Received: 30 July 2023 | Revised: 14 October 2023 | Accepted: 5 November 2023

DOI: 10.1002/fedr.202300031

RESEARCH ARTICLE

# First description and conservation implications of a unique stand of the Caucasian wingnut in Lapankuri (Georgia)

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**Funding information**
Franklinia

**Abstract**

Many north-temperate tree species survived glacial periods in small, low-density populations in refugia. These refugia are located in eastern and western North America, South Europe, East Asia, and western Asia. As a part of western Asia, Georgia harbors two main refugia: the Colchis in western Georgia and the eastern Great Caucasus, where many Cenozoic relict plants still exist. In this article, we report a new population of *Pterocarya fraxinifolia* (the Caucasian wingnut) which was discovered in the eastern Great Caucasus, near the village Lapankuri. The Lapankuri *P. fraxinifolia* stand is unique because the species grows not only in a narrow strip of riparian vegetation, but is also occurring in a broad band up to 100 m away from the river. *Pterocarya fraxinifolia* is dominant in the stand and is represented by large and old trees. Many other relict trees such as *Diospyros lotus* and *Juglans regia* are also present in the Lapankuri stand. Although some Cenozoic relict species are widely cultivated and naturalized in Central and Western Europe, natural stands of these plants provide the only evidence of their past growing conditions; therefore, conservation of this place is strongly advocated.

**KEYWORDS**

Cenozoic plants, conservation, Georgia, *Pterocarya fraxinifolia*, Refugia, relict plants

## 1 | INTRODUCTION

The Cenozoic period (the past 66 million years, Myr) was characterized by a gradual cooling in both hemispheres with temperature changes at high latitudes being more pronounced than close to the equator (Moran et al., 2006). Increased cooling of the Northern Hemisphere from 15 Myr ago onward caused a drop in diversity of temperate and subtropical forest biomes in the Northern Hemisphere and their retreat from mid to high latitude circumboreal distributions southward to refugial regions that preserved a warm and wet climate (Tiffney & Manchester, 2001; White et al., 1997; Zachos et al., 2001). These refugia of warm temperate woody plants are today located in East Asia, south-eastern and western North America, south-eastern Europe, and western Asia (Denk et al., 2001; McIver & Basinger, 1999; Milne, 2006; Milne & Abbott, 2002; Tarkhnishvili et al., 2012; Wen, 1999).

The Caucasus region was designated as one of 36 global "biodiversity hotspots" (Myers et al., 2000; Venevsky & Venevskaia, 2005). The Caucasus biodiversity hotspot includes Georgia, Armenia, Azerbaijan, and small portions of Russia, Iran, and Turkey. The region is characterized by a unique flora; many endemic species and five endemic plant genera are known from the area (Gagnidze et al., 2002; Grossheim, 1936). In addition, the Caucasus is one of the most important Pleistocene glacial refugia in the Northern Hemisphere. This claim is well supported by several lines of evidence: The presence of extant survivors of plant lineages with a wide Cenozoic distribution such as *Pterocarya fraxinifolia* (Poir.) Spach., *Zelkova carpinifolia* (Pall.) K. Koch, *Parrotia persica* C.A. Mey., and the high level of endemism in both plants and animals (Grossheim, 1936; Ketskhoveli, 1959; Kolakovskyi, 1961; Milne, 2004; Sharifi & Assadian, 2004; Tarkhnishvili et al., 2000; Zohary, 1973). Several characteristics favored survival of Cenozoic relicts in the Caucasus throughout the Pleistocene. The Caucasus is influenced by a warm and humid climate from the Black Sea, which supports the establishment of humid broad-leaved deciduous forests with an evergreen understory containing Cenozoic relict plants. Similarly, humid and warm winds coming from the Caspian Sea are captured by the eastern Great Caucasus range and Elburz mountain range promoting the formation of luxuriant mesophyllous vegetation with dominance of Cenozoic relict taxa (Akhani et al., 2010; Dagtekin et al., 2020; Denk et al., 2001; Martin-Benito et al., 2020).

