Garhwal Himalaya lies between the $29^026'$ to $31^028'$ N Lat. and $77^049'$ to $80^06'$ E Long. with a total area of about 3000 sq. kms (Gaur, 1982). It is
bounded by Tons river in the west separating it from Himachal Pradesh and district boundaries of Nainital, Almora, Bageshwar, and Pithoragarh in the East, separating it from Kumaon Himalaya. Starting from Siwalik foothills in the south the region extends up to lofty snow-clad peaks, making the Indo Tibetan boundary. Politically, the region incorporates the districts of Uttarkashi, Chamoli, Bageshwar, Tehri, Pauri, and Dehradun; the first two are the border districts. An 'Environmental Regeneration Potential' revealed that the areas are least investigated and deserved to be studied in detail for increasing status of management for sustainable conservation of the rich diversity in forest ecosystems of Submontane and Montane zones.

The present study on “Environmental Regeneration, Dominance, and Species Diversity of Tree Species in Forest Ecosystems of Submontane and Montane zones of Garhwal Himalaya” aimed

i. To develop Pluviothermal diagrams to identify wet and dry periods in some forest ecosystems of Garhwal Himalaya.

ii. To identify Dominance, Distribution pattern of tree species, comparison of forests after phytosociological analysis.

iii. To compute Regeneration potential of tree species in the forest ecosystems in sub-montane and montane zones of Garhwal Himalaya.

iv. To compute Species diversity.
The study has implications for management of forest resources. The information on vegetation would be helpful in solving ecological problems such as biological conservation and management options, and will help in better understanding of species abundance, resource partitioning, predictions of future changes, facilitating comparison among taxa, and resource utilization.

The study area was located in Submontane and montane zones of Pauri Garhwal of Uttarakhand. In Submontane zone Sal and Mixed Sal forests were analyzed and in Montane zone Pine, Mixed Pine and Oak forest were studied for Environmental regeneration, dominance and species diversity. The altitudinal range covered from 700-2050 m amsl. Geologically, the region is situated in Central Himalaya. The sites of submontane zone were located close to Dugadda town near Kotdwara in Lansdowne Forest Division (29°48’-29°48’ N Lat. and 78°36’-78°37’ E Long.). In Montane zone the sites were located at Adwani and Nagdev close to Pauri city (30°0’-30°10’N Lat and 78°40’-78°50’E Long).

Random field sampling was done for quantification and other quantitative parameters. Tree species diversity, structure, and compositions were studied by laying quadrats (size 10 x 10 m). The saplings and seedlings were studied by laying quadrats nested within the quadrats (size 5 x5 m for sapling and 2 x 2 m for seedling) laid to assess the tree structure and diversity.
In Submontane zone there was exhausting summers and severe winters. Heaviest rainfall occurs during June to October. November is usually dry with exceptions of occasional showers. The weather remains usually cold dry during January-February and hot dry from March to until September. The mean annual temperature was 21.8°C and total rainfall was 646 mm during 12 months. Pluviothermic diagram for this zone depicted January-February, June-October, and December were the wet months and March-May and November were the dry months.

In montane zone lowest temperature (11°C) was in January which increases until 24°C in July and decreased in the following months. Almost, each month had the rainfall in this zone, however, severe during the rainy season and minimum in summers and winters. The mean annual temperature was 17.1°C with total rainfall of 791.7 mm in the calendar year. The Pluviothermic diagram of montane zone showed that there were all wet months during the year.

In submontane zone Sal and mixed Sal forests were studied, whereas, in montane zone Pine, Mixed Pine and Oak were investigated. For the woody species, each site was studied using quadrat of 10 m x 10 m area. The size and the number of the quadrats needed were determined using species area curve method. The quadrat number was strictly based on number of individuals repeated, and such sampling procedure is duly recommended by large number of ecologists. The quadrats were placed
randomly at different locations to cover most of the species under different canopy covers. Each quadrat was sampled for its tree species composition, density, and basal cover. Each individual tree was measured for its circumference at breast height (CBH) i.e. 1.3m above ground level. Samples of all plant individuals were collected and later identified using the regional flora. The data gathered for each stand from all transect were subsequently pooled together for further analysis. All the woody species

• 31.5 cm CBH (circumference at breast height) were considered as trees

• and all the individuals of 10.5 to 31.4 cm CBH were tallied as saplings

• and all the individuals with CBH less than 10.5 cm are tallied as seedlings.

