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VEGETATION CHARACTERISATION THROUGH PROFILE DIAGRAM, GREAT HIMALAYAN NATIONAL PARK, HIMACHAL PRADESH

Running title: Vegetation Characterization using Profile Diagram

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UNESCO's World Heritage Site Great Himalayan National Park Conservation Area (GHNPCA) is highly undulating and difficult terrain to cover by ground and hence along with Remote Sensing and GIS based study, an attempt was also made to study the structure of the vegetation through profile diagrams. Stratified random sampling was performed. Materials used mainly vegetation map, Survey of India maps, hypsometer, graph paper, measuring tape and graph paper. Size of plots was determined based on species area curve. Observations recorded for the months of May and November.

For each vegetation type a plot of 25×10 m was laid along the gradient. Sample Plot has been drawn on graph sheets at an appropriate reduced scale (1 mm = 20 cm). Slope was obtained using hypsometer. A total of 66 sample plots were laid. Of these 46 were in communities with trees and shrubs and 20 were for grasslands. The sub tropical ground flora is quite disturbed and subjected to grazing and fire. Under broad leaved forest, regeneration of Aesculus indica is quite good with the presence of different age group plants. Ground flora is very rich because of thick humus and moist conditions under Broadleaf Mixed with Conifers Forests. In Secondary Scrub; Eco-development zone, been put to lot of biotic pressure. Secondary scrubs are found intermixed with agriculture. A very interesting community of Viburnum was located on way to Maror from Shakti. Subtropical riverain forests have Alnus nitida groth in narrow belts.

Pure disturbed as well as undisturbed patches of Hippophae salifolia are found under Temperate Riverain Forest. Alpine Scrub, Betula utilis forms the top story, first story is formed by Rhododendron companulatum. On steep slopes extensive grasslands are there. Alpine grasslands are found mixed with alpine scrub. Terraces with orchards are very common sites under Habitation /Agriculture/ /Orchard**.** Rocks with scattered growth of grasses in alpine zone above tree line. The effort will be useful, for mounting an information base, which will enable conservation practices in future.

Keywords: Conservation, profile diagram, sample plot, vegetation.

1. Introduction

UNESCO's World Heritage Site Great Himalayan National Park Conservation Area (GHNPCA) is highly undulating and difficult terrain. The various landforms can influence a conservation area in many ways like slope gradient, elevation and aspect, affect the quantity of solar energy, water, nutrients and other materials, while the slopes affect the flow of materials. Slope is also the deciding factor of intensity of disturbance, such as fire and wind, which are strongly influenced by the presence of vegetation (Swanson et al 1988).

Landscape is the mosaic of landform, vegetation and landuse (Urban et al 1987; Noss, 1990; Kim and Weaver, 1994). Therefore, landscape ecology has emerged as an important discipline to study the landscape structure, its functions and changes. Each landscape is composed of several landscape elements, each of which has its own significance in the ecosystem and is important in evaluating the landscape structure (Oliver & Larson, 1990).

The range of Himalayan Mountains varies greatly in height, aspect and topography, thus creating wide variety of microclimatic conditions. Distribution of vegetation is governed by climatic, edaphic and topographic conditions. Fragile ecosystem in the Himalayan region needs protection from changes in land use patterns. Change in land use pattern influences the composition of surrounding vegetation. Introduction of exotic species, especially weeds, has influenced ground flora in the Indian subcontinent. Therefore, monitoring of vegetation composition becomes a quite important aspect in forest management.

Community is a local association of several populations of different species. Phytosociological studies have been done to characterize vegetation structure and composition. Composition of vegetation can be described by the number of species present in all growth forms in vegetation. Traditionally vegetation composition has been based on ground surveys and laying of transects along or across the gradients. Listing of species at each level is primary requirement to carry out primary and secondary analysis of vegetation. Structure of vegetation can be described as to how these species are arranged vertically or horizontally or occupy the speciesace in any ecosystem. Plants occupy various positions in the community to meet their requirements like sun illumination, moisture, nutrients etc. Such an analysis gives an idea about the ecological importance and role of the species in an ecosystem. As we all know the role of tree species in regulating the ecosystem is maximum mainly due to their long life and efficiency to accumulate biomass (forage as well as woody) for further use by animal and human beings.

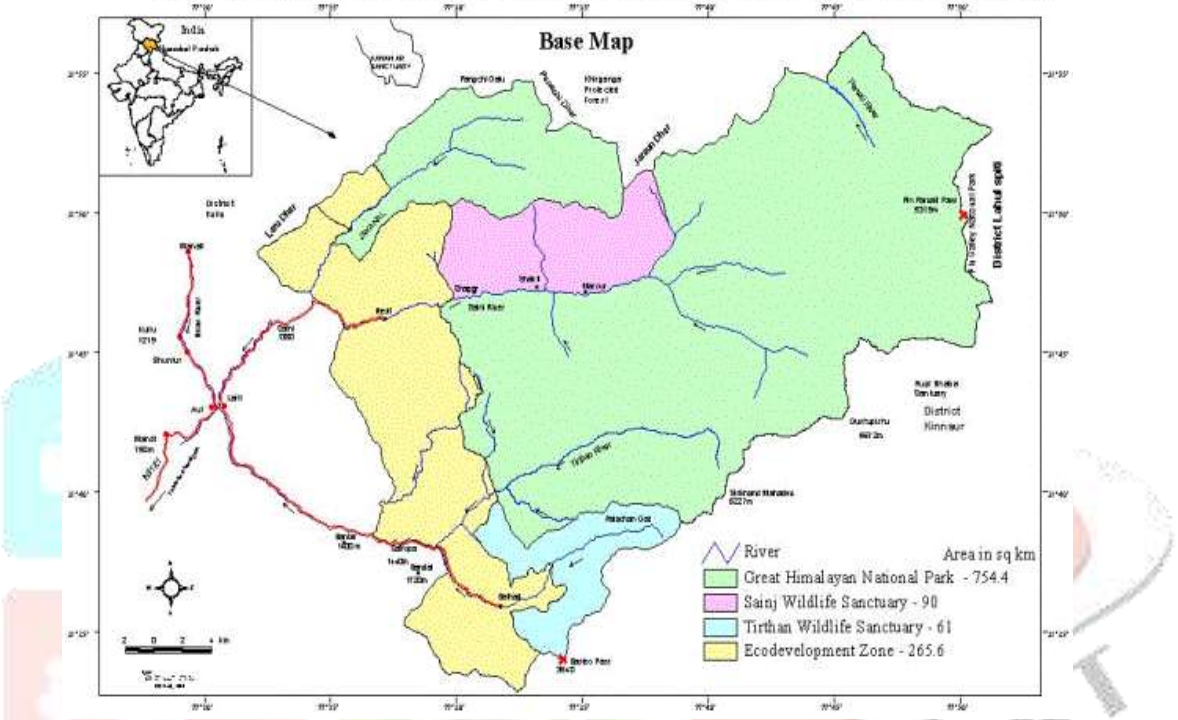
Advent of remote sensing has provided the possibilities to look at the spatial distribution and arrangement of plant communities. It also provides visualization of different physiographic and topographic variations of the terrain and thus facilitates such studies. Richards (1952) stressed the need to depict community structure in semi-schematic profile diagrams. In India, phytosociological studies using remote sensing have been carried out by, Roy, et al. (1992) in Andaman Islands, Singh (1993, 1994, 1995) in Madhya Pradesh and Sikkim Himalayas. Singh and Rawat, (1999) also studied the Floral Diversity and Vegetation Structure in Great Himalayan National Park, Western Himalaya. Variation in Vegetation Structure and Composition was studied byThrelfall et al. (2016) but the study was confined to the urban green spaceacross urban green space types. The vertical structure of one hectare of tropical rain forest was studied by Popma et al. (1988). Vegetation vertical complexity and species richness relationship was firstly conceived by (MacArthur and MacArthur (1961). They demonstrated through a positive relationship between foliage height diversity and bird species diversity. Afterwards many workers have studied on the importance of vegetation composition and structure for managed landscapes and natural taxas (e.g., White et al., 2005; Skowno and Bond, 2003). Naithani reported (2018) that sveral other scholars have also studied that vegetation communities are highly influenced by various topographical features (Puri 1950a; Roy and Jugran 1986; Warner 1991). Altitude as physiographic attributes, that have extreme impacts on the growth, distribution, structure, and form of tree species as stated by Wikum and Wali (1974). With slight change in altitude the topographic and climatic conditions differ as stated by Kharakwal et al., (2005). Not similar but species diversity of woody vegetation along altitudinal gradient of the Western Himalayas in Kedarnath Wildlife Sanctuary was also studied by Bhat et al. (2020).

Profile diagrams are one the best methods to provide visualization of different strata in the community and their spatial arrangements. This method of portraying the vertical vegetation stratification and structural association of plants provides immediate insight about the community. Community structure is depicted in three dimensions - height, depth (relative position) and crown cover.

