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The Impact of the Increment and Production Relationship on the Species Composition Change in Türkiye's Natural Forests

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Abstract

Aim of study: Forest species composition changes might be caused by both natural processes and human-related factors. The aim of this study is to examine the effect of the balance between annual increment and production of Türkiye's forests on species composition change.

Area of study: The study area is Türkiye that experienced a change of the balance of natural species composition in the last 10 years.

Material and method: The methodology employed in this study involved the collection and analysis of comprehensive data from multiple reliable sources. Statistical information was systematically gathered from Statistics of the General Directorate of Forestry of Türkiye (GDF).

Main results: Our analysis shows that *Fagus* and *Pinus* species have the fastest increasing timber production rate. Additionally, coniferous species are being replaced by non-coniferous species. This situation shows the concerns about transition to different types due to economic reasons and it raises concerns about the disruption of the current species composition.

Research highlights: The excessive demand for wood raw materials and production policies have an impact on the species composition change. Findings show a decrease in 3 of the 6 most widespread species in Türkiye's forests, which consist of 91.3% of the country's forest area.

Keywords: Natural Forests of Türkiye, Species Composition Change, Sustainability, Timber Production, Forest Management

Türkiye Doğal Ormanlarında Artım ve Üretim İlişkisinin Tür Kompozisyonu Değişimine Etkisi

Öz

Çalışmanın amacı: Ormanlardaki tür kompozisyonu değişimi hem doğal süreçlerden hem de insan kaynaklı faktörlerden ortaya çıkabilmektedir. Bu çalışmanın amacı Türkiye ormanlarının yıllık artım ve üretimi arasındaki dengenin tür kompozisyonu değişimine etkisini incelemektir.

Çalışma alanı: Çalışma alanı son 10 yılda doğal tür kompozisyonu dengesi değişen Türkiye'dir.

Materyal ve yöntem: Bu çalışmada kullanılan metodoloji, birden fazla güvenilir kaynaktan kapsamlı verilerin toplanmasını ve analizini içermektedir. İstatistiksel bilgiler, Türkiye Orman Genel Müdürlüğü (OGM) istatistiklerinden sistematik olarak derlenmiştir.

Temel sonuçlar: Analizimiz, *Fagus* ve *Pinus* türlerinin en hızlı artan kereste üretim oranına sahip olduğunu göstermektedir. Ayrıca iğne yapraklı türlerin yerini yapraklı türler almaktadır. Bu durum ekonomik nedenlerden dolayı farklı türlere geçiş endişelerini ortaya koymakta ve mevcut tür kompozisyonunun bozulmasına ilişkin endişeleri artırmaktadır.

Araştırma vurguları: Odun hammaddesine olan aşırı talep ve üretim politikaları, tür kompozisyonunun değişmesi üzerinde etkilidir. Bulgular, Türkiye'nin orman alanının yüzde 91.3'ünü oluşturan en yaygın 6 türden 3'ünde azalma olduğunu gösteriyor.

Anahtar kelimeler: Türkiye'nin Doğal Ormanları, Tür Kompozisyonu Değişimi, Sürdürülebilirlik, Hammadde Üretimi, Orman Yönetimi

Introduction

In recent years, factors such as climate change and increasing social demand for ecosystem services, have put increasing pressure on sustainable forest management practices due to anthropogenic impacts on natural resources (Santopuoli et al., 2021; Dagley et al., 2023). In Türkiye, many natural habitats have been fragmented, degraded, or destroyed due to rapid population growth in the last few decades (Kaya and Raynal, 2001). Looking at the statistics of General Directorate of Forestry in Türkiye (GDF, 2022), we realize that species composition and distribution of Türkiye's natural forests have changed, even in the last 10 years, which is relatively short time. Searching for general reasons for this change, we encountered different results in the literature.

In the study conducted in Slovenia, Bončina et al. (2003) asserted that the reasons for changing the species composition are both natural processes and human-related factors, specifically silvicultural practices, and the influence of ungulates. In addition, different factors such as diseases, fire, weather, and pollution have also been effective in changing the composition of species in some countries being in different geographical areas such as the US, Bolivia, Brazil, Guyana, Costa Rica, and Scotland (Steinman, 1999; Van der Sende et al., 2016; Hester et al., 2019). The study conducted by Goins et al. (2013) in western Ohio, in eastern North America, attributed the decrease in maple (*Acer spp.*) populations while the oak (*Quercus spp.*) populations increased to reasons such as exotic insects, invasive plants, and climate change. Durak and Durak (2015) examined the effect of management policies on the change of species composition in Western and Northern Europe. Looking at the situation in Türkiye, Komurlu (2022) stated that the change in increment and production balance disrupts sustainability.

Concerns about Türkiye's forests have been expressed by many national and international studies in the last 50 years, such as Uslu (1973), Pamay (1980), Miller Rosen (1997), Atmis (2021), Akkemik and Kavgaci (2022), Atmis et al. (2022) and Komurlu et al. (2022). Additionally, there are studies that evaluate Türkiye's forests from a positive perspective such as Yolasigmaz (2013), Esen and Yildiz (2017) and Keles et al (2017).

Since, forests provide essential raw materials to humanity, and the demand for these resources is steadily increasing, countries, that heavily rely on their natural forests as a source of raw materials, bear significant responsibilities in preserving and sustainably managing their ecosystems (Levers et al., 2014). In this context, annual forest volume increment and the production derived from these forests hold paramount importance from both environmental and economic perspectives. Annual increment serves as a crucial indicator of forest health and biodiversity. The growth rates of timber and the proportions of their value in relation to amenity may differ between the types of forests, potentially resulting in variations in their management strategies (Sun and Zhang, 2020). Additionally, it stands as a fundamental factor in the sustainability of forest resources. Briefly, annual forest increment might be utilized as a criterion to comprehend and manage the impacts of both natural and human-related factors.