The vegetation data were subsequently analyzed for further details.

In the entire study areas following forest types were recognized.

1. *Shorea robusta* forest
   - *Shorea robusta*
   - Mixed *Shorea robusta*

2. *Pinus roxburghii* Forest
   - *Pinus roxburghii*
   - Mixed *Pinus roxburghii* (*Pinus roxburghii–mixed broad leaf forest*)

3. *Oak Forest*
   - *Quercus leucotrichophora*
In the tree layer of Sal forest *Shorea robusta* had highest density (3.80). Minimum (0.01) was recorded for *Bauhinia vahlii, Tectona grandis, Acacia catechu, Lannea grandis, Helectres isora,* and *Gardenia turgida.* *Shorea robusta* exhibited maximum MBC (541.7) and *Gardenia turgida* showed minimum (84) value. Average was 310.20 across the site. Maximum value for TBC was again showed by *Shorea robusta* (2058.36) and minimum value was recorded for *Gardenia turgida* (0.84). IVI was maximum (180.72) for *Shorea robusta* and minimum for *Gardenia turgida* (0.59). Associated species were *Mallotus philippensis* and *Terminalia tomentosa.* Concentration of dominance was maximum with (0.82) and minimum value was (0.16) while species diversity ranged from 0.13 to 0.39. *Mallotus philippensis* appeared to be the co-dominant species in the tree layer. This species had the IVI value 45.22; Density 1.08; MBC 142; and TBC was 153.37.

In sapling layer, maximum and minimum values for density were recorded for *Shorea robusta* (15.76) and *Lannea grandis and Gardenia turgida* (0.98). *Shorea robusta* showed (73.2) highest MBC while lowest was shown by *Buchanania lanzan* (11.69). Average value was 41.67 across the site. *Shorea robusta* counted the highest value for TBC (1153.63) and *Acacia catechu* had the lowest value (37.80). Average value calculated across the site was 300.6. IVI was again maximum for *Shorea robusta* (66.0) while the lowest value recorded was for *Lannea grandis* (2.70).
Associated species were *Mallotus philippensis* and *Terminalia tomentosa*. The maximum and minimum values for concentration of dominance were 0.18 and 0.74. Species diversity ranged from a minimum of 0.20 to a maximum of 0.43. *Mallotus philippensis* appeared to be the co-dominant species in the sapling layer. The species had IVI 49.17; Density 12.18; MBC 68.5; and TBC was 834.30.

In seedling layer, *Shorea robusta* possessed maximum density (26.81), least (2.85) value was for *Acacia catechu* and *Gardenia turgida*. MBC was maximum (7.37) for *Shorea robusta*. *Tectona grandis* (1.76) showed minimum value. Average value across the site was 4.17. *Shorea robusta* showed the maximum value for TBC (197.5). *Acacia catechu* and *Gardenia turgida* exhibited the lowest value (5.70) for TBC. The average value calculated across the site was 56.0. The maximum value for IVI was (56.41) for *Shorea robusta* while the lowest value recorded was for *Acacia catechu* and *Gardenia turgida* (2.04). Maximum and minimum values for concentration of dominance across the sites were 0.48 and 0.97 while the range for species diversity was 0.02 to 0.38. *Mallotus philippensis* appeared to be the co-dominant species in the Seedling layer. This species had IVI value of 44.79; Density 20.98; MBC 6.98; and TBC was 146.4.

