SILVA WORLD

2025 Volume 4 Issue 2

e-ISSN: 2822-6127

PRENSIP

silvaworld.org

SILVAWORLD

2025 ● VOLUME 4 ● ISSUE 2

silvaworld.org silvaworldjournal@gmail.com

prensip.gen.tr info@prensip.gen.tr

SilvaWorld is a peer-reviewed scientific journal published by ***Prensip Publishing*** twice a year.
Use of any material hereunder requires a citation to ***SilvaWorld***.

S I L V A W O R L D

2025 ● VOLUME 4 ● ISSUE 2

T A B L E   O F   C O N T E N T S

http://silvaworld.org

SilvaWorld

e-ISSN: 2822-6127

https://prensip.gen.tr

RESEARCH ARTICLE

Effects of Different Auxin Concentrations on Growth of Autumn Olive (*Elaeagnus umbellata* Thunb.) Saplings

Ercan Oktan[1]✉ • Neslihan Atar[2] • Öznur Özkan[3]

[1]Karadeniz Technical University, Faculty of Forestry, Department of Forest Engineering, Trabzon/Türkiye
[2]Artvin Çoruh University, Faculty of Forestry, Department of Forest Engineering, Artvin/Türkiye
[3]Artvin Çoruh University, Institute of Science, Department of Forest Engineering, Artvin/Türkiye

ARTICLE INFO

Article History
Received: 24.08.2025
Accepted: 15.09.2025
First Published: 29.09.2025

Keywords
Cuttings propagation
Growth
IBA
Root collar diameter
Sapling height

ABSTRACT

Autumn olive (*Elaeagnus umbellata* Thunb.) is a versatile plant used for numerous purposes in nature, distinguished by its medicinal and ecological benefits. Its ability to adapt and grow in challenging environmental conditions, improve soil, and survive with minimal water makes it a critical species, particularly in combating climate change. While this highly important plant can be propagated from seed, studies on its vegetative propagation are limited. The success of vegetative propagation is not solely a dependent on obtaining rooted cuttings; it depends on the production of high-quality saplings from these cuttings. Therefore, data on the effects of saplings grown from rooted cuttings on long-term growth performance are important to demonstrate the success of the application. This study was conducted to determine the optimal Indole-3-Butyric Acid (IBA) concentration for the growth of surviving individuals obtained from rooted cuttings at different time intervals (June 19, 2023, and December 8, 2023) over a period of one and a half years. For this purpose, the effects of different concentrations of Indole-3-Butyric Acid [IBA (1000 ppm, 5000 ppm, and 8000 ppm)] on the root collar diameter and sapling height in *Elaeagnus umbellata* saplings propagated from cuttings were investigated. A control group was also created without hormone application. It was found that IBA application improved the growth of *E. umbellata* saplings, but the first year of measurements were not sufficient to assess growth performance. Among the hormone concentrations tested over the long term, a dose of 5000 ppm IBA was found to be more effective on growth ($p<0.05$). The success of vegetative propagation depends on obtaining high-quality saplings that meet the desired standards. Therefore, to achieve long-term results, the rooting and sapling production processes must be considered.

Please cite this paper as follows:

Oktan, E., Atar, N., & Özkan, Ö. (2025). Effects of different auxin concentrations on growth of autumn olive (*Elaeagnus umbellata* Thunb.) saplings. *SilvaWorld*, *4*(2), 54-65. https://doi.org/10.61326/silvaworld.v4i2.401

1. Introduction

Autumn olive (*Elaeagnus umbellata* Thunb.) is a member of the Elaeagnaceae family and grows native in Pakistan, China, India, Korea, and Japan. *E. umbellata* is commonly known as autumn olive and Japanese silverberry (Gamba et al., 2020). *E. umbellata* is a deciduous spiny branched shrub or small tree of about 3.5-5.5 m height and a diameter of 10 cm with clusters of elliptic, oblong, ovate, and alternate leaves (Ahmad et al., 2005, 2006; Chauhan et al., 2023). It is generally distributed at elevations of 1200–2100 m and grows at temperatures ranging from 43 to 55 °C (Ahmad & Kamal, 2002; Ahmad et al., 2006; Bhat et al., 2023) and a pH range of 5.5-9.5 (Ahmad et al., 2005). *E. umbellata,* which is very well adapted to arid conditions, prefers full sunlight and is capable of growing in saline, clay, and sandy soils. It grows very quickly and quickly covers the area where it is planted (Çelik & Çil,

✉ Corresponding author
E-mail address: oktan@ktu.edu.tr

2021). Its bright red or yellow edible fruits are extremely rich in antioxidants, carotenoids, lycopene and many other carotenoids (Fordham et al., 2001, 2002; Ghellam et al., 2021). These berries contain 17 times more lycopene than tomatoes. Lycopene has been linked to the prevention of some chronic diseases, including prostate cancer (Nazir et al., 2025; Üreyen Esertaş & Cora, 2024). Therefore*, E. umbellata* berries play a beneficial role in protecting human health and reducing the risk of many diseases (Bhat et al., 2023; Fordham et al., 2001; Ghellam et al., 2021). These miraculous berries have great industrial potential because they can be used and processed in the food industry (Khattak, 2012), as well as in the pharmaceutical and cosmetic industries. The autumn olive is found wild or cultivated as an ornamental plant due to its dense branching, fragrant blossoms, pointed, long-elliptical leaves, and short stems (Petrescu & Paraschiv, 2022). It is used as a hedge in urban areas due to its ornamental value, drought tolerance, adaptability to different environments, and compact structure (Patel, 2015). It is also a suitable plant for open areas in forests, garden edges, and grass areas. Autumn olive is valuable for shelter and nesting, and its protein-rich berries provide a continuous food source for wildlife (Kohri et al., 2011; Munger, 2003). Root nodules on autumn olives are infected by an endophyte that maintains a symbiotic relationship with the roots and helps provide nitrogen or nutrients to the plant (Graham, 1964; Kim et al., 1993). Thanks to its nitrogen-fixing ability, it can grow in eroded and degraded soils and is used for the stabilization of these areas (Ahmad et al., 2005; Torrey, 1978). Because its root nodules contain nitrogen-fixing actinomycetes, it grows well even in infertile soils. This symbiosis allows for the fixation and subsequent utilization of atmospheric nitrogen (Clark & Hemery, 2006; Malinich et al., 2017; Torrey, 1978). Thanks to its nitrogen-fixing ability and its ability to withstand drought, diseases, and infertile soils, the autumn olives are widely planted in degraded lands, arid regions and along highways to prevent soil erosion (Fordham et al., 2002). These characteristics, which can be considered important against global climate change, are one of the most important problems of our time, further increasing the importance of this species. The autumn olive is also used in the reclamation of mining sites. Therefore, its exceptional resistance to adverse conditions and its ability to grow even in adverse conditions are crucial for the improvement of these areas (Fowler & Adkisson, 1980). Autumn olive, which stands out with its multifaceted benefits, is a new and alternative species for Türkiye and has not been adequately studied. *E. umbellata* is generally propagated by seed, with limited vegetative propagation. Few studies have been conducted on the propagation of *E. umbellata* by cuttings, with most studies focusing on seed production (Ciccarese & Jinks, 1997; Eckardt & Sather, 1987; Fowler & Fowler, 1987; Olson & Barbour, 2004).

Cutting propagation, one of the vegetative propagation methods, is one of the most important propagation methods for evergreen broad-leaved and coniferous plant species, as well as deciduous fruit and shrub species (Kantar, 2017). The most important advantages of cutting propagation are that it enables the production of a large number of genetically superior plants in a short time and that it is a low cost, fast and simple method (Çorbacı et al., 2023; İzgi, 2020; Yang et al., 2021). Plant growth regulators are of great importance in cutting propagation. Auxins are plant hormones that have a positive effect on root formation and cutting quality, particularly in cutting propagation (Blythe et al., 2007; Taiz & Zeiger, 2013; Tien et al., 2020). Auxins are primarily used to increase plant production by improving rooting percentages and can also improve plant quality parameters such as adventitious root number root system symmetry, and root/shoot ratio (Bryant & Trueman, 2015; Hunt et al., 2011). These parameters have significant effects on tree stability, tree survival, and trunk volume in the nursery and plantation. For example, raising the number of adventitious roots from one to five increases nursery survival by 11% (Goldfarb et al., 1998), tree height after two years by 23% (Haines et al., 1992), and trunk diameter after five years by 12% (Foster et al., 2000) in various *Pinus* species. Therefore, the application of plant growth regulators can stimulate both root and shoot development, supporting faster and stronger sapling formation in the nursery and field at later stages (Hartmann et al., 2011; Neto et al., 2024). Therefore, their role in almost all growth and development processes and in obtaining healthier saplings in the following years is quite important (Batista-Silva et al., 2024; Pulatkan & Kaya Şahin, 2022; Yan et al., 2017). Indole-3-butyric acid is one of the auxins commonly used for root stimulation (Hartmann et al., 1997; Ludwig-Müller, 2000). Indole-3-butyric acid is preferred due to its ability to initiate root formation, its stability, and its non-toxic to plants over a wide concentration range. However, studies on its effects on the growth and development of saplings produced from cuttings are insufficient. This study was conducted to determine the appropriate IBA concentration for the growth of surviving plants from rooted cuttings obtained with different hormone concentrations.

2. Materials and Methods

Hardwood cuttings taken from the last annual shoots of an only individual located on the Kanuni Campus of Karadeniz Technical University were used as material in the study. Cutting preparation took place in February 2022 in a sterile environment reserved for production at The Research and Application Greenhouse at Faculty of Forestry, Karadeniz Technical University (Figure 1a). To reduce water loss from the leaves during the rooting process, the lower 4-5 cm leaves of the cuttings were cut. A total of 200 cuttings, 50 for each group, were prepared at 15 cm in length and planted 3-4 cm apart, with their leaves touching each other (Figure 1b). Cuttings were treated with three different hormone dose concentrations of powder IBA (1000 ppm, 5000 ppm, and 8000 ppm) for 5 seconds, was planted in 100% perlite, a medium with high water retention and aeration capacity. A control group without hormone application was also created and planted in the same environment (Figure 1c). During the rooting period, the cuttings were watered regularly and the conditions inside the greenhouse were made suitable. The greenhouse temperature was kept constant at 25±1°C and humidity at 60-70%. Callus and root formation on cuttings were observed daily starting from four weeks. Towards the end of May, the cuttings were carefully removed, and rooting, survival rates, and health status were recorded (Figure 1d). Rooted cuttings obtained by vegetative propagation were planted in polyethylene bags (12 cm x 23 cm) consisting of a mixture of River Sand + Forest Soil + Red Soil (1:2:2) (Figure 1e). The root collar diameter (mm) and height of the saplings (cm) grown in open fields were measured at different time intervals (June 19, 2023, and December 8, 2023) and their growth were recorded (Figure 1f, g).

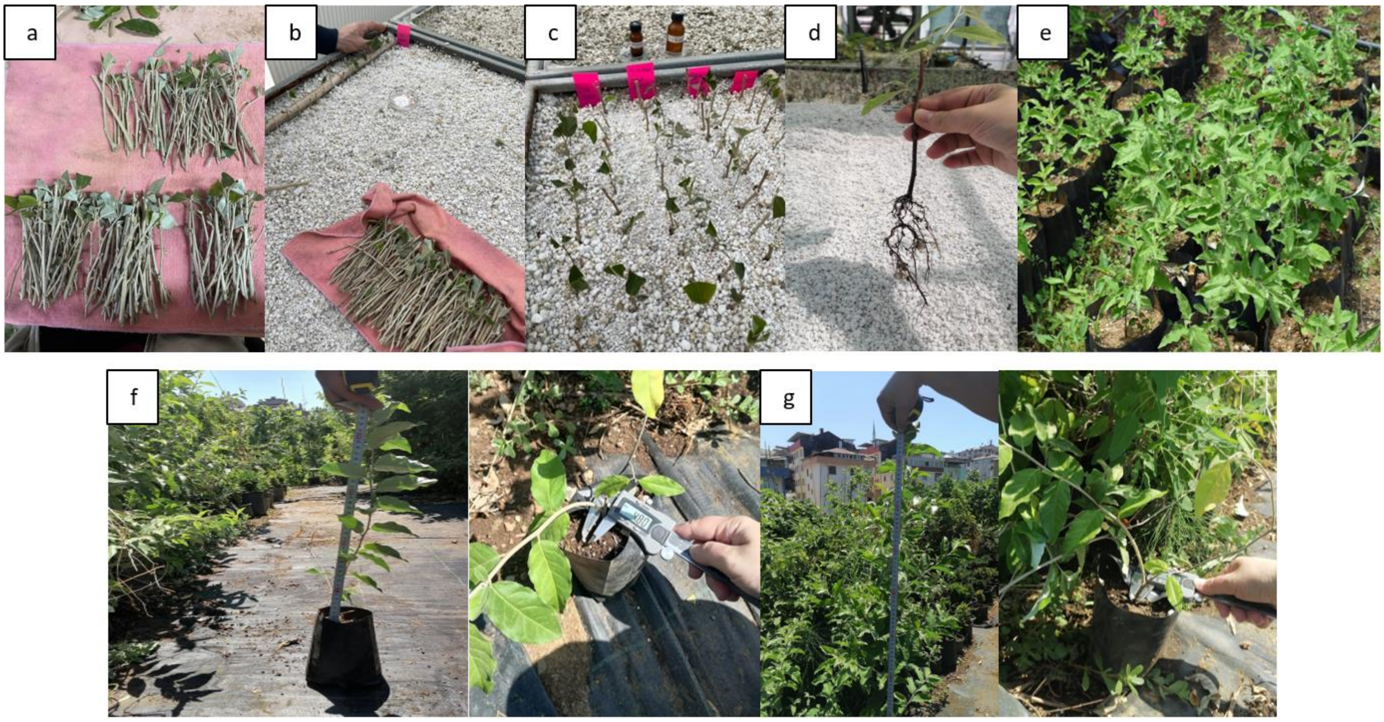

Figure 1. Hardwood cuttings of autumn olive (a), preparation (b), planting in perlite (c), observation of rooting data (d), planting of rooted cuttings in polyethylene bags in the open field (e), carrying out the first measurements on June 19, 2023 (f), carrying out the second measurements on December 8, 2023 (g).

2.1. Statistical Analysis

The IBM SPSS Statistics 23.0 statistical program was used to analyze the data. One-way analysis of variance was applied to determine the effects of hormone treatments on sapling growth, and homogeneous groups were identified using the Duncan test. Graphs were also generated for the results, and evaluations were made accordingly.

3. Results and Discussion

The effects of different IBA doses on the growth of *E. umbellata* saplings produced from cuttings were investigated. It was revealed that different hormone concentrations did not create a statistically significant difference in root length and root number measurements taken after the first rooting ($p>0.05$). However, measurements after transplanting revealed that different hormone concentrations produced statistically significant differences in root collar diameter and sapling height distributions.

The Kolmogorov-Smirnov test was used to test the normal distribution of root collar diameter and sapling height values from the measurements dated June 19, 2023. Accordingly, the data for both values were normally distributed ($p>0.05$) (Table 1). Whether the root collar diameter and sapling height showed a normal distribution as a result of hormone application was also evaluated with the box plot (Figure 2 and Figure 3).

Table 1. Normal distribution test of root collar diameter and sapling height measurements on June 19, 2023.

	Hormone	Kolmogorov-Smirnov[a]		
		Statistic	**df**	**Sig.**
Root collar diameter	Control	0.138	23	0.200*
	IBA 1000	0.129	23	0.200*
	IBA 5000	0.084	36	0.200*
	IBA 8000	0.112	27	0.200*
Sapling height	Control	0.115	23	0.200*
	IBA 1000	0.093	23	0.200*
	IBA 5000	0.131	36	0.125
	IBA 8000	0.090	27	0.200*

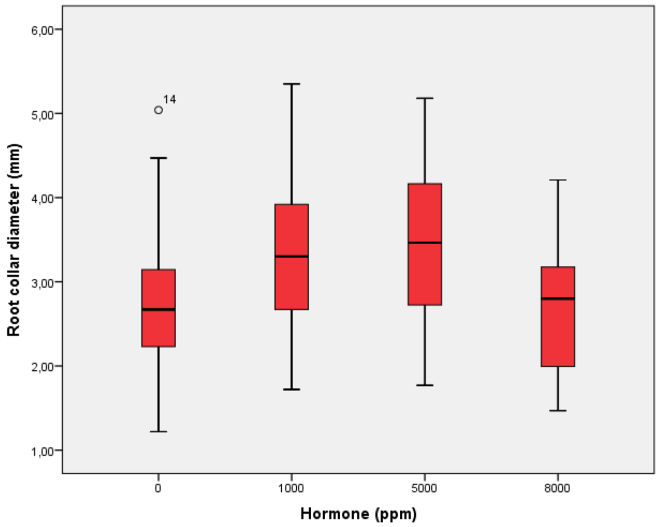

Figure 2. Box plot distribution of root collar diameter.

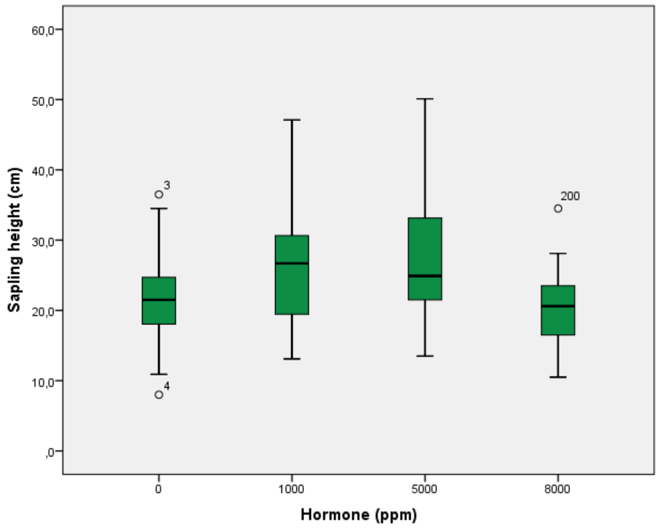

Figure 3. Box plot distribution of sapling height.

An examination of the box plot of the root collar diameter values reveals a normal distribution. However, one data appears to be extremely high in the control group's distribution. This data is considered negligible. On the other hand, the data show a statistically normal distribution, and the most ideal distribution in this distribution is shown by the data with the 5000 ppm IBA hormone.

An examination of the box plot of the sapling height values reveals a normal distribution. However, one data appears to be extremely high and one data appears to be extremely low in the control group's distribution. Similarly, one data appears to be extremely high in the distribution of the 8000 ppm IBA hormone group. This data point is considered negligible. On the other hand, the data show a statistically normal distribution, and the most ideal distribution in this distribution is shown by the data with the control group.

When variance analysis was applied to the root collar diameter and height measurements of *E. umbellata* saplings different hormone doses dated June 19, 2023, it was revealed that they showed statistically significant relationships ($p<0.05$) (Table 2).

Table 2. Analysis of variance (ANOVA) results for the effects of three different concentrations of IBA hormone (1000 ppm, 5000 ppm, and 8000 ppm) on root collar diameter and sapling height in *Elaeagnus umbellata* saplings on June 19, 2023.

		ANOVA				
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Root collar diameter	Between Groups	13.18	3	4.39	5.39	0.002
	Within Groups	86.41	105	0.82		
	Total	99.59	108			
Sapling height	Between Groups	933.56	3	311.19	5.56	0.001
	Within Groups	5881.49	105	56.01		
	Total	6815.05	108			

Due to the statistical differences found between the hormone doses as a result of the analysis, the Duncan test was applied, resulting in homogeneous groups. Two distinct groups were formed based on the Duncan test results. The control and IBA 8000 ppm hormone doses were grouped in one group for root collar diameter and sapling height growth, while the IBA 1000 ppm and IBA 5000 ppm hormone doses were grouped in the other group (Table 3 and Table 4). Accordingly, there was no difference between the control and IBA 8000 ppm hormone doses in root collar diameter and sapling height growth. The IBA 1000 and IBA 5000 hormones showed better growth compared to these applications, but there was no statistical difference between the two.

Table 3. Duncan test results for IBA (1000 ppm, 5000 ppm, and 8000 ppm) hormone doses differing in root collar diameter.

Root Collar Diameter			
Duncan[a,b]			
Hormone	N	Subset for alpha = 0.05	
		1	2
IBA 8000	27	2.67	
Control	23	2.79	
IBA 1000	23		3.37
IBA 5000	36		3.44
Sig.		0.640	0.775

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 26.355.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 4. Duncan Test results for IBA (1000 ppm, 5000 ppm, and 8000 ppm) hormone doses differing in sapling height.

