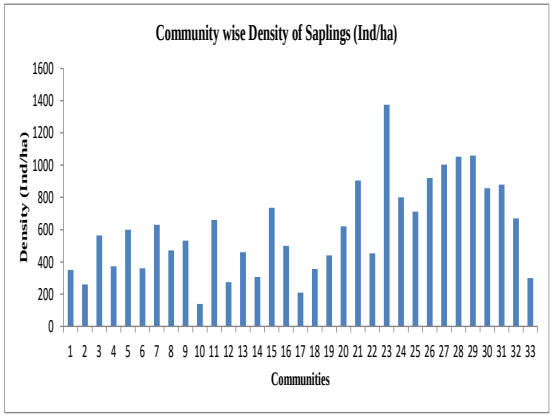


Fig. 5. Communities wise density of saplings.

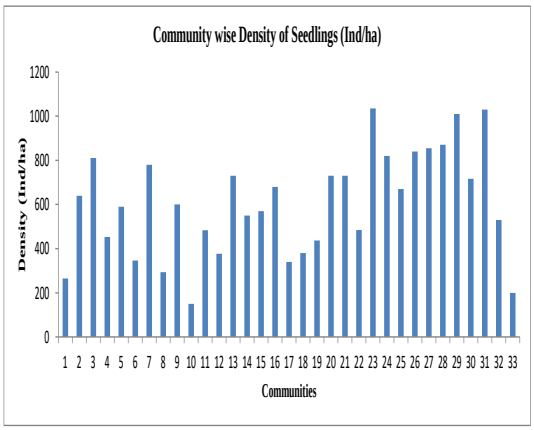


Fig. 6. Communities wise density of seedlings.

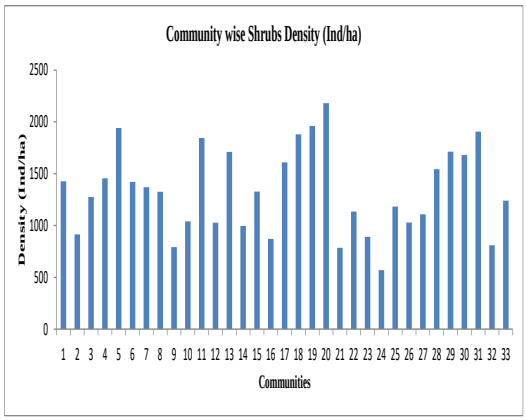


Fig. 7. Community wise Shrubs Density (Ind/ha).

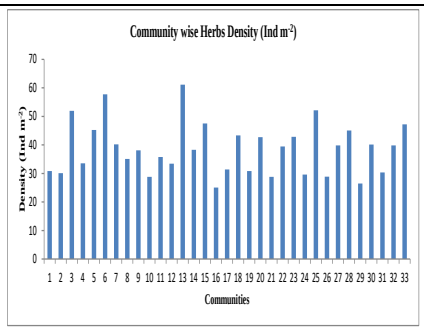


Fig. 8. Community wise Herbs Density (Ind m-^{2}).

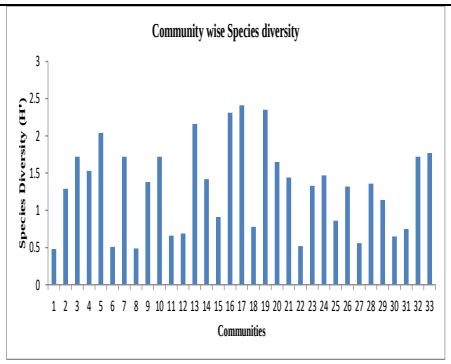


Fig. 9. Communities wise species diversity(H').

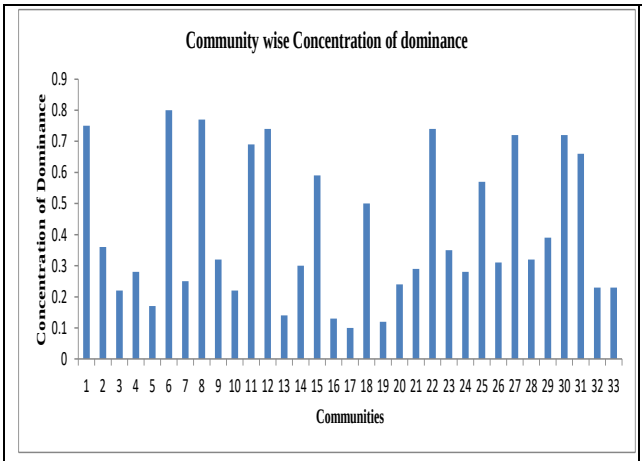


Fig. 10. Communities wise Concentration of dominance(Cd).

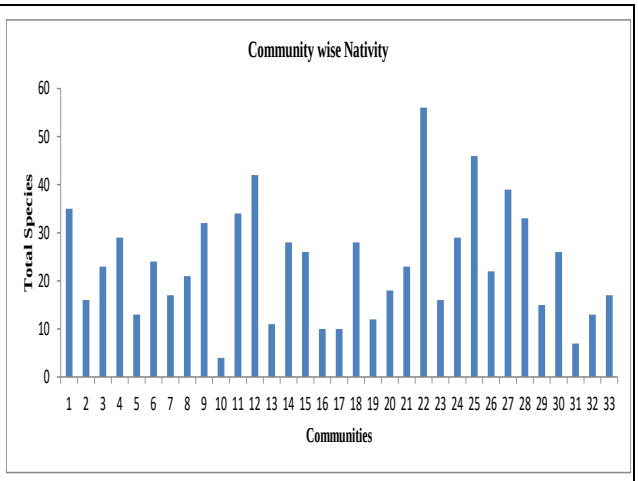


Fig. 11. Communities wise Nativity.

Table 1: Community types, distribution and major associates in Shivalik hills of Himachal Pradesh.

