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Dominant woody species, their distribution and threat in Ambrolauri, Georgia

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Abstract: The paper presents the maps of ecosystems and 11 dominant woody species of Ambrolauri municipality, Georgia (Europe). Forest cover comprises approximately 68% of the study area, most of which are natural forests. Almost all formations of natural forests, depicted on the Georgian section of the Map of the Natural Vegetation of Europe, are still preserved in the research area. Nearly 40% of the forested land is broadleaf forest. Woody species are better preserved in the upper reaches of rivers, while an anthropogenic transformation is most visible in the Lower Racha Floodplain. A majority of the species discussed in the paper are included in the IUCN Red List of Threatened Species. The paper also deals with the issues of forest land degradation and threats imposed by invasive species to biodiversity.

Keywords: woody species; IUCN Red List; vegetation mapping; natural forests

The conservation of biological diversity is a common concern of the humankind due to its ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values (UN1992). Mountainous regions are often distinguished by the diversity of ecosystems, which are the significant source of water, forest products, agricultural products and recreations (Khardziani et al. 2018). Many people, especially the poor, depend directly on the forest ecosystems for their livelihood (UNGA 2012). Mountain forests provide essential environmental goods and services such as timber, fuel wood, non-wood forest products, carbon storage, etc. (Veith, Shaw 2011). They fulfil an important role in tourism and recreation (Hosseini et al. 2018). Climate change has already triggered species distribution shifts in many parts of the world. The risk of extinction for European plants is expected to be larger (Thuiller et al. 2005). In many parts of the Georgian mountainous regions, forest land is prone to landslides and other natural hazards (Khardziani et al. 2017). Their diverse herbaceous layer and highly developed root systems stabilize steep slopes and protect the soil from erosion (Veith, Shaw 2011). The natural forest represents the most effective land cover type in the regulation of the hydrological regime (Hamilton, King 1983).

To assess the forest-related biodiversity, the information on tree species distribution is essential (Trombik, Hlásny 2013). In addition to forest and forest-type maps, maps of tree species distribution have great importance in forest planning (Tröltzsch et al. 2009). Strategic decision-making requires information on both the spatial and tem-

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poral options available for inclusion in the planning framework (Hoffmann et al. 2008). For decision-making at the site level, large-scale spatial data are required (Pressey et al. 2003). Following the collapse of the Soviet Union the countries of the Caucasus Ecoregion have been experiencing severe economic crises (Elizbarashvili et al. 2018), resulting in the expansion of illegal logging and trade in timber and other resources (Bohn et al. 2007). It is the countries' responsibility to conserve their biological diversity and use the biological resources in a sustainable manner (UN 1992). In the study region, illegal logging is not the only threat to forest diversity, but an invasion of pests, climate change, and forest land degradations are also present. The paper presents geobotanical patterns of some dominant woody species and imposed threats identified in terms of our research.

Study area. The study area is located in the Caucasus ecoregion, which is distinguished both by the uniqueness and the high level of its biodiversity (Bohn et al. 2007). The Caucasus has been recognized as one of the biodiversity hotspots of the world (Myers et al. 2000). Ambrolauri municipality is located in the north-west of Georgia (Figure 1). It is a mountainous municipality in the Racha-Lechkhumi-Kvemo Svaneti region. The total area comprises 1,142 square km. Ambrolauri is bordered by the municipalities Oni, Lentekhi Tsageri, Tskaltubo, Tkibuli, Chiatura and Sachkhere. The population is 11,186 people. The population density of the entire municipality is 8 people per square km and 736.3 people per square km in the town of Ambrolauri (NSOG 2016).

Ambrolauri municipality is located on the southern slope of the Caucasus in its central part. The municipality is bounded by the Lechkhumi Ridge in the north-west and by the Racha Ridge in the south. Most of the settlements are located in the Lower Racha Floodplain. The geological structure is dominated by Jurassic systems represented as clays, slates, sandstones and porphyrites, which are characteristic of the right tributaries of the Rioni River. Neogene and Quaternary systems are represented in the floodplain in the form of sandstones, clays, limestones and conglomerate. On the slopes adjacent to the Shori reservoir there are Jurassic and Cretaceous systems represented as limestones, dolomites, marlstones and sandstones (Gujabidze 1964). The following types of soils are found in the study area: Rendzic Leptosols, Eutric Cambisols, Albic Luvisols, and Umbric Leptosols (Sabashvili 1970; Urushadze, Ghambashidze2013). According to the Ambrolauri Meteorological Station, the average annual air tem-

