

**ASSESSMENT OF THE ORNAMENTAL VALUE AND ANALYSIS OF THE
PHENOLOGICAL DEVELOPMENT OF TREE SPECIES UNDER THE CONDITIONS OF
TASHKENT REGION****Nurullo Po‘latovich Mukhsimov**

Doctor of Philosophy (PhD) in Agricultural Sciences, Senior Researcher

nurullo.mukhsimov@mail.ru**Usmonova Dilfuza Dilshod qizi,**

PhD Researcher, Research Institute of Forestry

E-mail: usmonovadilfuza3636@gmail.com

Abstract. This scientific study aims to evaluate the role of urban green spaces and tree and shrub species in reducing air pollution and ensuring ecological sustainability in urban landscapes. The research provides a scientific analysis of the ability of plants to capture airborne particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and volatile organic compounds (VOCs), to neutralize these pollutants, and to absorb carbon dioxide (CO₂) while releasing oxygen through photosynthesis. The ecological and ornamental characteristics of Paulownia (*Paulownia tomentosa*), Catalpa (*Catalpa bignonioides*), dense elm (*Ulmus densa*), Sogdian (*Fraxinus sogdiana*), Pennsylvania (*Fraxinus pennsylvanica*), and poplar (*Populus alba*, *Populus deltoides*) were investigated. The selected tree species were evaluated based on their capacity to absorb CO₂ and improve air quality in urban environments, as well as their adaptability to climatic conditions and their contribution to ecological sustainability.

Keywords: Urban landscapes; air pollution; PM2.5; PM10; nitrogen oxides (NO_x); sulfur dioxide (SO₂); carbon dioxide (CO₂); photosynthesis; urban ecology; tree and shrub species; phenological development; ornamental value; ecological sustainability.

Annotatsiya. Mazkur ilmiy tadqiqot shahar landshaftlarida yashil maydonlar va daraxt-buta turlarining havoning ifloslanishini kamaytirish hamda ekologik barqarorlikni ta'minlashdagi rolini baholashga qaratilgan. Tadqiqotda o'simliklarning havodagi mayda zarrachalar (PM), azot oksidlari (NO_x), oltingugurt dioksidi (SO₂) va uchuvchi organik birikmalarni (VOC) ushlab qolish, ularni neytrallash, shuningdek, karbonat angidridni (CO₂) yutib, kislorod ishlab chiqarish jarayonlari ilmiy tahlil qildi. Ishda pavloniya (*Paulownia tomentosa*), katalpa (*Catalpa bignonioides*), sada qayrag'och (*Ulmus densa*), sug'diyona va pensilvaniya shumtoli (*Fraxinus sogdiana*, *Fraxinus pennsylvanica*), shuningdek terak (*Populus alba*, *Populus deltoides*) turlarining ekologik va manzaraviy xususiyatlari o'rganildi. Talangan daraxta turlari qanchalik CO₂ yutish qobiliyati bilan urban hududlarda havoni tozalashda, iqlimga moslashuvchanligi va ekologik barqarorligi bilan moslashuvchanlikni boholanadi.

Kalit so'zlar: shahar landshaftlari, havo ifloslanishi, PM2.5, PM10, azot oksidlari (NO_x), oltingugurt dioksidi (SO₂), karbonat angidrid (CO₂), fotosintez, urban ekologiya, daraxt-buta turlari, fenologik rivojlanish, manzaraviylik, ekologik barqarorlik.

Аннотация. Целью данного научного исследования является оценка роли городских зеленых зон и видов деревьев и кустарников в снижении загрязнения воздуха и обеспечении экологической устойчивости городских ландшафтов. Исследование представляет собой

научный анализ способности растений улавливать взвешенные в воздухе частицы (PM), оксиды азота (NO_x), диоксид серы (SO₂) и летучие органические соединения (ЛОС), нейтрализовать эти загрязняющие вещества и поглощать диоксид углерода (CO₂) с выделением кислорода в процессе фотосинтеза. Были исследованы экологические и декоративные характеристики павловнии (*Paulownia tomentosa*), катальпы (*Catalpa bignonioides*), густого вяза (*Ulmus densa*), согдийской ясени (*Fraxinus sogdiana*), пенсильванской ясени (*Fraxinus pennsylvanica*) и тополя (*Populus alba*, *Populus deltoides*). Выбранные виды деревьев оценивались на основе их способности поглощать CO₂ и улучшать качество воздуха в городских условиях, а также их адаптации к климатическим условиям и их вклада в экологическую устойчивость. Ключевые слова: Городские ландшафты; загрязнение воздуха; PM_{2.5}; PM₁₀; оксиды азота (NO_x); диоксид серы (SO₂); диоксид углерода (CO₂); фотосинтез; городская экология; виды деревьев и кустарников; фенологическое развитие; декоративная ценность; экологическая устойчивость.