Community type	SR	Altitudinal Range	Latitude (°)	Longitude (°)	Habitat (s)	Slope (°)	Aspect (s)	*Major Associates*
Acacia catechu	13	400-641	30.45- 32.003	76.01- 77.60	Shady Moist, Rocky, Dry	5-25	E, N, W, NE, NW, SE,SW	*Mallotus philippensis, Dalbergia sissoo, Cassia fistula*
Acacia catechu-Cassia fistula mixed	2	705-775	31.88-31.89	76.31-76.31	Shady Moist, Dry	10 - 25	SE	*Mallotus philippensis, Dalbergia sissoo, Albizia lebbeck*
*Acacia catechu-Chamaeropshumilis*mixed	2	582-690	31.64 -31.90	76.26- 76.60	Riverine, Dry	5 - 20	NE	*Dalbergia sissoo, Cassia fistula, Albizia lebbeck*
Acacia catechu-Mallotus philippensis mixed	4	614-790	31.65-32.07	76.13-76.45	Shady Moist, Dry	10-25	W, SE, NSE	*Dalbergia sissoo, Cassia fistula, Albizia lebbeck*
Bauhinia variegata-Terminalia myriocarpa mixed	1	760	31.66941	76.33361	Shady Moist	30	NE	*Mallotus philippensis, Chamaero pshumilis, Terminaliamyriocarpa*
Chamaeropshumilis	3	560-700	31.91-32.06	76.17 -76.63	Dry	15-30	S, W	*Mallotus philippensis, Pinus roxburghii, Dalbergia sissoo*
Cinnamomumtamala-Quercus glauca mixed	1	914	31.6956	76.9221	Shady Moist	20	E	*Celtis australis, Quercus oblongata, Pyrus pashia*
Dalbergia sissoo	5	485-580	31.75-31.87	76.34-76.65	Dry, Riverine, Shady Moist	5 - 10	E, NE,NW	*Acacia catechu, Morus serrata, Oroxylum indicum,*
Dalbergia sissoo-Acacia catechu mixed	4	478-625	31.39 - 32.10	76.02-76.86	Shady Moist, Dry	10-25	S, N, SE, NW	*Mallotus philippensis, Tectona grandis, Pistacia chinensis*
Dalbergia sissoo-Cassia fistula mixed	1	552	31.410516	76.84564	Dry	10	NE	*Melia azedarach, Ziziphus jujuba, Trema politoria*
Eucalyptus citriodora	8	439-1162	30.45 - 31.13	76.96-77.54	Dry, Riverine, Shady Moist	10-25	E, S, SE, SW	*Mallotus philippensis, Shorea robusta, Cassia fistula*
Eucalyptus tereticornis	11	434-1106	31.36-32.16	75.9-76.92	Shady Moist, Dry	10-30	N, S, W, NE, NW, SW, SE	*Mallotus philippensis, Cassia fistula, Pinus roxburghii*
Eucalyptus tereticornis-Acacia catechu-Dalbergia sissoo mixed	1	568	31.37417	76.79492	Dry	10	NE	*Cassia fistula, Mallotus philippensis, Toona ciliata*
Eucalyptus tereticornis-Pinus roxburghii mixed	3	573-830	31.45-32.13	76.02 - 76.68	Shady Moist, Dry	15-22	E, W, SW	*Acacia catechu, Cassia fistula, Chamaerops humilis*
Mallotus philippensis	3	575-914	31.54- 31.91	76.43- 76.94	Shady Moist	20-22	S, W, SE	*Cassia fistula, Chamaerops humilis, Celtis australis*
Mallotus philippensis-Bauhinia racemosa-Cassia fistula mixed	1	610	32.13198	76.15091	Shady Moist	30	W	*Chamaerops humilis, Grewiaoptiva, Phyllanthus emblica*
Mallotus philippensis-Chamaeropshumilis-Dalbergiasissoo mixed	1	770	31.8528	76.38141	Dry	15	NW	*Mitragyna parvifolia, Glochidion heyneanum, Melia azedarach*
Mallotus philippensis-Pinus roxburghii mixed	3	575-960	31.61-31.70	76.32 -76.93	Dry	25-30	E, SE, SW	*Toonaciliata, Cinnamomtamala, Pyruspashia*
Mallotus philippensis-Pyrus pashia - Salix tetrasperma mixed	1	1111	30.85642	77.00078	Dry	10	NE	*Litsea monopetala, Grewia optiva, Acacia catechu*

Community type	SR	Altitudinal Range	Latitude (°)	Longitude (°)	Habitat (s)	Slope (°)	Aspect (s)	*Major Associates*
Mallotus philippensis-Syzygium nervosum-Celtis australis mixed	1	916	31.5447	76.9469	Dry	15	W	*Eucalyptus tereticornis, Machilus duthiei, Toona ciliata*
Myrica esculenta-Quercus oblongata mixed	2	1365-1473	31.55- 31.56	76.99-77.00	Shady Moist, Dry	22-45	N	*Prunus cerasoides, Pyrus pashia, Quercus glauca*
Pinus roxburghii	40	532-1500	32.09- 30.89	77.02-76.01	Bouldry, Dry, Rocky, Shady Moist	2-35	E, W, N, S, SE, NW, NE, SW	*Acacia catechu, Chamaerops humilis, Mallotus philippensis*
Pinus roxburghii-Chamaeropshumilis mixed	2	560-578	31.67-31.71	76.32-76.40	Dry	15-35	NE	*Acacia catechu, Mallotus philippensis, Dalbergia sissoo*
Pinus roxburghii-Quercus oblongata mixed	3	1380-1495	31.55-31.56	76.99-77.00	Shady moist	25-40	N, W	*Myrica esculenta, Quercus oblongata, Pyrus pashia*
Quercus oblongata	5	910-1280	30.96-31.68	76.82-76.99	Shady Moist, Dry	15-40	N, NW	*Prunuscerasoides, Pyruspashia, Albiziachinensis*
Quercus oblongata-Quercus glauca mixed	1	1394	31.5650	76.9966	Shady Moist	40	N	*Myricaesculenta, Pinus roxburghii, Pyrus pashia*
Shorea robusta	10	300-740	30.45-31.74	76.17-77.60	Shady Moist, Dry	10-20	E, W, SE, NW, NE,	*Pinus roxburghii,Mallotus philippensis, Cassia fistula*
Shorea robusta-Acacia catechu mixed	4	414-731	30.45-30.55	77.28-77.60	Shady Moist, Dry	5- 35	S, W, SW, SE	*Albizia lebbeck, Cassia fistula, Mallotus philippensis*
Shorea robusta-Eucalyptus Citriodora mixed	3	440-569	30.45-30.53	77.27-77.54	Dry, Riverine, Shady Moist	15-25	E, W, NW	*Mallotus philippensis, Terminalia elliptica, Tectona grandis*
Tectona grandis	3	418-505	30.45-32.05	75.94-77.55	Shady Moist, Dry	10-40	W, NE	*Acacia catechu, Mallotus philippensis, Shorea robusta*
Terminalia elliptica	2	391-465	30.46-30.47	77.52-77.55	Shady moist	10-15	NE, NW	*Mallotus philippensis, Shorea robusta, Cassia fistula*
Terminalia myriocarpa-Acacia catechu mixed	1	616	31.71325	76.20676	Dry	10	N	*Pinus roxburghii,Mallotus philippensis, Shorea robusta*
Toona ciliata-Pinus Roxburghii mixed	1	960	31.08302	76.96658	Shady Moist	30	SW	*Acacia catechu, Pistacia chinensis, Pyrus pashia*
Lantana camara	2	491-1120	32.11-31.84	76.19-76.32	Dry	15-20	NE	*Justicia adhatoda, Carissa opaca,*

Abbreviations Used: SR= Site Representatives; NE= North East; W= West; N= North; E= East; SE= South east; NW= North West; SW= South West; S= South; N