On the other hand, products derived from forests contribute to the growth of the national economy and development. Forests not only yield products like timber, paper, and lumber but also support natural ecosystems and provide ecosystem services. Therefore, in addition to the existence or increase of the forest, species diversity is also important. Effectively managing these natural resources has critical importance for both economic and environmental sustainability. This study analyzes annual increment and production from Türkiye's natural forests by creating correlation analyses. The aim of this study is to analyze the impact of the relationship between annual increment and production in Türkiye's forests on species composition changes, with a particular focus on the species targeted for intensive production.

Material and Methods

The methodology employed in this study involved the collection and analysis of comprehensive data from reliable sources. Statistical information pertinent to Türkiye's forestry and wood product sectors was

systematically gathered from Statistics of General Directorate of Forestry of Türkiye (GDF).

Türkiye possesses 23.2 million hectares of forest area that yields an annual increment of 47.8 million m^3 (GDF, 2022) and according to FAO (2020), ranked sixth among countries that exhibited the highest annual increase in forest cover during the period 2010-2021. For this reason, we started our research with the data within the date range mentioned by FAO. First, we created a model to examine the relationship between the annual increase and the production amounts from Türkiye's forests. We formulated the production (*X*) from Türkiye's natural forests each year (*n*), the annual current increment obtained each year (*Y*), and the percentage between the increment and the production (*B*). Accordingly, this bilateral relationship is modeled as Eq.1, with the difference between the *B*s obtained each year being *ΔB* (Eq.2).

$$(X / Y)100 = B \quad (1)$$

$$\Delta B = B_n - B_{n-1} \quad (2)$$

ΔB gave us information about the change in the ratio of production to increment. Since the results of the model require detailed examination of Türkiye's forests, the production amounts of 6-coniferous and 5-non-coniferous species, which constitute the source of raw materials obtained from Turkish forests, has been subjected to correlation analysis to see the direction and intensity of production relationship of genera and species. A positive value indicates a positive correlation between variables, and the closer value to 1.00 indicates the strength of this relationship. The relationship is defined as very strong if it is R≥0.8 and strong if it is between 0.5>R>0.8 (İnan, 2009; Lefsky et al., 2005). First, variables are assigned as GDF (2022) presented: *CED* for *Cedrus spp.*, *JUN* for *Juniperus spp.*, PIB for *Pinus brutia*, *OPI* for *Other Pinus species*, *PIC* for *Picea spp.*, *ABI* for *Abies spp.*, *OCO* for other coniferous, *QUE* for *Quercus spp.*, *CAR* for *Carpinus spp.*, *FAG* for *Fagus orientalis*, *POP* for *Populus spp.*, *ALN* for *Alnus spp.* and *ONC* for other non-coniferous. In the statistics presented by GDF (2022), it is understood that the other *Pinus* species defined as *OPI* are *Pinus sylvestris*, *Pinus nigra* and *Pinus pinea*. Since *Pinus sylvestris, Pinus nigra* and *Pinus pinea* production amounts are not published separately by GDF (2022), they are considered as OPI in this study.

After the analysis, since all the correlation coefficients represent a strong and very strong positive relationship with each other, a new regression analysis has also been carried out to find the slope coefficient of these data, to understand the trend of increasing production in these genera and species demanding by forest industry. In this study, slope coefficients show the acceleration of increase or decrease in production. The fact that larger slope coefficients indicate that faster increase of the production amounts than other species. Firstly, we determined the significance of the identified slope coefficients. Hypotheses were formulated to determine their significance. Null Hypothesis (H0): The slope coefficient is not significant, meaning that there is an assumption that there is no change in the data. Alternative Hypothesis (H1): The slope coefficient is significant, implying that there is an assumption that there is a difference from zero in the data.

The collected data subjected to a comprehensive analysis using Python programming language, version 3.10.12, facilitated by a range of libraries including pandas, numpy, matplotlib, statsmodels, and scikit-learn. The pandas library was instrumental in data manipulation and transformation, enabling us to clean, merge, and organize the datasets for subsequent analyses. Numpy provided fundamental support for numerical operations, while matplotlib allowed us to generate visual representations of our findings.

Certain limitations were inherent to our study. The reliance on historical data and the unpredictable nature of future economic and environmental trends introduced inherent uncertainties into our projections. The complex interplay of ecological systems and economic factors necessitated a cautious interpretation of our findings. In addition, the relationship analysis inherent in correlation analysis gave us the direction and severity of this relationship rather than its causality. This

research adhered to ethical standards by utilizing publicly available, anonymized data.

Results and Discussion

As a starting point of the study, we created a model to examine the relationship between the annual increment and production amounts in Türkiye's forests. Model results show that the production obtained from Türkiye's natural forests each year (X) increases faster than the annual current increment (Y), and the percentage change (ΔB) between the increments proceeds the same results with this (Table 1).

Table 1. ΔB Model results

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
X(m^3)	12568519	13582462	14424365	13667987	14923209	16637598	17009998	15521622	19080137	22113248	24751066	27735268
Y(m^3)	40061594	40543474	41025353	42651596	44277840	45904083	46269389	46634694	47000000	47200000	47400000	47600000
B	31.37	33.5	35.16	32.05	33.7	36.24	36.76	33.28	40.6	46.85	52.22	58.27
ΔB	1.56	2.13	1.66	-3.11	1.66	2.54	0.52	-3.48	7.31	6.25	5.37	6.05

Additionally, it is shown annual B percentages in Figure 1-A and ΔB trends in Figure 1-B, according to the results of the model created for examining the relationship between increment and production in Türkiye's natural forests. As shown in the figures, B and ΔB tend to increase. This situation proves that the amount of production increases by a certain percentage each year and approaches the increment. In other words, wood production naturally increases each year, just like the annual increment, but the fact that wood production increases faster than the annual increment may cause the expectation from the increment to gradually decrease. This situation has created the question for a detailed examination of the production of Türkiye's forests.

