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High Altitude Forests in a Part of Kumaun in Central Himalaya : Analysis along Altitudinal Gradient

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Seven forest types viz. *Quercus leucotrichophora*; Rhododendron - dominated; *Pinus roxburghii*; *Quercus lanuginosa*; Oak - mixed; *Quercus semecarpifolia* and sub-alpine forest were identified along an altitudinal gradient of 1600—3100m in Kumaun Himalaya. In terms of basal area, density and diversity these forests fall within the range of moist temperate forests of Central Himalaya. The polar ordination of forest stands suggested a continuous intergrading of forests along the altitudinal gradient.

Key Words: Composition, Importance value, Ordination, Forest continuum

Introduction

Altitude represents a complex gradient in a mountainous region (Druitt et al. 1990), along which the abundance of a particular species and composition of a community change continuously. Much information exists on vegetation description along altitudinal gradient outside India (Whittaker 1960, Beals 1969, Hamilton 1975, Baruch 1984, Druitt et al. 1990) but only a few (Singh & Singh 1987, Tewari et al. 1989) reports are available for India. Particularly there is a lack of information on the analysis of vegetation above 2500m (Kalakoti et al. 1986, Adhikari et al. 1991). The present study provides a description of forest vegetation along an altitudinal gradient in hitherto less known high altitude zone of Kumaun (Central Himalaya).

Material and Methods

Study Area

The study area (30°2′ - 30°9′N and 79°55′ - 80°2′E) is situated in the upper reaches of Sarju catchment in the Western section of Greater Himalaya in Kumaun and ranges from 1600-4000m in altitude (figure 1). The area falls with in geomorphologically immature and tectonically active segment. Geologically, it comprises metasedimentaries of the lesser Himalayan autocthon in southern part and metamorphic rocks of the central crystallines of Gansser in north (Valdiya 1980).

Climate is cold temperate. Winter extends from October to March with heavy snowfall. Summer begins with moderate rise in temperature in April- May. Heavy monsoon rainfall occurs in July to mid September. The meteorological data obtained from comparable altitude, Munsiari (2250m), indicate that the mean monthly maximum temperature ranges from 12°C in January to 26°C in June, mean monthly minimum temperature varies from -1°C (Dec., Jan.) to 12°C (June). The annual average rainfall is 1959 mm, of which more than half occurs during the rainy season.

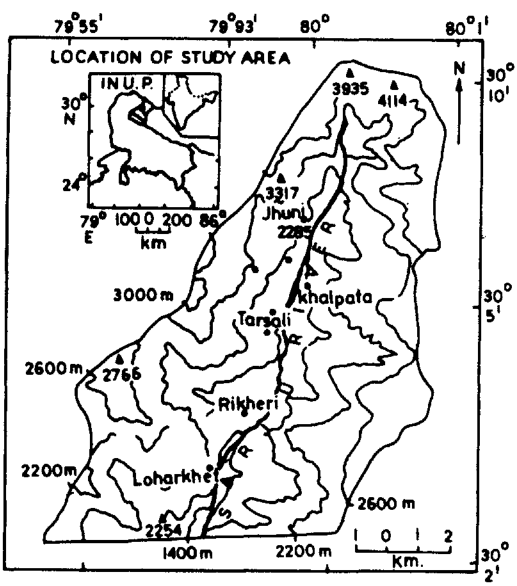

Figure 1. Map of study area (countours at 400 m interval)

Methods

Each of the fifty-one forest stands were analysed through ten, 10 x 10m quadrats located on varying aspects and altitudes. Care was taken to sample the most representative area for vegetation. Each quadrat was subdivided into four (5 x 5m) sample plots for examining shrubs, saplings and seedlings.

Circumference at breast height (cbh at 1.37m height from the ground) was measured for tree species. Individuals 31.5 cm cbh were considered trees, 10.5 - 31.5 cm cbh as saplings and 10.5 cm cbh as seedlings. A shrub was considered a phanerophyte with many branches from the base of stem. In the case of clumped shrub species (e.g. Himalayan bamboo), each culm was considered an individual plant.

Calculation of various quantitative measures such as density, frequency, basal area, importance value index (IVI), and diversity index (H') etc., were made following Saxena and Singh (1982). The polar ordination method described by Bray and Curtis (1957), with appropriate modifications suggested by Mueller-Dombois and Ellenberg (1974), was used to interrelate the vegetation samples.