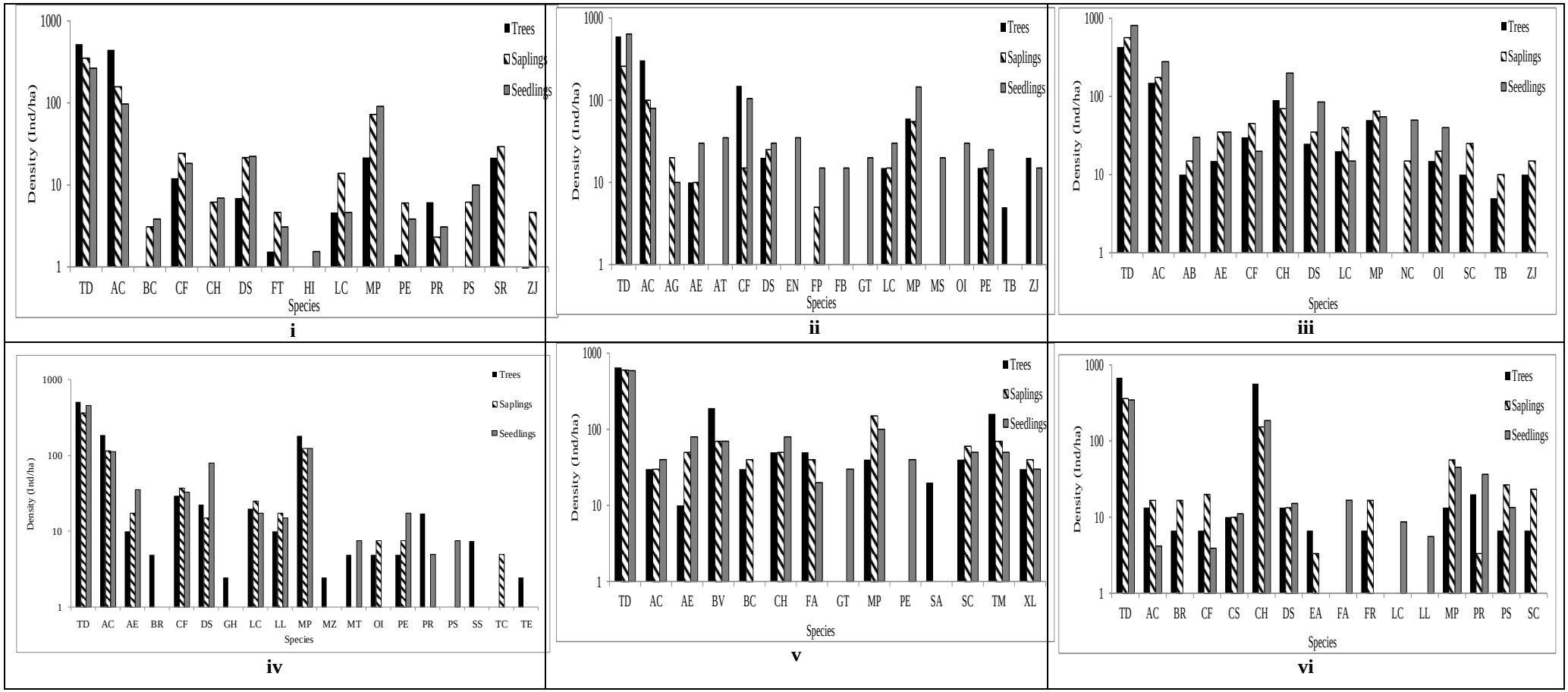
Table 2: Structural pattern of the identified communities in the Shivalik hills of Himachal Pradesh.

Sr. No.	Community Types	Trees				Shrubs	Herbs
		Density	TBA (m^2 ha^{-1})	Saplings Density (Ind ha^{-1})	Seedlings Density (Ind ha^{-1})	Density (Ind ha^{-1})	Density (Ind ha^{-1})
1.	*Acacia catechu*	519.72	16.07	350.47	265.47	1427.13	30.87
2.	*Acacia catechu-Cassia fistula* mixed	600.00	19.72	260.00	640.00	915.00	30.11
3.	*Acacia catechu-Chamaeropshumilis* mixed	430.00	5.47	565.00	810.00	1275.00	51.96
4.	*Acacia catechu-Mallotus philippensis* mixed	520.00	14.40	372.50	452.50	1455.18	33.57
5.	*Bauhinia variegata-Terminalia myriocarpa* mixed	650.00	15.98	600.00	590.00	1940.00	45.26
6.	*Chamaerops humilis*	676.62	35.98	360.00	346.42	1419.97	57.73
7.	*Cinnamomum tamala-Quercus glauca* mixed	600.00	12.57	630.00	780.00	1370.00	40.18
8.	*Dalbergia sissoo*	555.04	16.15	472.00	294.00	1325.10	35.08
9.	*Dalbergia sissoo-Acacia catechu* mixed	400.00	8.29	532.50	600.00	792.50	38.11
10.	*Dalbergia sissoo-Cassia fistula* mixed	160.00	0.69	140.00	150.00	1040.00	28.81
11.	*Eucalyptus citriodora*	726.25	40.60	660.00	483.75	1843.75	35.77
12.	*Eucalyptus tereticornis*	555.35	37.48	275.46	377.30	1025.86	33.43
13.	*Eucalyptus tereticornis-Acacia catechu-Dalbergia sissoo* mixed	590.00	9.13	460.00	730.00	1710.00	61.10
14.	*Eucalyptus tereticornis-Pinus roxburghii* mixed	731.76	27.21	306.67	550.01	996.68	38.26
15.	*Mallotus philippensis*	769.98	33.01	736.67	569.99	1327.38	47.51

16.	*Mallotus philippensis-Bauhinia racemosa-Cassia fistula* mixed	890.00	15.62	500.00	680.00	870.00	25.06
17.	*Mallotus philippensis-Chamaerops humilis-Dalbergia sissoo* mixed	250.00	0.54	210.00	340.00	1610.00	31.37
18.	*Mallotus philippensis-Pinus roxburghii* mixed	256.67	6.57	356.66	380.00	1880.01	43.31
19.	*Mallotus philippensis-Pyrus pashia-Salix tetrasperma* mixed	440.00	3.33	440.00	436.66	1960.00	30.82
20.	*Mallotus philippensis-Syzygium nervosum-Celtis australis* mixed	480.00	7.55	620.00	730.00	2180.00	42.74
21.	*Myrica esculenta-Quercus oblongata* mixed	1015.00	15.49	905.00	730.00	785.00	28.82
22.	*Pinus roxburghii*	652.00	46.35	453.00	484.61	1134.75	39.43
23.	*Pinus roxburghii-Chamaerops humilis* mixed	620.00	46.51	1375.00	1035.00	891.17	42.83
24.	*Pinus roxburghii-Quercus oblongata* mixed	886.67	27.02	800.00	820.00	569.99	29.64
25.	*Quercus oblongata*	700.00	27.73	712.00	670.00	1182.00	52.14
26.	*Quercus oblongata-Quercus glauca* mixed	950.00	20.70	920.00	840.00	1030.00	28.89
27.	*Shorea robusta*	725.00	50.03	1003.00	855.00	1108.00	39.83
28.	*Shorea robusta-Acacia catechu* mixed	652.50	40.68	1052.50	870.00	1542.50	45.04
29.	*Shorea robusta-Eucalyptus citriodora* mixed	853.32	61.23	1060.01	1010.00	1713.34	26.48
30.	*Tectona grandis*	880.77	22.07	856.67	716.67	1679.99	40.12
31.	*Terminalia elliptica*	645.00	105.17	880.00	1030.00	1905.00	30.38
32.	*Terminalia myriocarpa-Acacia catechu* mixed	670.00	10.83	670.00	530.00	810.00	39.81
33.	*Toona ciliata-Pinus roxburghii* mixed	720.00	27.99	300.00	200.00	1240.00	47.20

.Table 3: Community wise Species Diversity (H′) in the Shivalik hills of Himachal Pradesh.