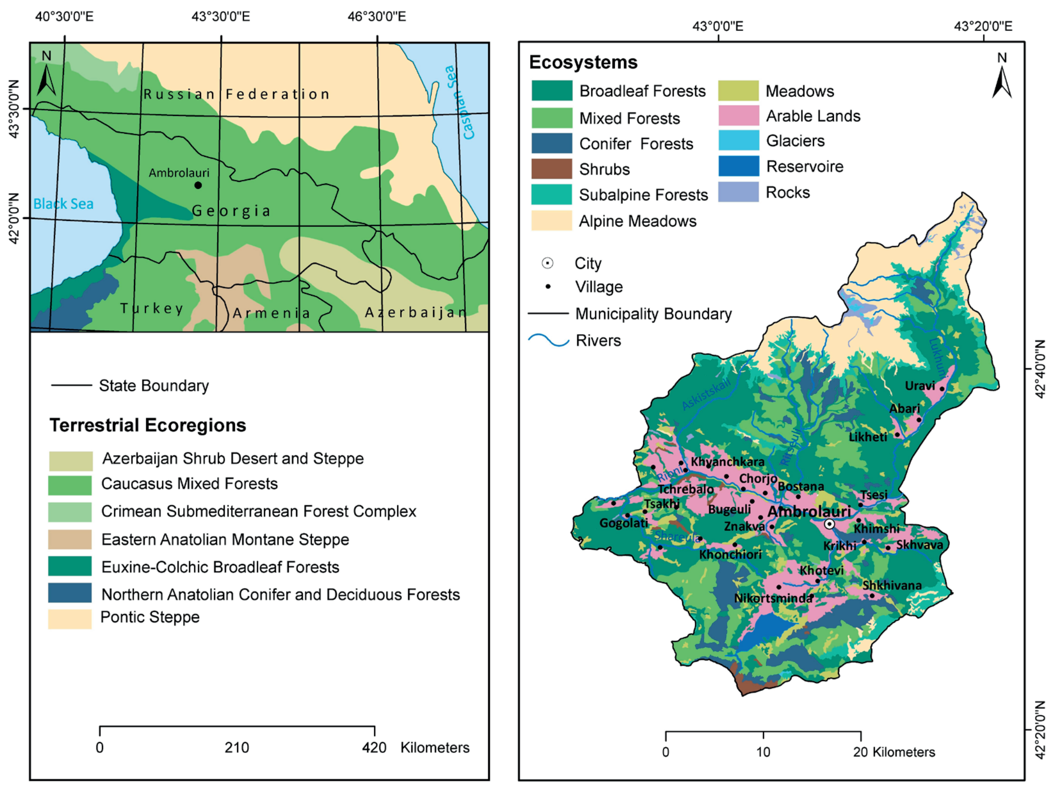

Figure 1. Study area

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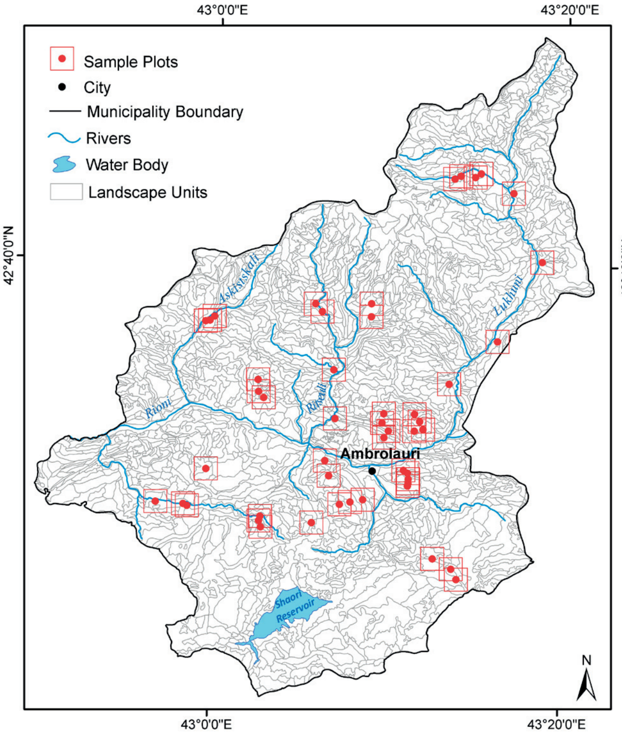