Although a considerable number of Euxinian-Hyrcanian Cenozoic relict taxa is today cultivated and partly naturalized in Central and South Europe, the documentation of natural stands of relict trees is the only way to understand how these species or their congeneric extinct counterparts grew in the past. Moreover, descriptions of natural forest vegetation in the Caucasus and adjacent areas commonly are restricted to work from the early nineteenth century such as Engler and Drude's Vegetation of the Earth (Radde, 1899) or general works such as Kolakovskyi (1961). Thus, the aim of this work was to study the small-scale distribution patterns of a well-known Cenozoic relict tree, *Pterocarya fraxinifolia*, in Lapankuri, eastern Great Caucasus and to report a new *P. fraxinifolia* stand occurring near the village Lapankuri.

## 2 | MATERIALS AND METHODS

A floristic study was carried out in the surroundings of the village Lapankuri, eastern Great Caucasus (Figure 1), in 2015 and 2016. Identifications of plants were based on Vascular Plants of Georgia (Gagnidze, 2005). Plant names and their authorities follow the International Plant Names Index (PNI, 2023).

## 3 | RESULTS

An impressive population of *P. fraxinifolia*, previously not mentioned in the literature, was discovered in eastern Georgia, in the surroundings of the village Lapankuri, located between 42°3′41.19″ N 45°32′24.99″ E and 42°3′47.52″ N 45°33′55.22″ E. The *P. fraxinifolia* stand was mapped using ArcGIS version 10.2.2 and the area of the stand was measured. The core area of the riparian forest with dominance of *P. fraxinifolia* is 35 ha (Figure 1). This place was characterized by the riverbed of the Lopota river, which forms a strongly braided river system. (Figure 2). The stand has a northern exposition; alluvial soils are widely distributed. The weather conditions prevailing in Lapankuri are characterized by a cold and moderate climate. The village of Lapankuri experiences a significant amount of rainfall, even during the month with historically low precipitation levels. The mean annual precipitation level amounts to 733 mm. The majority of rainfall occurs in April and the maximum precipitation level is 110 mm. The minimum precipitation level equals to 40 mm. The average annual temperature in Lapankuri is 7.9°C. The temperatures are highest in August, at around 20.6°C. The minimum temperature is in January, the temperature registers at a minimum value of −4.3°C.

On gravels, the pioneer species *Salix alba* is forming small patches, whereas *Pterocarya fraxinifolia* is restricted to the deeper alluvial soils. On the right side of the river Lopota, cultivated land is present.

