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STUDY OF *PTEROCARYA FRAXINIFOLIA* POPULATIONS IN GEORGIA TO IDENTIFY *IN SITU* CONSERVATION AREAS

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Abstract

In global environmental policy, particular attention is paid to the conservation of rare and endangered species. This issue has become particularly important in the context of global climate change and increasing anthropogenic impacts. Forest ecosystems in Georgia are harbor to numerous rare and vulnerable tree species that play significant ecological role and require carry out of additional research and implementing of conservation measures. Among these species is the Caucasian wingnut (*Pterocarya fraxinifolia* (Poir.) Spach.), listed in the Red List of Georgia are under threat in the context of global climate change. As a result of the inventory conducted across Georgia, Caucasian wingnut were found in both western and eastern part of the country. According to the findings, the target species has a restricted distribution in Western Georgia and several populations are located within protected areas. The situation differs in Eastern Georgia, where pure and mixed stands of Caucasian wingnut are relatively well presented Lopota, Bursa, Stori, Intsoba, Chelti and Alazani valleys. Although Caucasian wingnut is listed in the Red List of Georgia and is a strictly protected species and remain vulnerable due to substantial anthropogenic pressure from adjacent settlements. The study confirmed that well-developed stands of Caucasian wingnut occur in the Lopota River Valley. In this area, the target species is primarily distributed within 80 m of the riverbank, where it forms well-developed stands. According to the research findings, this range is proposed for in-situ conservation as a protected forest (Category II according to the Forestry Code of Georgia). This territory can serve as a potential protected area, facilitating the expansion of the national network of protected areas in accordance with Georgia's obligations under international agreements. As part of the study, a database was created for each study population of the Caucasian wingnut. Condition of species, mother trees, density of trees and natural regeneration is described in detail on locations. From 39 sample plots, 21 can be used as seed plots, 5 of them are in the Western Georgia and the remaining 16 locations are in the Eastern Georgia. Seeds were processed and stored in the seed bank of the Scientific-Research Center of Agriculture.

Key words: *Pterocarya fraxinifolia;* Riparian forests; Conservation

Introduction

The genus Pterocarya (Juglandaceae) includes 8 extant species distributed across Eurasia, with a biogeographical disjunction between East Asia and the Caucasus. Among them, *Pterocarya fraxinifolia* (Poir.) Spach - commonly known as the Caucasian wingnut - is of ecological and evolutionary significance. This species is the only member of the genus occurring outside East Asia and constitutes a vulnerable component of the Georgian flora. According to its conservation status it is classified as Vulnerable on the IUCN Red List, due to decline in population driven by habitat degradation and anthropogenic pressures (Gagnidze, *et al.*, 2002; Bétrisey *et al.*, 2019).

Caucasian wingnut represents a classical Arcto-Tertiary relict and typically grows under warm-temperate, humid climatic regimes characterized by mild winters and moist summers, mostly forming mixed stands with other deciduous species. The distribution of this species extends from lowland riparian forests up to 600–800 m, occasionally reaching 1200 m (Zohary, 1973; Kozlowski *et al.*, 2018a).

Anthropogenic factors have played an important role in shaping present range of the species'. Historically, extensive riparian forest systems—once dominated or co-dominated by *P. fraxinifolia*—were converted to agricultural land, while more recent pressures include gravel extraction, road and hydropower development and other forms of habitat fragmentation. As a result, natural populations are now largely presented to narrow corridors along rivers and streams, despite the species' broader climatic suitability (Sabo *et al.*, 2005; Fink & Scheidegger, 2018).

The evolutionary history of Pterocarya is well documented in the fossil record. It is stated that the genus was widespread through the Northern Hemisphere during the Cenozoic, first appearing in Europe during the Oligocene and becoming abundant in wetland and riparian vegetation during the Miocene and Pliocene (Mai, 1995; Reumer & Wessels, 2003).

However, the climatic fluctuations of the Pleistocene caused a noticeable fragmentation of the range and a retreat to the south, which eventually led to the extinction of Pterocarya species from much of Europe. Fossil pollen becomes rare after

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the Middle Pleistocene and macroremains are restricted to isolated southern European sites (Hrynowiecka & Szymczyk, 2011; Martinetto, 2015; Suc *et al.,* 2018).

Caucasian wingnut has significant cultural and practical value. Traditionally, its leaves, bark and fruits were used in folk medicine for treating dermatological and gastrointestinal ailments, as natural dyes for silk and as a source of vitamin C. The nuts of Caucasian wingnut are edible and often used in cooking thanks to their sweet taste. They are known to be rich in oils and proteins and can lower cholesterol levels. Its wood is used in construction and carpentry (Grossheim, 1942; Mahdavi *et al.,* 2019; Song *et al.,* 2021).