In tree layer of Mixed Sal forest *Shorea robusta* had highest density (3.35). Minimum (0.01) was recorded for *Pinus roxburghii*, *Azadirachta*
indica, Prunus cornuta, and Bauhinia purpurea. Shorea robusta exhibited maximum MBC (533.78) and Bauhinia purpurea showed minimum (108.9) value. Average was 389.90 across the site. Maximum value for TBC was again showed by Shorea robusta (1788.16) and minimum value was recorded for Bauhinia purpurea (1.36). IVI was maximum (126.97) for Shorea robusta and minimum for Bauhinia purpurea (0.55). Associated species was Mallotus philippensis. Concentration of dominance was maximum with (0.23) and minimum value was (0.12) while species diversity ranged from 0.35 to 0.48. Mallotus philippensis appeared to be the co-dominant species in the tree layer. It had the value for IVI 16.59; Density 0.48; MBC 178.67; and TBC was 85.76.

In sapling layer maximum and minimum values for density were recorded for Shorea robusta (23.16) and Acacia catechu and Bauhinia retusa (0.87). Shorea robusta showed (73.8) highest MBC while lowest was shown by Acacia catechu (11.69). Average value was 33.39 across the site. Shorea robusta counted the highest value for TBC (1709.2) and Acacia catechu had the lowest value (10.17). Average value calculated across the site was 414.89. IVI was again maximum for Shorea robusta (44.9) while the lowest value recorded was for Acacia catechu and Bauhinia retusa (0.8). Associated species was Mallotus philippensis. The maximum and minimum values for concentration of dominance were 0.20 and 0.14. Species diversity ranged from a minimum of 0.35 to a maximum
of 0.37. *Mallotus philippensis* appeared to be the co-dominant species in the Sapling layer. It had the values for IVI 32.3; Density 20.8; MBC 41.6; and TBC was 865.28.

In seedling layer *Shorea robusta* possessed maximum density (28.76), least (0.66) value was for *Dalbergia sissoo*. MBC was maximum (10.86) for *Shorea robusta*. *Dalbergia sissoo* (1.98) showed minimum value. Average value across the site was 5.65. *Shorea robusta* showed the maximum value for TBC (312.3). *Dalbergia sissoo* exhibited the lowest value (1.72) for TBC. The average value calculated across the site was 83.4. The maximum value for IVI was (46.3) for *Shorea robusta* while the lowest value recorded was for *Dalbergia sissoo* (0.66). Maximum and minimum values for concentration of dominance across the sites were 0.35 and 0.31 while the range for species diversity was 0.42 to 0.48. *Mallotus philippensis* appeared to be the co-dominant species in the Seedling layer. It had the following value for IVI 35.2; Density 22.9; MBC 9.09; and TBC was 208.1.

In the tree layer of Pine forest, *P. roxburghii* had highest density (5.54). Minimum (0.01) was recorded for *Bauhinia variegata*. *P. roxburghii* exhibited maximum MBC (611.32) and *Euphorbia royleana* showed minimum (123.50) value. Average was 316.66 across the site. Maximum value for TBC was again showed by *P. roxburghii* (3386.72) and minimum value was recorded for *Bauhinia variegata*, (3.25). IVI was maximum
(251.79) for *P. roxburghii* and minimum for *Bauhinia variegata* (0.85). Associated species were *Lyonia ovalifolia* and *Rhododendron arboreum*. Concentration of dominance was maximum with (0.91) and minimum value was (0.27) while species diversity ranged from 0.07 to 0.45. *Lyonia ovalifolia* appeared to be the co-dominant species in the tree layer. It had the following values for IVI 19.49; Density 0.23; MBC 277.96; TBC was 63.93.

