General Directorate of Forestry
Poplar and Fast Growing Forest Trees
Research Institute

Poplars, Willows and Other Fast Growing Species in Turkey

Country Progress Report for the International Poplar Commission

Time Period: 2016 - 2019

General Directorate of Forestry

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Prepared by: Poplar and Fast Growing Forest Trees Research Institute

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C O N T E N T S **P a g e**

I. POLICY AND LEGAL FRAMEWORK

General Directorate of Forestry, known as OGM in Turkey, is an institution affiliated with The Ministry of Agriculture and Forestry performing the forest protection and enhancement services and benefitting from them in a sustainable way within the frame of authorizations granted by the constitution and laws for 184 years.

Its main duties are;

• to manage forest and forest resources in an ecological integrity to provide multi-purpose sustainable benefits for society,

• to develop forest and forest resources with the approach of understanding close forestry to the nature,

• to protect forest and forest resources against any kind of danger.

With an agreement between Turkish Government and the Food and Agriculture Organization (FAO), Poplar and Fast Growing Forest Trees Research Institute was established at İzmit/Kocaeli in 1962. It is one of the twelve Forestry Research Institutes affiliated with General Directorate of Forestry and carries out its forestry activities throughout the country. Its main missions are to carry out research projects on poplar, willow, and other fast growing forest tree species and to provide technical assistance to private and public sectors to increase wood production from non-forest resources.

Activities to achieve specified aims in the forestry sector, one of the important sectors in the economics, are performed in the forest areas which cover 29% of the country. According to the data in 2020, approximately 19 million cubic-meter wood material was produced from 22.6 million hectares of “forest land” that The Ministry of Agriculture and Forestry is responsible for. Approximately 25% of 22.6 million hectares consists of natural stands of fast growing species. The leading species in the distribution of fast growing species are *Pinus brutia* and *Populus tremula* respectively.

The production of fast growing species in Turkey is estimated about 9,3 million cubic meter annually. However, since there is a shortage of raw wood material in Turkey to meet the demands of forest industries, Turkey has started importing wood material and giving the priority to industrial plantations based on fast growing species to fill this shortage.

In recent years, the share of private nurseries in the production of poplar saplings has considerably increased. Almost all of poplar plantations are carried out by private growers in Turkey. State owned nurseries continue producing poplar sapling from selected poplar clones for demonstrative purposes of nursery and plantation techniques.

II. TECHNICAL INFORMATION

1. Taxonomy, Nomenclature, and Registration

Identification and registration of the clones of the poplar, willow, and other fast growing species from different origins are being conducted in the experimental nurseries belonging to the Poplar Research Institute in accordance with the designated set of criterias. In addition to these works, materials are produced from some individuals

selected from the first selection *populeta* established in previous years, which have temporary clone numbers.

Varietal control are accomplished in all state owned nurseries during this period. Thus, improved and controlled materials are supplied for private poplar nurseries. The number of private nurseries has significantly increased during the last two years, and this situation created difficulties in accomplishing varietal control over them.

At the result of conducted poplar genetic studies during this report time; one of hybrid clone (*P. x euramericana*) "83.011.015" was offered to be commercially produced in Southeast Anatolian region and East Mediterrian region in 2016, which was the best clone growing in Urfa and Adana. Eastern cottonwood (*P. deltoides*) clones; "89.M.061", "89.M.004", "89.M.063", "89.M.060", "89.M.047", "D.92.282", "L.AVANZO" observed as the best clones according to the results of experiments set up in different provinces (Tokat, Sakarya, Kocaeli, Düzce, Edirne, Isparta) are candidate clones for the registration. Except "L.AVANZO", wood technological properties of the clones are evaluated in the labratory because wood technological properties of "L.AVANZO" has studied for the registration before.

2. Domestication and Conservation of Genetic Resources

Wide geographic distribution of poplar species and their adaptive ability to different environments make them as one of the most suitable plant species to investigate the genetic architecture of trees and their responses to several biotic stress factors. After sequencing the whole genome of *Populus trichocarpa*, poplar species were accepted as model organisms offering opportunities to develop many genomic tools such as high-density arrays or whole-genome microarrays.

Poplar is one of the economically most important plants growing in Anatolia. There are four poplar species that have economical value and distributed naturally in Turkey; *Populus nigra*, *Populus tremula*, *Populus alba* and *Populus euphratica* although hybrid poplar (*Populus x euramericana*), American black poplar (*Populus deltoides* Marsh.) are cultivated in our temperate regions. Developing and growing world population and ascending demand for energy sources increased the genetic studies on poplars. Thus, several researches have been studied on using poplars as energy sources so far.

a) Aigeiros section: Most of the cultivated poplars in Turkey belong to this section.

1. Indigenous Black poplars (*Populus nigra* L.)

Indigenous black poplar (*Populus nigra* L.) is an important tree species in terms of social, economic, and ecological interest in Turkey. Breeding and conservation programs of indigenous black poplar were initiated several decades ago in Turkey and continued with selection of best growing black poplar individuals from their natural populations throughout the country.

At this report period, 297 black poplar clones have been selected from all over Turkey and transferred into a clone bank. 12 microsatellite DNA loci have been used to

identify and assess genetic diversity of them. The results revealed that there is no significant difference in genetic diversity between the established clone bank and the natural stands of black poplars. This means that the clone bank have been established by representing the genetic diversity in natural stands of black poplars. Also, the level of genetic diversity in the established clone bank is suitable for the new breeding studies and Melet, Tunceli, and East Anatolian populations have the highest number of unique alleles. The low genetic differentiation has been found between the established clone bank and natural stands of black poplars and it has been indicated that gene flow is in high level among the populations. The established clone bank populations and the natural stand black poplar populations have genetically been separated as two groups. Lastly, it was observed that populations which are close to each other in geographical location have similar genetic structure.

Field trials including the registered black poplar clones such as (Gazi (TR – 56/52), Anadolu (TR - 56/75), Behiçbey (TR-62/154), Geyve (TR-67/1), Kocabey (TR-77/10)) and other *Populus nigra* clones were established in different provinences in Turkey. The clones "N.82.182", "Söğütlük", ve "Anadolu" were better in Konya province whereas the clones "N.92.142", "N.64.014", "N.62.172" had better growth in Kırşehir province. The clones "Geyve" ve "Kocabey" which are another best clones in Urfa province were offered to be commercially produced and used in plantations.

Although large poplar plantations meet the needs of the economy, natural genetic resources of the species have been highly degraded due to anthropogenic effects such as overexploitation and habitat fragmentations. To assess genetic diversity and structure of fragmented populations, 124 naturally distributed indigenous black poplar trees from two major rivers (Kızılırmak and Göksu) in Turkey were sampled and screened by using 20 nuclear microsatellite DNA loci. Studied populations appear to have experienced a recent bottleneck event which is likely to cause to reduction in allelic diversity and to increase heterozygosity (mean Ho = 0.80). Four populations representing upstream, middle and downstream parts of the Kızılırmak River were found to be differentiated from Göksu river population. Traditional management of indigenous black poplar coupled with bottleneck and hybridization events has played an important role in reduced genetic diversity and degradation of the genetic resources of the species in two river systems.

Effective population size is an important concept in conservation biology. Biased sex ratio lowers effective population size, consequently causing loss of genetic variation. Based on this, available microsatellite DNA marker data of 121 *Populus nigra* clones originated from 5 geographical regions were analyzed to evaluate genetic diversity of genders and to investigate possible effects of sex ratio on differentiation in these populations in Turkey. There was an abundance of identical genotypes in the dataset. The same genotypes were observed both in males and females that might be suggesting a rare occurrence of deviation from dioecism. Overall allelic richness was found to be similar for both genders whereas heterozygosity was higher in males.

Also, several studies on indigenous black poplar genotypes were conducted to examine the molecular networks underlying the complex nature of tree in responses to drought and soil pollutants. The effects of drought stress on this collection were firstly assessed. In this experiment, totally 10 641, 3824 and 9411 differentially expressed transcripts were identified to explain genetic basis of trees behind drought escape, avoidance and tolerance, respectively. Besides, genome-wide survey of heat shock proteins (HSP) and expression analysis of HSP genes under abiotic stress conditions in *Populus nigra* was studied.

2. The cultivations of Eastern Cottonwood (*Populus deltoides* Marsh.) and hybrids of Eastern Cottonwood (*Populus x euramericana*)

The clones of "*Samsun* (I-77/51)" and "I-214", which are from *Populus deltoides* and *Pxeuramerican* respectively, have been successfully grown and commercially used in poplar plantations in Marmara and Black Sea regions of Turkey since 2000s. According to results of countrywide studies, "83.011.015'' which clone of *P. x euramericana*, was offered to be commercially produced in Southeast Anatolian region and East Mediterrian region which was the best clone growing in Urfa and Adana. Eastern cottonwood (*P. deltoides*) clones; "89.M.061", "89.M.004", "89.M.063", "89.M.060", "89.M.047", "D.92.282", "L.AVANZO" observed as the best clones according to the results of experiments set up in different provinces (Tokat, Sakarya, Kocaeli, Düzce, Edirne, Isparta) are candidate clones for registration made by IPC. The determination of wood technological properties of these clones continues in the laboratory.

Also, the well growing and rust fungi tolerant clones of *P. deltoides* and *Pxeuramericana* were determined at early field stage in the trial sites at three different sites (Kocaeli-İzmit, Bursa-Yenişehir and Kırklareli-Lüleburgaz). It was found that *P.deltoides* clones 89.M.004, 89.M.063, 89.M.044, and *Pxeuramericana* clones OSTIA and PY-202 have high growth values and more tolerance to the rust mushroom. Also, genome-wide survey of heat shock proteins (HSP) and expression analysis of HSP genes under abiotic stress conditions in *Populus euramericana* was studied.

b) Leuce section: This section is divided into two sub-sections as white poplars (*Albidae*) and Aspens (*Trepidae*).

All white poplars are placed in the single species *Populus alba* which occurs at different sites of Turkey as individual trees or small groups like *Populus x canescens. Populus alba* does not have economic value to be grown commercially in Turkey. It is only grown as ornamental tree. In addition, the studies on determining genetic diversity with molecular markers and determining conservation strategies in white poplar populations, which are scientifically prioritized, are carried out by our Institute.

Populus tremula has a large geographic range in Turkey. It occurs in natural forest, sometimes forms pure stands as initial forms of development of forest communities, but this species mainly occurs in groups or individual trees.

