STRUCTURE OF FORESTS UNDER COMMUNITY CONSERVATION : A PRELIMINARY STUDY OF JARDHAR VILLAGE INITIATIVE IN GARHWAL HIMALAYA

R.L. Semwal* , S. Nautiyal , K.S. Rao, R.K. Maikhuri* and B.S. Bhandari**
*G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit,
P. Box-92, Srinagar (Garhwal) 246 174, India
G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora 263 643, India
**Department of Botany, H.N.B. Garhwal University, Srinagar (Garhwal) 246 174, U.P.

INTRODUCTION

The Himalaya a vast mountain system cover partly or fully eight countries of Asia i.e. Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan. The Himalayan ranges of the India lying within geographical limits of 26°20' and 35°40' North and 74°50' and 95°40' East, about 2500 km long, covering an area of 2,36,900 sq. km. India's recognition as one of four `megadiversity' centers of Asia and as one of ten largest forested areas in the world derives partly from the Himalaya. The Himalaya although cover only 18% of the geographical area of India, account for more than 50% of the India's forest cover, and 40% of the species endemic to the India sub-continent (Maikhuri *et al.,* 2000). Various programmes have been implemented, for the conservation of biological resources in the Indian Himalaya under the protected area network by establishing 3 biosphere reserves, 18 national parks and 71 wild life sanctuaries (covering 9.2% area of the Indian Himalaya). Enforcement in these protected areas has created a lot of conflicts between local people and protected area managers due to restrictions imposed on the traditional usufruct rights of the local people. These conflicts are causing major hurdles to achieve the goal of biodiversity conservation for which the protected areas have been setup (Gadgil, *et al.,* 1993; Nautiyal, 1998; Maikhuri *et al.,* 2000). Conservation of biological resources under community based conservation system has a long history in the Himalaya particularly in the Central Himalaya. Because the people of this region are well versed with the significance of natural resources which they harvest for meeting the essential livelihood needs. Various examples reveal the active participation and involvement of local people either at community or individual level towards conservation of the forest / natural resources. The Uttar Pradesh hills have a longer history of officially sanctioned local people's participation in forest management than any other part of the country. The *van panchayat* system is a village level institution and it has considerable potential for involving local communities in forest management for conservation. There are about 4,804 *van panchayats* in the U.P. hills covering an area of 2,44,800 hectares (Saxena, 1995).

The another important example of community based conservation is the well known Chipko movement and was the first movement of its kind in independent India. The Hariyali secred forest of the Garhwal Himalaya is also an example where people conserved the forest through socio-cultural and religious practices (Sinha and Maikhuri, 1998). The present study has been carried in the forest of Jardhar village (Tehri District) where villagers put efforts to conserve the surrounding forest (approximately 10 km^2) since last 20 years through their own indigenous knowledge. They have also given more emphasis for conservation of those species, having multiple use values. In the present study attempt was made to (i) analyse phytosociological attributes of different forest compartments; (ii) assess the regeneration potential and (iii) compare the structure of such protected patches with other (under govt. schemes) protected forests / reserved forests of the Central Himalaya.

METHODS

The phytosociological analysis of the all compartments of the Jardhar forest stands was done using standard methods as given in Ralhan *et al.,* 1982; Saxena & Singh, 1982. In case of trees and tree saplings of >10.5 cm. circumference (at Breast Height i.e. 1.37 m from the ground) have been grouped together (not studied separately). Also the size of the quardrats (10x10m) was kept similar for all strata (trees + sapling, tree seedlings and shrubs). Individuals whose CBH was below 10.5 cm were considered as seedlings. The diversity was determined by using Shannon Wiener (1963) index, and concentration of dominance following Simpson (1949). Beta diversity (BD) was calculated following Whittakar (1975).