In sapling layer maximum and minimum values for density were recorded for *P. roxburghii* (9.18) and *Bauhinia variegata* and *Pyrus pashia* (2.76). *P. roxburghii* showed (60.62) highest MBC while lowest was shown by *Cornus oblonga* (20.76). Average value was 42.45 across the site. *P. roxburghii* counted the highest value for TBC (556.49) and *Engelhardtia spicata* had the lowest value (58.37). Average value calculated across the site was 207.9. IVI was again maximum for *P. roxburghii* (117.2) while the lowest value recorded was for *Engelhardtia spicata* (14.8). Associated species were *Lyonia ovalifolia* and *Rhododendron arboreum*. The maximum and minimum values for concentration of dominance were 0.65 and 0.47. Species diversity ranged from a minimum of 0.06 to a maximum of 0.38. *Lyonia ovalifolia* appeared to be the co-dominant species in the Sapling layer. It had the following values for IVI 49.6; Density 5.61; MBC 59.36; TBC was 333.0.
In seedling layer *P. roxburghii* again possessed maximum density (10.11), least (4.28) value was for *Bauhinia variegata*. MBC was maximum (2.09) for *P. roxburghii*. *Engelhardtia spicata* (1.76) showed minimum value. Average value across the site was 2.78. *P. roxburghii* showed the maximum value for TBC (20.22). *Engelhardtia spicata* exhibited the lowest value (8.37) for TBC. The average value calculated across the site was 22.78. The maximum value for IVI was (27.12) for *P. roxburghii* while the lowest value recorded was for *Engelhardtia spicata* (11.28). Maximum and minimum values for concentration of dominance across the sites were 0.65 and 0.47 while the range for species diversity was 0.06 to 0.38. *Pyrus pashia* appeared to be the co-dominant species in the Seedling layer. It had the following values for IVI 38.14; Density 9.98; MBC 2.88; TBC 28.74.

In the tree layer of Mixed Pine forest *P. roxburghii* had highest density (3.10). Minimum (0.01) was recorded for *Carpinus viminea*. *P. roxburghii* exhibited maximum MBC (832.7) and *Bauhinia variegata* showed minimum (191.1) value. Average was 386.7 across the site. Maximum value for TBC was again showed by *P. roxburghii* (2581.3) and minimum value was recorded for *Rhamnus virgata* (6.4). IVI was maximum (139) for *P. roxburghii* and minimum for *Carpinus viminea*, (0.8). Associated species were *Rhododendron arboreum* and *Myrica esculenta*. Concentration of dominance was maximum with (0.24) and minimum
value was (0.08) while species diversity ranged from 0.41 to 0.53. *Rhododendron arboreum* appeared to be the co-dominant species in the tree layer. It had the following values for IVI 23.5; Density 0.50; MBC 474; TBC was 237.

In sapling layer maximum and minimum values for density were recorded for *P. roxburghii* (23.51) and *Prunus cornuta* (0.85). *P. roxburghii* showed (68.15) highest MBC while lowest was shown by *Toona ciliata* and *Sapium insigne* (10.89). Average value was 24.49 across the site. *P. roxburghii* counted the highest value for TBC (1602.2) and *Prunus cornuta* had the lowest value (13.52). Average value calculated across the site was 321.6. IVI was again maximum for *P. roxburghii* (86.4) while the lowest value recorded was for *Prunus cornuta* (2.77). Associated species were *Rhododendron arboreum* and *Myrica esculenta*. The maximum and minimum values for concentration of dominance were 0.50 and 0.13. Species diversity ranged from a minimum of 0.27 to a maximum of 0.50 *Rhododendron arboreum* appeared to be the co-dominant species in the Sapling layer. It had the following values for IVI 59.5; Density 19.67; MBC 42.76; TBC was 841.

In seedling layer *P. roxburghii* again possessed maximum density (27.61), least (0.76) value was for *Carpinus viminea* and *Millettia auriculata*. MBC was maximum (6.91) for *P. roxburghii*. *Bauhinia variegata* (2.08) showed minimum value. Average value across the site was 4.38. *P. roxburghii*
showed the maximum value for TBC (190.7). *Milletia auriculata* exhibited the lowest value (1.98) for TBC. The average value calculated across the site was 55.50. The maximum value for IVI was (64.3) for *P. roxburghii* while the lowest value recorded was for *Milletia auriculata* (1.23). Maximum and minimum values for concentration of dominance across the sites were 0.35 and 0.21 while the range for species diversity was 0.25 to 0.44. *Rhododendron arboreum* appeared to be the co-dominant species in the seedling layer. It had the following values for IVI 50.3; Density 21.01; MBC 7.01; TBC was 147.2 2.