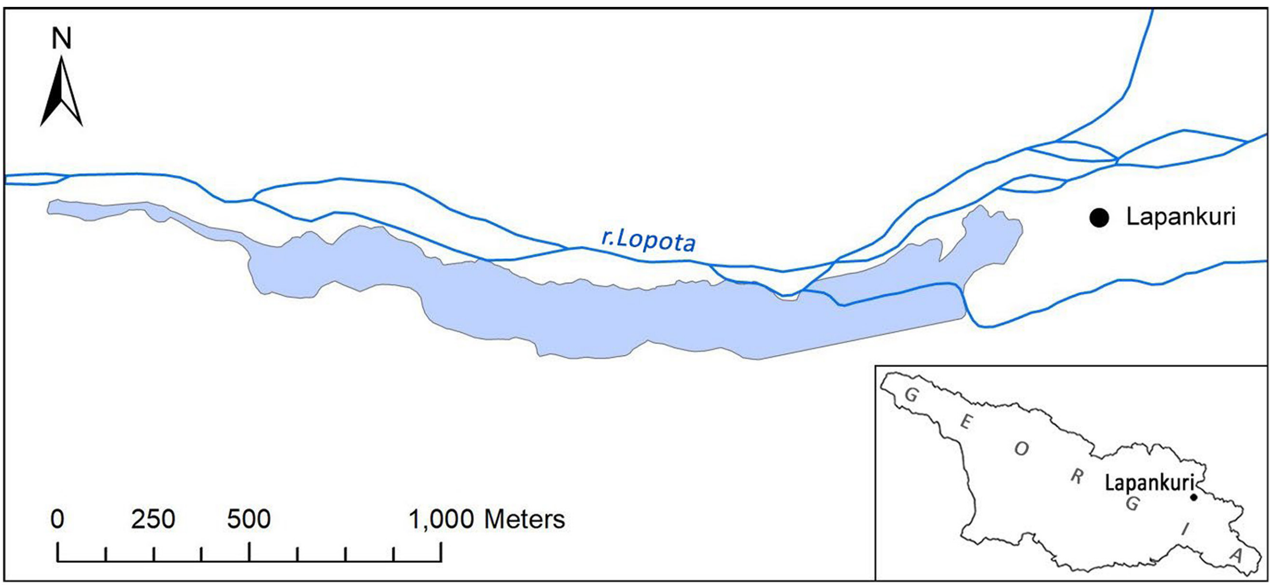


**FIGURE 1** Distribution of riparian forest dominated by *P. fraxinifolia* (in light blue) near the village Lapankuri.

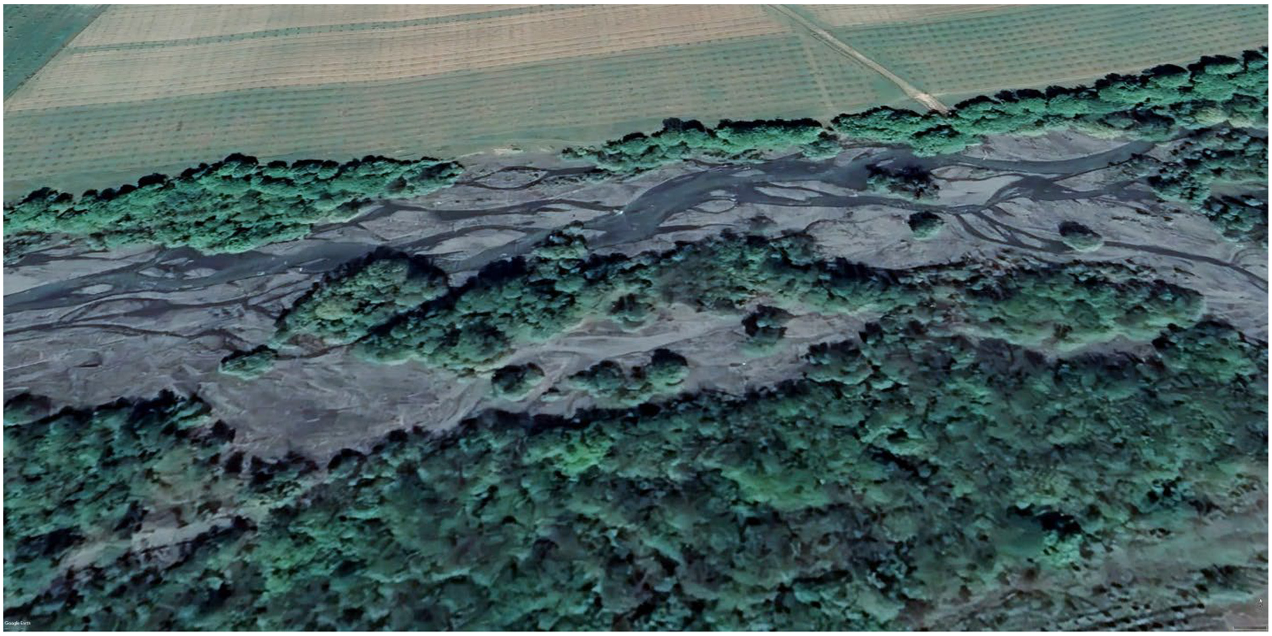

**FIGURE 2** Braided river system of river Lopota (Google Earth image).

**TABLE 1** List of common trees, shrubs, and lianas in Lapankuri *P. fraxinifolia*-dominated riparian forest.

| | |
|---|---|
| *Acer campestre* L. | *Mespilus germanica* L. |
| *Alnus barbata* C. A. Mey. | *Morus nigra* L. |
| *Carpinus betulus* L. | *Populus alba* L. |
| *Cornus mas* L. | *Populus nigra* L. |
| *Cornus sanguinea* L. | *Pyrus pyraster* (L.) Burgsd. |
| *Corylus avellana* L. | *Quercus robur* subsp. *pedunculiflora* (K. Koch) Menitsky |
| *Crataegus pentagyna* Waldst.et Kit. ex Willd. | *Rosa* sp. |
| *Diospyros lotus* L. | *Rubus* sp. |
| *Euonymus europaeus* L. | *Salix alba* L. |
| *Gleditsia triacanthos* L. | *Salix purpurea* L. |
| *Hedera pastuchovii* Woronow | *Sambucus nigra* L. |
| *Hibiscus syriacus* L. | *Smilax excelsa* L. |
| *Juglans regia* L. | *Ulmus minor* Mill. |
| *Ligustrum vulgare* L. | *Viburnum opulus* L. |

In Lapankuri, *Pterocarya* does not only grow along the main course of the river but forms an original and vast forest extending deep into the alluvial plain including natural levees. *Pterocarya fraxinifolia* is represented by old and large trees and is the dominant species. Close to the river Lopota, the sun-loving *Salix alba*, *Populus alba*, and *P. nigra* were restricted to gravels with shallow substrate. Sporadically, the riparian forest element *Quercus robur* subsp. *pedunculiflora* occurred (see Table 1, Figure 3). Other woody taxa like *Alnus barbata*, *Carpinus betulus*, *Acer campestre*, *Cornus mas*, *Diospyros lotus Crataegus pentagyna*, and *Juglans regia* were also present in the wingnut dominated forest (see Table 1; Figure 3).

