http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 7 (2): 212-218, 2004
ISSN 1028-8880

Increment and Growth in Timberline Scotch Pine (*Pinus sylvestris* L.) Stands at Ilgaz Mountain, Turkey

Serdar Carus
Department of Forest Management, Faculty of Forestry,
Süleyman Demirel University, 32260 Çünür, Isparta-Turkey

Abstract: In this study, it has been aimed to investigate increment and growth relations for volume and other volume increments of pure and undisturbed timberlines (2000 m above sea level) Scotch pine (*Pinus sylvestris* L.) stands at Ilgaz Mountain depend on site index and stand age. In this research; the pure, even aged or uneven-aged, undisturbed and naturally grown stand of Scotch pine stands were examined. For this purpose the sample plots of 4 forestline, 1 treeline and 1 dwarfish treeline were evaluated. The distribution of trees per hectare to the diameter classes, height-age, diameter-age, diameter-height, diameter-diameter increment, crown height- diameter and crown diameter-diameter were investigated. These characteristics which were derived from the measurements of sample plots were balanced with the most suitable models. The estimated values of model were compared with the values of the poor site (site class III in yield table).

Key words: Growth, increment, scotch pine, timberline

INTRODUCTION

Scotch pine is one of the commercially important native tree species in Turkey. It grows in a vast part of Turkey with about 738.000 ha from Eskişehir in the west to the Russian border in the east occupying the northern part of the country. It forms forests in the elevation between 0 and 2700 meters.

Mountain forests are forests at high altitudes (upper montane and subalpine zone) up to the alpine timberline (about 2000 to 2600 m above sea level), beyond which closed forest stands are not possible because of climatic reasons. Temperature and the length of the growing season primarily limit the growth of trees at the alpine treeline. However, the real timberlines occur the results of very different and complex effects. In the nature, sudden disappearance of forest could be seen very rarely. Generally, there is a transition zone. In this zone, three different lines could be seen such as "forestline", "treeline" and "dwarfish treeline". Forestline where forests crown closure class is decreased or come into existence limit. Treeline where forests crown closure class exists no more and the tree lives only in groups. Dwarfish treeline can be seen almost individually or small groups[1-5].

Struggle zone, which locates between the treeline and forestline, which has occurred because of insufficiency of temperature on the high mountainous areas. In this zone, hard weather conditions exposes the trees structure such as wind, low temperature, snow pressure, freeze etc. and trees are damaged due to these effects. In the struggle zone; the trees become shorter and their stem form differs from cylindrical type and their branches exist on through the ground surface. All the slow growing trees are covered by lichens. The top shoots are mostly broken by wind or high snow pressure and then lateral branch starts growing which are called candlestick or bayonet. Young trees have a camel hump as a result of numerous incline and decline because of snow pressure and show harp form (Fig. 1). The altitude difference between the forestline and the treeline is about 100-150 m. The sufficient crown closure class couldn't be seen just down the forestline. Land slopes, rocky lands, debris sedimentary, soil slides, avalanche gutters and erosion always corrupt the natural forest establishment[3,6,4].

The higher a place is in altitude the shorter the vegetation period is. At those altitudes even the photosynthesis increases because of sunlight, its amount differs depend on topography, slope and hillside. In contrast, the success of plantation couldn't be accomplished because of the physiological drought caused by the wind blowing frigid or warm.

The alpine zone and the timberlines in Turkey are showing the same specifications with the mentioned directions. The lands are covered with dwarfish trees and shrubs in Anatolia, variety of species are containing mountainous pasture. Rocky lands are the most remarkable specialties of timberline in Turkey. Forestline

Corresponding Author: Serdar Carus, Department of Forest Management, Faculty of Forestry, Süleyman Demirel University, 32260 Çünür, Isparta-Turkey

Table 1: Site description and characteristics of selected stands

Sample plot	Altitude (m)	Aspect	Slope (°)	Location	Type
1	2170	W	16	Küçük hacet	Treeline
2	2060	W	23	Küçük hacet	Forestline
3	2010	NW	16	Büyük hacet	Forestline
4	2080	NW	27	Büyük hacet	Forestline
5	2060	NW	21	Küçük hacet	Forestline
6	2120	NW	12	Küçük hacet	Dwarfish treeline

of *Pinus sylvestris* L., *Picea orientalis* are climbing through (2000-2600 m) of the north of Turkey, *Abies bornmülleriana* and *Populus tremula* forestline are climbing through 2100 m, in the middle Anatolia *Quercus spp.* forestline climbs through 2200 m, dwarfish treeline *Betula* spp., climbs through 2600 m, in the east Anatolia, *Pinus sylvestris* climbers through 2600 m and *Betula*'s dwarfish treeline climbs through 2800 m and various *Juniper* species have the largest slight at dwarfish treelines.

