Evaluation of Industrial Plantation Practices in Turkish Forestry

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ABSTRACT—*Due to Turkey's developing economy, the demand for wood raw materials is increasing daily. Given that natural forests will face difficulties in meeting this demand in the coming years, the concept of "Industrial Plantation" is assuming a significant role in Turkish forestry. The General Directorate of Forestry planned plantations for 165.000 hectares in its "Industrial Afforestation Works Action Plan" covering the 2013-2023 period, with 145.000 hectares actually being realized. This study presents the history, potential, and challenges of plantations in Turkish forestry, and develops recommendations.*

Keywords— Industrial plantation, Türkiye, wood harvesting

1. INTRODUCTION

According to 2024 data, Türkiye has a total forest area of 23.4 million hectares. This compares to the country's geographical area of 76.9 million hectares, indicating that 30% of the country's area is covered by forests. However, 13.813.598 hectares of this forest area (59%) is classified as productive forest area, while the remaining 49% is considered unproductive forest land for wood harvesting. Forest areas contain a total of 1.8 billion m^3 of wood, equivalent to 76.9 m^3 per hectare. The current annual wood volume increment is 50.9 million m^3 across the total area, equivalent to 2.18 m^3 per hectare. Turkish forestry utilizes an "Ecosystem-Based Multi-Purpose Planning System", and forests are planned under three main functions: economic, ecological, and socio-cultural. Of the total forest area, 9.349.665 ha (40%) are classified as economic, 11.902.673 ha (51%) as ecological, and 2.110.746 ha (9%) as socio-cultural functions [1]. This shows that the main wood raw material harvesting in Turkish forestry is made from only the economically functional portion of the total forest area, which constitutes 40%. Harvesting activities in other functional areas are quite low in quantity and are mostly of a sanitary harvesting nature. In terms of wood volume; app. 1 billion m^3 (57%) of the total volume is located in economic areas, 650 million m^3 (36%) in ecological areas, and 127 million m^3 (7%) in socio-cultural areas. In terms of wood volume increment 29.3 million m^3 (58%) of the total increment is in economic function areas, 18 million m^3 (35%) in ecological function areas, and 3.5 million m^3 (7%) in socio-cultural function areas. Total wood production from Turkey's forests by the General Forestry Directorate (OGM) varied between 11.5 million m^3 (2009) and 27.7 million m^3 (2021) in the 2009-2024 period, and a total of 23.2 million m^3 of wood was harvested in 2024. Within total wood harvesting, industrial wood amount ranged from 8.8 million m^3 (2009) to 20.9 million m^3 (2021), and 17.1 million m^3 of industrial wood was harvested in 2024. The amount of firewood harvested between 2009-2024 ranged from 4.8 million m^3 (2009) to 3.3 million m^3 (2017) [1].

Besides wood harvesting by OGM, over 3.5 million m3/year of poplar wood is harvested in Türkiye. Approximately 1.5 million m^3/year of this harvesting comes from domestic black poplar clones, and more than 2.0 million m^3/year comes from exotic poplar clones. The vast majority of poplar wood produced is obtained from small-scale afforestation plantations established by farmers [2].

Over time, as the use of natural products has gained momentum, people's tendency to use biomaterials has increased. It is known that as countries' income levels increase and their welfare levels improve, they benefit more from forest products. In line with Türkiye's development plans and strategic goals, it is aimed to expand the use of wood material. It is estimated that annual per capita wood raw material use in developed countries with high national incomes exceeds 1 m^3. In Türkiye, this value is between 0.5 and 0.6 m^3 [3]. It is expected that this value will increase as Türkiye's

income level increases, and per capita consumption will reach 1 m^3. Based on these data, it is clear that the demand for forest products will not be met by Türkiye's forests over time. Today, the supply-demand gap is met through poplar raw wood production, registered logging, and imports of raw, semi-finished, and finished wood products [4]. This method is clearly unsustainable. Establishing industrial plantations using fast-growing and exotic species is considered a powerful tool for closing this gap. Industrial plantations are forest areas designed specifically to meet the industry's demand for wood raw materials, typically using fast-growing and reclaimed tree species. These tree species have a single-species structure on the field and are planted in short-term and well-spaced afforestation.

