

Article

Pioneer community level syntaxonomy of forests of lesser Himalayan belt of upper Tanawal Mansehra, Pakistan

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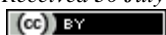
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Abstract

The present study is the first comprehensive investigation of forest communities of 127 stands in Upper Tanawal forests by quadrat method. Based on phytosociological analysis, the composition and distribution of tree species were described quantitatively on the basis of their IVI values using TWINSpan classification. With the help of IVI values of tree species from 127 sampling station, TWINSpan classified 20 tree communities. The occurrence of huge numbers of tree communities is due to restriction of single plant habit. Our investigation revealed that the diversity of trees species in this region decreases with increase in the elevation. *Pinus wallichiana* were observed the most dominant tree species at higher altitudinal areas. From 2 sampling sites, i.e. 2200 m and 2300 m of altitudes, pure coniferous community of *Taxus-Abies-Pinus wallichiana* was documented with only these three tree species. It was observed that the tree species like *Picea smithiana*, *Abies pindrow*, *Rhododendron arboretum*, *Cedrus deodara*, *Taxus baccata* and *Quercus* spp were rare in study area. All the tree communities as well as their associated biodiversity should be conserved and protected to ensure the future existence of these forest lands.

Keywords tree communities; TWINSpan; forests; Upper Tanawal.

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1 Introduction

Traditionally, forests played vital role in livelihoods of the people. Million years before the industrial revolution, forests and trees were the source of construction materials, fuel, energy, medicines and food as well (Williams., 2002). Huge portion of the natural forests resources of Pakistan are found in the regions of great Himalaya (Farooq et al., 2019). Himalayas are one of the world's highest mountains, possessing diverse floristic composition and exhibit important locations for research in ecology (Pei, 2001).

The phytosociological work, community description, diversity, distribution, governing environmental variables and anthropogenic disturbance in the Himalayan region has been studied in the past by various researchers, i.e. Ahmed (1986), Hussain and Illahi (1991), Sharma and Baduni (2000), Ahmed et al. (2006), Chawla et al. (2008), Kharakwal et al. (2009), Siddiqui et al. (2009), Ahmed et al. (2010), Todorica et al. (2010), Shaheen et al. (2011), Akbar et al. (2013), Akhtar and Bergmeier (2015), Bisht and Bhatt (2016) and Farooq et al. (2018). Handful investigations in plant sciences were conducted by various researchers from district Mansehra, i.e. Chaudhri (1960), Matin (2001), Khan (2009), Khan et al. (2012), Khan et al. (2016), Saeed et al. (2018), Farooq et al. (2019) etc.

Besides these all investigations in plant sciences not a single detailed quantitative study was carried which can describe various forests communities in this region. Therefore the present study was carried out to describe and quantitatively analyze the forest communities throughout its natural habitat in Upper Tanawal.

2 Study Area and Methodology

2.1 Study site

The present Upper Tanawal was a royal state in British era consist of far-flung and mountainous region of today's districts, i.e. Abbottabad, Haripur, Mansehra and Tor-Ghar. The study area touches western boundaries of lesser Himalaya (Farooq et al., 2019). This region has the extremely thick and rich natural forests (Watson, 1907).