Figure 2. Landscape units and described sample plots

perature is 11.2 °C. The average annual temperature in July is 21.7 °C, while in January it is –0.3 °C. The annual mean precipitation varies from 900 mm to 1 500 mm (Maruashvili 1986). The following types of climate occur in the region: temperate, quite humid climate, without dry season, moderately cold winter and relatively dry, hot summer; temperate, humid climate, without dry season, moderately cold winter and long warm summer; humid climate, with cold winter and long cool summer; humid climate, with cold winter and short cold summer; highland humid climate, devoid of real summer; highland humid climate, with permanent snow and ice cover (Kordzakhia 1964; Peel et al. 2007). Rioni is the main river of Racha, which divides the Ambrolauri municipality into two parts. The most important tributaries of the Rioni River are Askistskali, Ritseuli, Lukhuni, Shareula, and others. Racha is rich in karst waters, and there is an artificial reservoir Shaori (Maruashvili 1986). Ambrolauri municipality is geobotanically located in the Caucasus Hotspot (Myers et al. 2000), namely, in the ecoregion, the Caucasus mixed forests (Figure 1a) (Olson et al. 2001). Ambrolauri has all the forest formations that are spread in Georgia, according to The Map of the Natural Vegetation of Europe. These formations are as follows: Caucasian crooked and open woodlands (C), Mesophytic and hydromesophytic coniferous and mixed forests (D), Caucasian oriental beech and oriental beech-hornbeam forests (F), Hornbeam-oak mixed forests of the Caucasus (F7), Thermophilous mixed deciduous broad-leaved forests (G), Hygro-thermophilous mixed deciduous broadleaved forests (H) (Bohn et al. 2004; Bohn et al. 2007). In the study area, beech forests are dominant like in other mountain forests of Georgia. They occupy more than half of the entire forest land of the country (Ketskhoveli1959; Kvachakidze 2014).

Materials and methods. Creation of the maps of dominant woody species included primary data collection and GIS mapping, verification and data representation stages. Primary data collection was done in 2001 and included a description of the landscape structure and species composition within the sample plots. A total of 49 plots were studied (Figure 2), which were later used to create attribute tables for the vegetation layer.

At the next stage, during 2002–2005 a manually digitised polygon layer was created, comprising 2 362 spatial segments (Figure 2), upon which the maps of woody species represented in the paper were developed. The following materials were used as base maps for landscape digitisation: 1. Soviet topographic maps at a scale of 1: 50 000 published in 1959–1962; 2. Forest planning maps at a scale of 1: 100 000 published in 1989; and 3. Aerial images of Forest Department of Georgia taken in 2001.The landscape layer was digitised at a scale of 1: 50 000. Data from landscape plots were used for interpolation. Firstly, the point attributes were transferred to overlapping landscape units. Then, the data was replicated to similar landscape units. In this manner databases of 11 woody species described in the presented paper were built. An ecosystem map (Figure 1) was also created by categorising landscape units (Figure 2). In addition to the above-mentioned, landscape units were verified in 2012–2013 when research activities were undertaken by the authors.

Surveyed species are listed in Table 1. In the case of the box tree, the internationally accepted name is *Buxus sempervirens* L. (Species 2000, ITIS 2019), while in the national red list it is mentioned as *Buxus colchica* Pojark.

