

Stand Structure Characteristics of Natural Mixed Stands of Brutian Pine – Anatolian Black Pine and Regeneration Suggestions in Isparta, Turkey

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Abstract

Stand structure characteristic was determined one by one in 18 sample plots which PbPnd₁, PnPbd₁, PbPnd₂, PnPbd₂, PbPncd₃, PnPbcd₃ stand types of research areas. Each stand has 50x20 m dimensions. Vertical projection of tree crowns, height, diameter of whole trees and age with soil level was determined at the height of 80 cm in each sample plots. Light measurements were made both in sample plots and out of the sample plots; number of trees in actual stands structures, average age, diameters, total basal area, the social classes of existing individual according to their stem classes, storied, crown closure, according to composition ratio for tree species and basal area were found after a stand profile and their crown projection were drawn for each sample plot. In addition, these values were calculated on the basis of hectares. All sample plots are mono storied except third area and average actual crown closure for crown projection 0,22-0,90 and light intensity into the stand 0,22-0,76, average composition ratio with regard to number of trees 2,4 - 88,9 % and basal area 1,4 – 89,3 % is changed (for 18 sample plot). Period of reaching the biological independence for Brutian pine is 5-17 year, for Anatolian black pine is 7-18 year. Whether Anatolian black pine is in minority and grows slower than Brutian pine, period of age-height precedence for this specie is 7 years in minimum and obligatory period of age-height precedence is 2 years in natural regeneration studies. The aim of this study is to get a stand profile of natural stands in the regeneration stage that represents actual stand structure and to make the silvicultural evaluation about natural and/or artificial regeneration of these areas. Natural silviculture must be applied both natural and artificial regeneration studies and reforestation techniques that suitable for nature must be used in artificial regeneration areas. This is also important for the Brutian pine + Anatolian black pine mixed stands which its majority is natural forest.

Keywords: Stand structure, Mixed stands, Brutian pine, Anatolian black pine, Isparta.

Introduction

Turkey is a country which has different climates and surrounded on three sides by sea and found that the transition point connecting the continents and is in the center of triangle in Asia, Europe and the African. Geographical location, topography and climatic differences between the three continents in terms of plant and animal diversity bring our country different location (MEF, 2009). New forests established with silvicultural practices. Healthy and quality of forests which created and subsequently existing is increased with maintenance work and is provided continuity with regeneration work. Needs of the society the economic, ecological, social and cultural demands are resolved with all the studies. First of all, biological characteristics and ecological demands of tree species must be well-known, if we want to be successful in applications. These applications are determined according to characteristic of habitat, forest tree species, structure characteristic and management objectives (Genc, 2012). If stand is composed of more than one type tree-shrub which has contributed to the silvicultural system as total amount of area, volume, quantity or chest surface, has a proportion at least 10 %, there is a composition stand (Genc, 2012).

Mixed stands are widespread in our country and are seen as a functional stands. These old mixed stands have not been established by people. All of the mixed forest is almost formed under natural conditions and is recognized as a valuable mixture due to the natural suitability. Mixed stand is thought as pure stand and regenerated as a pure stand (Ata, 1992; 1995). This study was conducted within the boundaries of Isparta Regional Directorate of Forestry which has 15466 ha of mixed stands of Brutian pine and Anatolian black pine as natural regeneration in 18 areas. Stand structure characteristics are determined in this study for the first time in Isparta/Turkey. The aim of this study is to get a stand profile of natural stands in the regeneration stage that represents actual stand structure and to make the silvicultural evaluation about natural and/or artificial regeneration of these areas.

Material and Methods

Study areas

Forming material of the study sample areas were responsibility of Sutculer, Yukarıgokdere, Aglasun, Camoluk, Golhisar and Bucak Ranger District. Sample plots geographical location, climatic characteristics, geology, general soil properties and forest condition were evaluated. Sample plots are located in lakes district of north of the Mediterranean (IM, 2012a). Sample plots for the geographical position were located 37° 03' 48" - 37° 42' 08" north latitude and 29° 31' 14" - 31° 00' 25" east longitude. Plots of slope and the elevation were changed % 1-75, 965-1388 m respectively. Research areas are located from between in the Mediterranean climate with continental climate of the transition region in Central Anatolia (IM, 2012b). In the plots, average annual temperature were changed 1,8-23,6 °C and the amount of the monthly average rainfall 11,5-70,3 mm (Observation Time: 1970-2011; TSMS, 2012). The highest temperature in July was observed the maximum rainfall in December. According to Walter method, dry period were between the months of June-September. According to Thornthwaite water balance method, the annual average temperature in sample areas was 12 °C, though the average annual precipitation was 499 mm, water shortage sixth and tenth months and lots of water the first and fourth months were observed. According to this method, arid period was between June and September. According to the Erinc method, June was semi-arid month, July-September was arid, October was observed semi-arid climate.

