The sylviculture of Pinus brutia in Turkey

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Le pin d'Alep et le pin brutia dans la sylviculture méditerranéenne

Paris : CIHEAM
Options Méditerranéennes : Série Etudes; n. 1986-I

1986
pages 55-66

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Key words : Pinus brutia Henry. Turkey. Sylviculture (Habitat conditions, Seeding habits, Seed production, Nursery works, Artificial and Natural regeneration, Yield, Races and Hybrids).

ABSTRACT

Pinus brutia Henry is an important natural tree species of the eastern Mediterranean countries. The largest forest area of this species is in Turkey, with more than 3 million hectares distributed in Mediterranean, Aegean and Marmara Regions, it constitutes approximately 37% of the total confierous forests area of the country.

Besides its good performance on poor sites, as a hardy species, it also has considerably faster growth rate on good sites (up to 12 cu. meters/ha. per annum) as compared to the other coniferous species in Turkey.

In addition to wide-range utilization of its wood in various wood-based industries, P. brutia also provides the total resin production of the country.

This paper deals with races and hybrids of the species, ecobiological characteristics, seed production, nursery practice, natural and artificial regeneration, yield, causes and damages of P. brutia in Turkey.

INTRODUCTION OF THE SPECIES

Pinus brutia Henry. (syn. *Pinus halepensis var. brutia* "Ten." Henry, *Pinus elderica* Medwed., *Pinus pyrenica* David., *Pinus brutia* Ten.) is one of the important forest trees of the Mediterranean region, reaches its greatest distribution in southern Turkey where it has become one of Turkey's most valuable commercial tree (1).

Pinus brutia is named as "kizilçam" in Turkish corresponding to the word "redpine" in English which is because of its reddish young sprouts. The tree is also called Calabrician cluster pine or *Pyrenean pine* in English and *Pin des Pyrénées* or Pin nazaron in French (1,2).

Some botanists have indicated red pine to be a variety of Aleppo pine (*Pinus halepensis* Mill.), but the latest research studies justify its classification as a separate species (1,3). *Pinus brutia* is a coastal tree and is a drought resistant pine that withstands more aridity and poor soils than most timber species growing in Mediterranean climate. Although it requires mild winters, some of its provenances can grow successfully, out of its natural habitat, on sites of drier an cooler climate (4).

It grows fast in the early ages; under the conditions of understocked stand or open-grown trees the tree typically develops large spreading branches with diffuse crown; but in suitable conditions, it grows exceptionally fast with straight trunk and narrow crown and it may reach to a height of 35 meters. It is sensitive to continuous strong wind; in such a case, it does not grow well (5).

P. brutia is a restricted tree species in the eastern Mediterranean region. It is distributed to Italy, Greece, Turkey, Cyprus, Syria, Lebanon, Jordan, Palestine and the many Islands of Aegean and Mediterranean Sea. The species is also seen in northern Iraq and over the north coast of Black Sea in Crimea (1, 3, 5, 6, 8, 9).

The species has a wide range in Turkey. It grows mainly in extensive stands in southern and western Anatolian and is also found in the Marmara region (slide-show). It reaches greatest commercial importance in the southern Anatolian region. It also makes limited appearences on the coastal areas of interior Black sea region; in the region, the species occupies the bottom of the drier and warmer valleys. Besides, the tree has a few isolated populations in the region of southeastern Anatolian (Fig. 1).

The species grows from sea level to the elevation of 1 300 meters in south, the upper limit reaches to some points 1 650 meters in this region; but it is not common above 900 meters in the west. It appears between elevations of 200-400 meters in north-west of Black Sea region. In the indigenous *P. brutia* forests, the species is in pure stands. However, it grows in mixed stands with *Pinus nigra Arn. var. pallasiana* Schneid., *Cedrus libani Richard.*, *Juniperus excelsa* Bieb. and less commonly with *Abies cilicica* Carr. and some commercial broadleaved tree species (1, 3, 9).

According to the latest forest surveys, *P. brutia* forest covers an area of 3.096.064 hectares, which includes 37% of the total area of coniferous forests in Turkey (10).

HABITAT CONDITIONS

Climatic

The climate throughout the commercial range of *P. brutia* is predominantly mild with moisture adequate during all seasons. The annual precipitation is also adequate, but it is poorly distributed. During the growing season, long period of drought may occur and the temperature may be very high. However, as it is indicated above, since the moisture is adequate, it partly compensates the effect of temperature. Frost is rarely seen. The botanical range also takes some cooler local areas of relatively high precipitation in southwest and interior parts of Taurus mountains, in its boundaries within the limits of its range, *P. brutia* is found in localities which have precipitation as low as 412.8 mm. annual average, and only 128.4 mm. average in its growing-season. Throughout the chief commercial range (Muğla and Antalya regions) the average annual precipitation is 1 068.9 mm. to 1 220.9 mm., with 251.3 mm. to 353.9 mm. falling during the growing-season.

