The Biodiversity of Georgian Forests and the Current Situation

Rezo Vasadze[1*], Guguli Dumbadze[2], Sesili Gatenadze[2]

[1]N(N)LE Georgian Patriarchate St. Tbel Abuseridze Teaching University, The Service Against Forest Pests and Diseases, Ajara Forestry Agency, Batumi, Georgia
[2] Department of Biology, Batumi Shota Rustaveli State University, Batumi, Georgia
[*]rezovasadze1961@gmail.com

Abstract

Georgia, situated at the crossroads of Europe and Asia, boasts a rich and diverse ecosystem. It hosts a remarkable array of ecosystems shaped by diverse climatic conditions, ranging from humid-subtropical to dry-continental. Forests, which cover approximately 44.5% of Georgia's land area, harbor over 5,000 species of wild plants, including significant Tertiary relics such as *Rhododendron ponticum*, *Taxus baccata*, *Castanea sativa*, *etc*. Particularly in the Ajara region, which is recognized as one of 34 global biodiversity hotspots by the International Union for Conservation of Nature (IUCN), biodiversity remains a key ecological asset. Despite this richness, the forests of Georgia face increasing threats from invasive pests, diseases, and the impacts of climate change. This study evaluates the current biodiversity, forest health, and management challenges, with a focus on the Ajara region. Using data from the 2023 National Forest Census and field observations, the research examines species distribution, vegetation zonation, and the effects of environmental stressors on forest ecosystems. Moreover, it assesses current pest management and forest restoration efforts, emphasizing sustainable practices to mitigate the risks posed by climate change and invasive species. Results indicate that Georgia's forests contain a rich diversity of angiosperms, gymnosperms, and spore-bearing plants, distributed across various elevational zones. However, climate change-induced pests, such as *Cydalima perspectalis and Cryphonectria parasitica*, are causing significant ecological damage. Integrated Pest Management (IPM) strategies, including the use of pheromone traps and biological controls, have shown some success in combating these threats. Nevertheless, enhanced monitoring and climate-adaptive management are essential for ensuring the sustainability of these forests.

Key words: *Georgia, forest, biodiversity, pest control, climate change*

1. Introduction

Georgia, located at the confluence of Europe and Asia, boasts an exceptional diversity of flora due to its varied geography. The country's landscapes, spanning from the Caucasus Mountains to the Black Sea coast, host ecosystems that range from humid-subtropical to semi-arid. This diversity of climates allows Georgia's forests, which cover 44.5% of the total land area, to support over 5,000 species of plants, many of which are Tertiary relics (Gagnidze, 2000; Goginashvili et al., 2021).

Georgian forests are recognized as one of the world's 34 biodiversity hotspots, according to the International Union for Conservation of Nature (IUCN). Georgia's, especially Ajara's unique role as a refuge during the Ice Age preserved numerous species that have since disappeared

from the rest of Eurasia, making it a critical area for global biodiversity conservation (Ketskhoveli, 1959).

However, the forested area in Georgia is decreasing daily due to various negative factors such as fire, pollution, disease, insects, and incorrect planning. Georgia's forests are currently under significant threat from invasive species, pathogens, and the increasing impacts of climate change. The introduction of invasive species like the boxwood moth (*Cydalima perspectalis*) and bark beetles (*Ips typographus L., Dendroctonus micans Kugel., Ips sexdentatus Boern.*) (Vasadze et al., 2023; Vasadze R.&Vasadze Z . 2024; Beridze et al., 2024), along with the proliferation of chestnut blight *(Cryphonectria parasitica*) (Dumbadze et al., 2019), have caused substantial damage to key tree species. Moreover, climate change—evidenced by rising temperatures and altered precipitation patterns—has further weakened forest resilience, leaving them more vulnerable to pests and diseases (Gokturk et al, 2022; National Forest Census, 2023).

This paper aims to provide a comprehensive analysis of the biodiversity and forest ecosystems of Georgia, with a focus on the Ajara region. By examining the distribution of key plant species, the vertical zonation of vegetation, and the impact of environmental stressors on forest health, this study seeks to highlight the ecological significance of Ajara's forests and to identify the major challenges they face. The ultimate goal is to contribute to ongoing conservation efforts by offering insights into sustainable forest management practices that can help protect and preserve these valuable ecosystems.

2. Material and Methods

The study focuses on Georgia's forest ecosystems, with a particular emphasis on the Ajara region. The data on forest cover and biodiversity was derived from the National Forest Census of Georgia conducted in 2023. This census provided comprehensive information on the total forest area, species composition, forest health, and the distribution of forests across various elevation zones.