Method

Selection of sample plots

Stand structure characteristic was determined one by one in 18 sample plots which PbPnd₁, PnPbd₁, PbPnd₂, PnPbd₂, PbPncd₃, PnPbcd₃ stand types of research areas. But, in this article we gived 6 sample plots from each of stand type.

Profiling and evaluation of stand

In our study, each stand has 50x20 m dimensions (depending on the slope of land, the long edge 50 m, a short edge 20 m and total of 1000 m²) and was taken perpendicular to the contour curves. After selecting the sample areas roughly, areas were determined to be 1000 m². All individuals were given numbers which were larger than 4 cm in diameter breast height and height 5 m large. Trees were measured of coordinates and recorded in the form. Firstly, stand profiles drawn with 1/200 scale and then was processed tracing paper (Figure 1).

Numbered all trees were measured in the chest diameters (cm), heights (m) and stem classes (by IUFRO), (Saatcioglu, 1971) then recorded in the form. Each individual was proportioned taking into consideration the height values, the first-last green branch and dry branch. Stand profile areas were determined the social status of each tree and which they belong to stem classes. These findings were determined for storied. In addition, according to tree species and diameter classes, number of individuals and basal area values were calculated as hectares. Basal area of trees was determined by the formula ($\pi/4 \times d_{(1,30)}^2$) corresponding to the diameter breast height. Mixture status of the sample plots was evaluated according to the each tree species and each number, basal area with ratio of the total amount of the individual in the same area.

According to Eyupoglu (1989), period of reaching the biological independence for oriental spruce (*Picea orientalis* (L.) Link.) was the age which height was 80 cm. In each sample plots age measurements was measured number of 1-4 individuals by the amount. For this purpose, if the first class, or class 2c age measurements was done. These were selected which members of Brutian pine and Anatolian black pine has the same length and the same diameter.

Crown closure was carried out with scaled crown projection (stand profile) and light density measurements (Genc, 2012). Excel program was used for every calculation.

Results

Stand structure characteristic of sample plots

Development of stand ages and age values, crown closure status, storied status and composition status were evaluated.

Development of stand ages and age values

According to table 1, were evaluated development stages of trees-shrubs in research areas (Table 1). In our study, development stage were determined taking into account of average stem diameter and accordingly, each sample area was calculated tree species of diameter classes distribution as number and percentage. Most of the individuals were small, medium and large wood stages in the research areas. Reproduction-culture stage and thicket-sapling stage was less than number of individuals. Period of reaching the biological independence for Brutian pine is 5-17 year, for Anatolian black pine is 7-18 year (for 18 sample plot). Whether Anatolian black pine is in minority and grows slower than Brutian pine, period of age-height precedence for this specie is 7 years in minimum and obligatory period of age-height precedence is 2 years in natural regeneration studies (Table 2).

Crown Closure Status

Crown closure determinations were evaluated with scaled crown projection (stand profile) and light measurements were made both in sample plots and out of the sample plots. Light measurements were performed to close tree stems, so these values (Table 3) indicates the top and side light amount in stand. According to scaled crown projection, crown closure was 0.6, 0.5, 0.22, 0.79, 0.70, 0.89 respectively in Sutculer, Yukarı Gökdere, Aglasun, Gölhisar, Camoluk and Bucak Ranger District. Crown closure is indicated by "1" if crown closure is between 0,11-0,40 in management plans. Crown closure is indicated by "2" if crown closure is between 0,41-0,70 in management plans. Crown closure is indicated by "3" if crown closure is between 0,71-1,00 in management plans (Table 3). Stand profile and light measurement values are not the same in some areas. Furthermore, the light values that enters into the stand with values of the degree of projection of crown closure are not same. The main reason was that light measurements were made close to tree stems.

Storied Status

2e and 5th class individuals are dead and down individuals, so these are non-functional elements suppressed stands. 4th and 5th individuals are less than the contribution of silvicultural elements. Because, these individuals have no more effect on the amount of light that enters the stand, water loss through evapotranspiration and especially interception, beginning of natural pruning, prevention from grow up to weeds and brush, decomposition of soil litter, formation of mellow soil. So these are non-functional elements suppressed stands. For this reason, in our study, 1, 2a, 2b, 2c, 2d are functional superior stand elements and 3th class individuals are functional suppressed stand elements. This result was used for the first time in silvicultural study (Table 4).