In the Seedling layer *Q. leucotrichophora* once again was the dominant species with IVI value of 119.76 and density recorded was 20.80. MBC and TBC values were 5.37 and 111.69. Again the co-dominant species was *Rhododendron arboreum* with IVI of 59.0.

In the tree layer of Oak forest *Q. leucotrichophora* had highest density (4.80). Minimum (0.01) was recorded for *Ilex odorata, Maesa indica, Lonicera quinquelocularis,* and *Pinus roxburghii.* *Q. leucotrichophora* exhibited maximum MBC (529.14) and *Pinus roxburghii* showed minimum (103.10) value. Average was 263.08 across the site. Maximum value for TBC was again showed by *Q. leucotrichophora* (2538.87) and minimum was recorded for *P. roxburghii* (1.47). IVI was maximum (194.98) for *Q. leucotrichophora* and minimum for *P. roxburghii,* (0.83). Associated species were *Rhododendron arboreum* and *Myrica esculenta.*
Concentration of dominance was maximum with 0.80 and minimum value was 0.28 while species diversity ranged from 0.15 to 0.43. *Rhododendron arboreum* appeared to be the co-dominant species in the tree layer. It had the following values for IVI 17.26; Density 0.31; MBC 333.97; TBC was 103.53.

In sapling layer maximum and minimum values for density were recorded for *Q. leucotrichophora* (8.17) and *Litsea umbrosa* and *Aesculus indica* (0.22). *Q. leucotrichophora* showed (58.36) highest MBC while lowest was shown by *Quercus floribunda* (21.18). Average value was 43.38 across the site. *Q. leucotrichophora* counted the highest value for TBC (476.80) and *Litsea umbrosa* had the lowest value (5.70). Average value calculated across the site was 136.80. IVI was again maximum for *Q. leucotricophora* (104.4) while the lowest value was for *Litsea* (3.11). Associated species were *Rhododendron arboreum* and *Myrica esculenta*. The maximum and minimum values for concentration of dominance were 0.68 and 0.44. Species diversity ranged from a minimum of 0.30 to a maximum of 0.40. *Rhododendron arboreum* appeared to be the co-dominant species in the Sapling layer. It had the following values for IVI 52.66; Density 6.20; MBC 46.08; TBC was 285.6.

In seedling layer *Q. leucotrichophora* again possessed maximum density (20.80), least (0.46) value was for *Aesculus indica*. MBC was maximum (5.37) for *Q. leucotrichophora*. *Pinus roxburghii* (4.03) showed minimum
value. Average value across the site was 5.53. *Q. leucotrichophora* showed the maximum value for TBC (111.69). *Aesculus indica* showed the lowest value (2.41) for TBC. The average value calculated across the site was 37.0. The maximum value for IVI was (119.76) for *Q. leucotrichophora* while the lowest value recorded was for *Aesculus indica* (5.43). Maximum and minimum values for concentration of dominance across the sites were 0.68 and 0.42 while the range for species diversity was 0.30 to 0.44. *Rhododendron arboreum* appeared to be the co-dominant species in the seedling layer. It had the following values for IVI 59.0; Density 8.17; MBC 6.98; TBC was 57.0.

The species richness reported for *Shorea robusta* forest was 22, 15, and 18 species for tree, sapling, and seedling, respectively. Beta diversity of this forest for tree species ranged from a minimum of 1.6 to maximum of 2.69; for saplings it was 0.692 (minimum) and 1.364 (maximum); for seedlings the minimum and the maximum values were 1.25 and 2.587, respectively. Equitability for tree was maximum with 10.0 and minimum value recorded was 3.609; for saplings it ranged from 2.583 (minimum) to 11.628 (maximum); for seedlings the maximum and the minimum values reported were 4.0 and 1.06. Shannon-Weiner diversity had minimum and maximum values for tree sapling and seedling as 0.13 - 0.39; 0.20 – 0.43; 0.02 – 0.38, respectively. Concentration of dominance ranged from a maximum of 0.82 and minimum 0.16 for tree species. For saplings and
seedlings the minimum and the maximum values calculated were 0.18 – 0.74; 0.48 – 0.97, respectively.