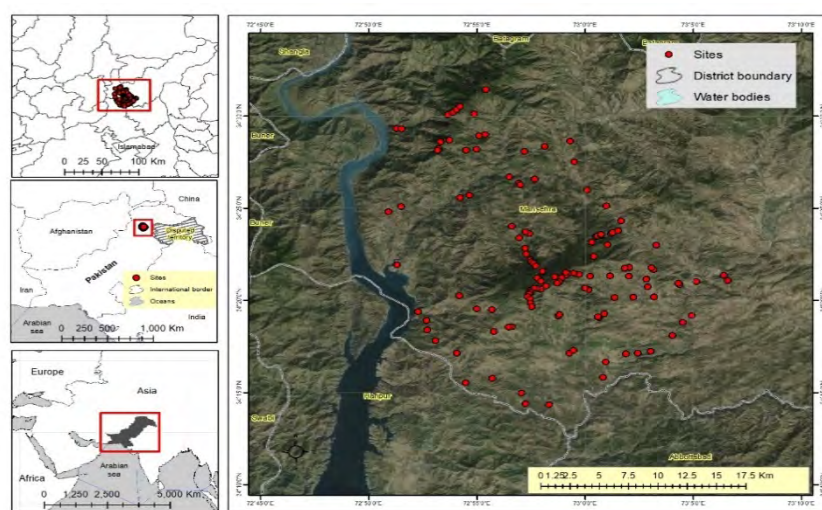


Fig. 1 Map of study area.

2.2 Data collection

Extensive vegetational investigation in the natural forests of Upper Tanawal was conducted during 2017. Quantitative phytosociological sampling was carried from 127 different sampling sites with Quadrates of 10 m² using Braun-Blanquet approach (Podong and Poolsiri, 2013). Phytosociological attributes like density, frequency, and canopy cover for each and every tree species in all stands were calculated following Mueller-Dombois and Ellenberg (1974). Relative values for each attribute were calculated as a presentation of percentage weightage of each species on all these parameters (Jayakumar et al., 2011).

Importance Value Index was calculated by (Zhang et al., 2014)

$$IVI = RD+RF+RCC/3$$

2.3 Analysis of data

PC-Ord Version 5 was used to analyze field data. The Importance value index (IVI) data was used for cluster analysis by TWINSpan (two-way indicator species analysis) to classify and arrange tree communities. The IVI was used to order each tree species and a tree species with highest IVI in a stand was believed as dominant tree species.

3 Results and Discussion

Total 53 tree species belonging to 39 genera and 25 families were recorded from 127 different sampling stations. Twenty major plants communities were recognized by TWINSpan starting from altitude of 500 m up to 2700 m from sub tropical and temperate zones in the study area. The IVI data obtained from 127 sampling stands in the subtropical and temperate vegetational zones of Upper Tanawal were analyzed by TWINSpan classification. The cluster analysis placed the 127 sampling stations in 20 groups (tree communities) (Fig. 2). The names of these tree communities were given on the basis of the indicator tree species of a particular community. Details of each community are described as follows:

- 1. *Pinus-Ailanthus-Populus* Community:** *Pinus-Ailanthus-Populus* community represents mixed coniferous forests types in the study area. This community was established from the altitude of 800 m up to 1600 m from 16 sampling stands having the latitude of 33°.31.35' N to 34°.48.38' N. The slope angle for this community ranges from 10° to 45° while 12.59% of the sampling area is covered by this community. Total 34 different tree species were recorded in association with this community. *Pinus roxburghii* and *Ailanthus altissima* was the indicator tree species of the community while *Corymbia citriodora*, *Melia azedarach*, *Pistacia chinensis* and *Robinia pseudoacacia* were recognized as associated tree species of the community. Highest IVI value was recorded for *Pinus roxburghii* (77.33) followed by *Ailanthus altissima* (34.92) and *Populus ciliata* (27.5). The recorded data of microclimate shows that the average atmospheric humidity of this habitat is 35.09% while the recorded average temperature for this community was 24.59°C.
- 2. *Dalbergia-Populus-Alnus* Community:** *Dalbergia-Populus-Alnus* community represents broad leaved deciduous forests type in the study area. This community was recorded from 2 sampling stations at elevations of 1100 m and 1450 m having the latitude of 34°.38.34' N and 34°.47.29' N. The slope angle for this community is 35 and 30 respectively whereas this community covered 1.57% of the total sampling area. *Dalbergia sissoo* (18.05) and *Populus ciliata* (9.20) was indicator species. Other dominant tree species of the community are *Ficus palmata*, *Robinia pseudoacacia*, *Ficus benghalensis* and *Grewia villosa*. Maximum IVI value was recorded for *Dalbergia sissoo* (18.05) followed by *Populus ciliata* (9.20) and *Alnus nitida* (8.83). Average humidity for this community was 33.38% while average temperature was 27°C during different months of the year.
- 3. *Pinus-Grewia-Olea* Community:** *Pinus-Grewia-Olea* community represents coniferous mixed evergreen forests in Upper Tanawal. This community was starting from the altitude of 900 m up to 1500 m in 11 sampling sites having latitude ranging from 34°.31.87' N to 34°.43.81' N. Slope angle for this community were recorded from 18° to 56° while the community covered 8.66% of the total sampling area. *Pinus roxburghii* and *Grewia villosa* was the indicator tree species with association of *Alnus nitida*, *Salix babylonica* and *Ficus palmata*. Highest Importance Value Index was recorded for *Pinus roxburghii* (47.89) followed by *Grewia villosa* (47.69) and *Olea ferruginea* (29.71). Recorded data of microclimate specify that average temperature of this community was 24.68°C and average atmospheric humidity was 32.20% during different months of the year.