Sapling Height			
Duncan[a,b]			
Hormone	N	Subset for alpha = 0.05	
		1	2
IBA 8000	27	20.49	
Control	23	21.72	
IBA 1000	23		26.14
IBA 5000	36		27.25
Sig.		0.554	0.592

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 26.355.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

In measurements taken during the first year (June 19, 2023), the highest average root collar diameter (3.44 mm) and sapling height (27.25 cm) were achieved with the 5000 ppm IBA hormone dose. However, there was no statistical difference between the root collar diameter (3.37 mm) and height (26.14 cm) values obtained with the 1000 ppm hormone dose. The 8000 ppm IBA treatment and the no-hormone control group did not produce a significant difference in the growth of *E. umbellata* saplings, and the saplings exhibited lower root collar diameter and height (Table 3 and Table 4). The differences in root collar diameter and height caused by different hormone concentrations are clearly evident in Figure 4 and Figure 5. With the increase in hormone dose (IBA 8000 ppm), root collar diameter and height growth showed a low growth and there was no difference with the control application without hormone application, which also reveals that the increase in hormone dose has an inhibitory effect on growth.

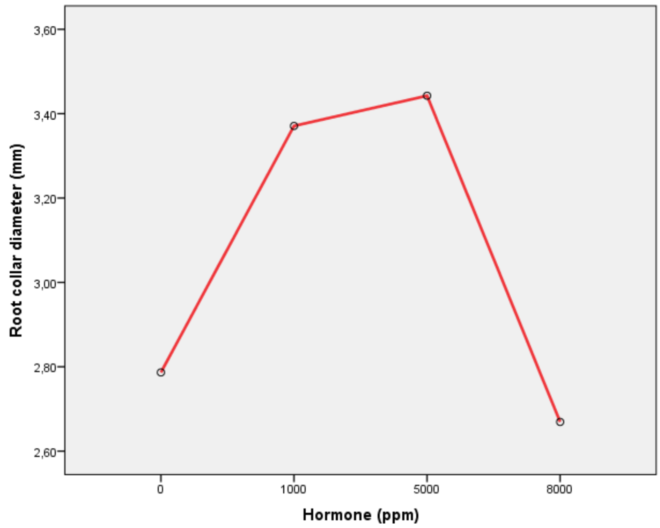

Figure 4. Effect of different hormone concentrations on root collar diameter in measurements conducted on June 19, 2023.

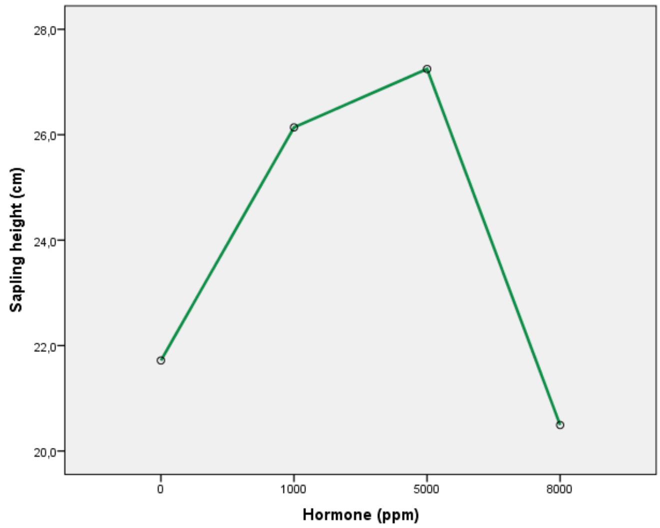

Figure 5. Effect of different hormone concentrations on sapling height in measurements conducted on June 19, 2023.

In measurements taken on December 8, 2023, root collar diameter was not normally distributed only for the control group ($p<0.05$), while height distribution was not normally distributed only for the IBA 8000 hormone dose ($p<0.05$) (Table 5). The box plot distribution of root collar diameter and sapling height as a result of hormone application is shown in Figure 6 and Figure 7.

Table 5. Normal distribution test of root collar diameter and sapling height measurements on December 8, 2023.

	Hormone	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Root collar diameter	Control	0.181	23	0.050
	IBA 1000	0.140	23	0.200*
	IBA 5000	0.105	35	0.200*
	IBA 8000	0.146	25	0.176
Sapling height	Control	0.171	23	0.079
	IBA 1000	0.140	23	0.200*
	IBA 5000	0.099	35	0.200*
	IBA 8000	0.213	25	0.005

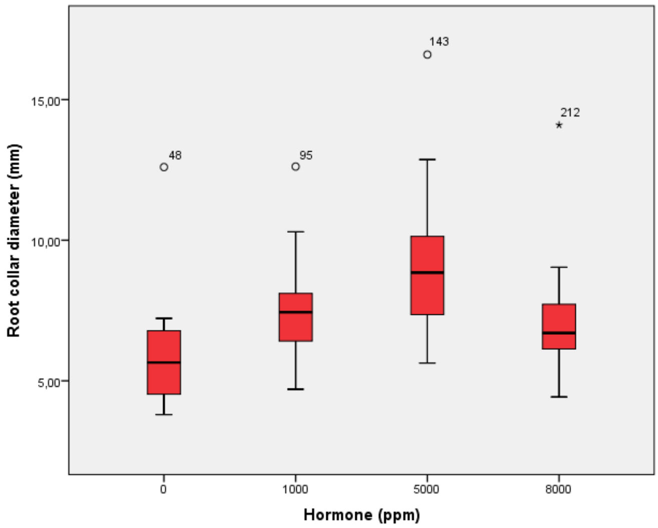

Figure 6. Box plot distribution of root collar diameter.

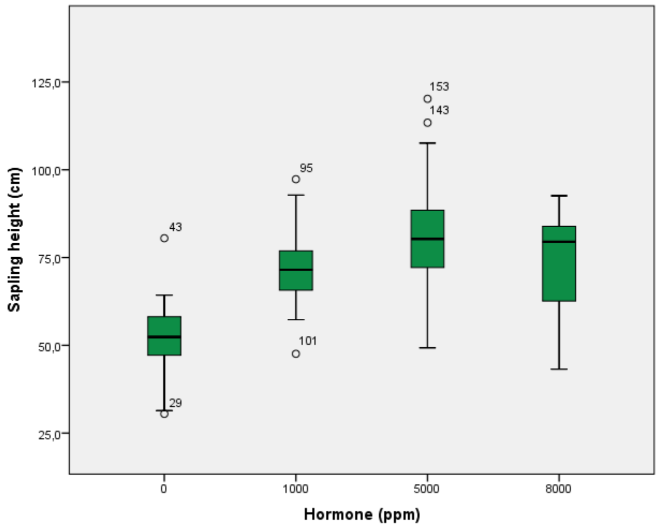

Figure 7. Box plot distribution of sapling height.

Examination of the box plot of the root collar diameter values reveals that the data are normally distributed. However, one data appears to be extremely high in the distribution of all groups. This data is considered negligible. On the other hand, the data are statistically normally distributed, and the most ideal distribution is shown in the data with 8000 ppm IBA hormone.

Examination of the box plot of the sapling height values reveals that the data are normally distributed. However, several data appear to be extremely high and two data appear to be extremely low. This data point is considered negligible. On the other hand, the data are statistically normally distributed, and the most ideal distribution is shown in the data with 1000 ppm IBA and 5000 ppm IBA groups.

When variance analysis was applied to the root collar diameter and sapling height measurements of *E. umbellata* saplings of different hormone doses dated December 8, 2023, it was revealed that they showed statistically significant relationships ($p<0.05$) (Table 6).

Table 6. Analysis of variance (ANOVA) results for the effects of three different concentrations of IBA hormone (1000 ppm, 5000 ppm, and 8000 ppm) on root collar diameter and sapling height in *Elaeagnus umbellata* saplings on December 8, 2023.

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Root collar diameter	Between Groups	147.96	3	49.32	11.72	0.000
	Within Groups	429.38	102	4.21		
	Total	577.34	105			
Sapling height	Between Groups	12328.08	3	4109.36	21.27	0.000
	Within Groups	19702.51	102	193.16		
	Total	32030.59	105			

Due to the statistical differences found between the hormone doses as a result of the analysis, the Duncan test was applied, resulting in homogeneous groups. Three different groups were formed based on the results of the Duncan test. The most effective hormone on both root collar diameter and height growth was the 5000 ppm IBA concentration, which constitutes a single group. The hormone doses of 1000 ppm and 8000 ppm IBA formed the same group for root collar diameter and sapling height growth. The lowest root collar diameter and height growth occurred in control cuttings without hormone treatment, which constituted a single group (Table 7 and Table 8).

Table 7. Duncan test results for IBA (1000 ppm, 5000 ppm, and 8000 ppm) hormone doses differing in root collar diameter.

Root Collar Diameter				
Duncan[a,b]				
Hormone	N	Subset for alpha = 0.05		
		1	2	3
Control	23	5.82		
IBA 8000	25		6.97	
IBA 1000	23		7.51	
IBA 5000	35			8.97
Sig.		1.000	0.344	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 25.719.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 8. Duncan Test results for IBA (1000 ppm, 5000 ppm, and 8000 ppm) hormone doses differing in sapling height.

Sapling Height				
Duncan[a,b]				
Hormone	N	Subset for alpha = 0.05		
		1	2	3
Control	23	51.89		
IBA 1000	23		71.92	
IBA 8000	25		73.06	
IBA 5000	35			81.42
Sig.		1.000	0.768	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 25.719.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

In the second measurements made on December 8, 2023, the highest root collar diameter (8.97 mm) and sapling (81.42 cm) were obtained at the IBA 5000 ppm hormone dose. The lowest root collar diameter (5.82 mm) and height (51.89 cm) of *E. umbellata* saplings were observed in the control group, which received no growth hormone treatment. No significant difference was found in root collar diameter and height between the IBA 1000 (7.51 mm and 71.92 cm) and IBA 8000 ppm (6.97 mm and 73.06 cm) hormone doses (Table 7, Table 8). The differences in root collar diameter and height growth caused by different hormone concentrations are clearly evident in Figure 8 and Figure 9. All hormone doses significantly increased the growth characteristics of the saplings compared to the control group.

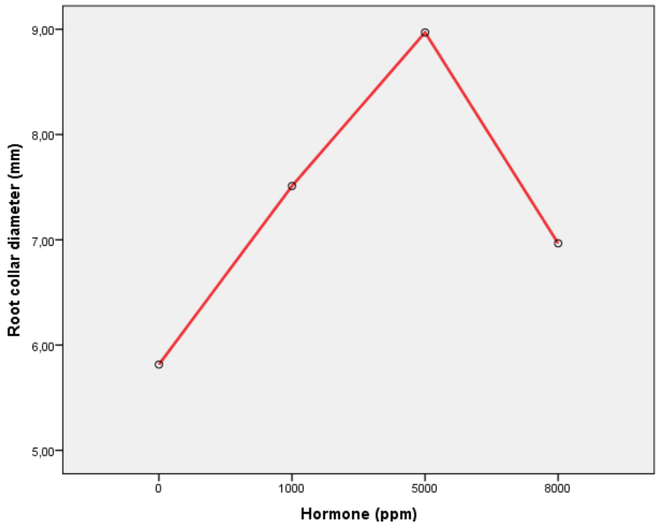

Figure 8. Effect of different hormone concentrations on root collar diameter in measurements conducted on December 8, 2023.

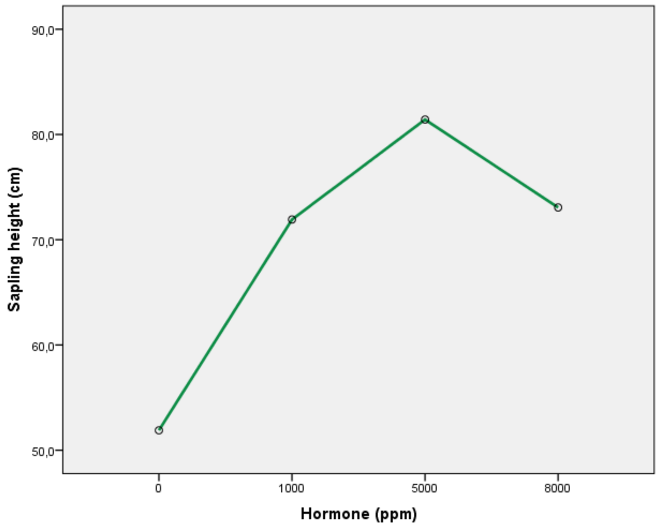

Figure 9. Effect of different hormone concentrations on sapling height in measurements conducted on December 8, 2023.

Based on these findings, when measurements taken at two different time intervals were evaluated together, it was revealed that IBA concentrations of 5000 ppm and 1000 ppm provided the highest sapling growth in the first measurement (June 19, 2023), and a concentration of 5000 ppm in the second measurement (December 8, 2023) resulted in the highest sapling growth. However, the best root collar diameter and height growth were achieved with a 5000 ppm IBA concentration in the second measurement after 1.5 years. Therefore, while expressing the effects of hormone concentrations on autumn olive cutting propagation, the importance of determining their long-term effects on sapling growth is better understood for obtaining accurate results.

While studies have extensively investigated the effects of different hormone concentrations on rooting and sapling quality of cuttings (Chen et al., 2023; Cüce, 2024; Çetin, 2024; Gerçekcioğlu & Aslan, 2021; İzgi, 2020; Khan et al. 2020), data on the long-term growth performance of saplings grown from these cuttings are limited. Furthermore, studies on the effects of different hormone concentrations on the rooting of cuttings of *E. umbellata*, a new and alternative plant in Türkiye, are also limited. The growth and development of saplings after planting in open fields is the most critical and long-term phase of a successful cuttings production process. Hormonal treatments directly support the production of high-quality saplings and indirectly improve the field performance of cuttings during this phase (Carlson, 1986; South et al., 1985; Wakeley, 1969). At the same time, during this phase, saplings leave the controlled environment and are exposed to natural environmental conditions. Therefore, long-term and regular monitoring of the growth of species will improve the process of producing healthy and high-quality saplings.

In this study, measurements made on *E. umbellata* saplings at different time intervals revealed that 1000 ppm and 5000 ppm IBA applications increased growth characteristics compared to the control. Auxin helps the plant establish a strong root system, which in turn affects sapling characteristics. Studies have shown that IBA, in particular, increases the rooting ability of cuttings. Correspondingly, it has been reported to increase survival, sapling development, and the formation of high-quality saplings. It accelerates both biomass growth and morphological development by increasing the sapling's water and nutrient uptake capacity. Good root development also may provide an increase in photosynthetic activity and other activities performed on leaves (Tien et al., 2020; Wahab et al., 2001). As a result, saplings obtained from rooted cuttings treated with hormones become more vigorous, more resilient, and more productive in terms of growth. This is also supported by the results obtained in Chandramouli (2001) study on *Bursera penicillata* cuttings, reported that increasing IBA concentration also increased sapling height and leaf number. Khan et al. (2020) demonstrated that the optimum concentration for better rooting and survival of saplings derived from kiwi (*Actinidia deliciosa*) cuttings was achieved with a dose of 3000 ppm IBA. Jan et al. (2015) reported that IBA significantly improved the survival rate of different olive cuttings, with the lowest survival rate was recorded in the control. Appropriate IBA concentrations have been reported to provide better rooting, sprouting, and survival rates in many different plant species (Henrique et al., 2006; Husen et al., 2017; Shahzad et al., 2019). Bayraktar et al. (2018a) investigated the rooting characteristics of hardwood cuttings of autumn olive (*Elaeagnus umbellata*). The highest rooting percentage (70%) was achieved with 5000 ppm IBA and 5000 ppm NAA, while the lowest rooting percentage (33.33%) was achieved in the control group. Cuttings treated with 5000 ppm IBA were reported to produce longer roots and a higher root number compared to other treatments. Bayraktar et al. (2018b) studied the effects of different hormones and their doses (IBA 1000 ppm, IBA 5000 ppm, NAA 1000 ppm, and NAA 5000 ppm) on softwood cuttings of autumn olive, along with the effects of different growing environments. The results showed that the highest rooting percentage occurred as 100% in IBA 1000 ppm treatment in perlite rooting media. In a study conducted by Çelik and Çil (2021) investigating the effects of different hormone concentrations and cutting collecting time on the rooting of *E. umbellata* cuttings, the best rooting rate (97.33%) was achieved with applications of 1000 or 2000 ppm IBA in May and 500 ppm in July. The best root length (11.90 cm) was obtained with May cuttings containing 500 ppm IBA; the highest salable saplings rate (89.30%) was achieved with the 1000 ppm IBA treatment in May. However, the rooting rate (48%) was lowest in control cuttings taken in March. In another study investigating the effects of cutting collecting time and different IBA concentrations on the propagation of *Elaeagnus umbellata* by cuttings, in IBA treatments alone, the following were observed: the highest rooting rate (84.89%) was obtained from autumn olive cuttings treated with 500 ppm IBA, and the lowest rooting rate (77.78%) was obtained from control cutting. When the autumn olive cuttings were evaluated in terms of other characteristics, the highest root length (9.05 cm) was found in 2000 ppm IBA application; the highest number of roots (8.40) was found in 1000 ppm IBA application; and the highest average sapling height (73.81 cm) was found in autumn olive cuttings treated with 2000 ppm IBA. IBA application has also been reported to increase sapling survival. The highest value (77.33%) was found in the 1000 ppm IBA application (Çelik, 2016). However, in contrast, Bounous et al. (1992) found that the cutting collecting time or IBA doses was ineffective upon rooting of the dormant cuttings of autumn olive.

The first measurements in the study, increasing the hormone concentration (IBA 8000) resulted in decreased growth performance on root collar diameter and height. In this case, this may be due to the initial inhibitory effect of increasing hormone concentration. Khan et al. (2020) reported a gradual decrease in sapling height when IBA concentrations exceeded 3000 ppm in kiwi (*Actinidia deliciosa*) cuttings. It has been reported that the decrease in plant height at higher concentrations may be due to the inhibitory effect of IBA above the optimum concentration (de-Klerk et al., 1999; Han et al., 2009). Various studies also mention the inhibitory properties of high hormone concentrations (Doungous et al., 2019; Tien et al., 2020). Furthermore, no significant difference was found between the highest hormone application (8000 ppm IBA) and the control group in the first measurements. In the second measurements, the 8000 ppm IBA application showed better growth in root collar diameter and height compared to the control. Therefore, monitoring the long-term effects of hormone applications on the growth and development of autumn olives will be important for making more accurate decisions regarding field performance.

4. Conclusion

Today, the threats posed by global climate change are increasing the need for highly adaptable species that provide functional and numerous ecological benefits. Furthermore, the importance of medicinal and aromatic plant species in combating diseases and food shortages indirectly brought about by climate change is becoming better understood. This study examined the long-term growth performance of vegetatively propagated *E. umbellata*. Among the IBA concentrations tested over long periods, a concentration of 5000 ppm was found to be more effective on growth. It was determined that IBA application improved the growth of *E. umbellata* saplings, but the first year of measurements was insufficient to assess growth performance. Since the final product of cutting propagation studies will be saplings, obtaining high-quality saplings is crucial. However, many studies are limited to the rooting stage and do not provide sufficient data on long-term outcomes. Furthermore, the inability to determine the survival rate and long-term growth performance of the resulting rooted cuttings prevents a clear assessment of their success in practice. The success of vegetative propagation depends on obtaining high-quality saplings that meet the desired standards. Therefore, to achieve long-term results, the rooting and sapling production processes must be considered as a whole. Furthermore, many environmental and biological factors can influence vegetative propagation, depending on the species. The study tested only one hormone, IBA. Therefore, the number of studies investigating the effects of different hormones and their concentrations, different growing environments, cutting type and length, environmental conditions, and cutting collecting time on the rooting, sapling growth and development of *E. umbellata* should be expanded.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

Ahmad, S. D., & Kamal, M. (2002). Morpho-molecular characterization of local genotypes of *Hippophae rhamnoides* ssp. Turkestanica a multi-purpose plant from Northern Areas of Pakistan. *Journal of Biological Sciences*, *2*(5), 351-354. https://doi.org/10.3923/jbs.2002.351.354

Ahmad, S. D., Sabir, S. M., Juma, M., & Asad, H. S. (2005). Morphological and biochemical variations in *Elaeagnus umbellata* Thunb. from mountains of Pakistan. *Acta Botanica Croatica*, *64*(1), 121-128.