This study evaluates industrial plantation activities carried out by the General Directorate of Forestry (OGM) during the 2013-2023 period, taking into account official statistics, implementation projects, activity plans, and literature.

2. BRIEF HISTORY OF INDUSTRIAL PLANTATIONS IN TÜRKİYE

As emphasized above, there is a gap between wood supply and demand in Türkiye. Türkiye's actual wood consumption is 30 million m^3, and this gap is being filled by poplar/eucalyptus plantations and imports. Therefore, the concept of introducing exotic species began as a means of introducing fast-growing species to address the wood shortage in Turkish forestry. After the impending wood shortage became apparent in the 1980s, interest in fast-growing species in Turkish forestry arose [5,6]. Experience with fast-growing species in Türkiye reveals that some fast-growing exotic species were tested for various purposes before 1939. For example, *Pinus pinaster* was tested in the Terkos sand dune stabilization project in 1880. Later, in 1939, some Eucalyptus species began to be used in some plantation practices in the Mediterranean region of Türkiye (Tarsus-Mersin). Later, some *P. x euramerican* poplar clones were introduced in 1946. In the 1950s, Turkish foresters initiated demonstration plantations and comparative trials of exotic coniferous species at various levels [7]. Several state forestry organizations and research institutions, such as the Poplar and Fast-Growing Forest Trees Research Institute-İzmit and the Eastern Mediterranean Forestry Research Institute (formerly the Eucalyptus Research Station), played an active role in all these stages. At the same time, numerous scientific studies on fast-growing weeds were conducted by the aforementioned forestry authorities in 1968 [8]. Studies on exotics of American origin began in the 1940s. Between 1972 and 1977, the project titled "TUR/71-521 Industrial Forestry Plantations" [8] mandated trials of all species and origins, primarily on fast-growing exotics, to address the wood supply-demand gap. In addition, within the scope of the "Coniferous Species Arboretum" project, trials were carried out on various species of American origin between 1969 and 1976 [9]. Most of the species and origin trials on fast-growing exotics were established in the Black Sea, Marmara, Aegean and Mediterranean coastal zones of Türkiye [7]. Looking at the species used as fast-growing exotics, interest in Turkish forestry has concentrated mostly on coniferous species (app. 80%). Along with coniferous tree species; some other experiments have also been carried out on broad-leaved tree species such as *Populus x euroamericana, P. deltoides, Eucalyptus camaldulensis, E. grandis, Alnus incana, A. sinuata, A. robusta, A. cordata, Acer saccharum, A. pseudoplatanoides, Acer negundo, Robinia pseudoacacia, Quercus rubra* and *Ailanthus altissima* [7]. In the 1990s, *Paulownia* Sieb. & Zucc. of Chinese origin was used for some experiments in nurseries and fields [10,11]. Turkish forestry system deals not only with tree species but also with fast-growing natural species such as *Fraxinus, Alnus sp., Populus tremula, Ulmus*, etc. [12].

Industrial plantation is defined as "afforestation established in areas with good and suitable habitat characteristics, by applying intensive soil preparation and maintenance measures, and by using genetically modified, high-yielding, fast-growing tree species with a short management period" [23,24]. A fast-growing tree species is defined by international organizations such as IUFRO and FAO as "tree species with an average annual volume increase per hectare of more than 10 m^3 at 30 years of age" [25].

The General Directorate of Forestry prepared the "Industrial Afforestation Works Action Plan (2013-2023)" [13], and within the scope of this plan, industrial afforestation was planned on 165.000 hectares. Of this, 145.000 hectares were allocated to Turkish Red Pine (*Pinus brutia* Ten.), 14.000 hectares to maritime pine, and the remaining area to ash, eucalyptus, and poplar species [13]. A total of 108.261 hectares of industrial plantations [14] were established between 2013 and 2023, with annual plantations ranging from 2.479 hectares (2013) to 24.058 hectares (2021). The most extensive studies were conducted using the *Pinus brutia* species in the Muğla (7.955 ha), Çanakkale (7.292 ha), and Mersin (7.110 ha) region (Table 1). The area built in these four regions constitutes 28% of the total area [14].