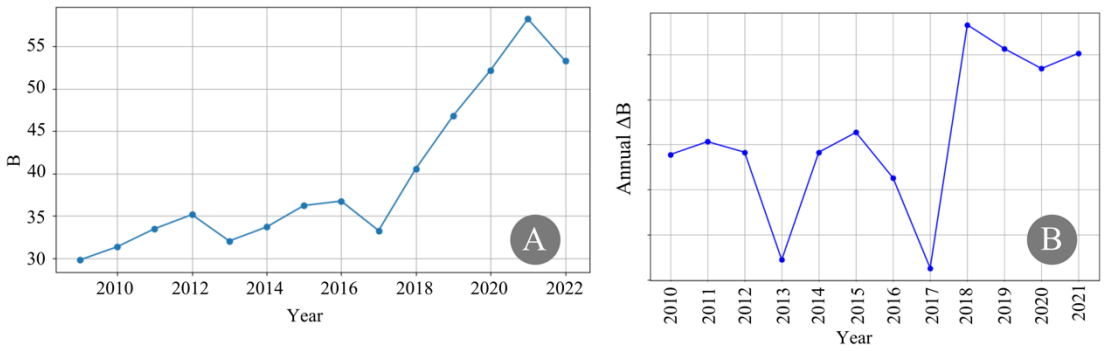

Figure 1. Annual B percentages among 2009-2022 (A) and Annual ΔB trends among 2010-2021 (B)

In the first step, we examine the production amount in detail. The production amount of raw materials obtained from Türkiye's natural forests was provided by official statistics of General Directorate of Forestry (Table 2). It is seen that 100% of the production from Türkiye's natural forests is obtained from the 6 coniferous and 5 non-coniferous genera (GDF, 2022). According to these statistics, it is seen that production is mostly concentrated on Pinus species (*PIB* and *OPI*) in each period. Examining the statistics, seeing that in 2000, the raw material production from forests was obtained mostly from *PIB*, *OPI*, *FAG* and *ABI*, respectively (Table 2). Looking at 2022, it is seen that the first three variables are the same in order, *PIB*, *OPI*, *FAG*. To see the production relationship and direction of these remarkable variables with others, these variables were subjected to correlation analysis.

Table 2. The production amounts assigned variables (m^3) (GDF, 2022)

	CED	JUN	PIB	OPI	PIC	ABI	OCO	QUE	CAR	FAG	POP	ALN	ONC
2000	37097	1810	3139545	2605400	242220	933232	13738	492794	13184	1267441	26021	7637	99911
2001	37477	1209	2797546	2269997	200436	847346	11689	583952	14608	1294502	25421	4051	115235
2002	43064	1357	2438341	3804416	196834	1036366	141035	513500	15242	1191522	18263	8952	111917
2003	26987	1545	2782780	2870385	205717	930498	148848	578151	139282	1215129	21622	10822	135332
2004	63029	1016	2961488	3283133	324536	907123	59746	731641	42263	1395310	23231	8982	175762
2005	57837	466	2980334	3452859	288093	822914	26588	663652	22853	1478591	43122	11536	160152
2006	68345	716	3670605	3870449	253109	1021697	66631	930333	30651	1644400	49506	13807	192040
2007	51463	18236	3924330	4102920	282649	1177608	49847	812678	37887	1841285	44431	9789	220254
2008	40649	1734	4774991	3823152	276960	1449753	47084	871931	44035	1814181	32978	13376	217375
2009	34466	5169	4330895	4466414	238546	1902573	95174	1106725	64840	2241098	34154	11930	204099
2010	74837	4487	4655804	5452185	313110	1671933	126388	1108167	70581	2589810	71395	19913	265414
2011	76121	3663	4945669	6181055	333929	1569372	116933	1206012	75949	2620777	48788	23616	445964
2012	67913	7475	5409140	6222895	345963	1646684	166849	1643231	121211	3079739	81103	27704	273286
2013	70505	4299	5156453	5639205	303828	1707548	92761	1220015	126433	2282523	47014	21676	216506
2014	93563	6831	5749785	6118358	348656	1703364	201996	1521470	115187	2974443	65418	21487	355494
2015	135275	10445	5949506	7465691	310775	1952331	125198	1616483	113840	3008851	60309	45547	446258
2016	135287	9443	5953480	6782605	328884	1896266	211795	1777371	167102	3506162	60130	19100	281317
2017	147712	14875	5405542	6395234	251827	1741647	413377	1757553	214755	3345541	64703	25265	418446
2018	177316	29959	6541644	7443431	636806	2067953	408451	2286005	301162	4032484	138236	49932	324418
2019	233880	23582	8715141	8166663	523561	2207613	520126	2744415	325723	4602055	155636	52689	391913
2020	249591	18204	8949265	9554848	641407	2663942	495117	2729199	318737	5371650	202460	50305	454956
2021	256091	30492	11852034	10494343	652930	2770936	436564	3263640	357483	5339145	217308	44397	418222
2022	225716	25411	11558700	9776829	563665	2634853	328475	3499342	357120	4674449	165042	43405	306049