Introduction. Air pollution in urban areas has become one of the major global environmental challenges, posing serious threats to human health and the sustainability of urban ecosystems. The increasing concentrations of particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and volatile organic compounds (VOCs) released into the atmosphere are disrupting the ecological balance of urban environments. Consequently, the implementation of environmentally safe and sustainable solutions has become a priority in modern urban planning. Urban green spaces, including parks, gardens, and landscaped areas, function as natural biofilters by capturing harmful airborne pollutants, neutralizing toxic substances, and improving air quality through oxygen production. The leaves, branches, and complex canopy structures of plants play a significant role in trapping atmospheric dust particles. Furthermore, plants absorb carbon dioxide (CO₂) through photosynthesis, thereby contributing to climate change mitigation [1].

In addition, green spaces regulate the urban microclimate, reduce noise pollution, and enhance the overall well-being of the population. The appropriate selection of tree and shrub species is a crucial aspect of urban greening. Different plant species vary considerably in their capacity for air purification, carbon sequestration, and ecological adaptability. From this perspective, *Paulownia* (*Paulownia tomentosa*), *Catalpa* (*Catalpa bignonioides*), dense elm (*Ulmus densa*), ash (*Fraxinus sogdiana* and *Fraxinus pennsylvanica*), and poplar (*Populus alba* and *Populus deltoides*) are considered promising species due to their ecological benefits and ornamental value under urban environmental conditions.

Methodology. This study was conducted to comprehensively evaluate the ecological and ornamental characteristics of tree and shrub species used in urban landscapes under the environmental conditions of the Tashkent region. The selected species included *Paulownia* (*Paulownia tomentosa*), *Catalpa* (*Catalpa bignonioides*), dense elm (*Ulmus densa*), Sogdian ash (*Fraxinus sogdiana*), Pennsylvania ash (*Fraxinus pennsylvanica*), and poplar (*Populus alba* and *Populus deltoides*) [2].

The research was carried out at three experimental sites located at different elevations (510 m, 600 m, and 805 m above sea level). At each site, the phenological development stages of the selected species including leaf emergence, flowering, fruit formation, and the vegetation period were systematically observed and recorded throughout the growing season. The ornamental characteristics of the tree and shrub species were evaluated using the N. I. Shtonda assessment method. According to this method, each species was evaluated based on 11 principal indicators, including plant height, crown shape and density, leaf shape and color, flowering period and duration, fruit ornamental value, leaf persistence, and overall ornamental appearance. Each indicator was scored on a 100-point scale, and the final scores were used to classify the plants into four categories: high, good, moderate, and low ornamental value. According to Beydeman I. N. phenological observations should be conducted from the onset of sap flow in the trunks of trees and shrubs until the beginning of the dormancy period.

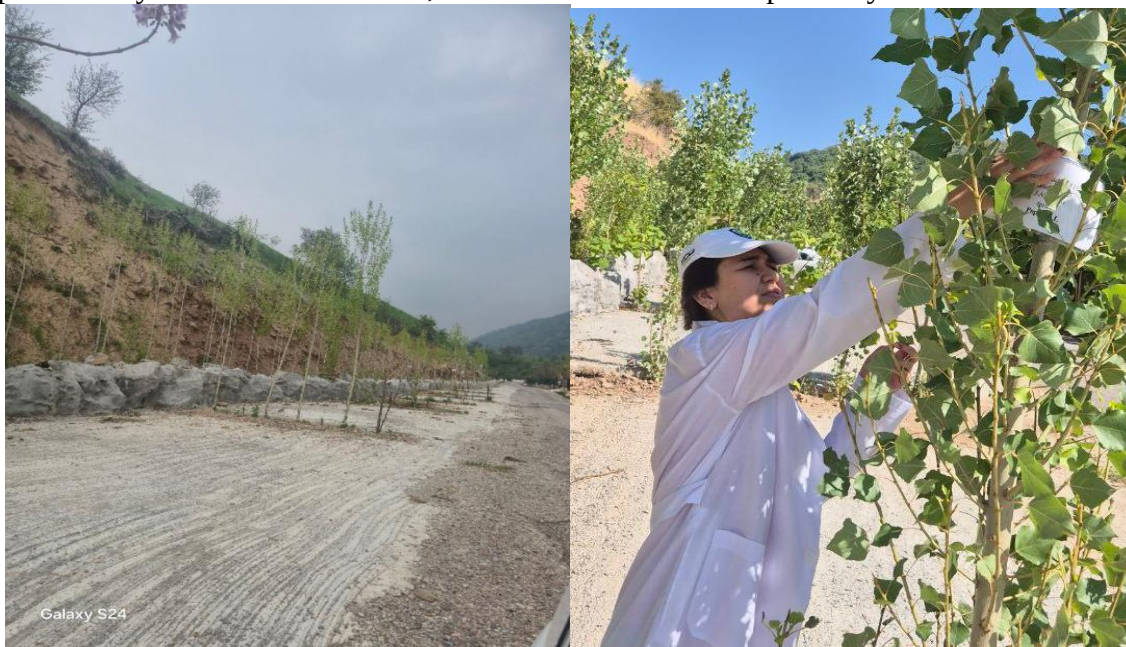
Based on this approach, the phenophases, growth duration, and developmental changes of the selected tree and shrub species in the Tashkent region were monitored during the 2025–2027 study period [3].

