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# Natural tree collectives of pure oriental spruce [*Picea orientalis* (L.) Link] on mountain forests in Turkey

**Ali Omer Ucler*, Zafer Yucesan, Ali Demirci, Hakki Yavuz and Ercan Oktan**

Faculty of Forestry, Karadeniz Technical University, Trabzon-61080, Turkey

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***Abstract:*** *Distribution area of oriental spruce [Picea orientalis (L.) Link.] in the world is only in the north-east of Turkey and Caucasian. Because of being the semi monopoly tree with respect to its distribution and representing the upper forest line, it is necessary to analyse, evaluate and model the stand structures of oriental spruce forests in Turkey. In this research, some sampling plots were selected in timberline and treeline in the subalpine forest zone in Turkey. In these sampling plots some information about occurrence and development of the tree collectives was obtained. A total of 12 sampling plots (6 in timberline and 6 of them in treeline) were studied and horizontal and vertical stand profiles were obtained, while number of trees ranges between 2-86 in the tree collectives in treeline and in timberline 3-12. According to this, area per tree in treeline and in timberline is determined as 1.02 $m^2$ and 3.75 $m^2$ on an average respectively. Mean age of trees to reach breast height is 43 years in treeline sampling plots and 22 years in timberline sampling plots. According to the ratio of h (mean height) / $d_{1.30}$ (diameter at breast height), stand stability values were calculated and it was determined if the stands were stable on the basis of the sampling plots. Stability values of the sampling plots changed between 33 and 75.*

***Key words:*** *Oriental spruce, Stand structure, Timberline, Tree collective, Treeline*

## Introduction

Oriental spruce [*Picea orientalis* L. Link.] is one of the most important species for Turkey because of the semi monopoly tree with respect to its distribution. Distribution area of Oriental spruce ranges between 550 to 2400 meters in Turkey and covers total area of 146300 hectares (Caliskan, 1998) on the north of east Blacksea mountains. Different habitat conditions, altitudes and stand structures cause functional grouping in oriental spruce forests in Turkey. In the past, wood production was the most important function. However all these forests were also intensively used for grazing and illegal tree felling. Nowadays, oriental spruce forests have gained more importance in Turkish forestry applications because of their landscape, recreation and natural conservation functions beside the wood production.

Conservation of forests is considerably deal with the "stand structure" (Renauld *et al.*, 1994). It is necessary to analyse, evaluate and model stand structure of mountain forests with respect to their management, development and comprehension (Schönenberger and Brang, 2001).

Mountain forests at higher altitudes are different from forests at low altitudes. Stands are generally in the form of a mixture of open areas, tree islands and groups (Schönenberger and Brang, 2001). There are some tree collectives which look like groups and are very important for development of these forests. In forests protection, the cluster structure characteristic in high elevation stands may serve as a model for arrangement of the seedlings in plantations and for silvicultural interventions aiming at higher resistance against disturbances. Kouch (1972, 1973), defined the group formations in subalpine spruce forests as "tree collective structure." Similarly in rocky mountains in USA tree societies with 20-30 trees and 3-10 m. length are called "tree islands" (Arno, 1984).

Alpine timberline is one of the most natural biological borders (Wardle, 1965). Dynamics here may be controlled by limitations imposed by abiotic environmental conditions on production of viable pollen (Szeicz and McDonald, 1995), seed bearing fruits (Manson, 1974), viable seeds (Barclay and Crawford, 1984), seed germination (Wardle, 1984), emergence and survival of seedlings (Arno, 1984; Wardle, 1984, 1985) or the survival of saplings and adults (Tranquillini, 1979). Mountain forests are generally found on steep slopes and they live under very extreme climatic conditions and in a very thin soil layer. The trees in these habitats are mostly under the threats of avalanches, rock falls, land slides, torrents and violent winds (Kienholz and Price, 2000). One of the most important functions of mountain forests is to protect the environment from these natural hazards (Schönenberger, 1998). In high mountainous areas, tree collectives should be accepted as resistant and stable stand elements. Because of the large gaps between the tree collectives, more light can enter into stands and this causes a richness in soil vegetation. In the tree collectives humus development is faster because gaps are not dominant. This is especially important in these habitats where the upper soil layers are subjected to erosion (Colak and Pitterle, 1999).

****Corresponding author:*** E-Mail: ucler@ktu.edu.tr, Tel.:+90 462 3772803, Fax: +90 462 3257499

Several studies have been carried out in the silvicultural reserve, particularly concerned with developing or adapting the silvicultural approach, natural regeneration and ecological stability in oriental spruce stands in Turkey (Ata, 1980; Eyuboglu *et al.*, 1995; Demirci, 2000). But no study has been done about the structures and occurrences of the subalpine oriental spruce forests.

The main objectives of the present study are: (a) to describe the structure of the 12 sampling plots in timber line and in tree line which were selected on the subalpine forest level; (b) to obtain some information about occurrence and development of the tree collectives in these sampling plots.

## Materials and Methods

In this research, 12 sampling plots were established (plot size 20 m x 20 m) in pure oriental spruce forests in eastern Blacksea region. The study area is located between 40°29′06″-40°50′00″ latitudes and 38°29′09″-39°13′04″ longitudes (Fig. 1).