Communities	**Species Diversity (H′)**				
	Trees	**Saplings**	**Seedlings**	**Shrubs**	**Herbs**
Acacia catechu	0.48	1.25	0.17	1.87	2.81
Acacia catechu-Cassia fistula mixed	1.29	2.13	0.3	1.83	2.21
Acacia catechu-Chamaerops humilis mixed	1.72	2.01	0.35	2.21	3.29
Acacia catechu-Mallotus philippensis mixed	1.53	1.87	0.12	2.68	2.28
Bauhinia variegata-Terminalia myriocarpa mixed	2.04	2.55	0.19	2.85	3.3
Chamaerops humilis	0.51	3.36	0.12	1.88	2.79
Cinnamomum tamala-Quercus glauca mixed	1.72	2.39	2.31	3.03	2.85
Dalbergia sissoo	0.49	1.78	0.05	1.97	2.69
Dalbergia sissoo-Acacia catechu mixed	1.38	1	0.17	2.25	2.94
Dalbergia sissoo-Cassia fistula mixed	1.72	2.44	0.06	1.26	2.14
Eucalyptus citriodora	0.66	1.5	0.24	1.65	2.58
Eucalyptus tereticornis	0.69	1.53	0.38	2.14	2.66
Eucalyptus tereticornis-Acacia catechu-Dalbergia sissoo mixed	2.16	2.07	0.22	2.05	3.44
Eucalyptus tereticornis-Pinus roxburghii mixed	1.42	1.99	0.22	2.08	2.76
Mallotus philippensis	0.91	0.98	0.96	2.32	3.13
Mallotus philippensis-Bauhinia racemosa-Cassia fistula mixed	2.31	2.4	0.37	1.98	2.73
Mallotus philippensis-Chamaerops humilis-Dalbergia sissoo mixed	2.41	1.63	0.17	2.53	2.82
Mallotus philippensis-Pinus roxburghii mixed	0.78	1.73	0.77	2.77	3.3
Mallotus philippensis-Pyrus pashia-Salix tetrasperma mixed	2.35	1.6	0.13	1.76	2.63
Mallotus philippensis-Syzygium nervosum-Celtis australis mixed	1.65	2.45	1.98	3.22	3.19
Myrica esculenta-Quercus oblongata mixed	1.44	1.41	1.44	3.65	3.11
Pinus roxburghii	0.52	1.48	0.43	2.15	2.84
Pinus roxburghii-Chamaerops humilis mixed	1.33	1.63	0.45	2.17	3.15
Pinus roxburghii-Quercus oblongata mixed	1.47	1.59	1.48	1.8	3.07
Quercus oblongata	0.86	1.71	1.17	2.53	3.32
Quercus oblongata-Quercus glauca mixed	1.32	1.98	1.8	2.39	3.13
Shorea robusta	0.56	1.06	0.4	1.96	2.92
Shorea robusta-Acacia catechu mixed	1.36	1.57	0.31	1.76	2.77
Shorea robusta-Eucalyptus citriodora mixed	1.14	1.4	0.35	1.73	2.57
Tectona grandis	0.65	1.97	0.2	2.49	3.11
Terminalia elliptica	0.75	1.11	0.58	1.35	2.82
Terminalia myriocarpa-Acacia catechu mixed	1.72	1.3	0.29	2.31	3.03
Toona ciliata-Pinus roxburghii mixed	1.77	1.94	0.11	2.35	2.88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100
10
1
Density (Ind/ha)
Trees
Saplings
Seedlings
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Species
i
TD AC AG AE AT CF DS EN FP FB GT LC MP MS OI PE TB ZJ
ii
TD AC AB AE CF CH DS LC MP NC OI SC TB ZJ
iii
TD AC AE BR CF DS GH LC LL MP MZ MT OI PE PR PS SS TC TE
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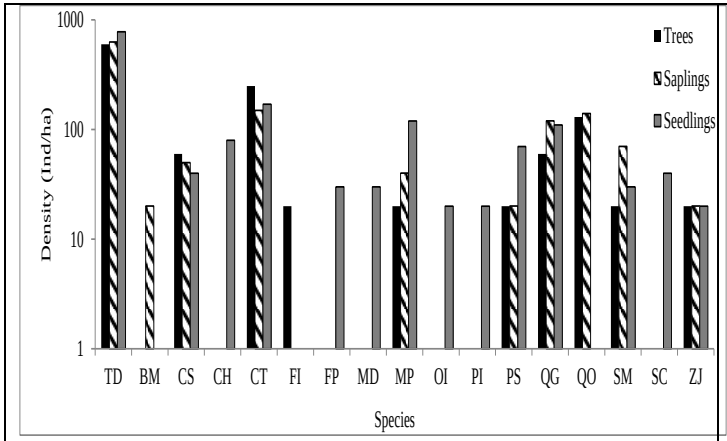

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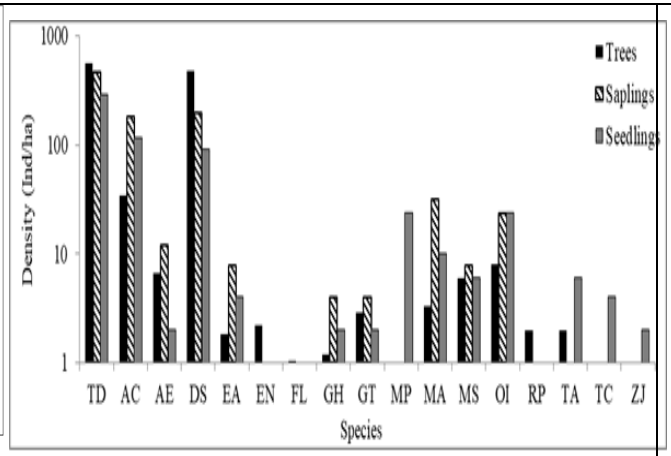

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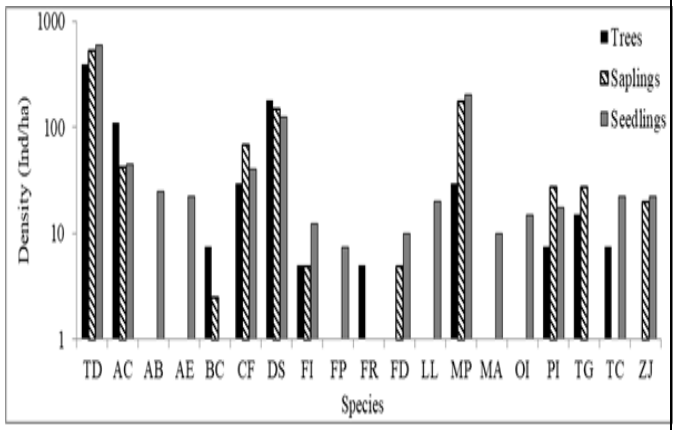