2. Study Area and Approach

The study was conducted in Great Himalayan National Park Conservation Area (GHNPCA) in Himachal Pradesh Fig. 1.1. The GHNP encompasses nearly 1171 km2 area and lies between 310 33' 00" N to 310 56' 56" N lat. and 770 17" 15" E to 770 52' 05" E long. and altitude varies from 1344 to 6248 m. According to Biogeographic Classification; GHNP falls under north-western Himalayan biotic province i.e., 2A (Rodgers et al 2000). The fauna of the park comprises 31 species of mammals (Gaston and Garson, (1993); Vinod and Sathyakumar (1999), 183 species of birds Gaston et al (1993), Ramesh et al (1999), and more than 125 species of invertebrates Uniyal & Mathur (1999). The Great Himalayan National Park Conservation Area comprises of five sub units viz. Jiwa, Sainj, Tirthan, Great Himalayan National Park Protected Area and Ecodevelopment Area. Broadly, three season can be recognised for the park area viz. summer (April to June), Rainy (July to September) and winter (October to March).

Great Himalayan National Park Conservation Area (GHNPCA), Himachal Pradesh



In the present approach structure of the vegetation has been shown through profile diagrams. Stratification of vegetation provides the opportunity to go for optimum sampling. Stratified random sampling is cost effective method of vegetation sampling. Because of changes in micro-environmental conditions, sampling has been done at different places to assess the variability as far as possible.

3. Materials used

Materials required for studying the composition and structure are mainly vegetation map, Survey of India maps, hypsometer, graph paper, measuring tape and related stationery like graph paper.

4. Methodology

Vegetation map prepared through visual interpretation provided the locational and spatial information about the different major plant communities. For community analysis profile diagrams have been made. Keeping in mind the accessibility, time and representatives, sample plots of were laid in each vegetation type. Size of plots was determined based on species area curve. After a few trials it was decided that plot size of 25×10 m size would be appropriate for forested areas and 1 x 1 m for grasslands for depicting the variability in composition and structure within the community. Ground flora varies in different seasons. Observations recorded here are for the months of May and November.

For each vegetation type a plot of 25×10 m was laid along the gradient. Sketch or line drawing of each tree inside the plot has been drawn on graph sheets at an appropriate reduced scale (1 mm = 20 cm) or smallest division of graph sheet is equal to 20 cm. Tree diameter was taken using ruler. Slope of the plot was obtained using hypsometer. Branching patterns, relative horizontal location, crown size etc. have been depicted for each community type along the gradient. Canopy has been depicted to give an idea of the crown shape and closer. The illustration made in the field was then drawn on fair tracing paper for the

purpose of multiplication with appropriate scale. Species found in upper, middle, lower stories and ground flora have been listed. The plants which could not be identified in the filed were preserved and identified later using relevant flora and with the helps experts. Local names were also noted.

5. Information Collected

Following information were collected for each sample plot.

Vegetation type (community type), location (position), species name: trees, shrubs, herbs, climbers etc., slope (%), average tree of each canopy laye, circumference at breast height, aspect, ground flora (in May), crown diameter, altitude, climber, lianas etc.and phenological stage.

6. Laying of Sample plots

Vegetation of an area can be expressed qualitatively as well as quantitatively. Various methods like line transact, systematic sampling, point method etc. are employed to study the structure of the vegetation. Most of these methods are time consuming and not economical and some of them are generally attempted in smaller study areas. In the present investigation stratified random sampling has been done. Satellite data has been classified through visual interpretation as per the classification scheme based on the reconnaissance survey and land cover/land use classes in the area. Sampling was done on homogeneous units. Samples plots were laid along the gradient and reference to North direction has been provided. For structural analysis normally 20×20 m plots are laid for woody vegetation and 1×1 m for grasslands and same has been followed here. As far as possible representative sites were selected for this purpose and marked on SOI maps.

7. Results and Discussion

A total of 66 sample plots were laid in the covering all communities. Of these 46 were in communities with trees and shrubs and 20 were for grasslands. Following discussion is based on preliminary analysis based on the ground data collected and profile diagrams or illustrations made during the fieldwork.

(a) Chir Pine Forest: (Subtropical Pine Forest: Himalayan Chir Pine Forest, 9/C1b)

In the study area west and south-west has subtropical vegetation. Chir Pine (Pinus roxburghii) is the dominant forest species from Sai Ropa to Ghusaini and Southern ASPECTSin Tirthan Valley up to Kharongcha. Forest around SaiRopa on the hills is good to disturbed. In Sainj valley very good forest can be seen on both sides on slopes Shangarh. At few places towards Shangarh from Sainj these are mixed with other broadleaf species. The ground flora is quite disturbed and subjected to grazing and fire.

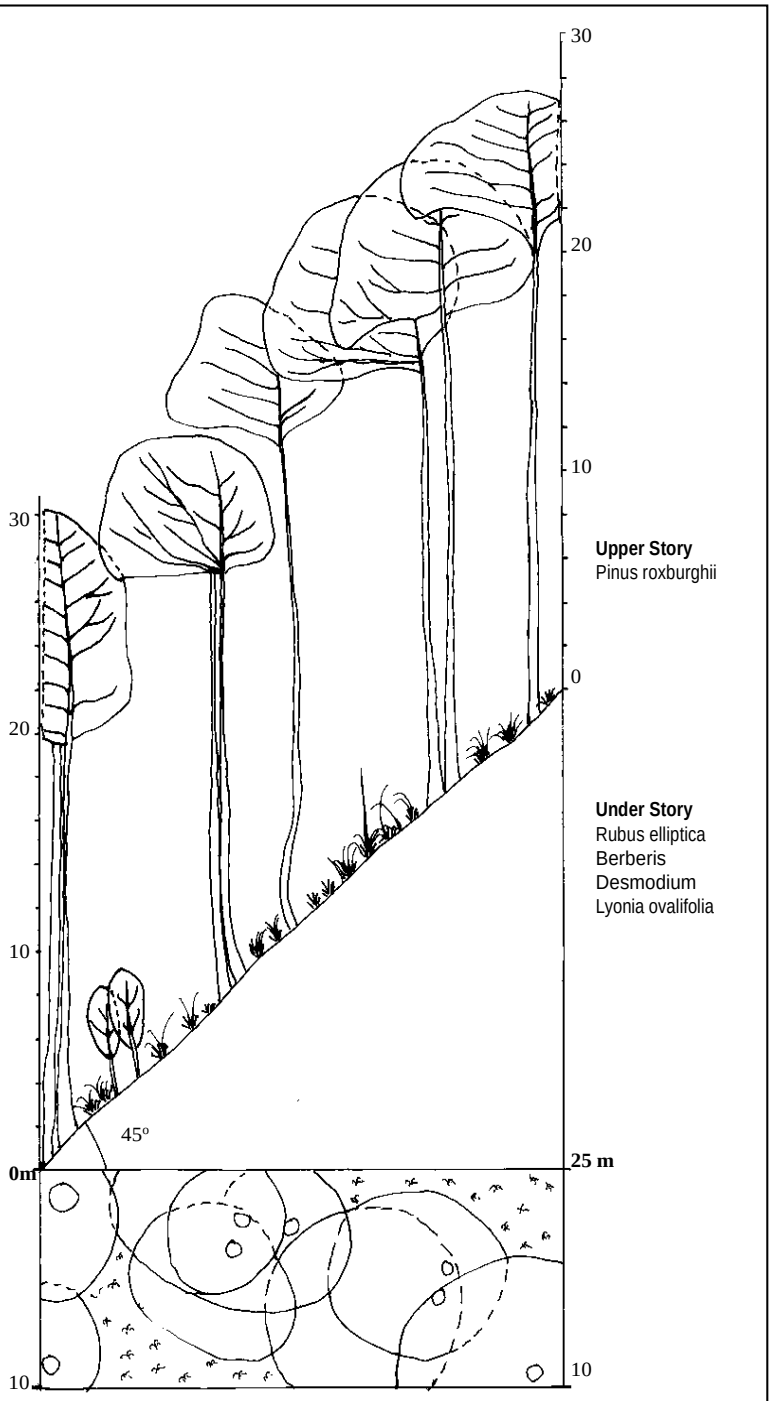


Fig. 1. Subtropical Chirpine Forest near Dewri village

The density of trees is very less on slopes of Tung village and slopes around Nevli. Biotic pressure is high on these forests. Following is list of the species occurring in subtropical pine forest, (Fig 1). Top story is of Pinus roxburghii. Upper and middle story is generally absent. Burnt stems of Pines indicate high disturbance due to frequent fires. Under stroey flora of shrub and herbaceous species is open to dense depending upon the biotic interference and boulders. Scattered shrub species like, Lyonia ovalifolia, Rubus ellipticus along with Berberis Species are the main species. Herbaceous plants include grasses and other common species.