Mountain ranges run parallel to coast in the region. Soils are also variable, but on gentle slopes tend to be deep, moderately fertile and slightly alkaline and on steeper slopes are usually shallow, rocky and interfile. In coastal districts of the Blacksea, whole year is rainy in the region but annual rainfall amount shows difference according to the seasons and months (Kayacik, 1952) and because of the increasing number of row mountains towards the east, higher amounts of rain occurred in high altitudes and more fog can be seen. Consequently importance of the altitude increases in the relation between the distribution area of oriental spruce and rainfall amount (Kucuk, 1986). The average annual temperature at the distribution area of the pure and mixed oriental spruce is between 5-10°C (Atalay, 1984). Six of the sampling plots are in treeline and 6 of them are in timberline (Fig. 2). Mean sea level of the study area is 1870 meters. Some information about the sampling plots are given in Table 1.

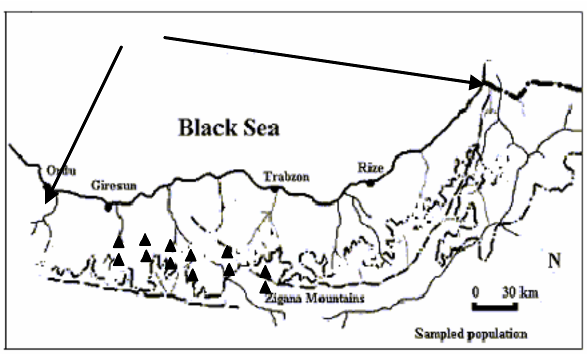



**Fig. 1:** Location of the sampling plots on the distribution area of oriental spruce in Turkey

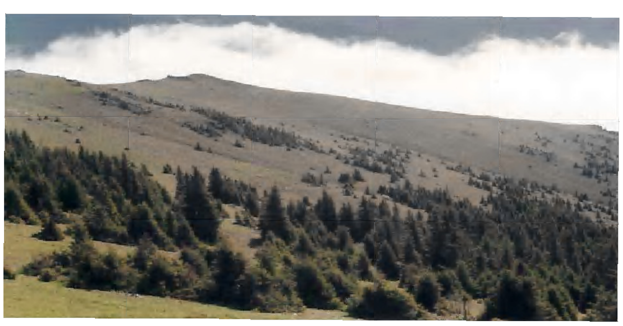


**Fig. 2:** General view from sampling plot 5 and 6 subjected to the research

**Table - 1:** General information about the sampling plots

| Sampling plots | Plot aspect | Altitude(m) | Slope(%) |
|---|---|---|---|
| 1 Treeline | West | 1850 | 45 |
| 2 Timberline | West | 1800 | 40 |
| 3 Treeline | Northwest | 1866 | 55 |
| 4 Timberline | Northwest | 1818 | 68 |
| 5 Treeline | East | 1968 | 50 |
| 6 Timberline | East | 1850 | 35 |
| 7 Treeline | Southwest | 1958 | 65 |
| 8 Timberline | Southwest | 1896 | 55 |
| 9 Treeline | Northeast | 1840 | 45 |
| 10 Timberline | Northeast | 1790 | 60 |
| 11 Treeline | Northeast | 1939 | 40 |
| 12 Timberline | East | 1880 | 40 |

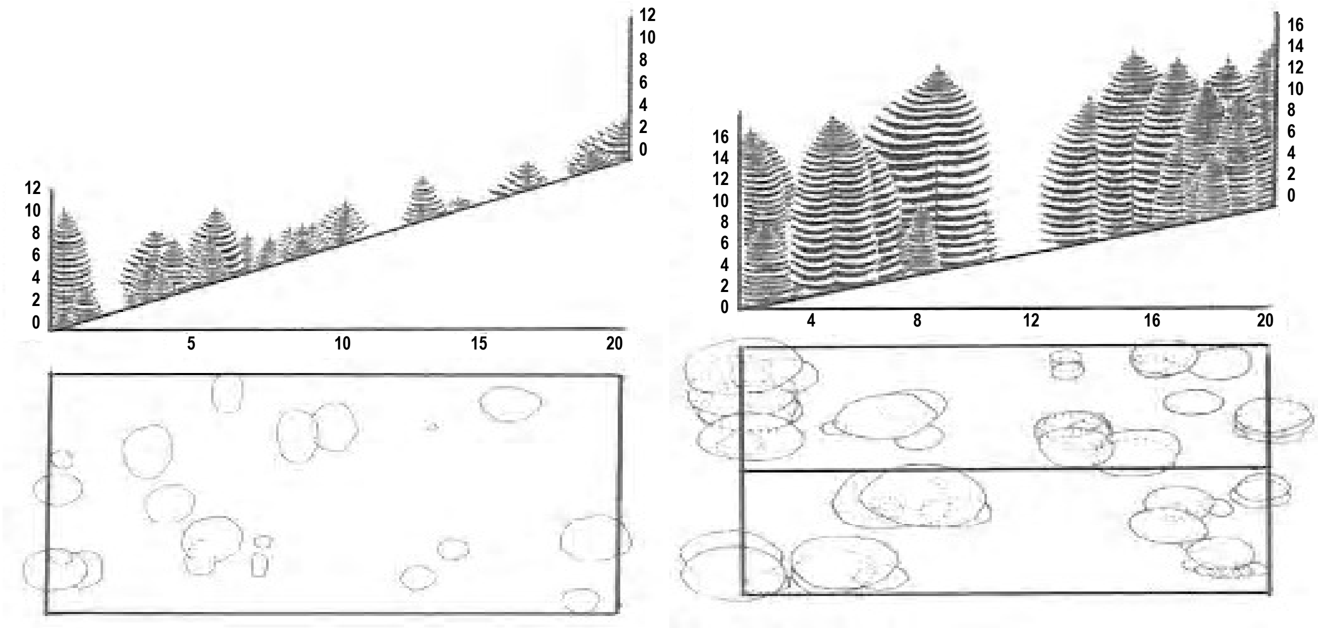
In order to separate the tree collectives in the sampling plots, characteristics of tree individual groups that separate themselves from their environment by their own formation, coverage area between group and heap, surrounded by a needle coat were determined (Kuoch and Aimet, 1970; Kuoch, 1972). In sampling plots, vertical stand profiles and horizontal tree crown coverages were drawn. Stand profiles were taken by the slope of a hill. Number and area of tree collectives, number of trees and area occupied per tree in tree collectives were determined. In order to determine if there are any differences between the collectives in treeline and timberline with respect to time to reach breast height (1.30 m.), mean value for the breast height ages in each sampling plot was calculated based on increment cores. In each sampling plot, cores were taken from 30 trees from different diameter classes and stand age, was determined. The cores were mounted and polished with sandpaper of increasingly finer grain and growth rings were counted under a binocular stereoscope (Motta and Dotta, 1994; Cuevas, 2002).