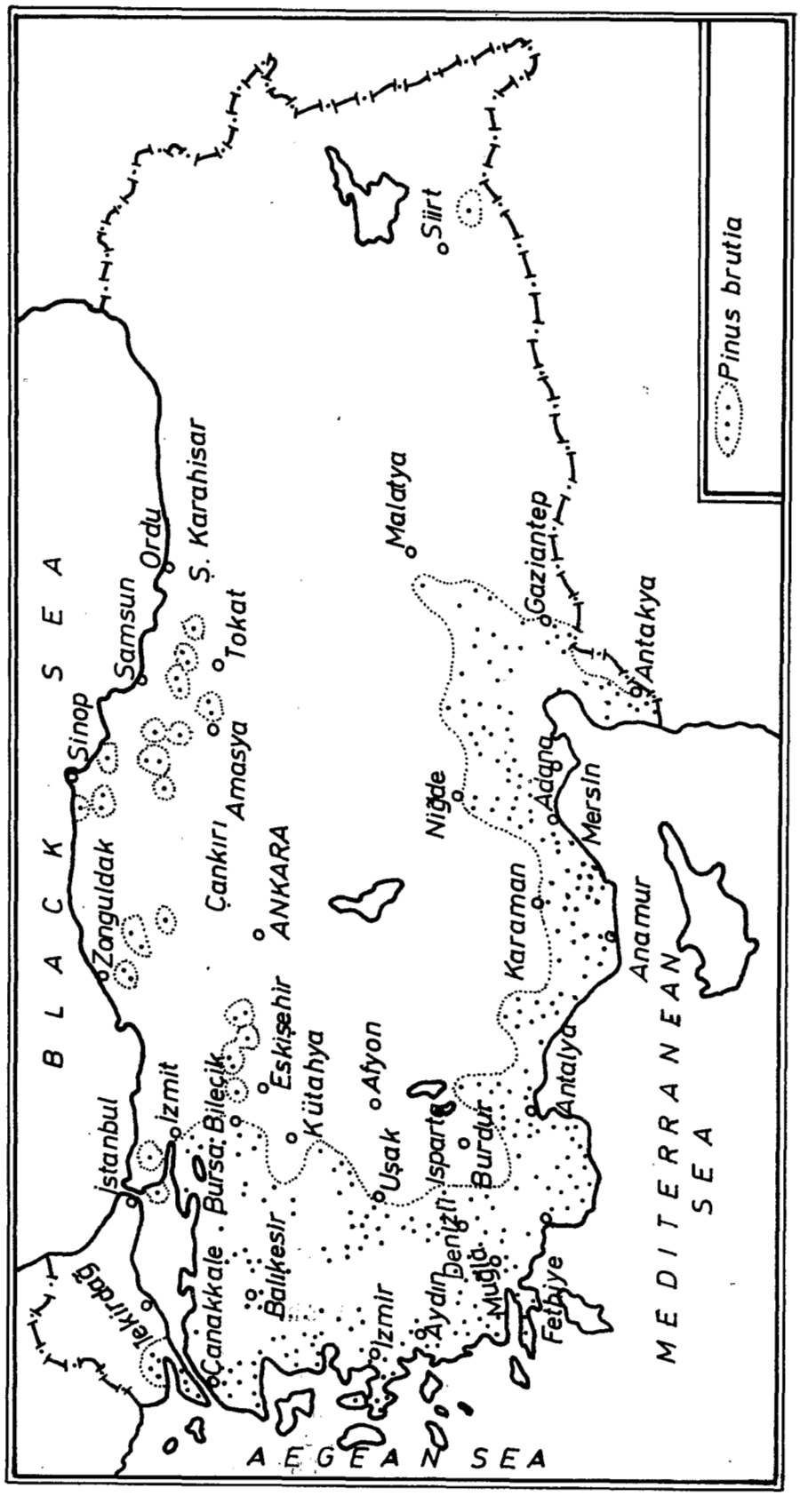
The average annual temperature in the range of *P. brutia* varies from 12.5 °C to 22.9 °C. The average temperature for January varies from 2.7 °C to 11.7 °C; for July from 24.3 °C to 30.8 °C. The maximum annual average is 18.1 °C to 22.7 °C and the minimum is 1.4 °C to 8.1 °C. The growing-season usually begins at the mid of February and ends at the first half of November at elevation of 400 meters. The average annual absolute humidity varies from 54 to 69 percent (11).

The growing-season period varies from 200 to 280 days and over; it is obvious that low temperature and snow fall are the main ecological factors limiting *Pinus brutia* from spreading beyond the defined habitat; in its natural habitat, the mean temperature does not go below 0 °C in January and the falling snow does not remain on the ground more than 15 days. Also the mean annual temperature is not less than 12 °C (12).

Soil

The soil conditions of natural range or red pine in Turkey has not been fully studied yet. However, it is known that the species is hardy and highly adaptable

Figure 1. The Natural Distribution of Pinus brutia Henry in Turkey



(Saatçioğlu, F. and Pamay, B.)

to various types of soils. The dominant soil types are red Mediterranean and Calcareous brown forest soils. It is indicated that the origin of soil does not considerably affect its growth (5). In southern Anatolian, *P. brutia* forests grow on calcareous soils which have sufficient depth and moisture. In addition to this, the tree may grow in different types of soils originated from andesite, sandstone, shist, granite and rarely on serpentine. It grows in soils with a wide range in structure varying from sandy clay, sandy loam to silt loam, but it prefers sandy and loamy soils for it enables the best development (12).