Most available scientific data on Caucasian wingnut is outdated in Georgia, which limits our understanding of its current distribution patterns. So, the goal of our research is to assess its current status, creation of a database, including its distribution range and formulate of appropriate conservation measures.

Material and Methods

Study object and study area: Caucasian wingnut is a fast-growing riverine tree that typically reaches 25–30 m in height and 1–1.5 m in diameter, characterized by whitish, non-fissured bark. Its pinnate leaves extend up to 60 cm or more, with 8–12 pairs of serrate, oblong to elongate-ovate leaflets that are glabrous and lustrous on the upper surface. The staminate catkins are 5–7 cm long and solitary at the ends of branchlets, while the pistillate catkins bear numerous sessile flowers. The fruit is an irregularly turbinate nut with wings broader than the body It reproduces both by seed and vegetatively, flowering in April–May and fruiting in September–October (Flora of Georgia, 1975; Flora of Azerbaijan, 1950–1961; Mehdiyeva *et al.,* 2025).

The study area includes the entire range of Caucasian wingnut in Georgia, located in the South Caucasus region and geographically divided into two parts: eastern and Western Georgia. Field research was carried out in various locations across both parts of the country. In eastern Georgia, surveys were conducted in Lagodekhi, Telavi, Kvareli and Akhmeta municipalities, all of which belong to the Kakheti region. In Western Georgia, the study area covered several regions, including Adjara, Samegrelo and Imereti (Table 1).

Field work: The primary identification distribution ranges of the selected species were determined, based on literature and herbarium data. The inventory data were collected using 500 sq.m. sample plots (20 m × 25 m) (Bonham, 2013). On the sample plots, the following data were obtained: GPS coordinates, altitude, slopes, exposition, stand density, species diversity and composition. Seed plots were allocated and investigations were conducted to predict the seed production and yield of study species. The allocation of seed plots was carried out according to the relevant methodologies (Japaridze, 2008; Sniezko *et al.,* 2017). It should be noted that although forests can occupy large territories, the target species has fragmented and small distribution ranges; therefore, the size of the seed plots had to be considerably smaller than standard. In cases where distribution area of the mentioned species was less than 1,500 ha, forest genetic reserves or genetic preservation areas were designated to maintain the gene pool of such species (FAO, DFSC, IPGRI. 2001; Geburek & Turok, 2005; Šijačić-Nikolić *et al.,* 2014).

Permanent seed plots were allocated primarily in the stands and in the absence of such stands temporary seed plots were established in the mature and over-mature stands, where seed production was assessed at intervals of 1–2 revisions and a standardized form was completed for each plot (Cherkezishvili, 2005).

The most effective method for conserving plant genetic resources is the establishment of a seed bank (Guarino *et al.,* 1995). Seeds were stored for short-term (1–3 years) and medium-term (4–10 years). Before storage, seeds were cleaned and processed; moisture content was adjusted to match storage temperature requirements (Hong & Ellis, 1996; IPGRI, 2009; Anon., 2014).

Data analysis: Data analysis was performed using Geographic information system (GIS) and DIVA systems, and maps containing geo-climate information were prepared (http://diva-gis.org). Appropriate statistical methods were used for data processing (Conklin & Meinzholt, 2004).

The differences between East Georgia and West Georgia by plant abundance, plant height, and plant diameter were assessed using a non-parametric Mann–Whitney U test. This test was selected because the data did not meet the assumptions of normality required for parametric analyses. Independent samples from the two regions were compared based on their rank distributions.

PCA was carried out with the selected variables, and these were reduced to three principal components representing most of the information in the original dataset. Regression analysis were conducted to evaluate the correlation between principal components (PCs) and ecological factors (r) and proportion of the variance (r^2, %) for a dependent variable (PCs) that explained by independent variables or ecological factors in the regression model. The statistical package SPSS ver. 21.0 was used for PCA and regression analysis.

Results

A total of 39 sites were studied, most of which (29 sites) were located in Kakheti region (Fig. 1). Expeditions were carried out throughout Georgia across the distribution range of Caucasian wingnut. Locations of target species were recorded in Western and Eastern Georgia. In Western Georgia, inventory was conducted in Khelvachauri, Chokhatauri, Lanchkhuti, Khobi and Zestaponi municipalities. Individual trees were noted near Khaishi village (Mestia municipality). Microgroups of targeted species were described mainly in the Western Georgia. Old trees were recorded in the Zestaponi Municipality, near Pirveli Sviri village and in Kolheti National Park within areas ranging from 0.5 to 1 ha, which were characterized by optimal natural regeneration. In the Eastern Georgia Caucasian wingnut occurs in much larger areas in riverine forests in the form of microgroups and stands. The species is widely distributed in the basins Bursa, Stori, Intsoba, Chelti and Alazani rivers, although the most well-developed stands are located along the shores of the Lopota River.