In addition to data from the National Forest Census, this study draws upon botanical surveys and field observations to document the presence of key species in Ajara's forests. The vertical zonation of vegetation was analyzed to understand the distribution of species across different altitudinal gradients. Special attention was given to the impact of pests, pathogens, and climate change on forest health, as well as to the management practices employed to address these challenges.

The analysis also includes an examination of forest restoration efforts, pest management strategies, and the role of natural regeneration in maintaining the health and sustainability of Georgia's forests.

3. Results and Discussion

3.1 Floral Diversity and Relic Species of Georgia's Forests

Georgia's forests boast a remarkable variety of plant life, with up to 5,000 species of wild and feral plants, including both angiosperms and gymnosperms. Additionally, the flora includes 8,300 species of spore-bearing plants, such as around 75 fern species, 600 species of moss (Bryophyta sensu stricto), 600 species of lichens, 5,000 species of fungi, and up to 2,000 species of algae. Many of these species are relics from the Tertiary period, which, while unable to form large independent ecosystems, thrive in mixed groves dominated by various woody

species. These groves, where individual species appear as separate biogroups, reveal the immense biological diversity present in Georgia's forests (Gagnidze, 2000; Goginashvili et al., 2021).

The uniqueness of Ajara's flora is largely due to its role as a refuge during the Ice Age, specifically in the Southern Kolkheti region (Ajara and Guria), where many species were preserved. These species, some of which have centuries-old evolutionary histories, trace their origins back to the Oligocene period and evolved from the ancient Arcto-Terrician flora. The "Mediterranean-Turghai" flora, as termed by Grosheim (1948), consisted of both deciduous and coniferous species, from which many modern species evolved through natural selection and adaptation.

Key relic species from this evolutionary process, now known as Tertiary relics, include: *Rhododendron ponticum (L.), Rhododendron ungernii (Trautv.), Laurocerasus officinalis (Roem.), Taxus baccata (L.), Laurus nobilis (L.), Buxus colchica (P.), Epigaea gaultherioides (Boiss.), Pterocarya pterocarpa (Michx.), Zelkova carpinifolia (Pall.), Acer velutinum (Boiss.), Castanea sativa (Mill.), Juglans regia (L.), Quercus pontica (Koch.), Betula medwedewii (Regel.), Rhamnus imeretina (Booth.), Fraxinus excelsior (L.), Tilia caucasica (Rupr.), Acer campestre (L.), Vaccinium arctostaphylos (L.), Phillyrea vilmoriniana (Boiss.), Arbutus andrachne (L.), Diospyros lotus (L.), Staphylea pinnata (L.), Staphylea colchica (Steven), Juniperus foetidissima (Willd.).*

These relic species form the foundation of Ajara's unique flora and contribute to its ecological richness. Over time, this diversity has shaped the distinct biological landscape of the region, further establishing Ajara as a critical area for biodiversity conservation.

3.2 Forest Cover and Vegetation Zonation in Georgia

According to the 2023 National Forest Census of Georgia, the country's total area of forests and forest lands covers approximately 3,420,400 hectares. Of this, 3,100,500 hectares are specifically covered by woody plants that constitute forests, accounting for 44.5% of the total land area of the country. Among the various regions, Ajara stands out with an exceptionally high forest cover rate of 68.9%, a figure that significantly surpasses the global average of 27% and the 15% forest cover seen in Georgia's neighboring countries. This substantial forest coverage places Georgia among the most forest-rich countries in Europe.

The diversity of Georgia's forests is remarkable, with over 400 woody species represented in the form of trees or shrubs. These species belong to 123 botanical genera and 56 families, and they are distributed across a wide range of elevations, from the seacoast up to altitudes of 2,900–3,000 meters. More than 60% of the forested area lies above 1,000 meters above sea level. Additionally, a significant portion of the forests (over 49%) is located on slopes with gradients of 26° to 35°, while 39% of the forests are spread on north-facing slopes.

Unlike other regions of the world that experience arid or semi-arid conditions, western Georgia is characterized by the absence of these vegetation belts. In this region, forests cover the plains and slopes from sea level, creating a lush and diverse landscape.

The vertical zonation of Georgia's vegetation is well-defined and is divided into several belts. In western Georgia, this zonation is relatively simple and is composed of five main belts, as described by D. Manjavidze (1965) and R. Kvachakidze (1996):

- Mixed subtropical forests, which extend up to 500-600 meters,
- Forests, which reach up to 1,900-2,000 meters,
- Subalpine zones, extending from 1,900 to 2,500 meters,
- Alpine zones, reaching 2,500 to 3,100 meters,
- Nival zones, located above 3,100 meters.