To examine the correlations among each of these, 13 different categories have been created, including 6 coniferous and 5 non-coniferous genera, as well as other coniferous and other non-coniferous. These data are expected to reflect the link between existing species and the demands of the private sector as GDF's most important customer. When the correlation between species is examined, it is seen that each variable creates a strong or a very strong positive correlation with another one (Table 3). When these correlations are examined separately, the data with the highest average correlation are significant. The highest average is in *FAG*, *QUE*, *CED*, *POP*, and *CAR*, respectively. It indicates a very strong correlation between production from *Fagus orientalis* and the increase in the production amount of any tree species. These correlations are particularly striking among species that reach a value of almost 1.00 between different species. The correlations of *Pinus brutia* with *Abies spp.*, *Quercus spp.* and *Fagus orientalis*, *Abies spp.* with *Fagus orientalis*, *Quercus spp.* with *Cedrus spp.* and *Carpinus spp.*, *Fagus orientalis* with *Cedrus spp.*, *Abies spp.* and *Quercus spp.*, and *Populus spp.* with *Picea spp.* are between 0.95 and 0.98. Therefore, it can be thought that the production tendency for these species is also in a stronger correlation with each other.

Table 3. Correlation values of each variable

	CED	JUN	PIB	OPI	PIC	ABI	OCO	QUE	CAR	FAG	POP	ALN	ONC
CED	1.00	0.86	0.92	0.93	0.90	0.87	0.91	0.95	0.94	0.95	0.94	0.91	0.75
JUN	0.86	1.00	0.84	0.82	0.86	0.79	0.82	0.87	0.88	0.85	0.86	0.82	0.62
PIB	0.92	0.84	1.00	0.95	0.87	0.94	0.79	0.98	0.91	0.94	0.93	0.85	0.71
OPI	0.93	0.82	0.95	1.00	0.86	0.96	0.83	0.96	0.89	0.97	0.90	0.91	0.84
PIC	0.90	0.86	0.87	0.86	1.00	0.82	0.80	0.89	0.88	0.90	0.95	0.87	0.63
ABI	0.87	0.79	0.94	0.96	0.82	1.00	0.80	0.93	0.87	0.95	0.87	0.86	0.78
OCO	0.91	0.82	0.79	0.83	0.80	0.80	1.00	0.86	0.93	0.89	0.86	0.84	0.71
QUE	0.95	0.87	0.98	0.96	0.89	0.93	0.86	1.00	0.95	0.97	0.94	0.89	0.73
CAR	0.94	0.88	0.91	0.89	0.88	0.87	0.93	0.95	1.00	0.93	0.91	0.88	0.67
FAG	0.95	0.85	0.94	0.97	0.90	0.95	0.89	0.97	0.93	1.00	0.94	0.91	0.81
POP	0.94	0.86	0.93	0.90	0.95	0.87	0.86	0.94	0.91	0.94	1.00	0.87	0.67
ALN	0.91	0.82	0.85	0.91	0.87	0.86	0.84	0.89	0.88	0.91	0.87	1.00	0.81
ONC	0.75	0.62	0.71	0.84	0.63	0.78	0.71	0.73	0.67	0.81	0.67	0.81	1.00

However, additional data are needed to fully clarify the results of the analysis. Therefore, it is necessary to find out how fast the production of these genera and species are increasing by the help of slope coefficient, especially for the first three, *PIB*, *OPI* and *FAG*. The rapid increase in production of these industry-demanded species necessitates determining the slope coefficient, which represents the rate of increase over time. This can be achieved through regression analysis for each species to identify which volumetric production data is increasing at a faster rate. The slope coefficient shows how data changes over time, with a larger slope representing a faster increase (Nash et al., 2021). The slope coefficients resulting from the regression analysis are given in Figure 2. However, it is also necessary to determine whether these coefficients are significant. The analysis shows that, for a significance level of $p < 0.05$, H0 was rejected for all variables (Table 4), indicating that the variables were found to be significant. Since H0 is rejected, Slope Coefficients are significant and acceptable, accordingly are shown in Figure 1. By comparing them with existing statistics, the data categories with the highest slope are *PIB*, *OPI*, *FAG*, *QUE*, and *ABI*, respectively. This shows that the production from *PIB*, which has the highest slope coefficient, is increasing faster than other species, every year. Likewise, the slope coefficient of *PIB* is greater than *OPI*, indicating that the production rate of both variables is increasing over the years, however the production amount from *PIB* is increasing faster than from *OPI*.