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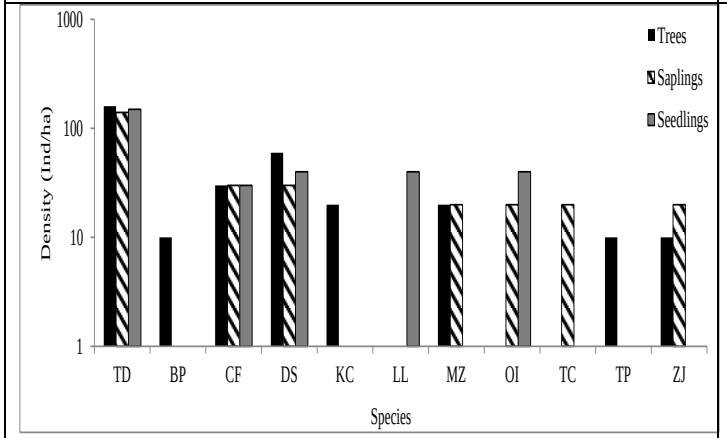

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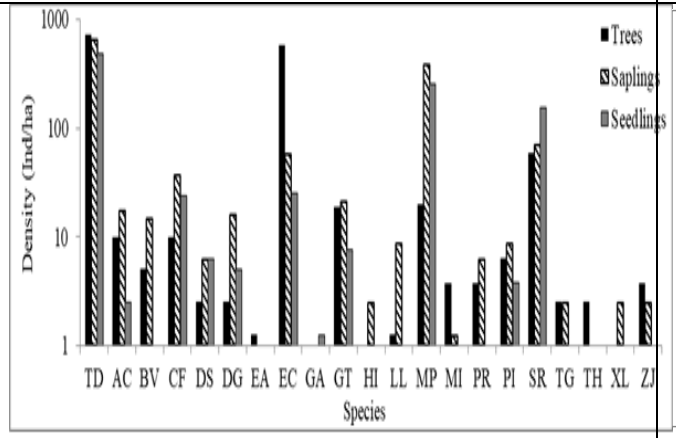

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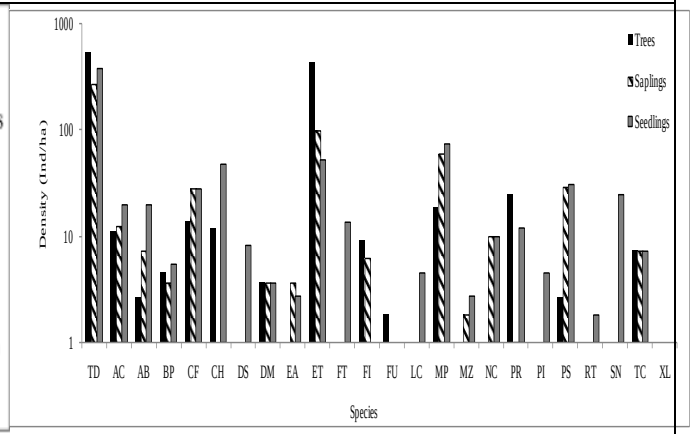

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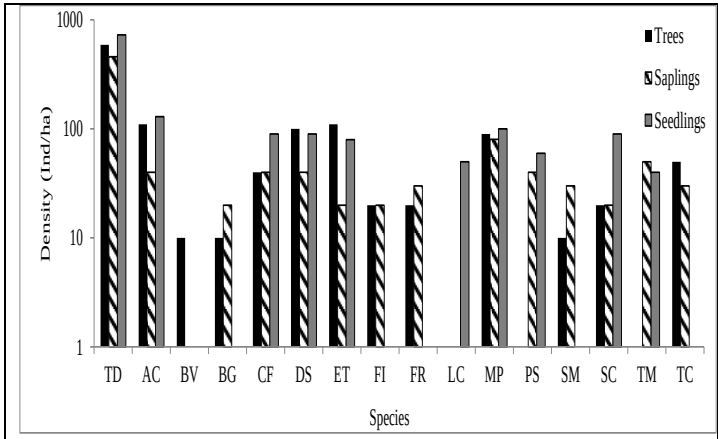

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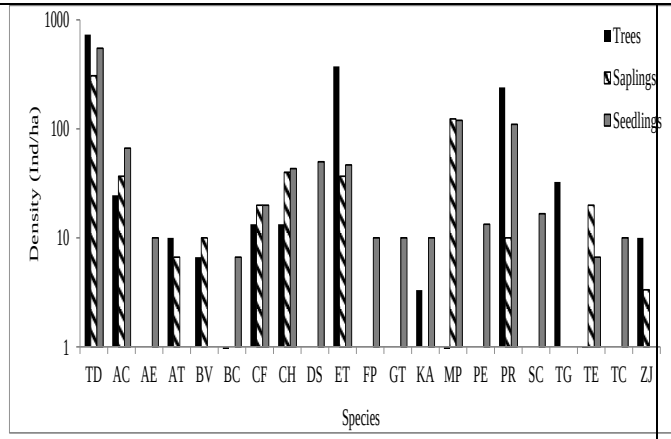

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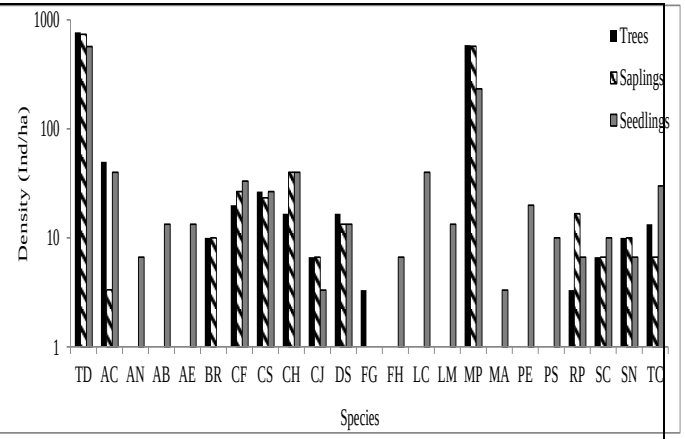

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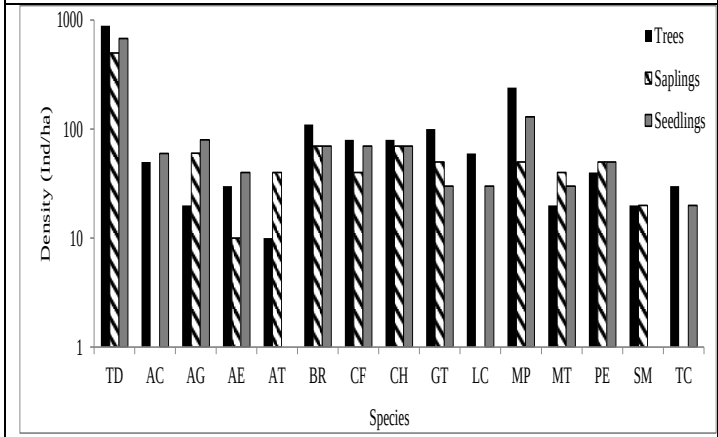