In eastern Georgia, the vertical zonation is more complex, with six distinct vegetation zones (Zazanashvili et al., 1995):

- Semi-deserts, dry steppes, and arid sparse forests (150-600 meters),
- Forest zones (600-1,900 meters),
- Subalpine zones (1,900-2,500 meters),
- Alpine zones (2,500-3,000 meters),
- Subnival zones (above 3,000 meters),
- Nival zones (above 3,500 meters).

This clear vertical stratification plays a crucial role in shaping the biodiversity and distribution of plant species across Georgia's diverse landscapes.

3.3 Forest Categories and Composition within Georgia's State Forest Fund

Georgia's forests, as reported in the 2023 National Forest Census, encompass a total area of 3,420,400 hectares, with the State Forest Fund being divided into two principal categories: Protected Areas and the State Agricultural Forest Fund. Together, these categories play a crucial role in the preservation of Georgia's rich biodiversity, as well as in the sustainable use of its forest resources.

Protected Areas make up a significant part of the forested landscape, covering 312.9 thousand hectares, which accounts for 10.4% of the total forest area. Within this category, the most important sub-regions include State Reserves, which span 136.6 thousand hectares (4.6%), and National Parks, covering 134.8 thousand hectares (4.5%). Other protected zones, such as natural monuments, forbidden areas, and protected landscapes, though smaller in size, collectively represent areas of high conservation value. These areas are vital in safeguarding unique ecosystems and species, ensuring that key habitats remain undisturbed.

In contrast, the State Agricultural Forest Fund occupies the largest portion of Georgia's forests, covering an extensive 2,694.7 thousand hectares or 89.6% of the total forested land. This category is further subdivided into resort forests (4%), green zone forests (9.2%), and soil protection and water regulation forests, which make up the bulk of this category at 76.4%. These forests are not only significant for their economic value but also for their role in protecting soil integrity and regulating water systems, particularly in Georgia's mountainous regions.

The composition of Georgia's forests is notably diverse, with deciduous trees dominating the landscape, accounting for 79.8% of the total forested area, while coniferous trees cover the remaining 20.2%. Among the deciduous species, beech stands out as the most prevalent, both in terms of the area it covers and the wood resources it provides. Additionally, a remarkable 95% of Georgia's forests are of natural origin, reflecting ecosystems that have evolved with minimal human intervention. These natural groves exhibit a wide range of compositions and structures, from dense forests to more open, mixed groves, further contributing to the country's biodiversity.

Within these forests, the undergrowth is rich in both evergreen and deciduous shrubs, along with a variety of broad-leaved and herbaceous plants. Notably, 90% of the undergrowth species are known for their medicinal properties, which add a layer of ecological and economic value. Key species in this regard include fruit-bearing trees such as Juglans *mandshurica* and *Juglans regia* (walnuts), *Castanea sativa* (sweet chestnut), and various species of *Vaccinium, Ribes,* and *Rubus.* These plants not only contribute to the biodiversity of Georgia's forests but also play an essential role in supporting local economies through the harvesting of fruits and other valuable products.

A large proportion of Georgia's forests (97.7%) are located on medium to steep slopes, where they perform critical environmental functions, particularly soil protection and water regulation. These forests, spread across challenging terrains, are instrumental in preventing soil erosion and managing water resources. In terms of forest moisture classification, the largest areas are found in groves categorized under moisture class III (40-59.9) and moisture class VI (≥100), which are characterized by higher moisture retention and greater biodiversity. In terms of density, forests with low frequency (0.3-0.4) account for 17.4% of the total area, average frequency (0.5-0.7) forests occupy the majority with 79.2%, and forests with high frequency (0.8-1.0) represent 3.4% of the forested landscape.

The unique characteristics of the Ajara floristic region have earned it global recognition. The International Union for Conservation of Nature (IUCN) has designated Ajara as one of the 34 biodiversity hotspots in the world, a recognition that underscores the region's exceptional biological diversity and the critical importance of its conservation. These hotspots are identified as areas where the greatest variety of species, particularly endangered species, are concentrated. Furthermore, Ajara is included in the list of 25 global regions recognized for their unique levels of biodiversity, making it a priority for both national and international conservation efforts. This designation highlights the necessity of ongoing protection and sustainable management to preserve Ajara's diverse ecosystems for future generations.