Results. Paulownia, commonly known as the “Adam’s Tree” or “Empress Tree,” belongs to the family Paulowniaceae. It is a fast-growing, deciduous tree characterized by its tall stature. Its leaves are large, reaching up to 70 cm in diameter, while its flowers are trumpet-shaped and pale violet to light pink in color. Under favorable environmental conditions, the tree can attain a height of 20-30 m and a trunk diameter of up to 1 m. Its seeds resemble cotton capsules and are enclosed in thin seed coats. Paulownia has been mentioned in historical records dating back to approximately 2600 BC and is native to Japan. Known as “Kiri” in Japanese, the tree symbolizes life, good fortune, and sacredness. According to traditional beliefs, planting a Paulownia tree near a house would attract the mythical Phoenix (Humo bird) to its branches, bringing prosperity and happiness to the family. In the nineteenth century, the German naturalist Philipp Franz von Siebold introduced Paulownia seeds from Japan to Europe. The genus was named Paulownia in honor of Grand Duchess Anna Pavlovna of Russia, daughter of Emperor Paul I. One of the most remarkable characteristics of Paulownia is its excellent adaptability to diverse climatic conditions. It grows successfully even in the hot and arid regions of Uzbekistan and can develop in soils containing up to 2% lime. Under suitable conditions, seedlings may reach their expected height within five years. The species possesses a long-lived root system, with a lifespan of 70-100 years, and retains a strong regenerative capacity, being able to resprout even after 4-8 harvests over an eight-year period. Its wood is lightweight, fire-resistant (withstanding temperatures of up to 400°C), resistant to decay and insect damage, making it a valuable raw material for the construction, furniture, and various industrial sectors. Paulownia flowers bloom profusely from early spring until May and are widely used as a raw material in the perfume and cosmetic industries. The species is also highly valued in apiculture, with the potential to produce up to. Paulownia honey is considered to be of high quality and has extensive applications in traditional and modern medicine. The introduction of Paulownia cultivation in Uzbekistan is closely associated with Professor Alisher To‘rayev, Doctor of Biological Sciences. Since the early 2010s, he has successfully introduced the species under local environmental conditions and established the in vitro propagation of Paulownia seedlings at the De Nova Agro laboratory.



Common Poplar (*Populus* spp.) The common poplar (*Populus* spp.) is a tall deciduous tree that can reach a height of 40–50 m and a trunk diameter of up to 1.5 m. It typically has a single, upright trunk, although some species may develop a bifurcated stem. The crown may be ovate, pyramidal, narrowly pyramidal, or broadly oval in shape. The bark of one-year-old shoots is gray,

grayish-brown, or light yellow, whereas the bark of mature trunks is grayish-brown and becomes deeply fissured with age. The buds vary in size and shape, ranging from rounded and bottle-shaped to spindle-shaped and cup-shaped. They are covered with numerous scales and may be arranged either appressed to or erect on the shoots. Bud scales may be either resinous or non-resinous and may be either aromatic or odorless. The leaves are petiolate and alternately arranged. Leaf blades may be entire or lobed and vary in shape, including linear, lanceolate, kidney-shaped, rounded, and rhomboid forms. Different leaf shapes may occur on the same tree. Both surfaces of the leaf blade are glabrous, and their coloration varies among species. The inflorescences are cylindrical catkins. The flowers may be either pendulous or erect and fall soon after flowering. Poplars are dioecious, bearing unisexual flowers on separate male and female trees. The male flowers are dark red, whereas the female flowers are greenish to dark reddish in color. Most poplar species flower either before or shortly after leaf emergence. The flowers develop in the axils of the bracts and possess slightly notched margins. The seeds are small, numerous, and covered with silvery hairs, measuring approximately 0.5–0.9 mm in width, which facilitates their dispersal by wind.