Multiple use principle, which has been implemented since the beginning of forestry, has gained more significance in recent years. Of forest ecological and protective aspects have gained importance. The combination of forestry functions goes with continuity, economy and productivity.

The objective of this study is to investigate increment and growth relations for volume and other volume elements of pure and untouched Scotch pine stands at Ilgaz region depending on timberlines. In this research; the pure, even aged or uneven-aged, untouched and naturally grown stand of Scotch pine tree were examined. In order to study increment and growth, Scotch pine material was collected from different sources (forestline, treeline and dwarfish treeline). For this purpose, 6 sample plots were evaluated (Table 1). The distribution of trees per hectare to the diameter classes, diameter-diameter increment, crown diameter and crown length were investigated.

MATERIALS AND METHODS

Ilgaz Mountain is located subeuxin part of the flora region of Euro-Siberian. The Mountain has generally vary plains. Ilgaz Mountain is located between the latitudes 41° 02'- 41 ° 05' at the north and between the longitudes 33° 42'-33 ° 45' at the east. The borders lay from west to east of the western part of Black Sea region.

The ridge lay from southwest to northeast extending 15-20 km at the altitude of 2200 m is the highest part of the mountain. Our study was conducted at Küçükhacet Hill (2546 m) and Büyükhacet Hill (2587 m) slopes which are the highest parts of the mountain. Küçükhacet hill at the west and Büyükhacet hill at the east of Ilgaz Mountain is the most important peak points of the ridge. Küçükhacet hill peak has a smoothly disturbed peak and it is massive seemingly bulge. Büyükhacet hills peak has a conic form. The main rock of Ilgaz Mountain is a metamorphic rock relating to Paleozoic time slight. This is the calcareous limestone blister where Küçükhacet and Büyükhacet hills stand. Soil is generally sandy clay and loamy texture in the region.

Since this mountainous region covers a very large area, it shows a different climatic, pedologic and geomorphologic condition. The expansion area alpine plants are limited to the highest elevations at Ilgaz Mountain. Therefore, alpine plants can only be seen above 2000 m where forest vegetation ends. *Pinus sylvestris* L., *Juniperus communis* subsp. *nana, Daphne oleides, Asperula nitida, Sesleria argentea, Avena versicolor, Poa alpina, Potentilla crantzii* var. crantzii, *Festuca ovina, Primula vulgaris, Stipa pontica* are the most frequently seen species among the alpine vegetation at Ilgaz Mountain. *Pinus sylvestris*' s dwarfish treeline climbs through 2400 m[7,8].

This region is located at the transition zone by both geographical and climatic regions. The closest meteorological station was located in altitude at 885m on Ilgaz Mountain. According to this station, the character of this climate is cold and rainy in high altitudes, hot and dry in low altitudes. The region shows a back Black Sea climatic characteristics. Spring and autumn are cool and rainy. Winter is very cold and generally snowy. According to Walter's method, a climatic diagram was derived from mean values of the period 1950-1990 (Fig. 2). The general climatic characteristics of study area (2085 m); annual mean temperature is 4.1°C, total monthly precipitation 1084 mm, the hottest month July 14.6°C, the temperature difference between the coldest (January) and the hottest month (July) is 21.3°C. De Marton's dryness coefficient is I=46.2, the area is identified as humid.

The basic climatic factors, which affect the ecosystems in the region, are atmospheric precipitation and weather temperature. The major part of precipitation occurs in the cold period of year. The stable temperature transition through 10°C occurs in the second half June and continues to the second half of September (Fig. 2).