## 4 | DISCUSSION

In the course of this study, natural populations of *P. fraxinifolia* were investigated throughout almost the whole distribution range of the species: in western Georgia – Colchis, eastern Great Caucasus, and in northern Iran, Hyrcanian forest region, and in the Zagros mountains. Not included in this survey were the regions south of the Black Sea. During the Cenozoic, the species, or its closely related ancestors, were widely distributed in western Eurasia extended to the north as far as Iceland (Mai, 1995).but nowadays it is restricted to the above-mentioned regions. *Pterocarya fraxinifolia* is widely cultivated in Europe and is a moderately cold tolerant species. (see, e.g., Lintunen et al., 2015, for frost tolerance and hardiness, and POWO for a general distribution including regions where *P. fraxinifolia* has been introduced; https://powo.science.kew.org/taxon/4424711?_gl=1*1npydcm*_ga*Njg3NzE3ODg5LjE2ODA1MTU4NzQ.*_ga_ZVV2HHW7P6*MTY5Mzg5OTY0Ny4zOC4xLjE2OTM4OTk2NjYuMC4wLjA.).

A unique stand of this species occurs in Lapankuri, eastern Great Caucasus. The Lapankuri *P. fraxinifolia*-dominated forest is situated between the villages Lapankuri and Napareuli along the river Lopota. Caucasian wingnut is a relict monoecious tree species that requires deep soils and sufficient air humidity; it grows in riparian forests in the areas of partially flooded forests and running water from lowlands up to 1730 m


**FIGURE 3** Transect of *Pterocarya fraxinifolia*-dominated forest in Lapankuri. _ _ _ _ _ *Acer orthocampestre*, ........... *Alnus arbata*, ______ *Carpinus betulus*, .......... *Cornus sp.*_._._._. *Corylus avellana*, _ . _ . _ *Crataegus sp.*, ooooo *Diospyros lotus*, OOOOO *Hedera pastuchovii*, ▨ *Juglans regia*, _._._._. *Mespilus germanica*, ▯▯▯▯ *Morus nigra*, ●●●● *Pterocarya fraxinifolia*, ______ *Quercus robur*, ▮▮▮▮ *Rubus sp.*, ▦ and *Salix purpurea*.

in the Zagros Mountains (Akhani & Salimian, 2003; Gulisashvili, 1961). This fast-growing anemophilous species prefers alluvial and clay soils with a humus layer, semi-deep to shallow soils with medium nutrient requirement (Gulisashvili, 1961; Hoseinpour et al., 2013; Sheykholislami & Ahmadi, 2009). Although being a thermophilous plant, it can stand short lasting winter frosts reaching –25°C (Gulisashvili, 1961; Lintunen et al., 2015).