All sample plots are mono storied except third area. The third sample plot, functional superior stand has a ratio of 56 % and the degree of crown closure is 22 % (according to crown projection). Consequently, foetid odour juniper and prickly juniper which has semi intolerant easily settled. Even, sample area has been invaded by juniper and kermes oak.

Composition Status

In our study, the third sample plot was found the lowest basal area. According to basal area values, all of the sample areas formed from mixed stand (Table 5,6). But, we considered the sample area of 18, nearly half of the stands tend to pure.

Stand Profiles and Evaluation of Sample Plots

Properties of the sample plots were given at the tables from 1 to 7. And also the average diameter breast heights and heights for Brutian pine and Anatolian black pine can be seen in Table 7. Likewise, reaching ages of the biological independence as to plots were calculated as 12 years for *Pb* and 8 years for *Pn* in plot 1, 17 years for *Pb* and 13 years for *Pn* in plot 2, 11 years for *Pb* (the value of a single tree) and 13 years for *Pn* in plot 3, 5 years for *Pb* and 8 years for *Pn* in plot 4, 6 years for *Pb* and 11 years for *Pn* in plot 5, 6 years for *Pb* and 8 years for *Pn* in plot 6, respectively.

Discussion

The six sample area which we selected was discussed in this article. It was decided that all of the stands were suitable for regeneration. But, natural regeneration studies were not available in all of the sample areas.

In sample plot of the number one, was observed breaking down of canopy all of the Anatolian black pine and some Brutian pine. It was not possible regeneration for Anatolian black pine. So two years ago, it is collected seed for Anatolian black pine in local stand area. These seedlings are produced preferably 1+2, 1+1, 2+0 containerized seedling. Then, should be done “The uniform clearcut system based on the natural seed fall and seed additional”. This stand have sufficient amount of seed tree. Within “The uniform clearcut system based on the natural seed fall and seed additional”(Genc, 2006), in cone year, before snowfall starts, it should begin to work in the area and is done at least 5 kg of seeds per hectare. Area mixture is recommended because; it is easier to set up in the stand. The amount of basal area as actual mixture were 0,88 Pb + 0,12 Pn. Area mixture was 0,7 Pb + 0,3 Pn recommended by us. Hole is opened around stump of old and new Anatolian black pine in shape of clump and group size. The deeps are prepared 2,5 X 1,25 m spacing. Ground cover is cleared and ground litter is mixed with soil. Or, Anatolian black pine is sowed with seeding in row (1 m line will be about 15 seeds or scatter with 1 g seeds per square meter). After Anatolian black pine is given the obligatory age-height precedence at least two years, studies is begun with Brutian pine in the first seed year.

In sample plot of the number two, there was no problem in point of ground cover. The amount of basal area as actual mixture were 0,59 Pn + 0,41 Pb. Area mixture was 0,6 Pn + 0,4 Pb recommended by us. The composition of area is easier to set up, so we recommended that composition of area. There is enough seed tree in stands. If you want to regeneration both of species, regeneration is started cone year in the same time. Seed felling is done in the area which will be regenerated. Crown clouser is reduced 0,5-0,6 for Anatolian black pine and 0,2-0,3 for Brutian pine. Brutian pine and Anatolian black pine are established as clump shelterwood posture-group shelterwood posture-large group shelterwood posture according to the mean tree height of the site. It is continued natural regeneration studies. If regeneration of both species does not coincide in the same year, Brutian pine cones collected starting work 1 years ago in stand or near surrounding.

Obtained seeds are produced preferably 1+0 containerized seedling or as bare root seedling. Anatolian black pine is taken into account in first cone year. Seed felling is done in the area which will be regenerated or aged reaching seed trees for Anatolian black pine (40-80 years old) (Urgenc, 1982; Genc, 2012) and crown clouser is reduced 0,5-0,6. For Brutian pine, clump clearcut posture-group clearcut posture is established wanted youth according to width. Then, 1+0 containerized seedling planted or seeds are planted. Area mixture was recommended 0,6 Pn + 0,4 Pb by us. Hole is opened around stump of old and new Brutian pine in shape of clump and group size. The deeps are prepared 3 X 2 m spacing. Ground cover is cleared and ground litter is mixed with soil. Or, Brutian pine is sowed with seeding in row (1 m line will be about 20 seeds or scatter with 2 g seeds per square meter). Later, Anatolian black pine is continued natural regeneration studies with uniform shelterwood regeneration system.