RESULTS AND DISCUSSION

The detailed characteristics of different forest compartments (sites) are mentioned in Table 1. A total of 81 species (20 species of trees, 24 species of shrubs and 37 species of herbs) were recorded from the Jardhar forest. Compartment wise distribution of species (trees and shrubs) is presented (Table 2a & 2b). However, herbaceous species (comprising of grasses (5), pteridophytes (3), sedges (2) and 27 forbs)

are not categorized according specific locality (segments) wise and encountered across the compartments in Jardhar forest at the time of present study (Table 2b). The number of species in tree + sapling, seedling and shrub strata indicates that these forest stands are comparatively species rich. The Chauksaur stand is relatively species poor than Buransdhar and Hadyan forest stands. Although dominance was shared by a number of species, no single species was found to compete with *Quercus leucotrichophora;* a climax species. On the basis of density, basal cover and Importance Value Index (IVI), *Q. leucotricophora* was found to be the most important and dominant species in all the forest stands of Jardhar (Table 3a, 3b & 3c). However, the presence of *Pinus roxburghii* in these forest stands particular in Chauksaur compartment is an indication towards possible threat to the co-existance of climax and associated species (Table 3a). The forests of *Q. leucotricophora,* which is a late successional and climax species when disturbed by various anthropogenic factors (*i.e*. lopping, cutting burning *etc*), are invaded by the early successional species (light demanding species) such as chir - pine (*P. roxburghii)* due to changed microclimatic conditions (Semwal and Mehta, 1996). Total basal area (tree + saplings) ranged from 18.35 to 46.57 m^2 ha^{-1} and total density varied between 1082 and 4179 ha^{-1} across the forest stands (Table 3a, b & C). Total basal area and density of tree layer was reported in the range of 27-191.5 m^2 ha^{-1} and 350 to 1787 plants ha^{-1}, respectively, for various broad leaved, traditionally conserved (secred grove) and protected (Nanda Devi Biosphere Reserve) forests of Kumaun and Garhwal Himalaya (Saxena and Singh, 1982; Singh and Singh, 1987; Bhandari and Tiwari, 1997; Sinha and Maikhuri, 1998; Maikhuri *et al.,* 2000). Higher values of density and lower values of basal cover suggest that the Jardhar forest stands are younger and newly conserved. High tree density suggest that the diversity and luxuriance of these community forest stands may be maintained in healthy state if the extent of biotic pressure is maintained to a optimum limit. Low tree density, basal cover and less number of species in Chauksaur forest stand reflect the forest is under high biotic pressure coupled with other abiotic factors which are not necessarily conducive for tree growth.

The number (density) of seedlings of any species can be considered as the regeneration potential of that species. From the density values (Table 4a, b & c), it is concluded that the regeneration of oak (*Q. leucotrichophora*) in Chauksaur compartment is low, as compared to other compartments, however, not as alarming as has been pointed out elsewhere (Saxena *et al.,* 1978; Ralhan *et al.,* 1982; Tiwari and Singh, 1982; Saxena and Singh, 1984 and Bankoti *et al.,* 1986). The co-dominance of *Pinus roxburghii* with *Q. leucotrichophora* particularly in Chuaksaur forest stand (Table 4a) is an indication that due to various anthropogenic pressure oak is not regenerates in comparison to pine. Degradation of the oak forest through high anthropogenic pressure will provide appropriate conditions for the pine (an early successional, low nutrien demander and shade intolerant species) to invade, thereby posing a serious threat to the ecological balance of this region (Singh *et al.,* 1984).

In Jardhar forest stands species richness is very high in shrub layers (present study) than any other broad leaved forests of Garhwal Himalaya (Bhandari and Tiwari, 1997; Bhandari *et al.,* 1998). High species richness in shrub layers may be due to relatively less developed canopy in these young forests which permit sufficient sunlight to reach the ground resulting in the luxuriant growth of shrub species (Table 2b).

A/F ratio was used to assess the distribution pattern of the species. Distribution pattern indicated that most of plots species are distributed contagiously (clumped) followed by randomly. Regular as well as random distribution as observed in the present case has not been reported in shrub layers from this part of the Himalaya (Table 5). It is interesting that the distribution pattern of trees did not correspond with the distribution pattern of shrubs. Similar findings have been reported for Central Himalayan forests by different workers (Saxena and Singh, 1982; Bhandari and Tiwari, 1997). Clumped (contagious) distribution in natural vegetation has been reported by Greig-Smith (1957); Kershaw, (1973) and Singh and Yadava, (1974). Odum (1971) described that in natural conditions, contagious (clumped) distribution is the most common type of distribution and is performed due to small but significant variations in the environmental conditions. Preponderance of random distribution in tree + sapling and seedling layers as compared to shrub layer reflects the dimension of biotic interferences in these strata.