Ahmad, S. D., Sabir, S. M., & Zubair, M. (2006). Ecotypes diversity in autumn olive (*Elaeagnus umbellata* Thunb): A single plant with multiple micronutrient genes. *Chemistry and Ecology*, *22*(6), 509-521. https://doi.org/10.1080/02757540601024819

Batista-Silva, W., de Paiva Gonçalves, J., Siqueira, J. A., Martins, A. O., Ribeiro, D. M., Nunes-Nesi, A., Zsögön, A., & Araújo, W. L. (2024). Auxin metabolism and the modulation of plant growth. *Environmental and Experimental Botany*, *226*, 105917. https://doi.org/10.1016/j.envexpbot.2024.105917

Bayraktar, A., Yıldırım, N., Atar, F., & Turna, İ. (2018a). Effects of some auxins on propagation by hardwood cutting of autumn olive (*Elaeagnus umbellata* Thunb.). *Turkish Journal of Forestry Research*, *5*(2), 112-116. https://doi.org/10.17568/ogmoad.401438

Bayraktar, A., Yıldırım N., Atar, F., & Turna, İ. (2018b). *Effects of different rooting media and hormones on propagation by softwood cuttings of Elaeagnus umbellata*. 4th Non-Wood Forest Products Symposium. Bursa.

Bhat, M. A., Mishra, A. K., Kamal, M. A., Rahman, S., & Jan, A. T. (2023). *Elaeagnus umbellata*: A miraculous shrub with potent health-promoting benefits from Northwest Himalaya. *Saudi Journal of Biological Sciences*, *30*(6), 103662. https://doi.org/10.1016/j.sjbs.2023.103662

Blythe, E. K., Sibley, J. L., Tilt, K. M., & Ruter, J. M. (2007). Methods of auxin application in cutting propagation: A review of 70 years of scientific discovery and commercial practice. *Journal of Environmental Horticulture*, *25*(3), 166-185. https://doi.org/10.24266/0738-2898-25.3.166

Bounous, G., Bullano, F., & Peano, C. (1992). Propagation by softwood cuttings of *Amelanchier canadensis* Medic., *Cornus mas* L., *Elaeagnus umbellata* Thunb. and *Hippophae rhamnoides* L. *Monti e Boschi*, *43*(4), 51-57.

Bryant, P. H., & Trueman, S. J. (2015). Stem anatomy and adventitious root formation in cuttings of *Angophora*, *Corymbia* and *Eucalyptus*. *Forests*, *6*(4), 1227-1238. https://doi.org/10.3390/f6041227

Carlson, W. C. (1986). Root system considerations in the quality of loblolly pine seedlings. *Southern Journal of Applied Forestry*, *10*(2), 87-92. https://doi.org/10.1093/sjaf/10.2.87

Çelik, D. (2016). *Güzyemişinin (Elaeagnus umbellata Thunb.) çelikle çoğaltılmasında çelik alma zamanı ve IBA uygulamalarının etkileri* (Master's thesis, Ondokuz Mayıs University). (In Turkish)

Çelik, H., & Çil, D. (2021). Effects of externally applied IBA doses on rooting and sapling characteristics of autumn olive berry cuttings taken at different periods. *International Journal of Food Science and Agriculture*, *5*(1), 33-40. https://doi.org/10.26855/ijfsa.2021.03.006

Çetin, B. (2024). The effect of hormone treatment on the rooting of Leyland cypress cuttings. *Forestist*, *74*(2), 138-141. https://doi.org/10.5152/forestist.2024.23036

Chandramouli, H. (2001). *Influence of growth regulators on the rooting of different types of cuttings in Bursera penicillata (DC)* (Master's thesis, Agricultural Sciences-Bangalore University).

Chauhan, S., Kumari, A., Saini, P., Jha, S. K., & Rawale, G. B. (2023). Ecotype diversity assessment of autumn olive (*Elaeagnus umbellata* Thunb.) in Himachal Pradesh. *Indian Journal of Ecology*, *50*(4), 1002-1007. https://doi.org/10.55362/IJE/2023/4004

Chen, H., Lei, Y., Sun., J., Ma, M., Deng, P., Quan, J., & Bi, H. (2023). Effects of different growth hormones on rooting and endogenous hormone content of two *Morus alba* L. cuttings. *Horticulturae*, *9*(5), 552. https://doi.org/10.3390/horticulturae9050552

Ciccarese, L., & Jinks, R. L. (1997). Effects of soaking, washing, and warm pretreatment on the germination of Russian- olive and autumn-olive seeds. *Tree Planters' Notes*, *48*(1/2), 18-23.

Clark, J., & Hemery, G. (2006). The use of autumn olive (*Elaeagnus umbellata* Thunb.) in British forestry. *Quarterly Journal of Forestry*, *100*(4), 285-288.

Çorbacı, Ö. L., Ekren, E., & Bayram, F. (2023). Farklı IBA (İndol-3-Bütirik Asit) dozlarının *Argyranthemum frutescens* (L.) Sch.Bip. (Çeşme Papatyası) çeliklerinin büyüme ve gelişmesi üzerine etkilerinin belirlenmesi. *Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi*, *24*(2), 108-116. https://doi.org/10.17474/artvinofd.1324619 (In Turkish)

Cüce, M. (2024). Şebinkarahisar'da yetiştirilen karadut odun çeliklerinin köklenmesi üzerine farklı oksin çeşitlerinin etkisi. *Karadeniz Fen Bilimleri Dergisi*, *14*(1), 304-314. https://doi.org/10.31466/kfbd.1405361 (In Turkish)

de-Klerk, G. J., van der Krieken, W., & de-Jong, J. C. (1999). The formation of adventitious roots: New concepts, new possibilities. *In Vitro Cellular and Developmental Biology*, 35, 189-199. https://doi.org/10.1007/s11627-999-0076-z

Doungous, O., Minyaka, E., Medza-Mve, S. D., Medueghue, A. F., Ngone, M. A., Simo, C., & Nsimi, A. M. (2019). Improving propagation methods of *Gnetum africanum* and *G. buchholzianum* from cuttings for rapid multiplication, domestication and conservation. *Agroforestry Systems*, *93*, 1557-1565. https://doi.org/10.1007/s10457-018-0269-8

Eckardt, N., & Sather, N. (1987). *The nature conservancy element stewardship abstract for E. umbellata practice*. Retrieved 08 Aug, 2025, from https://share.google/CJMNYURZkE6B7I5ig

Fordham, I. M., Clevidence, B. A., Wiley, E. R., & Zimmerman, R. H. (2001). Fruit of autumn olive: A rich source of lycopene. *HortScience*, *36*(6), 1136-1137. https://doi.org/10.21273/HORTSCI.36.6.1136

Fordham, I. M., Zimmerman, R. H., Black, B. L., Clevidence B. M., & Wiley E. R. (2002). *Autumn olive: A potential alternative crop*. XXVI International Horticultural Congress: Berry Crop Breeding, Production and Utilization for a New Century. Toronto.

Foster, G. S., Stelzer, H. E., & McRae, J. B. (2000). Loblolly pine cutting morphological traits: Effects of rooting and field performance. *New Forests*, *19*, 291-306. https://doi.org/10.1023/A:1006691808772

Fowler, D. K., & Adkisson, L. F. (1980). *Survival and growth of wildlife shrubs and trees on acid mine spoil*. TVA Tech. Note B37.

Fowler, L. J., & Fowler, D. K. (1987). Stratification and temperature requirements for germination of autumn olive (*Elaeagnus umbellata*) seed. *Tree Planters' Notes*, *38*(1), 14-17.

Gamba, G., Donno, D., Mellano, M. G., Riondato, I., De Biaggi, M., Randriamampionona, D., & Beccaro, G. L. (2020). Phytochemical characterization and bioactivity evaluation of autumn olive (*Elaeagnus umbellata* Thunb.) pseudodrupes as potential sources of health-promoting compounds. *Applied Sciences*, *10*(12), 4354. https://doi.org/10.3390/app10124354

Gerçekcioğlu, R., & Aslan, Z. (2021). Hünnap'ın (*Ziziphus jujuba*) yeşil ve odun çelikleri ile köklenmesi üzerine hormon uygulamalarının etkileri. *Gaziosmanpaşa Bilimsel Araştırma Dergisi*, *10*(2), 165-175. (In Turkish)

Ghellam, M., Zannou, O., Pashazadeh, H., Galanakis, C. M., Aldawoud, T. M. S., Ibrahim, S. A., & Koca, İ. (2021). Optimization of osmotic dehydration of autumn olive berries using response surface methodology. *Foods*, *10*(5), 1075. https://doi.org/10.3390/foods10051075

Goldfarb, B., Surles, S. E., Thetford, M., & Blazich, F. A. (1998). Effects of root morphology on nursery and first-year field growth of rooted cuttings of loblolly pine. *Journal of Applied Forestry*, *22*(4), 231-234. https://doi.org/10.1093/sjaf/22.4.231

Graham, S. A. (1964). The Elaeagnaceae in the southeastern United States. *Journal of the Arnold Arboretum*, *45*(2), 274-278.

Haines, R. J., Copley, T. R., Huth, J. R., & Nester, M. R. (1992). Shoot selection and the rooting and field performance of tropical pine cuttings. *Forest Science*, *38*(1), 95-101. https://doi.org/10.1093/forestscience/38.1.95

Han, H., Zhang, H., & Sun, X. (2009). A review on the molecular mechanism of plants rooting modulated by auxin. *African Journal of Biotechnology*, *8*(3), 348-353.

Hartmann, H. T., Kester, D. E., Davies, F. T., & Geneve, R. L. (2011). *Plant propagation: Principles and practices*, 8th Edition. Prentice-Hall.

Hartmann, H. T., Kester, D. E., Davies, F. T., & Geneve, R. L. (1997). *Plant propagation: Principles and practices*, 6th Edition. Prentice-Hall.

Henrique, A., Campinhos, E. N., Ono, E. O., & Pinho, S. Z. D. (2006). Effect of plant growth regulators in the rooting of *Pinus* cuttings. *Brazilian Archives of Biology and Technology*, *49*(2), 189-196. https://doi.org/10.1590/S1516-89132006000300002

Hunt, M. A., Trueman, S. J., & Rasmussen, A. (2011). Indole-3-butyric acid accelerates adventitious root formation and impedes shoot growth of *Pinus elliottii* var. *elliottii* × *P. caribaea* var. *hondurensis* cuttings. *New Forests*, *41*, 349-360. https://doi.org/10.1007/s11056-010-9227-7

Husen, A., Iqbal, M., Siddiqui, S. N., Sohrab, S. S., & Masresha, G. (2017). Effect of indole-3-butyric acid on clonal propagation of mulberry (*Morus alba* L.) stem cuttings: Rooting and associated biochemical changes. *Proceedings of the National Academy of Sciences, India - Section B: Biological Sciences*, *87*, 161-166. https://doi.org/10.1007/s40011-015-0597-7

İzgi, M. N. (2020). Farklı IBA (İndol-3-Bütirik Asit) dozları ve köklendirme ortamlarının bazı tıbbi bitkilerin köklenmesi üzerine etkileri. *Türkiye Tarımsal Araştırmalar Dergisi*, *7*(1), 9-16. https://doi.org/10.19159/tutad.590323 (In Turkish)

Jan, I., Sajid, M., Rab, A., Iqbal, A., Khan, O., Jamal, Y., Ahmad, N., Ali, A., Shakoor, M., & Shah, S. T. (2015). Effect of various concentrations of In-dole butyric acid (IBA) on olive cuttings. *Mitteilungen Klosterneuburg*, *65*, 49-55.

Kantar, A. (2017). *Hünnapın (Ziziphus jujuba* Mill*.) çelikle çoğaltılması* (Master's thesis, Ordu University). (In Turkish)

Khan, N., Hamid, F. S., Ahmad, F., Khan, S. A., Ahmed, I., Khan, M. A., Islam, S., Waheed, A., Shah, B. H., & Shah, H. (2020). Optimization of IBA concentration for rapid initiation of roots and ultimate growth of kiwi seedlings and the association between root system architecture and seedlings growth. *Pakistan Journal of Agricultural Research*, *33*(1), 63-71 https://doi.org/10.17582/journal.pjar/2020/33.1.63.71

Khattak, K. F. (2012). Free radical scavenging activity, phytochemical composition and nutrient analysis of *Elaeagnus umbellata* berry. *Journal of Medicinal Plants*, *6*(39), 5196-5203. https://doi.org/10.5897/JMPR11.1128

Kim, S. C., Ku, C. D., Park, M. C., Kim, C. H., Song, S. D., & An, C. S. (1993). Isolation of symbiotic Frankia Eulk1 strain from root nodule of *Elaeagnus umbellata. Korean Journal of Botany*, *36*, 177-182.

Kohri, M., Mahito, K., & Nakagoshi, N. (2011). Spatial-temporal distribution of ornithochorous seeds from an *Elaeagnus umbellata* community dominating a riparian habitat. *Plant Species Biology*, *26*(2), 174-185. https://doi.org/10.1111/j.1442-1984.2011.00313.x

Ludwig-Müller, J. (2000). Indole-3-butyric acid in plant growth and development. *Plant Growth Regulation*, *32*, 219-230. https://doi.org/10.1023/A:1010746806891

Malinich, E., Lynn-Bell, N., & Kourtev, P. S. (2017). The effect of the invasive *Elaeagnus umbellata* on soil microbial communities depends on proximity of soils to plants. *Ecosphere*, *8*(5), e01827. https://doi.org/10.1002/ecs2.1827

Munger, G. T. (2003). *Elaeagnus umbellata*. Retrieved 08 Aug, 2025, from https://www.fs.usda.gov/database/feis/plants/shrub/elaumb/all.html

Nazir, N., Khan, S., Karim, N., Nisar, M., Aziz, T., Shami, A., Al-Asmari, F., Alhhazmi, A. A., Al-Joufi, F. A., & Alwethaynani, M. S. (2025). Elucidating the phytochemical, antibacterial, and hepatoprotective effects of *Elaeagnus umbellata* leaf extract against liver injury in an animal model. *Cell Biochemistry and Biophysics*, *83*, 3933-3944 https://doi.org/10.1007/s12013-025-01767-6

Neto, F. J. D., dos Santos Carneiro, D. C., Putti, F. F., Rodrigues, J. D., Tecchio, M. A., Leonel, S., de Souza Silva, M. (2024). Physiological indexes in seed germination and seedling growth of rangpur lime (*Citrus limonia* L. Osbeck) under plant growth regulators. *Agronomy*, *14*(9), 2066. https://doi.org/10.3390/agronomy14092066

Olson, D. F., & Barbour, R. J. (2004). *Elaeagnus L*. Retrieved 08 Aug, 2025, from https://www.fs.usda.gov/nsl/Wpsm/Elaeagnus.pdf

Patel, S. (2015). Plant genus Elaeagnus: Underutilized lycopene and linoleic acid reserve with permaculture potential. *Fruits*, *70*(4), 191-199. https://doi.org/10.1051/fruits/2015014

Petrescu, A., & Paraschiv, M. (2022). The nutritional potential of some *Elaeagnus umbellata* biotypes selected in Romania. *JOURNAL of Horticulture, Forestry and Biotechnology*, *26*(4), 103-107.

Pulatkan, M., & Kaya Şahin, E. (2022) *Magnolia kobus* DC.'nin yeşil çelikle üretiminde farklı hormon uygulamalarının etkileri. *Ormancılık Araştırma Dergisi*, *9*, 24-29. https://doi.org/10.17568/ogmoad.1094961 (In Turkish)

Shahzad, U., Kareem, A., Altaf, K., Zaman, S., Ditta, A., Yousafi, Q., & Calica, P. (2019). Effects of auxin and media additives on the clonal propagation of guava cuttings (*Psidium guajava* L.) Var. Chinese Gola. *Journal of Agricultural Science and Food Research*, *10*(3), 265. https://doi.org/10.35248/2593-9173.19.10.265

South, D. B., Boyer, J. N., & Bosch, L. (1985). Survival and growth of loblolly pine as influenced by seedling grade: *13-year results*. *Southern Journal of Applied Forestry*, *9*(2), 76-81. https://doi.org/10.1093/sjaf/9.2.76

Taiz, L., & Zeiger, E. (2013). *Fisiologia vegetal*. Artmed.

Tien, L. H., Chac L. D., Oanh, L. T. L., Ly, P. T., Sau, H. T., Hung, N., Thanh, V. Q., Doudkin, R. V., & Thinh B. B. (2020). Effect of auxins (IAA, IBA and NAA) on clonal propagation of *Solanum procumbens* stem cuttings. *Plant Cell Biotechnology and Molecular Biology*, *21*(55-56), 113-120.

Torrey, J. G. (1978). Nitrogen fixation by actinomycete-nodulated angiosperms. *Bioscience*, *28*(9), 586-592. https://doi.org/10.2307/1307515

Üreyen Esertaş, Ü. Z., & Cora, M. (2024). Biological activities of *Elaeagnus umbellata* methanol extract. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, *27*(6), 1262-1268. https://doi.org/10.18016/ksutarimdoga.vi.1434448

Wahab, F., Nabi, G., Ali, N., & Shah, M. (2001). Rooting response of semi-hardwood cuttings of guava (*Psidium guajava* L.) to various concentrations of different auxins. *Journal of Biological Sciences*, *1*(4), 184-187. https://doi.org/10.3923/jbs.2001.184.187

Wakeley, P. C. (1969). Results of southern pine planting experiments established in the middle twenties. *Journal of Forestry*, *67*(4), 237-241. https://doi.org/10.1093/jof/67.4.237

Yan, S. P., Yang, R. H., Wang, F., Sun, L. N., & Song, X. S. (2017). Effect of auxins and associated metabolic changes on cuttings of hybrid aspen. *Forests*, *8*(4), 117. https://doi.org/10.3390/f8040117

Yang, X. P., Yu, H., & Wang, G. (2021). Studies on micro-cuttage propagation with hardwood cuttings of *Zanthoxylum bungeanum*. *Journal of Northwest Forestry University*, *36*, 145-149.

http://silvaworld.org
SilvaWorld
e-ISSN: 2822-6127
https://prensip.gen.tr

RESEARCH ARTICLE

Analysis of Urban Vegetation in terms of Smellscape: The Kastamonu City

Zeynep Şahanoğlu[1] • Elif Ayan Çeven[2]✉

[1]Kastamonu University, Institute of Science, Department of Landscape Architecture, Kastamonu/Türkiye
[2]Kastamonu University, Faculty of Engineering and Architecture, Department of Landscape Architecture, Kastamonu/Türkiye

ARTICLE INFO

Article History
Received: 12.08.2025
Accepted: 15.09.2025
First Published: 29.09.2025

Keywords
Kastamonu
Scented plants
Smellscape

ABSTRACT

The sense of smell is increasingly gaining importance as an element that enhances the user experience in urban open and green spaces. In this context, smellscape is not merely a visually based design approach; it supports the multisensory interaction individuals establish with space and enhances spatial memory. This study used qualitative data collection methods to examine the landscape effects of scented plants in the city center of Kastamonu. Literature review and field observation methods were used to investigate the smellscape components in the city, the scent diffusion of these components across seasonal cycles, and their spatial distribution. The primary objective of this study is to reveal the smellscape characteristics of existing plant species in Kastamonu's city center. To evaluate Kastamonu's existing landscape potential, this study emphasizes that scented plants should be integrated into landscape design processes with a user-centered approach that considers seasonal continuity and is based on sensory experience.

Please cite this paper as follows:
Şahanoğlu, Z., & Ayan Çeven, E. (2025). Analysis of urban vegetation in terms of smellscape: The Kastamonu city. *SilvaWorld*, *4*(2), 66-73. https://doi.org/10.61326/silvaworld.v4i2.395

1. Introduction

For many years, the discipline of landscape architecture has evaluated spaces primarily through visual perception; senses such as smell have remained in the background in the design process. However, with the development of environmental psychology, experience-based design, and multi-sensory space approaches in recent years, it has been seen that the understanding of space based solely on vision is insufficient, and senses such as smell, sound, and touch also have an essential place in environmental experience (Aytatlı & Kuzulugil, 2025; Drobnick, 2024; Porteous, 1985). In this context, smell plays a strong role in strengthening the emotional bond that individuals establish with a place, at various levels such as wayfinding, sense of belonging to a place, and psychological interaction (Ayan Çeven & Belkayalı, 2019, 2021; Ayan Çeven & Belkayali, 2023; Belkayali & Ayan, 2017; Henshaw, 2013; Oleszkiewicz et al., 2021; Qin & Xuan, 2023). While the concept of olfactory landscape encompasses the source, distribution form, perception process, and effects of environmental odors on the user, it is also related to seasonal cycles, environmental conditions, cultural memory, and traditional landscape elements (Ayan Çeven & Belkayali, 2023; Aytatlı & Kuzulugil, 2025).