As the upper limit of forests in this area was around 3100m, the study was confined within the altitudinal range of 1600-3100m.

Results and Discussion

Reconnaissance survey of vegetation revealed the presence of following overlapping forest types : *Q. leucotrichophora* (1650-1825m), *Rhododendron* - dominated (1800-2025m), *Pinus roxburghii* (1700-2050m), *Q. lanuginosa* (1875-2100m), Oak-mixed (2050-2625m), *Q. semecarpifolia* (2500-2875m), and sub-alpine (2800-3100m). The communities were named by their dominant tree species except for the subalpine forest where nomenclature follows Champion and Seth (1968).

Composition of Forests

The floristic composition of identified communities was as follows:

Quercus leucotrichophora *forest*: Besides the dominant canopy species, *R. arboreum*, *Lyonia ovalifolia* and *Neolitsea pallens* were dominant under - canopy species. *Arundinaria falcata*, dominated the shrub layer. Other important species of the shrub layer were - *Berberis asiatica*, *Boenninghausenia albiflora*, *Daphne papyracea*, *Cotoneaster bacillaris*. Notable ground layer species are - *Elatostemma sessile*, *Pilea scripta*, *Lecanthus peduncularis*, *Bupleurum hamiltonii*, *Valeriana jatamansi*, *Pteris cretica*, *Adiantum venustum*, *Onyahium contiguum*, *Pteridium aquilinum* var. *wightianum*.

Rhododendron *- dominated forest*: Besides the dominant *R.arboreum*, a second storey species, the other important tree associates were — *Betula alnoides*, *Lyonia ovalifolia*, *Acer cappadocicum*. Shrub layer - dominated by *Arundinaria falcata* had other associates like

Indigofera gerardiana, Prinsepia utilis, Pyracantha crenulata, Rhamnus virgata, Berberis asiatica were other. Except for *Anemone vitifolia, Thalictrum foliolosum, Geranium wallichianum, Dryopteris juxtaposita, D. chrysocoma, Polystichum squarrosum,* the other ground layer species were same as for *Q. leucotrichophora* forest.

Pinus roxburghii *forest*: Besides *P. roxburghii* accounting for 87.0 — 97.0% the other tree associates were Q. leucotrichophora, R. arboreum, Rhus wallichii etc.; shrub layer was represented by *Berberis asiatica, Woodfordia fruticosa, Artemisia nilagarica, Glochidion velutinum* were important species. Notable ground layer species were — *Themeda anathera, Chrysopogon gryllus, Origanum vulgare, Micromeria biflora, Anaphalis busua, Dryopteris cochleata* and *Athyrium pectinatum.*

Quercus lanuginosa *forest*: Dominance of *Q. lanuginosa* in the tree layer was followed by *R. arboreum* and *Q. floribunda.* Shrub layer was dominated by *Arundinaria falcata* alongwith *Boenninghausenia albiflora, Artemisia nilagarica* and *Cotoneaster bacillaris.* The ground flora resembled that of *Q. leucotrichophora* forest; the major species were : *Fragaria nubicola, Elatostemma sessile, Bupleurum hamiltonii, Onychium contiguum, Pteris cretica, Dryopteris juxtaposita,* and *Adiantum venustum.*

Oak-mixed forest: The dominance of the tree layer was shared by *Q. floribunda, Aesculus indica, Juglans regia, R. arboreum,* and *Lyonia ovalifolia.* Dominant species of the shrub layer were - *Arundinaria falcata, Berberis asiatica, Sarcococca saligna* at lower reaches, and *Chimonobambusa jaunsarensis* and *Thamnocalamus spathiflora* on upper reaches. Ground flora included : *Carex cruciata, Viola canescens, Ainsliaea aptera, Geranium wallichianum, Agrimonia eupatoria, Cheilanthes dalhousiae, Pteris cretica, Athyrium schimperi,* and *Polystichum squarrosum.*