In the present study, the similarity values for tree + sapling layers was 36.00 to 43.58%, for seedlings 47.90 to 62.80% and for shrubs 19.40 to 47.90% (Table 6). Saxena and Singh (1982) reported community coefficient values ranging between 1.30 and 32.50%, Ralhan *et al.,* (1982) between 8.11 and 64.18%, and Tiwari (1983) between 0.0 and 67.43% of different forests of Kumaun Himalaya. However, Mehta *et al.,* (1997) reported similarity 9.6% (between burnt grazed and unburnt grazed sites) to 74.9% (between unburnt protected and unburnt grazed sites) for the various forest compartments (sites) under different management regimes in Garhwal Himalaya. Low similarity between strata and stands indicates the microclimatic variations and hence species composition. Wikum and Wali, (1974) and Saxena and Singh, (1982) have pointed out the significant role of the site characteristics in plant distribution and similarity.

Diversity is a combination of two factors, the number of species present, referred to as species richness and the distribution of individuals among the species, referred to as evenness or equitability. Single species populations are defined as having a diversity of zero, regardless of the index used. Species diversity therefore, refers to the variations that exist among the different forms. In the present study Shannon - Wiener index of diversity has been used. The value of diversity ranged from 2.211 to 3.124, 3.097 to 3.350 and 2.596 to 3.203, respectively, for trees + saplings, seedlings and shrubs. The range of diversity in the present community forest stands is certainly higher than any other broad leaved forests of Central Himalaya (Ralhan *et al.,* 1982), however, it is lower than as reported for tropical forests (Knight, 1975). Moderate amount of anthropogenic pressure on Jardhar forest stands is helpful in maintaining the higher species diversity. Such view was also expressed by Thadani and Ashton (1995), Singh *et al.,* (1997).

The value of beta - diversity was 1.304, 1.53 and 1.41 for trees + sapling, seedling and shrub layers, respectively. These values are much lower than those reported for oak and chir pine forests of Kumaun (Tewari and Singh, 1985) and Garhwal (Bhandari *et al.,* 1997) Himalaya respectively. Small differences in the beta-diversity indicate that the growth forms among different stands respond in similar fashion (Adhikari *et al.,* 1991). Low value of beta diversity show that the species composition does not vary significantly across the slopes.

MAJOR CONCLUSIONS DRAWN

- ➔ As per the Champion and Seth's classification the Jardhar forest broadly falls under the "**Himalayan moist temperate forests"** category.
- ➔ In the present case trees and saplings were considered together (it is not possible to segregate them into trees and saplings now), hence the density value is significantly higher than reported. However, at the same time if sapling and tree density reported in the earlier studies is added together our values are quite comparable. In addition to this, Jardhar forest stands are newly regenerating after the protection given by local community and therefore, most of the individuals of different species are young having low basal cover and high density.
- ➔ Regeneration can be calculated on the basis of seedlings per unit area (please see the tables where all phytosociological attributes are given for different forest stands) and it has been briefly discussed in the present article. All the stands regeneration potential of *Q. leucotrichophora* (Oak) is high as compared to other species but co-dominance of *P. roxburghii* with *Q. leucotrichophora* (particularly in Chauksaur forest stand of the Jardhar forest) is an indication that if anthropogenic pressure will increase in that stand then oak will be replaced by pine as reported by earlier worker.
- ➔ IVI is used to evaluate the importance of a species in any ecosystem which reflects the sum total of relative frequency, relative density and relative dominance (basal cover) of a species. In the present case one can see that IVI was significantly higher for oak species than any other species in tree + sapling stratum and hence Oak is the species which is dominating the different stands of Jardhar forest. As far as shrub stratum is concerned it is evident that more than one species shared the importance in different forest compartments.
- ➔ It depends on the degree of protection is given to a forest. If the Jardhar forest is protected strictly like a sacred Oak - Rhododendron forest of 'Hariyali' (Density 1399 tree ha^{-1} and total basal cover 47.59 m^2 ha^{-1}) or as in the Nanda Devi Biosphere Reserve (Density 946 tree ha^{-1} and total basal cover 191.5 m^2 ha^{-1}), then, in due course of time it is most likely that the Jardhar forest will assume the similar structure having low density and diversity but high basal cover (it takes place due to poor regeneration of species in presence of well developed canopy and dominance by few big sized climax species). However, if the Jardhar forest is exploited at the same magnitude, as the other reserved Oak - Rhododendron forests of the Garhwal Himalaya are being disturbed currently, its diversity, density and basal cover will be like those forests studied by Ralhan *et al.,* 1982; Saxena and Singh, 1982, and other workers. Further, if the present level of anthropogenic pressure on Jardhar forest does not increase in future which is far less than existing pressure on the other govt. reserved Oak-Rhododendron forests of the region, it is most likely that Jardhar forest will remain species-rich and diverse as it is at present.