The Undergrowth Associated With the Species

In the southern Anatolian forest region, from sea shore climbing up to the southern slopes of Taurus Mountains, *P. brutia* is the main forest tree species up to 1 300 meters. Lower down, along the shore and up to 600-700 meters maquis is dominant; the species occasionally occurs to grow in maquis belt in which some deciduous and evergreen trees, shrubs such as *Q. infectoria* subsp. boissieri., *Cercis siliquastrum* L., *Fraxinus ornus subsp. cilicica.*, *Ceratonia siliqua* L., *Fontanesia phillyreoides* L., *Q. cossifera* L., *Q. collipri-ninos* L., *Pistesia terebintus* L., *Olea europea var. oleaster* L., *Erica verticillate* L., *Cotinus coggygria* L., *Spartium junceun* L., *Vitex agnus-castus* L. associate with the tree species. It grows in large stands above 900 meters; above 1 300 meters it is replaced by *Cedrus libani* A. Richard. or *Pinus nigra Arn. var. pallasiana* Schneid., and less commonly by *Abies cilicica* carr. (13). *P. brutia* also appears with Aleppo pine on the very local and calcareous hilly sites which take place between Seyhan and Ceyhan rivers near to Adana city.

The species is frequently a dominant forest tree in the Aegean forest region. It forms very large pure forests after the maquis belt which covers large areas below 400 meters along the coast and in depression places penetrated deeply inland (13). The leading species associated with *P. brutia* are *Q. infectoria* subsp. boissieri., *Strax officinelis* L., *Pistacia lentiscus* L., *Pyrus salicifolius* L., *Arbutus andrache* L., *Cercis siliquastrum* L., *Rhus coriaria* L., *Juniperus oxicedrus* L., *Phillyrea lotifolius* L., *Cistus creticus* L. and *Cistus salvifolius* L. Above the elevation of 800-900 meters *P. brutia* is changed by *Pinus nigra Arn. var. pallasiana* Schneid in this region (13, 14)

Causes of Damage

The factors affecting the management of *P. brutia* forest are various and extensive in Turkey. The ways of forest destruction range from illegal cutting to entomological factors, and the role of fire and grazing in diminishing the forests are extensive. Between 1973-1983 a total of 168,155 hectares of forest were burned. The amount of 80 percent of the burned areas was belonging to *P. brutia* forests. Owing to recent measures, the amount of burned forests per year has dropped 1/5 of the 1973-1983 average.

In the region, there is heavy and uncontrolled ordinary goat grazing. During the development of red pine stands this grazing has a very detrimental effect. According to the 1983 statistics there are 6,959,870 sheep and 5,509,518 goats in the range of *P. brutia* forest regions (15). At least half of this amount, that is 6,234,695 graze in the *P. brutia* forests. The damage by sheep and goats causes serious loss increment to young *P. brutia* seedlings when they are above the ground vegetation but have not gotten high enough for their leading shouts to be out of reach. The leaves and shouts of young seedlings are also eaten by rabbits in addition to sheep and goats. The damage by rabbits is limited mostly to small seedlings or sprouts.

There is also some illegal cutting in *P. brutia* forests which creates difficulties in operating a managed forest.

Disease and pests are not a major problem for *P. brutia* stands. There is a number of insects and fungi attacking *P. brutia*; but the important ones do not exceed three, which are mentioned as in the following.

Orthotomicus erosos Woll., which feeds on stem, bark and cambium,. causes serious damage to plantation and natural stands at thinning and thicked stages. The insect especially appears in the plantations established on shallow and poor site. Outbreaks characteristically develop in around felled timber, infested stems and sometimes fire-killed timber. It can be controlled by using trap trees or chemical trap called foremen.

Thoumetopoe pityocampa Schiff., which causes severe defoliation at all stages of natural stands and artificial plantation. This insect can cause the loss of at least 60 percent of the annual increment of pine plantation. It can be controlled by using stomach or contact insecticides.

One of the most serious fungal disease is;
Peridermium pini Willd., which causes loss of increment; research studies have been carried out for four years to find out the ways and means to control the fungi.

In favourable conditions the species has a good record of freedom diseases and does not cause soil deterioration.

SEEDING HABITS

Flowering and Fruiting

From personal observations and inferences from literature (1, 3, 16), vigorous open-grown of *P. brutia* seedlings start bearing male and famale flowers when

4-5 years old. Male and female flowers are found on same general branch but usually on different shoots. It is possible to observe that some *P. brutia* trees bear only male or famale flowers. The stigmate flowers become visible at the mid of January, as clusters of yellow stamens, set in groups on leafy twigs. Pollen-shedding usually begins at the first half of March and ends at the last half of May, depending on elevation, aspect, tree habitat and seasonal advance (16).