RESULTS

To facilitate the forest biodiversity conservation and planning at the local level, we created large-

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Table 1. Dominant woody species of the study area

Accepted scientific name (Species 2000, ITIS 2019)	Red Data Book of the Georgian SSR (SCNPGSSR 1982)	National Red List (GG 2014)	IUCN Red List categories	Elevation range (m a.s.l.)
Fagus orientalis Lipsky	–	–	LC	529–2 158
Castanea sativa Mill.	*Castanea sativa* Mill.	*Castanea sativa* Mill.	LC	392–1 578
Quercus petraea (Matt.) Liebl.	–	–	LC	403–1 701
Carpinus betulus L.	–	–	LC	392–2 128
Alnus glutinosa (L.) Gaertn.	–	–	LC	397–1 897
Buxus sempervirens L.	*Buxus colchica* Pojark.	*Buxus colchica* Pojark.	NT	392–1 686
Abies nordmanniana (Steven) Spach	–	–	LC	847–2 153
Picea orientalis (L.) Peterm.	–	–	LC	
Pinus sylvestris var. *hamata* Steven	–	–	LC	425–1 591
Betula pubescens var. *litwinowii* (Doluch.) Ashburner & McAll.	–	–	DD	1 056–2 519
Acer heldreichii subsp. *trautvetteri* (Medvedev) E. Murray	–	–	–	1 056–2 519

scale (1:50 000) vegetation maps of the Ambrolauri municipality (Georgia), which include the maps of species distribution and ecosystems. The paper also provides information about the threats to the vegetation which had been identified during the expeditions.

Around 68% of the Ambrolauri's territory is covered by forest ecosystems, most of which are natural forests (Figure 1). The majority of forest ecosystems (40%) are broadleaf forests. In the second place by area are mixed forests. The natural forests are relatively better preserved in the middle and upper reaches of the Ritseuli and Askitskali Rivers. The forest ecosystems are mostly transformed in the Lower Racha Floodplain, in the Krikhula and Khoteuri River valleys, and the Shareula River Basin. In these areas, forest ecosystems are mainly transformed into agricultural lands. An artificial reservoir occupies a certain area. Natural forests are also found in the Lukhuni River valley. In some places, the lower boundary of forest ecosystems is bordered by agricultural landscapes, many of which are historic viticulture landscapes. Ambrolauri is one of those mountainous regions of Georgia that have been left by a significant number of people since the 1990s. Under depopulation, some of the vineyards and orchards adjacent to the forest were naturally afforested. Currently, the process of restoring old vineyards in the region has begun, returning the value to local wines. This process is slowly stimulating the return of the population to the region, which has necessitated the clearing of forested old vineyards. Historical viticultural landscapes are of strategic importance for the development and keeping the region's population (Maisuradze al. 2019).

The upper boundary of the forest is adjacent to the alpine meadows, which were traditionally used for mowing and pasturing. Over the past two decades, due to the region's depopulation, the anthropogenic impact on them has declined, which has led to the natural afforestation along the alpine treeline.

The main woody species of the Ambrolauri ecosystems are: *Fagus orientalis* Lipsky (Rivers, Barstow 2017), *Castanea sativa* Mill. (Barstow, Khela 2018), *Quercus petraea* (Matt.) Liebl. (Gorener et al. 2017), *Carpinus betulus* L. (Shaw et al. 2014a), *Alnus glutinosa* (L.) Gaertn. (Shaw 2014), *Buxus sempervirens* L. (Chadburn, Barstow 2018), *Abies nordmanniana* (Steven) Spach (Knees, Gardner 2011), *Picea orientalis* (L.) Peterm. (Farjon 2013), *Pinus sylvestris* var. *hamata* Steven (Gardner 2013), *Betula pubescens* var. *litwinowii* (Doluch.) Ashburner & McAll. (Shaw et al. 2014c) and *Acer heldreichii* subsp. *trautvetteri* (Medvedev) E. Murray (Crowley, Rivers 2017).

The beech-dominated stands are found in the Askistskali River valley, on the upper reaches of the Lukhuni River and northern slopes of the Racha Ridge, as well as in the so-called "desert-forest" area in the Shareula River basin (Figure 3). In the valleys of the Shareula and Ritsula Rivers, they are mixed with hornbeam and chestnut. Pure stands of chestnut are common in the Shareula and Askistskali River valleys. The hornbeam is almost equally distributed in