Quercus semecarpifolia *forest*: *Quercus semecarpifolia* was the dominant tree species. *R. arboreum, R. barbatum, Viburnum grandiflorum,* were the other common associates. *Thamnocalamus spathiflora, Chimonobambusa jaunsarensis, Berberis umbellata* were common in the shrub layer. Ground layer species were - *Senecio rufinervis, Polygonum amplexicaule, Anemone rupicola, Potentilla fulgens, Anaphalis nepalensis, Dryopteris wallichiana, D. pulcherrinumrima, Asplenium trichomanes,* and *Osmunda claytoniana.*

Sub-alpine *forest*: *Betula utilis, Pyrus foliolosa, Q. semecarpifolia,* and *R. campanulatum* were the principal tree species. *Thamnocalamus spathiflora* dominated the shrub layer. Other notable shrubs were - *Berberis spp., Ribes spp., Salix spp., Cotoneaster microphylla, Lonicera spp.* Ground flora consisted of - *Ligularia amplexicaule, Potentilla argyrophylla, Senecio chrysanthemoides. S. grandiflora, Leontopodium himalayanum, Danthonia cachmeriana, Dryopteris barbigera, Osmunda claytoniana, Polystichum bakerianum, P. prescottianum, Asplenium viride.*

The total tree basal area of forests ranged from 31.3 to 81.4 m^2ha^{-1} and total tree density from 430 to 580 tree ha^{-1} (table 1). These values fall within the range (basal area: 30.2— 83.8m^2ha^{-1}; tree density: 420—1300 tree ha^{-1}) reported for moist temperate forests of Kumaun (Saxena & Singh 1982). Seedling and sapling density remained low throughout the area, evidently indicating poor regeneration of trees in this zone. The adverse environmental conditions (heavy snow accumulation in winter) accompanied by intense biotic interferences within forested area might account for the poor regeneration. More studies are needed to explain the causes of low seedling / sapling densities in these forests.

The diversity (H') values (tree: 0.46 — 2.74; saplings: 0.87 — 2.54; and shrub: 1.17 — 2.60) are within the range (0.8 — 3.40) reported for temperate forests of Central Himalaya and other parts of the world (Monk 1967, Risser & Rice 1971, Saxena & Singh 1982, Upreti et al. 1985).

Patterns of Communities

Forest continuum along altitudinal gradient: Polar ordination by and large suggested a continuity of communities with stands of particular community/forest type overlapping on one or more ordination axis (figure 2). Distribution of

Table 1 *Characteristics of various forests in study area: averaged value for - (1) Total tree basal area ($M^2 ha^{-1}$); (2) Total tree density (tree ha^{-1}); (3) Total sapling density (indiv. ha^{-1}); (4) Total seedling density (indiv. ha^{-1}); (5) Total shrub density (indiv. ha^{-1}); H' - Shannon's diversity index (a-tree; b-sapling; c-shrub).*

Forest type	1	2	3	4	5	H'		
						a	b	c
Quercus leucotrichophora	43.7	580	380	580	3630	2.20	2.25	1.90
Rhododendron dominated	37.9	430	300	750	7270	2.39	2.54	1.95
Pinus roxburghii	37.1	580	130	70	950	0.46	0.87	2.60
Quercus lanuginosa	67.8	430	420	410	3560	2.22	2.23	1.70
Quercus-mixed	81.4	580	360	660	13270	2.74	2.29	1.44
Q. semecarpifolia	63.3	450	240	300	13230	1.54	1.95	1.17
Sub-alpine	31.3	450	290	430	6230	2.29	1.62	1.92