Pistillate flowers can be born at the tip of new shoots or they can be in lateral position on shoots. After fertilization, they only develop into small green, nut-like as immature cones, during the first year; during their second year they expand rapidly and reach full size of the average 7.2 cm. (2.2 to 12.5 cm) long and get matured at the end of year. Briefly, the maturity of cones is reached in March of their third years (16, 17, 18).

Cone Production

As it is indicated earlier, open-grown seedlings of the species start bearing cones when they are only 4-5 years old. The first crops of viable seed commonly appear at 7 to 8 years and production is regular from 10 years in plantation and 15-20 years in natural stands. Some seeds are available every year but good seed crops are produced in 2 year intervals (17, 18). The mean weight and size of seeds increase in southern aspects. The percentage of empty seed is possitively correlated with cone age and altitude (17). In other words, the percentage of empty seeds in old cones is higher than those of young cones. The effect of age of seed tree on the percentage of empty seed is found insignificant; but the effect of tree age classes on germination percentage is very clear and for this reason the trees of 66-80 age are recommended for seed collection (17). In good seed crops the cone production per hectare is approximately 6 thousand in number and 2340 kgs weight, which means 234 kgs of seed (17-18).

The optimum germination temperature for *red pine* is 25 °C, the seeds are very sensitive to lower temperatures from 15 °C but less sensitive to higher temperatures from 30°-35 °C. The optimum moisture for germination is of 70 percent. The effect of the light on the germination is very clear, especially in different temperatures (17, 18).

Seed from 28 indigenous *P. brutia* provenances in Turkey had 82% (27 to 99) of germination. The seed can be stored 5-6 years at 4 °C and with a moisture of 7-8 percent (19).

Seed dissemination is variable depending on the length of time that cones remain closed after maturing. It is observed that some cones remain closed for many years, some of them open soon after maturing (3, 17, 18). It has been found out that seed from the closed cones have lower germinative ability than those cones which open soon (18). There are some evidences that show those characteristics to be inherited characteristics.

Among trees on which the cones open soon after maturing, seed dispersal continues over all the year; but, the majority of seed dispersal occurs only between June-October. Cone production varies greatly with size and crown classes; overtopped or subpressed trees produce very few or no cones; intermediate ones usually when they only have the open-crown or dominant trees are prolific producers.

SEED PRODUCTION AND NURSERY WORKS

Seed Production

The collection, processing and issue of seeds (and also tree improvement activities) are carried out by "The Directorate of Forest Tree and Seed Improvement Institute", in Turkey.

By the end of 1984, 49 seed stands have been selected in natural forests of *P. brutia* and registered in management plans. Besides, in the same period, 19 seed orchards were established in the different parts of natural range of the species. The cone harvesting usually starts in March and ends at the last week of April. The harvest of cones is carried out by Directorate of Silviculture and Reforestation groups depending on Concervancies (Directorates of Regional Forests). Seed extraction is carried out in the open air, under sun light, in nurseries. It is very easy to extract and store the seeds of the species.

There are great variations in germinative power of seeds and growing characteristics of seedlings are related to provenances and the trees of stands; moreover, *P. brutia* exhibits variations in time of leafing out in spring, leaf regeneration and tolerance to extreme conditions of soils and climate (16, 20, 21). There is much evidence that the variation is continuous and correlated with environmental factors. In these circumstances, it is very necessary to regulate the transfer of seed from the stand origin to the place of planting. For this purpose, not long ago, a simple zoning system was prepared by Atalay (12); and at present the tranfer of P. brutia seeds has been controlled by this zoning system. The zoning system was prepared by using two criteria; one of this is relative humidity of the growing season or vegetation period, and the other one is the duration of growing as a day in the year. In addition to this, the features of geography, continentality, exposure and elevation are taken into consideration.

Pinus brutia forests are divided into 6 regions and 18 subregions (Fig. 2). In the seed transfer, main regions