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Table 1. Some characteristics of the studied compartments (segments) of Jardhar forest

Compartments / segments	Aspects	Altitude (m)	Main features
1. Chauksaur	East & South	1800-2000	Old, comparatively degraded forest, sunny and located mainly on the ridge due to which high speed wind blows continuously
2. Hadyan	North	1600-2000	Young regenerated forest mainly from the old stock which had been over exploited in the past. Sunshine hours are limited.
3. Buransdhar	North & East	1500-2000	Old trees of oak (banj) and tree saplings are most frequent at the site. Some of the locations are sun facing while other are north facing and hence receive less sun rays especially during winter months

Table 2a. Tree species encountered on the three different compartments of the Jardhar forest.

Tree species	Vernacular name	Chauksaur compartment	Hadyan compartment	Buransdhar compartment
1.*Cinnamomum tamala* Nees	Dalchini	-	+	+
2.*Cornus capitata* Wall.	Bhamora	-	+	+
3.*Cornus macrophylla* Wall.	Khagsa	-	+	+
4.*Coculus laurifolius* DC.	Tilphara	-	+	+
5.*Englehardtia* sp	Mahuwa	+	-	+
6.*Fucus* sp	Chadula	-	-	+
7.*Litsaea* sp	Maliya	+	+	+
8.*Lonicera quinquilocularis* Hardw.	Bhatkukra	-	+	+
9.*Lyonia ovalifolia* Wall (Drude)	Aynar	+	+	+
10.*Machilus duthiei* King ex Hook.f.	Kaul	-	-	+
11.*Myrica esculenta* Buch - Ham.	Kafal	+	+	+
12.*Pinus roxburghii* Sarg.	Kulain	+	+	+
13.*Prunus cerasoides* D.Don	Paiyan	+	+	+
14.*Pyrus pashia* Buch-Ham.	Molu	+	+	+
15.*Quercus leucotrichophora* A. Camus	Banj	+	+	+
16.*Rhododendron arboreum* Smith	Burans	-	+	+
17.*Symplocos cretaegoides* Buch-Ham.	Lodh	-	+	+
18.*Rhus* sp	Akhoriya	-	+	-
19.*Viburnum* cotinifolium D.Don.	Gwaniya	+	+	+
20.*Viburnum* sp	Baith bamora	+	+	+

+ Species present ; - Species not present

Table 2b. Shrub species encountered on the three different compartments of the Jardhar forest.

Tree species	Vernacular name	Chauksaur compartment	Hadyan compartment	Buransdhar compartment
1. *Asparagus adscendens* Roxb.	Bhutroon	+	+	+
2. *Berberis asiatica* Roxb.	Kingora	+	+	+
3. *Berberis chitria* Lindl.	Totar	-	-	+
4. *Coriaria nepalensis* Wall.	Rikholya	+	+	+
5. *Cotoneaster bacillaris* Wall.	Ruins	+	+	+
6. *Cornus* sp	Gaunta	+	+	-
7. *Desmodium elagnas* DC	Chamlai	-	+	+
8. *Daphane paparacea* Decne.	-	-	-	+
9. *Euphorbia royleana* Boiss	Sullu	-	-	+
10. *Indigofera gerardiana* Wall.	Sakina	+	-	+
11. *Lonicera* sp	Garhruins	+	+	-
12. *Leucas* sp	-	+	-	-
13. *Myrisine africana* Linn.	Jhingariya	+	+	+
14. *Murraya* sp	Marchuliya	+	-	+
15. *Princepia utilis* Royle.	Bhenkal	+	+	-
16. *Pyracantha crenulata* D.Don.	Ghingaru	+	-	-
17. *Rhus parviflora* Roxb.	Tungla	+	-	+
18. *Rhus cotinus* Linn.	Jaltungla	-	-	+
19. *Rosa brunonii* Lindl	Kunjha	+	+	+
20. *Rubus ellipticus* Sm	Hinsar	+	+	+
21. *Rubus lasiocarpus* Sm	Kalihinsar	-	+	+
22. *Sarcococca* sp	-	-	+	+
23. *Woodfordia fruticosa* Kutz.	Dhaula	+	-	-
24. *Zanthoxylum alatum* Roxb.	Timru	+	-	-

Herbaceous species encountered across the compartment in Jardhar forest at the time of present study

Grasses: *Heteropogon contortus, Apluda mutica, Arundinella nepalensis, Eulalia quadrinervis, Pogonatherum crinitum* etc.