Table 1. Database of studied locations of *P. fraxinifolia* distribution

#	Region	Municipality	Location	Latitude	Longitude	Elevation (m.a.s.l)	Distribution patterns
1.	Samegrelo-Zemo Svaneti	Mestia	Khaishi village	42.81009161	42.04502413	623	Individual tree
2.	West Georgia	Khelvachauri	Near Kirnati village	41.48508267	41.72224669	105	Micro group
3.		Zestaponi	Pirveli Sviri village	42.09753513	42.94299051	201	Stand
4.		Lanchkhuti	Kolkheti National Park, bank of the Pichori river	42.142171	41.808969	21	Individual tree
5.		Lanchkhuti	Kolkheti National Park, bank of the Pichori river	42.139671	41.833372	17	Micro group
6.		Khobi	Kolkheti National Park, bank of the Pichori river	42.142872	41.809762	22	Stand
7.			Kolkheti National Park, bank of the Pichori river	42.149551	41.799215	3	Micro group
8.			Kolkheti National Park, bank of the Pichori river	42.140961	41.811311	2	Micro group
9.			Kolkheti National Park, bank of the Pichori river	42.15164832	41.9353577	3	Micro group
10.			Kolkheti National Park, bank of the Pichori river	42.15320055	41.92712737	3	Micro group
11.	East Georgia	Lagodekhi	Near Heretis Kari village	41.717452	46.056291	235	Stand
12.			Pona village (Shato-Kapito Touristic zone)	41.852987	46.109729	366	Stand
13.			Near Gelati village	41.805547	46.182052	321	Micro group
14.			Lagodekhi Protected Area	41.809384	4629441	425	Micro group
15.			Lagodekhi Protected Area	41.8093560	46.316328	454	Individual tree
16.			Lagodekhi Protected Area	41.8124047	46.224736	549	Micro group
17.			Lagodekhi Protected Area	41.8755529	46.240463	603	Micro group
18.			Lagodekhi Protected Area	41.8547100	46.240602	518	Micro group
19.		Kvareli	Kvareli, Bursa Gorge (opposite of Bzis Gora)	41.946218	45.842357	437	Micro group
20.			Kvareli, Bursa Gorge (opposite of Bzis Gora)	41.946227	45.832549	417	Micro group
21.			Kvareli, Bursa Gorge (opposite of Bzis Gora)	41.945038	45.832497	412	Stand
22.			Surroundings of Almati village, Intsobi Gorge	42.029725	45.690415	608	Micro group
23.			Surroundings of Almati village, Intsobi Gorge	42.029918	45.690931	586	Stand
24.			Surroundings of Almati village, Intsobi Gorge	42.029627	45.691035	589	Micro group
25.			At the Sabue bridge, Intsobi Gorge	42.026553	45.691415	575	Micro group
26.			Surroundings of Shilda village, Chelti Gorge	42.013174	45.737847	581	Individual tree
27.			Surroundings of Shilda village, Chelti Gorge	42.021509	45.775503	678	Stand
28.		Telavi	Near Pshaveli village, Stori Gorge	42.156798	45.420394	592	Stand
29.			Near Lechuri and Pshaveli vilages, Stori Gorge	42.147827	45.415849	571	Stand
30.			At the entrance of Lechuri village, Stori Gorge	42.133667	45.420431	554	Stand
31.			Surroundings of Pshaveli village, Stori Gorge	42.111925	45.429243	502	Micro group
32.			Surroundings of Lapankuri village, Lopota Gorge	42.075533	45.611817	635	Stand
33.			Surroundings of Lapankuri village, Lopota Gorge	42.074704	45.607748	631	Stand
34.			Surroundings of Lapankuri village, Lopota Gorge	42.081246	45.627087	675	Stand
35.			Near Napareuli village, Lopota Gorge	42.060472	45.521081	477	Micro group
36.			Surroundings of Napareuli and Lapankuri villages, Lopota Gorge	42.061743	45.535246	506	Stand
37.			At the bridge of Shakriani village, Alazani Gorge	41.987605	45.580200	352	Micro group
38.		Akhmeta	Babaneuri National Reseve, right bank of Stori river	42.070657	42.070657	430	Stand
39.			Babaneuri Nationak Reseve, right bank of Stori river	42.048264	42.048264	432	Individual tree

In the Intsoba Valley (Kvareli Municipality), Caucasian wingnut occurs in micro-populations within degraded riverine forest habitats at elevations of 500–600 m a.s.l. These micro-groups typically comprise 5–7 or 10–15 individuals, with a total area of occupancy of approximately 6 ha. In the Chelti River Gorge, Caucasian wingnut also occurs as micro-populations in degraded riverine forest habitats at similar elevations. In the Bursa River Gorge, Caucasian wingnut occurs in a fragmented distribution, including individuals up to 200 years old, and occupies a total area of approximately 51 ha. In the three valleys mentioned above, along with Caucasian wingnut, the following associate species were recorded in the sample plots: *Alnus glutinosa, Carpinus caucasica, Cornus sanguinea* subsp. *australis, Corylus avellana, Crataegus pentagyna, Juglans regia, Mespilus germanica, Quercus robur* subsp. *pedunculiflora, Q. petraea* subsp. *iberica, Rosa canina, Rubus* spp. *Salix caprea, Sambucus nigra, Smilax excelsa* are almost everywhere in the understory.