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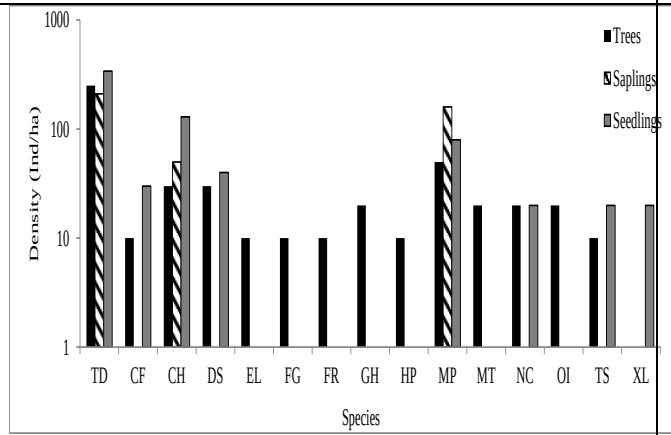

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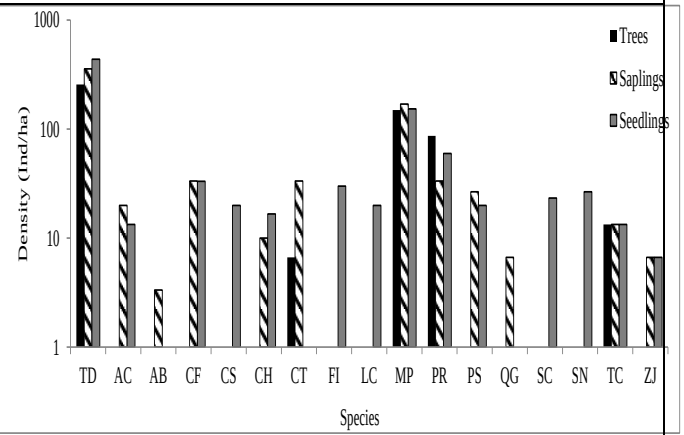

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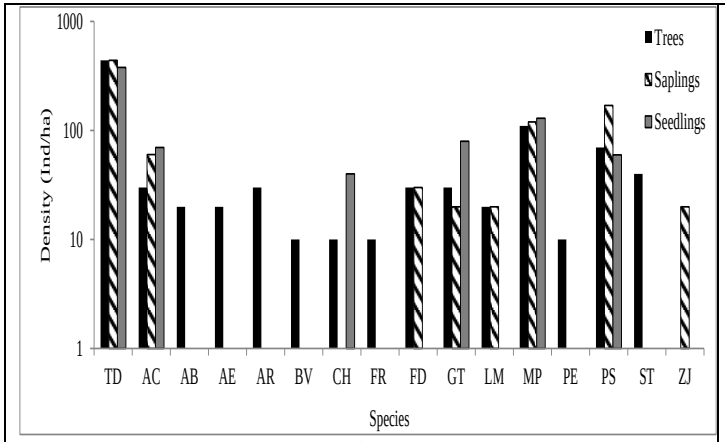

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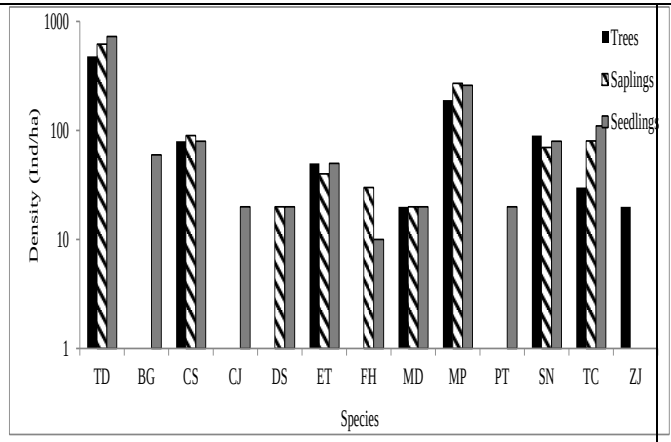

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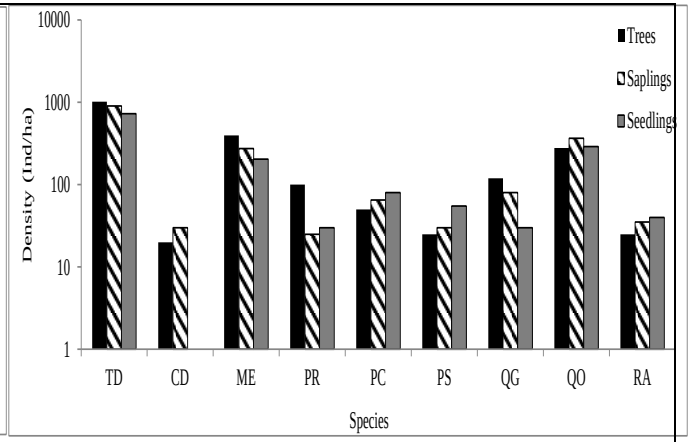

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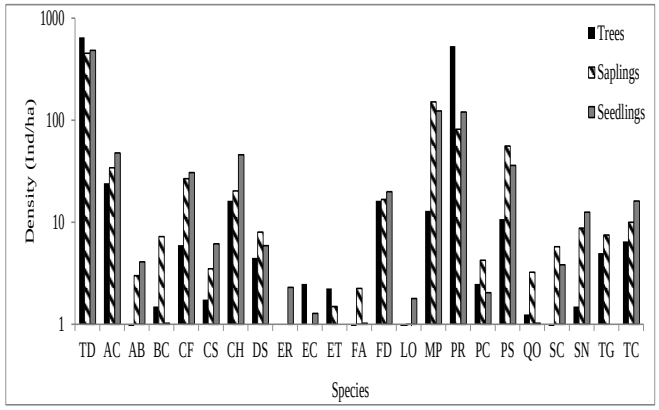

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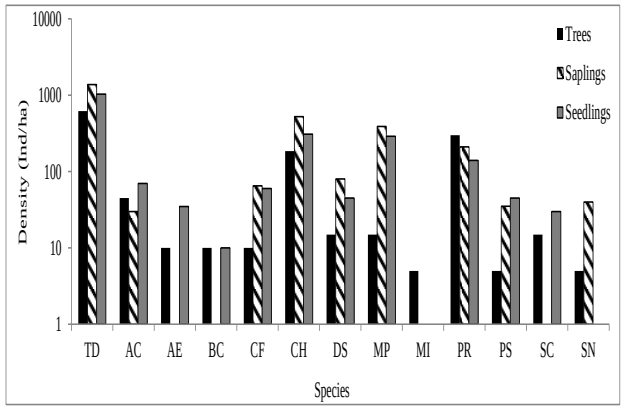

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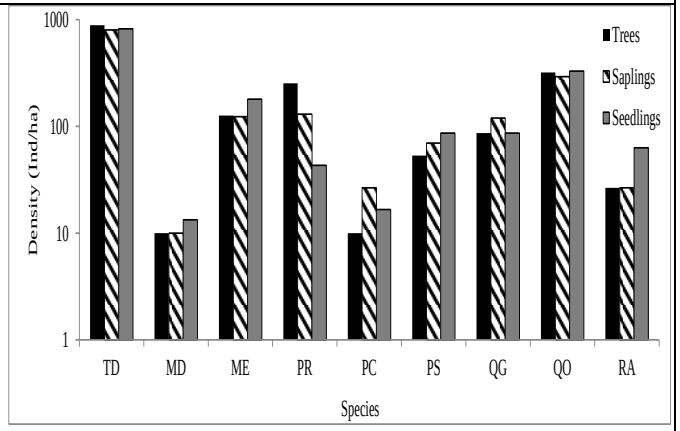

