Dendrochronological studies of Pinus roxburghii and Pinus wallichiana from Ghora Galli, Murree

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Research Article

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Abstract

The present study described the dendrochronological studies of *Pinus roxburghii* and *Pinus wallichiana* growing in Ghora Galli, Murree. Study area was subdivided into roadside and away from roadside. It was found that along road side the maximum diameter, age, growth rate and height of *Pinus roxburghii* were 71 inches, 304 age, 0.277 and 97 feet respectively. Similarly maximum diameter, age, growth rate and height of *Pinus roxburghii* growing away from road side were 93.5 inches, 328 years, 0.358 inches/year and 99 feet height respectively. Maximum DBH, age, growth rate and height of *Pinus wallichiana* growing along the roadside was 63 inches, 223 years, 0.392 inches/year and 83 feet height respectively. While, studying the trees of *Pinus wallichiana* growing away from road side it was found that the maximum DBH, age, growth rate and height were 56.5 inches, 158 years, 0.437 years/inches and 62 respectively. It was also found that growth rate of trees growing away from the road was greater than those growing along the road. A significant correlation between growth rate and height was found While studying the correlation between height and growth rate, it was found that there was no any significant correlation. In vegetation studies, it was found that dominant trees were from Pinaceae family. Shrubs were with three families while herbs contained eleven families and ferns were found with only two families. Maximum IVI from trees was of *Pinus wallichiana* with 11.07 belonging to Pinaceae family and 7.73 for *Hedera nepalensis* belonging to Araliaceae family. Similarly, 4.27 was maximum IVI for *Artemisia vulgaris* of Asteraceae family and 5.44 from ferns the maximum IVI of *Adiantum capillus* belonging to Adiantaceae family.

Introduction

Dendrochronology is a branch of science that deals with the study of tree rings (Speer, 2010). It is reliable dating approach that helps in various subfields like ecology, geomorphology, climatology and environmental sciences (Divya and Kaur, 2021). Tree-ring science is used to solve various problems of forest history, management, conservation, ecosystem, productivity and population dynamics (Iqbal *et al.*,. 2017). Trees are ranked as the most-lived organisms on our planet and their growth is affected by both abiotic and biotic factors (Coulthard *et al.*,. 2020). They are intimately bound to environment as they record natural and anthropogenic events or processes which can be seen in varying tree-ring patterns (Speer, 2010)

Pakistan is more vulnerable to climate change as the global increase in temperature leads Pakistan towards extremes climatic conditions and these changes occur due to regional temperature and precipitation episodes. Hence, tree rings help to determine these climatic extremes and predict the future climate (Shah *et al.*,. 2019). Coniferous forests are the important natural assets as they support the life in tropical as well as temperate regions around the globe. These forests are under climatological and ecological variations (Shaheen *et al.*,. 2015). Many researchers from different countries carried out the research work at variable capacities and innovations. Wahab *et al.*,., (2008) determined age and growth rate of conifers from Afghanistan. Siddiqui *et al.*,. (2013) determined the aspects of hydrology, fire, past climate and forest management by tree rings. However, by considering the dendrochronological impact and ecological significance, the present research work was carried out to determine age and growth rate, growth rate and dbh, growth rate and height, height and dbh relationships. This research may prove beneficial for understanding the past and future climate and conservation of the mentioned study site.

Materials and Methods

Study site

Ghora Galli Forest is located in district Murree between 33˚52 latitude and 73˚20 longitude with elevation of 2100 m. winter is cold and snowy while in summer, there is more rain as compared to lower altitudes. Temperature is moderate and does not fall below 27° F. Annual rainfall is 64 inches due to which the forest is dense and have diversity of plants. The rainiest month of winter and summer is March and August respectively (Cretelli and Garzentii, 1994).