Catalpa (*Catalpa* spp.) *Catalpa* (*Catalpa* spp.) is a genus of ornamental plants belonging to the family Bignoniaceae. It is characterized by large, simple leaves and attractive white, bell-shaped flowers arranged in panicles or racemes. The fruits are long (20-40 cm), bean-like, two-valved capsules containing numerous seeds. The seeds are flat and possess tufted hairs at their tips, which facilitate wind dispersal. The genus comprises approximately 14 species. *Catalpa* can be propagated by seeds, stem cuttings, and root suckers. Its wood is lightweight, soft, and highly resistant to decay. Depending on the species, *Catalpa* may grow as either a tree or a shrub, reaching heights from 1 to 32 m. Most species are either evergreen or deciduous and bear broad ovate or heart-shaped leaves. The trees produce attractive, fragrant flowers that are usually white or pale yellow and bloom from May to July. Their fruits are long, narrow capsules containing numerous seeds equipped with silky hairs that aid in wind dispersal. Several species of *Catalpa* have been described, including Southern catalpa (*Catalpa bignonioides*), Chinese catalpa (*Catalpa ovata*), and *Catalpa pulchra*. Another related ornamental species, Desert willow (*Chilopsis linearis*), locally known as “Xilokatalpa Tashkent,” is also widely cultivated in Central Asia, particularly in Tashkent. It flowers continuously from spring until late autumn and is regarded as one of the most valuable ornamental plants used in landscape design in Uzbekistan.



Dense Elm (*Ulmus densa* Litv.) Dense elm (*Ulmus densa* Litv.) is a large deciduous tree characterized by a broad, dense pyramidal crown and dark, fissured bark. It typically reaches a height of 10-20 m, with a crown that may be spherical or elliptical in shape. The leaves are thick, ovate to oblong, measuring 3-7 cm in length and 1.5-3 cm in width, with doubly serrated margins. The upper leaf surface is either glabrous or slightly pubescent. The petioles are short (6-7 mm) and sparsely hairy, while the young twigs are densely pubescent. The flowers are borne in clusters on short shoots. Each flower has a perianth divided into 4-5 lobes and contains four stamens. The fruit is a winged samara approximately 2 cm in length. Flowering occurs during February and March. The species is naturally distributed throughout Central Asia, including the mountainous regions of Uzbekistan. *Ulmus densa* is considered one of the most ornamental elm species and has long been widely planted in urban and rural landscapes for greening purposes. It is also naturally found in the valleys of mountain rivers across Central Asia and is commonly planted along large irrigation canals and in parks. The species is highly drought-tolerant and can also be successfully cultivated in the southern regions of the European part of the former CIS countries. Other elm species, including *Ulmus foliacea* Gilib., *Ulmus pumila* L., *Ulmus suberosa* Moench., *Ulmus pinnato-ramosa* Dieck., and *Ulmus androssovii* Litv., are likewise widely used in forestry and landscape planting.