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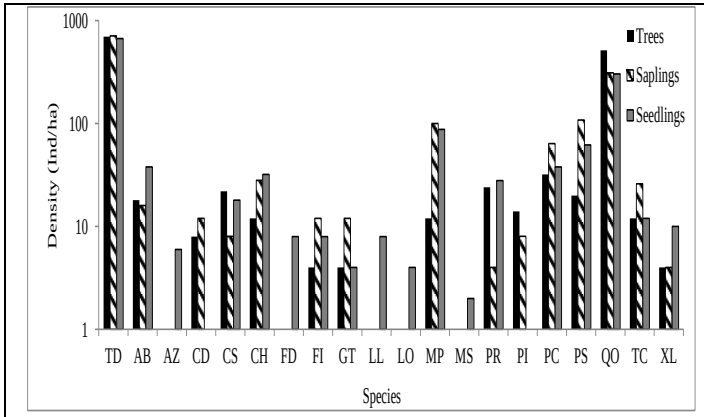

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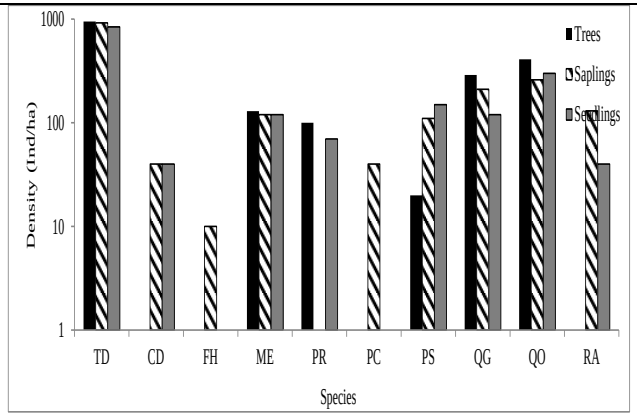

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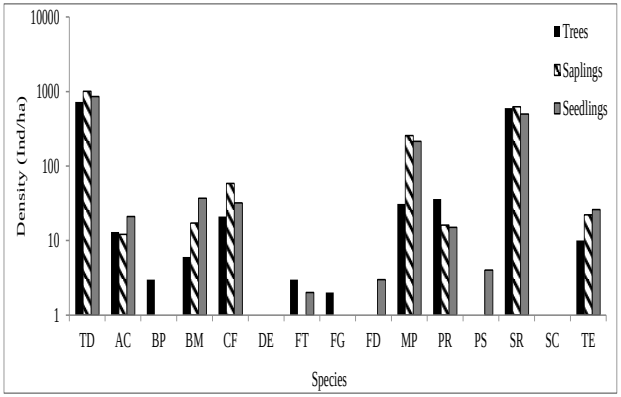

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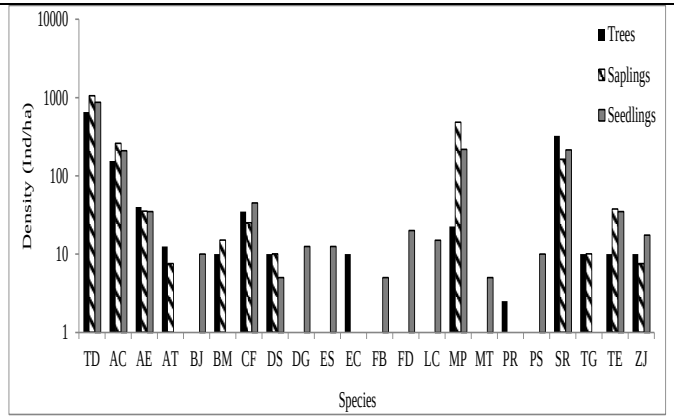

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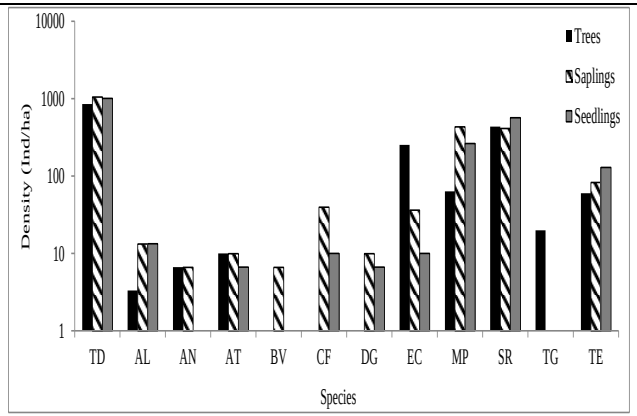

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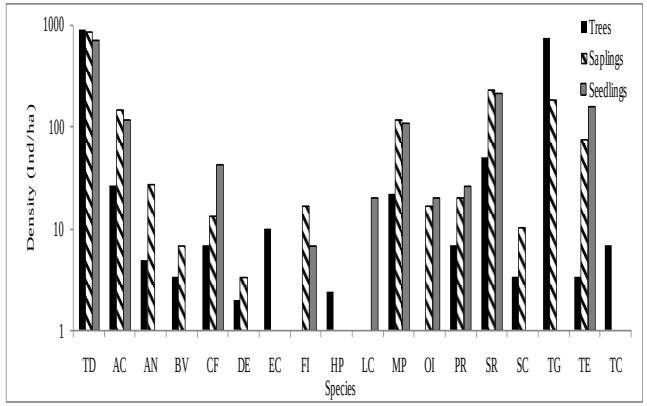

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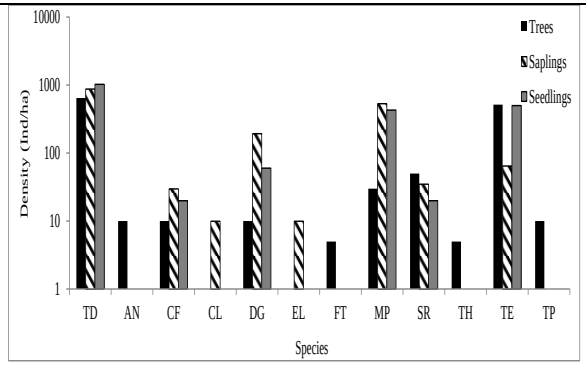

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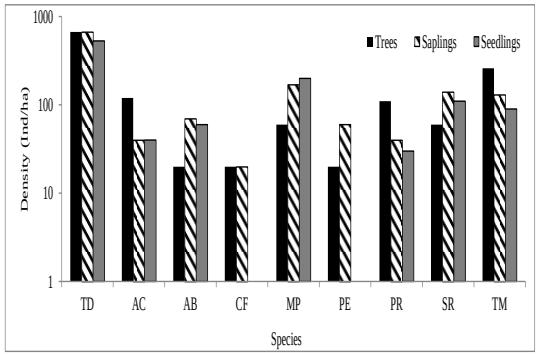

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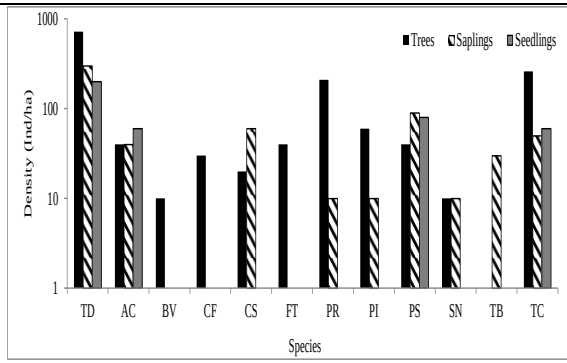

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Table 4: Community wise Concentration of Dominance (Cd) in theShivalik hills of Himachal Pradesh.