In the warm season, there are thick clouds, frequent fogs and prolonged periods of bad weather, which

Table 2: Mean tree characteristics and stand of the sample plots

	Individual tree (mean basal area)					Stand				
Sample plot	d cm	h m	v m^3	CL m	CD m	G $m^2\ ha^{-1}$	V $m^3\ ha^{-1}$	N trees ha^{-1}	h 100 m	T year
1	17.2	4.40	0.069	3.57	2.64	1.48	4.39	64	4.45	59
2	45.9	15.48	1.103	10.40	5.31	37.74	251.48	228	20.10	261
3	24.9	8.48	0.201	6.53	3.88	11.70	48.31	240	10.27	83
4	27.0	9.52	0.242	7.54	5.04	13.04	55.22	228	10.05	88
5	30.0	9.32	0.307	8.04	4.12	13.00	56.48	184	11.20	84
6	11.4	3.60	0.030	2.73	1.71	0.89	2.64	88	3.70	50
LINE MEANS (forestline=3,4,5;treeline=1 and dwarfish treeline=6) (excluding sample plot 2)										
Forestline	27.3	9.11	0.250	7.37	4.35	12.58	53.34	217	10.51	85
Treeline	17.2	4.40	0.069	3.57	2.64	1.48	4.39	64	4.45	59
Dwarfish treeline	11.4	3.60	0.030	2.73	1.71	0.89	2.64	88	3.70	50
Alemdağ	16.1	12.88	0.131	-	-	50.45	442.85	3381	15.53	85

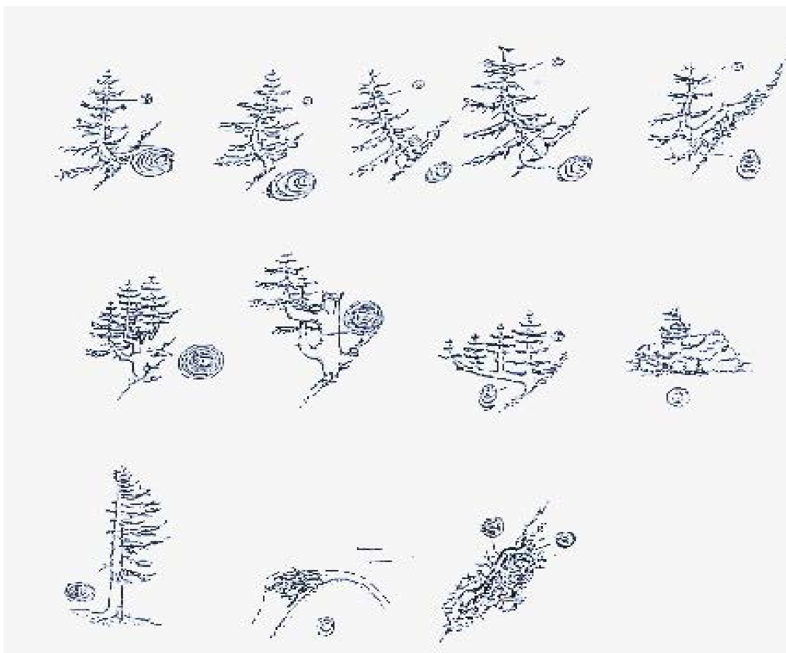

Fig. 1: Tree forms at coniferous trees in timberline (adapted from Çolak and Pitterle[4])

considerably decrease the mean temperatures of summer months. The monthly average wind velocity is maximum in the cold season and most often, in transition seasons, when wind velocities on the mountain tops are often higher than 25-30 m sn^{-1}.

Two different methods were adopted for collecting the material in order to fit the research objectives, i.e. the stand material and single tree material. The collected sample material from the upper 2000 m of mountain constituted the main data of study between the month August and September 1999. Plots numbered 2, 3, 4, 5 are in forestline, numbered 1 are in treeline and numbered 6 are in dwarfish treeline (Table 2). Diameter, height and volume of individual tree development trends were compared with poor site (site class III in yield table) mean tree values of Scotch pine. In the sample plots height, crown length, crown diameter and diameter increment measurements were taken from the 20-30 sample trees of different diameter at breast height (diameter). Stand volume and basal area were calculated from 6 sample plots and these trees are thicker than 4 cm in diameter by formulae 1 and 2. Each size of the plots was 50 m x 50 m. Their distributions to different age categories, sites and elevations were considered.