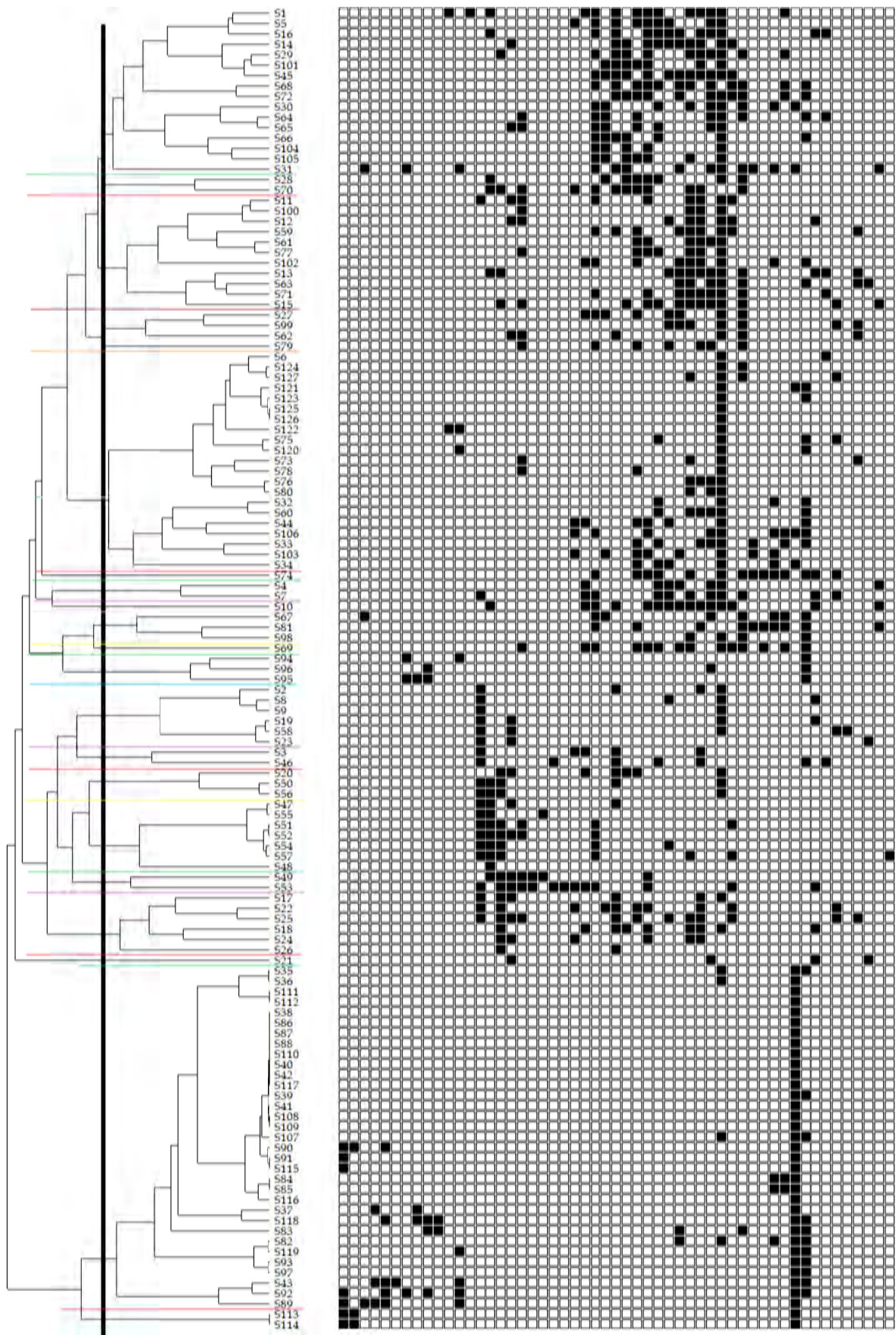


Fig. 2 Cluster dendrogram of 127 sampling sites presenting 20 tree communities.

4. ***Alnus-Pinus-Celtis* Community:** *Alnus-Pinus-Celtis* community represents mixed coniferous deciduous forests type in the study area. This community was documented from 4 sampling sites between elevations of 1050 m–1600 m having the altitude from 34°.31.93' N to 34°.47.75' N. Only 3.14% sampling area is covered by this community. *Alnus nitida* (20.33), *Pinus roxburghii* (10.24) and *Celtis australis* (8.13) are the indicator species with highest IVI values. Average atmospheric humidity was recorded as 44.75 % while average temperature was 26.63°C.
5. ***Pinus-Quercus-Pistacia* Community:** *Pinus-Quercus-Pistacia* community represents mixed coniferous evergreen forests in the study area. This community was found from the altitude of 900m up to 1850 m in 21 sampling stations within altitudinal range of 34°.31.78' N to 34°.47.10' N. Total 16.53% sampling area was recorded for this community. Total 25 species were recorded from this community. *Pinus roxburghii* (269.03), *Quercus incana* (33.69) and *Pistacia chinensis* (20.85) are indicators for this community with highest IVI. Average air humidity and average temperature was 36.69% and 24.51°C respectively.
6. ***Ficus-Pinus-Juglans* Community:** *Ficus-Pinus-Juglans* community represents mixed coniferous deciduous forests. The community was documented from only 1 sampling stand from the altitude of 1400 m with latitude 34°.43.34' N. The slope angle for this community was 48° whereas this community was recorded from south of the study area. Only 0.78% of the sampling area is covered by this community. Total 14 species were recognized from this community. *Ficus cariaca* (32.25), *Pinus roxburghii* (5.39) and *Juglans regia* (2.28) were documented as indicators with maximum IVI. Associated tree species of the community are *Ficus racemosa*, *Ailanthus altissima*, and *Pyrus bourgaeana*. Average temperature and average humidity was 28.05°C and 42% respectively.