At the last period, "The Ecological Properties of Aspen (*Populus tremula* L.) Communities and Their Regioning in Terms of Seed Transfer and Reforestation/Afforestation" entitled study related to *Populus tremula* was completed by Poplar and Fast Growing Forest Trees Research Institute. It was seen as result of the this study that Aspen which is the pioneer succession and/on secondary succession on the destroyed forest area can be used for reforestation and afforestation activities in the semiarid-subhumid region of Central and Northeastern Anatolia. Indeed, aspen is fastly spreading not only Central Anatolia especially Erciyes Mountain and upper Kızılırmak Basin but also in the NE Anatolia covering upper parts of Kelkit, Harşit and Çoruh basins. For this reason, reforestation and/or afforestation activities with aspen in the above mentioned areas can be considered as best way. Because, reforestation with the native tree species is very hard and takes long time; whereas, aspen easily spreads naturally. In order to establish aspen reforestation possibilities in the Erciyes Mountain, a study has been planned by Forest Directory of Kayseri. In addition, the studies on determining relationship between stand development and habitat characteristics in *Populus tremula* forests are carried out by our Institute. Also, genome-wide survey of heat shock proteins (HSP) and expression analysis of HSP genes under abiotic stress conditions in *Populus tremula* was studied.

c) Tacamahaca section:

Balsam poplars are not naturally distributed in Turkey, therefore; its species and cultivars have not been used in any kind of study in Turkey so far.

d) Turanga section:

Euphrates poplar (*Populus euphratica* Oliv.) is one of the four native species of poplars distributed naturally in southwestern Turkey. The species possesses great importance for both renewable energy resources and persistence of a healthy river ecosystem. Due to increased habitat destructions and fragmentation by human activities, the distribution area of this species has become narrower. To be able to assess future sustainability of the peripheral Euphrates poplar populations, it is important to know how much genetic diversity still remains after habitat fragmentation and loss. In addition, searching for potential genetic diversity present in species genetic resources is of great importance in terms of its resilience to changing environment as well as breeding and use.

At this report period, to explore genetic structure and diversity of Euphrates poplar, five natural populations in the Göksu and Euphrates river ecosystems were studied with 21 microsatellite DNA loci. Results demonstrated reduced level of genetic diversity (Ho: 0.44, uHe: 0.45) and low differentiation among two river populations (FST= 0.07), suggesting a common origin. It appears that severe past reductions in population sizes have resulted in loss of genetic variation of the species. Lack of suitable habitats due to water shortage and low groundwater table in watershed of the two rivers could be the main factors for possible past bottlenecks. This situation forced Euphrates poplar trees reproduce clonally and caused reduction in genetic diversity of

the residual populations. Native populations of this species in two rivers seemed to be marginal with continued gene pool shrinkage.

e) Willows:

There are around 500 willow species worldwide and 27 of which are naturally distributed in Turkey. With a great renewable energy potential, willows are an important component and indicator of a healthy river ecosystem in Turkey. They are used as one of the most effective phytoremediation tools in the world for cleaning and ecosystem rehabilitation applications. Therefore, several studies have also been carried out on determination and protection of genetic diversity of willows and on their breeding in our country at the last report period.

To understand the actual genetic structure of *S. alba* populations throughout Turkey, ten rivers were selected to represent seven geographic regions (Eastern Anatolian, Central Anatolia, Blacksea, Mediterranean, Aegean, Marmara, and Southeastern Anatolia) with different climate, location, flora-fauna, agricultural diversities and topography.*S. alba* populations in Turkey were comprehensively analyzed in terms of genetic diversity and population structure. High levels of genetic diversity were detected in studied populations, especially middle and down part of rivers. Sampled 23 populations placed in to five genetic groups have unique genetic structure with high level differentation because of the presence of geographic barriers and latitude longitude differences among them. On the other hand in another study, genetic structure of *Salix alba* populations in two river systems (Göksu and Kızılırmak Rivers) in Turkey were studied to provide information for effective conservation and breeding programs.Genetic structure analysis clearly revealed that *S. alba* populations in two different river systems represent two different founder populations with very high membership values. All populations maintain moderate level of genetic diversity.

It was observed some syptoms on willow (*Salix babylonica* Linn.), peculiar to phytoplasma such as witches-broom, early yellowing and partial or complete drying, in the parks and gardens of Erzurum, Erzincan, Tokat, Amasya, Sivas, Ankara, Eskişehir, Kütahya, Afyonkarahisar and Trabzon. PCR products of 1800 and 1200 bp were obtained from all the samples taken from symptomatic trees, respectively. With this study, the presence of this pathogen in different regions of Turkey were identified for the first time.

As known, Goat willow (*Salix caprea*) is an ecologically important, cold tolerant pioneer species which spreads in Europe and western and central Asia, in the Mediterranean Sea, central Anatolia and Black Sea regions in Turkey. Genetic diversity of 180 *Salix caprea* genotypes were characterized in Turkey at this report period. When *Salix caprea* populations were evaluated according to their genetic relations, two separate groups were formed; one group included populations in the Trabzon region and the other group included populations in the Artvin region.

Chloroplast (trnT-F, matK and rbcL) and nuclear genome (ITS) regions were used to explore the evolutionary relationships of *Salix* species which are native to

Turkey. Morphological and genetic results agree with traditional taxonomic concepts in clustering of two subgenera. Two coding cpDNA gene regions (matK and rbcL) are found as conserved whereas non-coding cpDNA (trn T-F) and nrDNA (ITS) evolved rapidly for Turkish salix.

f) Other Fast-Growing Tree Species

(a) Natural Fast Growing Species

Turkish Red Pine (*Pinus brutia*): According to 2019 data, Turkey has the 4 612 156 million ha *Pinus brutia* forest areas. 3,4 million ha of which is productive while about 1,2 million ha is unproductive, so that it is the most intensive distribution (Figure 1) among all fast growing species and the most important place at the plantation forestry studies in Turkey.

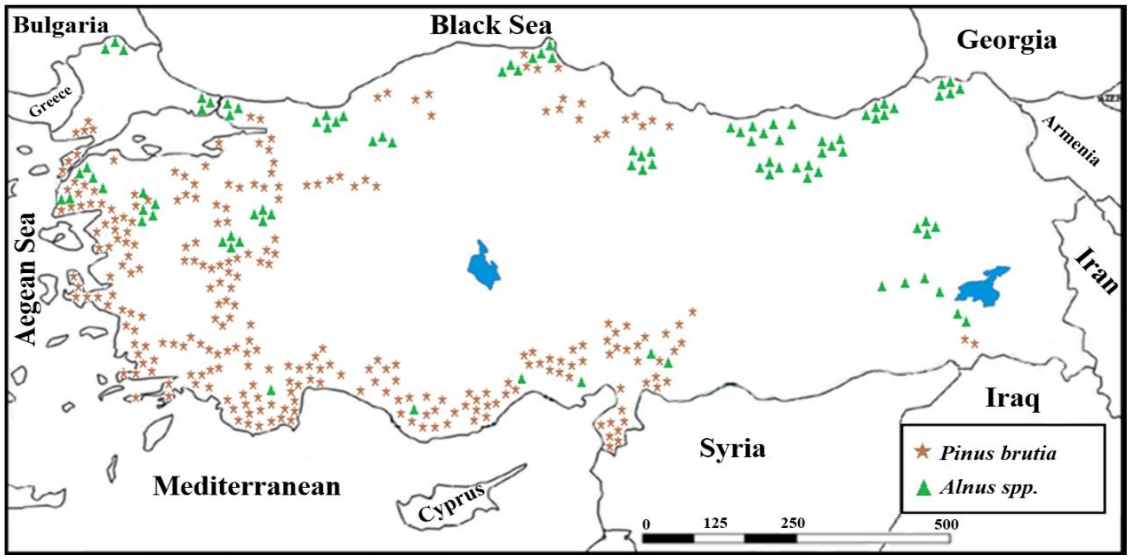

Figure 1. The distribution of *Pinus brutia* and *Alnus* spp. in Turkey.

In 1960s, breeding studies on Turkish pine (*Pinus brutia*) and other pine species began with the idea of providing seeds from seed stands to tree plantatitons in Turkey. With the introduction of planned afforestation period in 1964, Directorate of Forest Tree Seeds Research, Selection, and Control laboratories started working for the selecting seed stands, the collecting and conserving of seeds, the processing of seeds before sowing, dealing with seed garden forest, and exporting seeds. Also, the principles of selecting seed stands and plus trees were determined.

Six regions determined for collecting and transfering the seeds of Turkish pine and other pine species were revised in 1974 considering their vegetation periods and rate of relative humidity in their vegetation periods. Seed stands were selected based on the revised seed collection and transfer regions and then seed orchard forests were established by scions obtained from the selected plus trees in the seed stands.

The first seed orchard forest of Turkish pine were established in 1976 and its breeding studies based on the phenotypic selection continued until 1990s. With the preparation of National Tree Breeding and Seed Production Programme in 1993,

breeding studies were conducted together with genetic tests (progeny tests) and gene conservation studies.

From the beginning of the Turkish red pine breeding studies to today, 72 seed stands (10 423,3 ha) and 61 gene conservation forest (9504,10 ha) have been selected and 76 seed orchards (649,3 ha) was established. Also, nine breeding zones were determined in accordance with the tree breeding programme. Then, it was predicted to establish progeny tests in seven of them and the progeny tests were completed in five of them. It was computed that 25% and more genetic gain would be able to obtain from the selected individuals according to the results of the progeny tests. Thus, 12 genotypic seed garden were established based on the completed progeny tests. Controlled pollination studies were carried out with the 30 best families in progeny tests. Also, origin experiments were set up in 1988 to determine the suitable seed resources and seed transfer regions. In overall, tree breeding studies have been conducted in specified breeding zones and the the results of genetic tests are appropriate for those zones and the results of studies based on Turkish pine showed that variation among the Turkish pine populations is less than within Turkish pine populations. Also, high genetic diversity has been determined in molecular studies in Turkish red pine. It was determined that 11% of genetic diversity was among populations, 89% of them were within the population and other parameters were at normal values.

Mating system, pollen contamination and potential alergenic proteins of *Pinus brutia*, its genetic variation in different regions of Turkey, its population variations under different stress conditions, and morphological characteristics of mature and juvenile *Pinus brutia* were examined during the period of this report time.

Wild Cherry (*Prunus avium*): According to 2019 data, Turkey has the 10 730,5 ha *Prunus avium* forest areas (Figure 2). 9445,9 ha of which is productive while 1284,6 ha is unproductive and 232 ha is plantation area. As a result of the *Prunus avium* L. breeding studies, 4 gene conservation forest (448,9 ha) have been selected in Turkey.