Mixed *Shorea robusta* forest had generally greater species richness (32, 20, and 19 for tree, saplings, and seedlings, respectively) and diversity than *Shorea robusta* forest. Maximum and minimum values for Diversity indices were 0.40 – 0.35 (Tree), 0.37 – 0.35 (Sapling) and 0.48 – 0.42 (Seedling), respectively. Maximum and minimum values for concentration of dominance for tree, sapling and seedling were 0.23 -0.12; 0.20 – 0.14; 0.35 – 0.31, respectively. The values for equitability for tree species ranged from 10.14 to 11.52; for saplings it was 7.71 to 16.61; and for seedlings the range was 4.94 to 6.64.

Species richness in *Pinus roxburghii* forest for tree, sapling, and seedling was 10, 08, and 10, respectively. Species diversity for the entire three strata was in the range of 0.07 to 0.45; 0.06 to 0.38; and 0.05 to 0.47, respectively. The minimum and the maximum values for Concentration of dominance in tree, sapling, and seedling layer were 0.27 to 0.91; 0.47 to 0.65; and 0.29 to 0.93, respectively. The maximum values of beta diversity and equitability in all the three layers were 4.11, 3.75, and 6.0; 6.64, 5.55 and 6.42 respectively. The minimum values for the same were 1.93, 1.53 and 1.42; 1.68, 1.70 and 1.40 respectively.

For tree species richness in Mixed *Pinus roxburghii* forest was 27; for saplings it was 12 and for seedling layer the value of species richness was
14. Minimum value for concentration of dominance in the entire three layers was 0.08, 0.13, and 0.21 respectively. The maximum values for the same were 0.24, 0.50, and 0.35 respectively. Maximum and minimum values for Diversity index were 0.53-0.41 (Tree), 0.50-0.27 (Sapling) and 0.44-0.25 (Seedling). Maximum and minimum values for Beta diversity for tree, sapling, and seedling were 2.37-1.66; 1.42-0.50; 1.50-0.25, respectively. The values for equitability for tree species ranged from 7.71-19.22; for saplings it was 3.12-4.98; and for seedlings the range was 1.50-4.16.

The species richness reported for Quercus leucotrichophora forest was 17, 11 and 07 species for tree, sapling, and seedling, respectively (Table 9). Beta diversity of this forest for tree species ranged from a minimum of 1.42 to maximum of 2.30; for saplings it was 1.07 (minimum) and 2.50 (maximum); for seedlings the minimum and the maximum values are 1.33 and 3.33, respectively. Equitability for trees was maximum with 6.14 and minimum value recorded was 2.463; for saplings it ranged from 2.70 (minimum) to 4.29 (maximum); for seedlings the maximum and the minimum values reported were 4.98 and 2.86. Shannon-Weiner diversity had minimum and maximum values for tree sapling and seedling were 0.15-0.43; 0.30-0.40; 0.30-0.44, respectively. Concentration of dominance ranged from a maximum of 0.80 and minimum 0.28 for tree species. For
saplings and seedlings the minimum and the maximum values calculated were 0.44-0.68; 0.42-0.68, respectively.