(b) Broadleaf forest

Broadleaf forest of lower temperate and upper temperate vary in species composition. Lower temperate forests have Aesculus indica, Populus ciliata and Quercus dilatata as the top story trees. Rhododendron arboreum forms first story. Middle temperate boradleaf forests have trees of Acer species, Betula alnoides, Juglens regia, Prunus cornuta etc. Scattered trees of Taxus wllichiana occur in the lower story. Under story consists of plants like, Berberis, Impatiens, Strobilanthes, Polygonatum, Hedea etc. Regeneration of Aesculus indica is quite good as is evidenced from the presence of different age group plants (Fig 2).

Broadleaf forest of Kharsu Oak Forest (Himalayan Moist Temperate Forest: Upper Himalayan Western Forests, 12/C2a) occur in the upper reaches bordering alpine zone. Upper hills have very extensive stretches of "Kharsu" oak (Quercus semecarpifolia) and grow on very steep to almost cliff slopes especially along seasonal shallow streambeds. Upper story is of 20 m tall plants of Quercus semecarpifolia, and Acer caesium trees and can sometimes grow taller and share the top story and in lower ecotone zone Picea smithiana and Cedrus deodara are also found. Rhododendron arboreum and Acer caesium occupy lower story. Ground flora is relatively less thick and plants like, Carex, Polystichum aculeatum, Viola, Polygonum, Cheilanthes farinosa, Rosa sericea, Viburnum, Geranium, Podophyllum, Polystichum squamossus, Lonicera, etc. and young plants of Quercus semecarpifolia and Rhododendron arboreum (Fig. 3).

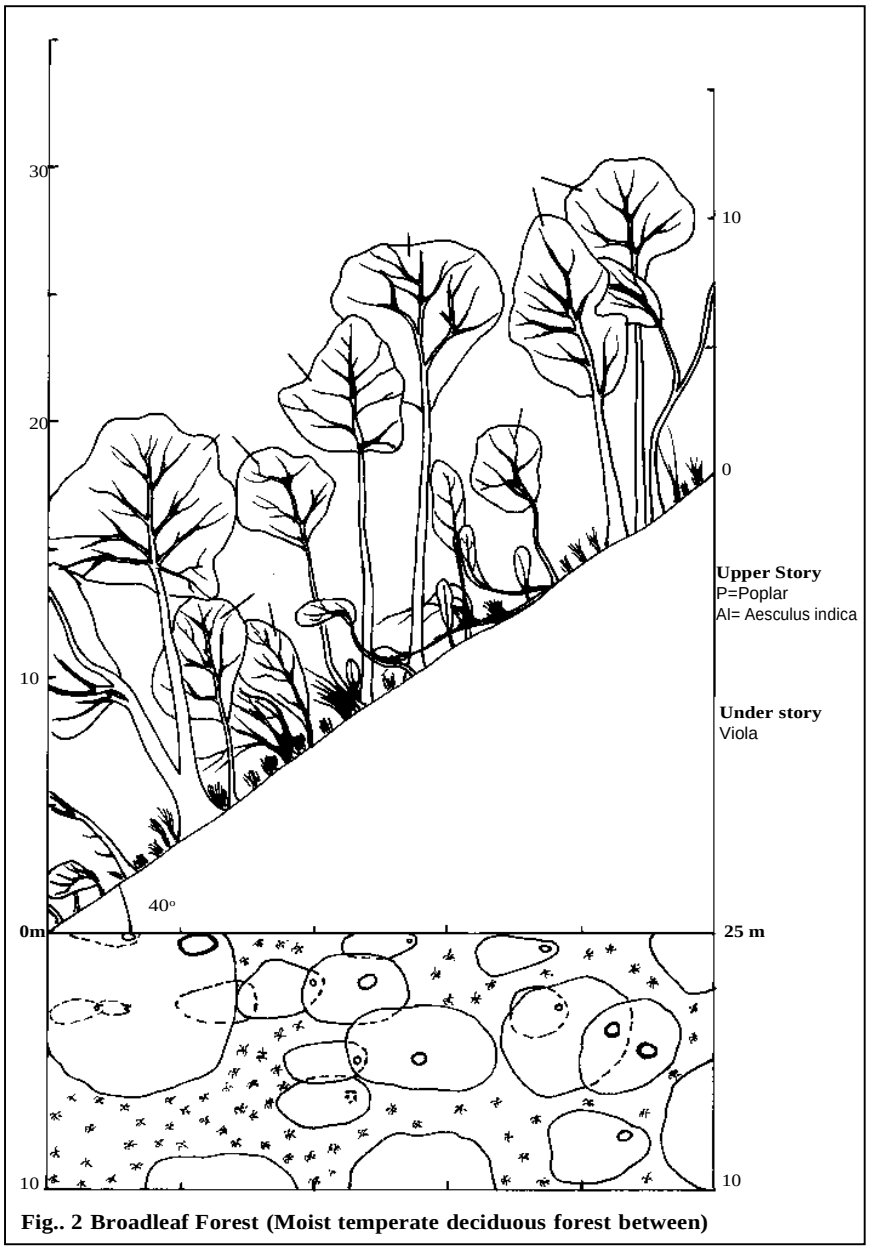


Fig.. 2 Broadleaf Forest (Moist temperate deciduous forest between)

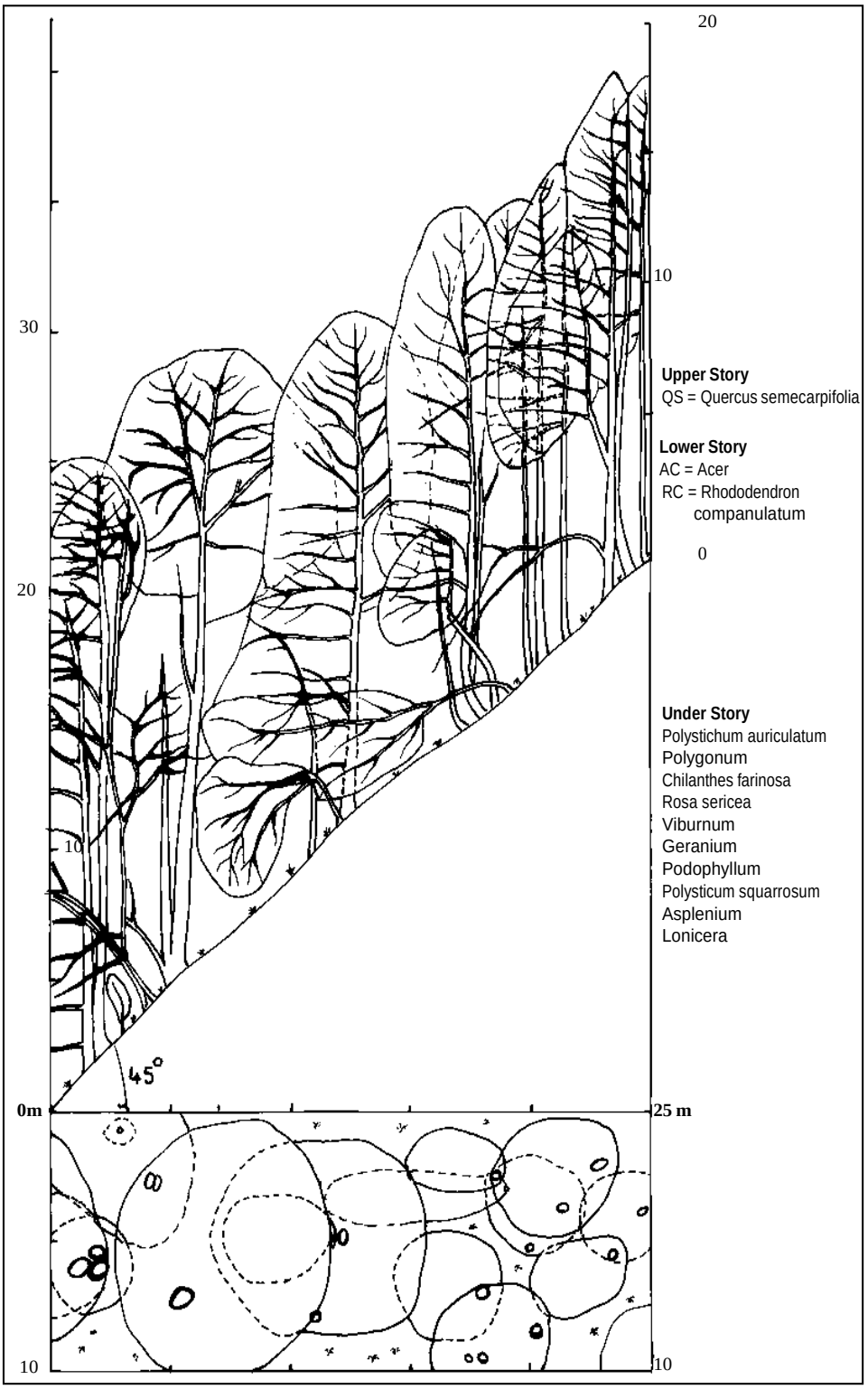


Fig. 3 Kharsu Oak Forest near Shilt

(c) Broadleaf Mixed with Conifers Forests: (Broadleaf mixed with conifer)

Mixed coniferous forests occupy relatively large areas and mixing of broadleaf and coniferous plants occurs. Top canopy is occupied by Abies pindrew, Aesculus indica and Aesculus indicia. Very tall trees of Abies pindrew grow mixed with Aesculus indica. Abundance of Aesculus indica is more and middle aged trees of this occupy the middle storys. Other species which are mixed share top canopy or upper story are Prunus cornuta, Juglens regia, Picea smithiana etc. Ground flora is very rich because of thick humus layer and moist conditions and consists of Polystichum, Hedera helix, Impatiens, Gallium, Adiantum, Urtica, Coniogramme fraxinea, Dryopteris species., Cyrtomium species., Aspeciesaragus species., Vitis species., Pteris cretica, Daphne papyracea, Clematis, Houtainya cordata, Calanthe, Pieris polyphylla, Smilacina etc. A clump of bamboo is also recorded. There are a few dead trees (top part missing), (Fig 4).