In sample plot of the number three, Brutian pine and Anatolian black pine is insufficient as quantity in the stand and there isn't a seed tree. So, artificial regeneration is the best solution. Brutian pine, Anatolian black pine and junipers is brought preferably planting or otherwise sowing. The amount of basal area as actual mixture were 0,60 Pn + 0,16 Pb + 0,14 Jo + 0,02 Jf. Area mixture was 0,50 Pn + 0,20 Pb + 0,20 Jo + 0,10 Jf recommended by us. For this, it is collected seed for three species in local area or if possible, seeds produced from collected seed. Because, admixed form is need to continue. One year ago seeds collected for Brutian pine, two years ago seeds collected for Anatolian black pine and Junipers. Obtained seeds are produced preferably 1+0 containerized seedling for Brutian pine, 1+2, 1+1, 2+0 containerized seedling for Anatolian black pine, 2+0 and 1+1 containerized seedling for Junipers. Hole is opened around stump of old and new Brutian pine, Anatolian black pine and Junipers in shape of clump and group size. The deeps are prepared 3 X 2 m spacing for Brutian pine and 2,5 X 1,25 m for Anatolian black pine. Produced seedlings are planted. For Juniper, if bare rooted seedlings are planted, it is used side-hole seedlings. If containerized seedlings are planted, it is used simple pit planting. The deeps are prepared preferably 3 X 3,5 m, 3 X 4 m or 3 X 5 m spacing for Foetid odour juniper, 3 X 2 m and 3 X 3 m for Prickly juniper (GDF, 2012). Or, Brutian pine, Foetid odour juniper and Prickly juniper is sowed with seeding in row (1 m line will be about 20 seeds or scatter with 2 g, 3 g, 1 g seeds per square meter for Brutian pine, Foetid odour juniper and Prickly juniper, respectively). Anatolian black pine is sowed with seeding in row (1 m line will be about 15 seeds or scatter with 1 g seeds per square meter).

In sample plot of the number four, distribution of individuals are homogeneous. Advance reproduction has well. According to management objective is obtained from 0,6 Pn + 0,4 Pb areal mixed stand by us. There is enough seed tree in stands. Anatolian black pine is given the obligatory age-height precedence at least two years compared to Brutian pine. First cone year, regeneration is done with the ATA group system for Anatolian black pine. Crown clouser is reduced 0,5-0,6 with seeding cutting. Two years later, should be done "The uniform clearcut system based on the natural seed fall and seed additional". Within "The uniform clearcut system based on the natural seed fall and seed additional"(Genc, 2006), in cone year, before snowfall starts, it should begin to work in the area and is done at least 5 kg of seeds per hectare. If you are prompted to work faster, two years ago, it is collected seed for Anatolian black pine in local stand area.

These seedlings are produced preferably 1+2, 1+1, 2+0 containerized seedling. Then, should be done "The uniform clearcut system based on the natural seed fall and seed additional". First seed year for Brutian pine, hole is opened around stump of old and new Anatolian black pine in shape of clump and group size. Area mixture was recommended 0,6 Pn + 0,4 Pb by us. The deeps are prepared 2,5 X 1,25 m spacing. Ground cover is cleared and ground litter is mixed with soil. Or, Anatolian black pine is sowed with seeding in row (1 m line will be about 15 seeds or scatter with 1 g seeds per square meter). After Anatolian black pine is given the obligatory age-height precedence at least two years, studies is begun with Brutian pine in the first cone year.

In sample plot of the number five, Anatolian black pine is insufficient as quantity in the stand and there isn't a seed tree. But, Brutian pine has enough seed tree. Therefore, it is collected seed for Anatolian black pine in local stand area two years ago. Then, should be done "The uniform clearcut system based on the natural seed fall and seed additional". According to management objective is obtained from 0,70 Pb + 0,30 Pn areal mixed stand by us. Within "The uniform clearcut system based on the natural seed fall and seed additional"(Genc, 2006), in cone year, before snowfall starts, it should begin to work in the area and is done at least 5 kg of seeds per hectare. First seed year for Brutian pine, hole is opened around stump of old and new Anatolian black pine in shape of clump and group size. The deeps are prepared 2,5 X 1,25 m spacing. Ground cover is cleared and ground litter is mixed with soil. Or, Anatolian black pine is sowed with seeding in row (1 m line will be about 15 seeds or scatter with 1 g seeds per square meter). After Anatolian black pine is given the obligatory age-height precedence at least two years, studies is begun with Brutian pine in the first cone year.