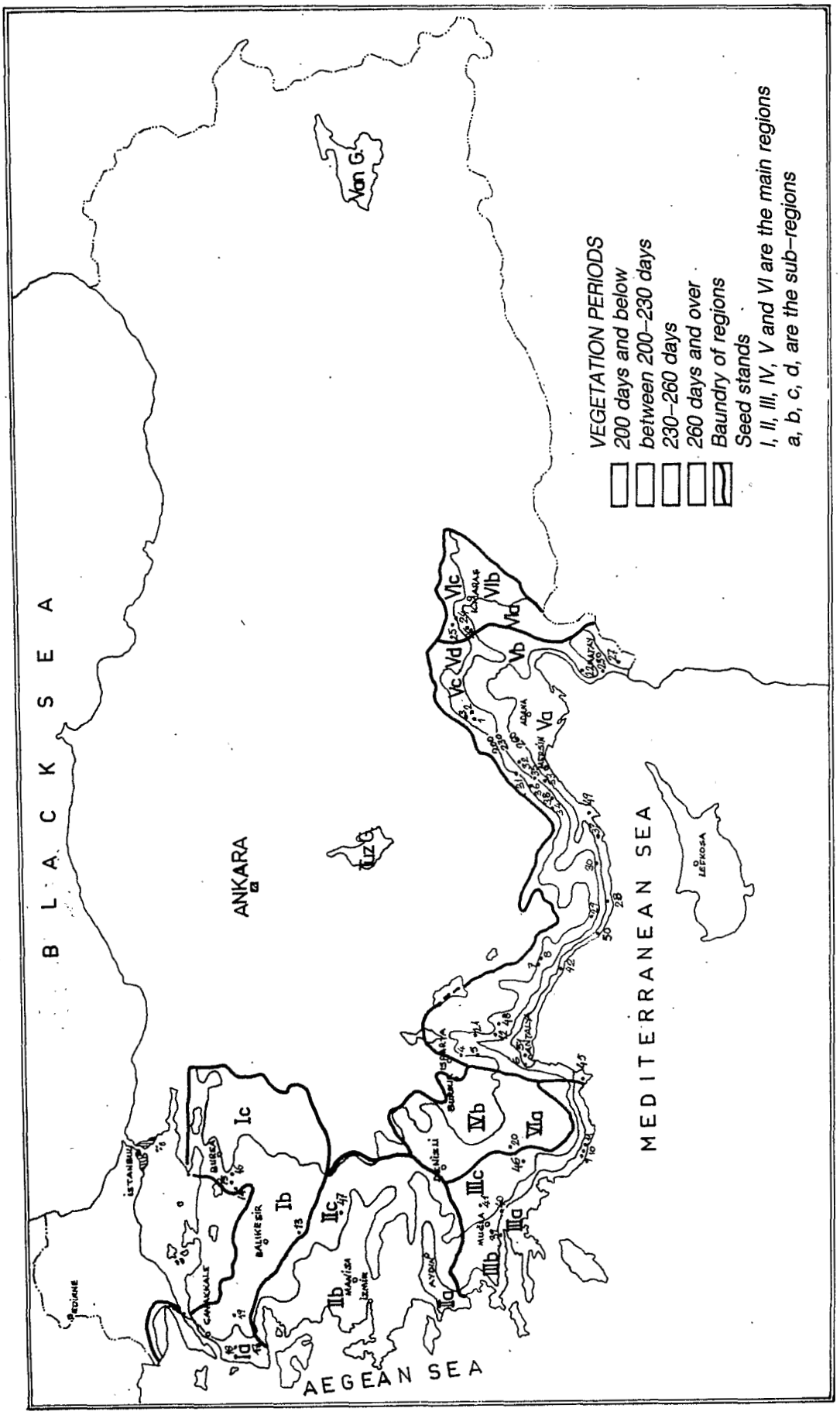


Figure 2. Regioning of the seed transfer of Pinus brutia Henry in Turkey

are separated according to relative humidity and sub-regions are separated according to duration of the growing season.

As to the distance of seed transfer of *P. brutia*, horizontal seed transfering must not exceed a distance of 150 kms. In this case, the exposure and elevation are taken into account.

If the seed stands are not existent in sub-regions, then the seed transfer is realized within the next sub-region, or adjoining sub-region; that is, if the seed stand is not existent in one region, seed may be supplied to seed transfer from adjoining sub-region or next subregion.

The seed derived from the stands may be transfered in vertical distance of upwards 150 meters and downwards 150 meters at mast.

Nursery Works

There are 60 permanent and 68 temporary state forest nurseries with a total area of 3,150 ha. and a production total capacity of 5 million in Turkey. *P. brutia* seedlings are produced at least in 30 of these; the production capacity is over 100 million per year. For the purpose of producing *P. brutia* seedlings, the ground of nursery is mostly ploughed in 30-35 cm depth by 2 or 3 furrow plow (plough) mounted to the medium size (2x4) rubber tyred tractor and then in light compact, the beds are raised by dragging over it heavy wooden sledge or disc-harrow. After leveling, the beds are prepared by means of a bed shaper. Furthermore, the heavy soil is deeply cultivated by using sub-soiler (or ripper-tine) for the purpose of airation of the soil. Where the soil is very compact, a well-rotted manure is advisable. The quantity of well-rotted manuer which should be used in varieties from 25 to 30 tons per hectare. Unrotted manure is not used, for the purpose of preventing the young seedlings from Damping-off danger. Sometimes, nurse crop like sainfoin (Onybrychis sativa) is grown in the rotation fields of nurseries to improve the soil.

P. brutia is extremely easy to raise in nurseries being robust and hardy. Seedbeds are prepared in 1.20 m. width and 20 cm height, with 20 cm space. The seeds are sown in lines by machines or drills. A seed bed consists of 7 sowing lines with distance of 15 cm intervals.

The stratification or pretreatment of *P. brutia* seeds before sowing is not essential, but may promote rapid, uniform germination. Seeds are sown in depth of 1 to 2 cm, and spring up off the soil in 21 to 25 days after sowing (22). The sowing in seedbeds or containers, in spite of being dependent on local conditions, should be completed by the end of March.

The seedling density at seedbeds should be kept at 180-250 individuals for *P. brutia*; this amount may be obtained by using 25 gr of seeds per sqm., the mixture of fine sand and sieved well-rotted manure is used as a covering material after sowing.