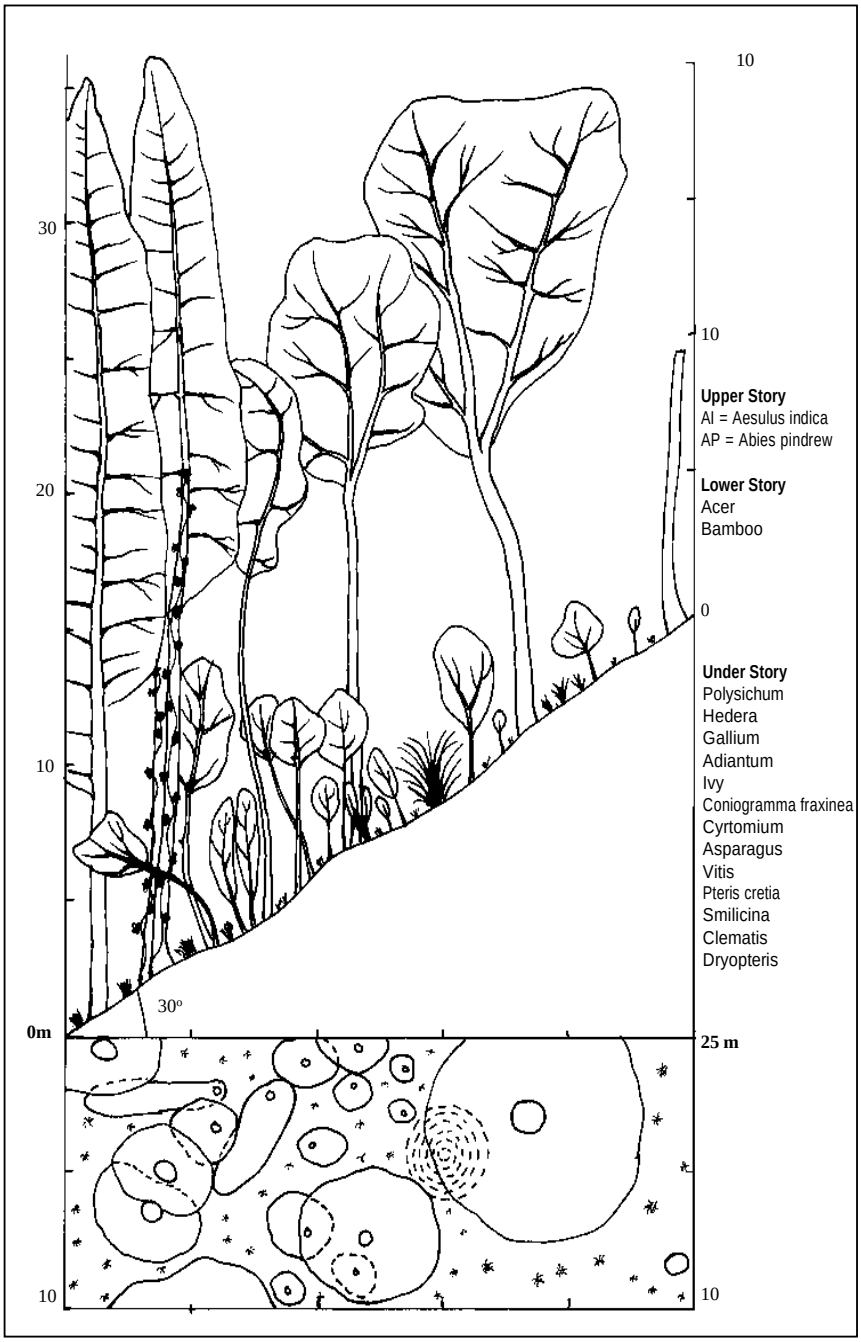


Fig. 4. Broadleaf Mixed Coniferous Forest near Rolla

(d) Mixed Conifer: (Temperate Coniferous Forest)

Park has very extensive stretches of coniferous forest and play a very important role in the temperate ecosystem and grow on steep slopes. Phytodiversity of these forests is very high. Dominant species are Cedrus deodara, Abies pindrew, and Pinus wallichiana, which form the top story, and trees up to 35 m tall can be seen. Huge trees of coniferous plants occur in the conservation area. At places these mixed with other

plants like Acer acuminatum, Picea smithiana and form the first story. Lower story is of Taxus wallichiana, Acer species and Rhododendron arboreum. In the under story species like Pteridium aquilinum, Geranium, Rubus ellipticus, Ranunculus, Dryopteris, Viola, Podophyllum emodi, Acer, Aspeciesaragus, Indigofera, Hedera helix, Rubia, Diplazium maxima, Carex, Impetiens, Fragaria vasca, Oplismensu compositus etc. In shaded area the ground flora is very rich whereas drier southern slopes have less ground flora. Pteridium acquilinum is indicator of the disturbance in these forests. Occurrence of Podophyllum is important. Plants of Podophyllum are very rare. These forests do not have thick shrubby middle layer and look cleaner. Rhododendron arboreum forms the lower story, Fig 5 and Fig. 6.