Environmental factors such as increasing building density, climate change, and air pollution, along with urbanization, lead to the loss of natural olfactory resources, leading to the erasure of traditional olfactory traces (Huang & Yuan, 2024; Xiao et al., 2017). Consciously integrating the sense of smell into design strengthens urban identity and contributes to cognitive processes such as wayfinding, psychological relaxation, and spatial belonging (M. He et al., 2022; Lygum & Xiao, 2025;

✉ Corresponding author
E-mail address: eayan@kastamonu.edu.tr

Song & Wu, 2022; Xiao et al., 2017). Therefore, the need for multi-sensory landscape strategies that include the sense of smell in creating sustainable and livable cities is increasing (Hao et al., 2025; J. He et al., 2022). Olfactory landscapes in urban environments emerge in two types due to natural and human intervention (Bentley et al., 2023). Plants, one of the natural landscape elements, are one of the most critical components of the olfactory landscape. Trees and other plant species often emit attractive and invigorating scents (Lewis, 1996). Urban vegetation provides city dwellers with multiple ecosystem services, providing multisensory experiences and interactions, and benefiting human health. Compared to visual interaction, the olfactory experience of urban vegetation has been less studied and undervalued (Wang et al., 2025). Urban spaces integrated with aromatic plants enrich the user experience by providing aesthetic and functional contributions (Xiong et al., 2023; Zhang et al., 2023). Despite the nature-based approach taken in urban spaces (Egerer et al., 2024), visually oriented designs have been prioritized, and important sensory cues such as olfaction have often been overlooked (Wang et al., 2025).

Wang et al. (2025), in their review of the literature, evaluated the role of plants in the olfactory landscape under four main headings: richness (diversity of plant odors emitted by urban vegetation and perceptible to humans), diffusion (concentration and spread of plant odor), and structure (spatial distribution, density, and accessibility of the plant olfactory landscape). They also emphasized the need for plants to be included in olfactory landscapes within the context of health-friendly species selection, within the context of the cultural traditions, and with principles of equitable access, considering different demographic groups. Song and Wu (2022) found that in urban environments, *Magnolia* and tree peony exhibit a woody and slightly medicinal odor, lilac emits a strong hyacinth-like odor, *Osmanthus* has a pungent sweet odor, and winter peony has a fresh sweet odor. The study, which yielded the highest evaluation value for *Osmanthus*, found that odor concentration and diffusion were related to plant density, tree height, receptor location, and spatial spacing.

The study aims to evaluate the plant species in Kastamonu's city center within the context of olfactory landscapes. The study examines the use of scented plants in the city, their spatial placement, and seasonal changes. The study examines not only the visual aspects of scented plants but also their functions in environmental psychology and sociocultural contexts. It also explores how integrating scented plants into urban landscapes enriches user experience and contributes to forming spatial belonging and urban identity. Finally, the impact of environmental factors on olfactory landscapes in cities is analyzed, aiming to offer strategic recommendations for creating healthier, more sensory, and user-centered living spaces by incorporating olfactory design.

2. Materials and Methods

This study was conducted in the provincial center of Kastamonu, located in the Black Sea Region of Türkiye (Figure 1). Kastamonu boasts a rich natural landscape with its mountainous topography and historical texture. The city center contains 21 parks, 127 playgrounds, and 28 sports complexes, totaling 97,478 m² of active green space (Öztürk & Özdemir, 2013). The amount of active green space per capita in the city, at 1.04 m², is well below the legal criterion of 10 m²/person, and the proportion of active green space in the city center is approximately 3% (Öztürk & Özdemir, 2013). Scented plants are used in parks, street plantings, and landscaping in areas such as Sinanbey Park, Cumhuriyet Square, Kışla Park, Cevizli Park, İstiklal Yolu Park, Harikalar Diyarı Park, and Turhan Topçuoğlu Park. However, there is a lack of in-depth systematic studies examining the scent properties of these plants.

The research examined various public, open, and green spaces in the city center. These areas include parks, median strips, roadsides, and recreational areas.

This study used qualitative data collection methods to examine the landscape effects of scented plants in the Kastamonu city center. In the first phase of the study, national and international literature on scented landscaping, the role of plant scents in landscape architecture, healing landscapes, and nature-based therapy approaches was reviewed. In this context, a comprehensive literature review, including previous academic studies, theses, and books, was conducted on the role of scented plants in landscape design and their effects on urban spaces. Open green spaces included in the Kastamonu zoning plan were also identified, and satellite maps were examined. In this phase, the vegetative zones obtained from the maps were scanned (Figure 2). In the study, observation-based studies were conducted in the city center. Walks were carried out, and as a result of the walks, plants with scent properties and their locations were mapped by the researchers based on the literature.

Following this desk-based study, plant species with scent properties were identified in the city center based on on-site observations. In this context, the olfactory landscape components of the city were identified using literature review and field observation methods (Bozkurt, 2021) in conjunction with other methods. These components were evaluated using criteria such as seasonality, spatial location, and odor perception, adapted from Wang et al. (2025). Scented plants observed during field observations were evaluated according to the following criteria:

Seasonality: It was assessed how the plants' scents varied seasonally and how seasonal influences shaped their distribution.

Spatial Location: It was evaluated the location of scented plants in residential areas and their distribution in different regions within the city. These criteria included the plants' impact on environmental conditions and users.

Odor Perception: It was also examined the perception of scents emitted from scented plants. Some plants naturally emit scents through wind or heat, while others only emit scents through physical contact (e.g., touching or crushing their leaves). These differences are essential in determining how and to what extent the olfactory experience is felt in the space.

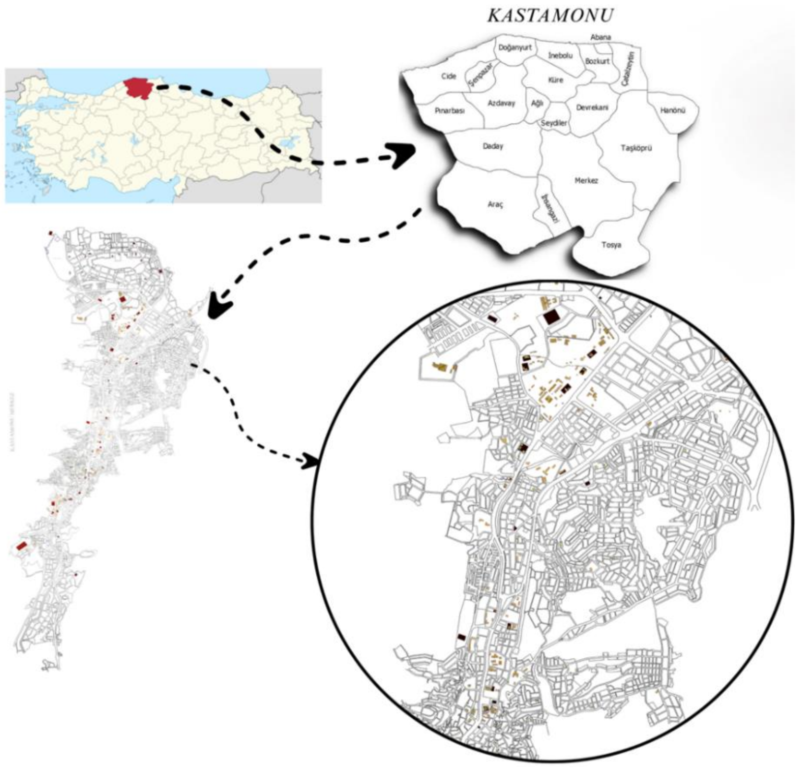

Figure 1. Study area location map.

Figure 2. Vegetal zones map.

3. Results

A general overview of the scented plant species used in urban areas is presented in Table 1. Thirteen different plant species were identified in the study area, all of which were included due to their distinct scent characteristics. These plants vary in their aromatic qualities. For example, mint, thyme, and rosemary are noted for their pungent, spicy scents, while roses, jasmine, and lilies are more prominent for their sweet and floral aromas. Considering the flowering periods, the months when scents are most intense in urban areas are determined to be May, June, and July. These periods stand out when visual landscape elements and scent-based sensory experiences reach their highest levels.

Table 1. Fragrant plants found in Kastamonu city.

Plant Name	Latin Name	Flowering Period	Fragrance Properties	Usage Areas
Honeysuckle	*Lonicera japonica*	May - September	Intense floral scent (Song & Wu, 2022; Xiao et al., 2017)	Gardens, walls, natural landscaping
Lavender	*Lavandula angustifolia*	June - August	Strong aromatic scent (Lygum & Xiao, 2025; Song & Wu, 2022)	Landscaping, parks
Rose	*Rosa* spp.	May - July	Strong floral scent (Sakıcı, 2014; Song & Wu, 2022)	Gardens, park areas, walking paths
Linden	*Tilia tomentosa*	June - July	Sweet floral scent (Sakıcı, 2014; Song & Wu, 2022)	Afforestation areas, park roads
Jasmine	*Jasminum officinale*	May - July	Sweet and intense scent (Song & Wu, 2022; Xiao et al., 2017)	Gardens, walls, recreation areas
Mint	*Mentha* spp.	June - October	Fresh, pungent scent (Eroğlu et al., 2005; Song & Wu, 2022)	Parks, gardens
Thyme	*Thymus vulgaris*	May - July	Strong aromatic scent (Song & Wu, 2022; Xiao et al., 2017)	Landscaping, natural areas, scented gardens
Rosemary	*Rosmarinus officinalis*	April - July	Spicy and intense scent (Lygum & Xiao, 2025; Song & Wu, 2022)	Landscaping, scented area designs
Acacia	*Robinia pseudoacacia*	May - June	Sweet floral scent (Bozkurt, 2021; Song & Wu, 2022)	Roadsides, park visual areas
Lilac	*Syringa vulgaris*	May - June	Strong and pleasant odor (Song & Wu, 2022; Xiao et al., 2017)	City landscaping, gardens, aesthetic areas
Iris	*Iris germanica*	April - June	Slightly sweet and earthy odor (Sakıcı, 2014)	Aesthetic gardens, walking paths, colorful landscape areas
Lily	*Lilium candidum*	June - July	Intense and heady odor (Song & Wu, 2022; Xiao et al., 2017)	Gardens, monumental landscapes, showy plant compositions
Oleaster	*Elaeagnus angustifolia*	May - June	Sweet and intense odor (Bozkurt, 2021; Song & Wu, 2022)	Rural landscapes, roadsides, natural green areas

3.1. Seasonality

The scent release of fragrant plants varies throughout the year depending on their blooming season. *Lonicera japonica* (honeysuckle) blooms between May and September, with the scent intensity increasing particularly in the evening. *Lavandula angustifolia* (lavender) blooms between June and August and emits a more intense scent in the morning. *Rosa* spp. (rose) exhibits intense scent release during the summer months of May and July. *Tilia tomentosa* (linden) stands out with its sweet floral scent between June and July. *Jasminum officinale* (jasmine) emits a strong scent between May and July, between late spring and early summer. *Mentha* spp. (mint) It is perceived with its fresh and pungent aroma between June and October, while *Thymus vulgaris* (thyme) is noted for its aromatic properties between May and July. *Rosmarinus officinalis* (rosemary) is characterized by its intense, spicy scent between April and July, while *Laurus nobilis* (bay laurel) emits subtle scents in late spring and early summer. Seasonal transitions cause the scent intensity of these species to increase or decrease, allowing for diverse sensory experiences throughout the year.

Table 2. Seasonal scent distribution of scented plants found in Kastamonu.

Plant Name	Plant Name	April	May	June	July	August	September	October
Honeysuckle	*Lonicera japonica*		✓	✓	✓	✓	✓	
Lavender	*Lavandula angustifolia*			✓	✓	✓		
Rose	*Rosa* spp.		✓	✓	✓			
Linden	*Tilia tomentosa*			✓	✓			
Jasmine	*Jasminum officinale*		✓	✓	✓			
Mint	*Mentha* spp.			✓	✓	✓	✓	✓

Table 2. (continued)

Plant Name	Plant Name	April	May	June	July	August	September	October
Thyme	*Thymus vulgaris*		✓	✓	✓			
Rosemary	*Rosmarinus officinalis*	✓	✓	✓	✓			
Acacia	*Robinia pseudoacacia*		✓	✓				
Lilac	*Syringa vulgaris*		✓	✓				
Iris	*Iris germanica*	✓	✓	✓				
Lily	*Lilium candidum*			✓	✓			
Oleaster	*Elaeagnus angustifolia*		✓	✓				

3.2. Spatial Placement

The spatial placement of scented plants plays a significant role in the emotional and cognitive connections users form with the space. During the fieldwork, it was determined that scented species were not widely used in the parks studied. It was observed that there were no specific design criteria for the spatial placement of fragrant plants, and most scented species were located on the walls of residential gardens. *Rosa* (rose) and *Lavandula* (Figure 3a) were used in central reservations. In contrast, *Tilia tomentosa* (Figure 3b) was used in small numbers along streams and parks, and *Lonicera japonica* was used as a boundary element in residential gardens (Figure 3c).

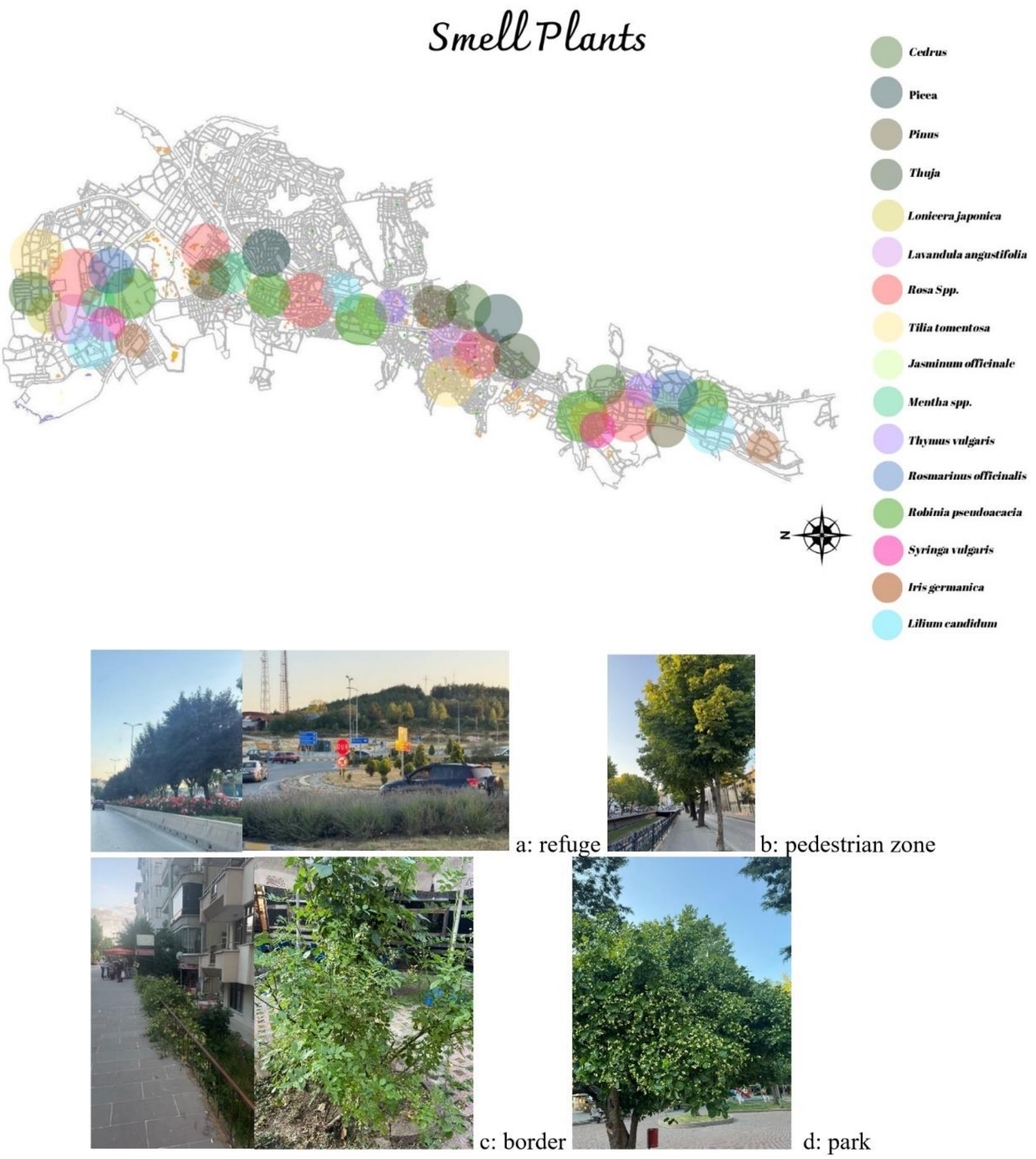

Figure 3. Spatial distribution map of plants.

3.3. Odor Perception

This study evaluated odor perception based on direct exposure to odor or perception through contact. The odor perception was determined to be the perception of odor by contact with the leaves of the plant species listed in Table 1, depending on their flowering period. When examining plant species in terms of odor perception through contact, it was determined that the odors of coniferous plant species, such as *Cedrus, Picea, Pinus,* and *Thuja*, were detected after contact with their leaves. In this context, it was determined that these species are frequently used in parks and median strips in the Kastamonu city center.

4. Conclusion

This study focused on the spatial location, perception, and seasonal evaluation of scented plants within the olfactory landscape of Kastamonu's city center. Field observations, literature reviews, and spatial analyses revealed that various species of fragrant plants are present in Kastamonu's parks, street plantings, green spaces, and historical neighborhoods. However, it was understood that most of these plants were randomly placed and not planned by a specific scent-focused design strategy.

The study concluded that scented plants make significant visual and sensory contributions to the urban landscape, particularly oleaster, rose, lavender, jasmine, honeysuckle, thyme, and lily. These plants facilitate urban residents' emotional connection to the space, encourage them to choose specific areas, and encourage social interactions and relaxation. For example, the scent of roses is strongly felt along walking paths and park entrances, while plants like lavender and jasmine are preferred in quiet park areas. Species such as honeysuckle and thyme, on the other hand, are more commonly used along streets and in areas integrated with natural patterns. Depending on each plant's location and flowering season, these distributions create different environmental impacts.

The effects of scented plants are linked to seasonal changes. Specifically, scent intensity increased in summer and decreased in winter. This raises an essential question regarding the continuity of the olfactory landscape: Considering seasonal variation in the placement and selection of scented plants plays a critical role in ensuring a practical olfactory experience throughout the year. Furthermore, plant placement has a direct impact not only on aesthetics but also on users' psychological and social experiences. Scents shape the atmosphere of a space, strengthening users' emotional bonds with the environment.

Spatial analyses have revealed that areas with scented plants are preferred by users seeking social interaction, relaxation, and peace. Strategic placement of these plants can further enrich the environmental experience and increase user satisfaction. However, a more conscious approach to plant placement is also necessary. Billottet (2020), on the other hand, noted that topographically, odors remain at or above the ground, depending on their molecules, and found that heavy molecular odors are trapped in the deepest points of architecturally hollow spaces. In this context, it is believed that the desired odors should be perceived in close contact with the nose, and scented plants should be incorporated into spatial designs, such as on walls and next to seating.

Another striking finding of the study is that academic research on olfactory landscapes in Kastamonu is scarce, and existing studies mainly focus on historical texture and urban memory. This suggests that olfactory landscapes are insufficiently considered in urban planning and design processes and are often neglected. The lack of systematic data on scented plants also leads to shortcomings in implementation processes, failing to fully utilize the aesthetic and functional potential of the olfactory element in landscape design.

Future studies should more systematically address the potential of scented plants in landscape design and explore their contributions to urban life more comprehensively. This will allow for more consciously designed olfactory landscape strategies in cities and create multisensory spaces that enrich the user experience.

4.1. Strategic Placement of Scented Plants

The spatial placement of scented plants is a key factor shaping the user experience. These plants deepen the environmental expertise, adding sensory depth beyond visual aesthetics. In parks, walking paths, and areas with intense social interaction, it is recommended to choose strongly scented species such as rose, lavender and jasmine. These plants leave a lasting impression on spatial memory and contribute to social interaction and active use of open spaces. On the other hand, quiet and individual rest areas (e.g., meditation areas, around benches) should feature more subtly scented plants, such as bay laurel or thyme. This strategy ensures that plants maintain a calm atmosphere while simultaneously creating a natural aromatic atmosphere, allowing them to be used most effectively in the right areas, considering user behavior.