The number of saplings and seedlings per unit area permit us to assess the regeneration potential in different forest types. In *Shorea robusta* forest there were 220 tree individuals per ha of which 150 individuals per ha were saplings and 180 individuals per ha were seedlings. It indicated 68% and 82% saplings and seedlings respectively. In mixed *Shorea robusta* forest the number of tree species was 320 individuals per ha of which 200 individuals per ha and 190 individuals per ha were saplings and seedlings respectively. It estimates 62.50% saplings and 59.37% seedlings. In *Pinus roxburghii* forest the number of trees was lower (100 individuals per ha) compared to above two forests of which 80 individuals per ha were saplings and 100 individuals per ha were seedlings. In this forest 80% were saplings and 100% were seedlings. It shows 100 % regeneration in this forest. In mixed *Pinus roxburghii* forest the number of tree species was 270 individuals per ha of which 120 individuals per ha comprised of saplings and 140 individuals were seedlings. The percentage of saplings in this forest was lowest (44.44%) across the sites; however, seedling percentage was 51.85%. In *Q. leucotrichophora* forest there were 170 trees per ha of which 110 individuals per ha were saplings and only 70 individuals per ha were seedlings. It estimates 64.70% and 41.17% saplings and seedlings, respectively. Across the forests the
number of saplings and seedlings was lowest in *Q. leucotrichophora* forest.

The number of species with seedlings or saplings differed at different positions. In *Shorea robusta* forest there were 22 tree species of which 15 species had saplings and 18 species had seedlings. In Mixed *Shorea robusta* forest of the total 32 tree species 20 species had saplings and 19 species had seedlings. In *Pinus roxburghii* forest there were only 10 tree species of which 08 species had saplings and all the 10 species had seedlings. In Mixed *P. roxburghii* forest the condition was poor. There were 27 tree species of which only 12 species had saplings and 14 species had seedlings. Almost same condition was observed in *Q. leucotrichophora* forest. In this case there were 17 tree species of which 11 species had saplings and only 07 species had seedlings.

The percentage of species with saplings and seedlings in different forests reveals that the regeneration situation was best in *S. robusta* forest and *P. roxburghii* forest and worst in Mixed *Pinus roxburghii* and *Q. leucotrichophora* forest. It is evident from the present figures of environmental regeneration potential that if identical environmental conditions remain in future the present *Shorea robusta* forest would be replaced after regeneration by the same species and the same situation was true for *P. roxburghii* forest. If we compare *Shorea robusta* and *Pinus roxburghii* forest in long future the condition was truer for *Pinus roxburghii*
forest than that of *Shorea robusta* forest. In mixed *Pinus roxburghii* because the regenerating sapling percentage was poor that’s why it can be predicted that the mixed *Pinus roxburghii* may change its dominance in near future and may be reclaimed in the forthcoming time. If we compare mixed *Pinus roxburghii* and oak, oak had better regeneration of saplings than mixed pine, however, poor regeneration of seedlings. It shows in future that the dominance in oak forest would be replaced by other species. Across the percentage of saplings highest regeneration potential of saplings was in *Shorea robusta* and *Pinus roxburghii* forest and worst in mixed *Pinus roxburghii* forest. It indicates that immediately in the near future the dominance of *Shorea robusta* and *Pinus roxburghii* forest would remain the same, however, in other forest types the dominance might be replaced slightly under identical environmental conditions. A cross examination with regeneration of seedlings of tree species indicates that there was 100% seedling regeneration in *Pinus roxburghii* forest. It shows in near future there are no chances of replacing dominance in *Pinus roxburghii* forest. However, in *Shorea robusta* forest there are 81.81% chances of replacing the dominance, followed by mixed *Shorea robusta* (59.37%), Mixed *Pinus roxburghii* (51.85%), and Q. leucotricophora forest (41.17%). Thus, regeneration in mixed *Pinus roxburghii* and Q. *leucotrichophora* forest is worst and in *Pinus roxburghii* forest it is the best. The physiognomic appearance in Tree layer the dominant species were *Shorea robusta, Shorea robusta, Pinus roxburghii, P. roxburghii* and Q.
leucotrichophora respectively in forest types of Shorea robusta, Mixed S. robusta, P. roxburghii, Mixed P. roxburghii and Q. leucotrichophora. The associated species on these forests were respectively Mallotus philippensis, Terminalia tomentosa, Lyonia ovalifolia, Rhododendron arboreum, and Rhododendron arboreum respectively.

In sapling layer the results were identical to tree layer. However, in seedling layer the dominant species were identical to tree and sapling layers never the less, in co-dominant species Lyonia ovalifolia was replaced by Pyrus pashia.