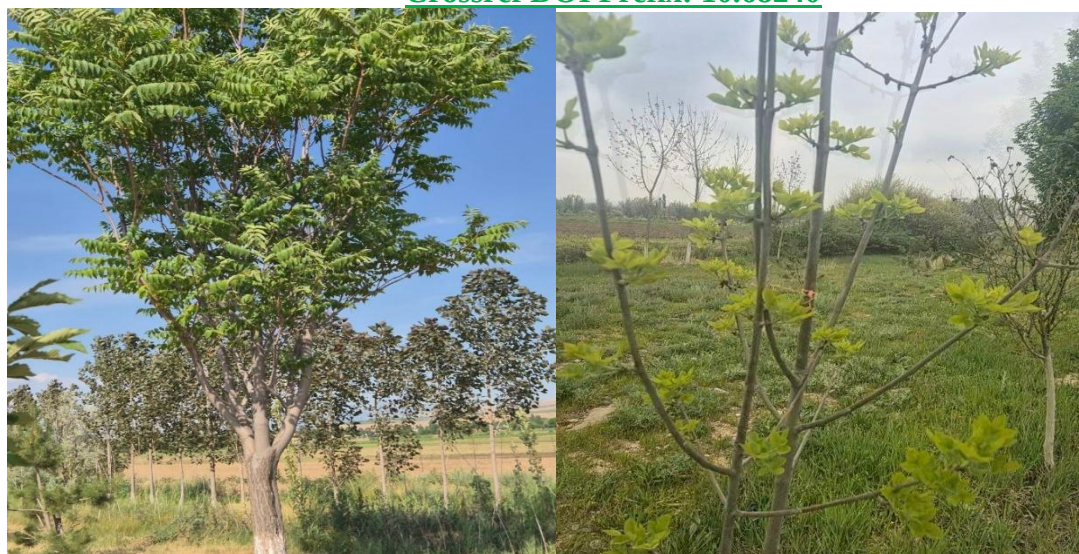


Eastern Cottonwood (*Populus deltoides*) Eastern cottonwood (*Populus deltoides*) is a fast-growing, broad-leaved, perennial tree species belonging to the genus *Populus*. It is distinguished by its considerable height, vigorous root system, and ornamental appearance. The species is widely distributed throughout Central Asia, the Caucasus, Russia, China, and other regions with temperate climates. The tree typically reaches a height of 15-30 m. Its trunk is straight, with gray bark that may occasionally exhibit a reddish tint. Young shoots are reddish-brown to purplish in color, giving the

tree a distinctive ornamental appearance. The leaves are broad, with either smooth or slightly serrated margins. The upper surface of the leaves is green, whereas the underside is whitish. *Populus deltoides* commonly grows along riverbanks, in moist soils, and on the foothills of mountainous areas. It is also widely planted in irrigated landscapes and urban green spaces for ornamental and environmental purposes. The species is highly tolerant of both cold and drought conditions and is recognized as one of the fastest-growing poplar species, making it particularly suitable for urban landscaping and afforestation projects.



Sogdian Ash (*Fraxinus sogdiana* Bunge) Sogdian ash (*Fraxinus sogdiana* Bunge) is an ornamental tree species belonging to the family Oleaceae. It can reach a height of up to 20 m with a trunk diameter of 60–70 cm. The branches are yellowish-gray, while the leaves are compound, arranged in whorls, and composed of 3–6 leaflets with finely serrated margins. The flowers are small and bloom during the second half of March. The fruits are winged samaras, approximately 4 cm long and 0.7 cm wide, containing elongated, ovate seeds. The wood of *Fraxinus sogdiana* has a reddish hue and possesses excellent technical properties. Consequently, it has long been used in the manufacture of furniture, construction materials, and various household products. Ash species are naturally distributed throughout the Mediterranean region and Asia Minor. In Europe, their natural range extends northward as far as Hungary, while in the southern regions of Russia, they are widely cultivated as ornamental flowering trees. However, because of their limited frost tolerance, these species do not naturally extend north of Crimea and are also susceptible to severe winter damage in Ukraine, restricting their wider distribution. Nevertheless, as a result of recent introduction and acclimatization programs, more than 20 species of ash have been successfully established and cultivated under the environmental conditions of Uzbekistan.



Pennsylvania Ash (*Fraxinus pennsylvanica* Marsh.) Pennsylvania ash (*Fraxinus pennsylvanica* Marsh.) is a tree species belonging to the family Oleaceae. It can reach a height of 25-30 m and a trunk diameter of 70-80 cm. Its dark green, pinnately compound leaves consist of 7-9 leaflets, which are elongated, pointed, and finely serrated along the margins. The branches are smooth and grayish-brown in color. The flowers are small and green, appearing before leaf emergence during April and May. The fruits are winged samaras measuring 3-5 cm in length and 0.5-0.8 cm in width. This species is native to North America and has been widely introduced into many countries across Europe and Asia, including Uzbekistan. *Fraxinus pennsylvanica* is a fast-growing species with a high degree of adaptability to various soil and climatic conditions. The tree is tolerant of both cold and drought, allowing it to grow successfully under diverse environmental conditions. However, it is sensitive to soil fertility and exhibits optimal growth on moist, fertile alluvial soils. Pennsylvania ash plays a significant role in improving the urban environment. Its dense foliage effectively traps airborne dust particles, partially absorbs harmful atmospheric gases, and contributes to the regulation of the urban microclimate. Therefore, the use of this species is of considerable importance in Tashkent and other rapidly urbanizing industrial cities, where it serves as an effective component of sustainable urban greening and environmental improvement.



Ornamental Characteristics of Tree and Shrub Species Extensive construction and urban beautification projects are being carried out in cities and rural areas throughout Uzbekistan. In particular, urban greening is implemented in accordance with the requirements of GOST 28329-89.