4.2. Plant Selection for Seasonal Changes

The seasonally variable scent release cycle of scented plants should be considered to ensure year-round olfactory continuity in the landscape. While they emit particularly intense scents in the summer, this effect diminishes significantly in the winter. To balance this, plants that emit scents in different seasons can be combined. For example, plants that emit dominant scents in the summer, such as lavender and rose, should be placed alongside plants that emit subtle scents in the winter, such as *Dianthus caryophyllus* (clove) or conifers. This strategy smooths seasonal transitions, ensuring a balanced landscape integrity in visual and olfactory aspects, and can provide the continuity of the olfactory landscape in urban areas.

4.3. More Extensive Use of Scented Plants in Public Spaces

Using scented plants more frequently in public open spaces in city centers, especially in areas with high user density, such as parks, green spaces, walkways, and squares, is recommended. These plants enrich the spatial experience by providing visual aesthetics and a sensory experience. Scented plants should be strategically placed at park entrances, along walkways, or in areas with high social interaction. Plants such as rose and lavender, in particular, attract users in these spaces and strengthen their connection to the space. More widespread and planned use of scented plants in public spaces can encourage people to spend extended periods in these spaces, thereby increasing social interactions.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

Ayan Çeven, E., & Belkayalı, N. (2019). Mekân, bellek ve koku. *TMMOB*, *1*, 6-8. (In Turkish)

Ayan Çeven, E., & Belkayalı, N. (2021). Smellscapes: Imagining and remembering the city. In Ö. Demirel & E. Düzgüneş (Eds.), *Landscape research-I* (pp. 124-146). Livre De Lyon.

Ayan Çeven, E., & Belkayali, N. (2023). Experiencing urban smells when walking: Kastamonu city case. *International Journal of Urban and Regional Research*, *47*(2), 237-257. https://doi.org/10.1111/1468-2427.13145

Aytatlı, B., & Kuzulugil, A. C. (2025). Scentscapes in landscape design: Aesthetic and functional uses. In M. Özyavuz (Ed.), *Peyzaj mimarlığı konuları* (pp. 93-116). Yaz.

Belkayali, N., & Ayan, E. (2017). Effect of smell in historical environments. *New Trends and Issues Proceedings on Humanities and Social Sciences*, *4*(11), 297-306. https://doi.org/10.18844/prosoc.v4i11.2885

Bentley, P. R., Fisher, J. C., Dallimer, M., Fish, R. D., Austen, G. E., Irvine, K. N., & Davies, Z. G. (2023). Nature, smells, and human wellbeing. *Ambio*, *52*(1), 1-14. https://doi.org/10.1007/s13280-022-01760-w

Billottet, C. (2020). *Architecture nose: Towards multisensory architecture, an exploration of the sense of smell* (Doctoral dissertation, Delft University of Technology).

Bozkurt, S. G. (2021). Sivas' da doğal olarak yetişen bazı odunsu ve çalı türlerinin peyzaj mimarlığında kullanım olanaklarının belirlenmesi. *Eurasian Journal of Forest Science*, *9*(3), 79-91. https://doi.org/10.31195/ejejfs.969214 (In Turkish)

Drobnick, J. (2024). *The smell culture reader*. Taylor & Francis. https://doi.org/10.4324/9781003579540

Egerer, M., Annighöfer, P., Arzberger, S., Burger, S., Hecher, Y., Knill, V., Probst, B., & Suda, M. (2024). Urban oases: the social-ecological importance of small urban green spaces. *Ecosystems and People*, *20*(1), 2315991. https://doi.org/10.1080/26395916.2024.2315991

Eroğlu, E., Kesim, G. A., & Müderrisoğlu, H. (2005). Düzce kenti açık ve yeşil alanlarındaki bitkilerin tespiti ve bazı bitkisel tasarım ilkeleri yönünden değerlendirilmesi. *Journal of Agricultural Sciences*, *11*(03), 270-277. (In Turkish)

Hao, S., Qiao, Y., Sun, H., Jing, Q., & Jia, M. (2025). *Multisensory urban design: Healing effects of visual, auditory, and olfactory enhancements in street landscapes*. https://doi.org/10.2139/ssrn.5173818

He, J., Hao, Z., Li, L., Ye, T., Sun, B., Wu, R., & Pei, N. (2022). Sniff the urban park: Unveiling odor features and landscape effect on smellscape in Guangzhou, China. *Urban Forestry & Urban Greening*, *78*, 127764. https://doi.org/10.1016/j.ufug.2022.127764

He, M., Wang, Y., Wang, W. J., & Xie, Z. (2022). Therapeutic plant landscape design of urban forest parks based on the Five Senses Theory: A case study of Stanley Park in Canada. *International Journal of Geoheritage and Parks*, *10*(1), 97-112. https://doi.org/10.1016/j.ijgeop.2022.02.004

Henshaw, V. (2013). *Urban smellscapes: Understanding and designing city smell environments*. Routledge.

Huang, Y., & Yuan, X. (2024). Smellscape as a healing factor in institutional gardens to enhance health and well-being for older people with dementia: A scoping review. *Journal of Clinical Nursing*, *33*(2), 454-468. https://doi.org/10.1111/jocn.16908

Lewis, C. A. (1996). *Green nature/human nature: the meaning of plants in our lives*. University of Illinois Press.

Lygum, V. L., & Xiao, J. (2025). Creating smellscapes with plants: A landscape architectural framework. *Urban Science*, *9*(3), 68. https://doi.org/10.3390/urbansci9030068

Oleszkiewicz, A., Abriat, A., Doelz, G., Azema, E., & Hummel, T. (2021). Beyond olfaction: Beneficial effects of olfactory training extend to aging-related cognitive decline. *Behavioral Neuroscience*, *135*(6), 732. https://doi.org/10.1037/bne0000478

Öztürk, S., & Özdemir, Z. (2013). Kentsel açık ve yeşil alanların yaşam kalitesine etkisi "Kastamonu Örneği". *Kastamonu University Journal of Forestry Faculty*, *13*(1), 109-116. (In Turkish)

Porteous, J. D. (1985). Smellscape. *Progress in Physical Geography*, *9*(3), 356-378. https://doi.org/10.1177/030913338500900303

Qin, Q., & Xuan, W. (2023). Multisource data–based urban odor mapping and construction of a scent-emotional system for public spaces. *Journal of Urban Planning and Development*, *149*(4), 05023040. https://doi.org/10.1061/JUPDDM.UPENG-4655

Sakıcı, Ç. (2014). Bitkilerin psikolojik katkıları. *Türk tarım Gıda Tarım ve Hayvancılık Bakanlığı Dergisi*, *216*, 38-43. (In Turkish)

Song, X., & Wu, Q. (2022). Study on smellscape perception and landscape application of fragrant plants. *Urban Forestry & Urban Greening*, *67*, 127429. https://doi.org/10.1016/j.ufug.2021.127429

Wang, C., Gao, B., Hao, Z., Li, L., Yang, L., Chen, W. Y., & Pei, N. (2025). Plant smellscape: A key avenue to connect nature and human well-being. *Urban Forestry & Urban Greening*, *107*, 128757. https://doi.org/10.1016/j.ufug.2025.128757

Xiao, J., Tait, M., & Kang, J. (2017). The design of urban smellscapes with fragrant plants and water features. In V. Henshaw, K. McLean, D. Medway, C. Perkins & G. Warnaby (Eds.), *Designing with smell: Practices, techniques and challenges* (pp. 83-95). Routledge. https://doi.org/10.4324/9781315666273

Xiong, X., Jin, H., Hu, W., Zeng, C., Huang, Q., Cui, X., Zhang, M., & Jin, Y. (2023). Benefits of *Jasminum polyanthum*'s natural aromas on human emotions and moods. *Urban Forestry & Urban Greening*, *86*, 128010. https://doi.org/10.1016/j.ufug.2023.128010

Zhang, X., Guo, J., Zhang, X., & Zhang, Q. (2023). Physiological effects of a garden plant smellscape from the perspective of perceptual interaction. *International Journal of Environmental Research and Public Health*, *20*(6), 5004. https://doi.org/10.3390/ijerph20065004

SilvaWorld http://silvaworld.org
SilvaWorld
e-ISSN: 2822-6127
PRENSIP https://prensip.gen.tr

RESEARCH ARTICLE

Field Assessment and Functional Evaluation of Agricultural Shelterbelts in Akmola Region of Kazakhstan

Dani Sarsekova • Gulshat Satybaldiyeva

Kazakh National Agrarian Research University, Faculty of Forestry and Land Resources, Department of Forest Resources, Game Management and Fisheries, Almaty/Kazakhstan

ARTICLE INFO

Article History
Received: 18.06.2025
Accepted: 17.09.2025
First Published: 29.09.2025

Keywords
Agroecological tool
Agroforestry
Kazakhstan
Protective function
Shelterbelt

ABSTRACT

Forest shelterbelts are vital components of agricultural landscapes, particularly in steppe regions susceptible to wind erosion and climatic extremes. This study evaluates the current condition and functional status of shelterbelts across four agricultural enterprises in the Akmola region of central Kazakhstan. Field surveys were conducted at the A.I. Baraev Scientific and Production Center of Grain Farming, Yesil-Agro LLP, Kazger LLP, and Rodina LLP. The assessment focused on morphometric characteristics, species composition, sanitary condition, and agro ecological effectiveness. Results indicate widespread degradation due to aging, poor maintenance, and absence of scientifically informed planning. Many shelterbelts have lost their protective and ecological functions, with some areas experiencing up to 80% tree mortality. Contributing factors include lack of regeneration efforts, disruption of hydrological processes, and absence of integrated agroforestry strategies. The study highlights the urgent need for a comprehensive restoration program involving removal of dead trees, replanting with climate-resilient species, regular maintenance, and GIS-based agro ecological planning. Without such interventions, the continued decline of shelterbelts will undermine soil conservation, agricultural productivity, and ecosystem resilience in the region.

Please cite this paper as follows:

Sarsekova, D., & Satybaldiyeva, G. (2025). Field assessment and functional evaluation of agricultural shelterbelts in Akmola region of Kazakhstan. *SilvaWorld*, *4*(2), 74-80. https://doi.org/10.61326/silvaworld.v4i2.373

1. Introduction

Despite the extensive documentation of shelterbelt designs, planting techniques, and their ecological benefits, relatively little research has focused on the *long-term performance, degradation processes, and current functional state* of these plantations in Kazakhstan. Most previous studies emphasize their historical establishment and initial effectiveness, yet there is limited empirical data on how shelterbelts have aged, the socio-economic and institutional factors behind their decline, and the effectiveness of restoration strategies under present-day climate change and water scarcity conditions. This gap highlights the need for updated field-based assessments that evaluate both existing and deteriorated shelterbelts in order to inform future policy and management approaches.

The development of protective afforestation in Kazakhstan began in the mid-20th century as part of a major initiative launched by the former Soviet Union. The objective was to establish forest belts to stabilize and increase agricultural productivity in the steppe and forest-steppe zones (Mukanov et al., 2010; Toktasynov et al., 2012). In the early years of the Virgin Lands Campaign, Kazakhstan achieved high crop yields due to the extensive use of agricultural machinery, including

Corresponding author
E-mail address: satybaldieva.gulshat@mail.ru

thousands of tractors and powerful equipment (Mukanov et al., 2010). However, the widespread plowing of virgin lands—combined with flat topography and strong winds—led to devastating dust storms in 1962–1963. These storms disrupted the ecological balance, caused significant soil erosion, and stripped away fertile topsoil, rendering the land less productive and accelerating soil fertility loss (Makhanova et al., 2022).

As land degradation spread, several arable areas were repeatedly withdrawn from cultivation and reassigned to the state forest fund to counteract dust storms. To combat wind erosion and improve crop yields, protective forest belts were established.

Kazakhstan also adopted a soil-conservation farming system that emphasized non-moldboard tillage and retention of crop stubble, a practice developed by Baraev (Sarsekova et al., 2021). Numerous forest reclamation stations were set up to oversee and carry out large-scale afforestation efforts in the steppe regions. The types, designs, planting techniques, and spatial planning standards for these protective plantations are extensively documented in the scientific literature (Amanzholova et al., 2024; Driscoll & de Beurs, 2024; Ruppert et al., 2020; Thevs et al., 2017). These plantations, particularly when used alongside other soil protection strategies, have proven effective in preventing erosion, improving soil moisture, and reducing the impacts of drought, dry winds, and dust storms.

Forest belts significantly contribute to increased crop yields and total grain production, even during years of drought (Cheverdina et al., 2023; Urazov et al., 2025). However, over the past 30 years, efforts to maintain and develop these forest belts in Kazakhstan have declined. As a result, many have deteriorated, dried up, or even caught fire. Given the ongoing climate crisis and growing water scarcity, there is now an urgent need to revise shelterbelt-related economic policies and take action to rehabilitate and restore these protective forests (Huiliang et al., 2022).

Studies indicate that roughly 60% of these plantings have exceeded their functional lifespan, with only remnants of the original belts from the 1960s remaining in many areas. Acknowledging the need for restoration, specialists are actively developing new methods and technologies for creating and enhancing shelterbelts (Jerusalem et al., 2017).

This study seeks to assess the condition of both existing and deteriorated shelterbelts through field surveys, taking into account their lifespan to better understand their current state and the factors contributing to their decline.

2. Materials and Methods

2.1. Study Areas and Their Characteristics

2.1.1. Study area

Field surveys of forest shelterbelts were conducted during the 2023 and 2024 growing seasons (June–August) on four representative farmlands in the Akmola Region, Kazakhstan (Figure 1). These farms were selected because of their different management systems, land-use histories, and shelterbelt conditions. The surveys included shelterbelt mapping, tree species identification, structural assessments, and evaluation of their influence on crop fields:

The Scientific and Production Center of Grain Farming named after A.I. Baraev, located in the village of Nauchny in the Shortandinsky district of Akmola region, was established in 1956 and functions as a leading research institution in northern and central Kazakhstan. The center focuses on the breeding and seed production of 17 varieties of grain, legume, oilseed, and forage crops. The total land area managed by the center is 5,814 hectares, comprising 5,486 hectares of arable land and 328 hectares of pasture. In 2023, the total sown area covered 4,405 hectares, distributed as follows: 2,857 hectares for spring wheat, 131.5 hectares for spring barley, 66 hectares for oats, 352 hectares for cereal crops like buckwheat and millet, 49 hectares for legumes, 115 hectares for oilseeds, 11.5 hectares for annual forage grasses, 268 hectares for newly planted perennial forage grasses, and 555 hectares of perennial forage grasses established in previous years. Additionally, 1 081 hectares were left fallow. The farmland has no natural water bodies such as lakes or ponds and depends entirely on precipitation and snowmelt for soil moisture. Research activities related to forage, grain, and fodder crops are carried out in areas that are protected by shelterbelts. In 2023, crop yields were reported as follows: buckwheat produced 3–3.5 c/hectare, millet 5–6 c/ha, barley 7–13 c/ha, oats 2–8 c/ha, and spring wheat 25–30 c/ha (URL1, 2025).

Yesil-Agro Limited Liability Partnership operates its farmland in the village of Kenesary, located in the Burabay district in the northwest of the Akmola region. The total land area amounts to 87,500 hectares, of which 40,000 hectares are used for crop cultivation. The farm primarily concentrates on growing and producing seeds for grain and legume crops (URL2, 2025).

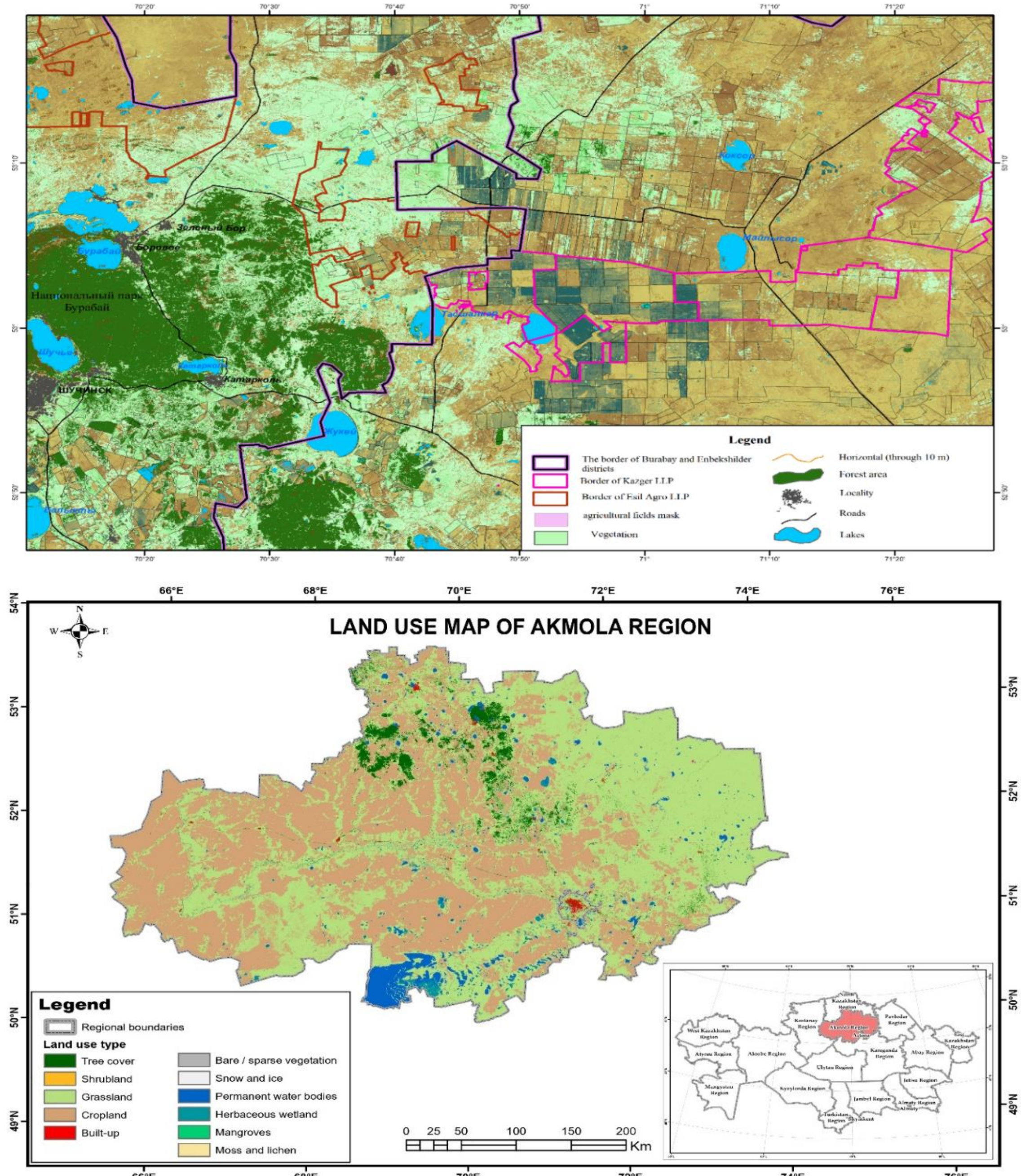

Figure 1. The study area farms and their locations in Akmola region of Kazakhstan.

On the farmland of Kazger Limited Liability Partnership: Kazger LLP, a crop production enterprise founded in 1997, manages farmland located in the Don and Krasnoflotsky rural districts of Enbekshildersky district in northeastern Akmola region. The company operates under long-term land lease agreements for agricultural use, with extensions available through 2051–2056. The total land area amounts to 50,719.52 hectares, including 50,178.13 hectares classified as farmland. This consists of 25,585.8 hectares of arable land, 24,592.33 hectares of pasture, and 541.39 hectares of hayfields. In 2023, the farm recorded the following crop yields: 2.82 centners per hectare for oats, 3.35 c/ha for soft spring wheat, and 2.85 c/ha for spring barley. However, crops such as curly flax and sunflower had to be written off due to insufficient moisture during the growing season, which was further worsened by high temperatures and low rainfall (URL3, 2025).

Rodina Limited Liability Partnership: an agricultural company, was formed in 1961 following the transformation of the New Life collective farm and has since undergone four reorganizations. Its farmland is located in the villages of Rodina, Zeleny Gai, and Sadovoe, in the northwestern part of Tselinograd district, Akmola region. Today, AF Rodina LLP operates as a diversified agricultural enterprise engaged in the production, storage, and sale of agricultural goods. Since 1999, the farm has been recognized as an elite seed producer, specializing in high-quality grain seed production and sales. The company's spring sowing area spans 50,000 hectares, with 40,000 hectares allocated to wheat cultivation across the Shortandinsky, Tselinogradsky, and Korgalzhynsky districts. Additionally, the farm has developed a 700-hectare irrigation system for growing silage corn, alfalfa, and other crops. In 2022, a modern irrigation system featuring 22 center-pivot machines was installed on a further 2,000 hectares. Despite these advancements, wheat yields in 2023 were relatively low—around 10 centners per hectare—compared to 20 c/ha the previous year, primarily due to a mismatch between the selected crop varieties and actual yield outcomes (URL4, 2025).