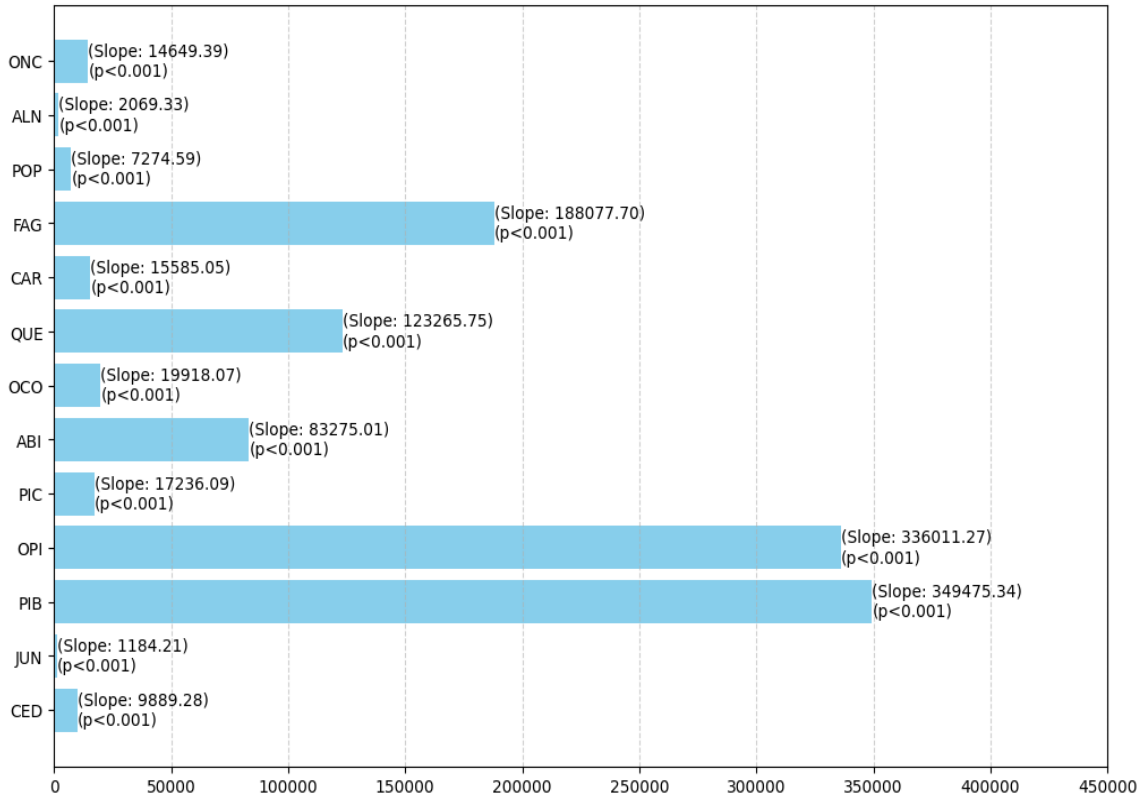

Figure 2. Slope coefficients of variables from production volume and their relevance

Table 4. Statistical Significance of Slope Coefficients

Variable	Test statistics	P-Value	Result
CED	6.660176	p<0.001	H0_Denied_(Significant)
JUN	4.684238	p<0.001	H0_Denied_(Significant)
PIB	9.887735	p<0.001	H0_Denied_(Significant)
OPI	11.445924	p<0.001	H0_Denied_(Significant)
PIC	11.57222	p<0.001	H0_Denied_(Significant)
ABI	12.96371	p<0.001	H0_Denied_(Significant)
OCO	5.534521	p<0.001	H0_Denied_(Significant)
QUE	7.854889	p<0.001	H0_Denied_(Significant)
CAR	5.41852	p<0.001	H0_Denied_(Significant)
FAG	9.774805	p<0.001	H0_Denied_(Significant)
POP	5.983856	p<0.001	H0_Denied_(Significant)
ALN	7.185166	p<0.001	H0_Denied_(Significant)
ONC	11.082494	p<0.001	H0_Denied_(Significant)

This situation has led to questions about forest areas, especially those belonging to species where production is increasing rapidly. There may be real concerns in categories with faster production growth. Therefore, it is necessary to examine the percentages of areas covered by these tree genera or species in Türkiye. According to data gathered from GDF (2022), the species listed in Table 5 occupy Türkiye's forest areas at specified percentages. Over a period of 10 years, an examination of Türkiye's forest area by species reveals that changes in areal percentages are supported by the correlation and regression analyses conducted in this study. The data indicate that the trends in the *PIB* and *OPI* variables are reflected in the areal percentages. Specifically, in the last decade, the area of *Pinus brutia*, represented by the *PIB* variable, has decreased by 4.16%, Other *Pinus* areas, indicated by the *OPI* variable, have decreased by 4.34%, and the area of Fagus orientalis, represented by the *FAG* variable, has decreased by 0.86%.

Table 5. Percentages of areas covered by tree species in Türkiye (%) (GDF, 2022)

Tree types	2012	2015	2018	2019	2020	2021	2022	Difference
Quercus spp.	23.77	26.34	26.25	26.19	29.42	29.42	29.40	5.63
Pinus brutia	27.01	25.11	25.13	25.23	22.74	22.74	22.85	-4.16
Fagus orientalis	9.05	8.50	8.56	8.51	8.19	8.19	8.19	-0.86
Juniperus spp.	2.65	4.29	4.26	4.24	6.42	6.42	6.68	4.02
Abies spp.	3.09	2.62	2.62	2.61	2.23	2.23	2.17	-0.92
Cedrus spp.	2.14	2.16	2.16	2.15	1.75	1.75	2.20	0.06
Picea spp.	1.54	1.45	1.45	1.44	1.60	1.60	1.50	-0.04
Other Pinus	28.89	26.52	26.56	26.63	25.22	25.22	24.55	-4.34
(Pinus nigra)	(21.65)	(19.00)	(19.03)	(19.15)	(18.31)	(18.31)	(17.54)	(-4.11)
(Pinus sylvest.)	(6.83)	(6.80)	(6.80)	(6.76)	(6.15)	(6.15)	(6.26)	(-0.57)
(Pinus pinea)	(0.41)	(0.72)	(0.73)	(0.72)	(0.76)	(0.76)	(0.75)	(0.34)
Alnus spp.	0.65	0.66	0.66	0.66	0.55	0.55	0.54	-0.11
Carpinus spp.	0.09	0.16	0.16	0.16	0.24	0.24	0.24	0.14
Populus spp.	0.03	0.07	0.07	0.07	0.10	0.10	0.21	0.18
Other Non-Con.	0.51	0.40	0.40	0.40	0.35	0.35	0.33	-0.18
Total (ha)	21678134	22342935	222621935	22740297	22933000	23110000	23245000	6.78