In the valley of the Stori River (Telavi Municipality), Caucasian wingnut is distributed up to 600 m a.s.l. upward. The species has been recorded along the banks of the Stori River, occurring both as micro-populations and as well-developed stands. In this valley, the following associated species were recorded with Caucasian wingnut: *C. caucasica*, *Diospyros lotus*, *Fraxinus excelsior*, *Morus nigra, Robinia pseudoacacia.* in the upper reaches of the river - *Fagus orientalis*. In this riverine forest, along with Caucasian wingnut, the following species were recorded: *A. glutinosa, C. caucasica* and *F. excelsior*. In some locations - *Acer campestre* and occasionally *Castanea sativa*, *Periploca graeca* were also recorded. Throughout the Lopota River Valley, Caucasian wingnut is found both in micro-populations and in pure and mixed stands. In the Lopota River Valley, Caucasian wingnut occupies a total area of approximately 165 ha, where the species forms the most well-developed pure and mixed stands compared to other recorded locations. In pure stands, Caucasian wingnut having an average height of 26 m and an average DBH of 40 cm were recorded in the vicinity of Lapankuri and Napareuli villages. In this area, Caucasian wingnut is primarily distributed within 80 m of the riverbank, where it forms well-developed stands. In the upper reaches of the Lopota River, this species is distributed up to 815 m a.s.l (Fig. 2). Only sample plots are marked on the map, small fragmented groups of Caucasian wingnut continuously followed along the Lopota River Valley.

Well-developed stands of Caucasian wingnut, in addition to those in the Lopota riverine forest, were found in the Stori River Valley, where a high-density pure stand (0.8) was described. In these pure stands, Caucasian wingnut exhibited an average height up to 30–32 m and an average DBH of 40–44 cm. The relief is flat, due to the swampy conditions, no regeneration was observed. In the same valley, at the entrance to Lechuri village, the widest stand of Caucasian wingnut with a density of 0.7 was recorded. On both banks of the river, Caucasian wingnut dominated stands were present.

In Lagodekhi Municipality, Caucasian wilgnut also forms micro-groups and stands in different places with different species compositions, although well-developed stands are under private ownership, where tourist centers are located. Due to the fact that Caucasian wingnut is listed in the Red Book of Georgia as a Vulnerable (VU D2), due to its small and fragmented distribution range, private owners are prohibited from cutting this trees. However, due to strong anthropogenic pressure the future status of these stands remains uncertain. In this Municipality, Caucasian wilgnut also distributed within the Lagodekhi Protected Areas. Here, the species occurs fragmentarily, both as micro-groups and mixed riverine forest stands, with good regeneration condition (Table 2).

The average tree diameter in the different locations of Western Georgia was 38 cm, while in the Eastern Georgia it was 41.4 cm. A similar pattern was observed for tree height - in Western Georgia, the average height of Caucasus Wingnut was 14 m, while in the Eastern Georgia it was 24 m.

The best stands in terms of composition, dendrometric characteristics, good regeneration and presence of superior mother trees are found in the Lopota and Stori valleys.

Regarding anthropogenic impact, Caucasus wingnut grows in floodplain forests located near to the settlements; consequently, threats to the target species and also to the forest ecosystems are increasing.

From the 10 locations studied in the Western Georgia, six are represented by micro-groups, two by individual trees, and stands are present at only two locations and only in the Kolkheti Protected Area. While from the 29 locations described in the Eastern Georgia, there were 13 stands, which were better developed than those in Western Georgia.

The Mann-Whitney U test results confirm that plant abundance, plant height, and plant diameter differ significantly between Eastern and Western Georgia. The significant p-value (p=0.01) suggests a big difference in plant abundance, plant height and plant diameter between the two regions. The higher mean rank for Eastern Georgia points to greater plant abundance in this region, highlighting a regional disparity in plant distribution (Fig. 3).

Table 2. Quantitive data (density, height, DBH, seed plots) for all locations (39 sites).