2.1.2. The topography of the study area

The Akmola region is situated on the western edge of Kazakhstan, bordered by the Ulytau Mountains to the southwest and the Kokshetau Heights to the north. The land generally slopes downward from east to west. Topographically, the region can be divided into three zones: the flat northwest area, the flat southwest area with scattered hills, and the elevated eastern section of the Kazakh folded terrain. In the northwest, near the Ishim Valley as it turns northward, the landscape consists of a flat plateau cut by dry ravines and gullies, ending abruptly at a ledge overlooking the Ishim Valley. The southwestern area, located south of the Ishim River, features a raised plain dotted with many flat-topped hills. Between these hills are shallow salt and fresh lakes of varying sizes. The eastern portion is characterized by a landscape called "melkosopochnik," which includes gently sloping hills, ridges, and hummocks formed by denudation of what was once mountainous terrain (Imangulova et al., 2020).

These hills range in height from 5-10 meters up to 50-60 meters, with some reaching 80-100 meters. Their shapes and sizes vary depending on the rock types they are made of: rounded hills are usually granite, gently sloping hills with softer peaks are often porphyry, and sharply pointed hills are typically quartzite. The basins nestled among the hills, spanning several meters to kilometers in diameter, frequently contain lakes (Smagulov et al., 2021).

The far northeast of the Akmola region stretches into the West Siberian Lowland. The region's highest elevation is Mount Kokshe, which reaches 947 meters above sea level, while the lowest point is Lake Sholaksor at 67 meters above sea level (Smagulov et al., 2021).

2.1.3. The climate of the study area

The climate of the Akmola region is distinctly continental and arid, characterized by hot summers and cold winters. Situated within the West Siberian climatic zone of the temperate belt, the area experiences considerable diurnal and seasonal temperature variations. Transitional seasons such as spring and autumn are not sharply defined, and the region benefits from a high number of sunny days annually. The solar radiation received during summer approaches levels typical of tropical zones, largely due to minimal cloud cover. Precipitation shows a decreasing gradient from north to south, with maximum rainfall occurring in June and the lowest in February. Snow cover generally persists for approximately 150 days each year. The region is also notable for strong winds and holds Kazakhstan's record low temperatures, with -57°C documented in Atbasar and -52 °C in Astana (Imangulova et al., 2020).

Water resources in Akmola are limited, with shallow, non-navigable rivers primarily sustained by meltwater and to a lesser extent by groundwater. During summer months, these rivers frequently experience drying and increased salinity. Major waterways include the Yesil River (also known as Ishim), a tributary of the Irtysh, along with its tributaries such as Ters-Akkan on the left bank, and Zhabai and Koluton on the right. Several rivers terminate in endorheic basins, including lakes like Nura, Selenta, and Ulenta. The region's basins of low hills and elevated plains are dotted with numerous lakes. Among the largest are saline lakes, such as Tengiz—located near the border with Karaganda region and spanning approximately 40 km in width—and Kalmyk-Kol. Freshwater lakes of smaller size, including Ala-Kol and Shoindi-Kol, are also present. Due to the shallow shores of many lakes, their morphology is subject to significant change under the influence of strong winds (Baisholanov et al., 2024).

2.1.4. The soil of the study area

The Akmola region is characterized by a terrain of steppes and semi-deserts, with considerable variation in soil types and vegetation influenced by topography and the nature of the underlying rock formations. North of the Ishim River, the landscape consists of grass steppes growing on southern chernozem soils, interspersed with numerous salt flats in the lowlands and thin, skeletal soils on the higher elevations. Vegetation here is drought-resistant, featuring species such as ipchak (*Festuca valesiaca* Tourn. ex L.), while Scots pine forests are commonly found on upland areas. The western third of Akmola, stretching from the Ishim valley eastward toward Astana, predominantly supports grass steppes on dark chestnut soils, although soil coverage is limited to approximately 30-40% of the surface. Further east of Astana, soils exhibit increased salinity with salt marshes becoming more widespread, and the vegetation shifts to being dominated by wormwood (*Artemisia absinthium* L.) and ipchak grasses. In the southern part of the region near Lake Tengiz, the landscape is characterized by open expanses of salt marshes covered primarily by wormwood and ipchak species (Saparov, 2014).

2.2. Survey Methods

Protective forest belts play a crucial role in agricultural landscapes, particularly in steppe areas vulnerable to wind erosion and extreme climatic conditions. The Akmola region, situated in central Kazakhstan, is significantly affected by strong winds, droughts, and declining soil fertility. Evaluating forest shelterbelts is essential to understand their condition and effectiveness, as the health and quality of these plantings directly influence soil conservation, prevention of wind erosion, enhanced crop productivity, and the overall sustainability of agricultural environments.

Assessment methods for these field-protective belts can be categorized into several key areas:

1. Morphometric assessment – involves measuring the physical characteristics of the forest belts.
2. Species and phytocenotic analysis – details the composition of trees and shrubs within the belts.
3. Sanitary condition evaluation – determines the overall health and vitality of the shelterbelts.
4. Agroecological efficiency – serves as a critical indicator of the belts' practical benefits to agriculture.

3. Results and Discussion

In the early 1960s, Kazakhstan launched large-scale initiatives to establish forest belts—permeable, semi-permeable, and impermeable—to shield agricultural lands from wind erosion, improve snow retention, and enhance crop productivity. However, recent field assessments reveal that many of these forest belts are now in severe decline and largely ineffective.

A.I. Baraev Scientific and Production Center of Grain Farming six longitudinal and transverse shelterbelts were evaluated, each consisting of three rows of *Ulmus parvifolia, Acer negundo, Caragana arborescens,* and *Populus* spp., planted at 1.5–3 m spacing. Originally intended as permeable windbreaks, the belts have become dense thickets dominated by *Caragana arborescens*, which outcompeted other species. Approximately 80% tree mortality was recorded, and full restoration is now required. This situation supports Temirbekov et al. (2022), Thevs et al. (2017), and Yapiyev et al. (2020), who highlighted the ecological dysfunction of unmanaged shelterbelts, particularly where invasive or fast-growing species dominate.

Kazger LLP: A two-row shelterbelt of *Lonicera tatarica, Amelanchier Medik,* and *Caragana arborescens* was established along grain field edges. Despite recent afforestation attempts, the lack of ecological and silvicultural planning has led to weak protective functions. The case reflects concerns from Imangulova et al. (2020) and Ruppert et al. (2020) regarding poor species selection and absence of adaptive design in Central Asia.

Yesil-Agro LLP: This enterprise maintains 792.8 ha of shelterbelts, established in the 1970s–80s with up to 12 tree and shrub species. Field surveys revealed belts in progressive decline with reduced crown density, weakened vitality, and structural disintegration. The decline is linked to insufficient thinning and delayed agro-technical interventions. Findings correspond to Baitassov et al. (2019) and Sarsekova et al. (2021), who demonstrated that without regular silvicultural treatments, aging belts lose resilience and protective efficacy.

LLP AF “Rodina” (Sadovoye village): Shelterbelts of 2–4 rows, primarily *Populus alba*, were evaluated. The trees, about 60 years old, exhibited:

80–90% mortality with many trees senescent and structurally unstable.

Heart rot prevalent in stumps, increasing fire hazard risk.

Hydrological alterations (uneven snow accumulation and spring waterlogging), negatively impacting sowing.

These findings are consistent with Cheverdina et al. (2023) and Huiliang et al. (2022), who reported that aging monocultures and poorly oriented belts can exacerbate ecological risks rather than mitigate them.

Table 1. Tree mortality by enterprise.

Enterprise / Site	Rows	Dominant Species	Tree Mortality (%)	Main Issues Identified
Baraev Center	3	Elm, Maple, Acacia, Poplar	~80%	Invasive *Caragana*, dense thickets
Kazger LLP	2	Honeysuckle, *Amelanchier*, *Acacia*	High, not quantified	Poor design, low protective effect
Yesil-Agro LLP	Multi-row (1970s–80s)	12 spp. mixed	Moderate–High	Weakening vitality, poor management
Rodina LLP (Sadovoye)	2–4	*Populus alba*	80–90%	Aging monoculture, rot, hydrological imbalance

Table 2. Shelterbelt design characteristics.

Enterprise / Site	Rows	Spacing (m)	Age of Belts	Notes
Baraev Center	3	1.5–3	~60 yrs	Dense thickets, invasive species
Kazger LLP	2	Not specified	Recent	Low ecological guidance
Yesil-Agro LLP	Mixed	Variable	40–50 yrs	Poor thinning, degradation
Rodina LLP	2–4	Not specified	~60 yrs	Old monocultures, structural decline

3.1. Overall Findings

Across all enterprises, the surveyed shelterbelts no longer provide reliable wind protection, snow regulation, or agro-engineering benefits. Instead, they now represent a liability due to:

- High mortality and senescence
- Dominance of invasive or unsuitable species
- Poor structural design and lack of silvicultural care
- Negative hydrological side-effects

Integrated management—including regular thinning, replanting, species diversification, and design adaptation to local soils and climate—is essential for restoring their protective and ecological functions (Baisholanov et al., 2024; Saparov, 2014; Temirbekov et al., 2022).

4. Conclusion

The assessment of field-protective forest belts across several agricultural enterprises in the Akmola region reveals significant degradation in both their structure and functionality. Originally established to combat wind erosion, regulate snow distribution, and enhance crop productivity, many of these shelterbelts have deteriorated due eto aging, poor maintenance, and lack of scientific oversight in their design and restoration.

At NPTsKhZ LLP named after A.I. Baraev, shelterbelts are overgrown, largely dead (up to 80%), and have lost their intended agro ecological function. Similarly, Yesil-Agro LLP's belts, although extensive and species-diverse, suffer from age-related decline and insufficient upkeep, rendering them ineffective. Kazger LLP has initiated afforestation activities; however, the lack of a methodological approach considering local ecological conditions has limited the success of these efforts. In Sadovoye, the situation is particularly critical—most trees in the forest belts are dead or dying, posing not only fire hazards but also negatively impacting field hydrology and delaying agricultural operations.

Across all surveyed sites, it is evident that the shelterbelts are no longer serving their protective, ecological, or agricultural roles effectively. Key issues include high tree mortality, absence of structured agroforestry planning, lack of regeneration efforts, and disruptions to the water regime caused by deteriorated belt structures.

To restore the effectiveness of these critical agro-landscape elements, a comprehensive and scientifically guided reconstruction program is necessary. This should involve:

- Removal of dead and hazardous trees;
- Replanting with locally adapted, drought- and wind-resistant species;
- Regular maintenance, including pruning and thinning;
- Integration of agro ecological and GIS-based planning to optimize shelterbelt design.

Without immediate intervention and long-term management strategies, the degradation of forest shelterbelts will continue to exacerbate soil erosion, reduce crop yields, and compromise the resilience of agricultural systems in Akmola region.

Future research should focus on developing adaptive afforestation models tailored to the region's climatic variability, testing the performance of mixed-species plantations, and exploring digital monitoring tools for long-term shelterbelt management.

Acknowledgment

This work was supported by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan under project no. IRN AP19679749 "*Mapping of forest shelter belts, their impact on productivity and water resources, expansion prospects, using geospatial technologies in the Akmola region*".

Conflict of Interest

The authors declare that they have no conflict of interest.

References

Amanzholova, R., Sarsekova, D., Stefan, C., Sagin, J., King, R., & Em, T. (2024). *TVET IT technologies support for the water resources, agro forest shelterbelts sustainability*. 4th International Conference on Smart Information Systems and Technologies (SIST). Astana.

Baisholanov, S., Akshalov, K., Mukanov, Y., Zhumabek, B., & Karakulov, E. (2024). Agro-climatic zoning of the territory of Northern Kazakhstan for zoning of agricultural crops under conditions of climate change. *Climate*, *13*(1), 3. https://doi.org/10.3390/cli13010003

Baitassov, A., et al. (2019). Degradation and restoration of windbreak functions in aging forest belts of Northern Kazakhstan. *Kazakhstan Journal of Forestry*, *5*(1), 23-31.

Cheverdina, Y., Bespalova, V., & Titova, V. (2023). Changes in parameters of effective soil fertility in the Kamennaya Steppe under the effect of forest shelter belts allocated to various landscapes. *Moscow University Soil Science Bulletin*, *78*(Suppl. 1), 18-27. https://doi.org/10.3103/S0147687423060030

Driscoll, E., & de Beurs, K. (2024). Using satellite imagery to track the development of the Green Belt of Astana, Kazakhstan: A remote sensing perspective on artificial forestry development. *Remote Sensing Applications Society and Environment*, *38*(3), 101543. https://doi.org/10.1016/j.rsase.2025.101543

Huiliang, L., Yongdong, W., Shengyu, L., Aikedai, A., & Haifeng, W. (2022). Efficiency of various shelterbelt configurations: A wind tunnel study. *Atmosphere*, *13*(7), 1022. https://doi.org/10.3390/atmos13071022

Imangulova, T. V., Yevloyeva, A. S., & Titova, M. A. (2020). Assessment of the Akmola Region territory on the degree of natural resources attractiveness. *Issues of Geography and Geoecology*, *3*, 77-82.

Jerusalem, V. L., Del Rosario-Garcia, M., Delos Reyes, A. M., Palencia, M. M., & Calilung, R. P. (2017). *Practical research 2: Exploring quantitative research*. Fastbooks Educational Supply, Inc.

Makhanova, N., Berdenov, Z., Wendt, J. A., & Sarsekova, D. (2022). Biogeographic potential of the North Kazakh Plain in the perspective of health tourism development. *GeoJournal of Tourism and Geosites*, *40*(1), 253-258. https://doi.org/10.30892/gtg.40130-826

Mukanov, B., Danchev, B., & Uteshkaliev, M. (2010). *Improving the sustainability and efficiency of the functional capabilities of agroforestry landscapes in northern and western Kazakhstan*. International Scientific and Practical Conference: Innovative Ways of Development of Forestry, Specially Protected Areas and Related Branches of the Agro-Industrial Complex in the Conditions of Market Relations. Almaty.

Ruppert, D., Welp, M., Spies, M., & Thevs, N. (2020). Farmers' perceptions of tree shelterbelts on agricultural land in rural Kyrgyzstan. *Sustainability*, *12*(3), 1203. https://doi.org/10.3390/su12031203

Saparov, A. (2014). Soil resources of the Republic of Kazakhstan: Current status, problems and solutions. In L. Mueller, A. Saparov & G. Lischeid (Eds.), *Novel Measurement and Assessment Tools for Monitoring and Management of Land and Water Resources in Agricultural Landscapes of Central Asia* (pp. 61-73). Springer. https://doi.org/10.1007/978-3-319-01017-5_2

Sarsekova, D., Perzadayeva, A., Kitaibekova, S., & Ayan, S. (2021). Recommendations for sustainable greening of urbanized ecosystems in dry-steppe zones of Akmola Region, Kazakhstan. *Alinteri Journal of Agricultural Sciences*, *36*(1), 99-108. https://doi.org/10.47059/alinteri/V36I1/AJAS21016

Smagulov, Y. N. (2021). Spatial differentiation of the impact of climate change on agriculture in Akmola Oblast. *Arid Ecosystems*, *11*, 279-286. https://doi.org/10.1134/S2079096121030124

Temirbekov, A., et al. (2022). Effectiveness of shelterbelts under changing climate conditions in the steppe regions of Kazakhstan. *Eurasian Journal of Environmental Research*, *6*(2), 115-123.

Thevs, N., Strenge, E., Aliev, K., Eraaliev, M., Lang, P., Baibagysov, A., & Xu, J. (2017). Tree shelterbelts as an element to improve water resource management in Central Asia. *Water*, *9*(11), 842. https://doi.org/10.3390/w9110842

Toktasynov, Z., Iskakov, S., & Sarsekova, D. (2012). *Handbook of the forester of Kazakhstan*. Astana.

Urazov, P., Usoltsev, V., & Urazova, A. (2025). Structure of aboveground phytomass of plantations in protective forest belts of the Sverdlovsk railway. *Electronic Archive of USFTU*, *1*(92). (In Russian)

URL1. (2025). *A. I. Barayev Research and Production Centre for Grain Farming*. Retrieved May 15, 2025, from https://baraev.kz/

URL2. (2025). *Agro Yesil's business profile*. Retrieved May 18, 2025, from https://eldala.kz/dannye/kompanii/11115-agro-esil

URL3. (2025). *Kazger*. Retrieved May 17, 2025, from https://eldala.kz/dannye/kompanii/20133-kazger

URL4. (2025). *LLP Agricultural Company "Rodina"*. Retrieved May 25, 2025, from https://afrodina.kz/

Yapiyev, V., Skrzypek, G., Verhoef, A., Macdonald, D., & Sagin, Z. (2020). Between boreal Siberia and arid Central Asia–Stable isotope hydrology and water budget of Burabay National Nature Park ecotone (Northern Kazakhstan). *Journal of Hydrology: Regional Studies*, *27*, 100644. https://doi.org/10.1016/j.ejrh.2019.100644

http://silvaworld.org
SilvaWorld
e-ISSN: 2822-6127
PRENSIP
https://prensip.gen.tr

REVIEW ARTICLE

The Role of Forest Fires in Plant Biodiversity: Ecological Responses and Succession

Nurcan Yiğit✉

Kastamonu University, Faculty of Forestry, Department of Forest Engineering, Kastamonu/Türkiye

ARTICLE INFO

Article History
Received: 05.08.2025
Accepted: 15.09.2025
First Published: 29.09.2025

Keywords
Floristic composition
Forest botany
Forest fire
Plant communities
Succession

ABSTRACT

Forest fires represent increasingly frequent disturbances in forested and semi-forested ecosystems, primarily driven by the interplay of natural processes and anthropogenic pressures. These events have reached alarming levels, significantly altering the structural, functional, ecological, and biological dynamics of forest ecosystems. Recognized as among the most destructive natural disturbances, forest fires exert direct and long-lasting effects on ecosystems that extend far beyond the mere burning of vegetation. This study aims to evaluate the ecological impacts of forest fires, with particular emphasis on their effects on floristic composition, the ecological responses of plant species, and the post-fire succession processes. Following fire events, substantial shifts in species diversity, dominance, and community structure are observed. The interplay between fire-resistant and fire-sensitive species plays a decisive role in shaping the trajectory of ecological succession. Moreover, the rapid proliferation of invasive species—often gaining a competitive edge in disturbed habitats—poses a serious threat to native plant diversity and overall ecosystem integrity. In this context, floristic monitoring studies are vital for informed conservation planning. Supporting natural succession, promoting the *in situ* conservation of native species, and implementing ecosystem-based management strategies emerge as critical tools for sustaining post-fire ecosystem resilience. This article adopts an interdisciplinary perspective to examine fire–flora interactions, synthesizing insights from the current literature and offering region-specific recommendations, particularly for forested ecosystems in Türkiye.

Please cite this paper as follows:

Yiğit, N. (2025). The role of forest fires in plant biodiversity: Ecological responses and succession. *SilvaWorld*, *4*(2), 81-87. https://doi.org/10.61326/silvaworld.v4i2.391

1. Introduction

Forest fires are among the most important natural processes affecting the structure and functions of ecosystems. They are among the environmental threats becoming increasingly frequent and severe due to increased human activities and climate change (Turner, 1989). While fires serve as a natural succession mechanism in some ecosystems, uncontrolled and frequently occurring fires, in particular, can have irreversible effects on floristic structure and biodiversity. They cause dramatic effects on plant composition, habitat fragmentation, destruction of ecological corridors, deterioration in soil structure and quality, and decreased biodiversity (Certini, 2005; Pausas & Keeley, 2009; Turner et al., 1997).

The ecological impacts of fires are not limited to tree burning or carbon release; they also profoundly affect plant communities' structural and functional properties. These effects are particularly evident in more sensitive components such as understory flora and ground cover plants. The responses of plant species to fire vary depending on species-specific adaptations, such as the fire resistance of root systems, seasonal seed set, and resprouting capacity.

✉ Corresponding author
E-mail address: nyigit@kastamonu.edu.tr

Floristic composition describes the number and distribution of plant species within an ecosystem and is an important indicator of ecosystem health. Fires affect this composition directly (species elimination) and indirectly (changes in competitive relationships, transformation of soil properties). For example, some species can rapidly become dominant during the post-fire succession process, while others can disappear entirely from the ecosystem.