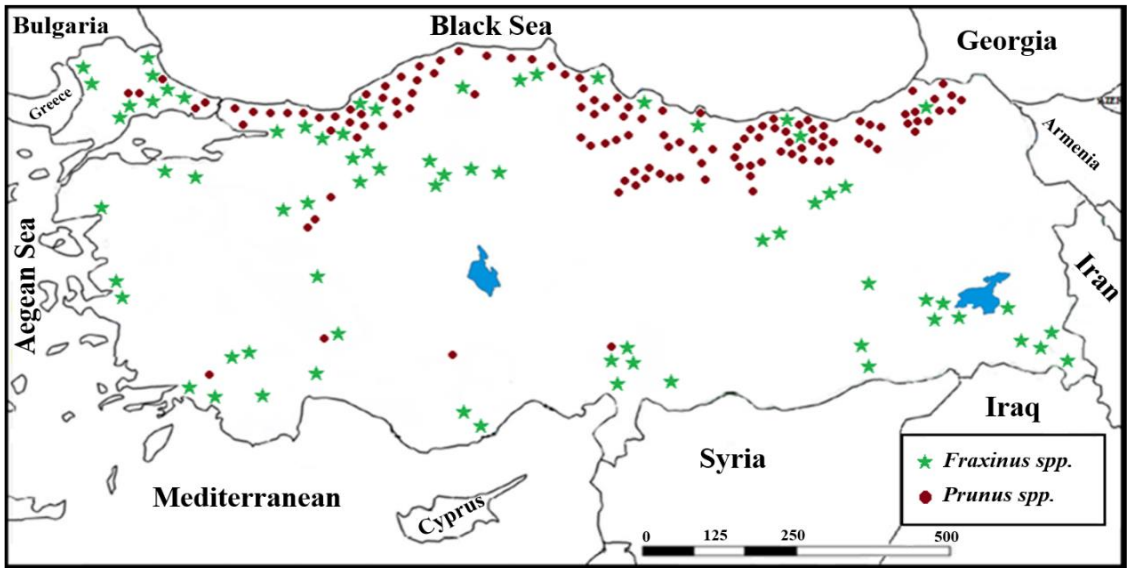

Figure 2. The distribution of *Prunus* spp. and *Fraxinus* spp. in Turkey.

At this report period, the genetic diversity of 22 *Prunus avium* L. populations, which are naturally distributed in Turkey, were determined by using SSR genetic markers. Then, the result of another project based on determining quantitative characters of *Prunus avium* L. was reported. In the research, experiments were established in three different provinces by using seedlings, which were produced from seeds based on 92 families of 8 *Prunus avium* L. populations. Plant height, the diameter of root collars were measured and a prediction on some plant characteristics, such as bud flush, bud set, and heredity level were made.

Also, genoprotective potential of total anthocyanin extracted from *Prunus avium* L. the determination of genetic releationships among *Prunus avium* L. rootstocks used and/or to be used with RAPD molecular markers, the intraspecific discrimination study of *Prunus avium*, phenolic content and biological activities of *Prunus avium* L. tissues, and the detection and prevalence of leucostoma cancer in *Prunus avium* L. were studied in the period of this report time.

***Fraxinus* spp. (*Fraxinus angustifolia*):** There are three native *Fraxinus* species in Turkey, which are *Fraxinus angustifolia*, *Fraxinus excelsior*, and *Fraxinus ornus*. *F. angustifolia*, particularly a suitable tree for lowland and sub-mountain areas, is a fast growing tree species for Turkey. The mean annual increment of *F. a.* subsp. *oxycarpa* stands in the Middle and Western Black See Region of Turkey reaches to 23.1 m^3/ha in plantation and 15,3 m^3/ha in natural stands in site I. class. According to 2019 data, Turkey has the 14 057,6 ha *Fraxinus angustifolia* forest areas (see Figure 2). 11 975,2 ha of which is productive while 2082 ha is unproductive and 1347 ha plantation area. As a result of the *Fraxinus* spp. breeding studies, 1 gene conservation forest (99,8 ha) and 4 seed stands (305,6 ha) have been selected in Turkey.

At this report period, progeny trial of Manna ash (*Fraxinus ornus subsp. cilicica* L.) was studied based on variation, correlation and heritability for survival, seedling height and root collar diameter of sixth year's result. Averages of survival, seedling height and root collar diameter were found 78.1%, 161.7 cm and 2.3 cm, respectively, while there was large difference among families and within family for the characteristics.Also, the identification and characterization of LEA genes which have a critical role in the abiotic stress response of plants on *Fraxinus excelsior* were studied in the period of this report time.

***Alnus* spp. (*Alnus glutinosa*):** In Turkey, *Alnus* species are represented by two species belonging to *Alnus* subgenus, which are *Alnus glutinosa* L. and *Alnus orientalis*. There are six taxa belonging to these species and two of them are endemic. Owing to faster growing character than other six *Alnus* taxa, *A. glutinosa* subsp. *barbata* is an economically valuable one among the other naturally distributed black alder taxa in Turkey. According to 2019 data, Turkey has the 210 223,1 ha *Alnus* spp. forest areas (see Figure 1). 173 628,9 ha of which is productive while 36 594,2 ha is unproductive. In spite of little proportion of this taxon’s forest in Turkey’s area, fast growing character, high biological regeneration ability raise its importance, especially for the region. Also, this taxon is used in the region prodominantly by the local public. At the

same time, there are vast suitable potential plantation areas in the region. As a study results, general mean volume increment of this species is 21 m^3/ha, at the age of 20, in site I class. At the result of the *Alnus* spp. breeding studies, 6 gene conservation forest (747,3 ha) and 7 seed stands (543,7 ha) have been selected in Turkey.

At this report period, morphological, anatomical and micromorphological properties of *Alnus glutinosa* (L.) *Gaertner subsp. barbata* (C. A. Meyer) Yalt. subspecies of *Alnus* L. (*Betulaceae*) genus were examined. It was observed some differences depending on elevations as morphologically, anatomically and micromorphologically.

***Robinia* L. (*Robinia pseudoacacia*):** *Robinia* L. species has resistance to air pollution and drought and many of them are grown as outdoor plants. *Robinia pseudoacacia* L. has become native species in Turkey and has been widely cultivated in side of roads, schoolyards, train stations, and village plantations. According to the data in 2019, *Robinia pseudoacacia* has 3518,4 ha forest area and 1 seed stands (156 ha) in Turkey. 3073,1 ha of the forest area of *Robinia pseudoacacia* is productive whereas 445,3 ha is unproductive. The forest areas of *Robinia pseudoacacia* are usually preffered for beekeeping to produce honey as non-wood forest products.

(b) Exotic Fast Growing Species

Introduction of fast growing species to Turkey was started in 1880's with *Pinus pinaster* and followed by *Eucalyptus camaldulensis* in 1939. In 1950's, there were set up demonstrative plantations and comparative experiments of exotic coniferous species at various levels conducted by several different organizations. The systematic studies on this subject were started by the Poplar and Fast Growing Forest Trees Research Institute-İzmit in 1968. "TUR/71-521 Industrial Forestry Plantations" entitled project was carried out by Turkey and Food and Agriculture Organization (FAO) between 1972 and 1977 years. Within the scope of this project, many species and origin experiments were intensively established at coastal regions of Black Sea, Marmara, Aegean, and Mediterranean by Poplar and Fast Growing Forest Trees Research Institute. In these trials, 81 exotic fast growing species were tried, and *Pinus pinaster* and *Pinus radiata* were given to special attention as the most promising species. As a result of the evaluation of the preliminary information obtained from these trials in 1980, it was concluded that the most promising exotic species in the Marmara, Black Sea region and some parts of the Aegean region are *Pinus pinaster* and *Pinus radiata*. A large part of the research based on native and foreign species in Turkey are conducted in adaptations trials. Origin trials are established with the species selected from these trials and species trials.

***Eucalyptus* spp.:** The first systematic studies on the subject of *Eucalyptus* cultivation in Turkey began with the establishment of Tarsus Eucalyptus Research Institute in 1967, which is called as East Mediterrian Forest Research Institute today. At first, the selection experiments of *Eucalyptus* species was set up country-wide. Then, the successful *Eucalyptus* indiviuals were selected and used in the comparision experiments of *Eucalyptus* species. Eventually, origin experiments was set up using achived

individuals from the comparision experiments of *Eucalyptus* species. 191 *Eucalyptus* species and 609 origins of which have been tested so far. According to 2019 data, Turkey has the 5212,7 ha plantation areas and 1 seed stands (1,1 ha) in *Eucalyptus* spp (Figure 3).

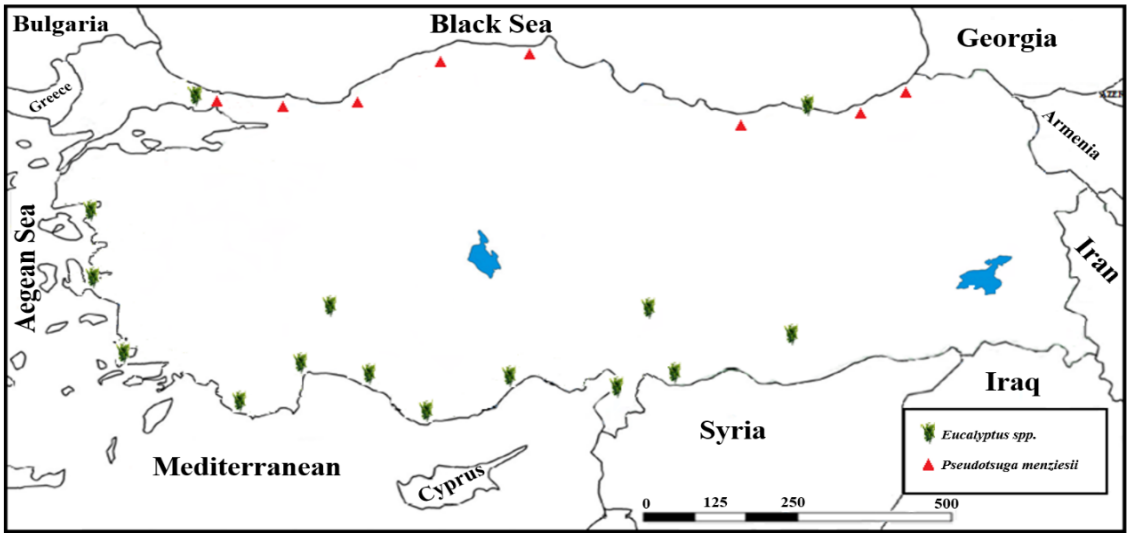

Figure 3. The distribution of *Eucalyptus* spp. and *Douglas* spp. in Turkey.

In the scope of Eucalyptus breeding studies carried out in a specific strategy, the species of *Eucalyptus camaldulensis* Dehn. and *Eucalyptus grandis* W.Hill ex Maiden have been found successful species after the results of elemination and comparsion experiments established in different regions and years. According to the results of origin experiments carried out on two successful species adressed above, it was suggested that Karabucak origin, which is the result of *Eucalyptus grandis* origin experiment, is suitable for deep and fertile lands, Willuna (7046 origin) is appropriate for lime-rich lands, Lake Albacutya (6845 origin) is proper for poor and dry lands.