According to GDF (2022) data, the six most common genera and/or species in Türkiye are *Quercus spp, Pinus brutia, Pinus nigra, Fagus orientalis, Juniperus spp.,* and *Pinus sylvestris*, respectively. These six species constitute 91.3% of Türkiye's 23.2 million hectares of forests (Table 5). One of the important situations in the table 5 is that the species covering the largest area has changed in 10 years. In addition, there has been a decrease in the forest areas containing the genera and species as *Pinus brutia, Pinus*

nigra, Pinus sylvestris, Fagus orientalis, Abies spp., Alnus spp. and *Other non-coniferous*, and the areas of genera such as *Quercus spp.*, *Populus spp., Carpinus spp.* and *Juniperus spp.* have increased. Concerning the increasing trend of ΔB, enhance the idea that the annual production amount may reach the annual increment of Türkiye's forests and one day exceed it (Komurlu et al, 2022). Kaya and Raynal (2001) state that intensive forestry practices further accelerate the loss of natural forest areas, especially along the coastal Black Sea, coastal Mediterranean, and Aegean regions.

There were 20 million hectares of forest area in Türkiye covering 23.4% of the country's surface area and only 39% of this area was productive in 1973 (GDF, 2022). The annual increment amount for that period was 20.5 million m^3 and the official and unofficial production amount of forests was 25.5 million m^3 (Uslu, 1973). According to this situation, it is seen that the annual wood production was more than the annual increment. Pamay (1980), states that production processes in Türkiye had not been rational, after the adoption of the forest law no: 6831. In 2022, Türkiye's forest area is 23.2 million hectares, covering approximately 30% of Türkiye's surface area (GDF, 2022). Additionally, the productivity rate of Türkiye's forests is 57% (Bilir, 2017). Although statistics show that forest areas are increasing, Gunsen and Atmis (2019) state that they have decreased in 19 of 81 provinces in Türkiye.

Our findings show that species with increased production in Türkiye may face with sustainability threats in the future, as long as they are supported by areal decrease. In other words, there may be a narrowing in the distribution areas of some species in Türkiye's forests, which may be under the threat of desertification and loss of biodiversity (Akkemik and Kavgacı, 2022). Likewise, contrary to the change in the size of forest area, Türkiye's mixed forest stands have been reduced (Aktürk and Güney, 2021). As an example, the structure of a mixed forest consisting of 10 different tree species has been reduced to three to five species due to incorrect procedures, in some parts of the Black Sea Region of Türkiye (Komurlu, 2020).

Despite all this, Yolasigmaz (2013) states that Türkiye is one of the unique countries that has been positively affected by the fundamental changes in the early 2000s and increased the amount of forest area, annual growth, biomass, carbon storage capacity and oxygen production. It is added that, despite these benefits and some problems in the sector, Türkiye has reached the level of transferring technology and knowledge in forest management to neighboring countries with its 150 years of forest application experience. The ecosystem structure in Türkiye's forests has improved due to increasing forest area, rehabilitation and increasing there are positive changes in forest management planning approaches (Keles et al. 2017).

In parallel with this, Esen and Yildiz (2017) states that Türkiye, which stands out with its high biodiversity, has started to give priority to local forest communities for forestry works, to afforest with income-generating native tree species and to carry out integrated rehabilitation works in their region. In addition to functionality, natural afforestation types also are preferred in Türkiye (Sahin et al. 2009).

In summary, there is such research discusses positive and negative aspects about Türkiye's forests. They especially evaluate the forests in Türkiye in terms of wood raw material needs. Zengin et al. (2013) states that management and planning have improved, and a management approach has been exhibited to focus on wood production. Likewise, addressing this situation from a management perspective, Atmis and Gunsen (2018) analyzed the forestry management approach of between 1989-2015 and found that revenues obtained from forests and economic growth are preferred to environmental concerns. Accordingly, to fully understand the issue, the demands of the private sector must also be examined, which is almost the only customer of Türkiye's forests.

Yip (2018) states that healthy forests must have a native forest species to support ecological integrity, and states that forest

owners decide tree species based on functional qualities. Smaill (2014) conducted a survey to determine the perception of stakeholders in forest management, concluding their perceptions have a significant impact on, but erroneous views predominate. Baskent (2022) states that, in determining wood raw material production strategies in Türkiye, stakeholders who are interested in timber supply are more influential than stakeholders focusing on wildlife conservation and other ecosystem goods and services. Accordingly, due to the overwhelming demand for wood products by private timber industries, there is a certain level of conflict between government institutions and other private stakeholders, especially those involved in the provision of forest products and sustainable forest management.

Our findings reflect that Türkiye's forests are increasing, especially the period mentioned by FAO, 2010-2021, but natural forests are beginning to transform into commercial species. Oruç (2012) stated that *Quercus* spp. hold significant value in the sheathing industry. Baştürk (1996) highlighted the suitability of *Juniperus spp.* for the particleboard industry and emphasized the importance of focusing on the afforestation of these species. While the increase in the areal percentages occupied by these species (Table 5) supports this assertion, recent studies have also aimed at expanding the areal presence of *Populus spp*. Heilman (1999) states that the using rate of *Populus spp.*, ranges from poles for rafters and other elements of construction in agrarian economies to the manufacture of paper, plywood, oriented strand board, and lumber in industrial nations. *Populus spp.* are fast-growing species and can reach slaughter maturity in 12-15 years (Saribas, 1985). For this reason, it can be predicted that *Populus spp.* areas and production will increase faster in the coming years. Considering areal increase of all three species with their lower slope parameters (Figure 1), this points us to the danger of monocultural management, even in certain areas. According to Kaya and Reynal (2001), monocultural management reduces habitat diversity, especially in forest areas where micro-habitat differences are essential for wildlife.