Relations between tree collective number of the trees in the tree collective and per area of the tree in the tree collective number of the trees in the tree collective were determined by the statistical programme SPSS (Erdogan, 1998) with applying 10 different regression model and the relation was expressed with the equation that has the highest $R^2$ value at $p<0.05$ significant level. Actually the amount of the area per tree in the treeline and timberline were compared at the sampling plots and it was determined that if there is any difference between each other at the significant level $p<0.05$. According to the ratio of h (mean height)/$d_{1.30}$ (diameter at breast height), stand stability values were calculated and it was determined if the stands are stable (Gassebner, 1986).

### Results and Discussion

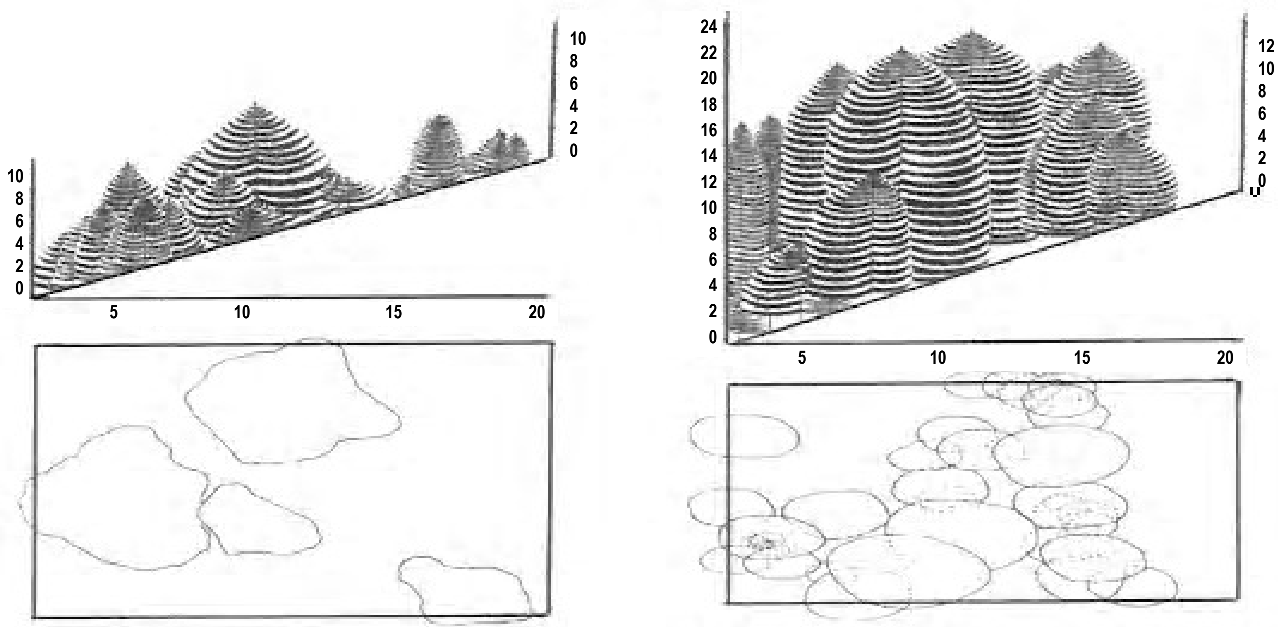
Horizontal and vertical stand profiles were obtained in all 12 sampling plots (Fig. 3-8). Number of trees per collective and area of the tree collectives are larger in tree line sampling plots than timber line sampling plots. Number of trees in the collectives ranged between 2 and 86 ($\bar{x}$ = 23) in tree line and between 3 and 12 ($\bar{x}$ = 6) in timberline. According to this, mean area occupied per tree in tree line and in timberline is 1.02 $m^2$ and 3.75 $m^2$, respectively (Table 2).