$$V=\sum^{n}\frac{1}{r+1}\cdot\frac{\Pi}{4}\cdot d_{1.3}^{2}\cdot\left(\frac{h}{h-1.3}\right)^{r} \qquad (1)$$

$$G=\sum^{\wedge}\frac{\pi}{4}d_{1.3}^{2} \qquad (2)$$

V= volume of sample plot (m^3), G= basal area of sample plot (m^2), n = total number of trees in sample plot, $d_{1.3}$= diameter (cm), r= form coefficient of stem (cone; r=2).

Age at the breast height and the thickness of the last 10 annual rings were also determined on the increment cores which were taken from 10 of 15 chosen sample trees

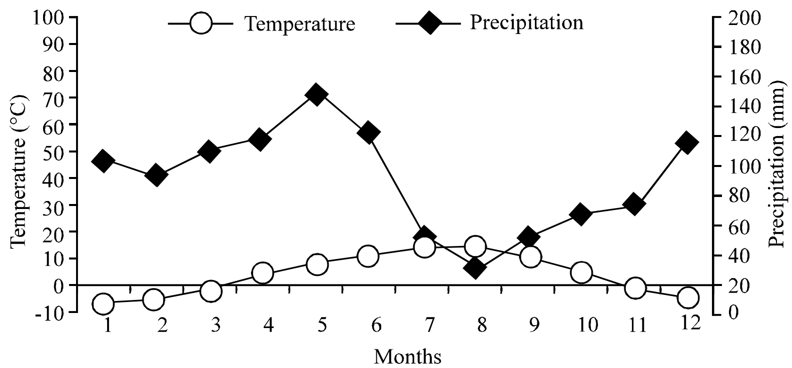

Fig. 2: Walter's method climate diagram of the study area

Fig. 3: Forestline, treeline and dwarfish treeline in timberline at Ilgaz Mountain

at different diameter classes by means of Pressler Increment Borer. Stand age of sample plots was calculated by using the storied stand volume and stand age (formula 3), as mean volume stand age.

$$T = \frac{\Sigma V_i . T_i}{\Sigma V_i} \qquad (3)$$

V_i = I 'th storied stand volume (m^3 ha^{-1}), T_i= I 'th storied stand age (year).

Height on 20-30 trees were also measured in each sample plots in order to determine the average stand height curve by formulae 4 and 5. h= tree height (m), d= diameter (cm), a_0,a_1 and a_2 = regression coefficients.

$$h=a_0+a_1*d+a_2*d^2 \quad (4) \qquad h=\frac{d^2}{a_0+a_1*d+a_2*d^2}+1.3 \quad (5)$$

Stem volume and basal area of trees sum in the sample plot were transformed by using modified coefficient hectare. The relationship between crown length-diameter, crown diameter- diameter, diameter-diameter increment was determined by formulae 6-9.

$$CL= a_0+a_1*d+a_2*d^2 \quad (6) \qquad CD= a_0+a_1*d \quad (7)$$

$$i_d=a_0+a_1*d \quad (8) \qquad i_d=a_0+a_1*d+a_2*d^2 \quad (9)$$

$$i_d =(\Sigma i_{dr} +\Sigma i_{dr2})/10 \quad (10)$$

CL= Crown length (m), CD=Crown diameter (m), i_d=annual diameter increment (mm).