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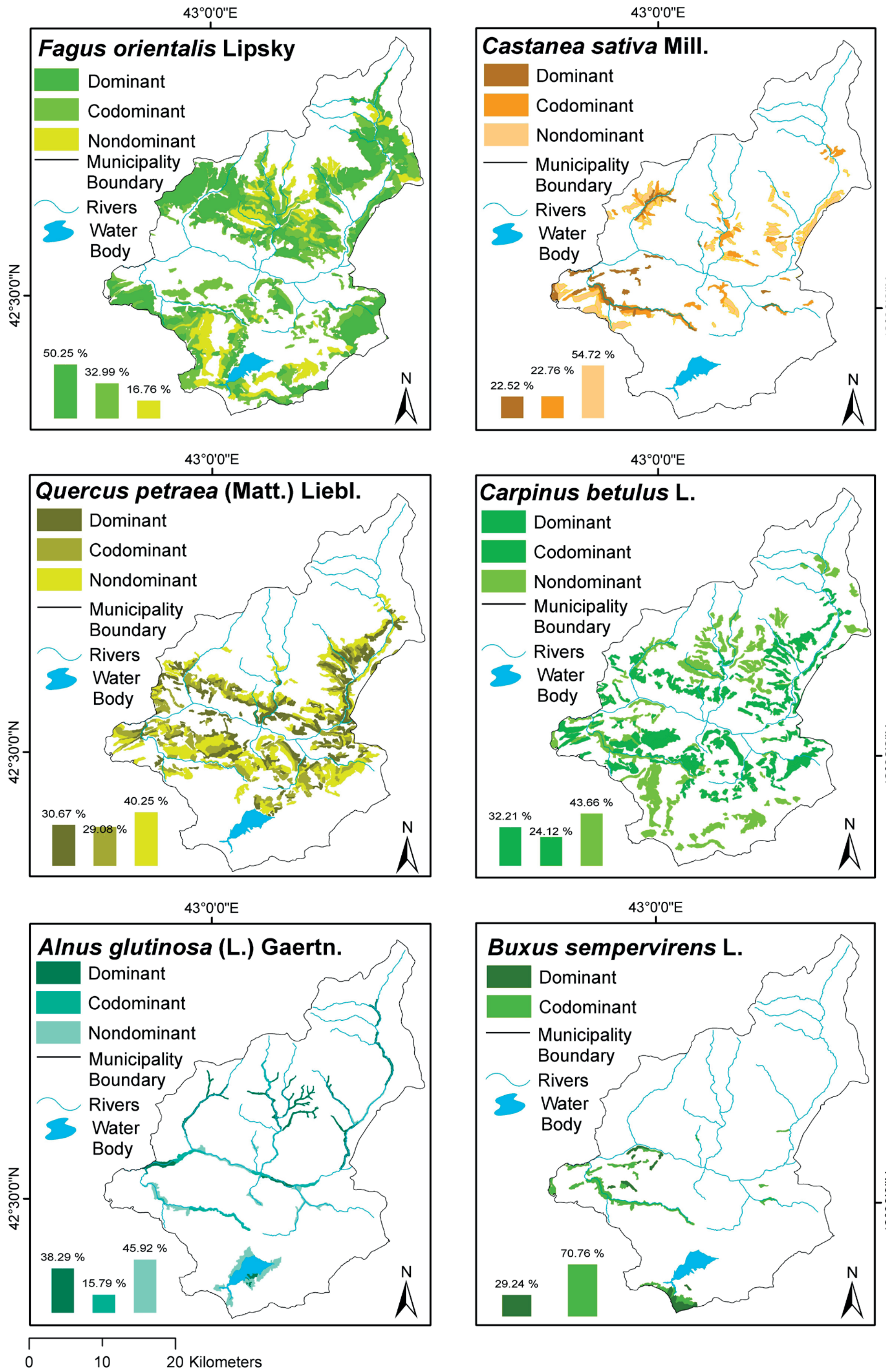

Figure 3. Distribution of broadleaf woody species in the Ambrolauri municipality

the area of broadleaf and mixed forests. In the northern part of the region it is mostly mixed with beech, and on the left side of the Rioni River it often forms a mixed combination with oak. The oaks are distributed in the forests adjacent to the Lower Racha Floodplain, adjacent to the agricultural landscapes and also in the Lukhuni River valley. The alder is common in the middle and lower reaches of the Rioni River and all its tributaries. The box tree is found to the southwest and south of the study region, especially in the Shareula River valley. Its distribution coincides with the chestnut area. Nowadays, the *Buxus colchica* Pojark.is threatened throughout the entire country because of the invasive species spread. Before the box tree moth, in 2009–2010 the invasive disease box blight *Cylindrocladium buxicola* spread in Georgia that destroyed more than a half of box trees, and since 2013 the box tree moth *Cydalima perspectalis* has oc-