7. ***Pistacia-Morus-Acacia* Community:** *Pistacia-Morus-Acacia* community indicates broad leaved deciduous forests type. The community was documented from altitude 750 m and 850 m in 2 sampling sites having latitude of 34°.30.15' N and 34°.35.05' N respectively. Both samples were recorded from eastern side with slope angle was 20° and 30° in the study area. This community covers 1.57% of the total sampling area. *Pistacia chinensis* (3.83), *Morus nigra* (3.45) and *Acacia modesta* (3.34) are indicator species while associated tree species are *Acacia modesta*, *Pyrus pashia*, *Celtis australis* and *Populus alba*. The recorded data during different months of the year indicates that average temperature was 24.50°C while recorded average humidity was 25.38%.
8. ***Populus-Broussonetia-Ailanthus* Community:** *Populus-Broussonetia-Ailanthus* community indicates broad leaved deciduous forests in the study area. This community was found at altitude of 850 m from single stand. This community was documented from eastern side having slope angle of 10° and covered 0.78% of sampling area. Total 15 different tree species were recorded in association with this community. *Populus alba*(35.34), *Broussonetia papyrifera* (1.70) and *Ailanthus altissima* (1.59) was the indicator tree species while *Ailanthus altissima*, *Pistacia chinensis* and *Corymbia citriodora* were recognized as associated tree species for the community. The recorded data of microclimate shows that the average atmospheric humidity of this habitat is 22.75% while recorded average temperature for this community was 24°C.
9. ***Quercus-Alnus-Juglans* Community:** *Quercus-Alnus-Juglans* community represents broad leaved evergreen forests type in this region. The community was recorded from 3 sites between elevations of 1600 m – 1700 m with latitude ranges from 34°.32.53' N to 34°.35.53' N and covers 2.36% of the total sampling area. *Quercus incana* (31.77), *Alnus nitida* (21.62) and *Juglans regia* (12.27) were the indicator tree species. Average humidity for this community was 44.58% whereas average temperature was 27.92°C during different months of the year.