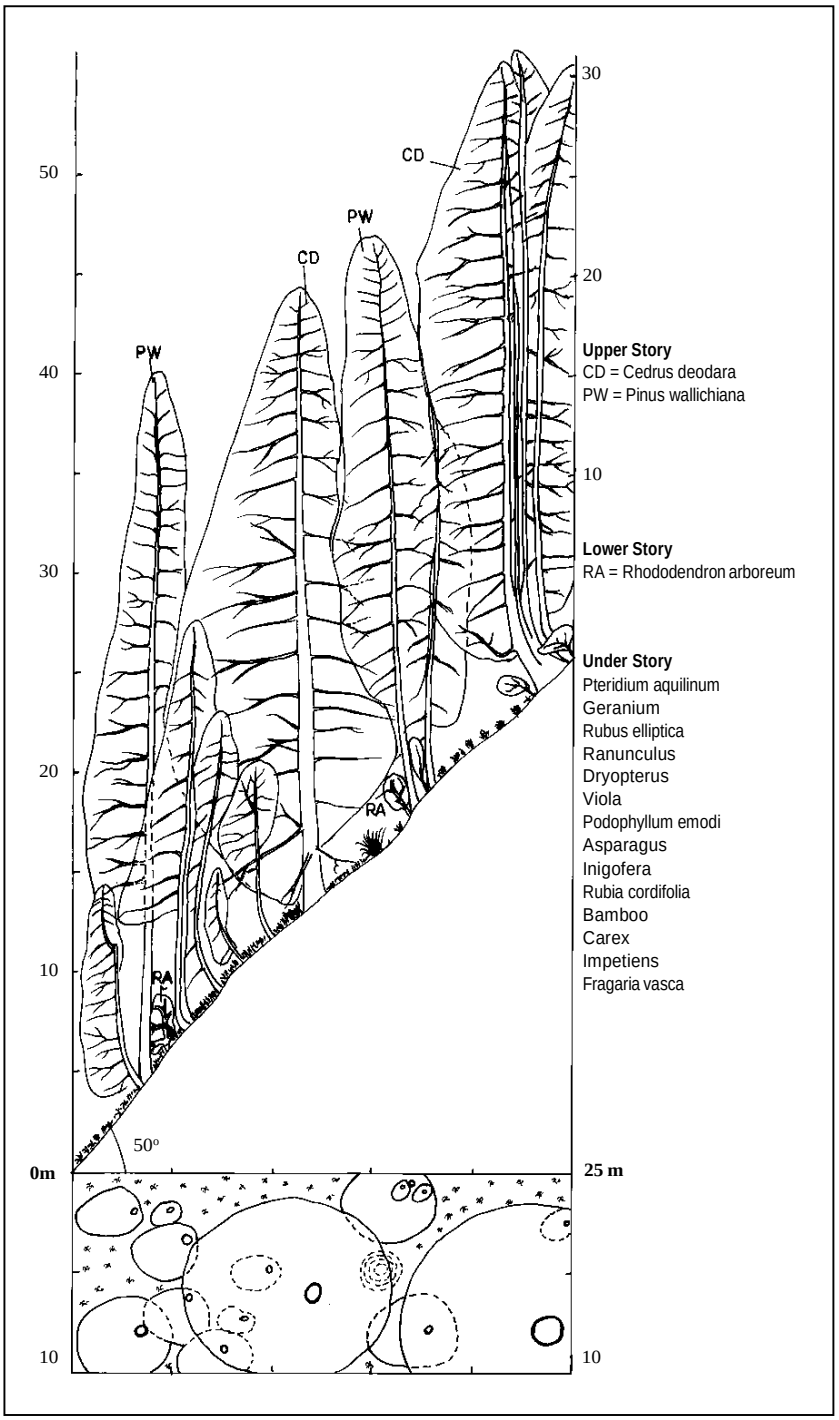


Fig. 5 Temperate Conifer Mixed near Shilt

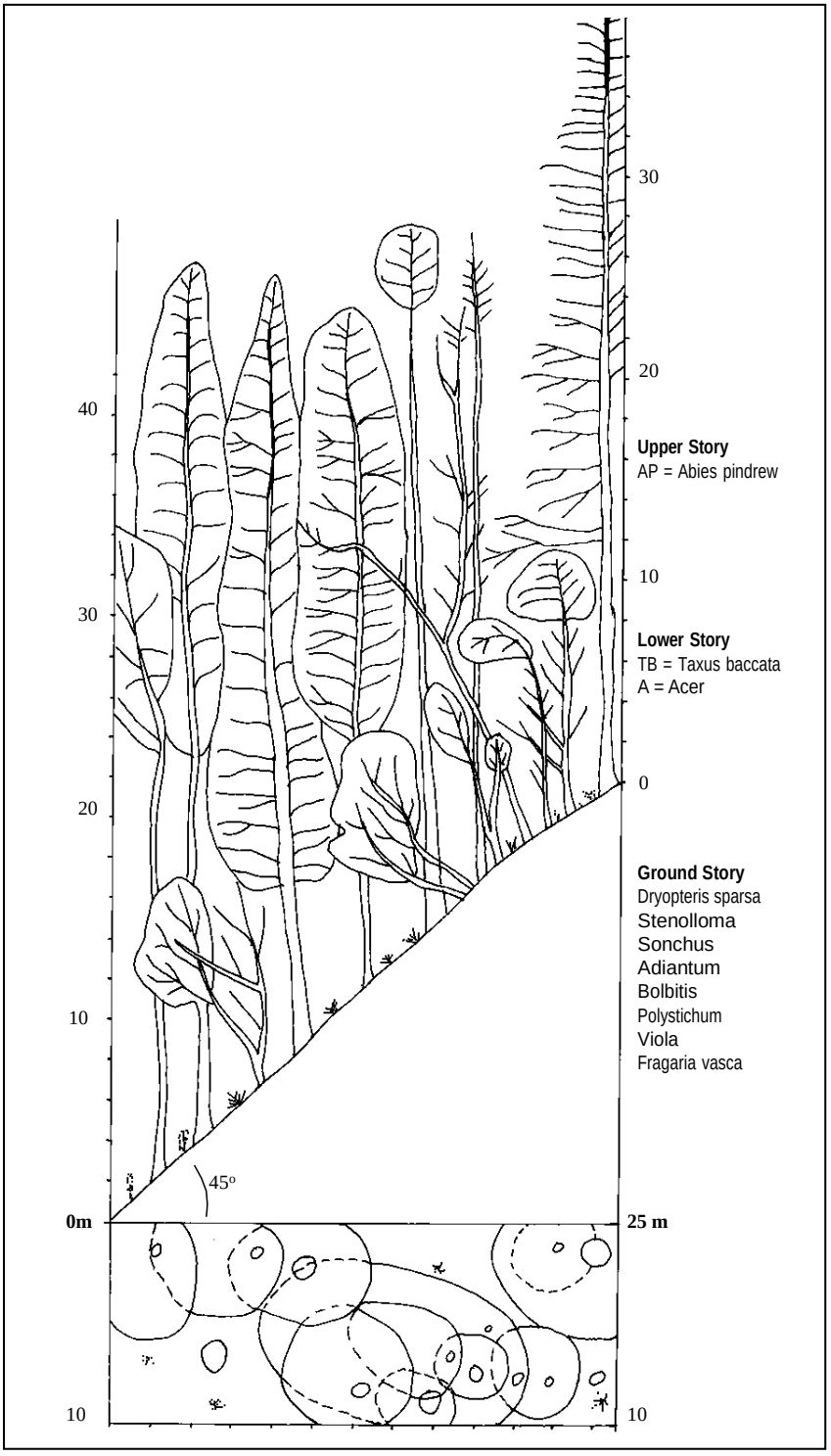


Fig. 6 Temperate Conifer Mixed with Broad leaf near Galiyar

Pure formations of Cedrus deodara are found around Shilt and above Shangarh, around Hemkhundi Thatch and between Shakti and Maror. Wild monkeys were sited in coniferous forest near Maror (Fig. 7).

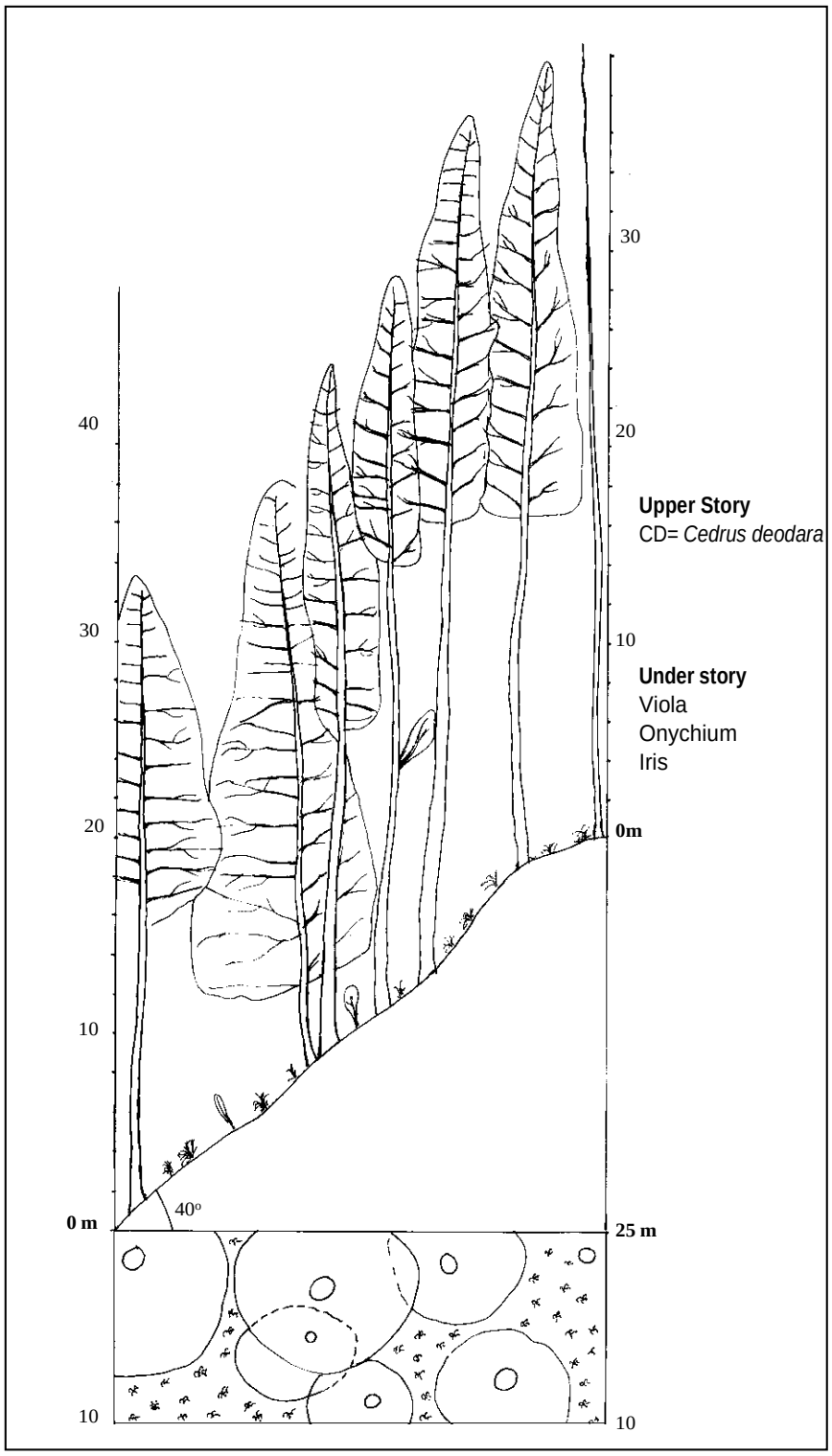


Fig. 7 Deodar (*Cedrus deodara*) Forest near Shangad

(e) Conifers Mixed with Broadleaf Forest

Coniferous trees are more in proportion than broadleaf trees. This type of mixed can be seen after Shangarh towards Lappa. Coniferous trees of Cedrus deodara, Picea smithiana, Pinus wallichiana, Taxus wallichiana etc. form the top story. Intermixed with these are species of Acer, Prunus etc. Ground story is more like that of broadleaf mixed with coniferous forests.