Ogur and Ocakverdi (2022) state that in locations where *Pinus brutia* dominates, it has begun to come under pressure from different species for various reasons, especially commercial concerns. In our study, when the slope coefficient of *Pinus brutia* and the change area are examined together, it gives similar results. Slope parameters show that production from the *Pinus brutia* is the fastest-increasing production type. On the other hand, the area it covers has decreased by 9.24% in the last 10 years. For this reason, when the species with increasing and cultivation areas due to their commercial value are considered together, it can be predicted that the distribution areas of *Pinus brutia* species in Türkiye might gradually decrease in the coming years.

Akkaya et al. (2020) states that as the US dollar gained value against the Turkish Lira, the private sector has turned to Türkiye's forests for its raw material needs, and this led to the substitution of some imported wood species with local ones. However, it is also stated that Türkiye's forests are not sufficient to meet this need due to its structure. Ozertan and Cosgun (2021) states that 38% of the industrial wood used in our country is fiber, 37% is log, and 16% is pulp wood. 84% of this need is obtained from local forests, 15% from the private sector and only 1% from imports. Using area of these raw materials covers panel (50%), timber (22%), pallet and packaging industry (21%), and other uses. GDF (2022) states that of the 25.5 million m^3 raw material produced from Türkiye's forests, 9.4 million m^3 is fiber, 8.6 million m^3 is log, and 5.4 million m^3 is pulpwood.

Examining the genera and species for this production is harvested from, it is seen that the species whose production is increasing rapidly are mostly coniferous species and generally are *Pinus* by the help of slope coefficients. 3 of the 6 most widespread categories in Türkiye are *Pinus* species. The areal decline of *Pinus brutia, Pinus nigra,* and *Pinus sylvestris* species and their replacement by non-coniferous species increases degradation concerns.

Conclusion

The private forestry industry moves away from species selectivity due to the constantly increasing demand for raw materials. For this reason, it is seen that all the domestic raw materials in the market are purchased by the private industry, regardless of type. Moreover, while the continuity of the primary species produced in Türkiye should be ensured, it is observed that there is a switch to different species due to economic concerns. This increases the concerns about the degradation of existing species for the coming years.

As Kaya and Raynal (2001) said, although there are many laws promoting biodiversity in Türkiye, the intense pressure on Türkiye's natural resources resulting from human and industry demand requires new techniques to promote sustainable resource use.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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References

Akkaya, M., Ok, K., Koç, M., Akseki, İ., and Akkas, M. E. (2020). Sectoral use of imported wood raw material in Turkey. Turkish Journal of Forestry, 21(3), 279-293.

Akkemik, U., and Kavgaci, (2022). Çölleşme ve biyolojik çeşitlilik kaybı. Türkiye Ormancılığı 2022, Türkiye'de ormansızlaşma ve ormanların bozulması. 91-106.

Aktürk, E. & Güney, K. (2021). Vegetation Cover Change Analysis of Phytogeographic Regions of Turkey Based on CORINE Land Cover Datasets from 1990 to 2018. Kastamonu University Journal of Forestry Faculty, 21(2), 150-164.

Atmis, E. (2021). Proceedings Book of 3rd International Congress on Agricultural and Food Ethics. The real dimensions of deforestation in Turkey. 58-63.

Atmis, E., Erdonmez, C., and Ozkazanc, N. K. (2022). Türkiye Ormancılığı 2022, Türkiye'de ormansızlaşma ve ormanların bozulması. Türkiyede ormansızlaşma, 37-50.

Atmiş, E., and Günşen, H. B. (2018). Comparative Analysis of forestry policy and implementation during the AK Party Period in Turkey. International Forestry Review, 20(4), 405-419.

Baskent, E. Z. (2022). Reflections of stakeholders on the forest resources governance with power analysis in Turkey. Land Use Policy, 115, 106035.

Baştürk, M. (1996). Boylu ardıç, (Juniperus excelsa Bieb.) odununun yongalevha üretimine uygunluğu üzerine araştırmalar. Journal of the Faculty of Forestry Istanbul University, 43(2), 155-168.

Bilir, N. (2017). General over-view of forest establishment in Turkey. Reforesta. 48-52.

Boncina, A., Gaspersic, F., and Diaci, J. (2003). Long-term changes in tree species composition in the Dinaric mountain forests of Slovenia. The Forestry Chronicle. 79(2), 227-232.

Dagley, C. M., Berrill, J. P., and Fraver, S. (2023). Forest restoration mitigates drought vulnerability of coast Douglas-fir in a Mediterranean climate. Canadian Journal of Forest Research. 53(3), 210-216.

Durak, T., and Durak, R. (2015). Vegetation changes in meso-and eutrophic submontane oak–hornbeam forests under long-term high forest management. Forest Ecology and Management, 354, 206-214.

Esen, D., and Yıldız, O. (2017). Forest restoration in the Mediterranean region of Turkey. Sustainable restoration of Mediterranean forests Analysis and perspective within the context of bio-based economy development

under global changes International Congress, Book of abstracts.

FAO. (2020). Global Forest Resources Assessment 2020: Main report. Rome.

GDF. (2022). Official statistics of General Directorate of Forestry of Turkey.

Goins, S. M., Chapman, J. I., and McEwan, R. W. (2013). Composition shifts, disturbance, and canopy-accession strategy in an oldgrowth forest of Southwestern Ohio, USA. Natural areas journal, 33(4), 384-394.

Günşen, H. B., and Atmış, E. (2019). Analysis of forest change and deforestation in Turkey. International Forestry Review, 21(2), 182-194.

Heilman, P.E. (1999). Planted forests: poplars. In: Boyle, J.R., Winjum, J.K., Kavanagh, K., Jensen, E.C. (eds) Planted Forests: Contributions to the Quest for Sustainable Societies. Forestry Sciences, vol 56. Springer, Dordrecht.