In sample plot of the number six, Brutian pine and Anatolian black pine is sufficient as quantity in the stand. There have seed tree both of species. There is no need to provide age-height precedence for Brutian pine in sample area. As area mixture was recommended 0,6 Pn + 0,4 Pb by us. Brutian pine individuals should be brought preferably planting or sowing. One year ago seeds collected for Brutian pine. Obtained seeds are produced preferably 1+0 containerized. Anatolian black pine are taken into account in first cone year. Seed felling is done in the area which will be regenerated or aged reaching seed trees for Anatolian black pine (40-80 years old) (Urgenc, 1982; Genc, 2012) and crown clouser is reduced 0,5-0,6. For Brutian pine, clump clearcut posture-group clearcut posture is established wanted youth according to width. Then, 1+0 containerized seedling planted or seeds are planted. First cone year for Brutian pine, hole is opened around stump of old and new Anatolian black pine in shape of clump and group size. The deeps are prepared 3 X 2 m spacing. Ground cover is cleared and ground litter is mixed with soil. Or, Brutian pine is sowed with seeding in row (1 m line will be about 20 seeds or scatter with 2 g seeds per square meter). Later, Anatolian black pine is continued natural regeneration studies with uniform shelterwood regeneration system.

All of the sample plots, regeneration area should be done land preparation which includes ground cover and ground litter. Edge length and depth should be 25-40 cm and 40 cm, respectively. Contour ridges are constructed with an interval of 2 to 2.5 m, 25-30 cm wide and 15-20 cm deep (except the third area). All of individuals must remove from the area, except for to be protected monumental trees (Genc and Guner, 2003), high quality timber and important species for wildlife (Genc, 2004). Dead and woodpecker trees should left the recommended amount (5-10 m³/ha) in the stand if any available (Ammer reference to Colak 2001). More than 50% of dead tree stock's diameter should be thicker than 20 cm and 50% should be dead and dying (Erdmann & Wrike reference to Colak 2001).

We can say that natural regeneration, seed tree must be found in a stand which can be seen seed year and has homogeneous distribution. Then, seed trees should have crown form which containing plenty of seed. Thirdly, seed trees must contain sufficient amount of healthy seed in seed year.

Later, seed tree must have durable stem and root structure in order to protect against temperature, drought and frost damage until youth could reach the biological independence. Fifthly, seed dissemination as nature or seed supplementation should meet mineral soil. Land preparation and cultivation should be done if any available. Finally, germinating bed should contain amounts of moisture, heat and oxygen (Genç, 2004). Due to these items artificial regeneration should be done in such areas if a stand does not have these conditions. For the continuation of biological diversity should be taken precaution and supported natural life in both natural regeneration and artificial regeneration.

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References

- Ata, C (1992): Regeneration problems of mixed stands. Bartın Forestry Faculty. Iufro S6.06-04, 21-33.
- Ata, C (1995): Silviculture technique. Zonguldak Black Diamond University, Bartın, 453p.
- Colak, A.H (2001): Nature conservation in forest. Ministry of Forestry National Parks and Game-Wildlife General Directorate, Ankara, 354p.
- Eyuboglu, A. K (1989): Oriental spruce of artificial regeneration. Published by Forestry Research Institute, Trabzon, 58. 107-123.
- Genç, M (2004): Silviculture technique. Published by Suleyman Demirel University, Isparta, 357p.
- Genç, M (2006): Silvicultural practices. Published by Suleyman Demirel University, Isparta, 357p.
- Genç, M (2012): Principles of silviculture. Published by Suleyman Demirel University, Isparta, 351p.
- Genç, M., Guner Ş.T (2003): Importance of monumental trees, monumental trees in the lake district of Turkey, Isparta Governorship, 322p.
- Genç, M., Kasarcı E., Kaya C (2012): A silvicultural evaluation on the researches of stand structure. Artvin Coruh University Journal of Forestry Faculty, 13(2), 293-306.
- General Directorate of Forestry(GDF) (2012): Department of Silviculture. Training note, Ankara, pp 80.
- Ministry of Environment and Forestry (MEF) (2009): Türkiye Forests. General Directorate of Forestry, Ankara, 197p.
- Isparta Municipality (IM) (2012a): <http://www.isparta.bel.tr/kentrehberi.asp?islem=sayfa&id=4>
- Isparta Municipality (IM) (2012b): <http://www.isparta.bel.tr/kentrehberi.asp?islem=sayfa&id=17>
- Saatcıoğlu, F (1971): Forest tending. Published by Istanbul University Faculty of Forestry, İstanbul, 303p.
- Turkish State Meteorological Service (TSMS) (2012): <http://www.dmi.gov.tr/veridegerlendirme/il-ve-ilceleristatistik.aspx?m= ISPARTA#sfB>
- Urgenc, S (1982): Improvement of forest trees. Published by Istanbul University Faculty of Forestry, İstanbul, 414p.