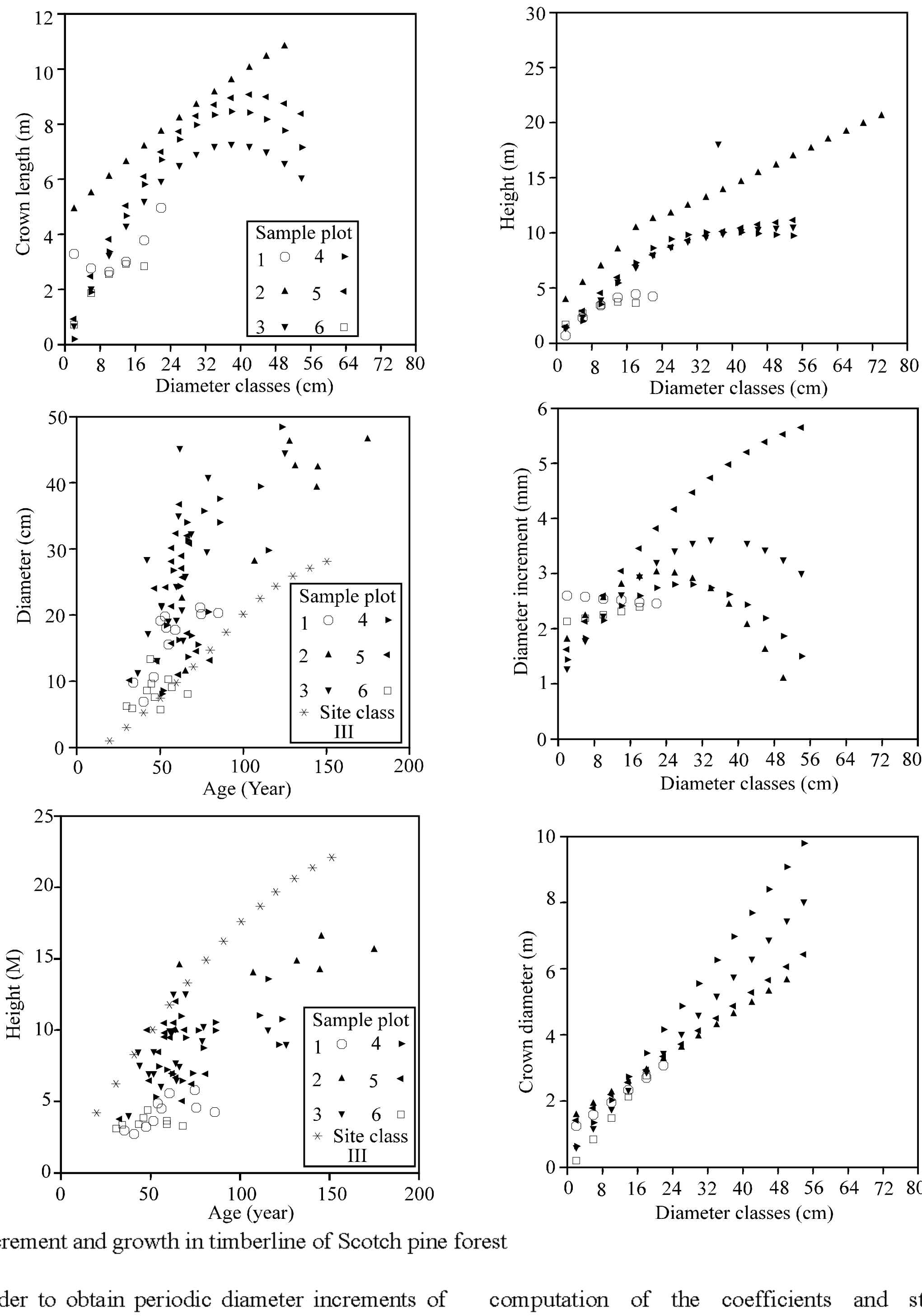

Fig. 4: Increment and growth in timberline of Scotch pine forest

In order to obtain periodic diameter increments of sample trees were used considering Σi_{dr} as two times thicker than last 10 years ring thickness. Annual diameter increment was found by equation 10. The dominant diameters d_{dom} and heights h_{dom} were computed as the mean diameters and heights of the 100 thickest trees per hectare. The measured data were stored and processed in computer by using SPSS Package software. In the computation of the coefficients and statistics of regression equations, the least squares method were used.