The seeds are often treated by using birds repellent before sowing to discourage birds and mice from eating them. For this purpose, an effective chemical mixture is used; the mixture contains two chemical substances named "*Pomarsol-forte and alumine dust*". In common use, for 15 kgs of P. brutia seeds, 800 gr Pomarsal-forte and 42 alumine dust (23) is needed.

After sowing, until germination of seeds, seedbeds should be watered for half an hour and once a day, late in the morning; after germination is completed the same procedure should be followed, but this time once in the early morning or late in the evening (20). When the seedlings are 2 months old, this time, watering is carried out only every other day.

Weeding is usually done by hand or machines; during the period of the first three months. The weeding is made once in three week intervals, then the weeding is carried out once in five weeks intervals. The Turkish foresters are usually not familiar with applying chemical herbicides in forest nurseries. In spite of this there are some research studies that have been carried out since a few years ago.

The roots are pruned by traction-drawn blades, cutting them at 18-20 cm below ground level, in August and only if necessary, so as to produce a limited taproot of 20 cm and a vigorous growth of fibrous side roots.

Damping-off is the most serious disease for one or 1,5 months old seedlings in nurseries. The best precaution against this fungi is early spring and less dense sowing. Another important point is to keep the soil reaction between 7.1 to 7.9. For this purpose, the soil to be sown in nursery must be tested before sowing. If it's not proper, then dressing the soil with sulphur or disinfecting the soil with 40 gr of 2% sulfuric acid gives good results.

PLANTATION ACTIVITIES

Potential Areas for Planting in the Forest Land of *P. brutia*

As it is indicated earlier, the forest land of P. brutia covers approximately 3.1 million hectares, which comprises about 37% of the total land of coniferous forests in Turkey. According to the latest forest surveys more than half of *P. brutia* forests are, at present in degraded conditions (the crown density is less than 10% of full crown density). This situation is not only a reflection of ecological condition but also in several areas, a result of illegal or legal overcutting, uncontrolled grazing and forest fires occuring in the course of several centuries.

Planting Techniques

P. brutia has been planted in Turkey for at least 40 years and during the past 20 years has been widely used in plantation. Between 1960-1983 a total of 279 thousand hectares of unproductive or degraded *P. brutia* forest land were regenerated artificially. The average amount of plantation is about 13 million hectares per year today.

The plantation activities are carried out by means of using mechanized and manual plantation methods. The methods can be explained as follows:

Mechanized plantation method: Mechanized plantation techniques were implemented in Turkey after 1965. At the begining, the typical method was cleaning the vegetation from the area by using heavy crawler tractor with a front mounted cleaning blade and rear mounted three (two)-tine ripper and subsequently ripping the area in two directions (at right angles). The biggest disadvantage of this method was a significant quantity of topsoil being carried away. However, major progress was achieved in testing and determining suitable plantation techniques during the last of 10 years.

It has been observed and determined that in several areas of *P. brutia* plantation, the implementation of proper mechanized methods provide high quality preparation and consequently and permit large-scale site preparation within short time.

In spite of all its advantages, the amount of suitable areas to use these methods is limited in the natural range of *P. brutia*, in Turkey.

Manual Plantation Methods: Present manual plantation techniques vary depending on topography, soil vegetation in different parts of the natural range. Generally, vegetation is cleared by cutting at ground level, either on the whole area, on strips or spots, and collecting the cuttings in piles parallel to contour of ground. Subsequently either grodoni or terraces are prepared, in areas with gentle slopes or where there is no erosion hazard, small interrupted terraces are prepared. Terraces are preferably prepared by inclination of 15 to 25 degrees towards of slope (Fig. 3). The terraces are prepared and arranged by spacings of 3 meters; the seedlings are planted, by 1.5 or 2 meter intervals on terraces. On the complete an deeply cultivated areas, spacings are arranged by 3x3 meter intervals.

It is recommended that both container and nakerooted seedlings should be planted closer to hillsides of previously prepared terraces, preferably with 60 cm width and 30 cm depth, in the region. By this way seedlings can benefit at highest possible level from the soil moisture through the dry summer months in the region (20).

Dibbling and Pit planting Methods: are the main methods used in planting of P. brutia in the region.

Dibbling: with this method nake-rooted seedlings of *P. brutia* are planted in slits opened in the soil using planting bar. The method is also called as "*slit planting method*" in forestry literature. The dibbling method gives satisfactory results on good soils and ecological conditions (25).

Pit planting: Depending on size of planting stock and opened pits, two types of pit planting are practiced:

1) Planting of small nake-rooted seedlings (1+0 years old) in small pits opened by hoe or mattock prior to planting. This method is more suitable for relatively much drier sites with stony and poor soil conditions.
2) Planting of containerized seedlings or tall nake-rooted seedlings in large-dimensioned pits, opened by spade.

In the natural range of *P. brutia*, planting is possible throughout the winter, from the first half of November to the last half of February. In principle, 1+0 years old, nake-rooted seedling of *P. brutia* are used in plantation; but on some sites such as erosion areas, semi-arid and arid sites, 1+0 years old containerized seedlings are planted.