Actually when mean area per tree values compared in tree line and in timber line, a significant difference was determined ($t$=9.31, $p$<0.001).



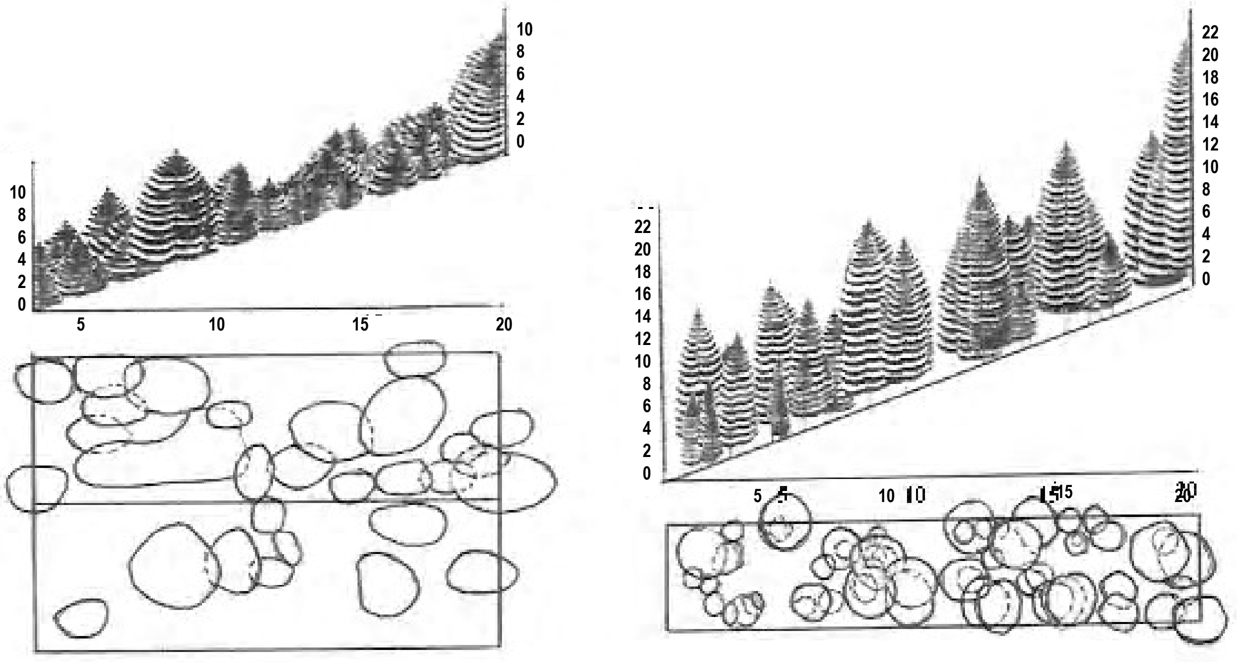

(a) (b)