Tables

Table 1. Stand development stages (Genç et. al., 2012)

| Stand development stage | Diameter breast height ($d_{1,30}$) | Symbol |
|--------------------------------|---------------------------------------|--------|
| Reproduction and culture stage | < 8,0 cm | a |
| Thicket stage | < 8,0 cm | a |
| Sapling stage | 8,0 cm – 10,9 cm | b |
| Pole stage | 11,0 cm – 19,9 cm | b |
| Small wood stage | 20,0 cm – 35,9 cm | c |
| Medium and large wood stage | > 36,0 cm | d |

Table 2. Number of tree species and amount according to diameter classes

| Sample plots | Tree species | Number of trees per hectare by stand development stages | | | | | | | Actual stand structures by the number of species individuals |
|--------------|-------------------------------|---|---------------------|---------|---------|-----|-------|------|--|
| | | 0-7,9 | 8-19,9 | 20-35,9 | 36-51,9 | ≥52 | Total | % | |
| | | 1 | <i>Pinus brutia</i> | 0 | 20 | 30 | 60 | 50 | |
| | <i>Pinus nigra</i> | 0 | 0 | 0 | 20 | 0 | 20 | 11,1 | |
| | Total | 0 | 20 | 30 | 80 | 50 | 180 | 100 | |
| 2 | <i>Pinus brutia</i> | 0 | 0 | 0 | 10 | 30 | 40 | 36,4 | PnPbd2 |
| | <i>Pinus nigra</i> | 0 | 0 | 0 | 40 | 30 | 70 | 63,6 | |
| | Total | 0 | 0 | 0 | 50 | 60 | 110 | 100 | |
| 3 | <i>Pinus brutia</i> | 0 | 10 | 10 | 0 | 0 | 20 | 8 | JoPnPbJfabcd1 |
| | <i>Pinus nigra</i> | 0 | 0 | 20 | 10 | 0 | 30 | 12 | |
| | <i>Juniperus oxycedrus</i> | 110 | 60 | 0 | 10 | 0 | 180 | 72 | |
| | <i>Juniperus foetidissima</i> | 0 | 10 | 10 | 0 | 0 | 20 | 8 | |
| | Total | 110 | 80 | 40 | 20 | 0 | 250 | 100 | |
| 4 | <i>Pinus brutia</i> | 40 | 80 | 30 | 70 | 30 | 250 | 62,5 | PbPndbca3 |
| | <i>Pinus nigra</i> | 20 | 20 | 30 | 70 | 10 | 150 | 37,5 | |
| | Total | 60 | 100 | 60 | 140 | 40 | 400 | 100 | |
| 5 | <i>Pinus brutia</i> | 0 | 0 | 30 | 80 | 30 | 140 | 73,7 | PbPndcb2 |
| | <i>Pinus nigra</i> | 0 | 30 | 10 | 10 | 0 | 50 | 26,3 | |
| | Total | 0 | 30 | 40 | 90 | 30 | 190 | 100 | |
| 6 | <i>Pinus brutia</i> | 0 | 0 | 10 | 60 | 10 | 80 | 19 | PnPcbcd3 |
| | <i>Pinus nigra</i> | 0 | 120 | 180 | 40 | 0 | 340 | 81 | |
| | Total | 0 | 120 | 190 | 100 | 10 | 420 | 100 | |

Table 3. According to scaled crown projection and light measurements crown closure of sample plots

| Sample plots | Locality | Scaled crown projection (Stand profile) | Light measurements | | |
|--------------|---------------------------|---|--------------------|------|---------|
| | | | Max | Min | Average |
| 1 | Sutculer ranger district | 0,6 | 0,42 | 0,02 | 0,07 |
| 2 | Y.Gokdere ranger district | 0,5 | 0,99 | 0,2 | 0,43 |
| 3 | Aglasun ranger district | 0,22 | 0,8 | 0,08 | 0,33 |
| 4 | Golhisar ranger district | 0,79 | 0,88 | 0,1 | 0,5 |
| 5 | Camoluk ranger district | 0,7 | 0,71 | 0,28 | 0,5 |
| 6 | Bucak ranger district | 0,89 | 0,57 | 0,04 | 0,11 |