Pteridophytes : *Adiantum edgeworthii, Cheilenthus albomarginata, Onychium contiguum,* etc.

Sedges *: Cyperus niveus, Eriophorum comosum* etc.

Forbs : *Anaphalis cinnamomea, Aster peduncularis, Artemesia japonica, Bergenia legulata, Bidens pilosa, Clematis* sp, *Chrysopogon aciculatus, Deplazium* sp, *Desmodium microphyllum, Desmodium trifolium Eupatorium* sp, *Gerbera gossypina, Geranium nepalense,Geranium wallichianum, Heterophyllum gerardiana, Impatiens balsamina, Micromeria nuducularis, Nepata hindostana, Oxalis corniculata, Plectranthus* sp, *Reinwardtia indica, Salvia* sp, *Strobillanthus* sp, *Swertia chiraita*, *Thalictrum foliolosum, Urtica parviflora, Viola betonicefolia* etc.

+ Species present ; - Species not present

Table 3a. Phytosociological attributes of trees + tree sapling stratum of Chauksaur compartment of Jardhar forest.

Tree species	Frequency (%)	Abundance	Abundance / Frequency ratio	Density ha^{-1}	Total basal cover $M^2 ha^{-1}$	Relative frequency	Relative density	Relative dominance	Importance Value Index
1) *Englehardtia* sp	28.57	4.00	0.140	114.0	0.342	9.09	10.54	1.863	21.50
2) *Litsea* sp	28.57	2.00	0.070	57.0	0.057	9.09	5.27	0.130	14.66
3) *Lyonia ovalifolia* Wall (Drude)	14.30	2.00	0.139	28.0	0.028	4.55	2.58	0.152	7.282
4) *Myrica esculenta* Buch - Ham	42.85	1.66	0.038	71.0	0.497	13.63	5.56	2.708	22.90
5) *Pinus roxburghii* Sarg	42.85	1.33	0.031	57.0	1.767	13.63	5.27	9.63	28.53
6) *Prunus cerasoides* D.Don	14.30	2.00	0.139	28.0	0.056	4.55	2.58	0.305	7.435
7) *Pyrus pashia* Buch-Ham	28.57	1.00	0.035	28.0	0.056	9.09	2.58	0.305	11.975
8) *Quercus leucotrichophora* Acamus	71.42	8.80	0.123	628.0	15.45	22.72	58.04	84.20	164.96
9) *Viburnum cotinifolium* D.Don	14.30	1.00	0.070	14.0	0.014	4.55	1.29	0.076	5.916
10) *Vinburnum* sp	28.57	2.00	0.070	57.0	0.057	9.09	5.27	0.310	14.67
Total				**1082.0**	**18.35**				**300.00**

Table 3b. Phytosociological attributes of trees + tree sapling stratum of Hadyan compartment of Jardhar forest.