While distinctions are sometimes made between fire-adapted and non-fire-adapted ecosystems, fires occur with varying frequency and severity in nearly all terrestrial biomes worldwide (Archibald et al., 2018; He et al., 2019; Keeley et al., 2011; McWethy et al., 2013). The flammability of a particular ecosystem is greatly influenced by the composition, structure and species composition of the community, climatic conditions or seasonality of conditions suitable for fire spread, and the frequency of ignition sources (Gill & Zylstra, 2005; Pausas & Keeley, 2009; Pausas et al., 2017).

Species' responses to fire vary depending on their ecological traits and the characteristics of the fire regime, particularly its frequency, intensity, seasonality, and the size of the burned area (He et al., 2019). Fire influences both the abundance and structure of plant communities, creating a dynamic and often complex ecological relationship—especially critical in the context of exotic plant invasions. Post-fire ecological succession refers to the temporal changes in community structure and species composition following a fire event. During this process, species that are fire-resistant or capable of rapid regeneration often become dominant, while slower-growing or fire-sensitive species may decline or disappear entirely. Consequently, the floristic composition can differ significantly between pre- and post-fire conditions. Furthermore, the expansion of invasive plant species into fire-cleared areas can exert competitive pressure on native flora, destabilizing the ecosystem and undermining biodiversity (Daskalakou & Thanos, 1996; Mandle et al., 2011).

This article critically evaluates the ecological consequences of wildfires on plant diversity, with a specific focus on post-fire succession dynamics. By integrating global and Türkiye-based case studies, it aims to highlight patterns, gaps, and practical implications for sustainable forest management.

2. The Relationship between Fire Regimes and Floristic Structure

A fire regime encompasses the full range of fire-related characteristics within an ecosystem, including frequency, intensity, seasonality, duration, and spatial extent. These parameters collectively play a critical role in shaping the floristic composition and ecological dynamics of each ecosystem. The effects of fire on biotic communities are not determined solely by the occurrence of fire itself but are strongly influenced by the specific attributes of the fire regime. In particular, the frequency, intensity, and timing of fires are key factors in determining plant species' survival and regeneration capacity (Gill & Zylstra, 2005; Keeley et al., 2011; Pausas & Keeley, 2009).

2.1. Fire Frequency and Intensity

In forest ecosystems where fires occur frequently, a new fire may occur before the natural succession process is complete. This causes slow-growing, late-succession species to be replaced by fast-growing, fire-resistant species. Excessive fire pressure can reduce floristic diversity, homogenize species diversity, and weaken ecosystem services. These effects have been observed, particularly in the Turkish red pine (*Pinus brutia* Ten.) forests of the Mediterranean and Aegean regions, where frequent fires occur (Akkemik et al., 2023; Bond & Wilgen, 1996; Kavgacı & Tavşanoğlu, 2010).

Fire intensity is related to soil surface temperature, burning depth, and the level of organic matter destruction. Low-severity fires affect only the surface shrub and herbaceous layer; High-intensity fires can destroy the seed bank, damage root systems, and disrupt soil structure, negatively impacting regeneration (DeBano et al., 1998). This leads to species losses and structural disruptions, particularly in the understory flora (Pausas et al., 2008).

2.2. Seasonality

The season in which a fire occurs can increase or decrease its impact depending on the phenological status of the plants. For example, a fire in spring can be fatal to plants that have not yet flowered and produced seeds, while late-summer fires may be less destructive because they occur after some species have dispersed their seeds. Furthermore, the season of the fire affects which species will benefit during succession (Daskalakou & Thanos, 1996).

2.3. Effects of Fires on Floristic Structure

Fire regimes can affect floristic composition in the short term (extinction of existing species or shift in dominant species) and in the long term (direction of succession, species persistence). In ecosystems frequently exposed to fire, fire-adapted species (e.g., resprouter shrubs, thick-barked trees, serotinous conifers) become prominent, while sensitive species face the threat of extinction. This can weaken the ecosystem's functional diversity and balance mechanisms (Keeley et al., 2011; Pausas & Verdú, 2005).

Fire regimes observed in Turkish forests are gradually changing due to climate change and anthropogenic impacts. Increased fire risk, particularly after long dry periods, triggers permanent transformations in the Mediterranean and flora, suppressing native species and causing floristic degeneration in some regions.

3. Plant Types Responding to Fire

Forest fires represent one of the most significant ecological disturbances, impacting flora, fauna, biodiversity, and landscape structure across fire-prone ecosystems worldwide. In Mediterranean regions in particular, fires act as powerful ecological forces, substantially altering species composition and disrupting ecological balance (Bond & Keeley, 2005; Pausas & Keeley, 2009). The extent to which plant species and communities respond to fire is shaped by various functional traits, physiological tolerances, and reproductive strategies that have evolved under recurrent fire regimes (Keeley et al., 2011).

Plant species exhibit capacities to persist in fire-affected areas (Kavgacı & Tavşanoğlu, 2010). Mediterranean vegetation, in particular, displays high fire adaptability due to both vegetative and generative traits (Kazanis & Arianoutsou, 2004; Paula et al., 2009; Tavşanoğlu & Gürkan, 2004). These adaptations are the result of long-term evolutionary processes (Pausas et al., 2004; Trabaud, 1994). Fire- adapted plant species are typically categorized into functional groups based on their mechanisms of persistence, regeneration strategies, and post-fire establishment potential. Many such species survive fire events by resprouting from dormant buds or underground organs such as tubers, lignotubers, or rhizomes. Fire-adapted species, which withstand fire damage due to their structural or chemical properties, are also prevalent in fire-prone regions (Clarke et al., 2013; Lamont et al., 2019). Mediterranean-type ecosystems are often dominated by maquis vegetation, characterized by species capable of regenerating both vegetatively and from seeds (Lavorel, 1999).

Understanding the distribution and ecological roles of fire-sensitive plant species is emerging as a critical research priority, particularly in the context of intensifying climate change. Global climate models predict a marked increase in the frequency and severity of wildfires in the coming decades (Bowman et al., 2020; Flannigan et al., 2009). Such changes are expected not only to amplify biomass loss but also to drive long-term shifts in vegetation composition, successional dynamics, and ecosystem functions (Ertürk et al., 2024a, 2024b; Özcan et al., 2024).

Fire-adapted plant species have evolved a range of survival strategies, including vegetative resprouting, fire-stimulated seed germination, the development of thick bark, and the production of protective chemicals (Keeley et al., 2011; Pausas & Keeley, 2009). For instance, some species maintain persistent soil seed banks, where seeds remain dormant and viable for many years. When fire occurs, the heat or chemical cues from smoke break dormancy, promoting synchronized germination. This adaptation, known as fire-induced germination, is crucial for the persistence of many woody and herbaceous species in ecosystems where crown fires are common (Ergan, 2017; Moreira et al., 2010; Tavşanoğlu et al., 2017).

However, the extent to which these strategies are effective under different fire regimes remains to be clarified in regional contexts. Accurately modeling the distribution patterns of plant groups responding to fires is crucial for post-fire ecosystem renewal, biodiversity conservation, and sustainability.

In this context, accurately predicting the impacts of changing fire regimes on plant communities and determining appropriate strategies not only contributes to ecological resilience and durability but also forms the scientific basis for climate-adapted land management and conservation strategies (Clarke et al., 2013; Pausas & Bradstock, 2007). Furthermore, changes in fire regimes caused by anthropogenic land use changes and invasive species are increasingly altering the selective pressures on plant communities, potentially disrupting long-standing evolutionary adaptations (Pausas & Bradstock, 2007).

4. Post-Fire Successional Dynamics of Floristic Composition

Plant species in Mediterranean-type ecosystems can re-enter the area after a fire due to their adaptability (Kavgacı & Tavşanoğlu, 2010). The ecological impact of fires can lead to an ongoing reconstruction process in the form of post-fire recovery of ecosystems (Doussi & Thanos, 1994), but can also result in ecosystem degradation, often due to human-induced factors, and a departure from existing floristic structure and structural characteristics (Moreira & Vallejo, 2009).

Suppose the dominant tree species can re-establish and develop rapidly after a forest fire. In that case, pre-fire environmental conditions will occur earlier, and the vegetation will rapidly return to pre-fire conditions (Arnan et al., 2007). The emergence of open land conditions after a fire creates favorable conditions for specific species or groups of species that could not disperse or were present at low densities in old, closed forests. In this context, species called pioneer species germinate rapidly and cover the site in the first year after a fire. Legumes and rockrose are the most prominent species in this context (Figure 1). Legumes, in particular, are crucial for post-fire vegetation dynamics because they improve soil nutrient content and provide a high organic matter input. These fire monitors survive by germinating their seeds hidden in the soil after the fire (URL1, 2025).

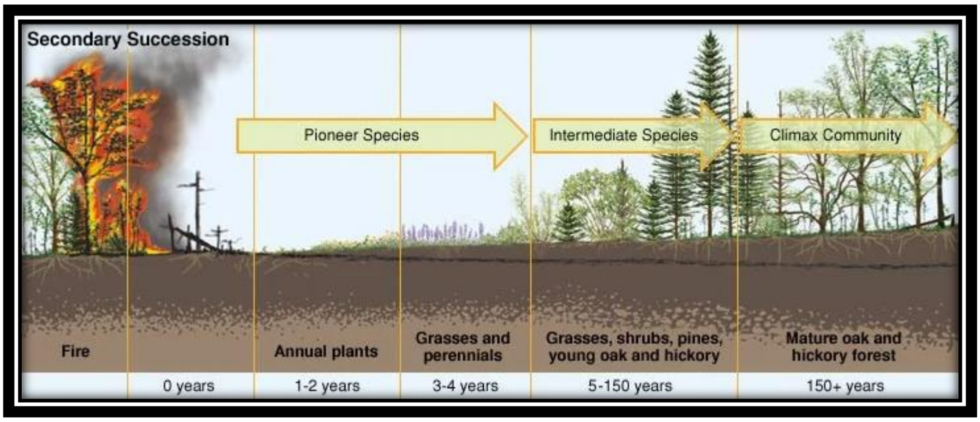

Figure 1. Stages of secondary succession (URL1, 2025).

5. Natural Succession and Floristic Regeneration Processes

Natural ecosystems are dynamic structures that undergo continuous change and development over time. Ecological succession, one of the processes underlying these changes, can be defined as reestablishing a specific order in habitats disrupted by significant events such as forest fires, floods, landslides, or anthropogenic activities (Begon et al., 2006). Plant communities begin with fast-growing and short-lived species in the early stages of natural succession and gradually give way to climax communities. Throughout this process, biodiversity, soil structure, microclimate, and interactions among species become increasingly complex (Prach & Pyšek, 2001). For example, herbaceous species become dominant after fires in the early succession stages and may eventually be overshadowed by shrubs and trees (Keeley et al., 2011). The succession process; It depends on the interaction of many environmental and biotic factors, such as fire, flood, and land abandonment, climate, soil properties (pH, moisture capacity, macro and micronutrients), and species diversity in the immediate environment (Mitchley, 2008).

The period immediately following fires is a critical one that must be carefully managed. During this period, the protection of forest soil and the prevention of alien species (e.g., *Ailanthus altissima, Robinia pseudoacacia, Acacia saligna*), which can rapidly colonize post-fire habitats and suppress native regeneration, are of great importance. Tropical and subtropical forests, including the Mediterranean Region, have evolved through fires. Minerals, organic materials, and seeds found in the soil of burned areas are sources of forest renewal. However, because these areas are completely open, they are also prone to loss through erosion, and great care must be taken to protect soil, a vital resource, in situ. Intensive land clearing, drainage, and restoration activities after fires can cause the loss of this valuable resource to wind and surface runoff. Therefore, forest regeneration can be significantly delayed (Kemer, 2022). Natural succession is important because it demonstrates the self-renewal capacity of ecosystems (Rey Benayas et al., 2009). Furthermore, the recovery of ecosystem services such as biodiversity, habitat quality, and carbon storage is directly related to successional processes.

6. Post-Fire Floristic Change and the Role of Invasive Species

Forest fires are powerful ecological disturbances that not only cause immediate damage to ecosystems but also drive long-term changes in floristic composition. Recent studies have demonstrated that fires lead to both temporal and structural alterations in plant diversity (Kavgacı & Tavşanoğlu, 2010; Kemer, 2022). However, the increasing frequency and intensity of forest fires—exacerbated by climate change and anthropogenic pressures—have been shown to negatively affect the composition and stability of native plant communities over time. In Türkiye, this trend poses a growing threat to the structural integrity of vegetation and has the potential to result in species losses and ecological imbalance (Akkemik et al., 2023).

In this context, invasive plant species emerge as a critical concern. These species often capitalize on the ecological vacancies created by fire, rapidly colonizing disturbed areas and outcompeting native flora (Richburg et al., 2004). Their proliferation can alter successional pathways, inhibit the regeneration of indigenous vegetation, and contribute to a decline in biodiversity. In addition, fire suppression policies—which interrupt natural fire regimes—can further disrupt floristic balance and exacerbate the ecological impacts of subsequent fire events (McLauchlan et al., 2020).

Thus, the ecological consequences of forest fires extend far beyond the immediate post-disturbance phase. The interplay between fire-driven habitat change and the spread of invasive species gives rise to complex and persistent ecological challenges, ultimately threatening ecosystem stability and biodiversity. Monitoring post-fire vegetation dynamics, evaluating the expansion of invasive species, and implementing proactive strategies to conserve native flora are therefore essential for maintaining the resilience and ecological integrity of fire-adapted forest ecosystems.

7. Conclusion and Recommendations

The forest fires, which have become more frequent and intense due to climate change and human pressure, have and will continue to impact natural plant species composition over time negatively. In areas affected by fires, herbaceous plant species diversity initially increases significantly, but then declines as woody species re-dominate. Studies have shown that a significant increase in species diversity occurs in the first few years after a fire, stabilizing after 20 years. The increased species diversity after the fire is reduced in areas subject to deep and mechanized tillage due to the inability of deeply buried herbaceous seeds to germinate. While removing hard-leaved woody species in these areas benefits the planted species, it can negatively impact shrub diversity and density. This negative impact on plant diversity caused by mechanization can be mitigated by conducting strip and zoned rather than full-scale operations. However, it is important to avoid mechanization as much as possible in areas that are home to rare and endemic species whose populations are expected to increase after fires (Akkemik et al., 2023).

All restoration efforts should be conducted within the framework of biodiversity principles, aiming to restore the natural forest ecosystem (Kemer, 2022). Natural succession and floristic regeneration processes are crucial for understanding the long-term recovery dynamics of degraded ecosystems and developing conservation strategies. Careful monitoring and guidance of these processes provide the scientific basis for sustainable habitat management and restoration practices.

Conflict of Interest

The author declares that there is no conflict of interest.

References

Akkemik., Ü., Kavgacı, A., & Akarsu, F. (2023). Orman yangınlarının bitki çeşitliliği üzerindeki etkileri. In A. Kavgacı, & M. Başaran, (Eds.), *Orman yangınları* (pp. 326-342). Türkiye Ormancılar Derneği Yayını. (In Turkish)

Archibald, S., Lehmann, C. E., Belcher, C. M., Bond, W. J., Bradstock, R. A., Daniau, A. -L., Dexter, K. G., Forrestel, E. J., Greve, M., & He, T. (2018). Biological and geophysical feedbacks with fire in the Earth system. *Environmental Research Letters*, *13*(3), 033003. https://doi.org/10.1088/1748-9326/aa9ead

Arnan, X., Rodrigo, A., & Retana, J. (2007). Post-fire regeneration of Mediterranean plant communities at a regional scale is dependent on vegetation type and dryness. *Journal of Vegetation Science*, *18*(1), 111-122. https://doi.org/10.1111/j.1654-1103.2007.tb02521.x

Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From individuals to ecosystems*. Blackwell Publishing.

Bond, W. J., & Keeley, J. E. (2005). Fire as a global 'herbivore': The ecology and evolution of flammable ecosystems. *Trends in Ecology & Evolution*, *20*(7), 387-394. https://doi.org/10.1016/j.tree.2005.04.025

Bond, W. J., & Wilgen, B. W. (1996). *Fire and plants: Population and community biology series*. Springer. https://doi.org/10.1007/978-94-009-1499-5

Bowman, D. M., Kolden, C. A., Abatzoglou, J. T., Johnston, F. H., van der Werf, G. R., & Flannigan, M. (2020). Vegetation fires in the Anthropocene. *Nature Reviews Earth & Environment*, *1*(10), 500-515. https://doi.org/10.1038/s43017-020-0085-3

Certini, G. (2005). Effects of fire on properties of forest soils: A review. *Oecologia*, *143*, 1-10. https://doi.org/10.1007/s00442-004-1788-8

Clarke, P. J., Knox, K. J. E., Bradstock, R. A., & Munoz-Robles, C. (2013). Post-fire recovery of woody plants in eastern Australian forests: The role of fire severity, interval and resprouting. *Journal of Vegetation Science*, *24*(4), 724-733.

Daskalakou, E. N., & Thanos, C. A. (1996). Aleppo pine (*Pinus halepensis*) post-fire regeneration: The role of canopy and soil seed banks. *International Journal of Wildland Fire*, *6*(2), 59-66. https://doi.org/10.1071/WF9960059

DeBano, L. F., Neary, D. G., & Ffolliott, P. F. (1998). *Fire's effects on ecosystems*. John Wiley & Sons.

Doussi, M. A., & Thanos, C. A. (1994). *Post-fire regeneration of hardseeded plants: Ecophysology of seed germination*. 2nd International Conference of Forest-Fire Research. Coimbra.

Ergan, G. (2017). *Akdeniz bitkilerinin yangınla olan ilişkisinin incelenmesi ve yangın efemerallerinin tespiti* (Master's thesis, Hacettepe University). (In Turkish)

Ertürk, N., Arıcak, B., Şevik, H., & Yiğit, N. (2024b). Possible change in distribution areas of *Abies* in Kastamonu due to global climate change. *Kastamonu University Journal of Forestry Faculty*, *24*(1), 81-91. https://doi.org/10.17475/kastorman.1460616

Ertürk, N., Arıcak, B., Yiğit, N., & Sevik, H. (2024a). Potential changes in the suitable distribution areas of *Fagus orientalis* lipsky in Kastamonu due to global climate change. *Forestist*, *74*, 159-165. https://doi.org/10.5152/forestist.2024.23024

Flannigan, M., Stocks, B., Turetsky, M., & Wotton, M. (2009). Impacts of climate change on fire activity and fire management in the circumboreal forest. *Global Change Biology*, *15*(3), 549-560. https://doi.org/10.1111/j.1365-2486.2008.01660.x

Gill, A. M., & Zylstra, P. (2005). Flammability of Australian forest fuels. *Forest Ecology and Management*, *68*(2), 87-93. https://doi.org/10.1080/00049158.2005.10674951

He, T., Lamont, B. B., & Pausas, J. G. (2019). Fire as a key driver of Earth's biodiversity. *Biological Reviews*, *94*(6), 1983-2010. https://doi.org/10.1111/brv.12544.