The selection of appropriate tree and shrub species is of particular importance, as these plants not only enhance the aesthetic appearance of landscapes but also play a vital role in improving the urban ecological environment. Vegetation absorbs and neutralizes sulfur dioxide (SO₂) and other harmful gases, reduces airborne dust, mitigates noise pollution, and suppresses disease-causing microorganisms through the release of phytoncides. Therefore, the evaluation and proper selection of tree and shrub species are of considerable scientific and practical importance. The ornamental characteristics of tree and shrub species were evaluated using the N. I. Shtonda method, which assesses plants based on 11 principal indicators. These include tree height, crown shape and density, leaf and fruit color, flowering period and duration, leaf persistence, and the overall duration of ornamental appeal. Each characteristic was assigned a score, and the overall ornamental value was determined using a 100-point evaluation system. Based on the final score, the species were classified into the following groups:

- Group I - Very high ornamental value (more than 90 points)
- Group II - High ornamental value (81-90 points)
- Group III - Moderate ornamental value (51-80 points)
- Group IV - Low ornamental value (below 50 points)

According to the research findings, the ornamental evaluation of tree and shrub species at the three experimental sites was as follows: Experimental Site I (510 m above sea level): *Paulownia* (67 points) and *Catalpa* (62 points) demonstrated moderate ornamental value and were classified into Group III. *Poplar* received 33 points, indicating low ornamental value, and was therefore assigned to Group IV. Experimental Site II (600 m above sea level): *Eastern cottonwood* (*Populus deltoides*, 47 points) and *Pennsylvania ash* (*Fraxinus pennsylvanica*, 41 points) were classified into Group IV because of their low ornamental value. In contrast, *Sogdian ash* (*Fraxinus sogdiana*, 51 points) and *Dense elm* (*Ulmus densa*, 57 points) exhibited moderate ornamental value and were assigned to Group III. Experimental Site III (800 m above sea level): *Paulownia* (67 points) and *Catalpa* (57 points) again demonstrated moderate ornamental value and were classified into Group III. *Poplar* scored 44 points, placing it in Group IV due to its relatively low ornamental value.

№	Ko'rsatkichlar	I-tajriba maydon					II- tarriba maydon					III-tajriba maydon	
1	Daraxt va butaning balandligi	2	1	2	4	5	1	2	4	5	1	1	2
2	Erkin o'sadigan shoxlarning (krona) shakli	2	2	1	1	2	5	4	5	2	2	2	2
3	Shohlarining zichligi	2	5	2	1	2	2	6	4	2	1	1	1
4	Daraxt-butalar shoxlari va tanasining ranglari	3	5	3	1	2	5	4	5	4	2	4	2
5	Mavsumda (bahor-kuz) barglarning ranglari	2	6	4	2	4	6	5	5	3	2	3	2
6	Gullash davrida ko'rinishi	5	14	18	10	12	6	10	5	12	12	12	12
7	Gullash davri davomiyligi	5	14	13	10	10	6	10	4	16	15	16	15
8	Mevaning rangi, hajmi	2	8	3	2	2	2	2	2	7	6	7	6
9	Mevaning daraxt-butada saqlab turish davri davomiyligi	2	2	4	2	2	2	2	2	6	6	6	6
10	Barglarning davomiyligi	4	3	4	4	4	4	4	4	2	4	2	4
11	Daraxt-butaning manzaraligi davomiyligi	4	7	8	4	6	8	8	4	8	6	8	6
Umumiy ball		33	67	62	41	51	47	57	44	67	57	67	57

Evaluation of Ornamental Characteristics According to the evaluation conducted using the N. I. Shtonda method, Experimental Site I (510 m above sea level) showed that Paulownia and Catalpa scored 67 and 62 points, respectively, indicating moderate ornamental value and placing them in Group III. In contrast, poplar received 33 points, corresponding to low ornamental value and was therefore classified into Group IV. At Experimental Site II (610 m above sea level), Eastern cottonwood (*Populus deltoides*) and Pennsylvania ash (*Fraxinus pennsylvanica*) scored 47 and 41 points, respectively, and were classified into Group IV, indicating low ornamental value. Meanwhile, Sogdian ash (*Fraxinus sogdiana*) and dense elm (*Ulmus densa*) scored 51 and 57 points, respectively, placing them in Group III, which represents moderate ornamental value. These findings demonstrate that the ornamental performance of the studied tree species varies according to altitude and environmental conditions, reflecting differences in their adaptability to local ecological factors.



Results and Discussion

The results of the study demonstrated that the investigated tree and shrub species differed significantly in their ecological and ornamental characteristics under the environmental conditions of the Tashkent region. Phenological observations revealed that all studied species successfully completed the principal stages of their growth cycle—including leaf emergence, flowering, and fruit development—indicating their successful adaptation to the local climatic conditions.