Tending of Plantation

Removal and control of competitive weeds and woody vegetation and cultivation of the soil to prevent moisture loss are normally carried out during 3-5 years following the establishment of the plantations. Basically manual techniques are applied. Replacement plantings are also carried out in this period. Tending operations are applied once a year.

Protection of Plantation Areas

It is normal pratice to fence all plantation to keep out grazing livestock and to deter villagers from using the areas for agricultural purpose.

Compartments in plantation areas are enclosed either with natural breaks, such as streams or ridges, or with cleaned end unplanted breaks or broadleaved belts against fire hazard and probable outbreaks of insects attacks or diseases.

NATURAL REGENERATION OF STANDS AND MANAGEMENT

Reproduction Methods

A number of silvicultural systems have been used to regenerate pure stands of *P. brutia* in Turkey; the most consistently successful of these has been "*the Shelterwood Uniform Method*". In this method, the application area is over the entire stand, it can also be applied in zones. Cutting is done by leaving shelter trees over the stands or zones.

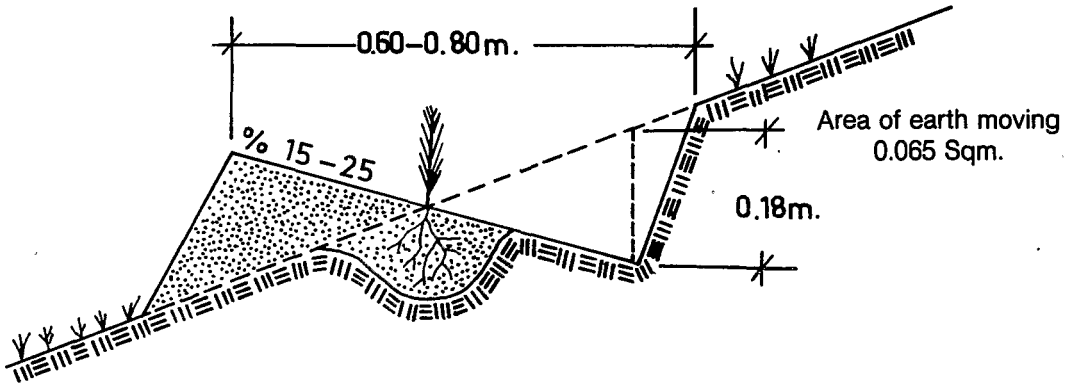


Figure 3. A Profile of a Grodoni Terrace

Two other silvicultural methods which are used with good success in Turkey are as follows:

Strip-Shelterwood Method: The application area is a narrow strip, cut along the edge of old stand. At any given time cutting is concentrated in certain strips and the rest of the stand remains temporarily untouched.

Strip-Clearcutting Method: The method removes all the trees on an area with one cutting operation. Natural reproduction is by means of the seeds of trees on adjacent stands. Cutting is done in strips of 20 meters (20 m. is the longest seeding range of *P. brutia* seeds) in width at the border of a stand. This method is not used on areas subject to soil erosion hazard. The number of stands to use this method in the natural range of *P. brutia* are limited.

Structure of Stands and Regeneration Activities

Natural stands of *P. brutia* can be classified in three groups considering the regeneration conditions. These are:

a. *First group:* The density of canopy of the stands is more than 40% of the full crown density and under the stand canopy there are only small herbs and grasses or no weeds. The stands in this group can be reproduced using the natural regeneration methods. In these stands the number of trees is enough for natural seeding and their distribution is homogeneous. In such kind of stands subpressed or overtopped trees can not be seen. The average age of the trees are more than 50 years. Tending operations have no effect on the stands of this age. The germination conditions of the soil are favourable.

The conditions needed for natural establishement of seedlings are often well known, but sometimes difficult to create. P. brutia is extremely light demanding tree and in general, successful natural regeneration arises on sites which are open or under a light tree canopy which has a thin (1-3 cm) litter of needles and an adequate seed supply within about 50 m and the absence of heavy grazing.

The best seedbed for natural reproduction is a film-like layer of forest floor, while the thicker litter is unsuitable. In such a case, regenerating is greatly stimulated by partly removing the thick layer and after that, the ground must be torn by using rake for creating favourable germinative conditions (26).

The stands in the first group, can be reproduced by using only one seed felling. The seed felling consists of the removal of 70 or 75% of the crop and regeneration of 50-60 stems per hectare. Under such circumstances, the light intensity in the stand is between 75 to 80% of the full light. In general, natural regeneration springs up on abundance in thin litter, following the seed felling (slide-show). On fertile gaps where there is stronger growth of weeds, and especially grasses, the sparse regeneration and re-stocking by planting is the best policy. The final felling follows in 1 or 2 years when the regeneration is 40 cm high. The presence of one or two seedlings per sqm. is accepted as a criteria of success.