The *P. fraxinifolia* stand in Lapankuri is composed of trees of different age, saplings, young trees, and old trees are present here. Special interest deserves the appearance of tall trees up to 30 m tall, which are well represented in the Caucasian wingnut stand in Lapankuri and distinguish it from all other known populations in the whole distribution range of the species (Figure 4). Gulisashvili (1961) reported that *Pterocarya fraxinifolia* never forms monodominant populations. However, the Lapankuri stand is characterized by the dominance of Caucasian wingnut. The presence of seedlings suggests that the Lapankuri Caucasian wingnut-dominated forest is a self-sustaining population (Figure 5).

*Pterocarya fraxinifolia* is an important component of the riparian forests in the eastern Great Caucasus and northern Iran and usually grows in small groups along rivers (Gulisashvili, 1961). The Lapankuri Caucasian wingnut stand is unique since the species distributed here not only directly along the river and adjacent channels as in all other known stands of the eastern Great Caucasus, for example, in Ninigori 41°50′57″ N 46°13′52″ E (Kakheti; personal observation), but also forms a vast forest growing 100 m away from the river bank. The establishment of this *P. fraxinifolia* stand appears to depend on the natural fluctuation of the water level of the river Lopota, which creates appropriate ecological conditions for the species' growth and also enables transportation of *P. fraxinifolia* seeds further away from the river, where they germinate and seedlings grow. A similar situation, in which *P. fraxinifolia* grows away from the river, was found in North Iran - Khan Bebin population 36°58′01.4″ N; 55°01′40.4″ E (personal observation).

**FIGURE 4** Tall *P. fraxinifolia* tree in Lapankuri riparian forest.

Here the Caucasian wingnut, similar to the Lapankuri stand, grows not only along the river, but also at some distance from the river. However, large and old individuals are absent and *Pterocarya* is not dominant but part of a mixed forest.

It should be mentioned that also in the Colchis region of western Georgia, *Pterocarya* grows not only along rivers but also in the adjacent alluvial forest. This can be explained by the presence of high groundwater levels. But in the Colchis region, Caucasian wingnut is represented by young and juvenile trees (personal observation) because of intensive logging of the Colchic lowland forest. To the best of our knowledge,

**FIGURE 5** Seedling of *P. fraxinifolia* in Lapankuri riparian forest.

the Lapankuri *P. fraxinifolia* stand is unique throughout the species distributional range, because (i) the tree is dominant in the riparian forest, (ii) is represented by large and old trees in addition to the presence of seedlings, and (iii) grows not only along the river, but further away from the river in alluvial lowland forest. We assume that this situation might reflect the natural condition of *Pterocarya*-dominated lowland forests in prehistoric times. Therefore, conservation actions are of utmost importance to protect this unique Caucasian wingnut stand.

Besides *P. fraxinifolia*, other important relict taxa are well presented there. Among them are: *Quercus robur* subsp. *pedunculiflora* which is a relict taxon with distribution in south-eastern Europe, from the Balkan Peninsula across Crimea to the Caucasus and northern part of Anatolia. In southeastern and eastern Georgia, this sun-loving species grows along rivers forming riparian forests together with willow and poplar species. Vicariant species of *Quercus robur* subsp. *pedunculiflora* in western Georgia is *Quercus robur* subsp. *imeretina* (Steven ex Woronow) Menitsky. Both taxa are closely related to the strictly European species *Q. robur* L. s.str. All these taxa are members of section *Quercus* and recent leaf morphological and genetic research shows that there is limited difference between *Q. robur* and *Quercus robur* subsp. *pedunculiflora* (Curtu et al., 2011).