Kavgacı, A., & Tavşanoğlu, Ç. (2010). Akdeniz tipi ekosistemlerde yangın sonrası vejetasyon dinamiği. *Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi*, *A*(2), 149-166. (In Turkish)

Kazanis, D., & Arianoutsou, M. (2004). Long-term post-fire vegetation dynamics in *Pinus halepensis* forests of Central Greece: A functional approach. *Plant Ecology*, *171*, 101-121. https://ddoi.org/10.1023/B:VEGE.0000029376.15741.b4

Keeley, J. E., Pausas, J. G., Rundel, P. W., Bond, W. J., & Bradstock, R. A. (2011). Fire as an evolutionary pressure shaping plant traits. *Trends in Plant Science*, *16*(8), 406-411. https://doi.org/10.1016/j.tplants.2011.04.002

Kemer, N. (2022). Orman yangınları ve sonrası: Orman ekosistem restorasyonu. *Avrupa Bilim ve Teknoloji Dergisi*, (33), 373-381. https://doi.org/10.31590/ejosat.1054290 (In Turkish)

Lamont, B. B., He, T., & Pausas, J. G. (2019). Fire as a selective agent for both serotiny and nonserotiny over space and time. *Critical Reviews in Plant Sciences*, *39*(2), 140-172. https://doi.org/10.1080/07352689.2020.1768465

Lavorel, S. (1999). Ecological diversity and resilience of Mediterranean vegetation to disturbance. *Diversity and Distributions*, *5*(1-2), 3-13. https://doi.org/10.1046/j.1472-4642.1999.00033.x

Mandle, L., Bufford, J. L., Schmidt, I. B., & Daehler, C. C. (2011). Woody exotic plant invasions and fire: Reciprocal impacts and consequences for native ecosystems. *Biological Invasions*, *13*, 1815-1827. https://doi.org/10.1007/s10530-011-0001-3

McLauchlan, K. K., Higuera, P. E., Miesel, J., Rogers, B. M., Schweitzer, J., Shuman, J. K., Tepley, A. J., Varner, J. M., Veblen, T. T., & Adalsteinsson, S. A. (2020). Fire as a fundamental ecological process: Research advances and frontiers. *Journal of Ecology*, *108*(5), 2047-2069. https://doi.org/10.1111/1365-2745.13403

McWethy, D., Higuera, P., Whitlock, C., Veblen, T., Bowman, D., Cary, G., Haberle, S., Keane, R., Maxwell, B., & McGlone, M. (2013). A conceptual framework for predicting temperate ecosystem sensitivity to human impacts on fire regimes. *Global Ecology and Biogeography*, *22*(8), 900-912. https://doi.org/10.1111/geb.12038

Mitchley, J. (2008). Old Fields. Dynamics and restoration of abandoned farmland, Edited by Viki A. Cramer and Richard J. Hobbs, ix + 334 pp., 23 × 15 × 1.5 cm, ISBN 978 1 59726 075 6 paperback, GB£ 26.50, London, UK: Island Press. *Environmental Conservation*, *35*(2), 191-192. https://doi.org/10.1017/S0376892908004815

Moreira, B., Tormo, J., Estrelles, E., & Pausas, J. G. (2010). Disentangling the role of heat and smoke as germination cues in Mediterranean Basin flora. *Annals of Botany*, *105*(4), 627-635. https://doi.org/10.1093/aob/mcq017

Moreira, F., & Vallejo, R. (2009). What to do after fire? Post-fire restoration. In Y. Birot, (Ed.), *Living with wildfires: What science can tell us: A contribution to the science – policy dialogue* (pp. 53-58). European Forest Institute.

Özcan, A. U., Gülçin, D., Tuttu, G., Velázquez, J., Ayan, S., Stephan, J., Tuttu, U., Varlı, A., & Çiçek, K. (2024). The future possible distribution of Kasnak oak (*Quercus vulcanica* Boiss. & Heldr. ex Kotschy) in Anatolia under climate change scenarios. *Forests*, *15*(9), 1551. https://doi.org/10.3390/f15091551

Paula, S., Arianoutsou, M., Kazanis, D., Tavsanoglu, Ç., Lloret, F., Buhk, C., Ojeda, F., Luna, B., Moreno, J. M., Rodrigo, A., Espelta, J. M., Palacio, S., Fernández-Santos, B., Fernandes, P. M., & Pausas, J. G. (2009). Fire-related traits for plant species of the Mediterranean Basin. *Ecology*, *90*(5), 1420. https://doi.org/10.1890/08-1309.1

Pausas, J. G., & Bradstock, R. A. (2007). Fire persistence traits of plants along a productivity and disturbance gradient in mediterranean shrublands of south-east Australia. *Global Ecology and Biogeography*, *16*(3), 330-340. https://doi.org/10.1111/j.1466-8238.2006.00283.x

Pausas, J. G., & Keeley, J. E. (2009). A burning story: The role of fire in the History of life. *BioScience*, *59*(7), 593-601. https://doi.org/10.1525/bio.2009.59.7.10.

Pausas, J. G., & Verdú, M. (2005). Plant persistence traits in fire-prone ecosystems of the Mediterranean Basin: A phylogenetic approach. *Oikos*, *109*(1), 196-202. https://doi.org/10.1111/j.0030-1299.2005.13596.x

Pausas, J. G., Keeley, J. E., & Schwilk, D. W. (2017). Flammability as an ecological and evolutionary driver. *Journal of Ecology*, *105*(2), 289-297. https://doi.org/10.1111/1365-2745.12691

Pausas, J. G., Llovet, J., Rodrigo, A., & Vallejo, R. (2008). Are wildfires a disaster in the Mediterranean basin? – A review. *International Journal of Wildland Fire*, *17*, 713-723. https://doi.org/10.1071/WF07151

Pausas, J. G., Ribeiro, E., & Vallejo, R. (2004). Post-fire regeneration variability of Pinus halepensis in the eastern Iberian Peninsula. *Forest Ecology and Management*, *203*(1-3), 251-259. https://doi.org/10.1016/j.foreco.2004.07.061

Prach, K., & Pyšek, P. (2001). Using spontaneous succession for restoration of human-disturbed habitats: Experience from Central Europe. *Ecological Engineering*, *17*(1), 55-62. https://doi.org/10.1016/S0925-8574(00)00132-4

Rey Benayas, J. M., Newton, A. C., Diaz, A., & Bullock, J. M. (2009). Enhancement of biodiversity and ecosystem services by ecological restoration: A meta-analysis. *Science*, *325*(5944), 1121-1124. https://doi.org/10.1126/science.1172460

Richburg, J., Patterson III, W., & Ohman, M. (2004). *Fire management options for controlling woody invasive plants in the northeastern and mid-Atlantic US*. Retrieved 01 Aug, 2025, from https://www.umass.edu/nebarrensfuels/publications/pdfs/Richburg_Ohman-Invasives_Fire_final_report.pdf

Tavşanoğlu, Ç., & Gürkan, B. (2004). Akdeniz havzasında bitkilerin kuraklık ve yangına uyumları. *Ot Sistematik Botanik Dergisi*, *11*(1), 119-132. (In Turkish)

Tavşanoğlu, Ç., Ergan, G., Çatav, Ş. S., Zare, G., Küçükakyüz, K., & Özüdoğru, B. (2017). Multiple fire-related cues stimulate germination in Chaenorhinum rubrifolium (Plantaginaceae), a rare annual in the Mediterranean Basin. *Seed Science Research*, *27*(1), 26-38. https://doi.org/10.1017/S0960258516000283

Trabaud, L. (1994). Postfire plant community dynamics in the Mediterranean Basin. In J. M. Moreno & W. C. Oechel (Eds.), *The role of fire in the Mediterranean-type ecosystems* (pp. 1-15). Springer. https://doi.org/10.1007/978-1-4613-8395-6_1

Turner, M. G. (1989). Landscape ecology: The effect of pattern on process. *Annual Review of Ecology and Systematics*, *20*, 171-197. https://doi.org/10.1146/annurev.es.20.110189.001131

Turner, M. G., Romme, W. H., Gardner, R. H., & Hargrove, W. W. (1997). Effects of fire size and pattern on early succession in Yellowstone National Park. *Ecological Monographs*, *67*(4), 411-433. https://doi.org/10.1890/0012-9615(1997)067[0411:EOFSAP]2.0.CO;2

URL1. (2025). *Secondary Succession*. Retrieved Jul 28, 2025, from https://www.britannica.com/science/secondary-succession

AIMS & SCOPE

The journal aims to be a platform where scientific materials produced about forestry are brought together by encouraging communication among scientists in different fields of forest science.

Original results of basic and applied research from all fields of forestry related to forest ecosystems and their functions including those in the landscape, non-wood products, and wood industry are published as original scientific papers, short communications, and review articles.

AUTHOR GUIDELINES

Manuscripts must be submitted to the journal in electronic version through online submission system at https://prensipjournals.com/ojs/index.php/silva/index following the Author Guidelines of the journal.

Types of Paper

Research articles, review articles, short communications, and letters to the Editor.

• Research articles: original full-length research papers which have not been published previously and should not exceed 7500 words or 25 manuscript pages (including tables and figures)

• Review articles: on topical subjects and up to 10000 words or 25 manuscript pages (including tables and figures)

• Short communications: describing work that may be of a preliminary nature or a case report; preferably no more than 3000 words or 10 manuscript pages (including tables and figures)

• Letters to the Editor: should be included on matters of topical interest and not exceeding 2000 words or 10 manuscript pages (including tables and figures)

Page Charges

This journal has no page charges.

Preparation of Manuscripts

Papers must be written in English. Prepare your text using a word-processing software and save in ".doc" or ".docx" formats. Manuscripts must be structured in the following order:

• ***Title Page File***
  - Title (Concise and informative. Avoid abbreviations and formulae)
  - Author names and affiliation addresses (Full names should be given, no abbreviations. The corresponding author should be identified with an asterisk. Each affiliation address should include institution, faculty/school, department, city, and country)
  - ORCID numbers for all authors.
  - Corresponding author's e-mail, telephone number, and address
  - Acknowledgements (if applicable. Keep these to the absolute minimum)
  - Compliance with Ethical Standards
    - ❖ Conflict of Interest Statement
    - ❖ Statement on the Welfare of Animals (if applicable)
    - ❖ Statement of Human Rights (if applicable)

• ***Main File***
  - Title
  - Abstract (Should be between 100 and 400 words. References and abbreviations should be avoided)
  - Keywords (Minimum 4, Maximum 6 keywords)
  - Introduction
  - Materials and Methods
  - Results
  - Discussion (Can be combined with Results section if appropriate)
  - Conclusion (Can be combined with Discussion section if appropriate)
  - References
  - Table(s) with caption(s) (on appropriate location in the text)
  - Figure(s) with caption(s) (on appropriate location in the text)
  - and appendices (if any)

Manuscript Formatting

Use a 12-point Times New Roman font, including the references, table headings and figure captions, double-spaced and with 25 mm margins on all sides of A4 size paper throughout the manuscript. The text should be in single-column format.

• Each page must be numbered with Arabic numerals, and lines must be continuously numbered from the start to the end of the manuscript.
• Use italics for emphasis.
• Use only SI (international system) units.
• Use "dot" for decimal points.
• Use italics for species name.

References

SilvaWorld uses APA style (7th edition). Accordingly, authors must format their references as per the guidelines below. Please ensure that each reference cited in the text is also presented in the reference list. Authors should always supply DOI or URL of the work cited if available.

In-text citation (Narrative):

…The results of Ayan (2022) support…
…Ayan and Yer (2020) indicated that…
…According to the method of Ayan et al. (2021)…

In-text citation (In parenthesis):

…It was found to be isometric (Ayan, 2018)…
…is highly susceptible to diseases (Ayan & Kara, 2019)…
…have been studied (Yer et al., 2020)…

Two or more works in the same parenthesis:
…extremely toxic for the environment (Ayan & Turgut, 2021; Ayan, 2018, 2019; Sönmez et al., 2020a)…

Citation in the reference list:
References should be listed first alphabetically and then further sorted chronologically at the end of the article. The citation of all references should conform to the following examples:

Article:

Lastname, N., Lastname, M., & Lastname, O. (Year). Title of the work. *Title of the Journal*, *Volume*(Issue), Page numbers. DOI

Ayan, S. (1998). Tüplü sarıçam *Pinus silvestris* L. fidanı üretiminde yavaş yarayışlı gübrelerin etkileri. *Developmental & Comparative Immunology*, *35*(12), 1366-1375. https://doi.org/ 10.1016/j.dci.2011.07.002

Öztürk, S., & Ayan, S. (2015). Management alternatives in national park areas: The case of Ilgaz Mountain National Park. *Eco Mont-Journal on Protected Mountain Areas Research*, *4*(4), 37-44. https://doi.org/10.1046/j.1467-2979 .2003.00121.x

Yer Çelik, E. N., Baloğlu, M. C., & Ayan, S. (2021). Gene expression profiles of Hsp family members in different poplar taxa under cadmium stress. *Turkish Journal of Agriculture and Forestry*, *45*(10), 102-110. https://doi.org/1 0.1111/jfd.13229

Article by DOI (early access):

Ayan, S., Çalışkan, E., Özel, H. B., Yer Çelik, E. N., Yılmaz, E., Gülseven, O., & Akın, S. S. (2022). The influence of effective microorganisms on physiological characteristics of containerized Taurus Cedar (*Cedrus libani* A. Rich.) seedlings. *Cerne*. https://doi.org/10.1590/01047 760202228013018

Book:

Lastname, N., Lastname, M., & Lastname, O. (Year). *Title of the work*. Publisher.

Oidtmann, K., Xao, Q., & Lloyd, A. S. (2018). *The food need by the year 2050*. Elsevier.

Book Chapter:

Lastname, N., Lastname, M., & Lastname, O. (Year). Title of the chapter. In N. N. Lastname, A. Lastname & B. Lastname (Eds.), *Title of the book* (pp. Page numbers). Publisher.

Barbati, A., Mugnozza, G. S., Ayan, S., Blasi, E., Calama, R., Cicatiello, C., Canaveira, P., Collalti, A., Corona, P., Rio, M. del R., Ducci, F., & Perugini, L. (2018). Adaptation and mitigation. In G. A. E. Gall & H. Chen (Eds.), *State of Mediterranean forests* (pp. 51-63). Elsevier. https://doi.org/10.1016/b978-0-444-81 527-9.50010-5

Dissertation or Thesis:

Lastname, N. (Year). *Title of dissertation/thesis* (Doctoral dissertation/Master's thesis, Name of Institution).

Ayan, S. (1990). *Determination of the characteristics of growing media and production technique for containerized oriental spruce (Picea orientalis (L.) link.) seedlings* (Doctoral dissertation, Karadeniz Technical University).

Ayan, S. (1988). *Appreciation on height growth of ten years of age of norway spruce (Picea abies (L.) karst.) origins in Eastern Black Sea region* (Master's thesis, Karadeniz Technical University).

Conference Proceedings:

Lastname, N., Lastname, M., & Lastname, O. (Year). *Title of the work*. Title of the Conference. City.

Ayan, S., Ayan, Ö., Altunel, T., & Yer, E. N. (2014). *Honey forests as an example agroforestry practices in Turkey*. World Congress of Agroforestry. New Delhi.

Institution Publication:

Institution name. (Year). *Title of the work*. URL

FAO. (2020). *Forestry statistics 2018*. http://www.fao. org/3/cb1213t/CB1213T.pdf

Internet Source:

Lastname, N. (Year). *Title of the work*. Retrieved May 15, 2020, from URL

Ayan, S. (2019). *Utilization of Zeolite as plant growing media*. Retrieved Jan 12, 2021, from https://earsiv.kastamonu.edu.tr/

Table(s)
Tables, numbered in Arabic, should be in separate pages with a short descriptive title at the top. Place footnotes to tables below the table body and indicate them with superscript lowercase letters (or asterisks for significance values and other statistical data).

Figure(s)
All illustrations should be labelled as 'Figure' and numbered in consecutive Arabic numbers, Figure 1, Figure 2 etc. in the text. If panels of a figure are labelled (a, b, etc.) use the same case when referring to these panels in the text. Figures are recommended to be in electronic formats such as PNG, JPEG, TIFF (min. 300 dpi). All figures or tables should be presented in the body of the text.

Online Manuscript Submission
Authors are requested to submit manuscripts via the journal's online submission system at https://prensipjournals.com/ojs/index.php/silva/login

Submission Checklist

- Author Guidelines of the journal has been read and adhered
- **Title Page File**
  - Title
  - Full names, e-mails, and affiliation addresses of all authors
  - ORCID numbers of all authors
  - Corresponding author's e-mail, telephone number, and address
  - Ethical statements
- **Main File**
  - Continuous page numbers
  - Continuous line numbers
  - Blinded document (no personal information is present)
  - Title
  - Abstract (100-400 words)
  - Keywords (4-6 keywords)
  - All figures and tables are numbered and cited in order in text
  - Completeness and accuracy of the references have been checked
  - References have been edited as per the Journal guidelines

Publication Frequency

The journal includes original scientific articles on a variety of different subjects in English and is being published twice a year in March and September.

Publication Fees

SilvaWorld is an open access journal. No submission or publication charges are collected. All authors and readers have free access to all papers.

PUBLICATION ETHICS

Details about Publication Ethics can be found at https://prensipjournals.com/ojs/index.php/silva/policy

OPEN ACCESS POLICY

Details can be found at https://prensipjournals.com/ojs/index.php/silva/open-access

REVIEW PROCESS

Double-Blind Review and Evaluation Process

Double-Blind Review is a method applied for publishing scientific publications with the highest quality. This method forms the basis of an objective evaluation of scientific studies and is preferred by many scientific journals.

The views of referees have a decisive place in the publication quality of a Journal. *SilvaWorld* uses the double-blind review method, which means that both the reviewer and author identities are concealed from the reviewers, and vice versa, throughout the review process, in the evaluation process of all studies. For this reason, the authors are asked to blind their manuscripts before submitting. All the studies submitted to *SilvaWorld* are evaluated by double-blind review method according to the following steps.

1. Initial Evaluation Process

The studies submitted to *SilvaWorld* are first evaluated by the editor. At this stage, studies that are not in line with the aim and scope of the journal, are weak in terms of language and narrative rules in English, contain scientifically critical mistakes, are not original worthy, and cannot meet publication policies are rejected. Authors of rejected studies will be notified within one month at the latest from the date of submission. Eligible studies are sent to the field editor to which the study is relevant for pre-evaluation.

2. Pre-Evaluation Process

In the pre-evaluation process, the field editors examine the studies, introduction and literature, methods, findings, results, evaluation and discussion sections in detail in terms of journal publication policies, scope and authenticity of study. Study which is not suitable as a result of this examination is returned to the author with the field editor's evaluation report within four weeks at the latest. The studies which are suitable for the journal are passed to the referee process.

3. Referee Process

The studies are sent to the referees according to their content and the expertise of the referees. The field editor examining the study may propose at least two referees from the pool of *SilvaWorld* Advisory Board or referee pool according to their field of expertise or may propose a new referee appropriate to the field of study. The editors evaluate the referee's suggestions coming from the field editor and the studies are submitted to the referees. Referees are obliged to guarantee that they will not share any process or document about the study they are evaluating.

4. Referee Evaluation Process

The period given to the referee for the evaluation process is 15 days. Proposals for corrections from referees or editors must be completed by the authors within 1 month according to the "correction instruction". Referees can decide on the suitability of the study by reviewing the corrections and may also request multiple corrections if necessary.

Referee Reports

Referee evaluations are based in general on the originality of the studies, the method used, and the conformity with the ethical rules, the consistent presentation of the findings and results, and the examination of the literature.

This review is based on the following elements:

1. Introduction and Literature: The evaluation report contains the presentation and purpose of the problem addressed in the study, the importance of the topic, the scope of the relevant literature, the timeliness and the originality of the study.

2. Methodology: The evaluation report includes information on the suitability of the method used, the choice and characteristics of the research group, validity and reliability, as well as on the data collection and analysis process.

3. Findings: The evaluation report includes opinions on the presentation of the findings obtained in the frame of the method, the correctness of the analysis methods, the aims of the research and the consistency of the findings, the presentation of the required tables, figures and images and the conceptual evaluation of the tests used.

4. Evaluation and discussion: The evaluation report includes the opinion on the subject based on findings, relevance to research questions and hypotheses, generalizability and applicability.

5. Conclusion and suggestions: The evaluation report contains the opinion on the contributions to the literature, future studies and recommendations for the applications in the area.

6. Style and narration: The evaluation report includes compatibility of the title with the content, appropriate use of English in the study, refers and references in accordance with the language of the study and APA rules.

7. Overall evaluation: The evaluation report contains opinion on the authenticity of the study as a whole, its contribution to the educational literature and the applications in the area. The journal considers that scientists should avoid research which kills or damages any species of animal which, using IUCN criteria, is regarded as threatened or is listed as such in a Red Data Book appropriate for the geographic area concerned. In accordance with this view, papers based on such research will not be accepted by the Journal, unless the work had clear conservation objectives.

Plagiarism Detection

In agreement with publishing policies of *SilvaWorld*, plagiarism check is required for each study that has undergone the "Review Process". The Turnitin plagiarism checker software is used for plagiarism detection.

Proofs

Proof documents will be sent to the corresponding authors via e-mail. Proofs should be checked immediately and responses should be returned back within 15 working days. It is the responsibility of the authors to check carefully the proofs. No changes will be allowed after this stage.

DISCLAIMER

The Publisher and Editors cannot be held responsible for errors or any consequences arising from the use of information contained in this journal; the views and opinions expressed do not necessarily reflect those of the Publisher and Editors.

Editor or members of the editorial board are not responsible for the author's opinions and manuscript contents. Authors are responsible for the ethical originality of and possible errors in their manuscripts.

This journal is available online at http://silvaworld.org

Kindly visit website to search the articles and register for table of contents e-mail alerts.

LICENCE

PUBLISHER

PRENSIP

Prensip Publishing and Consultancy Ind. Trade. Co. Ltd.
Kuzeykent mah. Orgeneral Atilla Ateş Paşa cad. No:15 CD,
İç Kapı No:31, Merkez/Kastamonu, 37150, TÜRKİYE
info@prensip.gen.tr

SILVA WORLD