RESULTS AND DISCUSSION

Trees of forestline can not reach larger dimensions with increasing age comparing growing trees on poor site

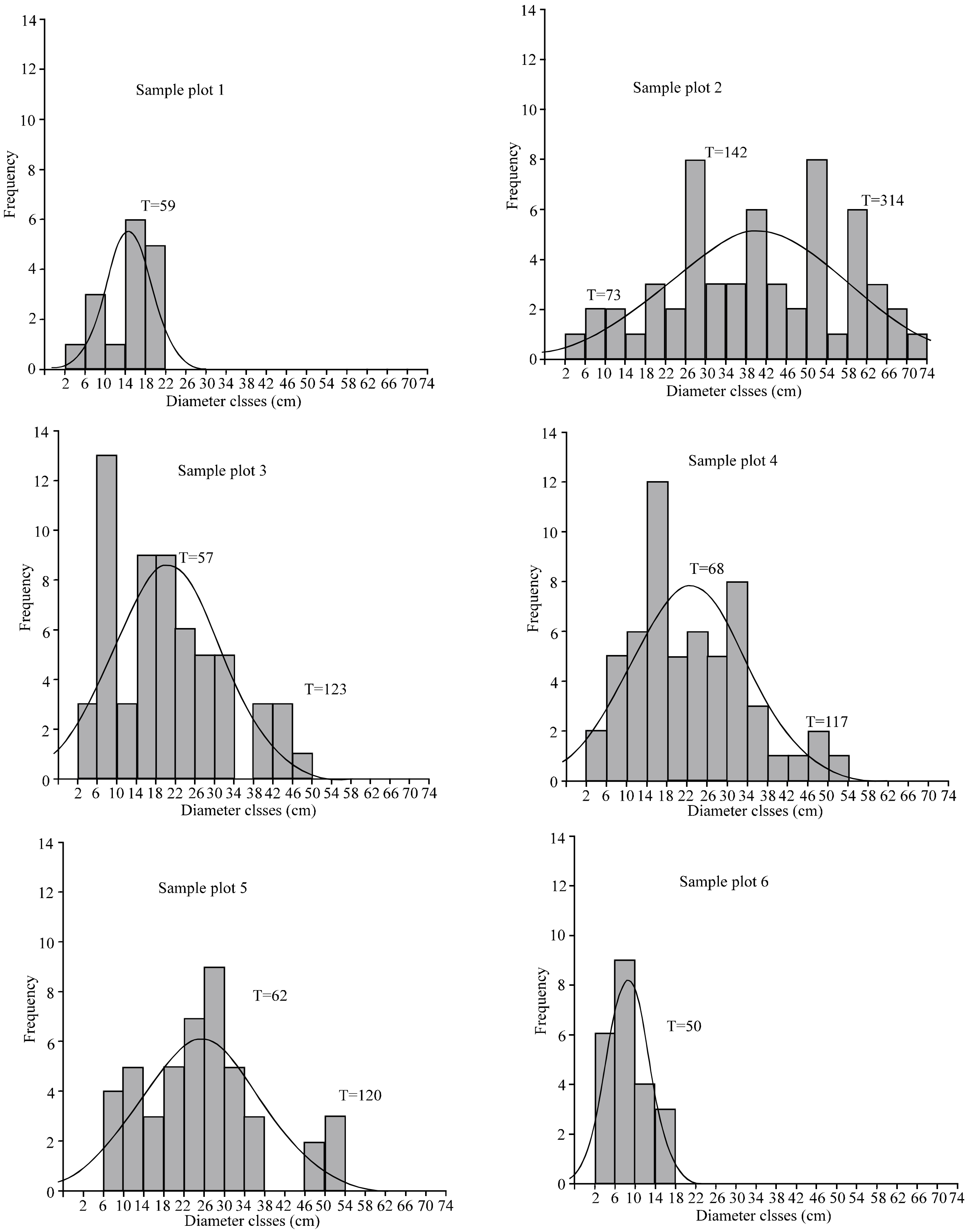

Fig. 5: The alteration number of trees in diameter classes in the sample plots

(yield table III). Diameter, height and volume of individual tree indicate a sharp decrease from forestline to dwarfish treeline. Scotch pine stands with green crowns reaching the ground horizontal and vertical structures of the sample plots Fig. 3, 4 and 5 values of dwarfish treeline are extremely low. Basal area and volume of stand are alike characteristics of single tree. The number of trees per hectare of three lines is extremely low from the values site class III in yield table.