*Carpinus betulus* commonly occurs on well-drained soils. This species is not only a relict plant component of beech and oak forest but it also grows in lowland riparian forests of western Georgia in better drained soils (Denk et al., 2001). Similarly to western Georgia, *C. betulus* is well presented in the riparian forest of Lapankuri. It is noteworthy that this species is often referred to as *C. caucasica* Grossh. in the literature, but considered a synonym of *C. betulus* in modern taxonomic accounts (e.g., Govaerts, 2003). Nevertheless, as in *Pterocarya* (Maharramova et al., 2018), *Fagus* (Kurz et al., 2023), and other tree species, there might be some hidden, cryptic species in western Eurasia. These will only be detected by thorough phytogeographical investigations and renewed efforts in the morphological monitoring of widespread tree taxa.

*Diospyros lotus* is native to the Balkans, Turkey, Caucasia, Central Asia to China, and Japan. It is closely related to the Japanese species *D. kuroiwai* Nakai (Yonemori et al., 2007). It occurs on foothills in the Colchic refugium and in riparian forests of the eastern Great Caucasus.

*Acer campestre* is a very common accessory element in well-drained forests and riparian stands in Europe and western Asia (Grimm & Denk, 2014). The species is typically found along forest-edges in fully humid, warm-temperate climates. Recently, populations of *A. campestre* occurring in western Georgia were described as a new species *A. orthocampestre* Grimm & Denk (2014). The populations from eastern Georgia have not been investigated and the species distribution toward the east is unknown. However, based on the distributional pattern of *A. campestre* in the North Caucasus, East Georgia, Azerbaijan, and North Iran, where it is confined to humid temperate climates, following strictly the river valleys, we assume that all populations of *A. campestre* to the east might belong to *A. orthocampestre* (Grimm & Denk, 2014).

*Alnus barbata* is a Euxino-Hyrcanian species which occurs frequently in riparian forests of eastern Georgia and almost everywhere in the Colchic refugium. This pioneer species is tolerant to frequent flooding, and grows even in shallow standing water (Denk et al., 2001). It is closely related to *A. glutinosa* (L.) Gaertn.

## 4.1 | Implications for conservation

Due to habitat loss, construction of roads, and establishment of settlements, of agricultural land and of hydropower plants, natural riparian forests are very rarely found in western Eurasia. Moreover, especially in Central and Western Europe, natural water level fluctuation is regulated by dams and channels, which prevent the formation of riparian forest. Therefore, in situ conservation of naturally grown riparian forest, especially when dominated by rare Cenozoic relict plant species, is one of the most important aims in conservation biology. *Pterocarya fraxinifolia* is included in the Georgian Red Data Book (Kacharava, 1982) as a rare arboreal Cenozoic relict. However, logging of this tree was observed in different Caucasian wingnut-dominated places of the eastern Great Caucasus. *P.fraxinifolia* is listed in the IUCN Red List as vulnerable (Betrisey et al. 2019). *Pterocarya fraxinifolia* is protected in Lagodekhi Nature Reserve (Kakheti, eastern Georgia) and in Colchic National Park in western Georgia; however, the species is still under the threat of human influence and ongoing climate change coupled with anthropogenic environmental change. The unique Caucasian wingnut stand of Lapankuri requires a special protection status in order to prevent further damages, especially logging, establishing of maize field plantations, and pastures.

## 4.2 | Concluding remarks

A considerable number of Cenozoic relict trees are today planted and naturalized in Central and Western Europe (e.g., *Syringa, Aesculus, Pterocarya, Juglans*, and others). Natural stands of these taxa are threatened by human activities in combination with a warming climate. In this article, we document a newly discovered natural stand of Caucasian wingnut, *Pterocarya fraxinifolia*, in eastern Georgia and emphasize its uniqueness. Unlike previously reported natural stands of *Pterocarya fraxinifolia*, the here reported one is a dominant stand of large and old trees of *Pterocarya* extending across a wide alluvial plane away from the river bed. With a rich second tree layer and shrub layer and seedlings of *Pterocarya*, this stand might well resemble forests of Caucasian wingnut from prehistoric times. Protection of this alluvial forest is strongly recommended.

## ACKNOWLEDGMENTS

We thank foundation Franklinia for supporting our study. The authors are grateful to David Dzebisashvili for driving us safely to different *Pterocarya fraxinifolia* populations in Georgia. Special thanks are due to Norbert Frotzler for drawing the transect of *Pterocarya fraxinifolia* stand in Lapankuri.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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