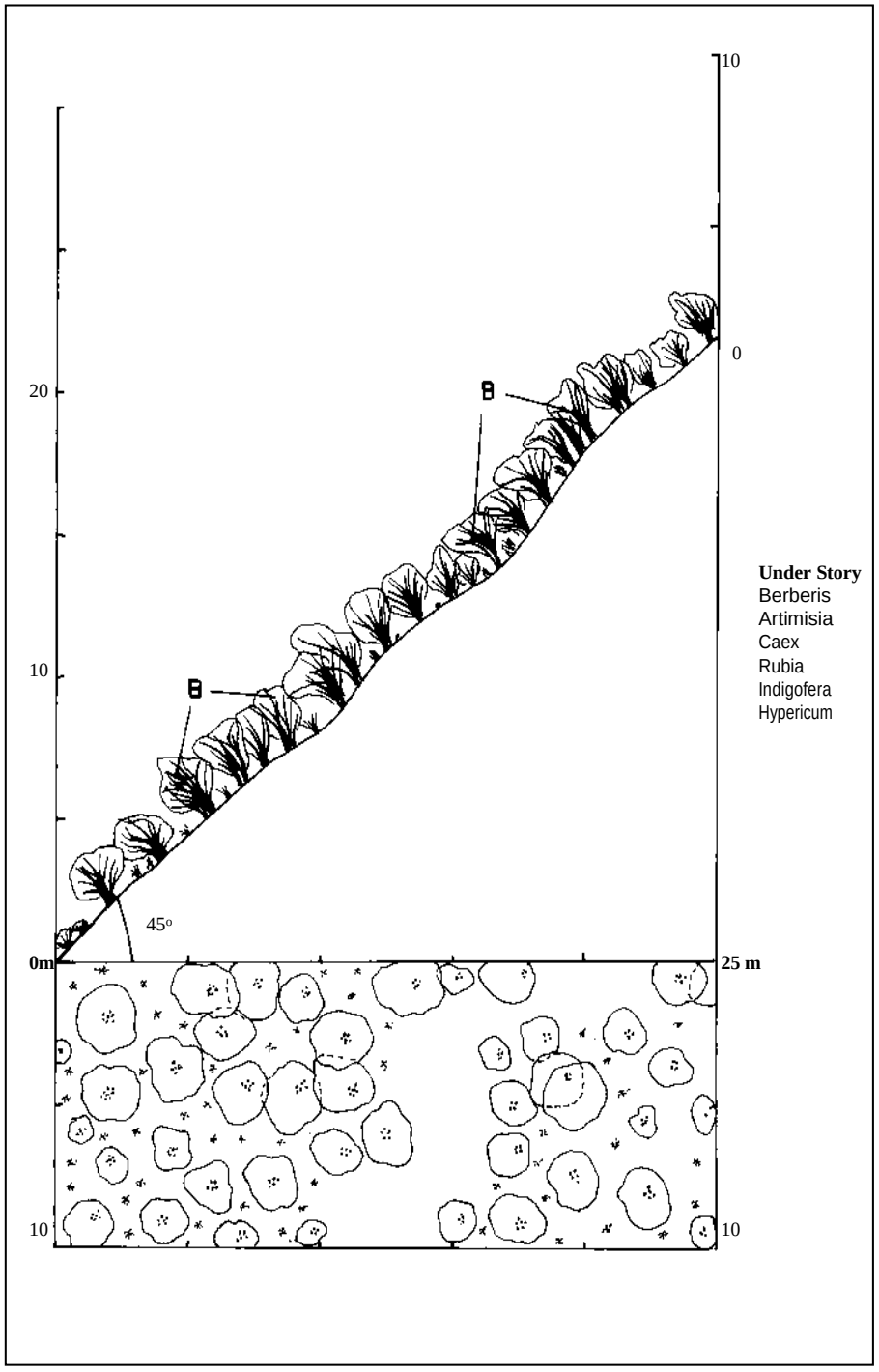


Fig. 8 Himalayan Temperate Scrub

(f) Secondary Scrub: (Himalayan Temperate Parklands, 12/DS2)

In Eco-development zone southern slopes have long been put to lot of biotic pressure. Secondary scrubs are found intermixed with agriculture. Scrubby one has replaced original vegetation. Berberis species forms the top story. Artimisia, Carex, Hypericum, Rubia, Indigophera etc. are other plants, which form the ground flora elements. Occasionally scattered trees of Pinus wallichiana are also seen, (Fig .8).

(g) Viburnum Scrub:

A very interesting community of Viburnum was located on way to Maror from Shakti. A more or less pure formation of Viburnum Grandiflorum Patch is quite dense and pants are up to 5 m tall.

(h) Subtropical Riverain Forest

Even though the valleys are narrow, riverbed at some places is quite wide. These riverbed and side slopes have different species composition. These are the formations of riverain forest. Two types of riverain forests have been located in the study area. Subtropical riverain forests have Alnus nitida and grow in narrow belts. Since these are very narrow and were under shadow on satellite data therefore could not be delineated. These are found in the riverbeds quite frequently from Ghusaini to Bathad and up to Rolla speciesecially at the bends of rivers. In Sainj Valley riverbeds of Nevli and towards Baha areas have these types of forests. Good forest of this type can be seen along Rupa nala and Sainj River. Dela Khad after Lappa has moderately less disturbed forests of Alnus nitida, Celtis tetrandra, Pyrus species etc. Girardinia diversifolia, Diplazium esculentum etc. very common and grow abundantly. (Fig .9)

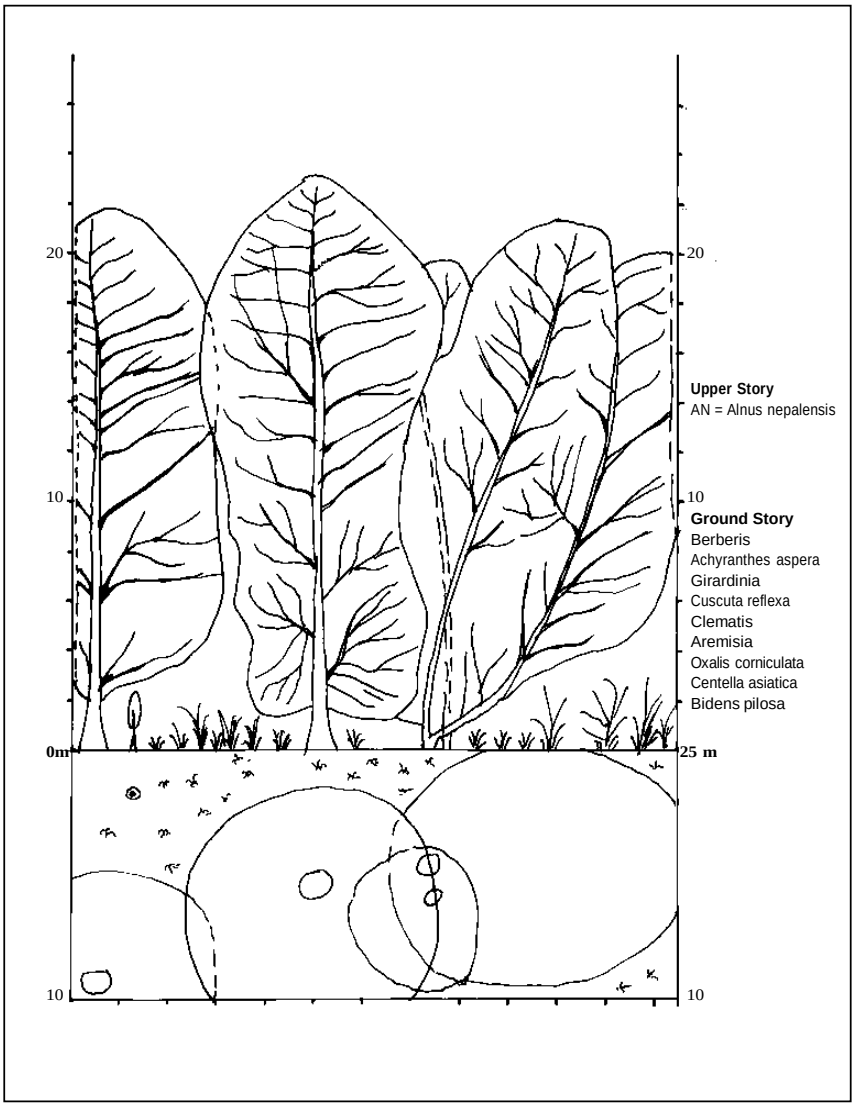


Fig. .9 Subtropical Riverain Forest near Ghusaini

(i) Temperate Riverain Forest (Hippophae Scrub)

Pure disturbed as well as undisturbed patches of Hippophae salifolia are found around Shakti village. These found along the riverbed either on little elevated land or quite close to water. Trees are up to 8 m tall. Top canopy is Hippophae salicifolia (about 5 m tall). Presence of Girardinia diversifolia and Cannabis sativa indicates biotic disturbance. Epiphytic fern Pleopeltis is found in these patches. Other associates are Sorberia tomentosa, Rosa webbiana etc. Species found are listed in table below.