**Fig.3:** (a) Tree collectives in sample plot 1, (b) Tree collectives in sample plot 2



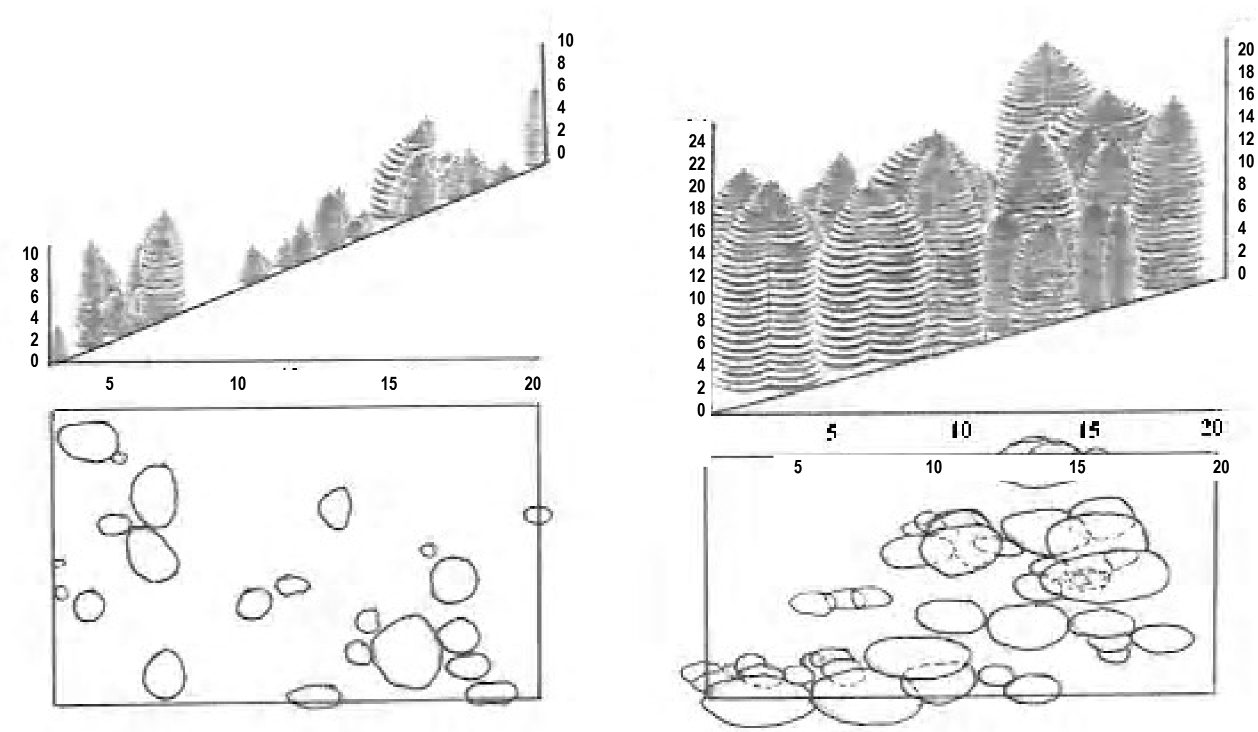

(a) (b)

**Fig. 4:** (a) Tree collectives in sample plot 3, (b) Tree collectives in sample plot 4



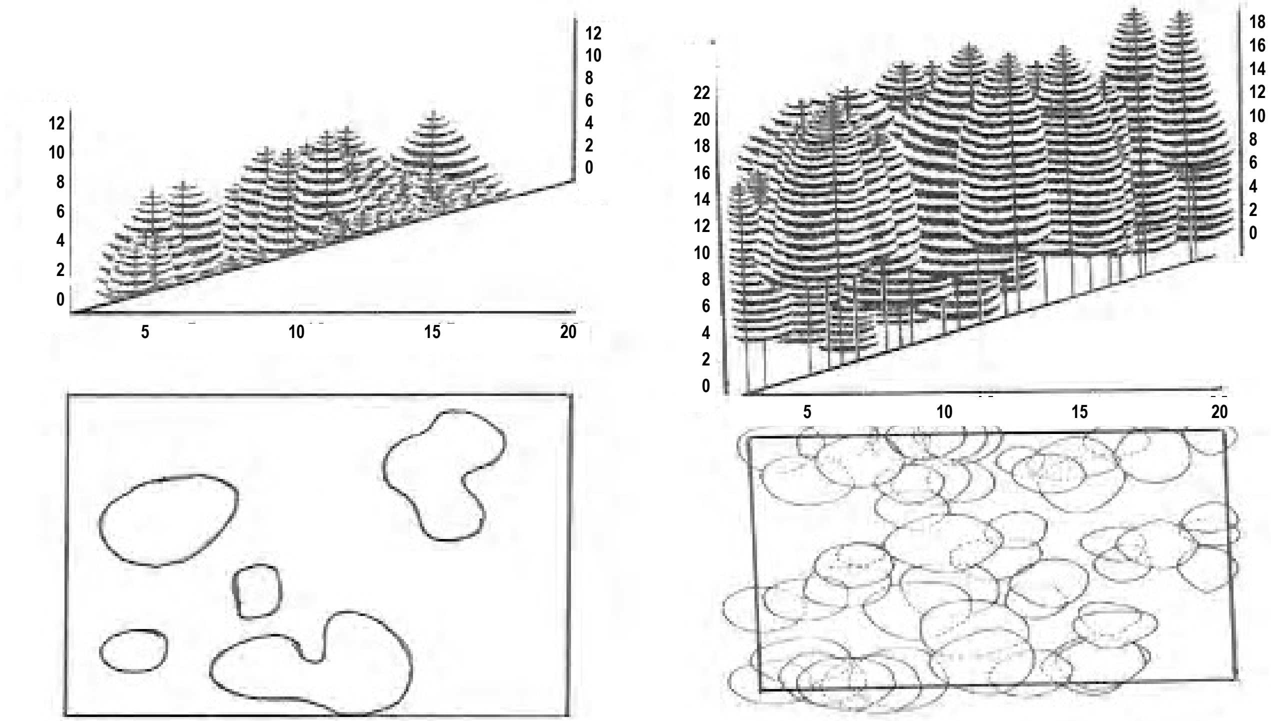

(a) (b)