Region		Municipality	Number of trees per plots	Mean height of tree (m)	Mean diameter of tree (cm)	Seed plots +Yes/ -No
Western Georgia	Adjara	Khelvachauri	5	16	80	+
	Samegrelo	Tsalenjikha	2	16	60	-
	Imereti	Zestafoni	20	20	28	+
		Khobi	30	14	32	+
	Guria	Lanchkhuti	1	10	16	-
			4	8	14	-
	Samegrelo	Tsalenjikha	2	16	60	-
		Khobi	12	14	42	+
			4	12	20	-
			5	12	22	+
			3	14	40	-
Eastern Georgia	Kakheti	Lagodekhi	15	16	26	-
			21	26	100	+
			9	24	40	+
		Kvareli	6	14	26	-
			7	12	22	-
			12	14	38	+
			3	20	52	-
			10	16	26	+
			9	17	26	+
			5	12	24	-
			5	5	18	-
			6	22	32	-
		Telavi	56	18	16	+
			32	36	44	+
			15	20	80	+
			8	10	26	+
			18	24	38	+
			9	26	38	+
			29	26	38	+
			4	18	40	-
			16	30	46	+
			5	32	80	-
		Akhmeta	1	24	90	-
			1	14	28	-
			6	26	40	+
			7	24	38	+
			9	24	40	+

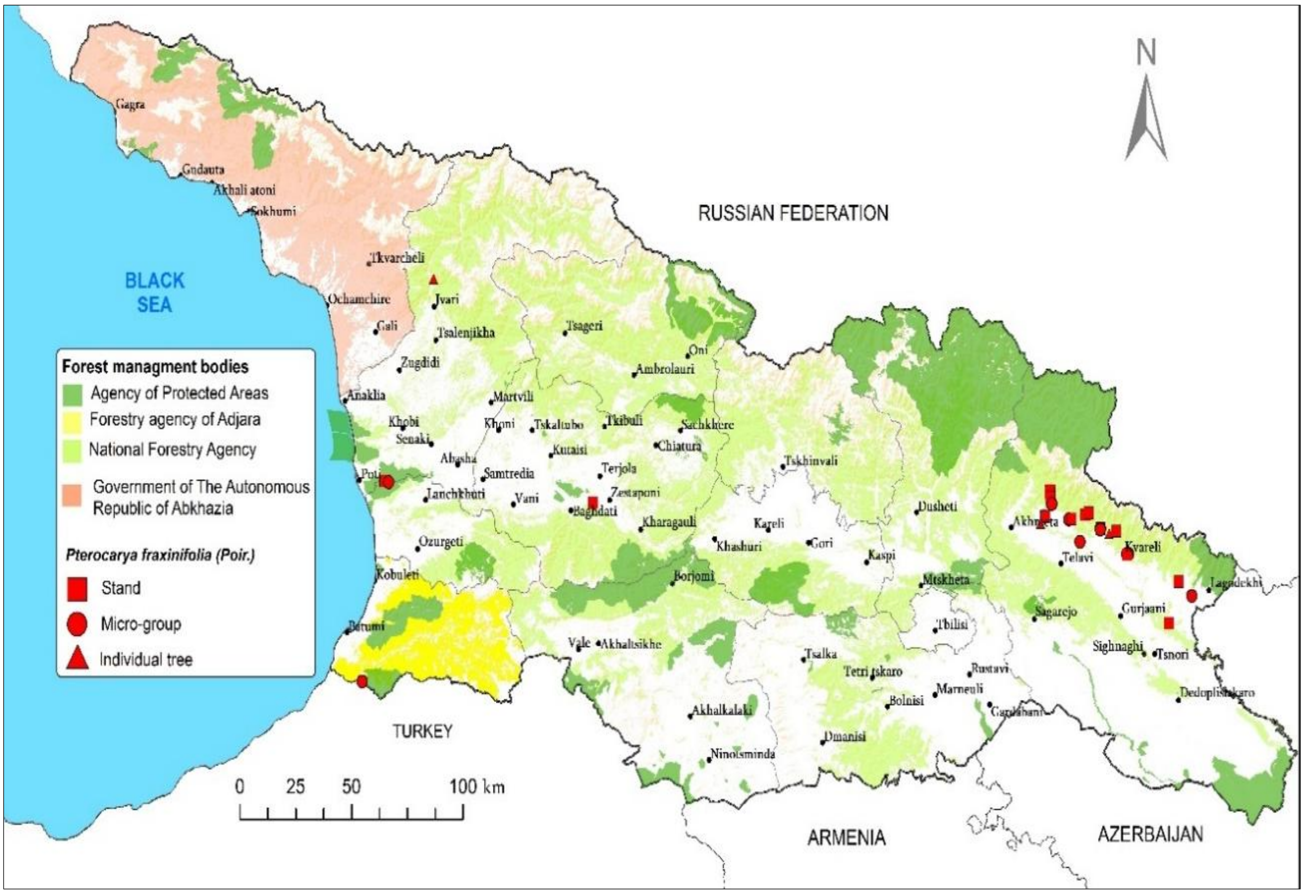


Fig. 1. *P. fraxinifolia* locations in Georgia.