Sampling, preservation, preparation, and microscopic analysis

Those trees were selected for sampling which were healthy and sound and have uniform diameter. The rotten trees were rejected. Cores were taken at breast height, 1.3 m above the ground (Kuniholm, 2001; Raphael, 1994; Mares, 2009). The diameter of tree was measured with dbh measuring tape from where the core is extracted (Mueller-Dombis and Ellenberg, 1974). The geographical coordinates and elevation of sampling site was noted using the Global Positioning System instrument (Wahab *et al.*,. 2008). Plastic straws were used for the packing of wood samples to avoid any damage and both ends were closed by paper tape. The sampled cores were labeled with core code (Hart and Mayer, 2008). Cores were air dried in absence of sunlight to avoid cracks formation (Friedrich *et al.*,. 2004). Cores were mounted on wooden frames with wood glue. After a week, sanding was performed with sand papers of (120, 180 and 320 grit sizes) fixed with electric sander machine (Peck, 1973; Stokes, 1968). Crossdating was done with the help of binocular stereomicroscope and annual rings were measured with high resolution connected with velmex measuring system installed with VOORTECH'S Measure J2X.

Point Center Quarter Method (PCQM)

Point center quarter method was used for sampling forest species. This technique is preferred because it has been used by various workers. It is fast, flexible and requires less labor. In this method, distance was utilized instead of fixed sample area and used in those communities where plants are widely distributed.

In this study area, sampling points were randomly selected. Each sampling point served as center and was subdivided into four quarters with the help of a compass. The nearest tree to the point in each quarter was selected. The circumference, diameter and aerial coverage of each of these four trees were recorded and distance between the point and each of these four trees was recorded. Then all the distances were added in the sample and total distance was divided by number of distance to obtain a mean distance of point to plant. Mean area was find out by squaring the mean distance after Ludwig and Reynolds, 1988.

Moreover, a large amount of descriptive information including site description was recorded for each stand. Geographical coordinates were measured by Global positioning system. Local interviews were carried out to get information about plant uses. A total of 20 plant species were collected after Grieg-Smith, 1979.

Plants collection and their vegetation study

The plant species were collected from the site and they were dried, pressed and mounted on plant sheets. An inventory was prepared and voucher specimen was taken from Dr. Sultan Ahmed Herbarium, Government College University, Lahore, Pakistan.

Density

This parameter relates to the counting of the individuals per unit area

$$\% \text{ Density} = \frac{Total number of species in a quadrat}{Total area} \times 100$$

$$\text{Relative Density} = \frac{Number of individual species}{Total number of all species} \times 100$$

Frequency

It is the chance of occurrence of species in a particular area (Oasting, 1956)

$$\% \text{ Frequency} = \frac{No. of quadrat in which plants are present}{Total number of quadrats} \times 100$$

$$\text{Relative Frequency} = \frac{Frequency of a species}{sum of frequency of all species} \times 100$$

$$\text{Relative Cover} = \frac{Cover of individual species}{sum of cover of all species} \times 100$$

Importance Value (IV)

It is applied on the basis of relative values. It is the sum of relative frequency, relative density and relative cover.

Importance Value Index (IVI)

It was calculated by following formula after Risser and Rice, 1971.

$$\text{IVI} = \frac{Relative density + Relative frequency + Relative cover}{3}$$

Result and discussion

Tables 1 and 2 explain comparative age, DBH, growth rate and height of trees between trees growing along and away from road. Twenty trees of *Pinus roxburghii* Sarg., were cored, from which eleven cores from code P.rox. 1 to P.rox. 11 were taken from trees growing along road side and last nine having core code P.rox.12 to P. rox. 20 were taken from those trees growing away from the road. The trees of *P. roxburghii* growing along road side have age in the range of 193 to 312. Tree having maximum age 312 has DBH 83.2 inches and attains height of 97 feet's similarly tree having minimum age i.e., 193 has DBH 49 and its height was 66 feet. Maximum growth rate i.e., 0.277 inches/year was observed in the tree having 69.5 inches DBH and 256 years age. On the other

hand, trees which were growing away from the road, have age in the range of 160 to 328 years. The maximum age was 328 years with DBH 73 inches and its height was 77 feet and minimum age was 160 with DBH 51.5 inches and 99 feet tall. Maximum growth rate i.e., 0.358 was found in a tree having 261 years age and 93.5 inches DBH and minimum growth rate i.e., 0.22 was observed in tree having 73 inches DBH and 328 years age.

Table 1
Total age and growth rate of *Pinus roxburghii* from Ghora galli, Murree along road side

Sr. No.	Core Code	DBH (inches)	Radius (Inches)	Age	Growth rate (inches/year)	GPS Readings	Heights of trees (ft.)
1	P.Rox1	67	33.5	253	0.265	N33 52.814;E073 20.873	88
2	P.Rox2	58	29	213	0.272	N33 52.817;E073 20.866	86
3	P.Rox3	60	30	229	0.262	N33 52.815;E073 20.868	82
4	P.Rox4	60.5	30.25	248	0.244	N33 52.810;E073 20.866	73
5	P.Rox5	49	24.5	193	0.254	N33 52.811;E073 20.868	66
6	P.Rox6	66.5	33.25	256	0.259	N33 52.805;E073 20.854	83
7	P.Rox7	71	35.5	304	0.234	N33 52.876;E073 20.804	72
8	P.Rox8	69.5	34.75	251	0.277	N33 52.789;E073 20.796	93
9	P.Rox9	51.3	25.65	195	0.263	N33 52.766;E073 20.785	78
10	P.Rox10	52.6	26.3	198	0.266	N33 52.774;E073 20.773	84
11	P.Rox11	83.2	41.6	312	0.267	N33 52.776;E073 20.760	97

Table 2
Total age and growth rate of *Pinus roxburghii* from Ghora galli, Murree, away from the road

Sr. No.	Core Code	DBH (inches)	Radius (Inches)	Age	Growth rate (inches/year)	GPS Readings	Heights of trees (ft.)
1	P.Rox12	93.5	46.75	261	0.358	N33 52.753; E073 20.739	92
2	P.Rox13	51	25.5	182	0.280	N33 52.753;E073 20.735	88
3	P.Rox14	73	36.5	212	0.344	N33 52.752;E073 20.676	99
4	P.Rox15	72.5	36.25	205	0.354	N33 52.751;E073 20.633	93
5	P.Rox16	51.5	25.75	160	0.322	N33 52.755;E073 20.630	92
6	P.Rox17	79	39.5	243	0.325	N33 52.757;E073 20.624	87
7	P.Rox18	73.5	36.75	236	0.311	N33 52.749;E073 20.606	94
8	P.Rox19	59.5	29.75	205	0.290	N33 52.753;E073 20.605	86
9	P.Rox20	73	36.5	328	0.22	N33 52.696;E073 20.676	77

Tables 3 and 4 explain comparative age, DBH, growth rate and height of trees growing along and away from the road. Forty nine trees of *P. wallichiana* were cored, from which twenty three cores from the core code P.w.1 to P.w. 23 were taken from the trees growing along the roadside and remaining twenty six having code P.w 24 to P.w. 49 were cored from the trees growing away from the road. All the trees of *P. wallichiana* growing along the road have age in the range of 73 and 223. Tree having maximum age i.e., 223 had DBH 51 inches and height of 57 feet, similarly tree having minimum age i.e., 73 years had 24.2 inches DBH and its height was 73 feet. Maximum growth rate i.e., 0.392 inches/ year was observed in the tree having 31 inches DBH with 98 years of age and 79 feet height. On the other hand, trees which were growing away from the road had ages in the range of 71 and 158. The maximum age was 158 with a DBH of 51 inches and 50 feet height while the minimum age was 71 with a DBH of 31 inches and its height was 54 feet. Maximum growth rate i.e., 0.437 was found in tree having 31 inches DBH, age of 71 years and 54 feet height while minimum growth rate i.e., 0.301 was observed in a tree with DBH 39.2 inches having 133 years and age of 79-year and 53 feet height.

Table 3

Total age and growth rate of *Pinus wallichiana* from Ghora Galli, Murree, along the road side

Sr. No.	Core Code	DBH (inches)	Radius (Inches)	No. of double rings	Age	Growth rate (inches/year)	GPS Reading	Height (fts)
1	P.W 1	35	17.5	----	124	0.282	N33 53.209; E073 20.993	37
2	P.W 2	47	23.5	----	169	0.27	N33 53.232; E073 20.993	43
3	P. W 3	63	31.5	----	216	0.266	N33 52.346; E073 21.022	42
4	P.W 4	37	18.5	3	162	0.22	N33 52.849; E073 21.024	34
5	P.W 5	61	30.5	----	202	0.30	N33 52.840; E073 21.035	48
6	P.W 6	39.7	19.85	----	124	0.320	N33 52.847; E073 20.956	66
7	P.W 7	54.3	27.15	----	186	0.292	N33 52.834; E073 20.947	71
8	P.W 8	42	21	1	133	0.315	N33 52.846; E073 20.951	68
9	P.W 9	45	22.5	----	135	0.333	N33 52.839; E073 20.949	77.5
10	P.W 10	51	25.5	----	223	0.22	N33 52.839; E073 20.945	57
11	P.W 11	39.4	19.7	1	167	0.235	N33 52.838; E073 20.936	43
12	P.W 12	42	21	----	138	0.304	N33 52.835;E073 20.942	68
13	P.W 13	51	25.5	----	201	0.267	N33 52.834;E073 20.944	77
14	P.W 14	43	21.5	----	147	0.292	N33 52.832;E073 20.942	67
15	P.W 15	31	15.5	----	98	0.392	N33 52.832;E073 20.938	79
16	P.W 16	32	16	----	101	0.317	N33 52.833;E073 20.939	76
17	P.W 17	24.2	12.1	----	73	0.331	N33 52.830;E073 20.936	73
18	P.W 18	40.5	20.25	----	126	0.321	N33 52.832;E073 20.940	67

Sr. No.	Core Code	DBH (inches)	Radius (Inches)	No. of double rings	Age	Growth rate (inches/year)	GPS Reading	Height (fts)
19	P.W 19	42.7	21.35	----	131	0.326	N33 52.823;E073 20.943	78
20	P.W 20	43.3	21.65	----	140	0.309	N33 52.823;E073 20.933	77
21	P.W 21	38.2	19.1	2	113	0.338	N33 52.820;E073 20.924	73
22	P.W 22	31.2	15.6	----	91	0.343	N33 52.818;E073 20.923	72
23	P.W 23	44.2	22.1	----	152	0.291	N33 52.811;E073 20.914	83

Figure 1a and 3a explain the relationship between growth rate in inches/year and DBH in inches in *Pinus roxburghii* and *Pinus wallichiana* along roadside. It was found that growth rate was inversely proportional to the DBH with the standard value was 0.0546 and 0.1849. Figure 2a and 4a explain the relationship between DBH and growth rate in inches/year in *Pinus roxburghii* and *Pinus wallichiana* growing away from road. The standard value was 0.0872 and 0.0728. Figure 1b and 3b explain the relationship between growth rate in inches/year and height in feet in *Pinus roxburghii* and *Pinus wallichiana*. In these cases, if growth rate was increased than height was also increased with the standard value 0.5788 and 0.4521 respectively. Similar results were obtained in Fig. 2b and 4b but correlation was found be less significant as compared to roadside plants. Here the standard value was = 0.7099 and 0.0746. It was noted that those trees, both of *Pinus roxburghii* and *Pinus wallichiana* growing away from road have greater growth rate than those growing along the road and this may be due to much disturbance on the road. While those trees which were away from road, face comparatively less disturbance as well as pollution.

Age of trees varies from site to site, species to species and even tree to tree. Similarly it varies among the same sized trees (Ahmed *et al.*,., 2011). Ahmed *et al.*,., (2009) observed that *Pinus wallichiana* and *Pinus roxburghii* is a fast-growing tree. It was suggested that those trees which are growing in moist temperate region have highest growth rate.

According to McCarthy and Weetman, (2006) there is poor relationship between age of tree and DBH. Same results were also presented by Ahmed and Ogden (1987). Therefore, this relationship was not focused. The correlation between DBH and growth rate was calculated because it have significant value to estimate the environmental impact on tree. Normally DBH of the tree increases with increased growth rate. *Pinus wallichiana* and *Pinus roxburghii* showed negative correlation between DBH and growth rate. Similar results were mentioned by Ahmed *et al.*,., 1990 and Wahab *et al.*,., 2008. Diameter, growth rate and age showed significant relationship in majority of stands but sometimes this correlation was negative. Like age, growth rate cannot be predicted from diameter of tree. But this is a product of climatic factors like rain, temperature, moisture level etc. and even of genetic factors. In the same way it was found that there is direct relationship between growth rate and height of the tree.

From the study area, there were two dominant tree species which were *Pinus roxburhii* and *Pinus wallichiana* and two ferns which were *Adiantum capillus* and *Dryopteris stewartii* was collected. There were three shrubs and fifteen herbs which are mentioned in table 4. There were two members of family Pinaceae which were *P. roxburghii* and *P. wallichiana*. The IVI value of *P. wallichiana* was greater with 11.07 than *P. roxburghii* with 11.03. In case of ferns, there were two families, Adiantaceae and Dryopteridaceae and one member in each family. IVI of *Adiantum capillus* was greater with 5.44 than *Dryopteris stewartii* with 4.83. Among the shrubs, there were total three families Araliaceae, Caprifoliaceae and Pumicaceae which have *Hedera nepalensis*, *Viburnum grandiflorum* and *Punica granatum*. The IVI value was 7.73, 4.07 and 4.90 respectively. In Asteraceae there were three members which were *Artemisia vulgaris*, *Cirsium arvensis* and *Taraxacum officinale*. The IVI of these were 4.27, 2.46 and 4.17 respectively. The maximum IVI was of *Artemisia vulgaris*. Similarly, family Labiateae had three members which were *Ajuga bracteosa*, *Marrubium vulgare* and *Micromeria biflora* which have IVI 3.07, 3.52 and 4.17 respectively. Other families were Apocynaceae Brassicaceae, Gerraniaceae, Liliaceae, Primulaceae, Ranunculaceae, Rosaceae, Saxifragaceae and Velarianaceae. The members of these families were *Vinca major*, *Capsella bursa-pastoris*, *Geranium rotundifolium*, *Tulipa clusiana*, *Androsace rotundifolia*, *Ranunculus laetus*, *Duchesnia indica*, *Berginia ciliate* and *Valeriana jetamansii*. The IVI of these members was 3.24, 3.32, 3.69, 3.07, 1.67, 1.71, 5.29, 3.87, 3.61 and 2.72. It was found that Ranunculus laetus had maximum IVI among herbs and *Tulipa clusiana* had minimum IVI value with 1.67 among herbs. Pinaceae have maximum IVI value as 22.1 while family Liliaceae had IVI with 1.67.

Declarations

Ethical Approval

I (on the behalf of my team) confirm that no any human, animal or plant was harmed during this whole study. During coring precautionary measures were taken to avoid any damage to plants.

This whole study was carried out in Ghora galli Murree, Punjab, Pakistan forests and not form any public place and the participation of whole team was purely voluntary.

Competing interests

This study was purely for educational purpose not for financial.

Authors' contributions

Dr. Nadeem Ullah (Corresponding Author) was team leader. He guided team members during sampling and later on during lab work. Dr. Shafiq-ur-Rehman guide during thesis writeup, correlation of data and later during manuscript writing. Muhammad Tayab and Muneeb Akram Ghumman were graduate students and whole study was related to their degree. Muhammad Waheed was a taxonomist and help during identification of plants.

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Availability of data and materials

The whole study was carried out in the labs of university of central Punjab, Lahore and Government College University, Lahore.

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Figures

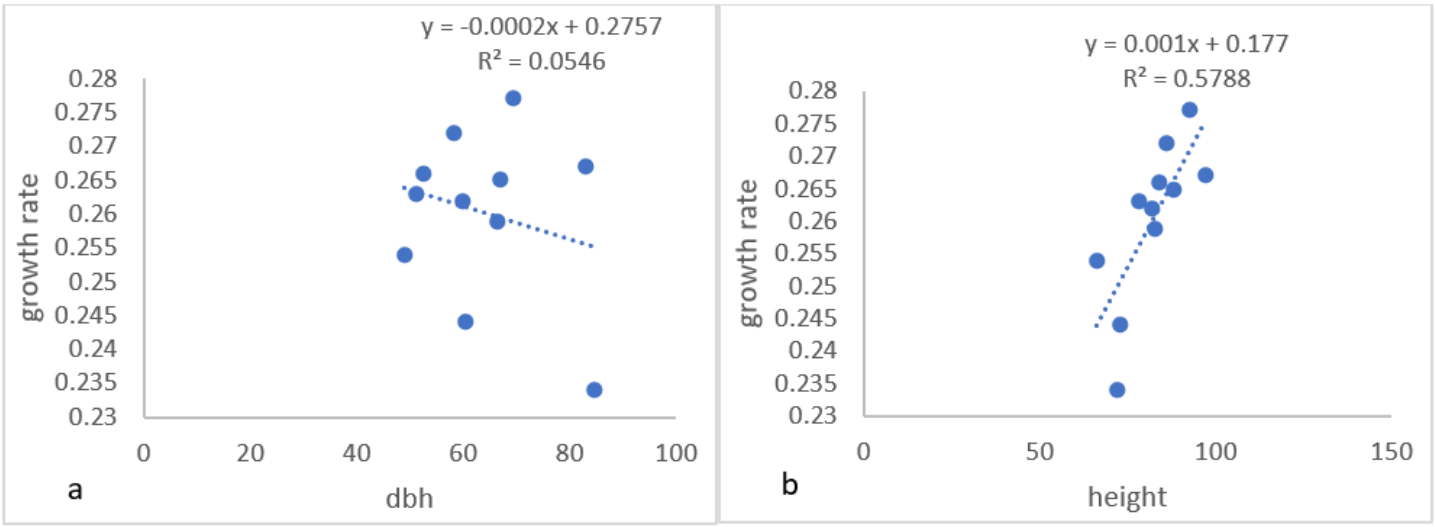

Figure 1

Correlation between growth rate and dbh (a), growth rate and height (b) of *Pinus roxburghii* along the roadside

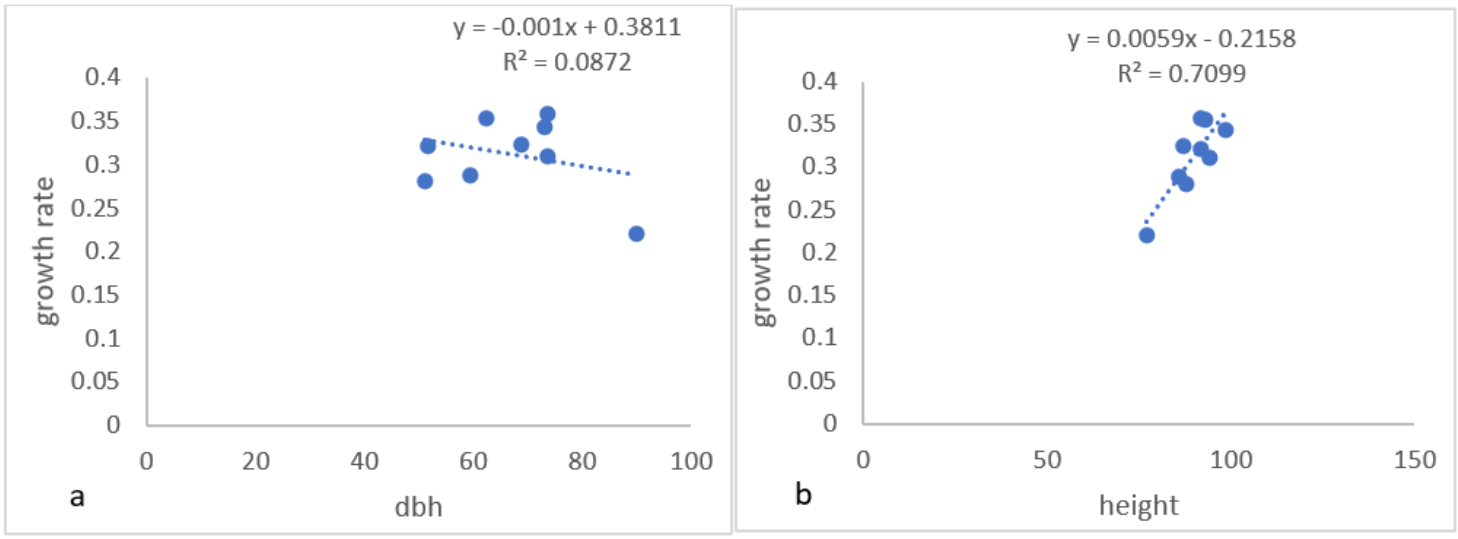

Figure 2

Correlation between growth rate and dbh (a), growth rate and height (b) of *Pinus roxburghii* away from the roadside

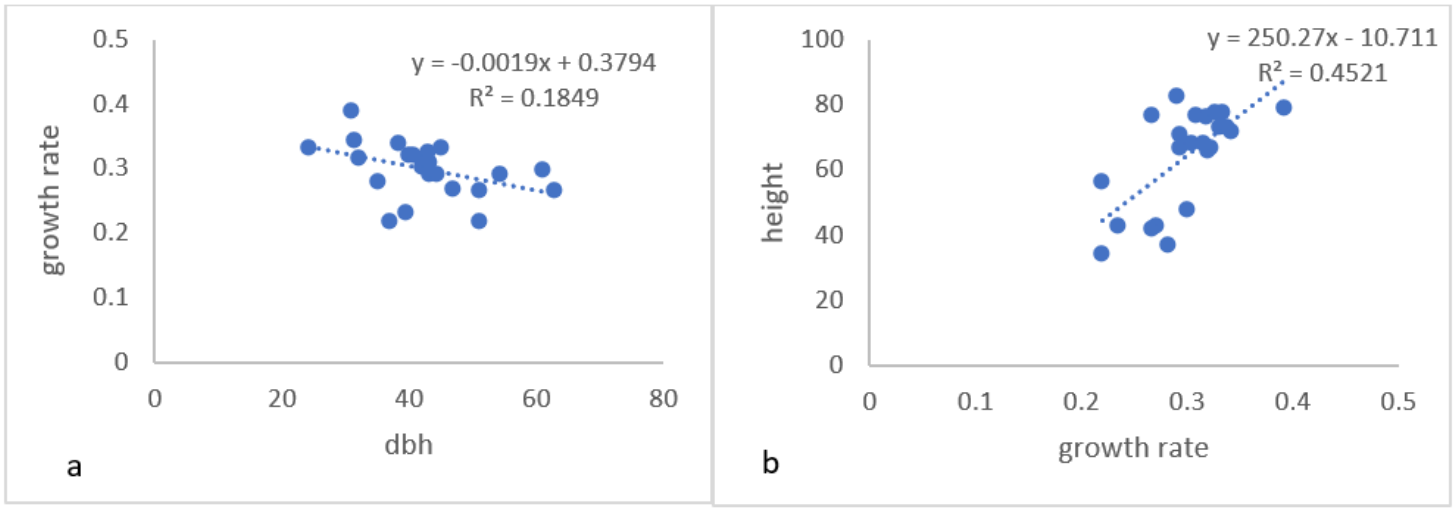

Figure 3

Correlation between growth rate and dbh (a), growth rate and height (b) of *Pinus wallichiana* along the roadside

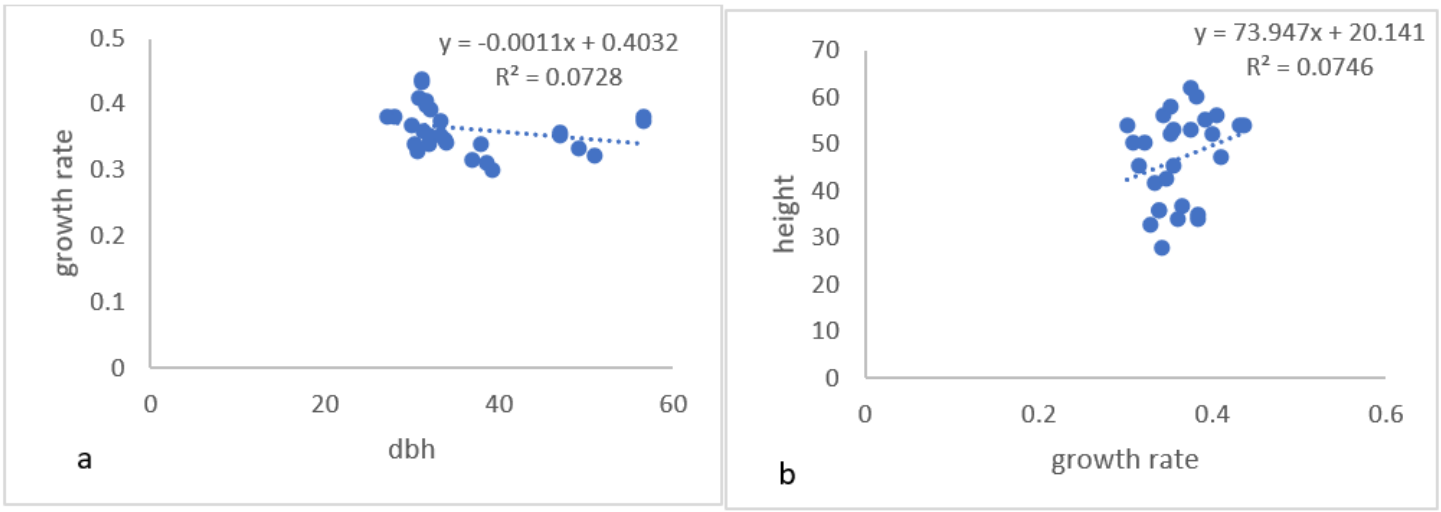

Figure 4

Correlation between growth rate and dbh (a), growth rate and height (b) of *Pinus wallichiana* along the roadside

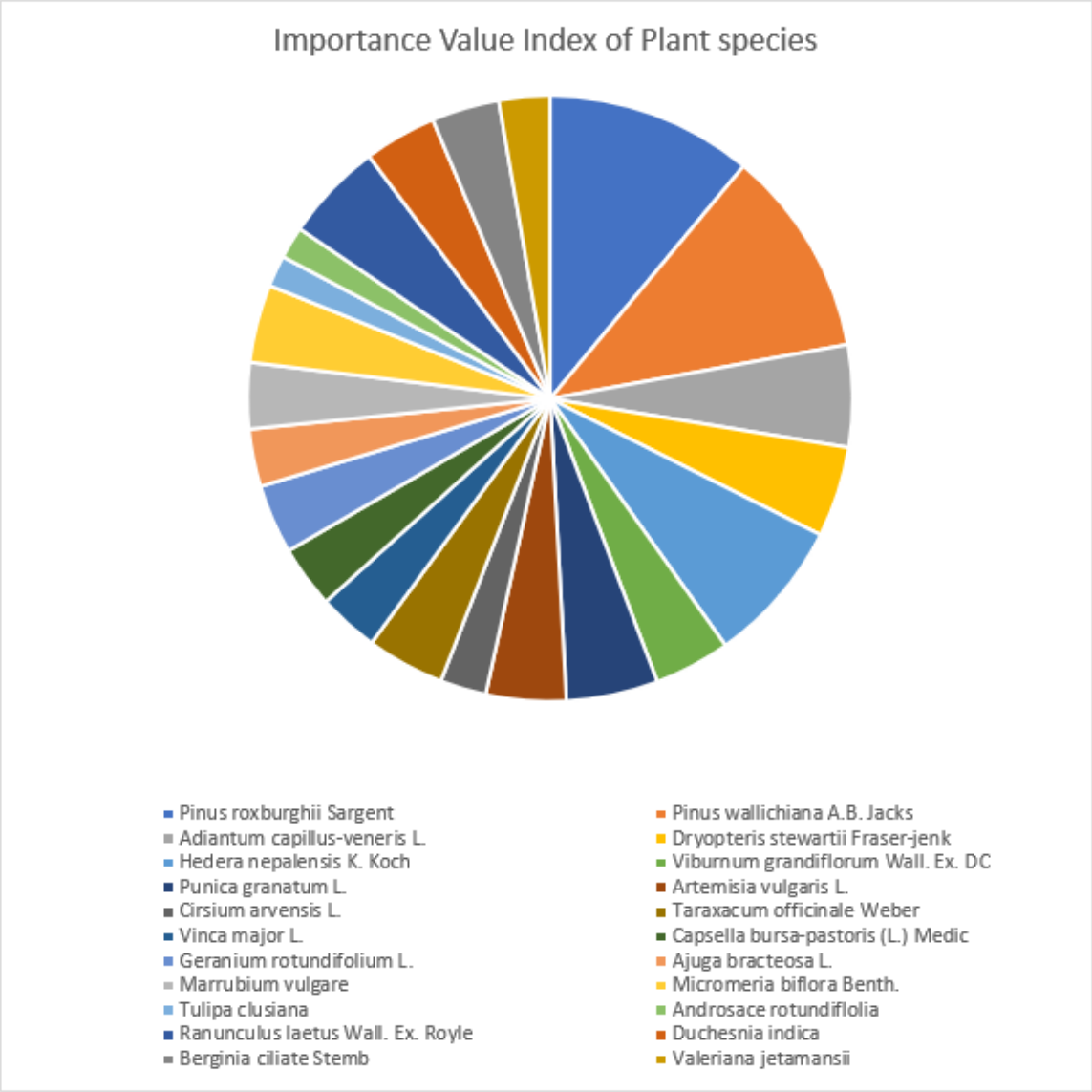

Figure 5

Legend not included with this version