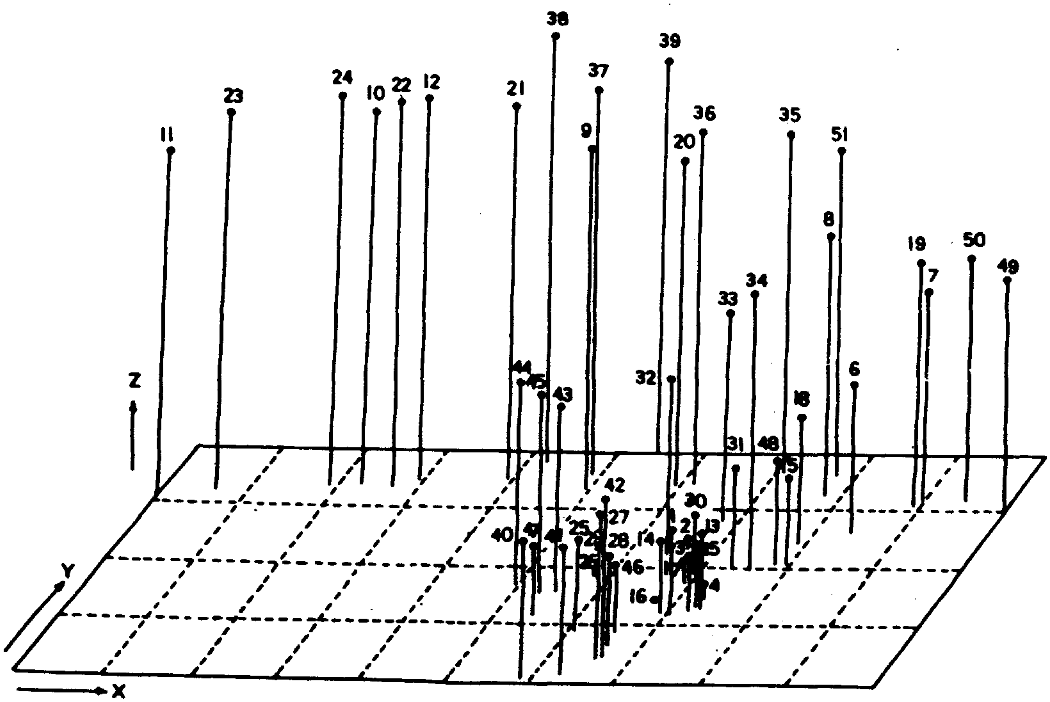

Figure 2. Three dimentional ordination of 51 forest stands (numbers above bars represent stand number).

forest stands within a two-dimentional ordination field (figure 3a) suggested that stands on Y-axis are arranged according to their altitude. Similar continous intergrading of forests along