3.4 Timber Stock and Forest Health in Georgia

The average timber stock in Georgia's forests is estimated at 231.8 m^3 per hectare. This stock includes both growing timber from single trees and non-growing timber such as dried wood (7 m^3/ha) and broken wood (7.2 m^3/ha). In total, the volume of timber in Georgian forests amounts to 528.2 m^3 per hectare. Additionally, the timber increment—or the rate of growth—is noteworthy, averaging 6 m^3/ha annually, which contributes to the forest's overall annual growth of 13.7 million m^3. Georgia's forests are predominantly mountainous, with 85% of the forest area situated in high-altitude regions, and 73% of these forests occur on slopes above 1,000 meters. The annual growth of timber stock amounts to approximately 4.5 million m^3, providing a valuable resource for the country's forestry industry. Natural forests, which cover 680.7 thousand hectares (22.6% of the country's forested area), make up a significant portion of this growth. However, 642.1 thousand hectares of Georgia's forest land are currently in temporarily occupied territories, such as Abkhazia, where natural forests cover 507.1 thousand hectares (with 479.9 thousand hectares under forest cover) and an additional 173.6 thousand hectares in other areas, with 162.2 thousand hectares being forested (First National Forest Inventory of Georgia, 2023).

3.5 Impact of Pests and Diseases on Georgian Forests

The overall health of Georgia's forests, while seemingly stable based on forestry tax indicators, has been significantly affected by long-term biotic and abiotic factors. In particular, climate

change has led to rising temperatures, which have contributed to the proliferation of pests and diseases on an unprecedented scale. The rapid spread of these pest diseases is unlike anything previously recorded in the forest history of Georgia, and the consequences are profound, with certain areas of forest ecosystems destroyed and several species facing the threat of extinction.

One notable example is the decline of the evergreen Colchian larch, which has been severely impacted by the pathogenic fungus *Cylindrocladium buxicola*, causing widespread weakening and dieback of this species. Similarly, boxwood species in Georgia have been affected by a combination of bacteria, soil fungi, and sterile fungal mycelium, resulting in widespread wilting.

The greatest damage to Georgian boxwood has been caused by the invasive insect *Cydalima perspectalis,* which has led to the withering of 90% of the boxwood population in Georgia.
Among the pests affecting *Picea Orientalis*, several species require continuous monitoring due to their destructive impact, including: *Ips typographus L., Ips acuminatus Eichn., Dendroctonus micans Kugel., Ips sexdentatus Boern., Pytiogenes bidentatus Fabr., Pytiogenes quadridens Hert*. (Vasadze et al., 2022; Vasadze et al., 2023; Beridze et al., 2024)

The decline in the sanitary condition of eastern spruce forests often results not only from these primary pests but also from a suite of secondary trunk pests, such as: *Pityocteines curvidens Cerm,. Pityocteines spinidens Reitt., Cryphalus abietis Ratz., Cryphalus pussilus Cyll., Pityogenes bidentatus Hrbst., Pityogenes quadridens Hrbst., Pityogenes chalgographus L., Crypturgus cinereus Hrbst., Trypodendron lineatum Oliv., Hylugrops palliatus Gyll., Blastophagus piniperda L., Anisandrus dispar F., Orthotomicus suturalis Gyll., Orthotomicus proximus Eichh., Dryocoetes autographus Eichh., Pityophthorus pityographus Ratz., Monochamus galloprovincialis Oliv., Monochamus sutor L., Pogonocherus caucasicus Cill., Morimus verecundus Fald., Tetropium castaneum L., Tetropium fuscum F., Rhagium inquisitor stshukini Sem., Rhagium inquisitor L., Rhagium mordax Dg., Callidium violaceum L., Pissodes pini caucasicus Roub., Pissodes harciniae Hrbst., Pissodes piniphilus Hrbst., Sirex argonautarum Sem., Paururus juvencus L., Dioryctria splendidella* (Vasadze et al., 2024).

The situation in Chestnut Grove is similarly dire. The European chestnut *(Castanea sativa Mill.),* an important species for both biodiversity and the economy, is suffering from chestnut blight caused by the fungus *Cryphonectria parasitica* (Dumbadze et al., 2018, Vasadze et al., 2022). This disease has resulted in both group-focal and scattered wilting across large areas of chestnut groves. Similarly, the elm species (*Ulmus glabra Huds*.) are being affected by the *Ophiostroma ulmi* fungus, further degrading the health of the forests.