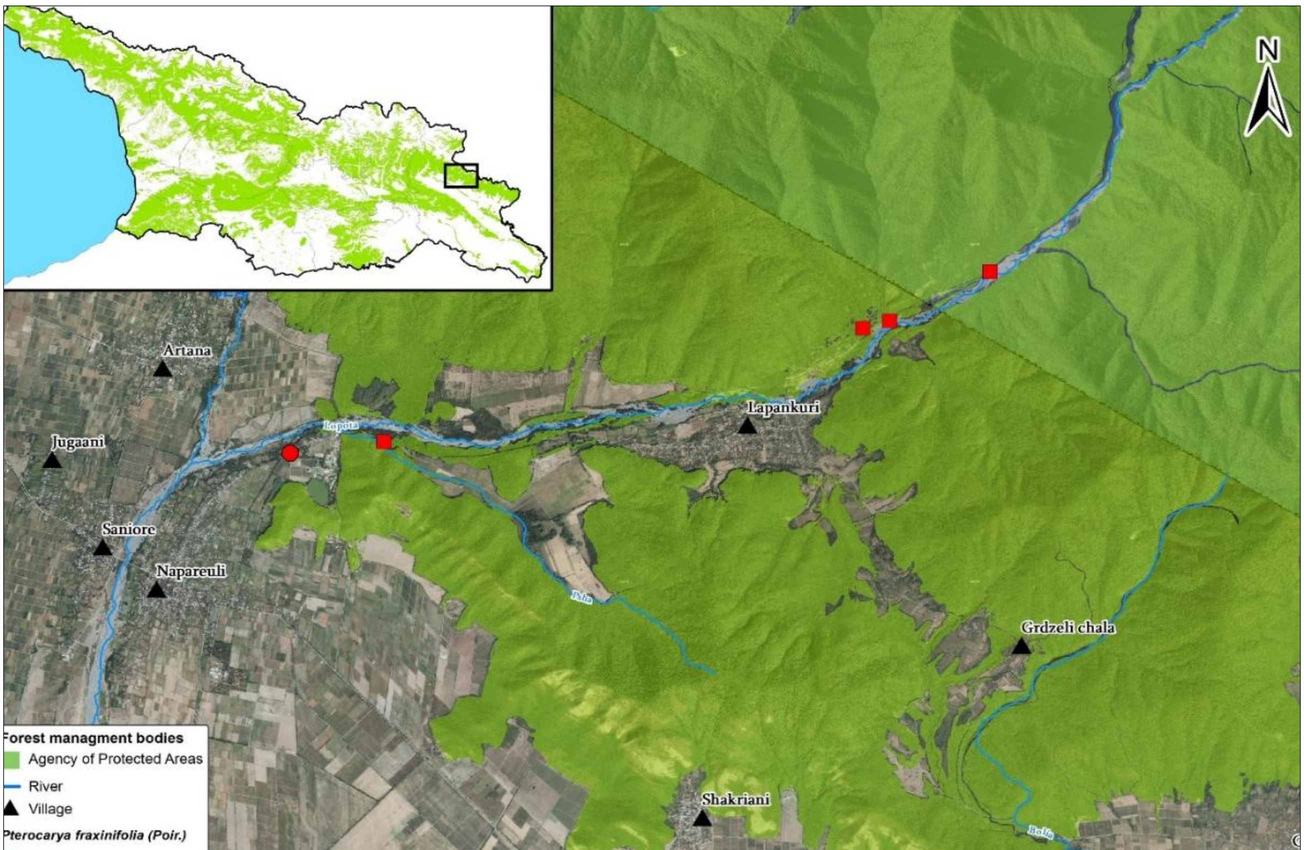
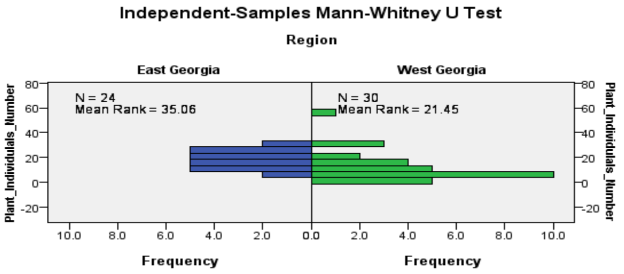
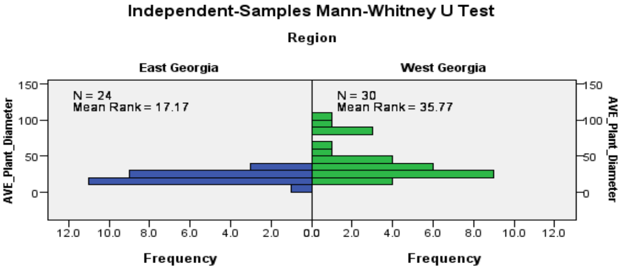