Table 4. Storied status belong to sample plots

| Sample plots | The distribution of individuals in stem (tree) class | | | | | | | | | | | | | | | | | | Total of number trees (N) | | |
|--------------|--|------|----|------|----|------|---------------------------|------|---|------|----|-----------------------------|--------------|------|---|-----|---|-----|---------------------------|-----|----|
| | Functional* | | | | | | | | | | | | Functional** | | | | | | | | |
| | 1 | 2a | 2b | 2c | 2d | 2e | Functional superior stand | | 3 | 4 | 5 | Functional suppressed stand | | | | | | | | | |
| N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | | | | |
| 1 | 1 | 5,6 | 1 | 5,6 | 10 | 55,6 | | | 2 | 11,1 | 12 | 80 | 2 | 11,1 | 1 | 5,6 | 1 | 5,6 | 2 | 20 | 18 |
| 2 | 3 | 27,3 | 1 | 9,1 | 7 | 63,6 | | | | | 11 | 100 | | | | | | | | | 11 |
| 3 | | | | | 14 | 56 | | | | | 14 | 56 | 11 | 44 | | | | | 11 | 44 | 25 |
| 4 | 18 | 45 | | | 21 | 52,5 | 1 | 3 | | | 40 | 100 | | | | | | | | | 40 |
| 5 | 5 | 26,3 | 2 | 10,5 | 11 | 57,9 | | | | | 18 | 94,7 | 1 | 5,3 | | | | | 1 | 5,3 | 19 |
| 6 | 16 | 38,1 | 5 | 11,9 | 5 | 11,9 | 16 | 38,1 | | | 42 | 100 | | | | | | | | | 42 |

*Functional superior stand: Except 2e stem class individuals

**Functional suppressed stand: Except 4th and 5th stem class individuals

Table 5. Basal area values according to tree species

| Sample plots | Tree species | Basal area (1000 m ²) | Basal area per hectare (m ²) | % |
|--------------|-------------------------------|-----------------------------------|--|------------|
| 1 | <i>Pinus brutia</i> | 2,433 | 24,33 | 87,9 |
| | <i>Pinus nigra</i> | 0,335 | 3,35 | 12,1 |
| | Total | 2,768 | 27,68 | 100 |
| 2 | <i>Pinus brutia</i> | 0,975 | 9,75 | 40,9 |
| | <i>Pinus nigra</i> | 1,409 | 14,09 | 59,1 |
| | Total | 2,384 | 23,84 | 100 |
| 3 | <i>Pinus brutia</i> | 0,092 | 0,92 | 16,1 |
| | <i>Pinus nigra</i> | 0,342 | 3,42 | 60 |
| | <i>Juniperus oxycedrus</i> | 0,08 | 0,8 | 14 |
| | <i>Juniperus foetidissima</i> | 0,056 | 0,56 | 9,9 |
| Total | 0,57 | 5,7 | 100 | |
| 4 | <i>Pinus brutia</i> | 2,41 | 20,41 | 58,4 |
| | <i>Pinus nigra</i> | 1,456 | 14,56 | 41,6 |
| | Total | 3,866 | 34,97 | 100 |
| 5 | <i>Pinus brutia</i> | 2,144 | 21,44 | 89,3 |
| | <i>Pinus nigra</i> | 0,257 | 2,57 | 10,7 |
| | Total | 2,401 | 24,01 | 100 |
| 6 | <i>Pinus brutia</i> | 1,184 | 11,84 | 41,1 |
| | <i>Pinus nigra</i> | 1,696 | 16,96 | 58,9 |
| | Total | 2,88 | 28,8 | 100 |

Table 6. Composition ratio of sample plots according to basal area

| Composition ratio of sample plots according to basal area | |
|---|--|
| Sample plots | Composition ratio |
| 1 | %87,9 <i>Pb</i> + %12,1 <i>Pn</i> |
| 2 | %59,1 <i>Pn</i> + %40,9 <i>Pb</i> |
| 3 | %60 <i>Pn</i> + %16,1 <i>Pb</i> + %14 <i>Jo</i> + %1,7 <i>Jf</i> |
| 4 | %58,4 <i>Pb</i> + %41,6 <i>Pn</i> |
| 5 | %89,3 <i>Pb</i> + %10,7 <i>Pn</i> |
| 6 | %58,9 <i>Pn</i> + %41,1 <i>Pb</i> |