After the steps mentioned above have been achieved, it has been passed to further breeding studies, such as clon comparision experiments and crossing species. In the clonal experiments studied on *E. camaldulensis* in 1991, the successful indivuals at the age of 6 such as clone C126 (overall 49 349 m^3/ha /year; the average of the best ten clones 43 189 m^3/ha/year) were applied according to 3mx3m planting distance. On the other hand, it was observed that some of *E. grandis* clones at the age of 5 and 3ç25mx3.25m planting distance made higher increment accoring to the results of *Eucalyptus* hybrid clone experiment that carried out in Tarsus-Karabucak province. Some *Eucalyptus* clones, such as *E. grandis* (Clone G96: 82,230 - 51,356 m^3/ha/year and clone G42: 54.017-47.806 m^3/ha/year), *E. camaldulensis* (Clone C188: 49 927 - 35 869 m^3/ha/year and clone G60: 41 2018 – 29 659 m^3/ha/year), and hybrid clones (Clone M77: 39 393 – 22 902 m^3/ha/year and clone M85: 38 366 – 28 609 m^3/ha/year) which are better and successful in Karabucak province conditions were suggested to the industrial plantation to be utilized. Besides, intermediate results of a project based on the comparison experiment of *Eucalyptus* clone will be received at the end of the 2020 years.

Maritima pine (*Pinus pinaster* Aiton): Maritima pine is one of the fast growing forest tree species most widely used in the industrial plantations in Turkey. According to 2019 data, it has the widest distribution area after poplar plantations among the exotic fast growing species in Turkey, which is 57 378,4 ha (Figure 4). In Turkey, plantations have been established in various ecological conditions of regions by using particularly Land and Corsican origins of Maritima pine.

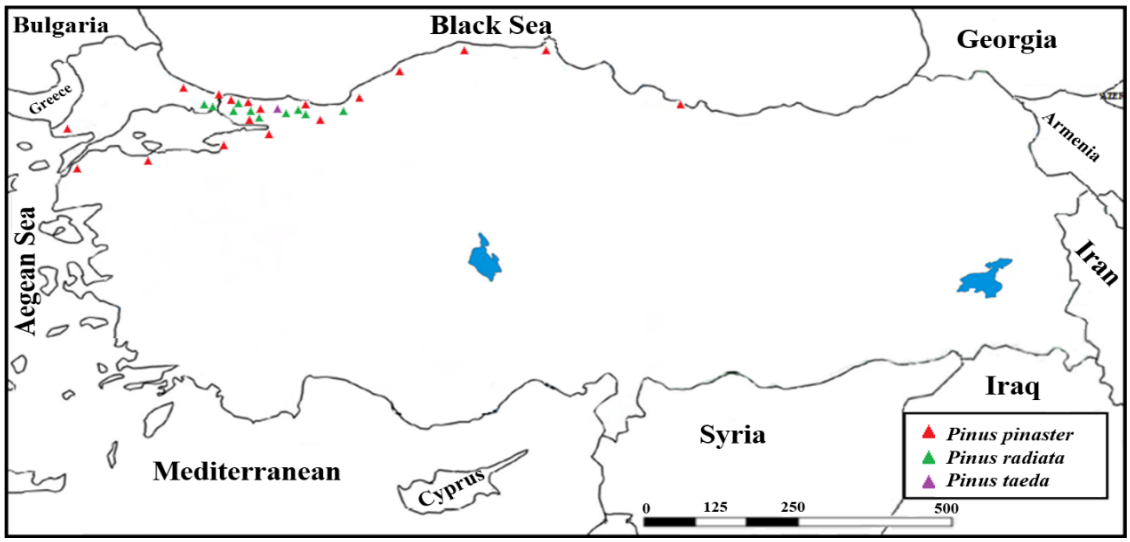

Figure 4. The distribution of *Pinus pinaster*, *Pinus radiata*, and *Pinus taeada* in Turkey.

In the early 1980s, the result of the adaptation experiments and species trials established in vaious regiongs of Turkey by PRI in the 1970s showed that the most promising exotic species in the Marmara, Black Sea region and some parts of the Aegean region is *Pinus pinaster*. At the same time, some snow/wind damage and displayed many broken branches due to the weight of early snowfalls were observed in the Maritima pine plantations (especially Land origin). At the result of origin trials with *Pinus pinaster*, it was determined that Corsican origins of Maritima pine is more resistant to disease, snow, and wind damages. After these results, only Corsican origin was used in Maritima pine plantations in Turkey. From the beginning of the Maritima pine breeding studies to today, 5 seed stands (453,1 ha) have been selected and 1 seed orchard (3,3 ha) was established in Turkey.

At the this report period, three progeny tests were set up in Marmara region (Istanbul-Çatalca, Gebze, Kandıra-Kefken) by using 140 families selected from the origin experiments and seed stands established with the *Pinus pinaster* species based on the Corsica origin and they were evaluated by four-year periods. As a result of these experiments, 30 families were detected in terms of better genetic gain, heredity level, the diameter growth and height growth.

***Pinus radiata* D. Don:** This species reaches the fastest growth in Western and Eastern Blacksea region and Eastern Marmara. So, this is one of the most investigated species as Maritima pine. However, because of *Evetria buoliana* (Schiff.) harm, this species is the most controversial one, in point of passing to limited plantations stage. Although the

most resistant origins of the species have been determined, they are no longer used in plantations. According to 2019 data, there are 1790,2 ha plantation areas and 2 seed stands (6,1 ha) of *Pinus radiata* (see Figure 4).

***Pseudotsuga menziesii* Mirb. Franco:** The use of *Pseudotsuga menziesii* which was firstly experimented in 1951 for astatic and industrial goals is recommended for the plantation areas on Castanetum-Fagetum zone at the rate of 20%, in Eastern and Western Balcksea regions by 1250 m altitude. The origins are stated to reach to 10 m in height, 18/m^3/ha in volume increment at the age of 16. In this species which show faster growing at advanced years, no serious insect harm and disease has been detected. According to 2019 data, *Pseudotsuga menziesii* has 608,6 ha planted area and 1 selected seed stand (7,4 ha) in Turkey.

Pinus taeda: According to 2019 data, 36,3 ha areas have been established for a demonstrative plantation of *Pinus taeda* in Turkey.

3. Plant Health, Resilience to Threats and Climate Change

3.1. Biotic

3.1.1. Poplars

Poplar trees are one of the most important species due to its high increment power, its easy production with vegetative way, the usage of its wood in different industrial area, and the its global plantation. Poplar trees are attackted by plenty of different insect species which damages to the leaves, the shoots, the stems, the trunks, and the roots from its plantation to its harvesting. In this case, several studies have been conducted.

In a study carried out in Kastamonu region, *Gryllus desertus Pallas*, *Gryllotalpa gryllotalpa* (Linnaeus, 1758), *Chionaspis salicis* (L.), *Lepidosaphes ulmi* (L.), *Polyphylla fullo* (L.), *Saperda populnea* (L.), *Paranthrene tabaniformis* (Rott.), *Lymantria dispar* L., *Crepidodera aurata Marsham*, *Crepidodera aurea* (Geoffrey), and *Melasoma populi* L. were determined as poplar pests.

It has been informed that *Hemiptera heteroptera* ve *Cerambyx cerdo* damage the poplar trees in Gölbaşı district in Adıyaman province by eating all the leaves of them and opening a hole into their stems within 1-2 years after planting.

Insects damaging trees and shrubs in Izmit and Hendek state nurseries and some privately run nurseries were detected. It was found that *Chrysomela (Chrysomela) populi* Linnaeus 1758, *Lepidosaphes ulmi* (Linnaeus 1758), and *Clostera anastomosis* (Linnaeus 1758) damage *Populus spp.* whereas *Prociphilus* sp. and *Hyphantria cunea* (Drury 1773) are harmful pests for *Fraxinus spp.* In addition, the damage of *Myzus (Nectarosiphon) persicae* (Sulzer 1776) on *Prunus avium* L. was determined.

Wood decaying macrofungi in the catchment of Izmit –Yuvacık watershed were identified and *Coprinellus disseminatus* was detected at the bottom of *Populus alba* species.

3.1.2. Willows

Willows utilized both as firewood and construction wood in Turkey are valuable species which has traditionally been cultivated on the borders of fields and river sides

since ancient time. Recently, willow plantations have been practiced as in poplar plantation because of the increasing demand on the need of wood raw material and several experiments have been performed considering willow cultivation.

In a study conducted on willows in Bartın region, *Philaenus spumarius* (Linnaeus), *Ceresa bubalus* (Fabricius), *Pterocomma pilosum Buckton* , *Trachys minutus* (Linnaeus), *Chrysomela vigintipunctata* (Scopoli), *Crepidodera aurata* (Marsham), *Crepidodera aurea* (Geoff.), *Phyllodecta vitellinae* (Linnaeus), *Plagiodera versicolora* (Laicharting), *Pyrrhalta (Galerucella) lineola* (Fabricius), *Scoliopteryx libatrix* (Linnaeus), *Lymantria dispar* (Linnaeus), *Nymphalis antiopa* (Linnaeus), *Nymphalis polychloros* (Linnaeus) , *Lygaeonematus compressicornis* (Fabricius), and *Pontania proxima* (Lepel) were determined as harmful insects for willows.

The antibacterial effects on *Bacillus subtilis* ATCC 6633, *Escherichia coli* ATCC 25922, *Enterecoccus faecalis* ATCC 29212, *Staphylococcus aureus* ATCC 29213, *Staphlococcus epidermidis* ATCC 12228 and *Salmonella typhimurium* ATCC 14028 strains were investigated by using the extracts prepared from the leaves, branches and roots of the *Paeonia peregrina* L. plant, leaves and shell of young branches of *Salix alba* L., *Salix babylonica* L. plants and ethanol, methanol, acetone, hexane, distilled water, chloroform, ethyl acetate extracts. It was investigated by using disc diffusion method. Paeonia peregrina L. leaf extracts showed high antibacterial activity on *S. aureus* bacteria and a broad spectrum antibacterial effect on test bacteria was detected. Antibacterial activity of *Salix alba* L. extracts were determined on *S. epidermidis* and *E. coli* bacteria. *Salix babylonica* L. extracts showed limited antibacterial effect.

Eight hydroalcoholic extracts from *Salicaceae* family namely, *Salix acmophylla* (male and female), *Salix amplexicaulis* (male and female), *Salix excelsa* (male and female) and *Salix eleagnos* (male and female) collected from different locations of Turkey were investigated *in vitro* for antimicrobial activity against fourteen bacteria strains including, *Bacillus subtilis, Escherichia coli, Enterobacter aerogenes, Enterococcus faecalis , Enterococcus faecium, Klebsiella pneumoinae, Pseudomons aeruginosa, Pseudomonas fluorescens, Staphylococcus aureus, Salmonella enteritidis, Staphylococcus epidermidis, Salmonella infantis, Salmonella kentucky* and *Salmonella typhimurium* and one fungus which is *Candida albicans*. Except *E. coli, B. subtilis, K. pneumoniae* and *P. aeruginosa,* others were affected by at least one plant extract. For *Candida albicans,* all plant extracts did not show any antimicrobial activity against this yeast except male and female *Salix amplexicaulis*.