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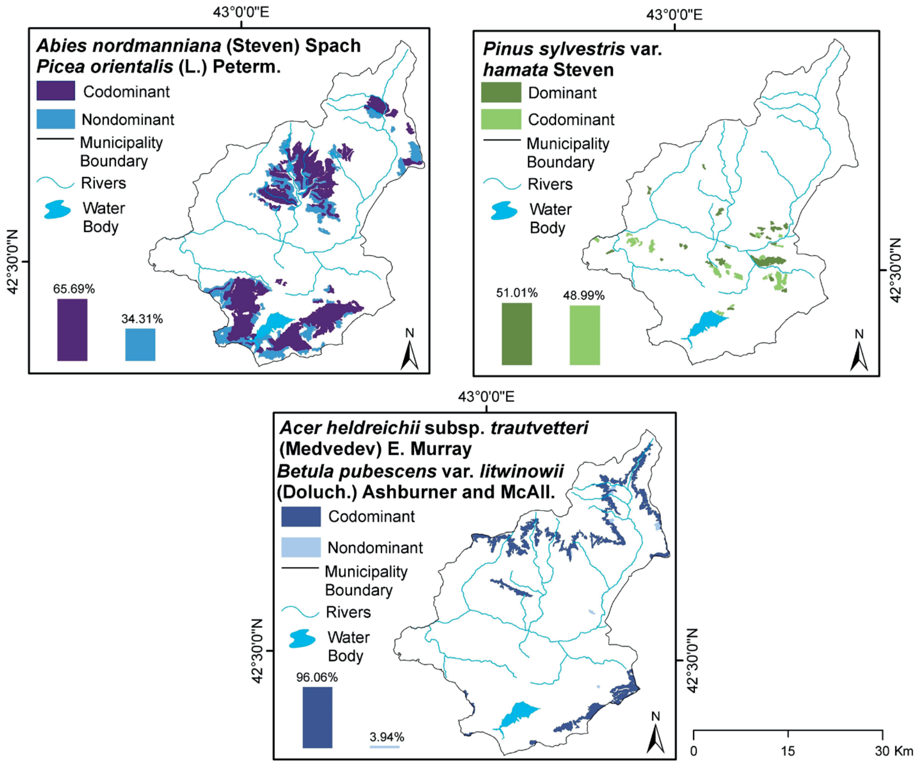

Figure 4. Distribution of coniferous and alpine woody species in the Ambrolauri municipality

curred (Supatashvili et al. 2019). The box blight has spread in Ambrolauri municipality as well. During the field trip in summer 2019 in Ambrolauri, we were told by residents that they could save the box tree in the town park by special treatment with the help of the local government, but the day could not save the plant in "Tchelishi Udabno" (Shareula River basin).

Among the coniferous species in Ambrolauri, spruce and fir are dominant (Figure 4). A relatively small number of pine trees was mostly cultivated during the Soviet times, especially in the Lower Racha Floodplain. Spruce and fir are mostly mixed, pure stands are found rarely. The spruce and fir trees are mainly concentrated in the Ritsuli River valley and on the Racha Ridge, on the slopes adjacent to the Shaori reservoir and in the upper reaches of the Lukhuni River. In the Ambrolauri municipality, forest land degradation caused by landslide processes is evident. Two experimental plots described in 2002 in the valley of the Latashuristskali River (right tributary of Lukhuni) are now completely destroyed by the landslides. Alpine forests are composed of birch and highland maple. There is also found highland oak (Figure 4).

According to the geobotanical characteristics forested areas of Ambrolauri can be divided into seven more or less uniform zones (Figure 5): (*i*) Middle and upper reaches of the Askistskali River; the zone is characterized by the dominance of pure stands of beech, which is mixed with chestnut and hornbeam at the bottom of the valley; (*ii*) The middle and upper reaches of the Rietseuli River; this area is characterized by spruce and fir dominance, which are mostly mixed with beech, less with hornbeam; (*iii*) Upper reaches of the Lukhuni River valley with beech and spruce-fir-beech-hornbeam stands, in some places with oak; (*iv*) Slopes adjacent to the Shaori reservoir with spruce-fir and spruce-fir-beech-hornbeam stands; (*v*) The Shareula River gorge, dominated by chestnut-hornbeam and beech-chestnut phytocoenosis; (*vi*) Lower Racha Floodplain, also middle and lower reaches of the Lukhuni River, dominated by hornbeam and oak; and (*vii*) Upper reaches of Askistskali, Ritseuli, and Lukhuni, also the extreme south-east of Ambrolauri, dominated by birch and highland maple. The sixth zone is the most transformed of the named areas.