**Fig. 5:** (a) Tree collectives in sample plot 5, (b) Tree collectives in sample plot 6



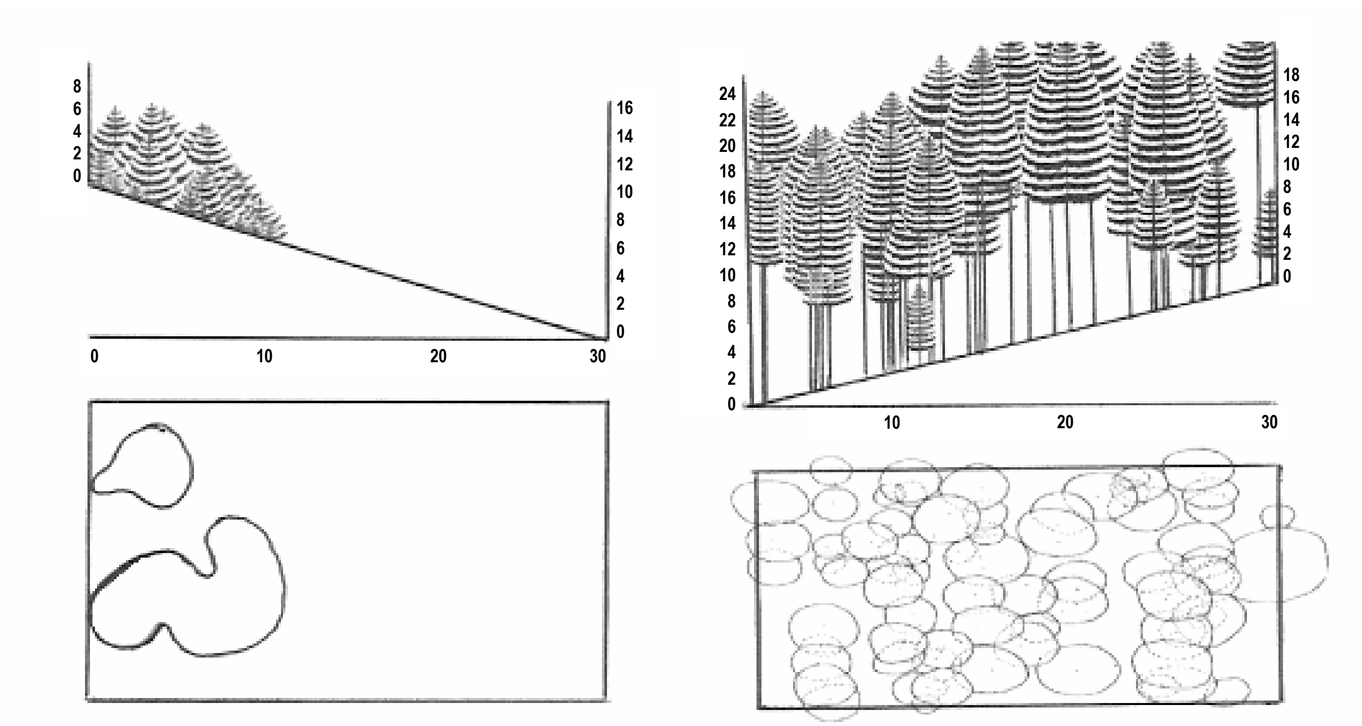

(a) (b)

**Fig. 6:** (a) Tree collectives in sample plot 7, (b) Tree collectives in sample plot 8




(a) (b)

**Fig. 7:** (a) Tree collectives in sample plot 9, (b) Tree collectives in sample plot 10




(a) (b)

**Fig. 8: (**a) Tree collectives in sample plot 11, (b) Tree collectives in sample plot 12

**Table - 2:** Mean values of some qualities of the tree collectives

| Plot | Number of the trees in the tree collectives | | | Area of the tree collective ($m^2$) | | | Area per tree in the tree collective ($m^2$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}$ | min | max | $\bar{x}$ | min | max | $\bar{x}$ | min | max |
| 1 | 8 | 2 | 22 | 5.0 | 0.4 | 11.8 | 0.9 | 0.2 | 5.1 |
| 2 | 5 | 3 | 12 | 18.8 | 2.8 | 37.8 | 3.8 | 1.0 | 8.0 |
| 3 | 27 | 12 | 46 | 32.9 | 15.4 | 49.4 | 1.2 | 0.9 | 1.7 |
| 4 | 8 | 5 | 9 | 38.5 | 20.5 | 57.1 | 5.6 | 2.8 | 10.2 |
| 5 | 7 | 2 | 35 | 6.9 | 2.1 | 24.3 | 1.4 | 0.2 | 3.9 |
| 6 | 7 | 4 | 12 | 23.7 | 7.7 | 42.2 | 3.7 | 1.1 | 6.4 |
| 7 | 5 | 2 | 11 | 3.1 | 0.4 | 9.5 | 0.7 | 0.2 | 1.6 |
| 8 | 7 | 4 | 11 | 15.5 | 4.3 | 25.0 | 2.2 | 0.9 | 3.1 |
| 9 | 24 | 5 | 60 | 12.2 | 4.1 | 21.6 | 0.8 | 0.3 | 2.1 |
| 10 | 5 | 4 | 8 | 19.4 | 14.2 | 26.0 | 3.8 | 3.3 | 4.5 |
| 11 | 66 | 46 | 86 | 30.1 | 15.0 | 45.2 | 0.4 | 0.3 | 0.5 |
| 12 | 6 | 4 | 10 | 24.4 | 15.9 | 37.4 | 3.9 | 3.4 | 4.5 |

**Table - 3:** Stability values of the sampling plots

| Sampling plot | h | d | h / d |
|---|---|---|---|
| 1 | 2 | 0.03 | 67 |
| 2 | 10 | 0.14 | 71 |
| 3 | 3 | 0.04 | 75 |
| 4 | 10 | 0.18 | 56 |
| 5 | 3 | 0.04 | 75 |
| 6 | 9 | 0.18 | 50 |
| 7 | 3 | 0.04 | 75 |
| 8 | 13 | 0.18 | 72 |
| 9 | 2 | 0.06 | 33 |
| 10 | 17 | 0.23 | 74 |
| 11 | 2 | 0.04 | 50 |
| 12 | 18 | 0.26 | 69 |

