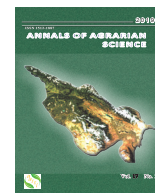




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The vegetation of Mtatsminda-Kustba area (Mamadaviti Ridge, East Georgia, South Caucasus)

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ABSTRACT

The vegetation of the eastern part of Mamadaviti Ridge – Mtatsminda-Kustba area is studied for the first time. The vegetation is highly modified due to human-induced impacts. It is a mixture of natural and near natural vegetation and the artificially planted woody plantations. Vegetation units of both mesophilous and hemixerophilous ecosystems are present. Wetland vegetation communities are formed on the shores of the lake Kustba. Natural and near natural vegetation includes broad-leaved forests, shibliak-type hemixerophilous shrubberies, meadow-steppes and steppes, as well as vegetation of rock and scree ecotypes. Common reed plant communities (*Phragmitetum australis*) occur locally. The area is marked by extensive zones covered with highly diverse artificial plantations. There are both coniferous and deciduous, as well as mixed plantations, which are established with sole use of introduced species. The current condition of the main units of vegetation, the degree of their modification and stress, as well as the main directions and trends of successive changes in vegetation are established. The flora of the study area is composed of ca. 750 species of vascular plants. Both boreal and Ancient Mediterranean florogenetic connections are expressed. Almost all life forms of plants of different bio-ecology are represented. Forty-eight endemic species of the Caucasus were recorded.

Keywords: Vegetation, Typological composition, Flora, Endemic species, Heterogeneity, Recreation zone.

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Introduction

Location and physiographical conditions

The study area covers the eastern part of the Mamadaviti Ridge, in particular, the Mtatsminda-Kustba (frequently referred to as Turtle Lake) section. The area is a recreational zone.

The study area is characterized by heterogeneity of physiographical conditions (terrain, soil cover, climate) as compared to the rest of Mamadaviti Ridge.

There are two macro slopes – south- and north-facing. Given the relatively small area of the territory, the altitudinal amplitude is rather high – around 485 m to 1060 m asl. The terrain is characterized by the dominance of slopes of different inclination. