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Original Research Article

Tree Ring Studies of *Pinus wallichiana* and *Pinus roxburghii* for Climate Reconstruction in Ghora Galli Murree

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Abstract

This study investigates the growth characteristics of *Pinus roxburghii* and *Pinus wallichiana* in Ghora Galli, Murree, comparing trees from roadside environments with those from undisturbed areas. Analysis of diameter at breast height (DBH), age, height, and growth rates reveals significant differences influenced by environmental conditions. Roadside trees show lower growth rates and DBH, likely due to soil compaction, pollution, and altered microclimates. Conversely, trees in undisturbed areas exhibit higher growth rates and more consistent growth patterns, suggesting that reduced human disturbance allows for optimal tree development. The findings emphasize the dominance of *Pinus roxburghii* and *Pinus wallichiana* in the forest structure, highlighting their significant ecological roles. Additionally, the study illustrates the importance of a diverse plant community across different ecological layers, which enhances ecosystem stability, supports biodiversity, and promotes soil health. These results provide valuable insights for forest management strategies and urban planning, offering guidance on sustaining healthy tree populations in areas influenced by human activity.

Keywords: *Pinus roxburghii*, *Pinus wallichiana*, Growth Characteristics, Roadside vs. Undisturbed, Forest Management.

INTRODUCTION

Dendrochronology, the scientific study of annual growth rings in trees, provides crucial insights into past environmental conditions and climatic changes. The term originates from Greek, where "Dendro" means "tree," "Chronos" refers to "time" or past events, and "Logos" signifies "study." Tree rings reflect variations in growth influenced by climatic factors, with each ring representing a year of growth (Fritts, 1971; Speer, 2010; Nadeem-ullah and Khan, 2009). Theophrastus (372–287 B.C.) was among the first to observe growth layers in trees, noting that silver firs possess layered structures similar to onions. While the distinction between bark and wood was unclear in silver firs, conifers exhibited pronounced and identifiable rings.

The systematic development of dendrochronology as a dating technique emerged in the early 20th century through the pioneering work of Andrew Douglas in the United States. In 1937, Douglas established the first dedicated tree-ring laboratory at the University of Arizona in Tucson (Wyant and Reid, 1992; Schweingruber, 1988). His contributions laid the foundation for the field, enabling precise dating of environmental events through tree-ring analysis.

Ghora Galli, located in Tehsil Murree, District Rawalpindi, sits at an elevation of approximately 2100 meters (33.83°N, 73.35°E). The region experiences cold, snowy winters and rainy summers, fostering dense forests and diverse plant life. Annual rainfall averages around 64 inches, with March and August marking the peak rainy months in winter and summer, respectively. The moderate climate, with temperatures rarely dropping below 27°F, supports lush vegetation. The landscape, characterized by moist, grassy ground, provides habitat for various insects and small fauna, contributing to the region's ecological richness (Cretelli and Garzanti, 1994; Ali *et al*., 2016).

MATERIALS AND METHODS

Those trees were selected for sampling which were healthy and sound and have uniform diameter. The rotten trees were rejected (Kuniholm, 2001). Cores were taken at breast height because it is easy to handle. For the accurate age estimation, the tree should be cored at point of germination but certain problems exist in taking cores from base, borer touches to the ground again and again during coring is one of the major hurdles among others (Raphael, 1994; Mares, 2009, Nadeem-ullah and Khan, 2009).

Cores were placed in open air for drying but only when there is dry climate otherwise cores may be dried in an oven for 24 hours. Drying is important if wet core is mounted then cracks may develop as it goes on drying. Drying should not be done in sunlight because it will develop cracks (Friedrich *et al*., 2004). The method of Peck, (1973) and Stokes, (1996) for mounting and untwisting of cores was followed. Similarly, the method of Francis and Loftus, (1977) for sanding of cores was followed. Cross dating was done with the help of light microscope. Annual rings were counted under the low and high magnification of microscope and visually cross matched. Rings were studied with the help of Velmex Measuring system. Sample was put on the stage of the measuring system and image was seen on computer with the help of microscope, having a digital camera on its upper side.

Vegetation Study

Plant species were collected from a specific site, dried, pressed, and mounted on plant sheets for identification. An inventory was created, and voucher specimens were deposited at Dr. Sultan Ahmed Herbarium at Government College University, Lahore, Pakistan (Ahmed & Siddiqui, 2005). For the quantitative data analysis frequency, density, cover and IVI of species was calculated by using formulas used by Joshi *et al*., 2019 with some modifications. All formulae are given below.

$$\%\ \text{Density} = \frac{\text{Total no.of species in a quadrat}}{\text{Total Area}} \times 100$$

$$\text{Relative Density} = \frac{\text{Number of individual species}}{\text{Total no.of all species}} \times 100$$

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

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

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

$$\text{IVI} = \frac{\text{Relative Density} + \text{Relative Frequency} + \text{Relative Cover}}{3}$$

RESULTS AND DISCUSSION

The tables and figures present detailed data on the growth characteristics of *Pinus roxburghii* and *Pinus wallichiana* from Ghora Galli, Murree, highlighting the influence of roadside environments versus undisturbed areas on tree growth. The analysis provides insights into variations in diameter at breast height (DBH), age, height, and growth rate, reflecting the complex interplay between environmental conditions and tree physiology.

The data in Table 1 reveals the age and growth rate of *Pinus roxburghii* sampled along the roadside. The DBH values range from 49 to 93.5 inches, with corresponding growth rates varying between 0.234 to 0.358 inches per year. The diversity in growth rates indicates site-specific influences, likely driven by soil compaction, pollution, and microclimatic conditions. The tallest trees, exceeding 90 feet, exhibit moderate growth rates, suggesting a trade-off between vertical and radial growth, consistent with studies by Pretzsch *et al*., (2015) that highlight environmental limitations on DBH expansion.

Table 2, representing *Pinus roxburghii* from areas away from the road, shows comparatively higher growth rates in several instances, peaking at 0.437 inches per year. This pattern aligns with research indicating that reduced human disturbances and better soil aeration foster improved radial growth (Singh, 2017). Trees away from the roadside appear to achieve greater DBH and overall age, supporting findings by Gillner *et al.*, (2014) that roadside environments can hinder long-term growth potential through pollutant exposure and root zone degradation.

The *Pinus wallichiana* data in Table 3 shows a broader range of DBH values, from 24.2 to 63 inches, among roadside samples. Growth rates vary, with the highest reaching 0.392 inches per year. A notable aspect is the variability in tree height, suggesting heterogeneous growth conditions along the road. This variability may reflect the fragmented light availability and intermittent water stress often observed in roadside environments (Escobedo *et al*., 2011). Additionally, the presence of double rings in some samples highlights growth interruptions, potentially induced by drought or episodic stress events (Lloyd & Farquhar, 1996).

Table 4 presents *Pinus wallichiana* samples taken away from the road, where growth rates are generally higher, with several trees displaying rates above 0.4 inches per year. The greater uniformity in height and DBH suggests more stable environmental conditions and less anthropogenic interference. These findings resonate with Bottalico *et al.,* (2016), who noted that trees in undisturbed areas often outperform roadside counterparts in both radial and vertical growth.

The figures illustrate correlations between growth rate and DBH or height for each species across both environments. Figure 1 shows a positive correlation between growth rate and DBH for *Pinus wallichiana* along the road, although the relationship appears less pronounced compared to Figure 3, which depicts trees away from the road. This suggests that while roadside trees grow consistently, their radial expansion is limited by environmental stressors, corroborating findings by Nowak *et al*., (2004).

Figure 2 demonstrates the correlation between growth rate and height for *Pinus wallichiana* along the roadside. The scatter suggests variability, reflecting uneven growth conditions. In contrast, Figure 4, representing trees away from the road, shows a more linear relationship, indicating consistent height increments under favorable conditions.

For *Pinus roxburghii*, Figure 5 reveals a modest correlation between growth rate and DBH along the road, implying that factors such as soil compaction or limited root expansion may restrict radial growth (Craul, 1992). Figure 7, however, displays a stronger correlation for non-roadside trees, aligning with studies that highlight the benefits of less disturbed environments on DBH growth (Thomas *et al*., 2018).

Figures 6 and 8 compare growth rate and height correlations for *Pinus roxburghii*. Trees along the roadside show greater variability, indicative of fluctuating environmental factors. Conversely, the tighter correlation in Figure 8 supports the hypothesis that trees in undisturbed areas can allocate more energy towards vertical growth, consistent with Zhang *et al*., (2019).

Overall, the data and figures collectively highlight the nuanced effects of roadside environments on tree growth. The comparative analysis underscores the need for forest management strategies that consider species-specific growth responses and the environmental challenges posed by proximity to human activity (Moser *et al*., 2015). These findings provide valuable input for afforestation projects and urban planning initiatives aimed at sustaining tree populations in mixed-use landscapes.

The table provides valuable insight into the species composition and ecological dynamics of the studied habitat. It includes data on frequency, density, cover, and relative indices such as relative frequency, relative density, and relative cover, which together offer a clear picture of the community structure. The species listed represent a variety of plant families, including trees, ferns, shrubs, and herbs, each contributing differently to the overall ecosystem.

In the tree category, *Pinus roxburghii* and *Pinus wallichiana*, both from the Pinaceae family, are dominant species with high frequencies (45% and 42%, respectively) and substantial cover values (65% and 68%). These values suggest that both species are not only widespread but also have a significant physical presence in the community. Such dominance in frequency and cover typically signifies their role as foundational species, which contribute to shaping the structure of the forest or habitat. Their Relative Frequency (11.47% for *P. roxburghii* and 10.71% for *P. wallichiana*) and Relative Density (9.06% and 9.36%) further emphasize their importance, resulting in Important Value Index (IVI) values of 33.1 and 33.22, respectively. IVI is an ecological measure used to assess the relative contribution of a species to the community based on its frequency, density, and cover, and the high values here underscore the significant ecological roles of these species, such as providing canopy cover, shelter, and food for fauna, as well as playing a critical role in soil dynamics (Whittaker, 1975; Odum, 1971).

In the fern category, *Adiantum capillus-veneris* from the Adiantaceae family and *Dryopteris stewartia* from the Dryopteridaceae family show moderate frequencies (22% and 21%) and densities (15 and 13). Despite their relatively lower values compared to the tree species, they still cover substantial ground, with the former contributing 32% and the latter 27%. Ferns often play important ecological roles, including providing ground cover and supporting microhabitats for various organisms, particularly in moist environments (Baker *et al*., 2015). The presence of these species could indicate a well-developed understory layer that supports plant diversity and aids in maintaining soil moisture and stability (Haines *et al*., 1995).

The shrub layer, dominated by species such as *Hedera nepalensis* from the Araliaceae family, *Punica granatum* from the Pumicaceae family, and *Viburnum grandiflorum* from the Caprifoliaceae family, contributes significantly to both the structural complexity and the functional diversity of the habitat. *Hedera nepalensis* stands out with the highest Relative Frequency (8.16%) and cover (45%), which suggests that it is an important shrub species in this community. This species is often associated with forest understories and can serve as a ground cover plant, important for preventing soil erosion and supporting various herbivorous species (Hill *et al*., 2016). The relatively high cover of *Punica granatum* (21%) further highlights its role in the lower canopy, contributing to food sources for wildlife, particularly birds and insects (CABI, 2024).

The herbaceous layer is highly diverse, with species such as *Artemisia vulgaris*, *Taraxacum officinale* and *Cirsium arvensis* from the Asteraceae family, *Vinca major* from the Apocynaceae family, all showing varying levels of frequency and cover. *Artemisia vulgaris*, for example, with a Relative Density of 5.43% and Relative Cover of 4.83%, is a species commonly found in disturbed habitats and plays a role in medicinal use as well as providing nectar for pollinators (Duke, 2008). *Taraxacum officinale*, with a Relative Frequency of

5.1%, also stands out due to its wide distribution and ability to colonize disturbed areas, often providing food for pollinators and acting as a pioneer species in ecological succession (Royer & Dickinson, 1999).

Additionally, species like *Capsella bursa-pastoris* (Brassicaceae) and *Geranium rotundifolium* (Gerraniaceae) reflect a typical pattern of herbaceous dominance in disturbed sites, where their high frequencies (10% and 12%, respectively) and moderate cover values (15% and 18%) suggest their role in early succession stages (Bazzaz, 1975). These species contribute to the rapid colonization of disturbed soils, improving soil health and preventing erosion (Sternberg, 2008).

The diversity in the herbaceous layer is further indicated by species like *Ajuga bracteosa*, *Marrubium vulgare*, and *Micromeria biflora*, which contribute to the diversity of the understory, supporting ecosystem services such as nitrogen fixation, medicinal value, and providing habitats for a variety of insect species. *Ajuga bracteosa* and *Micromeria biflora*, with significant relative densities (3.02% and 5.13%), show that some species in this family are well-suited to occupy niches in the understory, contributing to biodiversity and enhancing ecosystem resilience (Lamb *et al*., 1999).

In terms of overall community structure, the Important Value Index (IVI) is an excellent tool for understanding the relative importance of different species. The IVI values for *Pinus roxburghii* (33.1) and *Pinus wallichiana* (33.22) reinforce the idea that these species dominate the ecosystem, both structurally and functionally, while the IVI for other species such as *Adiantum capillus-veneris* (16.32) and *Hedera nepalensis* (23.2) suggests that these species are important contributors to the ecological complexity but play secondary roles compared to the Pinaceae trees.

This data provides crucial information on how different species contribute to the ecological functioning and biodiversity of the habitat. The balance between tree, shrub, fern, and herb layers supports ecosystem stability by providing a variety of niches, contributing to soil health, and supporting food webs. The dominance of tree species such as *Pinus roxburghii* and *Pinus wallichiana*, coupled with a diverse herbaceous and fern layer, indicates a relatively mature, well-structured habitat that can support a wide array of plant and animal life (Smith *et al*., 2017; Grime, 2001).

Table 1: Total Age and growth rate of *Pinus roxburghii* from Ghora Galli, Murree along road side

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

Table 2: Total Age and growth rate of *Pinus roxburghii* from Ghora Galli, Murree away from the road side

Sr. No.	Core Code	DBH (In.)	Radius (In.)	Age	Growth rate	Height (ft)	GPS reading
1	P.Rox12	93.5	46.75	261	0.358	92	N33°52.753 E073°20.739
2	P.Rox13	51	25.5	182	0.280	88	N33°52.753 E073°20.735
3	P.Rox14	73	36.5	212	0.344	99	N33°52.752 E073°20.676
4	P.Rox15	72.5	36.25	205	0.354	93	N33°52.751

Sr. No.	Core Code	DBH (In.)	Radius (In.)	Age	Growth rate	Height (ft)	GPS reading
							E073°20.633
5	P.Rox16	51.5	25.75	160	0.322	92	N33°52.755 E073°20.630
6	P.Rox17	79	39.5	243	0.325	87	N33°52.757 E073°20.624
7	P.Rox18	73.5	36.75	236	0.311	94	N33°52.749 E073°20.606
8	P.Rox19	59.5	29.75	205	0.290	86	N33°52.753 E073°20.605
9	P.Rox20	73	36.5	328	0.22	77	N33°52.696 E073°20.676

Table 3: Total Age and growth rate of *Pinus wallichiana* from Ghora Galli, Murree along the road side

Sr. No.	Core Code	DBH (In.)	Radius (In.)	Age	Growth rate	Height (ft)	GPS reading
1	P.W 1	35	17.5	124	0.282	37	N33°53.209 E073°20.993
2	P.W 2	47	23.5	169	0.27	43	N33°52.232 E073°20.993
3	P.W 3	63	31.5	216	0.266	42	N33°52.356 E073°20.022
4	P.W 4	37	18.5	162	0.22	34	N33°52.849 E073°20.024
5	P.W 5	61	30.5	202	0.30	48	N33°52.840 E073°20.035
6	P.W 6	39.7	19.85	124	0.320	66	N33°52.847 E073°20.956
7	P.W 7	54.3	27.15	186	0.292	71	N33°52.834 E073°20.947
8	P.W 8	42	21	133	0.315	68	N33°52.846 E073°20.951
9	P.W 9	45	22.5	135	0.333	77.5	N33°52.839 E073°20.949
10	P.W 10	51	25.5	223	0.22	57	N33°52.839 E073°20.945
11	P.W 11	39.4	19.7	167	0.235	43	N33°52.838 E073°20.936
12	P.W 12	42	21	138	0.304	68	N33°52.835 E073°20.942
13	P.W 13	51	25.5	201	0.267	77	N33°52.834 E073°20.944
14	P.W 14	43	21.5	147	0.292	67	N33°52.832 E073°20.942
15	P.W 15	31	15.5	98	0.392	79	N33°52.832 E073°20.938
16	P.W 16	32	16	101	0.317	76	N33°52.833 E073°20.939
17	P.W 17	24.2	12.1	73	0.331	73	N33°52.830 E073°20.936
18	P.W 18	40.5	20.25	126	0.321	67	N33°52.832 E073°20.940
19	P.W 19	42.7	21.35	131	0.326	78	N33°52.823 E073°20.943
20	P.W 20	43.3	21.65	140	0.309	77	N33°52.823 E073°20.933
21	P.W 21	38.2	19.1	113	0.338	73	N33°52.820 E073°20.924
22	P.W 22	31.2	15.6	91	0.343	72	N33°52.818 E073°20.923
23	P.W 23	44.2	22.1	152	0.291	83	N33°52.811 E073°20.914

Table 4: Total Age and growth rate of *Pinus wallichiana* from Ghora Galli, Murree away from the road side

Sr. No.	Core Code	DBH (In.)	Radius (In.)	Age	Growth rate	Height (ft)	GPS reading
1	P.W 24	38.1	19.05	112	0.340	36	N33°52.853 E073°21.043
2	P.W 25	49.1	24.55	147	0.334	42	N33°52.861 E073°21.051
3	P.W 26	28	14	73	0.383	35	N33°52.880 E073°21.060
4	P.W 27	30	15	82	0.366	37	N33°52.892 E073°21.061
5	P.W 28	33.7	16.85	97	0.347	43	N33°52.896 E073°21.059
6	P.W 29	32	16	90	0.355	45	N33°52.902 E073°21.049
7	P.W 30	31.6	15.8	79	0.4	52	N33°52.891 E073°21.049
8	P.W 31	33.1	16.55	91	0.376	53	N33°52.891 E073°21.042
9	P.W 32	32.2	16.1	82	0.393	55	N33°52.890 E073°21.039
10	P.W 33	31.2	15.6	72	0.433	54	N33°52.894 E073°21.039
11	P.W 34	31.4	15.7	87	0.361	34	N33°52.890 E073°21.029
12	P.W 35	30.5	15.25	93	0.328	33	N33°52.892 E073°21.011
13	P.W 36	30.2	15.1	89	0.339	36	N33°52.892 E073°21.009
14	P.W 37	27.2	13.6	71	0.383	34	N33°52.893 E073°21.006
15	P.W 38	31.8	15.9	93	0.341	28	N33°52.833 E073°20.998
16	P.W 39	31	15.5	71	0.437	54	N33°52.874 E073°20.985
17	P.W 40	33.1	16.5	94	0.352	52	N33°52.881 E073°20.980
18	P.W 41	30.8	15.4	75	0.411	47	N33°52.871 E073°20.974
19	P.W 42	34.1	17.05	99	0.344	56	N33°52.858 E073°20.965
20	P.W 43	36.8	18.4	117	0.314	45	N33°52.862 E073°20.961
21	P.W 44	38.5	19.2	124	0.310	50	N33°52.858 E073°20.965
22	P.W 45	39.2	19.6	133	0.301	54	N33°52.857 E073°20.966
23	P.W 46	31.7	15.8	78	0.406	56	N33°52.853 E073°20.964
24	P.W 47	51	25.5	158	0.323	50	N33°52.844 E073°20.960
25	P.W 48	47	23.5	132.5	0.354	55.5	N33°52.843 E073°20.958
27	P.W 49	56.5	28.25	149	0.378	61	N33°52.845 E073°20.953

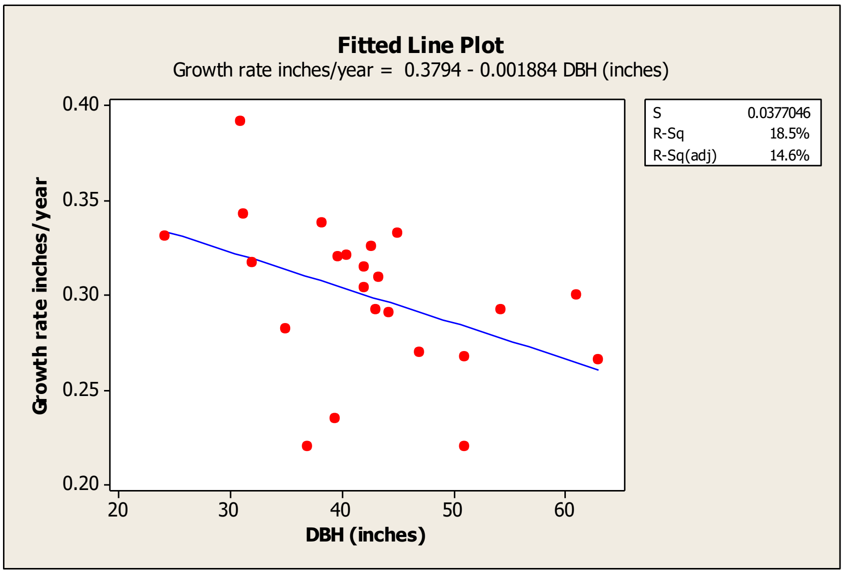


Figure 1: Correlation between growth rate (Inches/year) and DBH (Inches) of *Pinus wallichiana* along the road side

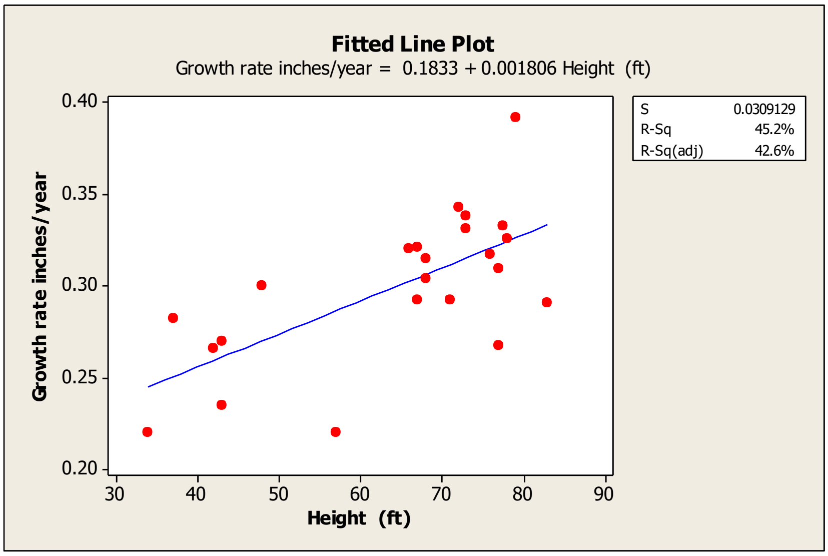


Figure 2: Correlation between growth rate (Inches/year) and Height (fts.) of *Pinus wallichiana* along the road side

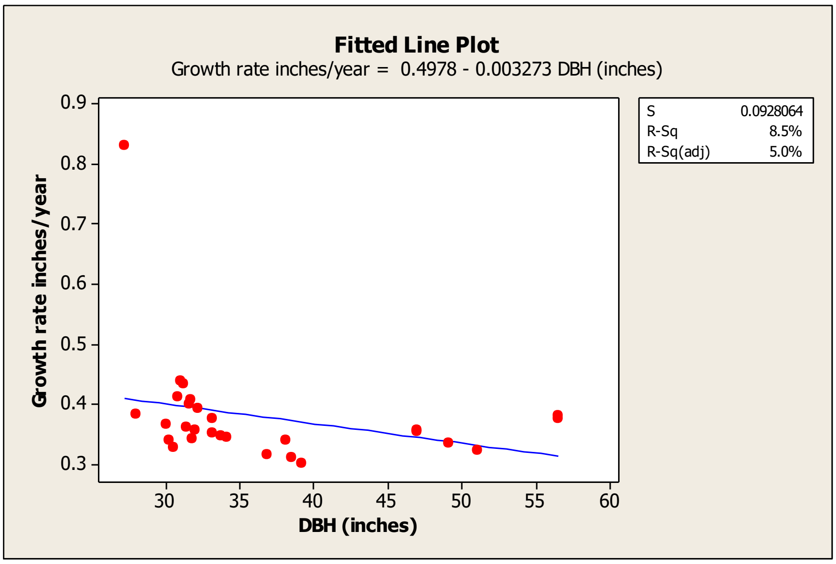


Figure 3: Correlation between growth rate (Inches/year) and DBH (Inches) of *Pinus wallichiana* away from the road

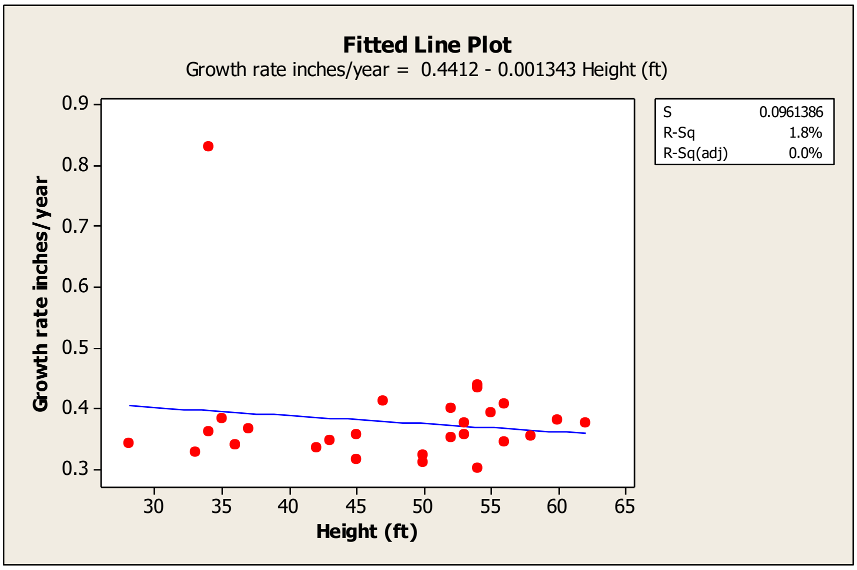


Figure 4: Correlation between growth rate (Inches/year) and Height (fts.) of *Pinus wallichiana* away from the road

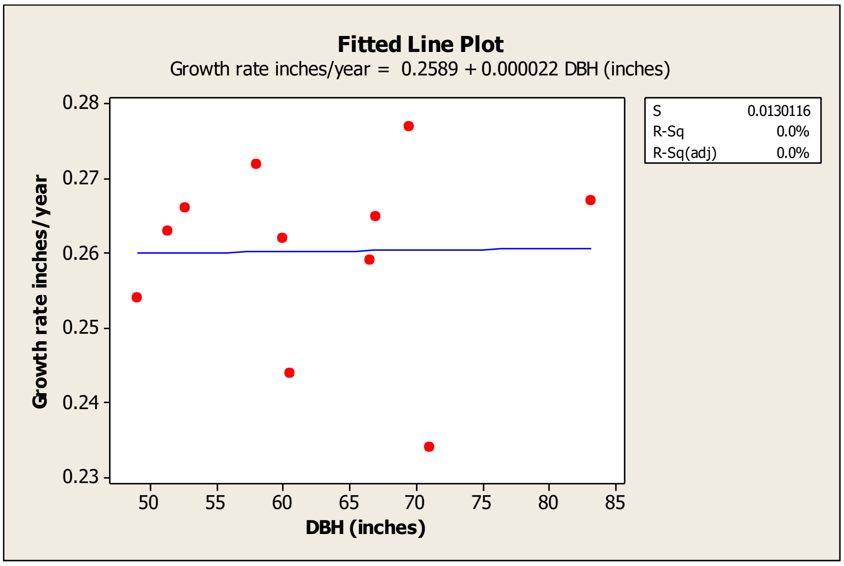


Figure 5: Correlation between growth rate (Inches/year) and DBH (Inches) of *Pinus roxburghii* along the road side

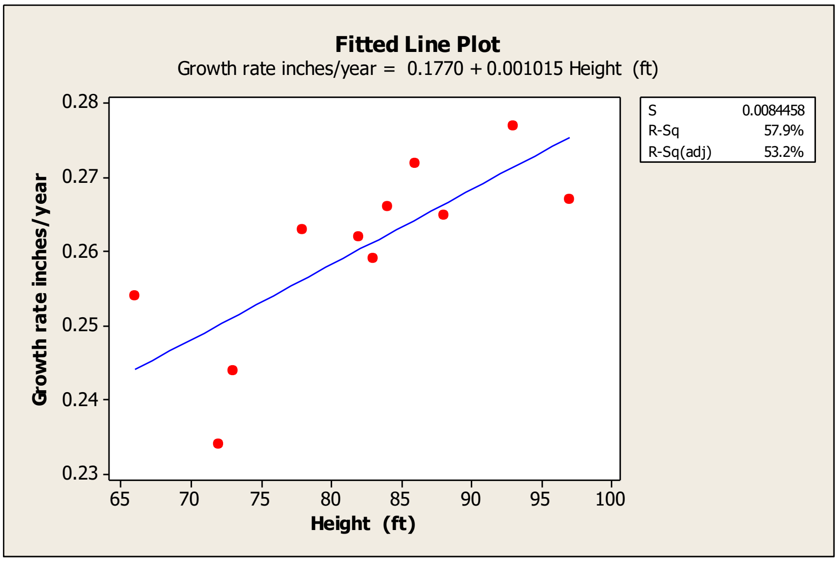


Figure 6: Correlation between growth rate (Inches/year) and height (fts.) of *Pinus roxburghii* along the road side

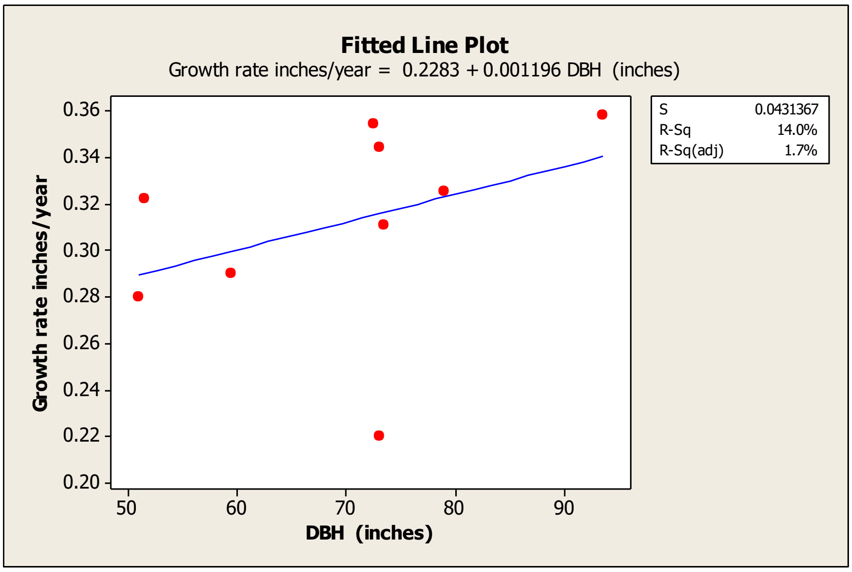


Figure 7: Correlation between growth rate (Inches/year) and DBH (Inches) of *Pinus roxburghii* away from the road

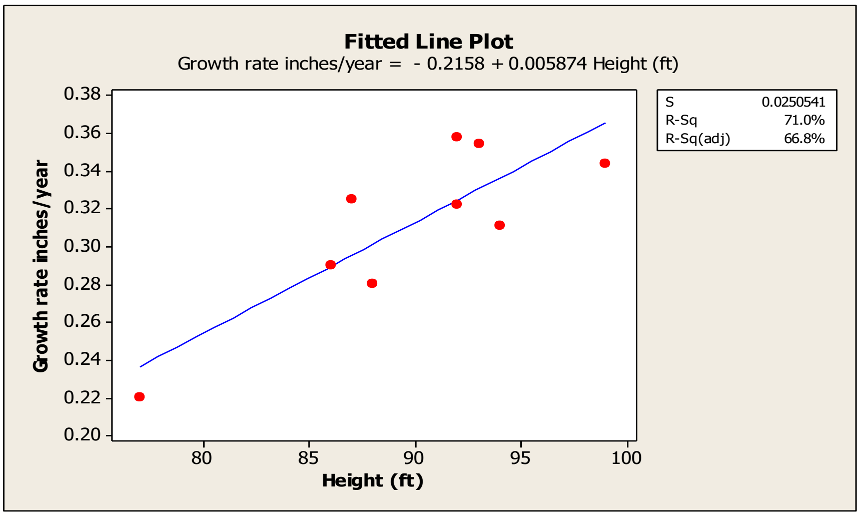
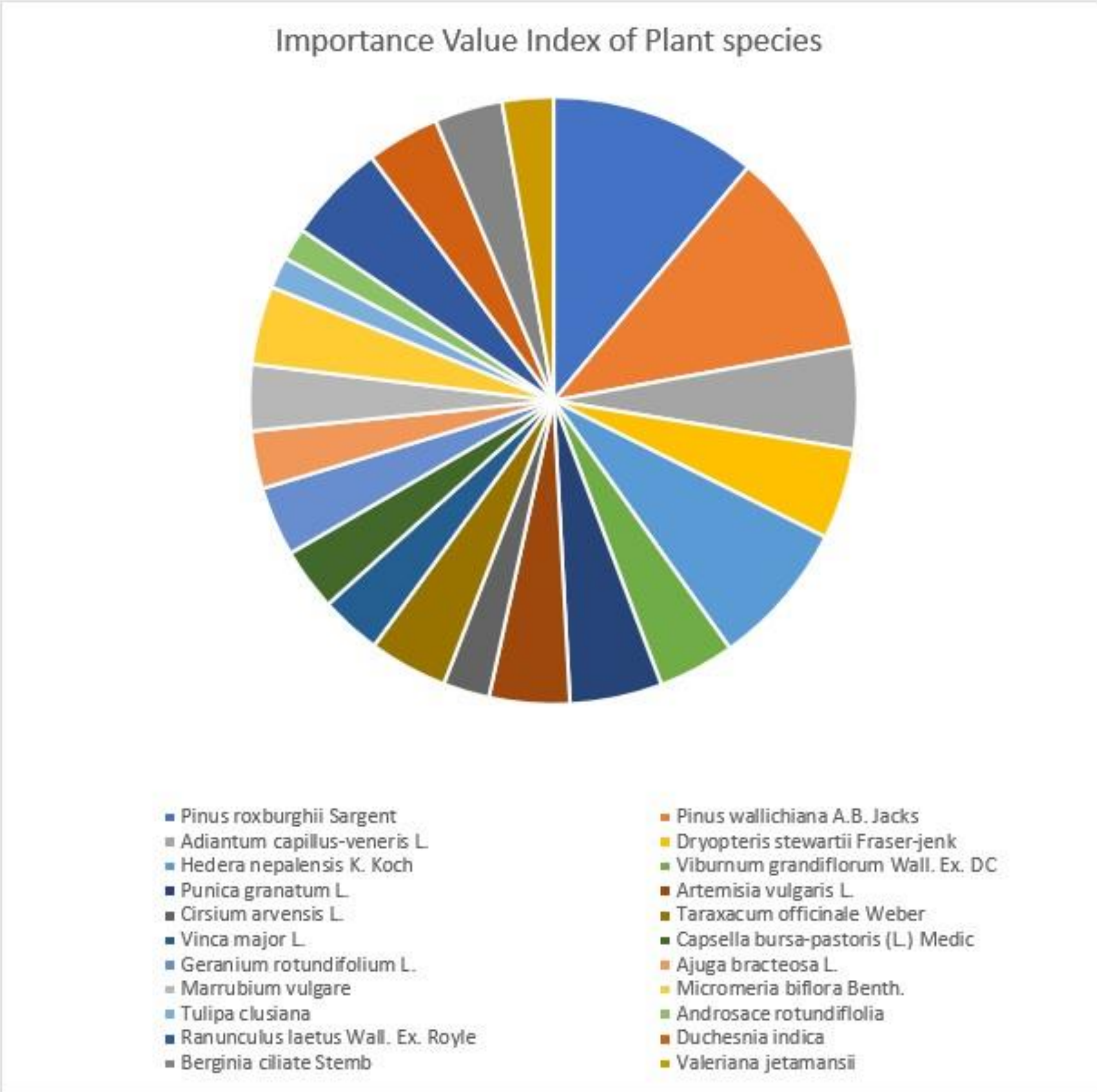


Figure 8: Correlation between growth rate (Inches/year) and height (fts.) of *Pinus roxburghii* away from the road

Family	Species name	% F	Density	% Cover	Relative Frequency	Relative Density	Relative Cover	IV	IVI
Trees									
1)Pinaceae	1)*Pinus roxburghii* Sargent	45	30	65	11.47	9.06	12.57	33.1	11.03
	2)*Pinus wallichiana* A.B. Jacks	42	31	68	10.71	9.36	13.15	33.22	11.07
Ferns									
2)Adiantaceae	*Adiantum capillus-veneris* L.	22	15	32	5.61	4.53	6.18	16.32	5.44
3)Dryopteridaceae	*Dryopteris stewartia* Fraser-jenk	21	13	27	5.35	3.92	5.22	14.49	4.83
Shrubs									
4) Araliaceae	*Hedera nepalensis* K. Koch	32	21	45	8.16	6.34	8.70	23.2	7.73
5) Caprifoliaceae	*Viburnum grandiflorum* Wall. Ex. DC	15	15	20	3.82	4.53	3.86	12.21	4.07
6) Pumicaceae	*Punica granatum* L.	20	21	17	5.10	6.34	3.28	14.72	4.90
Herbs									
7) Asteraceae	1. *Artemisia vulgaris* L.	10	18	25	2.55	5.43	4.83	12.81	4.27
	2. *Cirsium arvensis* L.	07	9	15	1.78	2.71	2.90	7.39	2.46
	3. *Taraxacum officinale* Weber	20	15	15	5.10	4.53	2.90	12.53	4.17
8) Apocynaceae	*Vinca major* L.	15	10	15	3.82	3.02	2.90	9.74	3.24
9) Brassicaceae	*Capsella bursa-pastoris* (L.) Medic	10	15	15	2.55	4.53	2.90	9.98	3.32
10) Gerraniaceae	*Geranium rotundifolium* L.	12	15	18	3.06	4.53	3.48	11.07	3.69
11) Labiateae	1. *Ajuga bractteosa* L.	15	10	15	3.31	3.02	2.90	9.23	3.07
	2. *Marrubium vulgare*	10	15	18	2.55	4.53	3.48	10.56	3.52

Family	Species name	% F	Density	% Cover	Relative Frequency	Relative Density	Relative Cover	IV	IVI
	3. *Micromeria biflora* Benth.	10	17	25	2.55	5.13	4.83	12.51	4.17
12) Liliaceae	*Tulipa clusiana*	10	5	5	2.55	1.51	0.96	5.02	1.67
13) Primulaceae	*Androsace rotundifolia*	07	6	8	1.78	1.81	1.54	5.13	1.71
14) Ranunculaceae	*Ranunculus laetus* Wall. Ex. Royle	25	13	29	6.37	3.92	5.60	15.89	5.29
15) Rosaceae	*Duchesnia indica*	17	12	19	4.33	3.62	3.67	11.62	3.87
16) Saxifragaceae	*Berginia ciliate* Stemb	18	13	12	4.59	3.92	2.32	10.83	3.61
17) Velarianaceae	*Valeriana jetamansii*	11	12	9	2.80	3.62	174	8.16	2.72



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