The distribution of volume by diameter classes, as well as the overall volume, is needed as input to many forest management decisions. Site quality and age affect diameter distribution in timberline Scotch pine stands. It is observed that the Scotch pine mountain forest growing on forestline can reach larger diameters with increasing age, to growing trees on dwarfish treeline (Fig. 4). Forestline has generally uneven aged and multistoried stand structures. In timberline Scotch pine stands reaches ideally display a group like structure. Shiyatov[1] reported that the formation of age generations in Siberian larch (*Larix sibirica* Ledeb.) forests located at the timberline most strongly depends on favorable or unfavorable thermal conditions in each period, with their improvement or deterioration causing changes in the proportion of trees of the corresponding age, which is reflected in the age spectrum.

Diameter growth in Scotch pine stands is affected by site quality and by age. The shape of the diameter growth curves were determined by a regression equation and has been graphically represented in Fig. 5. It is observed that crown length was obtained in timberline taller than normal canopy Scotch pine stands. Crown diameter was also different than normal canopy Scotch pine. However, this can be due to open canopy (Fig. 4 and 5). Mean volume and basal area increment for Scotch pine stands at forestline, treeline, dwarfish treeline and site class III is 0.628 m^3 ha^{-1}, 0.148 m^2 ha^{-1}, 0.074 m^3ha^{-1}, 0.025 m^2 ha^{-1}, 0.053 m^3 ha^{-1}, 0.002 m^2 ha^{-1}, 5.21 m^3 ha^{-1}, 0.594 m^3 ha^{-1}, respectively.

In this study, increment and growth characteristics of timberline Scotch pine forests were studied. Site quality and age affect diameter distribution in timberline Scotch pine stands. It is observed that the Scotch pine growing on forestline can reach larger single tree and stand volume and volume elements increments with increasing age, to growing trees on treeline and dwarfish treeline (Fig. 4 and 5). Crown length and crown diameter in Scotch pine stands are affected by site quality and age. According to these results, some recommendations have been also given below which will be useful for those who work in forestry.

At high altitudes favorable and unfavorable sites are usually distributed in a fine spatial mosaic. Respecting this mosaic of site conditions automatically leads to the concept of group structure in the afforestation. Favorable locations are given preference, i.e. planted groupwise, while unfavorable locations such as gullies or patches with well-established tall forbs are not planted at all.

The results of this study show that the development of Scotch pine in the timberline of Ilgaz Mountain occurs at comparatively low temperatures. Vegetation period has average duration three months, but depending on the precipitation varies from 2 to 4 months. The climatological conditions and their effect on the ecosystems in Turkey timberlines are one of the most important abiotic factors.

REFERENCES

1. Shiyatov, S.G., 1967. Climate Fluctuations and Age Structure of Tree Stands in Open Larch Forests of the Polar Ural Mountains, Tundra vegetation and the Ways of Its Utilization, Leningrad, Nauka, pp: 271-278.
2. Kearney, M.S., 1982. Recent Seedling Establishment at Timberline in Jasper National Park. Alberta. Canadian J. Bot., 60: 2282-2287.
3. Aksoy, H.,1987. Silvikültür Ders Notları, Istanbul Üniversitesi, Orman Fakültesi, Türkiye, pp: 99.
4. Çolak, H.A. and A. Pitterle, 1999. Yüksek Dağ Silvikültürü (Cilt I- Orta Avrupa)- Genel Prensipler, Orman Genel Müdürlüğü Yayınları, Ankara, Turkey.
5. Moiseev, P.A., 2002. Effect of Climatic Changes on Radial Increment and Age Structure Formation in High-Mountain Larch Forests of the Kuznetsk Ala Tau. Russian J. Ecol., 33: 7-13.
6. Schonenberger, W., 1998. Adapted Silviculture in Mountain Forests in Switzerland, Proceedings of IUFRO International Division Seoul Conference, Seoul, Korea, pp: 142-147.
7. Avci, M., 1998. Ilgaz daglari'nda bitki ortusunun dagilipi ve bu dagilipi etkileyen cografi faktorler. Proceedings of the Kasnak Mepesi ve Turkiye Florasi Sempozyumu, (KMTF'98), Istanbul, Turkiye, pp: 698-716.
8. Hannes, M. and H. Aksoy, 1998. Turkiye ormanlari. Bati Karadeniz Ormancilik Araptirma Enstitusu Yayinlari, No. 1, Bolu, Turkiye.