3.1.3. Other Fast Growing Species

The pine processionary moth which commonly damages to coniferous species, especially *Pinus brutia,* is one of the most important forest pest in Turkey. To reduce the negative effect of continously and unconsciously using chemical pesticides on the environment and human health, alternative fighting methods agains to pests gain more importance. In this case, many studies have been carried out to fight harmful insects by utilizing entomopathogenic fungi and essential oils as effective and safe methods.

Essential oils (ginger, rosemary, and eucalyptus) and two isolates of entomopathogenic fungus *Metarhizium brunneum* (V275 and 4556) were carried out on the pine processionary moth. The results showed that 1% concentration of non-phytotoxic ginger were very effective on the first instar larvae in laboratory conditions whereas the effect of ginger was the highest on third instar larvae. Overall, the effect essential oils were the same in field conditions. Also, the results revealed that the isolates of *Metarhizium brunneum* has a great potential to keep the harmful effects of the pine processionary moth under the control.

In other study that entomopathogenic fungi, such as *Metarhizium brunneum* (V275) and *Beauveria bassiana* (Bals.) Vull. (BMAUM M6-4) were applied in laboratory and field conditions to the pine processionary moth damaging to *Pinus brutia* forests in Barla/Isparta, the results showed that the the application of fungi to the insect resulted in 100% mortality.

Harmful and useful insect species for *Robinia* spp were studied in the period of this report time. As a result of studies, while *Acyrthosiphon pisum* (Harris), *Aphis craccivora* Koch, *A. gossypii* Glover (*Hemiptera: Aphididae*), *Calocoris annulus* (Brullé), *C. roseomaculatus* subsp. *angularis* (Fieber) (*Hemiptera: Miridae*) and *Hypera postica* (Gyllenhal) (*Coleoptera: Curculionidae*) were found as pest of *Robinia* spp., its natural enemies were determined as *Coccinella septempunctata* (L.), *Scymnus rubromaculatus* (Goeze) (*Coleoptera: Coccinellidae*), Epis*yrphus balteatus* De Geer (*Diptera: Syrphidae*), *Lipolexis gracilis* (Foerster) (*Hymenoptera: Braconidae*). It was also observed that the three natural insects *Calocoris annulus* (Brullé), *C. roseomaculatus* subsp. *angularis* (Fieber) (*Hemiptera: Miridae*) and *Hypera postica* (Gyllenhal) are the host of *Robina* spp. for the first time.

Pest and beneficial insect species on *Prunus* spp. were also studied in cherry orchards. The results showed that *Archips rosanus* L., *Rhagoletis cerasi* Linnaeus, *Tropinota hirta* Poda,, *Stephanitis pyri* Fabricius, Myzus cerasi F., *Capnodis tenebrionis* L., *Scolytus rugulosus* Müller and *Tetranychus urticae* Koch were the pets of cherries. In addition, *Coccinella semptempunctata* L., *Synharmonia conglobata* L., *Scymnus pallipediformis* Gunther, *Metasyrphus corollae* Fabricius and *Chrysoperla carnea* Stephens being the most were mostly observed predators.

The biology, natural enemies, and control methods of insects and fungi which *Pinus brutia* trees host were studied in the period of this report time. Some of them are *Neodiprion sertifer, Dioryctria sylvestrella* (Ratxeburg) (*Lepidoptera: Pyralidae*), *Heterobasidion annosum, Thaumetopoea wilkinsoni Tams, Thaumetopoea pityocampa, Tomicus destruens* Woll., *Anomognathus ispartaensis* sp. M. (*Coleoptera:Staphylinidae: Aleocharinae*), *Marchalina hellenica* Genn., *Artemisia santanicum* L. and *Artemisia absinthium* L.

Also, the phenolic compounds and antioxidant capacity of leaves of *Fraxinus excelsior* and *Fraxinus americana* were studied and phytoplasma disease on *Acacia* spp. growing in architectural landscapes were determined in the period of this report time.

3.2. Abiotic

During this report period (at the last 4 year), an average of 2611 forest fires occurred in our country. The amount of burned forest area is 9531 ha, 90.7% of it is Red Pine forests.

4. Sustainable Livelihoods, Land-use, Products, and Bioenergy

These days, the need for thick wood material in wood industries is decreasing while the demand for thin material is increasing, the biggest problem is environmental pollution. One of the biggest influences of environmental pollution is the spread of petroleum products used on wood materials as chemical protectors. Therefore, there are several researches performed on the different fast-growing species to find out the effect of planting density, ecological diversity, and different treatments on their growth and wood properties and to try prevent the ecology from used chemicals on wood materials.

(a) Nursery Practices and Propagation Techniques

Poplar plantations are generally established by using stem cuttings, one or two-year old rooted and unrooted plant. Therefore, planting material is very important for a successful plantation. According to the research, cutting plant and one or two-year old rooted and unrooted plant showed similar results on survival rate, diameter and height increment. As known, using unrooted saplings are cheaper and more practical than using rooted saplings. In this way, a great deal of economy is secured in the poplar plantations.

The seeds were collected from 16 individuals of *Populus euphratica* growing along Fırat river, and they were used to raise tubed saplings. Three plantations were established with these seeds in nursery in Birecik. Since the large amount of the natural areas of *Populus euphratica* utilized in this study disappeared, established plantations could be assessed as a gene protection area. Since *Populus euphratica* demands a high amount of the light and tends to be sympodial growth, it shows a stratification tendency based on its habitat eficieny after a while, which happened after 10 years in the study area. As a result of this, some of *Populus euphratica* block the development of others by expanding their crowns were observed. Also, *Populus euphratica* plantations were established in Harçik, Tunceli, which founds in northern region of Birecik and gets a lot of snowfalls. The most of *Populus euphratica* individuals in this region dried and were affected by the frost damage after the age of four due to heavy snowfalls and lower temparatures. Therefore, one of the most important factors restricting the distribution of *Populus euphratica* in north altitudes is extremely low temperatures.

The effect of sowing type and seedbed density on the morphological characteristics of narrow-leaved Ash (*Fraxinus angustifolia ssp. oxycarpa* Vahl.) seedlings have been investigated in nurseries (İzmit and Hendek in Turkey). According to the results, while sowing type was not affecting the morphological characteristics of ash seedlings, seedbed denstiy significantly influenced them. The height of seedlings and the diameter of root collar increased as the seedbed denstity decreased. With this

decline, the thickness of seedling stems (>2mm) and the weight of dried root and stem also increased.

The effects of seedbed density on some morphological properties in Douglas-Fir (*Pseudotsuga menziesii* (Mirb.) Franco) seeedlings studied. The results revealed that the maximum number of quality douglas seedlings per unit area can be obtained from 2+0 aged douglas seedlings grown in 3 cm seedbed density.

The effects of growing incidence and the use of herbicide on the production of quality seedlings from *Pinus brutia* were studied in the period of this report time. The analyses showed that the spacing of 7.5 cm resulted in the best seedling based on morphological characteristics. In addition, according to the quality distribution of the seedlings based on TSE 2265 February/1988, 98% of the seedlings grown at 7.5 cm spacing were graded as first class. Also for future chemical weed control practices, it was determined that Turkish red pine tolerated clopyralid up to 1%.

(b) Planted Forests

The climate zone, the soil type, the soil pH, the moisture holding capacity of the soil of the land are paid attention when poplar plantations will be established. Continental climate zone is suggested for *Populus nigra* clones while coastal and temperate climate zones are recommend for *Populus deltoides* and *P x euramericana* clones. Sandy loam and alluvial soils which keep the sufficient amount of water and render the penetration of the plant roots till at least 2 m depth of the soil possible are recommended for the poplar plantations. The soil pH value between 6.5 and 7.5 is preferred because poplar trees grow in the optimum performance among those pH values.

The objective and maintenance of establishing the plantation is considered when poplar plantations will be set up. Using wide planting spaces (starting from 4mx4m) and maintenance pruning after 2^{th} and 3^{th} year of the plantation are suggested for the production of industrial wood material such as wood veneer and log. Narrow planting spaces (from 3mx1,5m to 3mx5m) and no maintenance pruning are recommended for the maximum wood production per unit area. Since poplar species demand more water, it is suggested that irrigations of the plantations are generally performed with the surface or sprinkler systems four times per year during the first four years of the plantations and then two or three times in the rest of years till the end of the rotation time. Also, the removal of invasive weeds are recommended at least two times (in May and July) per year during the first four years of the plantation and one time in 5^{th} and 6^{th} years of the plantation.

It has been a controversial topic how the plantations which has come to the end of their rotation period should be regenerated. In a study carried out to find out which regeneration method, artifical or natural, is better, different types of natural and artifical forest management techniques were used. The results of the study suggested that the applications of artifical regeneration method are more suitable for the industrial plantations. Morever, the results of economic analysis based of internal rate of return

showed that artifical regeneration method are more cost-effective for the industrial plantations.

Recently, the need for thick wood material in wood industries is decreasing while the demand for thin wood material is increasing. Planting density plays an important role that affects the diameter of the trees in a plantation. The alternative densities in the trial areas established in Izmit with different clones (I-214, I-45/51, SAMSUN, İZMİT and 89.M.060) in a range planting densities (4,5 m^2, 6 m^2, 9 m^2, 12,0 m^2, 16 m^2, 25 m^2, 36 m^2) were analyzed using internal rate of return and benefit cost ratio. 89.M.060 clone showed having highest internal rate of return and benefit – cost ratio.

The effects of clone differences and different plant density on the acoustic measurement and mechanical property have been examined using different hybrid poplar clones, such as I-214 (*Populus nigra x P. deltoides*), I-45/51 (*Populus nigra x P. deltoides*), I-77/51 (*P. deltoides*), 89.M (*P. deltoides*) and S.307 (*P. deltoides*). The results of the study revealed that the variation in basic density was found between 0.32 and 0,42 g/cm^3. The highest wood density value belonged to clone I-77/51 whereas clone I-214 had the lowest value. Morever, the lowest velocity values were obtained from I-214 and I-45/51 while I-77/51 and S.307 had the highest value.

Sakarya and Samsun provinces located in Marmara region and Middle Black Sea region respectively, have a great potential to produce hybrid poplars. Socioeconomic structure, problems, and expectations of poplar producers living in these provinces have been studied with the purpose of contributing to improving poplar production. According to the results of the study, poplar producers have the similiar average age (58 years old) at both provinces and most of them are farmer. On average, the experience of poplar producers in Samsun province is 20 years while this experience is 26.5 years in Sakarya. Morever, the average of poplar production area that poplar producers in Samsun province run is 3.8 ha whereas the average area is 2.3 ha in Sakarya province and it was determined that traditional family-run are performed in these areas.

According to the results of *Populus euphratica* planted along irrigation channels in Şanlıurfa province, it was determined that since *Populus euphratica* has more resistance in salinity, high temperature, and ground water than other *Populus ssp*., the utilization from this species enormously matter in areas in southern regions to improve the soil and to make production. Studying and focusing on this species is important because *Populus euphratica* resist the summer drought thaks to its roots going deep, and it is the one of rare species which can survive in dessert ecology, and it has a high survival rate.