- 10. *Alnus-Leucaena-Quercus* Community:** *Alnus-Leucaena-Quercus* community represents broad leaved evergreen forests in Upper Tanawal. This community was recognized only from 800 m with latitude of 34°.33.78' N and covered 0.78% of the sampling. Total 14 tree species were recorded in this community. *Alnus nitida* (35.66), *Leucaena leucocephala* (4.73) and *Quercus incana* (3.52) are the indicator species whereas associated tree species of the community are *Quercus incana*, *Salix babylonica*, *Ailanthus altissima* and *Ficus palmata*. The recorded data of microclimate indicates that average temperature of this community was 28.05°C whereas average atmospheric humidity was 22% during different periods of the year.
- 11. *Quercus-Aesculus-Cornus* Community:** *Quercus-Aesculus-Cornus* community represents broad leaved evergreen forests in this region. The community was recorded from 3 sites between altitudinal ranges of 1900 m up to 2100 m. The community covers 2.36% of the total sampling area. *Quercus incana*, *Aesculus indica* and *Cornus macrophylla* are the indicator species for this community. Highest IVI value was recorded for *Quercus incana* (23.95) while minimum IVI showed by *Pistacia chinensis* (3.23). Average temperature and average humidity were 31.25°C and 47.83% respectively.
- 12. *Acacia-Pinus-Bombax* Community:** *Acacia-Pinus-Bombax* community symbolized broad-leaved deciduous forests in Upper Tanawal. This community was found from the altitude of 800m up to 1000 m in 6 sampling stands. It covers 4.72% of sampling area. Total 10 different tree species were recorded in association with this community. *Acacia modesta* (40.07), *Pinus roxburghii* (19.07) and *Bombax ceiba* (7.46) was indicator tree species whereas *Ficus racemosa* and *Ficus carica* were documented as associated tree species in the community. Recorded average humidity was 27.13% whereas recorded average temperature for this community was 24.13°C.
- 13. *Acacia-Corymbia-Olea* Community:** *Acacia-Corymbia-Olea* community documented as broad-leaved-evergreen forests type of the study area. This community was recorded from 2 locations at altitudinal range of 750 m and 950 m and covered only 1.57% of the total sampled area. Highest IVI was documented for *Acacia modesta* (8.18) while minimum IVI was recorded for *Punica granatum* (1.03). Average recorded temperature and humidity was 20.50°C and 31.38% respectively.
- 14. *Ficus-Acacia-Dalbergia* Community:** *Ficus-Acacia-Dalbergia* community confirmed broad-leaved deciduous forests type in study area. This community was recorded from altitude of 750 m up to 900 m in 3 stands and exhibit 2.36% of total sampling area. Highest IVI value was documented for *Ficus benghalensis* (38.25) followed by *Acacia modesta* (14.88) and *Dalbergia sissoo* (12.31). The average humidity and average temperature of this habitat was 26.97% and 21.08°C respectively.
- 15. *Dalbergia-Acacia-Ficus* Community:** *Dalbergia-Acacia-Ficus* community showed broad leaved deciduous forests type in Upper Tanawal. This community was recorded from 7 stations from altitude between 500m to 1000m and covered 5.51% total sampling region. Among the indicator species *Dalbergia sissoo* (46.99) exhibits highest IVI, whereas lowest IVI was recorded for *Celtis australis* (1.96). Average temperature and average humidity for this habitat was 19.02°C and 26.05% respectively.
- 16. *Bombax-Ficus-Leucaena* Community:** *Bombax-Ficus-Leucaena* community represents broad-leaved deciduous forests of the region. The community was recorded from elevation of 500 m and 700 m in 2 stands which covered only 1.57% of sampling area. *Bombax ceiba* (7.37), *Ficus benghalensi* (6.40) and *Leucaena leucocephala* (5.97) are indicator species whereas *Melia azedarach*, *Cassia fistula* and *Dalbergia sissoo* are the associated tree species of the community. The recorded data of microclimate shows that the average atmospheric humidity of this habitat was 24.88% whereas average temperature was 18.50°C.