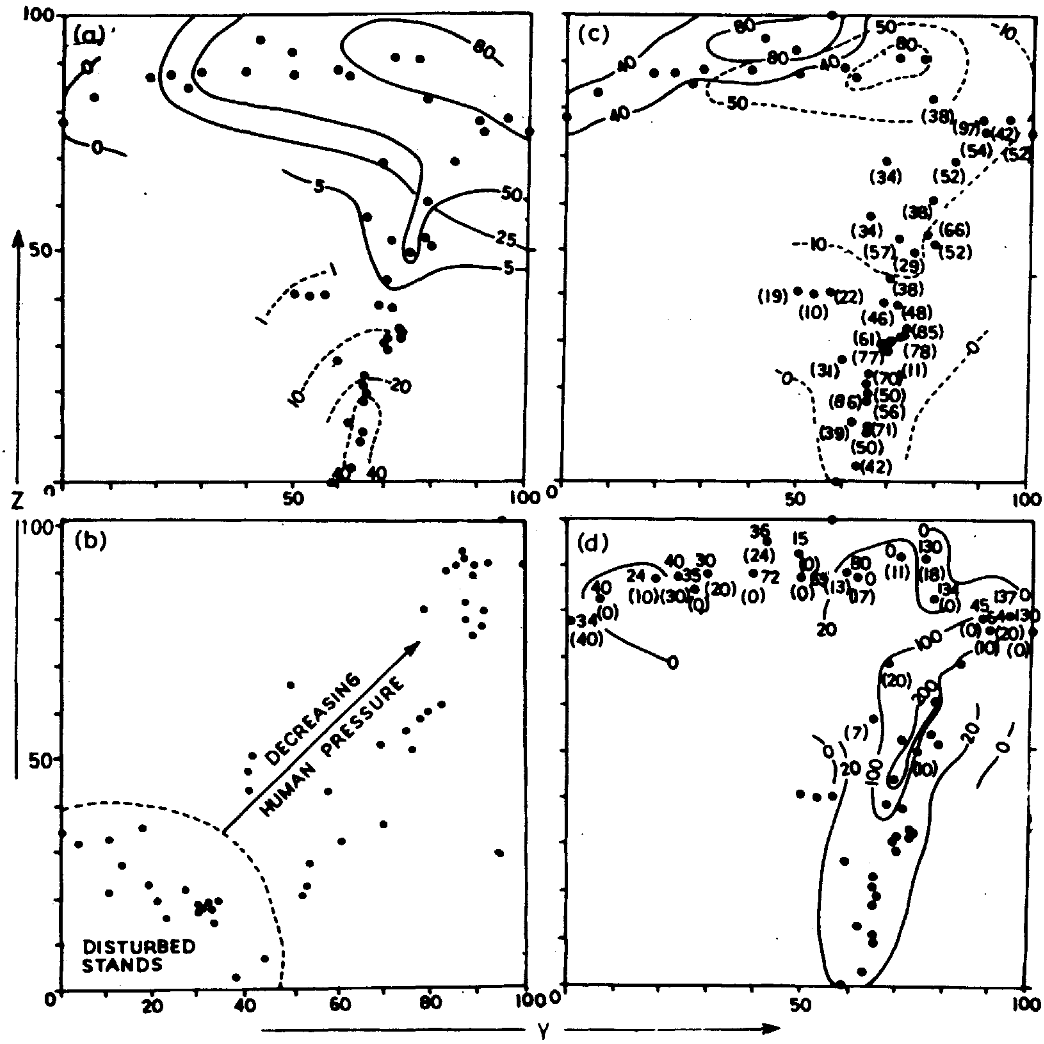

Figure 3. Patterns of species along altitudinal gradient. 3a, Distribution of community types (symbols represent different dominant types ● *Q. leucotrichophora*; O *Rhododendron*; +-oak-mixed; Δ *Q. lanuginosa*; □ *Pinus roxburgii*; ▲*Q. semecarpifolia*; ● Sub-alpine forest). Contour lines depict importance value distribution for *Q. lencotrichophora* (broken lines), *Q. semecarpifolia* (unbroken lines); 3b, Stand/community distribution along pressure gradient (Y-Z ordination); 3c, Importance value distribution of Rhododendron spp. (values in parentheses IVI for *R. arboreum*, broken line contour *R. barbatum* and unbroken line *R. campanulatum*; 3 d, Importance value (density) distribution for three bamboo species. Unbroken contour - *A. falcata*; values in parentheses- *C. jaunsarensis*; and values above stand point (not in parentheses) - *T. spathiflora*

altitudinal gradient is reported for low altitude (300—2500m) forests of Kumaun (Singh & Singh 1987, Tewari et al. 1989). Although total tree basal area, successional status etc., were major attributes for spatial positioning of stands and communities on X-axis, the positioning also reflected the impact of the altitude. Altitude splits the arrangement of stands (X-axis) into two, i.e. (i) increase in altitude slightly corresponded with increase in X-axis position up to a certain limit (*Q. semecarpifolia* forest), and (ii) further increase in altitude caused a rapid fall in X-axis position of stands (subalpine forest).

Obviously in this zone of Himalaya, increasing altitude (Y-axis) corresponds with decreasing biotic (human) pressure. Stand positions in other ordination (Y-Z) indicated that increasing biotic pressure in low altitude forests causes a cluster of communities (figure 3b), whereas, stand/communities were more continuous towards the higher altitude (lowering biotic pressure). Similar clustering of forest stands on account of human disturbance was earlier reported in Kumaun region (Rikhari et al. 1989).

Patterns of importance value distribution along altitudinal gradient: Response of few dominant trees to altitude is depicted in figure 3 a-d. Patterns for two climax species (i.e. *Q. leucotrichophora, Q. semecarpifolia*) of Central Himalaya are shown in figure 3a. In *Q. leucotrichophora*, the centre of dominance was located on lower extremity of altitude (Y-axis) and the dominance decreased towards the higher ranges (Y-axis) and a successive decline was apparent up to *Q. leucotrichophora* zone. All three Rhododendron species (*R. arboreum, R. barbatum, R. campanulatum*) occupied more or less distinct altitudinal zones (figure 3c). Similarly among shrubs three species of Himalayan bamboo (*Arundinaria falcata, Chimonobambusa jaunsarensis, Thamnocalamus spathiflora*) were common and had different distributional ranges along the altitude gradient (figure 3d). Thus distribution of the importance value for species along altitudinal gradient suggests that the dominance of one species is replaced gradually by the other, but some times this replacement is quite sharp (figure 3a-d).

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