Table 7. The aspect, elevation, inclination, average diameter breast heights, heights and average ages for Brutian pine-Anatolian black pine each sample plots

| le plots | Tree species | Aspect | Elevation | Inclination | Average DBH (cm) | Average Height (m) | Average Ages A0,0 | A0,8 |
|----------|-------------------------------|--------------------|-----------|-------------|------------------|--------------------|-------------------|------|
| 1 | <i>Pinus brutia</i> | North-Northeast | 1255 m | 57,5% | 40,93 | 17,03 | 130 | 118 |
| | <i>Pinus nigra</i> | | | | 46,25 | 19,00 | 129 | 121 |
| 2 | <i>Pinus brutia</i> | North-Northwestern | 1020 m | 75% | 55,40 | 20,00 | 166 | 149 |
| | <i>Pinus nigra</i> | | | | 50,15 | 18,07 | 191 | 178 |
| 3 | <i>Pinus brutia</i> | South-Southeastern | 1273 m | 5,75% | 21,45 | 8,25 | 37 | 26 |
| | <i>Pinus nigra</i> | | | | 32,47 | 12,75 | 55 | 42 |
| | <i>Juniperus oxycedrus</i> | | | | 7,34 | 2,50 | | |
| | <i>Juniperus foetidissima</i> | | | | 19,00 | 8,25 | | |
| 4 | <i>Pinus brutia</i> | North-Northwestern | 1041 m | 55% | 28,18 | 15,70 | 84 | 79 |
| | <i>Pinus nigra</i> | | | | 31,86 | 17,30 | 82 | 74 |
| 5 | <i>Pinus brutia</i> | South | 1286 m | 25% | 43,26 | 17,03 | 120 | 114 |
| | <i>Pinus nigra</i> | | | | 23,32 | 8,90 | 142 | 132 |
| 6 | <i>Pinus brutia</i> | North-Northwestern | 1219 m | 47,50% | 42,87 | 17,05 | 74 | 69 |
| | <i>Pinus nigra</i> | | | | 23,55 | 13,05 | 85 | 77 |

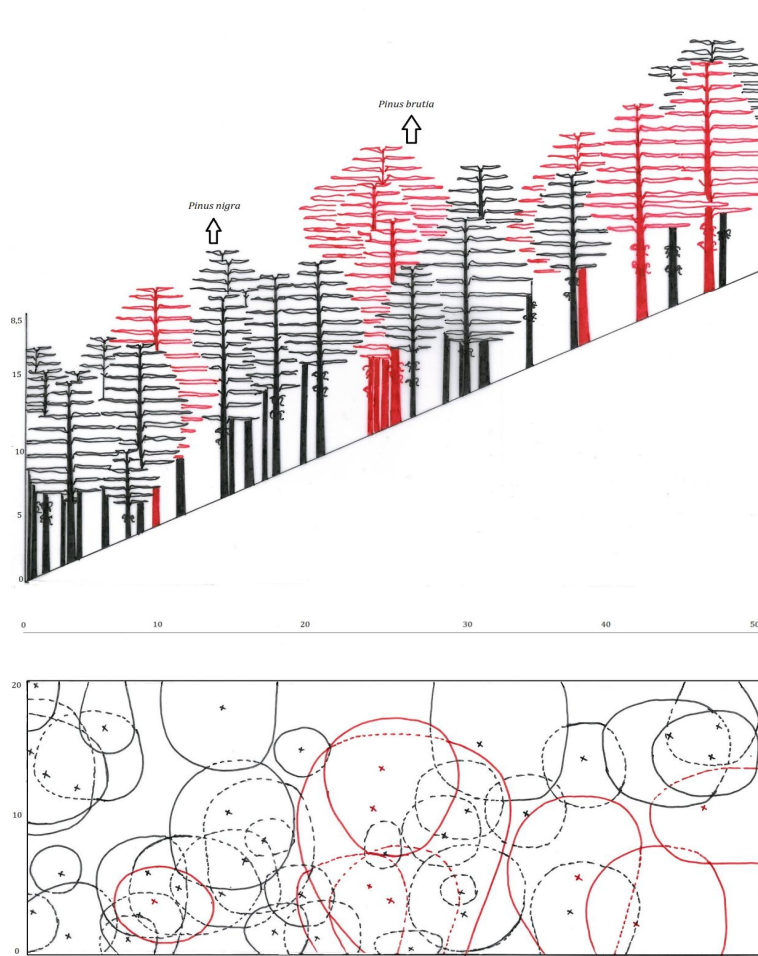


Figure 1. Stand profile and crown projection belong to number of 6 (The height of dry and wet branches is estimated from ground level)