Povloniya, Pavlovino, павлония		Katalpa		Terak	Qizil terak		Sadaqayrag och	Pensilvaniya shumtoli	Sugdiyona shumtoli	Daraxt-butaning o'zbekcha, lotincha, ruscha nomi	
500 m	810 m	500 m	810 m	500 m	810 m	600 m	600 m	600 m	600 m	Daraxt turi joylashgan joy, daraxtzor tarkibi	
5III	1III	1III	2III	1III	1III	1III	10III	1III	1III	Shira yurishini boshlanishi	
15 III	10III	10III	10III	10III	10III	10 III	22 III	10III	10III	Bo'rtish	O'suvchi kurtaklarni bo'rtishi
25 IV	18III	18III	20III	18III	18III	18 III	3 IV	18III	18III	Ochilishi	
25 IV	25III	25III	25III	25III	25III	22 III	10 IV	25III	25III	Barglar paydo bo'lishi	Barg rivojlanishi
28 IV	5IV	5IV	10IV	5IV	5IV	5 IV	18 IV	5IV	5IV	Butkul barg paydo bo'lishi	
15X	6X	6X	10X	6X	6X	6X	26IX	25IX	20IX	Sarg'ayishi boshlanishi	
25X	15X	22X	20X	15X	18X	20X	15X	10X	6X	Butkul sarg'ayishi	
12X	1XI	10XI	2XI	30X	1XI	25X	5XI	20X	15X	To'kilishni boshlanishi	
25XI	20XI	30XI	22XI	22XI	20XI	5XI	15XI	5X	1XI	To'kilishni tugashi	
20 III	12 III	12 III	12 III	12 III	12 III	12 III	5VI	12 III	12 III	Gullashni boshlanishi	Gullashi
10 IV	28 III	28 III	28III	28 III	28 III	25 III	20IV	28 III	28 III	Gullashni tugashi	
3 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	Gullash darajasi	
10X	24X	20IV	20IV	20IV	20IV	20 IV	20V	20IV	20IV	Pishib yetilish	Meva (umug) yetilishi va to'kilishi
30X	10XI	10V	10V	10V	10V	5V	10VI	10V	10V	Pishib yetilishini tugashi	
8XI	16XI	10V	10V	10V	10V	5V	5 VI	10V	10V	To'kilishini boshlanishi	
20XI	24XI	25V	25V	25V	25V	20V	25VI	25V	25V	To'kilishini tugashi	
2 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	3 o'rta	2 o'rta	3 o'rta	3 o'rta	Hosildorlik darajasi	
20 III	20 III	20 III	20 III	20 III	20 III	25 III	25 III	20 III	20 III	O'zidan tabiiy nihollar paydo bo'lishi	
28 III	25 III	25 III	25 III	25 III	25 III	28 III	IV	25 III	25 III	Boshlanishi	Novda o'sishi

Phenological Observations The results of the phenological observations revealed significant differences in the onset and completion of the growing season among the studied species, including Paulownia, Catalpa, Populus (white poplar and eastern cottonwood), and ash (*Fraxinus* spp.). Early spring phenophases, particularly sap flow and bud swelling, generally commenced during the first and second ten-day periods of March. These developmental stages began relatively earlier in *Populus*

species (1–10 March), whereas they occurred slightly later in *Catalpa* and *Paulownia*. These differences can be attributed to species-specific biological characteristics and their levels of ecological adaptation. Leaf emergence and full leaf expansion occurred from late March to early April and exhibited an almost synchronous pattern across all studied species. The relatively small differences observed between the 500 m and 810 m elevation sites suggest that climatic conditions at these altitudes are broadly similar. Nevertheless, at the higher elevation (810 m), certain phenological stages were delayed by approximately 3–7 days, primarily due to lower air temperatures. More pronounced differences were observed during the autumn phenophases. Leaf yellowing and leaf fall occurred earlier in *Populus* species, typically from late September to early October, whereas *Paulownia* and *Fraxinus* species entered these stages later, from late October to November. This indicates that the latter species possess a relatively longer growing season. Overall, the findings demonstrate that the phenological rhythms of tree species are determined not only by their genetic characteristics but also by the elevation of the growing site and prevailing climatic conditions. In particular, temperature and moisture availability play a crucial role in determining the onset, duration, and completion of the vegetation period.