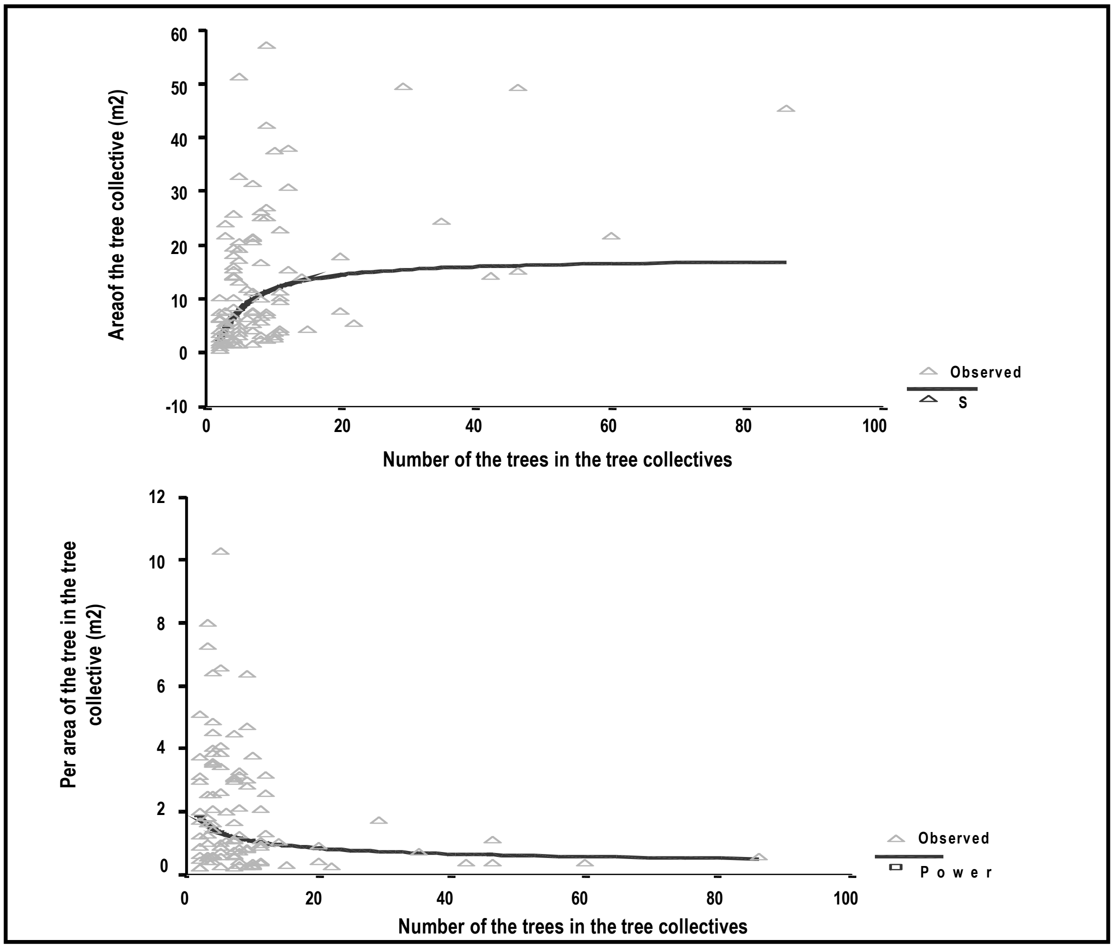



**Fig. 9:** Regression curves due to the concerned equation models

Relations between area of tree collective number of trees in tree collective and per area of tree in the tree collective number of trees in tree collective were determined with 10 different regression models and the relation was expressed with the equation that has the highest $R^2$ value at $p<0.05$ significant level. For collective area "S" regression model and for area per tree in the collective "power" regression model are the most suitable models. Equations and the curves of the relations are given in Fig. 9.

To have a long crown that reaches to the ground and low h (height) / $d_{1.30}$ ratio for the trees in the collectives are the most important stability factors for the subalpine protection forests (Mayer and Ott, 1991). If the ratio is under 80, it is assessed as stable, if it is between 80-100, low stability is mentioned and if it is higher than 100, it is assessed as not stabile (Gassebner, 1986). According to this assessment, all the sampling plots in the present study are stable (Table 3).

**Table - 4:** Mean age (years) of the trees to reach breast height in sampling plots

| Plot | Treeline | Timberline |
|---|---|---|
| 1 | 41 | 24 |
| 2 | 51 | 19 |
| 3 | 44 | 21 |
| 4 | 41 | 25 |
| 5 | 35 | 18 |
| 6 | 46 | 22 |
| Average | 43 | 22 |
| Standart Deviation | 5.4 | 2.7 |

Tree collectives in treeline and timberline were significantly different in time to reach breast height diameter. Time to reach breast height diameter was twice as long in tree line trees (43 years) as in timberline trees (22 years) (Table 4).