Hester, A. J., Britton, A. J., Hewison, R. L., Ross, L. C., and Potts, J. M. (2019). Long-term vegetation change in Scotland's native forests. Biological Conservation, 235, 136-146.

İnan, M. (2009). Uzaktan algılama verileri ve orman meşcerelerine ait dendrometrik elemanlar arasındaki spektral ilişkiler. Eskişehir Osmangazi Üniversitesi, Mühendislik ve Mimarlık Fakültesi Dergisi, 22(3), 21-33.

Kaya, Z., and Raynal, D. J. (2001). Biodiversity and conservation of Turkish forests. Biological conservation, 97(2), 131-141.

Keleş, S., Durusoy, I., and Çakır, G. (2017). Analysis of the changes in forest ecosystem functions, structure and composition in the Black Sea region of Turkey. Journal of Forestry Research, 28, 329-342.

Kömürlü, M., (2020). Orman Amenajman Planları, Uygulamalar ve Orman Varlığımız - Mustafa Kömürlü. Türkiye Ormancılar Derneği'nin 95. Kuruluş Yıldönümünde: Orman Varlığımız ve Ormancılık Üretim Faaliyetleri. Türkiye Ormancılar Derneği Yayın No: 51. ISBN: 978-975-93478-8-8. Sayfa; 31. Ankara, 2020.

Komurlu, M., Atmis, E., Alan, M. and Ondaral, S. (2022). Aşırı odun üretimi. Türkiye Ormancılığı 2022, Türkiye'de ormansızlaşma ve ormanların bozulması. pp.53-76

Lefsky, M. A., Hudak, A. T., Cohen, W. B. and Acker, S. A. (2005). Patterns of covariance between forest stand and canopy structure in the Pacific Northwest. Remote Sensing of Environment, 95(4), 517-531.

Levers, C., Verkerk, P. J., Müller, D., Verburg, P. H., Butsic, V., Leitão, P. J., Lindner, and M., Kuemmerle, T. (2014). Drivers of forest harvesting intensity patterns in Europe. Forest ecology and management, 315, 160-172.

Miller Rosen, A. (1997). The geoarchaeology of Holocene environments and land use at Kazane Höyük, SE Turkey. Geoarchaeology: An International Journal, 12(4), 395-416.

Nash, S., Morgan, K. E., Frost, C., and Mulick, A. (2021). Power and sample-size calculations for trials that compare slopes over time: Introducing the slopepower command. The Stata Journal, 21(3), 575-601.

Ogur, E., and Ocakverdi, H. (2022). Plant Sociology and Ecology of the Area Between Yayladağı, Kışlak (Hatay) and the Syrian Border. ANADOLU Journal of Aegean Agricultural Research Institute, 32(1), 7-27.

Oruç, S. (2012). Hatay (Dörtyol) yöresinde doğal olarak yetişen saplı meşe (Quercus robur L.) odununun bazı teknolojik özellikleri ve kullanım alanları üzerine araştırmalar (Master's thesis, Fen Bilimleri Enstitüsü).

Ozertan, G., and Cosgun, A. (2021). Masif ahşap sektörü raporu. Ahşap kullanımının artırılması için massif ahşap sektörü raporu.

Pamay, B. (1980). Türkiye ormancılığının ana sorunları. Journal of the Faculty of Forestry Istanbul University, 30(2), 68-92.

Sahin, İ. F., Sever, R., Koca, H., Kayserili, A., & Altas, N. T. (2009). Turkey Forest with Respect to Sustainability. In International Symposium on Sustainable Development (pp. 191-194).

Santopuoli, G., Temperli, C., Alberdi, I., Barbeito, I., Bosela, M., Bottero, A. Klopčič, M., Lesinski, J, Panzacchi, P, and Tognetti, R. (2021). Pan-European sustainable forest management indicators for assessing Climate-Smart Forestry in Europe. Canadian journal of forest research, 51(12), 1741-1750.

Saribas, M. (1985). Yamaç arazilerde kavakçılık. Journal of the Faculty of Forestry Istanbul University, 35(2), 115-120.

Smaill, S. J., Bayne, K. M., Coker, G. W., Paul, T. S. and Clinton, P. W. (2014). The right tree for the job? Perceptions of species suitability for the provision of ecosystem services. Environmental Management, 53, 783-799.

Steinman, James R. (1999). Changes in Composition of the Mixed Mesophytic Forest: Effects of Succession and Disturbance.

Sun, X. and Zhang, D. (2020). A theoretical and empirical analysis of joint forest production: Timber supply and amenity services. Forest Policy and Economics, 115, 102132.

Uslu, S. (1973). Türkiye'de orman tahribatı ve doğurduğu problemler. Journal of the Faculty of Forestry Istanbul University, 40-47.

Van der Sande, M. T., Arets, E. J., Peña-Claros, M., de Avila, A. L., Roopsind, A., Mazzei, L., et al.

(2016). Old-growth Neotropical forests are shifting in species and trait composition. Ecological Monographs, 86(2), 228-243.

Yip, V. (2018). Species Diversity and Preferred Attributes of Trees: A Case Study of the Private Urban Forest in the Greater Toronto Area. A thesis submitted in conformity with the requirements for the degree of Master of Science.

Yolasigmaz, H.A. (2013). Forestry in Turkey from the Forest Management Perspective. International Caucasian Forestry Symposium

Zengin, H., Yeşil, A., Asan, Ü., Bettinger, P., Cieszewski, C. and Siry, J. P. (2013). Evolution of modern forest management planning in the Republic of Turkey. Journal of Forestry, 111(4), 239-248.