Conclusion. The results of this study showed that the scientifically based organization of urban green spaces and the proper selection of tree and shrub species are among the most important factors in stabilizing the urban ecological environment. The studied plant species were found to play a significant role in improving urban air quality by reducing airborne particulate matter (PM), gaseous pollutants (NO_x, SO₂), and volatile organic compounds (VOCs), as well as by absorbing carbon dioxide (CO₂) and producing oxygen. Under the conditions of Tashkent region, *Paulownia*, *Catalpa*, and Norway maple are recommended as species with high ecological and ornamental potential for urban ecosystems. These species can be effectively used in urban greening, landscape design, and ecological monitoring as bioindicator species. Among them, *Paulownia* (*Paulownia tomentosa*) stands out as a leading species in urban ecological areas due to its high CO₂ absorption capacity, rapid growth rate, and large leaves, which contribute to oxygen production and air purification. *Catalpa* (*Catalpa bignonioides*) and Norway maple (*Acer negundo*) have high ornamental value and are recommended for improving the aesthetic appearance of urban green spaces and landscape design. In addition to effectively trapping dust and harmful gases, they are also notable for their non-allergenic properties and their ability to moderate the urban climate. Sogdian ash (*Fraxinus sogdiana*) and green ash (*Fraxinus pennsylvanica*) successfully thrive in urban ecological areas, improving soil and air quality through their adaptive characteristics. These species are important for strengthening urban ecology due to their adaptability to local climatic conditions, rapid growth rate, and resilience. White poplar (*Populus alba*) and black poplar (*Populus deltoides*) are distinguished by their resistance to cold and drought conditions. They help maintain ecological balance in urbanized areas by absorbing dust and reducing noise pollution. However, they have relatively moderate or low ornamental value and are less recommended as primary decorative species in urban landscaping.

Phenological observations showed that the above-mentioned species maintain stable growth in urban ecological areas, with consistent patterns in their growth, flowering, and fruiting stages. Overall, the results of the study confirm that improving urban ecology requires expanding green spaces, diversifying plant species, and implementing sustainable management practices. In particular, the widespread introduction of highly ecologically efficient species can reduce air pollution, optimize the microclimate, and improve the quality of life of the population. In the future, it will be important to develop monitoring systems in this field, further study the bioindicator properties of plants, and implement innovative landscaping technologies in practice.

References

1. Pugachevskiy A.V. *Monitoring dinamicheskogo sostoyaniya lesnykh fitotsenozov ...* – Moskva: Nauka, 1988.
2. Qayumov A.Q. *Dendrologiya: darslik*. – Toshkent: Cho‘lpon nomidagi nashriyot-matbaa ijodiy uyi, 2012. – S. 167–186.
3. Qayumov A.K., Berdiyev E.T. *Dendrologiya*. – Toshkent: Fan va texnologiya, 2015. – S. 55–61.
4. Rozimova X.R. *Bioekologiya: o‘quv qo‘llanma*. – Toshkent, 2024. – B. 40–48.
5. Beydeman I.N. *Uchebno-metodicheskiy kompleks distsipliny metody fenomonitoringa*. – Ekaterinburg, 2008.
6. Berdiyev E.T., Gulomkhojaev Sh.F. *Manzarali daraxtlarni ko‘paytirish: o‘quv qo‘llanma*. – Toshkent: ToshDAU, 2019. – 317 b.
7. Choi S. [и др.]. Changes in particulate matter concentration and meteorological variables after changing forest structure in oak-dominated forests nearby highway tollgate // *Forest Science and Technology*. 2022. № 4 (18). С. 150–159.
8. Arbaeva A. [и др.]. Ecological role of tree and shrub plantations in urban landscapes // *Ukrainian Journal of Forest and Wood Science*. 2025. Т. 16. № 1. С. 108–127.
9. Aung A. P. P. [и др.]. Enhancing Urban Air Quality Resilience Through Nature-Based Solutions: Evidence from Green Spaces in Bangkok // *Architecture*. 2026. Т. 6. № 1.
10. Bhatti U. A. [и др.]. The effects of socioeconomic factors on particulate matter concentration in China's: New evidence from spatial econometric model // *Journal of Cleaner Production*. 2023. Т. 417.
11. Bi S. [и др.]. Optimizing Urban Green Spaces for Air Quality Improvement: A Multiscale Land Use/Land Cover Synergy Practical Framework in Wuhan, China // *Land*. 2024. Т. 13. № 7.
12. Degtyareva, I.A., Khidiyatullina, A.Ya. 2011. Evaluation of the influence of natural associations of hydrocarbon-oxidizing microorganisms on the state of oil-contaminated soil. *Scientific Notes of Kazan University*, 153:29.