Tree species	Frequency (%)	Abundance	Abundance / Frequency ratio	Density ha^{-1}	Total basal cover $M^2 ha^{-1}$	Relative frequency	Relative density	Relative dominance	Importance Value Index
1) *Cinnamomum tamala* Nees	12.50	1.00	0.080	13	0.013	1.60	0.31	0.046	1.95
2) *Cornus capitata* Wall	100.00	6.00	0.060	600	4.20	12.79	14.36	15.112	42.26
3) *Cornus macrophylla* DC	25.00	1.00	0.040	25	0.458	3.20	0.60	1.648	5.448
4) *Coculus laurifolius* DC	12.50	1.00	0.080	13	0.026	1.60	0.31	0.093	2.003
5) *Litsea* sp	62.50	1.8	0.029	113	0.113	7.99	2.70	0.406	11.096
6) *Lonicera quinquilocularis* Hardw	37.50	1.33	0.035	50	0.40	4.80	1.20	1.440	7.44
7) *Lyonia ovalifolia* Wall (Drude)	55.56	4.00	0.072	250	1.25	7.11	5.98	4.500	17.59
8) *Myrica esculenta* Buch - Ham	38.00	1.33	0.035	50	0.25	4.86	1.20	0.900	6.96
9) *Pinus roxburghii* Sarg	37.50	3.00	0.080	113	2.71	4.80	2.70	9.751	17.251
10) *Prunus cerasoides* D.Don	25.00	2.00	0.080	50	0.20	3.20	1.20	0.720	5.12
11) *Pyrus pashia* Buch-Ham	50.00	1.75	0.035	88	0.264	6.40	2.11	0.950	9.46
12) *Quercus leucotrichophora* Acamus	100.00	20.25	0.203	2025	14.53	12.79	48.46	52.281	113.531
13) *Rhododendron arboreum* Smith	75.00	5.00	0.067	375	2.625	9.60	8.97	9.445	28.015
14) *Symplocos cretaegoides* Buch-Ham	25.00	2.50	0.100	63	0.126	3.20	1.50	0.453	5.153
15) *Rhus* sp	12.50	1.00	0.080	13	0.026	1.60	0.31	0.093	2.003
16) *Viburnum* cotinifolium D.Don	50.00	1.50	0.030	75	0.075	6.40	1.79	0.269	8.459
17) *Vinburnum* sp	63.00	4.20	0.067	263	0.526	8.06	6.29	1.892	16.459
Total				**4179**	**27.792**				**299.98**

Table 3c. Phytosociological attributes of trees + tree sapling stratum of Buransdhar compartment of Jardhar forest.

	Frequency %	Abundance	Abundance/ Frequency ratio	Density ha^{-1}	Total basal cover $M^2 ha^{-1}$	Relative frequency	Relative density	Relative dominance	Importance value index
1. *Cinnamomum tamala*	22.2	1.50	0.067	33	0.067	2.70	0.99	0.143	3.833
2. *Cornus capitata*	66.6	2.33	0.035	160	1.120	8.106	4.79	2.405	15.301
3. *Cornus macrophylla*	33.3	1.33	0.040	44	0.882	4.05	1.32	1.893	7.263
4. *Coculus laurifolius*	33.3	1.33	0.040	44	0.132	4.05	1.32	0.283	5.653
5. *Englehardtia* sp	11.1	1.00	0.090	22	0.066	1.35	0.66	0.141	2.151
6. *Fucus* sp	11.1	1.00	0.090	11	0.077	1.35	0.33	0.165	1.845
7. *Litsea* sp	66.6	2.83	0.042	180	0.360	8.11	5.39	0.773	14.273
8. *Lonicera quinquilocularis*	22.2	2.50	0.113	55	0.385	2.70	1.65	0.826	5.176
9. *Lyonia ovalifolia*	33.3	3.33	0.100	111	0.555	4.05	3.33	1.191	8.571
10.*Machilis duthiei*	22.2	1.00	0.045	22	0.088	2.70	0.66	0.188	3.548
11.*Myrica esculenta*	88.8	3.12	0.035	277	5.79	10.81	8.30	12.43	31.54
12.*Pinus roxburghii*	22.4	1.00	0.045	30	1.77	2.70	0.90	3.800	7.40
13.*Prunus cerasoides*	44.4	7.25	0.163	320	4.16	5.40	9.59	8.932	23.922
14.*Pyrus pashia*	44.4	1.75	0.039	77	0.385	5.40	2.31	0.827	8.537
15.*Quercus leucotrichophora*	88.8	12.37	0.139	1100	21.88	10.81	32.96	46.98	90.75
16.*Rhododendron arboreum*	88.8	7.12	0.080	630	8.19	10.81	18.88	17.586	47.276
17.*Symplocos cretaegoides*	44.4	1.00	0.023	44	0.308	5.46	1.32	0.661	7.381
18.*Viburnum* cotinifolium	55.5	2.00	0.036	111	0.222	6.76	3.33	0.476	10.566
19.*Vinburnum* sp	22.4	1.50	0.066	66	0.132	2.73	1.98	0.283	4.993
Total	-	-	-	**3337**	**46.57**	-	-	-	**299.88**

Table 4a. Phytosociological attributes of tree seedling stratum of Chauksaur compartment of Jardhar forest.