Biological control measures, such as inoculation of diseased chestnut trees with specific strains, have shown promising results in halting the spread of *Cryphonectria parasitica* in affected chestnut groves. Additionally, a combination of integrated pest management strategies, including the use of pheromone traps, the placement of insect-catching trees, and the breeding of entomophagous insects in laboratory conditions have been employed to reduce pest populations. Forest management practices also include sanitary cutting, thinning, and the removal of waste trees to restore the health and resilience of affected forest areas. These comprehensive efforts aim to mitigate the damage caused by pests and diseases and ensure the long-term sustainability of Georgia's valuable forest ecosystems.

3.6 Integrated Pest Management Strategies

In response to the growing threat posed by pest infestations, Georgia has implemented a series of Integrated Pest Management (IPM) strategies aimed at controlling and reducing the spread of harmful species. These strategies focus on both monitoring and controlling pest populations through a combination of biological, mechanical, and chemical methods.

One key method in these efforts is the use of pheromone traps, which help monitor and manage populations of bark beetles, particularly in spruce forests. By attracting and capturing pests like *Ips typographus* and *Dendroctonus micans*, pheromone traps offer an effective way to control infestations before they reach destructive levels.

Biological control methods have also been instrumental in reducing pest populations. One successful example is the introduction of the predatory beetle *Rhizophagus grandis*, which has proven effective in controlling *Dendroctonus micans* populations. This natural predator helps keep harmful beetle populations in check, reducing the need for chemical interventions (Vasadze et al., 2024; Beridze et al, 2024).

Sanitary cutting—the selective removal of infected and dead trees—has been another critical measure in maintaining forest health. Between 2013 and 2023, over 700,000 cubic meters of timber were harvested through sanitary cuts (Table 1). This proactive approach has helped limit the spread of pests and diseases by removing weakened trees that could otherwise act as breeding grounds for insects and pathogens.

However, the ongoing impacts of climate change, including rising temperatures and shifting precipitation patterns, are expected to exacerbate pest outbreaks in the coming years. These environmental changes may increase pest proliferation, making continued investment in IPM strategies essential to safeguarding Georgia's forests. Integrating advanced monitoring technologies and proactive forest management will be critical in combating the challenges posed by both existing and emerging threats (Gokturk et al. 2022).

Table 1. Volume of Firewood and Timber Cut (2013-2023)

Year	Timber (m^3)	Firewood (m^3)	Total (m^3)
2013	5,395	70,499	75,894
2014	5,125	72,856	77,981
2015	4,726	70,784	75,510
2016	4,409	61,013	65,422
2017	6,749	62,285	69,034
2018	8,710	49,921	58,631
2019	4,451	54,039	58,490
2020	5,989	52,839	58,828
2021	5,951	46,858	52,809
2022	5,298	54,677	59,975
2023	5,342	50,205	55,547

From 2013 to 2023, the volume of timber and firewood cut in Georgia's forests exhibited significant fluctuations. The peak in wood extraction in 2014, driven largely by firewood demand, marks a period of intense forest utilization. However, a notable decline in wood cutting occurred from 2015 to 2016, suggesting a shift towards more conservative forest

management practices, possibly in response to increasing pest infestations and the need for forest conservation.

The sharp increase in timber cutting in 2018 reflects a targeted intervention, likely involving sanitary cutting to remove diseased or pest-infested trees. This period aligns with the spread of invasive species like *Ips typographus L.*, *Dendroctonus micans Kugel.*, *Ips sexdentatus Boern.*, Cryphonectria parasitica, and so on, which led to widespread damage in key tree species, necessitating the removal of affected trees.

The relatively steady extraction levels from 2020 onwards indicate stabilization in forest management practices. While pest control measures have helped mitigate the damage, the data suggest that continued monitoring and climate-adaptive management are crucial to sustaining Georgia's forests amidst ongoing ecological challenges (Table 1).

4. Conclusion and Suggestions

Georgia's forests are vital to global biodiversity, serving as habitats for rare species and providing essential ecosystem services. Despite their ecological significance, these forests are under significant threat from pests and diseases. The impacts of climate change, characterized by increasing temperatures and shifts in precipitation patterns, have intensified these challenges by fostering conditions conducive to pest outbreaks and diminishing the natural resilience of forest ecosystems.

Integrated pest management (IPM) strategies, including the use of biological control agents, pheromone traps, and sanitary cutting, have shown success in mitigating pest damage and preserving forest health. However, with the accelerating impact of climate change, forest management practices must continue to evolve. Continuous monitoring, research, and the development of climate-resilient practices are essential to ensure the long-term protection of Georgia's forests.