The inner Himalayan region in the Sainj valley important and unique formations along the riverbed is found. These are temperate riverain forests and are found in patches about 2 km before the Shakti to 5 km after towards Maror.

(j) Alpine Scrub: (Birch-Rhododendron Scrub Forest): (Dwarf Rhododendron Scrub)

Above the tree line occurs dwarf vegetation formed by Rhododendrons and Betula utilis. These are thick sometimes-impenetrable areas bushy vegetated areas. Betula utilis forms the top story and first story is formed by Rhododendron companulatum. Because of the pressure from snow most of the plants are bending towards down slope. Ground flora is mainly of Rhododendron anthopogon, Rosa webbiana, and young to middle aged Rhododendron companulatum plants. Ground flora is mainly of species of Primula, Potentila etc. (Fig.10 and 11).

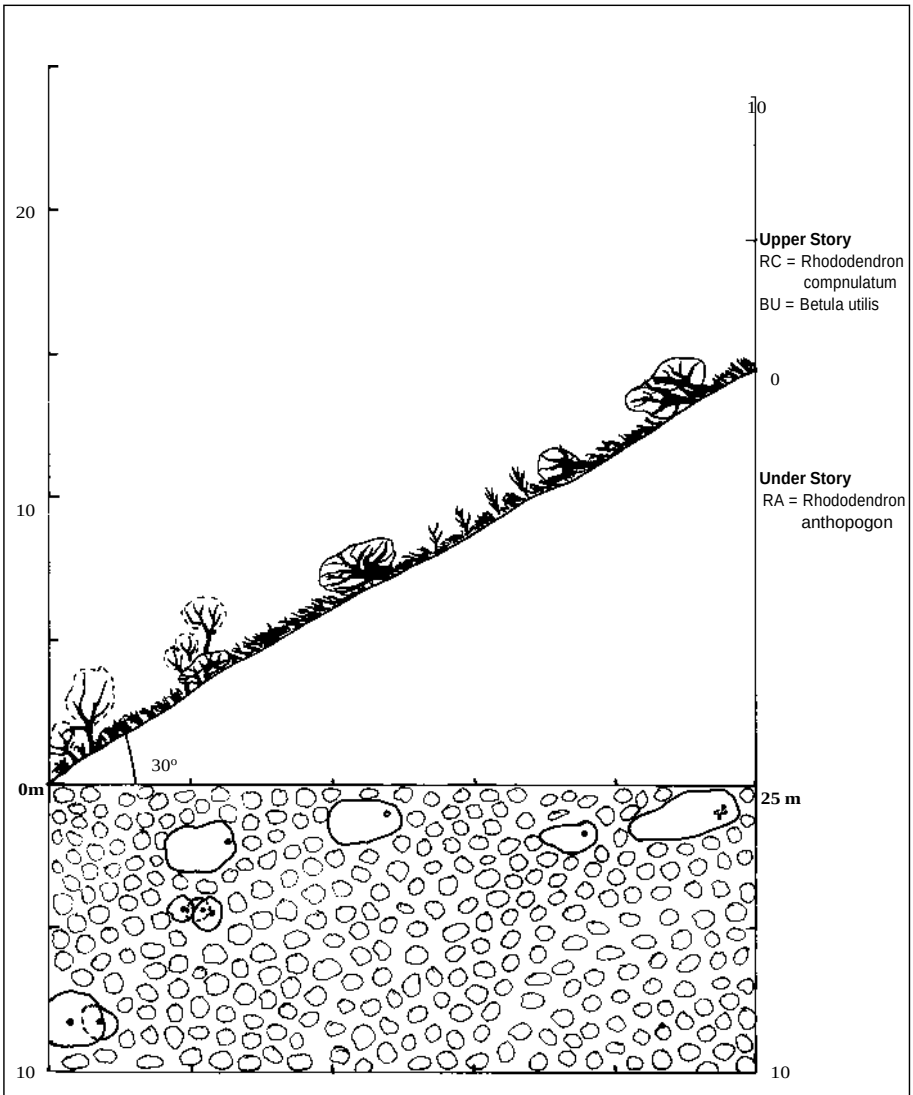


Fig.. 11 Betula-Rhododendron Scrub after Rukhundi top towards Gumtrao

(k) Alpine Scrub (Deciduous Scrub)

Alpine scrub is mainly dominated by Rhododendron companulatum and Rhododendron anthopogon. These bushes can grow up to 4 m tall. Stems are much branched and slanted because of the pressure of snow i.e. adaptation to snow. The branching is very profuse and almost difficult to negotiate. Good formations can be seen Around Dhela Thatch, Gumtrao and Rukundi top in small patches around Basleo pass. These are more or less pure formations, however sometimes Betula and Quercus trees might occur, (Fig 12).

(l) Slope Grasslands

On steep slopes around Shakti and upper reaches of Tirthan and Palachan Gad have extensive grasslands. The terrain is rugged and steep. Grass plants of Themeda triandra, Oplismenus, Agrostis etc.and other plants like Aster, Cheilanthes farinosa, Sedum, Colebrookia oppositifolia etc. occur intermixed.

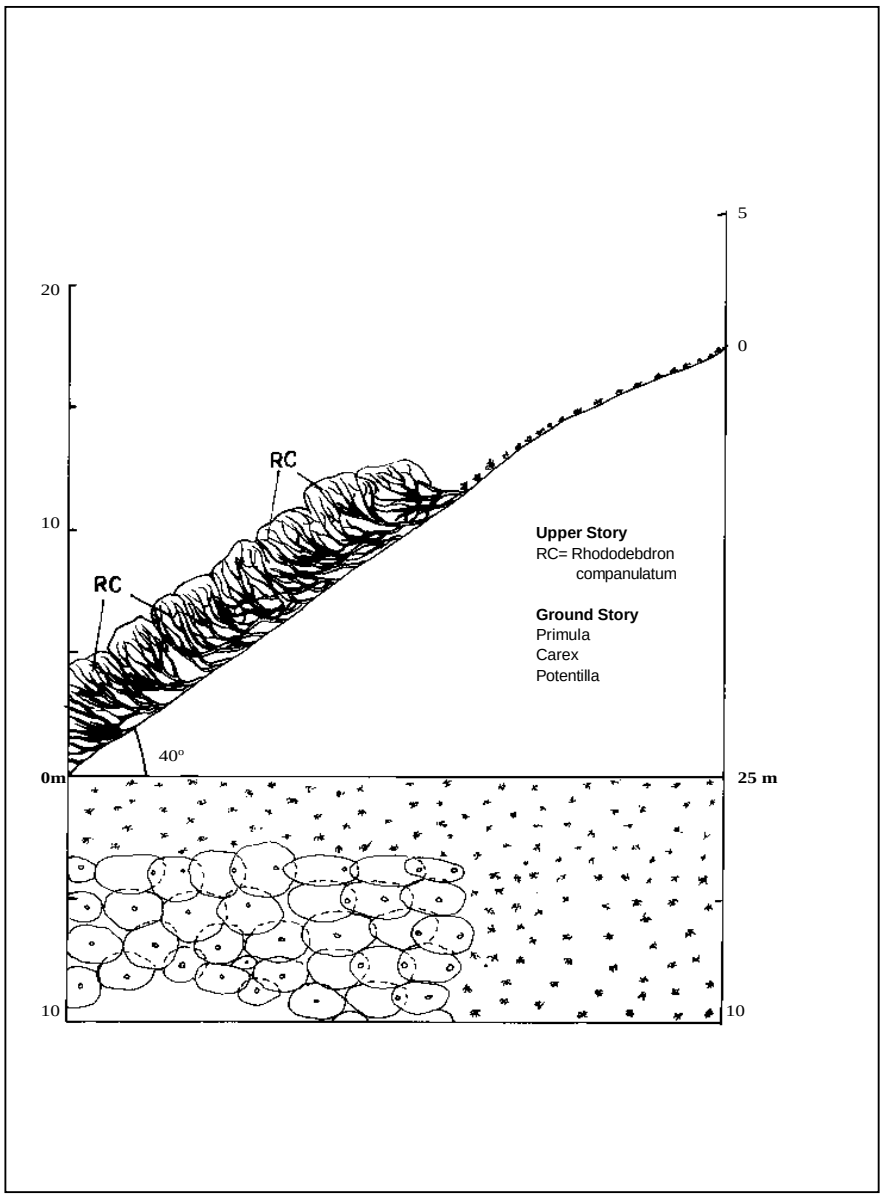


Fig. 12 Alpine Scrub and Alpine Grassland near Gumtrao

(m) Grasslands /Blanks/Alpine Pastures

Grassland may be very extensive as well as small as forest blanks. In forest blanks these are the camping sites of shepherd. Alpine grasslands commonly known as "thatch" are found either growing extensively or mixed with alpine scrub of Rhododendron on relatively protected slopes. Various species of Primula, Potentilla, Carex, Gentiana, etc. found abundantly. Grasslands near Chipni are quite extensive and used by villagers for grazing and fodder. Near Gumtarao these are the habitats of wild animals like Musk Deer (Fig 13).