Tree species	Frequency (%)	Abundance	Abundance / Frequency ratio	Density ha^{-1}	Total basal cover $M^2 ha^{-1}$	Relative frequency	Relative density	Relative dominance	Importance Value Index
1) *Englehardtia* sp	42.85	2.00	0.047	85.00	0.0204	10.71	5.32	4.32	20.35
2) *Litsea* sp	42.85	3.66	0.085	157.00	0.0126	10.71	9.84	2.67	23.22
3) *Lyonia ovalifolia* Wall (Drude)	28.57	6.50	0.227	185.00	0.0629	7.14	11.59	13.34	32.07
4) *Myrica esculenta* Buch - Ham	28.57	4.50	0.157	128.00	0.64	7.14	8.02	13.58	28.74
5) *Pinus roxburghii* Sarg	57.14	1.75	0.031	100.00	0.065	14.28	6.26	13.79	34.33
6) *Prunus cerasoides* D.Don	42.85	5.00	0.117	214.00	0.0513	10.71	13.41	10.88	34.90
7) *Pyrus pashia* Buch-Ham	28.57	2.00	0.070	57.00	0.0046	7.14	3.57	0.97	11.68
8) *Quercus leucotrichophora* Acamus	57.14	6.50	0.114	371.00	0.152	14.28	23.24	32.25	69.77
9) *Viburnum* cotinifolium D.Don	28.57	2.50	0.087	71.00	0.011	7.14	4.45	2.33	13.92
10) *Vinburnum* sp	42.85	5.33	0.124	228.00	0.0274	10.71	14.28	5.81	30.8
Total				**1596.0**	**0.4712**				**299.98**

Table 4b. Phytosociological attributes of tree seedling stratum of Hadyan compartment of Jardhar forest.

Tree species	Frequency (%)	Abundance	Abundance / Frequency ratio	Density ha^{-1}	Total basal cover $M^2 ha^{-1}$	Relative frequency	Relative density	Relative dominance	Importance Value Index
1) Cornus capitata Wall	50.00	2.00	0.050	125	0.0137	11.69	7.23	4.00	22.90
2) Coculus laurifolius DC	25.00	1.50	0.060	38	0.0012	5.84	2.20	0.35	8.40
3) Litsea sp	38.00	3.67	0.097	138	0.0048	8.88	7.99	1.42	18.29
4) Lyonia ovalifolia Wall (Drude)	37.50	3.00	0.080	113	0.0088	8.77	6.54	2.60	17.91
5) Myrica esculenta Buch - Ham	38.00	3.67	0.097	138	0.0289	8.88	7.99	8.55	25.42
6) Pinus roxburghii Sarg	25.00	2.00	0.080	50	0.0155	5.84	2.89	4.58	13.31
7) Prunus cerasoides D.Don	1.25	3.00	2.400	38	0.0053	0.29	2.20	1.56	4.05
8) Pyrus pashia Buch-Ham	25.00	2.50	0.100	63	0.0061	5.84	3.64	1.80	11.28
9) Quercus leucotrichophora Acamus	88.00	8.57	0.094	750	0.210	20.57	43.40	62.16	126.13
10) Rhododendron arboreum Smith	25.00	4.00	0.160	100	0.031	5.84	5.78	8.88	20.5
11) Symplocos cretaegoides Buch-Ham	25.00	1.00	0.040	25	0.0013	5.84	1.45	0.38	7.67
12) Viburnum cotinifolium D.Don	25.00	2.00	0.080	50	0.004	5.84	2.89	1.18	9.90
13) Vinburnum sp	25.00	4.20	0.160	100	0.0072	5.84	5.78	2.13	13.75
Total				**1728**	**0.3378**				**299.51**

Table 4c. Phytosociological attributes of tree seedling stratum of Buransdhar compartment of Jardhar forest.