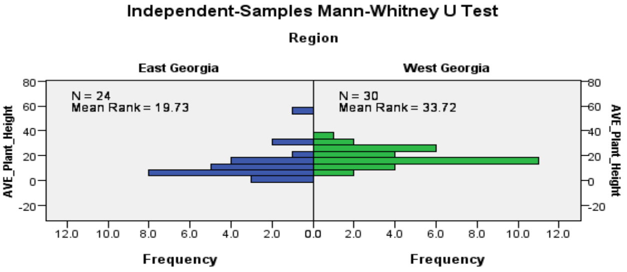
Fig. 2. Caucasian wingnut locations in the Lopota River Valley.



Total N	54
Mann-Whitney U	178.500
Wilcoxon W	643.500
Test Statistic	178.500
Standard Error	57.402
Standardized Test Statistic	-3.162
Asymptotic Sig. (2-sided test)	.002

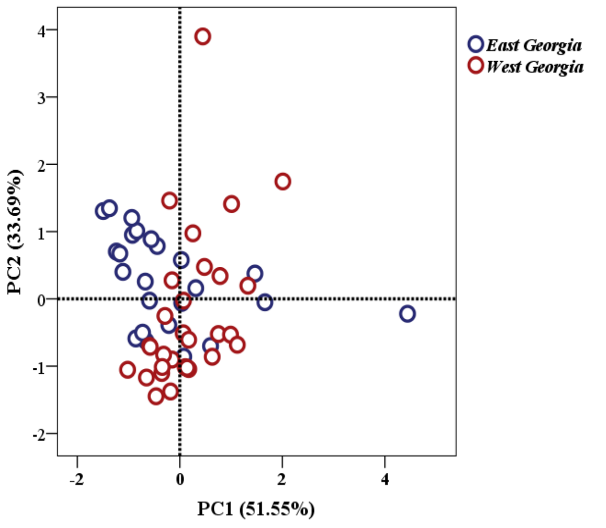


Total N	54
Mann-Whitney U	608.000
Wilcoxon W	1,073.000
Test Statistic	608.000
Standard Error	57.291
Standardized Test Statistic	4.329
Asymptotic Sig. (2-sided test)	.000



Total N	54
Mann-Whitney U	546.500
Wilcoxon W	1,011.500
Test Statistic	546.500
Standard Error	57.366
Standardized Test Statistic	3.251
Asymptotic Sig. (2-sided test)	.001

Fig. 3. Differences in plant abundance, height and diameter between East and West Georgia, according to the Mann–Whitney U test (39 sites)



Component	Initial Eigenvaues		
	Total	% of variance	Cumulative 0%
1.	1.546	51.546	51.546
2.	0.921	30.688	82.235
3.	0.533	17.765	100.000
		Component	
		1	2
Plant individual		-0.497	0.851
Mean height of plants (cm)		0.771	0.430
Mean diameter of plants (cm)		0.840	0.110

Fig. 4. The Principal Component Analysis (PCA) of number of plants, mean plant height (cm), and mean plant diameter of *P. fraxinifolia* in Eastern and Western Georgia (39 sites)

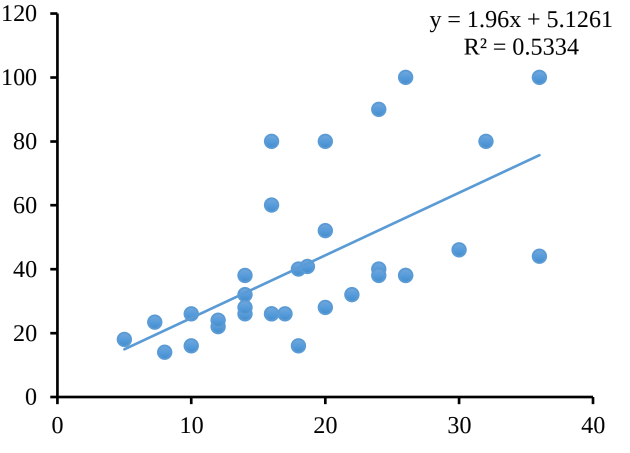


Fig. 5. Relationship between plant height (cm) and diameter (cm) of *P. fraxinifolia*.

The Principal Component Analysis (PCA) was conducted on three plant morphological traits: number of plants per individual, mean plant height (cm), and mean plant diameter. Three components were identified explaining 100% of the total variance. The first principal component (PC1) accounted for 51.55% of the variance and was positively associated with mean plant height (loading = 0.771) and mean plant diameter (loading = 0.840). The second principal component (PC2) explained 30.69% of the variance and showed a strong loading for individual plants (loading = 0.851). Together, PC1 and PC2 explained 82.24% of the total variance (Fig. 4).