According to the results of studies for the determination of job satisfaction, it has been estimated that carbon storage in Southeast Anatolia region would be 12 times higher than now if the job satisfaction there increases and the potential poplar production areas there are completely used.

Plantation areas of *Populus euphratica*, which cover the small distribution area in Turkey, and protected areas in natural disturbution areas of it were observed in

Birecik district in Şanlıurfa province. There is an approximately 1.5 hectar area of mature *Populus euphratica* within urban site is being protected. The area has a limited size due to dams of Birecik and Karkamış, the constructions of concrete sets to prevent from floods in streambed, urbanization and agricultural activities. Since the species found in the area cannot make enough water-intake due to human pressure and urban buildings, they continues to disappear in the area.

(c) Naturally Regenerating Forest

In Turkey, there are five naturally distributed poplar species. These are;

1. Black Poplar (*Populus nigra* L.)
2. White Poplar (*Populus alba* L.)
3. Grey Poplar (Hybrids *tremula x alba* named as *Populus x canescens* Smith)
4. Aspen (*Populus tremula* L.)
5. Euphrates Poplar (*Populus euphratica* Oliv.)

Populus tremula L., which can be observed at an altitude of 2900 m in Turkey, naturally is distributed in Turkey as pure stands or groups with coniferous and deciduous tree species. The natural distribution of *Populus tremula* L. occurs forest areas apart from the step regions of Southeast and Middle Anatolia in Turkey (Figure 5) and its most intensive distribution in Turkey is observed in Gümüşhane, Erzurum, Koyulhisar, Bingöl, and Şebinkarahisar.

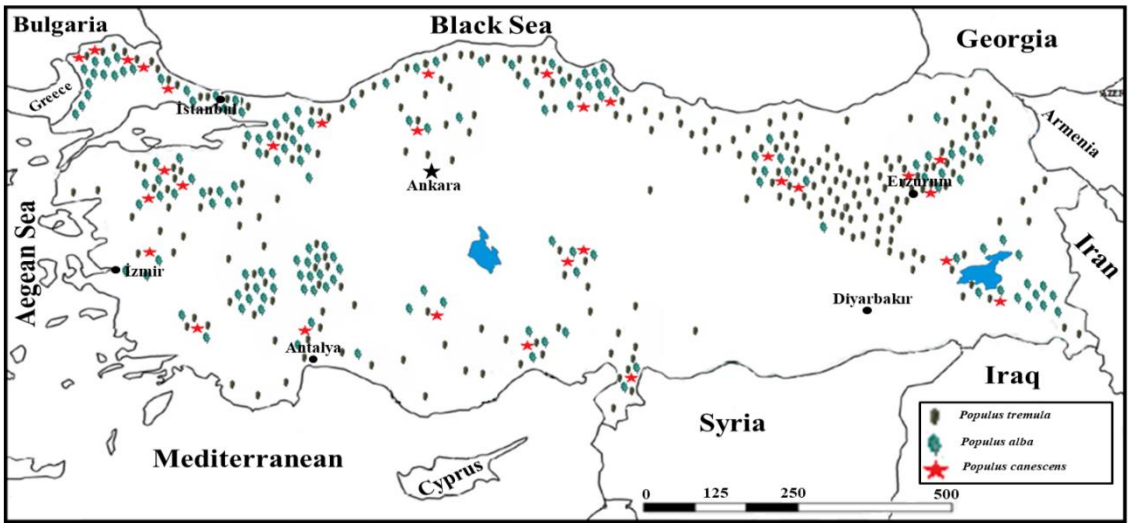

Figure 5. The distribution of *Populus alba, Populus tremula,* and *Populus canescens* in Turkey.

Turkey has the 22.6 million forest areas which covers 29% of the country. *Populus tremula* L. is the pioneer species among the natural distribution of other poplar species in Turkey due to its 287 005,5 ha natural distribution. 152 408,8 ha of which is productive while 134 596,7 ha is unproductive. According to 2019 data, the wood production from these areas of *Populus tremula* L. is about 132 134 m^3.

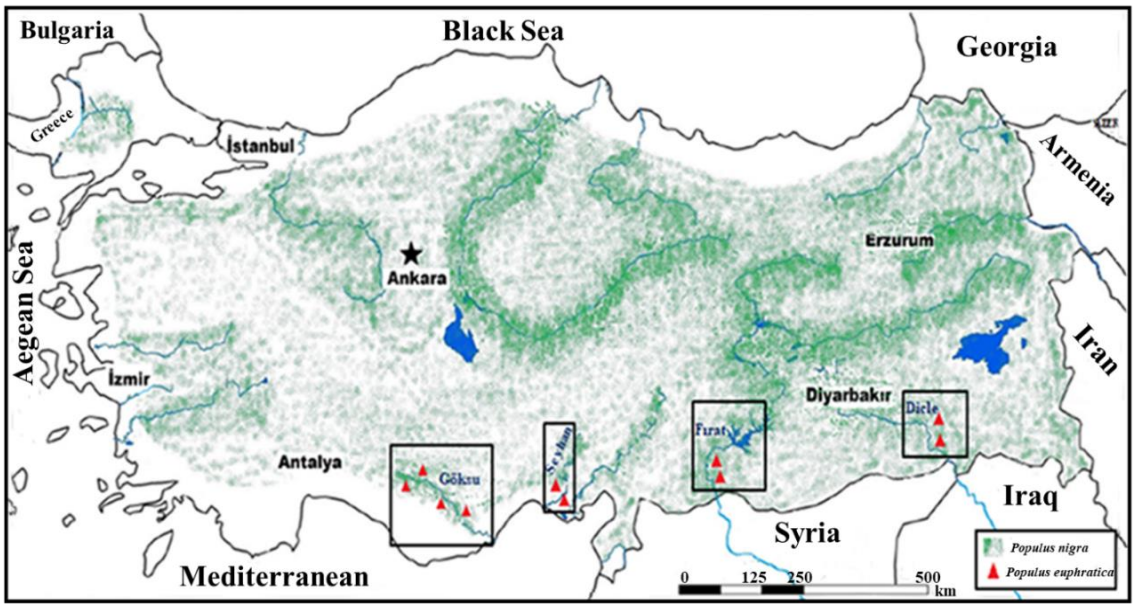

Figure 6. The distribution of *Populus nigra* and *Populus euphratica* in Turkey.

Black poplars *(Populus nigra L.)* are one of the main tree species in central and east part of Turkey. Row plantations with Black poplars are of the traditional practiced poplar cultivation in Anatolia. River or stream side, field and road side plantations have been established for centuries by the farmers. The other poplar species (White Poplar and Grey Poplar) often can be seen along the edges of streams and rivers (Figure 6).

Willows have a wide natural distribution in Anatolia and the number of their natural taxons in Turkey is 24 (Figure 7). They can spread out along the valleys of major rivers as small groups or individually. Total area of willows is 3020,1 ha. 288,7 ha of which is productive while 2731,4 is unproductive.

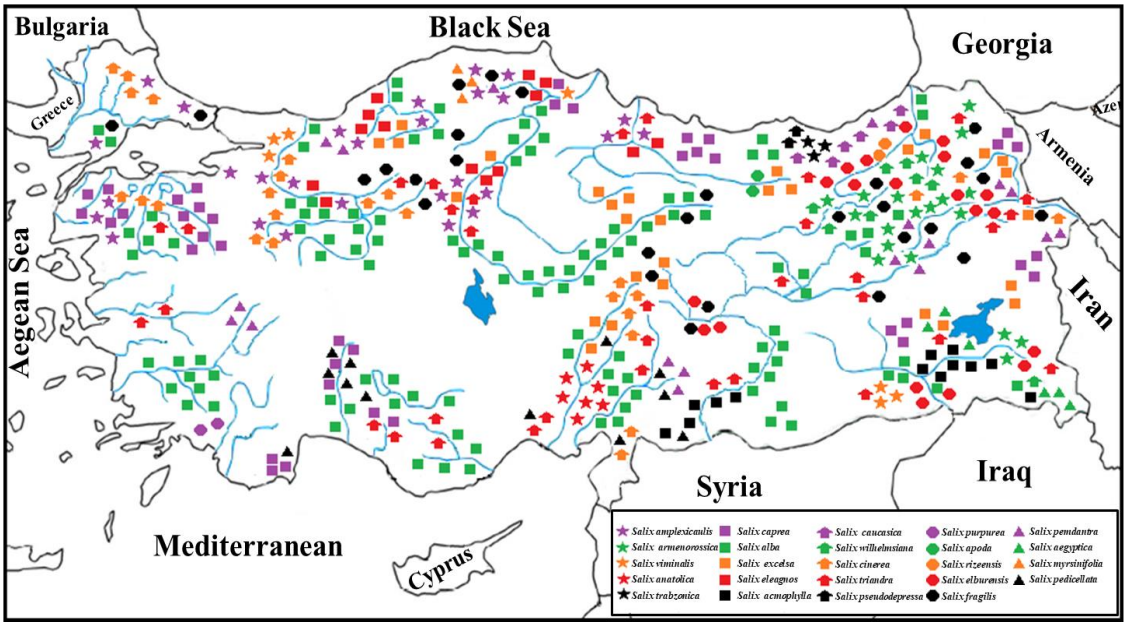

Figure 7. The distribution of *Salix* spp. in Turkey.

Salix alba whose all forms from tree to large shrubs are known is the most important willow species in Turkey. Many ecotypes and hybrids from particularly *Salix fragilis* and *Salix excelsa* are available in Turkey. Turkey has also endemic species of willows. These are *Salix rizeensis* in Soğanlı Mountains of Black Sea region, *Salix anatolica* in Adana, and *Salix purpurea* subsp. *leucodermis* in Aegean region of Turkey.

(d) Agroforestry and Trees Outside Forests

Agricultural intercropping can be applied during the first three years of hybrid poplar plantations. The application of intercropping under poplar plantations is preferred for mainly for two objectives. While the first objective is to increase the profitability of poplar plantation investments, the second objective is to provide some annual income for the farmers who have allocated a part of their limited land for poplar cultivation. Poplar plantations should be established at larger spacings such as 6m x 6m, 5m x 7m and 5m x 8m in order to increase the productivity and profitability of agricultural intercropping. Some agricultural crops can be grown successfully during the first three years period along the strips among rows of young poplar trees where the ground is out of the limits exploited by trees. Bean, potato, tomato, corn, sugar beet, melon, water melon, green pepper, eggplant, zucchini, lettuce and cucumber are recommended as agricultural intercrop species, but they require irrigation and top soil working for their cultivation.