Table 1. Distribution of industrial plantation activities (ha) in Türkiye by region during the 2013-2023 period.

Region	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Balıkesir	131	192	268	137	158	141	728	458	1 910	735	25
Çanakkale	-	172	486	559	443	658	1 220	1 177	1 205	1 261	111
Denizli	-	168	179	68	84	70	500	1 950	1 083	998	380
Antalya	24	376	373	232	278	331	314	504	308	360	125
Sinop	98	148	162	150	300	164	314	163	20	300	85
Mersin	27	123	382	205	208	238	438	1 008	1 780	1 969	731
Hatay	90	102	120	69	102	18	317	872	2 985	404	60
İstanbul	964	1 018	724	577	565	560	785	1 257	1 545	868	369
Kütahya	-	-	-	-	-	-	-	507	710	220	100
Konya	-	-	-	-	-	-	-	105	100	200	100
Kahramanmaraş	-	-	50	21	50	122	256	917	785	632	106
Zonguldak	-	29	35	37	45	43	50	96	150	79	172
İzmir	284	658	1 138	1 001	950	748	2 097	1 863	2 500	1 170	1 076
Muğla	-	523	862	702	718	623	2 210	2 200	2 500	2 173	101
Bursa	199	316	370	337	366	310	530	1 449	1 516	1 525	363
Sakarya	530	788	819	492	459	415	600	1 447	1 159	927	150
Bolu	60	54	37	-	-	-	-	31	106	-	-
Adana	35	150	292	256	244	283	814	1 553	1 968	2 780	970
Amasya	-	77	99	145	150	196	205	254	500	74	55
Isparta	37	254	215	139	99	65	700	1 221	1 087	980	512
Eskişehir	-	-	-	-	-	-	-	281	142	-	-
Total	**2 479**	**5 148**	**6 611**	**5 127**	**5 219**	**4 985**	**12 077**	**19 312**	**24 059**	**17 655**	**5 591**

3. POTENTIAL AREAS FOR INDUSTRIAL PLANTATIONS IN TÜRKİYE

Fast-growing species and the potential for industrial plantations are among the main concerns in Turkish forestry. Therefore, to bridge the wood gap based on fast growing exotics, some research has been initiated to identify potential areas for such plantations. Initially, it has been determined that 5% of degraded forest could be used for this purpose [9]. Some publications state that there is a potential plantation area of 1.5 million hectares with fast-growing exotics based on intensive mechanization [15]. Furthermore, this potential suitability of 1.5 million hectares for fast-growing plantations has been confirmed [16]. If the approximately 1 million hectares of potential state land and forests deprived of natural regeneration conditions and requiring planting are added to the 2.2 million hectares, the area requiring planting in the above-mentioned area will be considerably larger [7].

In fact, excluding hybrid poplars, the total area of fast-growing plantations established throughout Türkiye is approximately 80.000 hectares [17,18]. In fact, *Pinus pinaster*, *Peudotsuga menziessi*, *Pinus radiata*, *Pinus taeda*, and *Eucalyptus camaldulensis* are the main exotic species with small/large plantation areas. Currently, there are 53.901 hectares of *P. pinaster*, 140 hectares of *P. menziessi*, 1.692 hectares of *P. radiata*, 17 hectares of *Pinus taeda* [19], and 20.000 hectares of *E. camaldulensis* [20] plantations in Türkiye. Because poplar plantations are private enterprises, no verified data are available. According to estimates, there are 200.000 hectares of poplar plantations in various regions of Türkiye, mostly on agricultural lands [21].

To meet the wood shortage, the General Directorate of Forestry targeted the establishment of 165.000 hectares of plantations with fast-growing species between 2013 and 2023 [13], and this target was realized as 108.261 hectares [14]. As for the regions of Türkiye, in the Mediterranean and Aegean regions, the native species, *Pinus brutia* has demonstrated superiority over most of the introduced species. *Eucalyptus* species can also be used in suitable ecological areas in this region. In the Marmara region, *Pinus pinaster*, along with *Pinus radiata*, has performed quite satisfactorily. Native species *Pinus brutia* and *Alnus barbata* can be used in suitable areas in this region. In the Western and Central Black Sea regions, *Pinus pinaster* is the most successful species in plantations. Additionally, Douglas fir has been evaluated as a potential species for this region [22]. In the Eastern Black Sea region, *Pseudotsuga menziesii*, *Pinus*

radiata, and *Alnus sp*. are potential species [23].

4. CONCLUSIONS AND RECOMMENDATIONS

When industrial plantations are established with suitable fast-growing species, suitable growing areas, and appropriate mechanization techniques, higher wood yields per unit area are achieved compared to traditional afforestation [24]. Because the geographic structure of Türkiye limits the land that fully meets the suitability criteria for such plantations, the idea of implementing industrial plantations across very large areas is unrealistic. Unfortunately, plantation practices based on unrealistic goals have led to poor examples in the history of forestry. The conversion of broadleaf forests, valuable for biodiversity, to monoculture coniferous forests through clear-cutting is a prime example. Furthermore, the planting of *Pinus pinaster* in productive beech areas in the Black Sea Region is another practice that has been criticized on many fronts. Therefore, it is beneficial to plan plantation programs based on land inventories and actual areas. Furthermore, if these practices are expanded to large areas, the disadvantages of monoculture creation and genetic pollution in the context of global climate change should be taken into account.

Considering Turkey's topographic structure, the implementation of industrial plantations presents some challenges stemming from land conditions. Existing land conditions, particularly sloping and rocky terrain, often hinder the proper use of mechanization techniques, essential for industrial plantations. In this case, industrial plantations often devolve into conventional afforestation activities. To avoid such situations, industrial afforestation should be carried out in suitable areas, while traditional afforestation methods should be employed in other areas as conditions permit. Areas below a certain elevation or marginal (rocky and travertine) areas should not be preferred for these industrial plantations [24].

According to legislation regarding the implementation of industrial plantations [13], the initial slope limit was set at 30%, but this limit was later increased to 50% due to difficulties in finding potential sites and the inability to implement annual programs. Increasing the slope limit negatively impacted the industrial nature of these practices. Indeed, even if other characteristics are suitable, in areas with a slope exceeding 30%, normal soil cultivation is not possible due to the high slope, requiring terrace preparation, and terrace spacings that do not allow for narrow planting intervals. However, as explained above, short management periods and narrow planting intervals should be preferred in industrial afforestation. Only in this way will it be possible to achieve high yields and economic value per unit area [24].

In Türkiye, forestry sector organizations, and particularly the panel sector, with their ever-increasing capacity, are placing significant pressure on raw material supply. Alternative methods for these sectors' raw material supply should be developed (private afforestation, incentives, plantations in other countries, etc.). Efficient management of forests by fast-growing native species such as alder should enable them to assume a portion of the raw material supply. This should reduce the production pressure on the natural forests that the panel sector provides raw materials for. In recent years, industrial afforestation activities have been carried out in areas created using traditional methods (e.g., with wide 3x2 m spacings for red pine), but areas that have not yet completed their management periods are being cleared. This practice is flawed. Indeed, management periods and planting intervals affect average yield per unit area [24].

The private sector, and particularly the panel sector, should be supported in its efforts to produce its own raw materials. In this context, private afforestation initiatives should be expanded. Incentives provided to the private sector for land allocation, technical support, credit, and financing could be further increased. Furthermore, knowledge and experience in poplar cultivation should be utilized, and support for poplar afforestation should be increased and sustained.

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