Tree species	Frequency (%)	Abundance	Abundance / Frequency ratio	Density ha^{-1}	Total basal cover $M^2 ha^{-1}$	Relative frequency	Relative density	Relative dominance	Importance Value Index
1) Cinnamomum tamala Nees	33.3	1.66	0.050	50	0.038	3.85	1.34	0.315	5.565
2) Cornus capitata Wall	44.4	2.25	0.050	100	0.021	5.13	2.68	2.076	9.868
3) Cornus macrophylla DC	44.4	2.26	0.050	100	0.0296	5.13	2.68	2.922	10.732
4) Coculus laurifolius DC	44.4	3.00	0.067	133	0.0182	5.13	3.56	1.78	10.47
5) Englehardtia sp	22.2	2.00	0.090	44	0.0061	2.56	1.17	0.60	4.33
6) Ficus sp.	22.2	2.00	0.090	44	0.0924	2.56	1.17	0.91	4.16
7) Litsea sp	33.3	1.12	0.033	77	0.0077	3.85	2.06	0.76	6.67
8) Lonicera quinquilocularis Hardw	22.2	3.00	0.135	66	0.0044	2.56	1.77	0.43	7.76
9) Lyonia ovalifolia Wall (Drude)	44.4	3.25	0.073	140	0.088	5.13	3.75	8.68	17.56
10) Machilis duthiei King ex Hook f.	22.2	3.00	0.135	66	0.0085	2.56	1.77	0.83	5.16
11) Myrica esculenta Buch - Ham	88.8	5.37	0.060	470	0.188	10.26	12.59	18.57	41.12
12) Pinus roxburghii Sarg	22.2	2.25	0.101	55	0.0286	2.56	1.47	2.02	6.85
13) Prunus cerasoides D.Don	44.4	4.50	0.101	200	0.0240	5.13	5.36	2.36	12.85
14) Pyrus pashia Buch-Ham	44.4	1.12	0.025	77	0.0154	5.13	2.06	1.52	8.70
15) Quercus leucotrichophora Acamus	100	13.22	0.132	1322	0.343	11.55	35.43	33.85	80.84
16) Rhododendron arboreum Smith	77.7	5.14	0.066	400	0.188	8.97	10.72	18.57	38.26
17) Symplocos cretaegoides Buch-Ham	55.5	1.6	0.028	88	0.0068	6.41	2.36	0.670	9.44
18) Viburnum cotinifolium D.Don	66.6	2.5	0.037	166	0.0210	7.69	4.45	2.07	14.21
19) Vinburnum sp	33.3	4.0	0.120	133	0.010	3.85	3.56	0.98	8.39
Total				**3731**	**1.0129**				**299.95**

Table 5. Distribution pattern of tree + sapling, tree seedling and shrub species in different compartments of Jardhar forest.

Compartments	**Distribution (%)**		
	Regular (r)	**Random (R)**	**Clumped (C)**
Chauksaur compartment			
Trees + saplings	0.00	30.00	70.00
Tree Seedlings	0.00	20.00	80.00
Shrubs	0.00	0.00	100.00
Hadyan compartment			
Trees + saplings	0.00	35.30	64.70
Tree Seedlings	0.00	15.38	84.62
Shrubs	0.00	0.00	100.00
Buransdhar compartment			
Trees + saplings	5.26	52.64	42.10
Tree Seedlings	5.26	31.58	63.16
Shrubs	0.00	0.00	100.00

Table 6. Similarity index (Community coefficient) calculated on the basis of density of trees + tree saplings, tree seedlings and shrub species for different compartments of Jardhar forest

	Chauksaur compartment	Hadyan compartment	Buransdhar compartment
Trees + tree saplings			

Chauksaur compartment	100	36.00	43.58
Hadyan compartment		100	40.37
Buransdhar compartment			100
Tree seedlings			
Chauksaur compartment	100	62.80	47.90
Hadyan compartment		100	60.10
Buransdhar compartment			100
Shrub species			
Chauksaur compartment	100	19.40	22.78
Hadyan compartment		100	47.90
Buransdhar compartment			100

Table 7. Species diversity (H) in different forest strata and beta diversity (B) of Jardhar forest

Compartments	Shannon-Wiener index of diversity (H)	Beta diversity (B)		
		Trees + tree saplings	Tree seedlings	Shrub species
Chauksaur compartment				
Trees + saplings	2.211			
Tree seedlings	3.097			
Shrubs	3.203			
Hadyan compartment				
Trees + saplings	2.825	1.304	1.532	1.410
Tree seedlings	3.350			
Shrubs	3.064			
Buransdhar compartment				
Trees + saplings	3.124			
Tree Seedlings	3.272			
Shrubs	2.596			

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