4.1. Harvesting and Utilization

(a) Harvesting of Poplars, Willows, and Other Fast-Growing Trees

According to data obtained from General Directorate of Forestry (OGM) in Turkey during this report period, the average wood raw material obtained from the natural forest of Turkey is 18 356 251 m^3/year. About 31% (5 726 149 m^3/year) of which was provided from the natural stands of fast growing species. While the natural stands of *Pinus brutia*, which is one of fast growing species, met 30% (5 510 542 m^3/year) of the production obtained from the natural stands of fast growing species, other fast growing species in Turkey, such as *Populus tremula*, *Fraxinus* spp., *Alnus* spp., and *Salix* spp. contributed to 1% of the remaining wood production from fast growing species.

After the production obtained from the natural stands of *Pinus brutia*, the highest second industrial wood production with 93 254 m^3/year was performed on the natural stands of *Populus tremula* in the period of this report time and it was followed by the industrial wood production of 74 313 m^3/year made from the natural stands of *Fraxinus* spp.

The average industrial wood production of 26 300 m^3/year was provided from the natural stands of *Alnus* spp. in the period of this report time while the average industrial wood production per year of 21 740 m^3/year were obtained from the natural stands of willows.

In this report period, total wood production from industrial plantations based on fast growing species is approximately 3.6 million m^3/year. The average industrial wood

production produced from the poplar plantation is 3 385 154 m^3/year, which is 94% of the total wood production per year. 20 154 m^3/year of the production obtained from the poplar plantations was met from the plantations of *Samsun* (77/51) clone in Samsun/Gölardı Poplar subdistrict, which is the only Forest sub-district making wood production based on poplar plantations by being affiliated with OGM.

The poplar plantations was followed by the plantations of *Pinus pinaster* contributing to approximately 5% of the total production. The average industrial wood production made from the plantations of *Pinus pinaster* was 180 391, 182 m^3/year in the period of this report time, which is the second highest production after poplar clone plantations.

The rest of the production was provided from the plantations of *Eucalyptus* spp., *Psuedotsuga menziesii*, and *Pinus radiata*. The average industrial wood production based on the plantations of *Eucalyptus* spp., *Pseudotsuga menziesii*, and *Pinus radiata* was 18 093, 402 m^3/year, and around 97% of which was met from the plantations of *Eucalyptus* spp in the period of this report time. While around 2% of this production was provided by the plantations of *Pseudotsuga menziesii*, the remaining percent was met by the plantations of *Pinus radiata*.

Tree volume tables of *Populus tremula*, its silvicultural charteristics and natural distribution areas in Turkey were evaluated in the period of this report time. A new natural distribution area was found in Turkey for *Populus tremula* and its stand dynamics were studied.

Single tree biomass production estimation of *Populus x canescens* (Aiton) Sm. and short term biomass production, natural regeneration of the pure and mixed stands of *Alnus glutinosa* Gearth. subsp. *barbata* were evaluated in the period of this report time. Also wood production from the natural stands of *Fraxinus* angustifolia Vahl. and site and silvicultural characteristics of *Prunus avium* L. were examined as well.

Tree volume tables of *Pinus brutia* was constructed developing single and double entry tree volume equations. It was also studied on modelling distribution of diameter and height in natural stands of *Pinus brutia*. For harvesting timber from *Pinus brutia* stands, the operation and the optimal schedule of timber harvesting were evaluated in the period of this report time.

(b) Utilization of Poplars and Other Fast-Growing Species for Various Wood Products

The conventional usage fields of the wood of poplar and other fast growing species in Turkey can be summarized as stated below:

- Veneer industry (veneer covering, boxes, plywood, and matches),
- Packaging industry (pallets, crates, boxes etc.),
- Furniture industry (sawn wood, mostly used for internal parts),
- Wood chipping industry (paper pulp, panels from chipped wood), and
- Construction sector (sawn wood, mostly for roof construction).

The wood of poplar clones is used as a useful raw material in the manufacturing industry, particularly in the following products:

- Special paper production; napkin, table napkin, towels, thin packaging papers and paperboards,
- General purposed paper pulp production; well bleached semi chemical sulphide pulp.
- Production of construction panels; insulation panels, ceiling covers and fiber boards.

In the period of this report time, in Turkey, the highest industrial wood production was provided by natural stands of *Pinus brutia* while half of which was used in fibre-chips industries, pallet industries utilized approximately 40% of this production. The remaining production was used by construction industries, joinery and flooring industries, and other industries.

All the production obtained from the natural stands of *Populus tremula* was utilized by fibre-chips industries.

While half of the production obtained from the natural stands of *Fraxinus* spp. was preferred by fibre-chips industries, the remaining production was utilized by furniture industries, plywood industries, joinery and flooring industries, coating industries, decoration industries, and other industries, respectively.

More than half of the production obtained from the natural stands of *Alnus* spp. was used by fibre-chips industries and this usage was followed by furniture industries, plywood industries, and other industries.

While 30% of the production obtained from natural stands of willows was used in fibre-chips industries, the remaining production was preferred in pallet and packaging industries.

More than half of the production obtained from poplar plantations was mostly preffered by construction industries, which is about 51%. While about 30% of this production was utilized in wood board industries, the remaining production was used by packaging industries, plywood industries, furniture industries, and other industries.

The utilization of the production obtained from the plantations of *Pinus pinaster* was mainly shared with two industries, which are fibre-chips industries (approximately 84% of the use) and pallet industries (about 16% of the use).

Industrial wood production from the plantations of *Eucalyptus* spp. was utilized in fibre-chips industries and pallet industries. Nearly all industrial wood production obtained from the plantations of *Pseudotsuga menziesii* was used in fibre-chips industries whereas all industrial wood production made from the plantations of *Pinus radiata* was preferred by fibre-chips industries. Smallest part of the industrial wood production of *Pseudotsuga menziesii* was utilized in construction industries.

It is expected to obtain qualified and quantitatively wood raw material from the plantations when priority is given to establishment of plantations to meet the shortage of wood raw material. Therefore, studying wood technological properties on wood material which will be obtained from industrial plantations based on fast-growing species is important. In this case, many studies have been done on wood technological properties of fast growing species so far.

Deep eutectic solvents (DES) are characterized for environmentally friendly and they can react with wood components to dissolve them. Pulp and paper production possibilities from European black poplar (*Populus nigra* L.) using a green DES were investigated and it was found that some pulp and paper properties of DES pulps were comparable with traditional pulping methods.

The effect of layer orientation on some technological properties of plywood and LVL produced from poplar (*Populus deltoides*), wood was investigated. For this purpose, 5-layers plywood, laminated veneer lumber (LVL), LVL that laminated the middle layer perpendicular to the other layers and plywood that laminated the middle layers parallel to each other were produced. The highest mechanical strength values were obtained from LVL panels while the lowest values were found in plywood that laminated the middle layers parallel to each other.

It was aimed to determine some physical, mechanical and technological properties of thermo-mechanical densified wood materials after heat treatment at different temperatures and durations. Specimens prepared from black poplar (*Populus nigra*) woods was subjected to heat treatment in atmospheric pressure environment at four different temperatures (140 °C, 160 °C, 180 °C and 200 °C) and two different duration (7 and 9 h). Heat-treated samples were then densified using a hydraulic press at 150 °C with compression ratios of 20% and 40%. According to the obtained results, it can be suggested to use these two methods together in order to eliminate the negative effects of both heat treatment and densification modification on the wood material.

Recent trends in the wood preservation industry is the usage of environmental friendly wood protection methods including Dimethylol dihidroxy ethylen eurea (DMDHEU). The physical and mechanical properties of parallel strand lumbers by using pressure and temperature with melamine formaldehyde glue after modifying strands from fast growing hybrid poplar wood (I-77/51) (*Populus deltoides*) with DMDHEU resin. DMDHEU modificaiton caused increase in some physical properties but decrease in mechanical properties.

Willows have been traditionally cultivated in Turkey and they have been the subject in different studies from the science to the art. A study to show the importance of using the willow wood indicated that the willow shields, which, even in war, show no compromise on the splendor of the Ottoman Empire.

(c) Utilization of Poplars and Other Fast-Growing Trees as a Renewable Source of Energy ("Bioenergy")

The study based on the determination of the poplar clones for bioenergy was started in 2017 to contribute to energy production by using the biomass of fast growing species as renewable energy resources and establishing plantations based on fast growing species. The project still continue and it will be finished in 2031.

5. Environmental and Ecosystem Services

a) Site and Landscape Improvement

Combating desertification (Cold and Drought Resistance) and Salinization

Poplars: At this reporting period, decomposition of leaves were examined in *Populus nigra*. C, N and P concentrations in decomposing leaf litter differed according to months. However, a special trend based on any parameter wasn't determined for C, N and P concentration.Also, ITS and LSU-rDNA nüclotide sequences based confirmation of *Cytospora chrysosperma* ve *Chondrostereum purpureum* from symptomatic cancered tissues of *Populus nigra* and gene regulation network behind cold stress bud dormancy break, boron toxictiy, and drought tolerance and were studied.

An important part of the valley bases in Central Anatolia shows salt-sodic soil characteristics. After chemical treatment was applied to the soil, three year-old abele (*Populus alba* L.) seedlings were planted and their survival rates and growth performances were followed. Abele achieved 42% more growth in gypsum and sulfur treated areas than in control areas and showed an average survival rate of 36% in all processing areas.

Willows: Some plant-based biostimulants, also called botanicals, are attractive options due to their safety, renewability and low cost and they can be used as innovative and promising agents to address current challenges to sustainable agriculture. Willow tree (*Salix* spp.) extracts are rich in many bioactive compounds including salicylates. Therefore, willow trees were used in several studies in terms of site and landscape improvement.

In this report period, extracts of willow bark contain substantial amounts of salicin, which can be converted into the phytohormone salicylic acid, and have been used in traditional medicine for their anti-inflammatory and analgesic activities. The potential of willow bark and leaf extracts were evaluated as plant-based biostimulants to improve maize (Zea mays cv. Caramelo) growth in the absence and presence of salinity stress. In hydroponics experiments, especially, willow bark extracts enhanced root growth and development. Aqueous extracts of willow tissues may be used as biostimulants to improve crop performance although effects may not be salinity specific.

Other Fast Growing Species: In this report period, with the study of the effect of Maritime Pine (*Pinus pinaster* Aiton) plantations on soil organic carbon and nutrient stocks in Izmit-Kerpe district, it was observed that the amount of dead plant material and the rate of carbon and nitrogen (C/N) in the coppice forest plantations based on *Pinus pinaster* were almost two times greater than that of leafy coppice forests. That was associated that the decomposition and decay occur in coniferous species slower than that of deciduous plants.

The effect of use of *Alnus glutinosa* subsp. *barbata* and *Robinia pseudoaccacia* on afforestation sites in terms of the soil respiration and the soil nitrogen mineralization and microbial respiration potential of the alder were studied. Also, the way of the

ecosystem service of *Fraxinus excelsior* L. and *Robinia pseudoaccacia* were evaluated under different scenarios, such as climate change and traffic density in the period of this report time. The results revealed that those species can be used as a part of restoration practies in degraded forestlands.

Also, the effect of cold stress, climate change, summer drought, soil-bedrock properties on *Pinus brutia* and the ability of soil recovery of *Pinus brutia* were evaluated in the period of this report time.

Row (or shelterbelts and windbreaks) and Gallery plantations

Row plantations used poplar species have been a traditional technique utilized by the farmers in Anatolia for centuries. It has been established in the sides of fields and rivers or alongside roads and watercourses and also used as windbreaks in the areas which have the dry climate and the sweep effect of the wind.

The distance between trees in row plantations is recommended 5 m for the clones of *I-214* and Samsun while 1m is suggested for the indigenous black poplars. Priority in gallery plantations is given to hybrid poplar clone *I-45/51* and the indigenous black poplar clones of *Gazi* (TR-56/52) and *Anadolu* (TR-56/75) due to their fairly tolerance to extreme site conditions. Also according to the results of *Populus euphratica* planted along irrigation channels in Şanlıurfa province, it was determined that *Populus euphratica* is an important species for row afforestation, gallery afforestation, and plantations which will be established during drainage and irrigation channels in this region.

b) Phytoremediation

Poplars: Boron (B) is an essential nutrient for normal growth of plants. Despite its low abundance in soils, it could be highly toxic to plants in especially arid and semi-arid environments. Boron pollution is a main pollution mineral in Turkey, due to several mining activities and natural mineral imbalance in the lands of country. In This report period, several studies on black poplars has been conducted to select the best genotypes that can be used in remediation of polluted soils. Genome-wide transcriptome studies revealed candidate genes of poplar trees responsible in boron uptake, transport and detoxification. Comparative transcriptome studies between *P. nigra* and *P.alba* indicated salicylic acid mediated boron rejection in poplars and the genes responsible in boron toxicity tolerance.

Poplars are known to be tolerant species to B toxicity and accumulation. B accumulation and tolerance level of black poplar clones were firstly tested in this report period. Rooted cutting of these clones were treated with elevated B toxicity to select the most B accumulator and tolerant genotype. The results of the study indicated that black poplar is quite suitable for phytoremediation of B pollution.

Also, since Boron (B) toxicity is an expanding environmental problem throughout the world, B removal performance of poplar and willow species in constructed wetland (CW) were investigated. These species were treated with simulated wastewater having five B concentrations (0.5, 5, 10, 20 and 40 ppm). These tree species

had an important potential for remediation of wastewater in CW by increasing the filtering capacity of the sediment and leading to phytostabilization of B around the rhizosphere. In terms of their B removal ability, *P.nigra* and *S.anatolica* had the highest B removal capacities with phytoextraction while *S.alba, P.alba* and *S.babylonica* had more phytostabilization performance in CW.

Willows: In this report period, heavy metal concentration (Pb, Co, Cr, Cd, Fe, Cu, Zn, Mn) was detected from the samples obtained from the soil, leaf, root and barks of the (*Salix fragilis* L.) which were picked from four different regions Karasu River (Üzümlü, Yedisu, Tercan) in Erzincan province and around Işıkpınar stream. It was found that heavy metal concentration was accumulated more in the root of the plants and the amount of heavy metal was more in Yedisu locality. It was concluded that it would be a biomonitor for the determination of heavy metal contamination of *S. fragilis* L.

III. GENERAL INFORMATION

1. Administration and Operation of the National Poplar Commission or Equivalent Organization

(a) National Poplar Commission of Turkey conducts the activities in accordance with the regulation issued in 1964 by the government of the Republic of Turkey. The postal address of the Commission is:

Kavak ve Hızlı Gelişen Orman Ağaçları Araştırma Enstitüsü Müdürlüğü
Ovacık Mahallesi, Hasat Sok. No: 3
41140 Başiskele- Kocaeli /TURKEY

(b) The first Executive Board Meeting was made in Ankara in May 2017. Activities and applications based on the 17 decisions taken in 8th National Poplar Commission in 2014 were evaluated. The 9th National Poplar Commission was gathered in April 2019 in Afyon/Turkey. In the meeting, the importance of using registered poplar species and poplar species which will be registered in the future to fill the shortage of the wood raw material in Turkey and conserving gene resources of poplar and willow species were addressed as well as discussions were made on presentations prepared and given by researchers dealing with poplar and willow species. Following day, the Executive Board Meeting was gathered and was divided into two different specialized groups. They prepared proposals relevant to the topics of their expertise and 22 of which was accepted. A workshop "The Biology and Silvicultural Properties of *Populus tremula* L. and Its Usage in The Forest Industry" was held in September 2019 in Kayseri/Turkey and *Populus tremula* L. was discussed in detail.

(c) Each year, a daily education including technical information and applications on the poplar cultivation are given to the students of the Faculty of Forestry.

1000 leaflets were printed in 2017 to introduce Poplar trees and to increase the awareness of society on the effect of Poplar pollens.

A book named as "The Ecological Properties of Aspen (*Populus tremula* L.) Communities and Their Regioning in Terms of Seed Transfer and Reforestation/Afforestation" was published by İbrahim ATALAY in 2019.

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3. Relations with Other Countries

A protocol "The Development Project of Georgia's Poplar Cultivation" was signed with Georgia in 2017. "Cooperation Protocol in Forestry Field" was protocolled with Uzbekistan in 2018 with the end of "The Development Project of Uzbekistan's Poplar Cultivation" protocolled with Uzbekistan in 2015.

4. Innovations not included in other sections

Atmospheric pollen concentration has been studied in 62 locations of Turkey. Although poplar pollen was seen most of those locations, it was detected only Zonguldak, Bartın, and Ankara provinces had slightly higher poplar pollen concentration while other locations had lower poplar pollen concentration. Studies carried out around Turkey show that children's sensitivity to poplar tree pollen is around 1.4-14.9% while this is 6.5-38% in matures. As a result, the concentration of poplar pollen in Turkey is not in the level that the society can negatively be affected.

Due to their salicin content, the *Salix* species (*Salicaceae*) have been utilized as a treatment of various disorders in the traditional medicine field through human history. Products are sold under the name of willow bark and leaves on the market. Macroscopic and microscopic examinations, foreign matter determination, loss on drying testing, total ash determination, identification reactions as well as TLC and HPTLC analysis were performed on six different sold under the name of "Willow bark" according to the criteria defined in the European Pharmacopoeia 7.0. None of the six materials examined were found to be suitable for pharmacopeia. This study reveals the question of the reliability of spice sellers, which are perceived as the supply center for herbal products, and the necessity of supervising the products sold.

The extract contents of *Pinus brutia* and *Pinus pinaster* were evaluated in the period of this report time. While turpentine and resin of both *Pinus brutia* and *Pinus pinaster* were analyzed, essential oil and bark tannin extractives of *Pinus brutia* were also evaluated in the period of this report time.

IV. SUMMARY STATISTICS

Table 1. Indicate area (ha) of fast-growing species in Turkey

Forest Categories	Species	Forest Areas in 2020 (ha)		
		Productive Area	Unproductive Area	Total Area
Natural Forests	*Populus tremula*	152 408,8	134 596,7	287 005,5
	Salix spp.	288,7	2731,4	3020,1
	Pinus brutia	3 446 338	1 165 818	4 612 156
	Fraxinus angustifolia	11 975,2	2082,4	14 057,6
	Alnus spp.	173 628,9	36 594,2	210 223,1
	Robinia pseudoacacia	3073,1	445,3	3518,4
	Prunus avium	9445,9	1284,6	10 730,5
	Total	**3 797 158,6**	**1 343 552,6**	**5 140 711,2**
Planted	*P.deltoides, P x.euramericana*	75 000		75 000
	Populus nigra	65 000		65 000
	Pinus pinaster	57 378,4		57 378,4
	Eucalyptus spp.	5212,7		5212,7
	Pinus radiata	1709,2		1709,2
	Fraxinus angustifolia	1347		1347
	Pseudotsuga menziesii	608,6		608,6
	Prunus avium	232		232
	Pinus taeda	36,3		36,3
	Total	**206 524,2**		**206 524,2**
Agroforestry	Poplars	3600		3600
	Total	**3600**		**3600**

Table 2. Main purpose in management of Poplars and Ownership

Description (Poplars)	Main Purpose of Management	Ownership Percentage (%)		
		Public	Private corporate	Private smallholder
Natural Forest	Wood production	100		
Planted Forest	Wood production	1	1	97
	Environmental	1		

Table 3. *In-situ* conservation areas of fast-growing species in Turkey

Seed resources	Species	The number of *In-situ* Conservation Areas	Total Area (ha)
Seed Stands	*Pinus brutia*	72	10 423,3
	Populus tremula	2	683,3
	Alnus spp.	7	543,7
	Fraxinus spp.	4	305,6
	Pinus pinaster	5	453,1
	Robinia pseudoacacia	1	156
	Pinus radiata	2	6,1
	Eucalyptus spp.	1	1,1
	Pseudotsuga menziesii	1	7,4
Gene Conservation Forests	*Pinus brutia*	61	9504,10
	Populus tremula	2	148,7
	Alnus spp.	6	747,3
	Fraxinus angustifolia	1	99,8
	Prunus avium	4	448,9
Seed Orchards	*Pinus brutia*	76	649,3
	Pinus pinaster	1	3,3

Table 4. *Ex-situ* conservation areas of fast-growing species in Turkey

Species	Facility Location	Establishment Purpose	The number of Clones	Establisment Year	Area (da)
Populus nigra ssp.	Ankara/Behiçbey	Cuttings/Clone Bank	354	1995	0.7
Populus nigra ssp.	Ankara/Behiçbey	Populetum	250	2006	5
Populus nigra ssp.	Seydişehir	Cuttings/Clone Bank	248	2008	1
Populus alba	Ankara/Behiçbey	Cuttings/Clone Bank	3	1995	
Hybrid Poplars	Ankara/Behiçbey	Cuttings/Clone Bank	50	2008	0.3
Hybrid Poplars and *P.deltoides*	İzmit	Cuttings/Clone Bank	408	2015	0,5
Salix spp.	Ankara/Behiçbey	Cuttings/Clone Bank	169	2011	0.5
Salix spp.	İzmit	Cuttings/Clone Bank	169	2013	0.5
Pinus pinaster	Bursa	Seed Garden	30	2018	30
Fraxinus ornus	Kerpe Research Forest	Seed Garden	21	2018	30

Table 5. The average production from natural stands and plantations of fast-growing species per annual

Classification	Species	Average Annual Production (m^3)
Natural Stand	*Pinus brutia*	5 510 542
	Populus tremula	93 254
	Fraxinus spp.	74 313
	Alnus spp.	26 300
	Salix spp.	21 740
	Total	**5 726 149**
Plantations	*Populus* spp.	3 385 154
	Pinus pinaster	180 391,182
	Eucalyptus spp.	17 579,133
	Pseudotsuga menziesii	476,269
	Pinus radiata	38
	Total	**3 583 638,584**

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