To better safeguard Georgia's forests against future threats, several key strategies should be prioritized:
Enhancing Pest Monitoring Systems: Leveraging advanced technologies for pest monitoring can significantly improve the accuracy and timeliness of responses to infestations. Real-time data collection and predictive modeling tools can enable more effective interventions, helping to reduce the severity of pest outbreaks before they cause widespread damage.

Strengthening Biological Control Methods: Enhancing biological control methods is essential for sustainable forest management. The introduction and research of new biological control agents, particularly those well-suited to Georgia's unique forest ecosystems, can offer more environmentally friendly and long-lasting solutions for managing pest populations without relying on chemical interventions.

Implementing Climate-Resilient Forest Management: Forest management practices must be adapted to cope with the stressors of climate change. Afforestation programs that prioritize pest-resistant species and strategies designed to increase the forests' adaptive capacity in the face of drought and temperature rise are crucial for ensuring long-term forest health and stability.

Fostering International Collaboration: Addressing these challenges will require continued international collaboration. Partnerships between Georgian forestry institutions, academia, and international organizations will facilitate knowledge exchange, resource sharing, and the development of effective pest control and forest management practices. These collaborations will be instrumental in implementing sustainable management solutions at scale.

Involving Local Communities: Engaging local communities in forest management through education and participatory initiatives can bolster conservation efforts. Public awareness campaigns that emphasize the ecological importance of healthy forests and promote sustainable forest use at the community level are critical for ensuring long-term conservation. Empowering local populations to take an active role in forest protection will strengthen both ecological and social resilience.

In conclusion, the successful protection of Georgia's forests requires a multifaceted approach that integrates cutting-edge technologies, climate-adaptive strategies, and community involvement. By continuing to innovate and collaborate, Georgia can effectively confront the ongoing threats posed by pests and climate change, ensuring the sustainability of its forests for future generations.

5. References

Beridze M., Dumbadze G., Gokturk T., Vasadze R. 2024. Current Status of Bark Beetles Distribution and Identification in Georgia-Turkey Border Area. Afr.J.Bio.Sc. 6(11):1711-1721.

Dumbadze G., Gokturk T., Vasadze R., Lomtatidze N., Chakhvadze Kh. 2018. Intensity of Chestnut Drying and Natural Restoration of the Forest in Keda Municipality (Ajara, Georgia). International Journal of Ecosystems and Ecology Science, 8(2): 347-352.

Gagnidze R. 2000. Diversity of Georgian flora. WWF Global, Tbilisi. pp 21-32.

Goginashvili, N., Togonidze, N., Tvauri, me., Manvelidze, Z., Memiadze, N., Zerbe, S., Asanidze, Z. 2021. Diversity and degradation of the vegetation of mountain belt forests of central Adjara (the Lesser Caucasus), Georgia. J. For. Sci, 67: 219–241

Gokturk, G Dumbadze, L Jgenti, R Vasadze. 2022. The Effects Of Global Warming On Insects. International Scientific Conference "Modern Problems of Ecology" 8: 44-54.

First National Forest Inventory of Georgia. Report. 2023. Enabling the Implementation of Georgia's Forest Sector Reform - ECO.Georgia. Tbilisi.

Ketskhoveli, N. 1959. Flora of Georgia. Tbilisi: Academy of Sciences of the Georgian SSR.

Kvachakidze R. 2010. Geobotanical regions of Georgia. Tbilisi, Science, 176 p.

Manjavidze D. 1982. Relic forests of Ajara and their national and economic importance. Metsniereba, Tbilisi. 262 p.

Vasadze R., Mamuladze M., Vasadze Z. 2023. Some Biological Features of the Crustagean Typographer. International Journal of Advanced Research, 11(06):255-267.

Vasadze R, Vasadze Z. 2024. Causes of the general sanitary impact of combinations of dark coniferous trees and dynamics of forest assessment indicators according to forest types. Batumi, Georgia. 223 p.

Vasadze R., Dumbadze G., Gokturk T., Chachkhiani-Anasashvili N. 2022. The biological characteristics of *Ips typographus* in Adjara spruce forests. 4th International Forest Entomology and Pathology Symposium (ENFITO 2022). 12-15 May, Trabzon, Turkey.

Zazanashvili N., Gagnidze R., Nakhutsrishvili G. 1995. The high mountain on the new vegetation map of Georgia. Journal of Vegetation Science, 6(1): 157-158.