In Shorea robusta forest there was no competition between dominant and co-dominant species in tree layer. As the former had 180.72 value of IVI and later had 45.22. In sapling layer of the same forest during the study period there was no competition between dominant and co-dominant species, however, in future if identical environmental conditions avails the Mallotus philippensis may replace the Shorea robusta. It is because of the fact that the former had the IVI value of 66 and latter had 49.17. In seedling layer also identical conditions existed as the Shorea robusta had the IVI value of 56.41 and Mallotus philippensis had 44.79. In seedling layer the IVI values of Mallotus philippensis the co-dominant species and Terminalia tomentosa seemed to be competitive species as the former had the IVI value of 44.79 and latter had 42.39.
In Mixed *Shorea robusta* forest dominant species had the value of IVI 126.97 and co-dominant had the value of 28.69 in Tree layer. Thus, these species were not competitive. In sapling layer of the same forest the dominant species i.e. *Shorea robusta* had the value of IVI 44.9 and co-dominant species *Terminalia tomentosa* exhibited the value 33.4. It is interesting that in Sapling layer maximum species were competitive because of the fact that there was minor difference in IVI values amongst the species. The seedling layer of the same forest showed the identical trend to sapling layer.

In tree layer of *Pinus roxburghii* forest the dominant species was *Pinus roxburghii* with the IVI value of 251.79 and the co-dominant species was *Lyonia ovalifolia* with the value of 19.49. Though there was no competition between the dominant and co-dominant species, however, the IVI values showed the maximum remaining species in the forest of tree layer were competitive. In sapling layers this forest exhibited the identical trend. However, the seedling layer of this forest had *Quercus leucotrichophora* as dominant species and *Pyrus pashia* was the co-dominant species. The species *Rhododendron arboreum* was found competing with dominant and co-dominant species.

In Mixed *Pinus roxburghii* forest *Pinus roxburghii* was the dominant species with the IVI value of 139.0. The co-dominant species was *Rhododendron arboreum* having 23.5 IVI value. Most of the species in
Tree layer were competitive among themselves except *Pinus roxburghii*. In sapling layer of this forest *Pinus roxburghii* was the dominant species with IVI value of 86.4. The co-dominant species was *Rhododendron arboreum* with importance value of 89.5. *Myrica esculenta* and *Quercus leucotrichophora* were competitive with dominant and co-dominant species. In seedling layer of this forest the position was identical to sapling layer; however, in this layer there was no competition of *Q. leucotrichophora* with *R. arboreum*. Nevertheless it was competing with *Sapium insigne*.

In tree layer of *Q. leucotrichophora* the co-dominant species was *R. arboreum* with the importance value of 17.26. It was competitive with other species like *Myrica esculenta* and *Q. floribunda*. In sapling and seedling layer of this forest position was identical to tree layer.

Distribution pattern of tree, sapling and seedling strata in all the forests, and all the strata of the forests significantly showed contagious distribution. Regular distribution was lowest and sometimes absent for instance in *P. roxburghii* forest there was no regular distribution of species in any stratum. Random distribution occupied the intermediate position between regular and contagious, it showed minimum percentages.

It is concluded from the present study that rainfall increases with altitude and vice-versa is true for temperature. With the change in altitude dominance of a community also changes. Species diversity and
dominance are generally inversely related. Dominance changes with the change in altitude. In all the forests and in all the strata species are mostly distributed contiguously. Random and regular distribution is rare. The percentage of species with saplings and seedlings in different forests reveals that the regeneration situation was best in *Shorea robusta* forest and *Pinus roxburghii* forest and worst in Mixed *Pinus roxburghii* and *Q. leucotrichophora* forest.

The information generated through this investigation would certainly help forming baseline for future research studies in this rich biodiversity area as well as in developing plans for using natural resources sustainably.
Environmental Regeneration, Dominance and Species diversity of Tree Species in Forest Ecosystems of Submontane and Montane zones of Garhwal Himalaya

Summary