Most of the woody species of Ambrolauri are inscribed on The IUCN Red List of Threatened Species (Table 1), while only two of them, box tree and chestnut, are included in the national red list (GG 2014). These two species were also included in Red Data Book of the Georgian SSR (SCNPGSSR 1982). At present, the ecological state of chestnut and box

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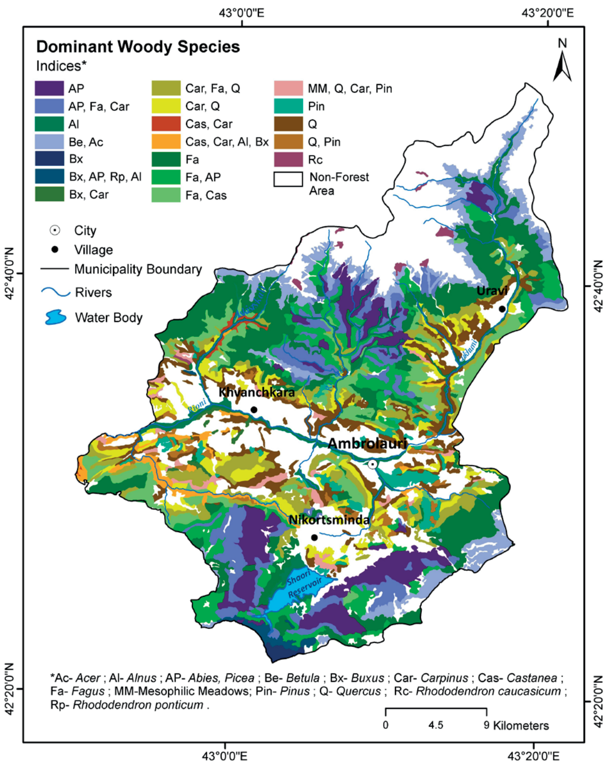

Figure 5. Basic forest formations of the Ambrolauri municipality

tree is particularly alarming in terms of invasive species propagation and degree of damage. In addition to invasive pest propagation, forests in the region are endangered by illegal logging and geodynamic processes triggered by climate change. The data from the National Statistics Office of Georgia show that illegal logging is still taking place, and no restoration works facilitating the reforestation are implemented at present (Geostat 2019).

DISCUSSION AND CONCLUSIONS

Ambrolauri municipality is characterized by the high forest cover, dominated by beech formations and spruce-fir ones in the second place. The natural forests are better preserved in the middle and upper part of the Rioni tributaries. The forest is most transformed in the area of the Lower Racha Floodplain.

Biodiversity is still endangered by illegal logging, which is becoming a driving factor of geodynamic processes. The latter are also accelerated due to the highly inclined slopes and geological substrate. As a result, the forests have become sparse and in some valleys the ecosystem equilibrium has been breached.

The spread of invasive pests threatens the region's flora. An example of this is the damaged box tree and chestnut groves in the Shareula River valley.

Ten of the eleven species we studied (excluding *Acer heldreichii* subsp. *trautvetteri* /Medvedev/ E. Murray) are inscribed on the global red list, while the national red list recognises only two of them (*Castanea sativa* Mill. and *Buxus colchica* Pojark.). This can be explained by the explicit threats to chestnut and box trees revealed so far at the national level. We believe that a higher value should be given to other species at the national level as well, so that development projects do not mean a threat to natural forests.

There are no forest restoration support activities in the region, which is confirmed by official data. Promoting forest restoration is essential for the future development of the region. We also believe that it is important to take into account the principle of landscape equality when pursuing conservation policies in the region. This means that the restoration, enhancement, and also the management of forests on the one hand and historic agricultural landscapes on the other, must be fulfilled holistically. This is of great importance for strengthening the local communities and preventing depopulation.

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