- 17. *Ficus-Olea-Acacia* Community:** *Ficus-Olea-Acacia* community indicates broad leaved evergreen forests of this region. This community was documented from 6 stations between altitudinal range of 600 m – 750 m and covered 4.72% sampling area. Maximum IVI value was documented for *Ficus benghalensis* (26.81) while minimum IVI was recorded for *Leucaena leucocephala* (0.94). The average temperature and average atmospheric humidity for this community was 25.25°C and 32.25% respectively.
- 18. *Lannea-Bombax-Ficus* Community:** *Lannea-Bombax-Ficus* community showed broad leaved deciduous forest types of this region. The community was recorded in a single station at 700 m from south and covered only 0.78% sampling area. Total 4 different tree species were recorded in association with this community including *Lannea coromandelea*, *Bombax ceiba*, *Ficus carica* and *Pistacia chinensis*. Maximum IVI was documented for *Lannea coromandelea* (3.94). Average humidity and average temperature for this habitat was 29.75% and 24.25°C respectively.
- 19. *Pinus-Quercus-Abies* Community:** *Pinus-Quercus-Abies* community represents mixed-coniferous- evergreen forests type in Upper Tanawal. This community was found from 33 stations at higher elevation between of 1600 m up to 2700 m and covered 25.98% of the sampling area. Maximum IVI value was recorded for *Pinus wallichiana* (338.18) followed by *Quercus incana* (59.81) and *Abies pindrow* (19.11). Associated tree species were *Pinus roxburghii*, *Juglans regia* and *Rhododendron arboretum*. The average temperature for this community was 26.07°C while the average humidity was recorded as 43.90%.
- 20. *Taxus-Abies-Pinus* Community:** *Taxus-Abies-Pinus* community represents pure coniferous evergreen forests of the study area. This community was found in 2 stations from altitude of 2200 m and 2300 m in West of study area and covered 1.57% of sampling area. Only *Taxus baccata* (7.94), *Abies pindrow* (7.02) and *Pinus wallichiana* (6.30) was documented from this community. Recorded data shows that the average humidity of this habitat was 53.25% whereas recorded average temperature for this community was 18.50°C.

Table 1 Summary of communities and associated tree species of 127 stands from the study area.