Communities	Species Diversity (H')				
	Trees	Saplings	Seedlings	Shrubs	Herbs
Acacia catechu	0.75	0.27	0.41	0.20	0.08
Acacia catechu-Cassia fistula mixed	0.36	0.25	0.13	0.22	0.15
Acacia catechu-Chamaerops humilis mixed	0.22	0.16	0.12	0.14	0.05
Acacia catechu-Mallotus philippensis mixed	0.28	0.24	0.17	0.09	0.04
Bauhinia variegata-Terminalia myriocarpa mixed	0.17	0.09	0.11	0.07	0.04
Chamaerops humilis	0.80	0.37	0.68	0.27	0.10
Cinnamomum tamala-Quercus glauca mixed	0.25	0.10	0.12	0.06	0.06
Dalbergia sissoo	0.77	0.27	0.11	0.19	0.07
Dalbergia sissoo-Acacia catechu mixed	0.32	0.17	0.10	0.13	0.05
Dalbergia sissoo-Cassia fistula mixed	0.22	0.09	0.67	0.44	0.14
Eucalyptus citriodora	0.69	0.27	0.23	0.31	0.04
Eucalyptus tereticornis	0.74	0.66	0.22	0.19	0.08
Eucalyptus tereticornis-Acacia catechu-Dalbergia sissoo mixed	0.14	0.06	0.14	0.15	0.04
Eucalyptus tereticornis-Pinus roxburghii mixed	0.30	0.27	0.30	0.18	0.08
Mallotus philippensis	0.59	0.11	0.18	0.14	0.05
Mallotus philippensis-Bauhinia racemosa-Cassia fistula mixed	0.13	0.19	0.09	0.15	0.07
Mallotus philippensis-Chamaerops humilis-Dalbergia sissoo mixed	0.10	0.23	0.20	0.09	0.03
Mallotus philippensis-Pinus roxburghii mixed	0.50	0.25	0.32	0.08	0.04
Mallotus philippensis-Pyrus pashia-Salix tetrasperma mixed	0.12	0.23	0.26	0.32	0.03
Mallotus philippensis-Syzygium nervosum-Celtis australis mixed	0.24	0.13	0.19	0.05	0.05
Myrica esculenta-Quercus oblongata mixed	0.29	0.30	0.27	0.14	0.05
Pinus roxburghii	0.74	0.28	0.31	0.16	0.07
Pinus roxburghii-Chamaerops humilis mixed	0.35	0.07	0.09	0.15	0.05
Pinus roxburghii-Quercus oblongata mixed	0.28	0.28	0.29	0.18	0.05
Quercus oblongata	0.57	0.23	0.30	0.10	0.04
Quercus oblongata-Quercus glauca mixed	0.31	0.17	0.20	0.10	0.05
Shorea robusta	0.72	0.22	0.13	0.19	0.06
Shorea robusta-Acacia catechu mixed	0.32	0.16	0.12	0.32	0.05
Shorea robusta-Eucalyptus citriodora mixed	0.39	0.22	0.47	0.29	0.10
Tectona grandis	0.72	0.18	0.10	0.10	0.06
Terminalia elliptica	0.66	0.42	0.12	0.39	0.06
Terminalia myriocarpa-Acacia catechu mixed	0.23	0.15	0.19	0.11	0.05
Toona ciliata-Pinus roxburghii mixed	0.23	0.26	0.42	0.12	0.02

CONCLUSIONS

The Himalaya one of the largest and youngest mountain chain in the world covers close to 16.2 % of India's total geographical area. Despite rich in natural resources, most of its people are marginalized and still live on subsistence level. The unscientific exploitation of natural resources is one of the leading reasons for environmental degradation and aggravating the impact of natural hazards. Vulnerable mountain ecosystems need proper management against negative climatic and anthropogenic influences for their future sustainability (Halloy and Mark 2003, Holzinger *et al.,* 2008, Erschbamer *et al.,* 2011). Being biodiversity rich belt, the resources in Shivalik hills are utilized by the inhabitants of the region for medicine, food (wild edible), fodder, fuel, timber, making agriculture tools, religious and various other purposes. Rapid exploitation of fodder and fuel species from the forests has been identified as one of the big problems in the region. Area needs strict conservation policies and their proper implementation for conserving biodiversity. But, before the scientific approach to conserve the natural resources from anthropogenic and natural hazards, there is immediate need for education and awareness at community level for conservation (Giam *et al.,* 2010). Great cause for loss of biodiversity is rapid multiplication of invasive species in the Shivalik hills specially *Lantana camara*. Introduction of invasive species resulted in huge change in regeneration potential of native and endemic plant species. Another important cause for continuous depletion of biodiversity from Shivalik hills is protests from graziers in the high-altitude areas of the Himalaya toward migration of Gujjar community during summers. Due to which they began to stay in the Shivalik hills throughout the year. This results in deviation from the traditional pattern of grazing for their cattles resulting in their hold for grazing in the Shivalik forests throughout the year. This results in poor regeneration of fodder land wild edible plant species. Apart from Gujjars, there are many communities who live nearby forests throughout the year and totally depend upon forest resources for their day to day needs. Reckless cutting of trees and shrubs of nearby forests for agriculture is also one of the reasons for loss of bio resources. Long monsoon inundations also lead to further erosion due to low vegetation cover in Shivalik land nearby riversides. Also, developmental activities specially mining and drilling are also going on with fast rate which is also expected to pose a major threat to biodiversity of the region in future.

Strategies for biodiversity conservation and management. Although government is taking strict steps in destroying these invasive species but still scientific approach and involvement of scientific communities is lacking. Local involvement of communities at village level and involvement of forest department is essential so that steps can be initiated at grass root level. In order to conserve biodiversity of the region, management authorities, ecologists and local communities need to initiate speedy actions like; (i) Steps in eradication of weed species and restoration of degraded areas; (ii) Better grazing practices and

knowledge about sustainability to grazers; (iii) Sustainable harvesting of ethnobotanical plants; (iv) Proper coordination between research and development agencies; (v) Steps should be taken to avoid the heavy loss in rainy season; (vi) Database development through regular monitoring of communities would help in developing adequate management plan for their conservation.

FUTURE SCOPE

In the Shivalik hills of Himachal Pradesh such detailed study by considering various ecological parameters especially regeneration potential in different forest types was not attempted by earlier workers. So current study will provides first hand information about various factors responsible for loss of biodiversity in different forest types in the study area. Proper integrated study by considering anthropogenic and natural causes behind loss of biodiversity will help in preparing policies to recover the loss of biodiversity.

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Conflict of Interest. None.

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