Number of trees in the collectives ranged between 2 and 86 ($\bar{x}$ = 23) in tree line and between 3 and 12 ($\bar{x}$ = 6) in timberline. According to this, mean area occupied per tree in treeline and in timberline is 1.02 $m^2$ and 3.75 $m^2$, respectively. Actually when mean area per tree values compared in tree line and in timberline, a significant difference was determined ($t$=9.31, $p$< 0.001). Due to increased altitude, distance between trees in the tree collectives decreases (Mayer and Ott, 1991). Mayer and Pitterle (1988) emphasised that on the lower side of the current timberline, number of the trees in the tree collectives change between 2-5 and the mean area for being alive is 15-80 $m^2$, on the upper side of the current timberline number of the trees change between 5-10 and mean area for being alive is 1-20 $m^2$.

Also our study presents some similarities with those of Kuoch and Aimet (1970). They also emphasised that from the treeline zone towards the closure forest in the lower altitudes, number of the tree collectives decreases and their structures are changed. In their research number of trees in the collectives ranged between 4 and 28 ($\bar{x}$ = 20) in tree line and between 4 and 8 (= 7) in timber line. In the research about the tree collectives of the *Piceetum subalpinum* and *Larici Pinetum cembrae* in subalpine level in east Tyrol, it was determined that these collectives have an extreme number of trunks (40 individuals in 15 $m^2$) in small areas (Mayer and Pitterle, 1988).

As it is seen from Fig. 8, it was determined that relation between the number of the trees in the tree collectives and collective area is not linear. Also it was determined that while the number of the trees increasing in the collective, the amount of the area per tree in the collective decreases. So it is possible to express these curves with the opinion of while trees in the collectives making height and diameter growth, because of increasing pressure to each other, crown development slow down and crown coverage areas become small.

In natural needle leafed stands (especially Spruce stands): (1) Generally dense, irregular and gathered trunk distributions like small collectives are seen. (2) Between the tree groups, uneven-aged stand structure in small areas can be seen with an age difference more than 100 years. (3) In small areas, because of opening the tree crown, between the small collectives towards the forest border, some habitats dangerous for needle leafed trees are originated. Uneven aged stand structures in small areas can be seen by finding old trees on the layer of young trees and tree groups (Ott, 1995).

Tree collectives in treeline and timberline were significantly different in time to reach breast height diameter. In the present study results are similar with those of Indermühle (1978). It was determined that one of the most evident characteristic is the slow height growth in the early years and 50 or more years is necessary for *Picea abies* to reach breast height. Once the trees in these zones reach 1-3 m. height, height growth rates of these trees were similar to that of trees at lower altitudes. In high regions of the Italian Alps natural *Pinus cembra* individuals can reach to 120 cm. height in 44 years (Motta and Dotta, 1994).

Improvement efforts in subalpine forest lands having extreme characteristics such as grazing, periodical drought, poor germination bed, rarel seed years and insufficient heat accumulation pose important obstacles in natural regeneration. The most important criteria is suitability to nature. Group formation factor which improves survival chance of trees and is characteristic for near Alp zone forest lands, should be taken into consideration for regeneration especially for oriental spruce stands. It is necessary to benefit from existing individuals as much as possible because of hard regeneration and slow growth due to the existing ecological conditions in the eastern Blacksea region near Alp zone forests. The most important idea is to stabilize the existing tree collective formations by taking ecological factors that are heterogeneous in small areas (Schonenberger, 2001; Kräuchi *et al.,* 2000).

Most of the sampling plots in tree line and some of the sampling plots in timber line included in this study, show uneven aged stand structure (Cuevas, 2002). So it is possible to say that "selecting structure" in the perpendicular direction is the most important stand structure in the near Alp zone forests. Because of having many individuals on the bottom and on the intermediate level of the stands in selecting structure, stand structure has a great importance preventing avalanches and landscape function (Schonenberger and Brang, 2001). So it is important to protect and improve the existing formations.

Since it takes quite long time to reach breast height it is necessary to use primary and secondary seedlings and individuals existing in the area. Afforestation is very important in high altitude forest lands because of unsuitable natural regeneration conditions. In the Alp zone reforestation, after determining suitable and unsuitable habitat conditions, plantings should be done as small collectives by the help of the potted seedlings obtained from the true originated seeds. To increase the success it is important to prevent seedlings to cover the whole area (Schonenberger, 2001).

The artificial encouragement and intensification of the tree collectives could be made rational when the forest is young. In the future desired tree collectives with green crown coat till the surface could be protected by removing very dense tree collectives or trees in interval layer out. In order to realize this aim, the distance of the trees in the marginal side of the young tree collectives should be at least a crown size of a thick trunked tree in the collective. This value changes locally but according to the branch type of spruce, it is approximately 8-10 meters. Tree collectives should not be in big spaced. The ideal state in an oldest tree collective should not exceed 5-7 trees and 2-3 acre (Colak and Pitterle, 1999).

Episodic regeneration and mortality at the *Picea glauca* treeline in Canada is triggered by climatic fluctuations and may influence subsequent recruitment for up to 50 years (Szeicz and McDonald, 1995). *Picea abies, Pinus sylvestris, Betula pubescens* and *Sorbus aucuparia* also establish themselves episodically at Swedish alpine timberlines (Kullman, 1983, 1990). Establishment at the alpine timberline is infrequent because high seed production and adequate dispersal to safe sites are rarely followed by the favourable environmental conditions needed during early growth (Arno, 1984) and low browsing pressure (Cuevas, 2002).

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