The correlation analysis revealed a statistically significant positive relationship between tree height and diameter, indicating coordinated growth between these traits across all study areas (Fig. 5).

Conclusion

Caucasian wilgnut is an important plant species as ornamental and reforestation purposes. It is unevenly distributed across the territory of Georgia and is dominant in the eastern part of the country, especially in the Kakheti region. Despite being thermophilous, the plant demonstrates a tolerance to short-duration winter frosts. As for the Western Georgia, although this species grows mainly along rivers, it is also common in adjacent alluvial forest in Colchis (Gulisashvili, 1961; Hoseinpour *et al.,* 2013).

The study results revealed differences between the populations of Western and Eastern Georgia, which is induced by different regional ecological and geographical factors (Ketskhoveli, 1959; Nakhutsrishvili, 2013).

For all studied areas, positive relationship between plant height and diameter was identified. This relationship is a fundamental concept in forest ecology and yield. Tree height generally increases with diameter as a result of growth processes, mechanical stability requirements and competition for light (Pretzsch, 2009; West, 2009).

The presence of better-developed stands of Caucasus wingnut in Eastern Georgia compared to Western Georgia can be explained by differences in terms of hydrological and geomorphological conditions of these two regions.

Although the climate in Eastern Georgia is drier, Caucasian wingnut is present in valleys, that support preservation of groundwater reserves and presence of relatively deep alluvial soils, creating favorable conditions for intensive growth of this species (Kozlowski *et al.,* 2018a; Tielidze *et al.*, 2019; Davitashvili *et al*., 2024).

It should also be noted that floodplain forest, which constitute the habitat of Caucasian wingnut, are much better preserved in eastern than in Western Georgia. In Western Georgia anthropogenic pressure on floodplains had a negative impact and most of them were reduced and preserved only in small, fragmented areas (Nikolaishvili *et al.,* 2015).

Current studies using ecological niche modeling and conservation assessments provide a comprehensive understanding of its evolutionary history, distribution dynamics and current vulnerability (Song *et al.,* 2021). Our findings have revealed the current status of target species. Although ecological niche modeling predicts potential distribution based on climatic variables, the inventory data presented in this study demonstrate that actual distribution is further constrained by anthropogenic pressures and site-specific ecological conditions.

As a result of this study, GIS-based distribution maps of Caucasian wingnut in Georgia were created, seeds were collected and processed for storage in the seed bank, a database was prepared in Georgian-English, and the most viable population was identified in Telavi Municipality (Lapankuri location), a reasonable *in-situ* conservation location. Conservation of the natural habitat of the Caucasian wingnut, as an Arcto-Tertiary relict, in terms of ongoing environmental changes and current land-use practices is crucial (Davitashvili *et al.,* 2024). As Caucasian wingnut occurs in the degraded riverine forests and the degradation process is irreversible, appropriate conservation measures are urgently required to protect this species.

According to the research findings, Lapankuri distribution range is proposed for in-situ conservation as a protected forest (Category II according to the Forestry Code of Georgia). This designation does not imply the establishment of an IUCN protected area category (e.g., National Park); rather, it provides a formal legal framework for the protection of a species already listed as Vulnerable in the Red List of Georgia. The application of this category enables the state to better manage the substantial anthropogenic pressures currently threatening these riparian habitats. This territory can serve as a potential protected area, facilitating the expansion of the national network of protected areas in accordance with Georgia's obligations under international agreements.

Management of areas in private ownership is relatively complicated. Forest maintenance is carried out according to the owner's interests, because beautiful forest attracts tourists and high pressure of visitors may reduce natural regeneration of the species, which could lead to long-term degradation of stand. Within the framework of the present study, seed plots were identified. In Western Georgia (Adjara), a target-species location was recorded in Khelvachauri municipality, near Kirnati village, where a healthy, abundantly seed-bearing stand of Caucasian wingnut is present. In eastern Georgia, within Telavi municipality, the most suitable seed plots were allocated in target species locations in the Lopota and Stori River basins. In Western Georgia, the species is protected within Kolkheti National Park, while in eastern Georgia it is conserved in the Lagodekhi Protected Areas. Within the Lagodekhi Protected Areas, the species often occurs as fragmented micro-groups or as individuals. This limited and scattered distribution increases the populations vulnerability to localized disturbances and complicates effective ecosystem-level management. Despite these challenges, the Lagodekhi Protected Areas provide a relatively stable environment for the species. Within the protected boundaries, anthropogenic impact is minimal, and although the distribution remains fragmented, the species exhibits good regeneration capacity.

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