S. No	Communities	Stands (S)	No. of stands	Associated tree spp
1	<i>Pinus-Ailanthus-Populus</i>	1,5,14,16,29,30,31,45,64,65,66,68,72,101,104,105	16	<i>Corymbiacitriodora, Melia azedarach</i>
2	<i>Dalbergia-Populus-Alnus</i>	28,70	2	<i>Ficuspalmata, Robiniapseudoacacia</i>
3	<i>Pinus-Grewia-Olea</i>	11,12,13,15,59,61,63,71,77,100,102	11	<i>Alnusnitida, Salix babylonica</i>
4	<i>Alnus-Pinus-Celtis</i>	27,62,79,99	4	<i>Leucaena leucocephala, Ficuspalmata</i>
5	<i>Pinus-Quercus-Pistachia</i>	6,32,33,34,44,60,73,75,76,78,80,103,106,120,121,122,123,124,125,12,127	21	<i>Pinus wallichiana, Ficuspalmata</i>
6	<i>Ficus-Pinus-Juglans</i>	74	1	<i>Ficusracemosa, Pyrus bourgaeana</i>
7	<i>Pistacia-Morus-Acacia</i>	4, 7	2	<i>Pyrus pashia, Celtisaustralis</i>
8	<i>Populus-Broussonetia-Ailanthus</i>	10	1	<i>Pistaciachinensis, Corymbiacitriodora</i>
9	<i>Quercus-Alnus-Juglans</i>	67,81,98	3	<i>Cedrusdeodara, Prunus armeniaca</i>
10	<i>Alnus-Leucaena-Quercus</i>	69	1	<i>Ailanthus altissima, Prunus armeniaca</i>
11	<i>Quercus-Aesculus-Cornus</i>	94,95,96	3	<i>Quercus robur, Rhododendron arboretum</i>
12	<i>Acacia-Pinus-Bombax</i>	2,8,9,19,23,58	6	<i>Fiscscarica, Ficusracemose</i>
13	<i>Acacia-Corymbia-Olea</i>	3,46	2	<i>Acacia nilotica, Morusnigra</i>
14	<i>Ficus-Acacia-Dalbergia</i>	20,50,56	3	<i>Corymbiacitriodora, Pinus roxburghii</i>
15	<i>Dalbergia-Acacia-Ficus</i>	47,48,51,52,54,55,57	7	<i>Ailanthus altissima, Bombax ceiba</i>
16	<i>Bombax-Ficus-Leucaena</i>	49,53	2	<i>Melia azedarach, Dalbergia sissoo</i>
17	<i>Ficus-Olea-Acacia</i>	17,18,22,24,25,26	6	<i>Grewiavillosa, Ficusracemose</i>
18	<i>Lannea-Bombax-Ficus</i>	21	1	<i>Pistaciachinensis</i>
19	<i>Pinus-Quercus-Abies</i>	35,36,37,38,39,40,41,42,43,82,83,84,85,86,87,88,89,90,91,92,93,97,107,108,109,110,111,112,115,11,117,118,119	33	<i>Prunus cornuta, Pinus roxburghii</i>
20	<i>Taxus-Abies-Pinus</i>	113,114	2	No associated tree species

In present study, above mentioned 20 tree communities were recognized by TWINSpan. On the basis of the details given above, it is possible to explain distribution and forests types in Upper Tanawal. The occurrence of large number of tree communities is due to restriction of only single plant habit and also we know that distribution of tree flora is low as compared to shrubs and herbaceous flora. The mosaics of species composition and community structure in any forest are governed by different environmental factors (Bajpai et al., 2012).

Altitude is one of the most important determinants of tree distribution due to its direct impact on micro climate of the habitat (Singh et al., 2009). In our study area, *Taxus-Abies-Pinus wallichiana* community was recognized from elevation of 2200-2300 m. Similar result was documented by Ahmed et al. (2006), who also reported *Pinus wallichiana* community from 2300 m elevation. *Pinus-Punica* community with 18 species were recognized by Khan et al. (2012), from Thandiani forests at altitude of 1412m while, in our study area at 1400 m *Ficus-Pinus* community was recorded with 14 species. The difference might be due to climate, aspect and slope angle.

The tree species such as *Abies pindrow*, *Rhododendron arboretum*, *Picea smithiana*, *Taxus baccata*, *Cedrus deodara* and *Quercus* spp were recorded rare. These natural forests were disturbed in the past by natural as well as anthropogenic activities as a result degrading rapidly. It is recommended that more quantitative study should carried out including health, disturbance, mature, over mature, and logged tree species to find out present status of these forest. This study will help to plan to conserve these natural forests of this region for sustainable use.

4 Conclusions

Pinus roxburgii was found to be most common tree species contributing to the formation and domination of the most forest communities moreover *Pinus wallichiana* can be good potential forest species if given proper regeneration and conservation at higher altitudes.

Pinus roxburgii and *Quercus* spp together play major associational role as they contribute as dominant and codominant species to about 25% of the total forest.

Taxus baccata is found in very minute quantities but it was recorded from interviewing that once it had been a common tree species in the area.

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