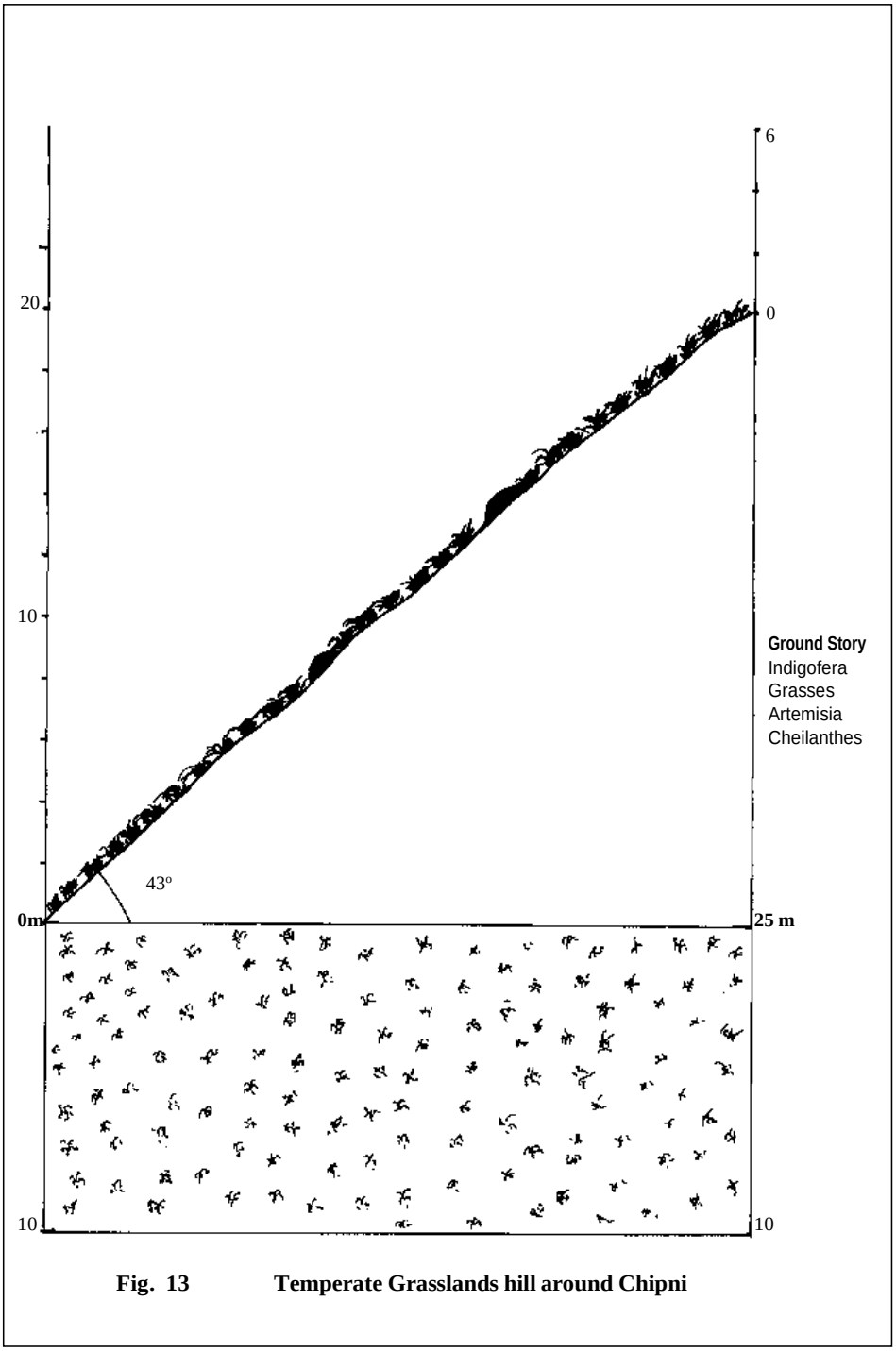


Fig. 13 Temperate Grasslands hill around Chipni

(n) Habitation /Agriculture/ /Orchard (Apple Orchards)

Himachal Pradesh has found tremendous potential in horticultural crops. Apple orchards are everywhere and have become a 'big' source of income. Terraces with orchards are very common sites. Indigenous plants grow only on bunds and along nala or streams. Iris species is most commonly found. In

agroforestry practices Pyrus malus (apple) and peach are grown along with various cereal crops like, wheat, maize, Elucine corcana, paddy, 'karnkhan' etc., (Fig. 14).

(o) Exposed Rocks with slope Grasses

Rocks are covered with scattered growth of grasses. Found in alpine zone above tree line. Themeda triandra, Oplismenus compositus, Agrostis species etc. are the grasses found in these slope grasslands.

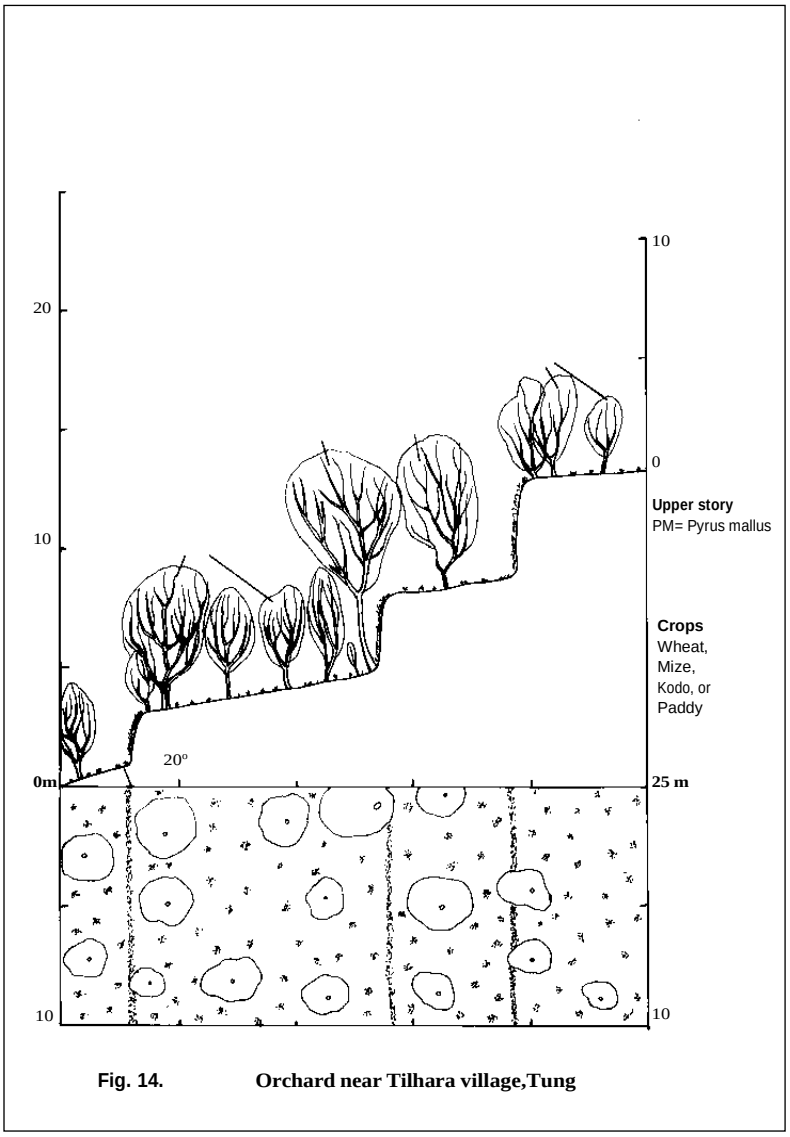


Fig. 14. Orchard near Tilhara village,Tung

Conclusions

The mountains play important role in the Himalayas in relation to biodiversity. The present study was carried out to assess the variation in vegetation charaterisation along the altitudinal gradient in a part of Western Himalaya. The vegetation structure according to the altitudes fix the priority and future distribution of habitats for the animals. Diversity in the forest support more diverse animal communities. The Wildlifers and Forest Managers might get benifited thorugh this study to locate sites for regeneration and sustainable forest management together with conservation actions. So, it is prerequisite to preserve the forests strata to ensure conservation of wildlife habitats.

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