There are very important points to underline here, which affect the natural reproduction of *P. brutia* stands. These are:

1) It must be avoided from regenerating the natural stands on steep slopes with shallow soils.
2) Seed fellings must be certainly completed either before seed dispersal in May or before the seeds germination in November.
3) Before the regeneration activities, close local observation of the ground and light condition favouring the generation must be examined carefully.
4) The protection against the damage agents (usually ordinary goats) must be provided at least 10 years after regeneration.

b. *Second group:* The density of the canopy of stand has been much broken and less than 20 percent of the full light. There are many kinds of herbs and brush under the canopy of the stands. The natural regeneration of stands is impossible; owing to the number of seed trees is not enough and their distribution is not homogeneous. The stands in this group can only be regenerated by using artificial methods. In the natural range of *P. brutia*, the amount of degraded forest land is more than 1.5 million hectares.

c. *Third group:* This group consists of the young natural stands and plantations of P. brutia. Most of the stands are at the age of thinning or tending stage. They are between 10 to 40 years old. The amount of such young stands and plantation covers an area of about 10 percent of the total area of *P. brutia* forests. The thinning operations in the young stands have been delayed and neglected for many years. However, the experiments related to the thinning operations are in progress, and there are some successful completed operations in Turkey.

In thinning, the aim is to produce poles and sawlogs of high quality. Thus, the early thinning which begins when the crowns of the young trees reach one another, favours straight-stemmed trees with small branches and removes the crooked-stemmed and large branched trees. The first operation of thining usually begins with young trees, 6 or 7 years old; in the plantation this age is between 10 to 12 years owing to spacings used. When the natural prunning begins, the grade of thinning (which is from below i.e. "low" thinning) becomes heavier with intervals between each thinning, which are at least of 5 years. The desirable rate of diameter growth is 1-2 growth rings per centimeter which gives trees a stem diameter of 70 cm at 1.3 meters.

It is preferable to use a combination of selection (biological) and sistematic tending method during the first treatment, but the consecutive operations must be in favour of the crop trees only. The first operation consists in removing a third (1/3) of the trees (28).

It is necessary to carry out low prunning at height of 2.5-3 m at early stage, to reduce knots and obtain fire protection.

Management Method

Pinus brutia forests of Turkey had been planned and administered in accordance with "*the diameter classes forest management method*" till the years of 1963. It will be evident that this method is not appropriate for *P. brutia* forests if the stand structure of these forests is examined carefully. Besides, the method is not suitable to reproduce highly intolerant tree species like *P. brutia.* Since 1965 "the age *classes forest management method*" has been accepted and applied without controversy. Up to 1965, a great part of the forest of P. brutia were degraded by crude application of the selection method. So, now there are many stands which act as the subject for inmediate regeneration.

The age classes management method is the most suitable one for *P. brutia* forests because of biological and ecological conditions of the species. The age classes method takes 10 years for complete regeneration.

The rotation ages of *P. brutia* forests are 50 years for good sites, 60 years for medium and poor sites. The rotation ages of forest units that are used for turpentining are over 60 years for all site classes. The rotation ages of mine prop plantation are 30 and 40 years for good; medium and poor sites respectively.

Rates of Growth and Yield of Produce

The height of matured *P. brutia* trees in Turkey is 15-25 m and rarely 40 meters. The diameters of up to 140 cm at 1.3 m above ground level have been recorded in the natural *P. brutia* forests in Turkey. The maximum mean annual increment (yield class) is 5.5-7.5 cubic meters per hectare in nature stands. In good sites of *P. brutia* stands, the amount can reach up to 10-12 cubic meters per year. The current annual increment will probably increase to 15 cubic meters on using seeds from suitable provenance and applying intensive soil cultivation.

The total growing stock of *P. brutia* forests is around 162 million cubic meters in Turkey. 92% of the total belongs to productive forests, the remaining 8% is unproductive. The distribution of *P. brutia* forests according to the sites are: 9% on good site, 45% on medium and 46% on poor site respectively. In addition to this, the distribution of growing stocks in productive forests of P. brutia, with respect to their diameter classes is as follows:

Diameter classes	*Percentage*
First class (8-19.9 cm)	1
Second class (20-34 cm)	36
Third class (35-54 cm)	34
Fourth class (55 cm and over)	19

Pinus brutia makes a major economic contribution to the social use of the people, who are employed in the forests and forest Industries in its natural range in Turkey.

The timber of *Pinus brutia* is used in a very wide range from fencing posts through telephone and transmission poles to pit wood, railway sleepers and sawlogs for box-making, general construction and joinery industries, its wood is also suitable for pulp and board manufacture (26). One defect which degrades sawlogs is "black or loses knots", which can be prevented by low prunning in early ages. It is also subject to produce great amount (around 3 thousand tons) of turpentine each year. In addition to this, its bark is also suitable for adhesive production.

RACES AND HYBRIDS

In view of the natural distribution of the species, it is highly probable climatic-geographic races to exist. Heritable differences in characteristics of seed germination, development of seedlings and forms of crown, resistance to continental climate from different origins have been reported (1, 3, 4, 21).

In addition to all, it can be recognized the scattered pyramidal var. as *P. brutia Ten. var. pyramidalis* selik and compacts variety as *P. brutia Ten. var. agrophiotii* Popaionanou, occurring throughout the distribution area (1, 3, 5, 13).

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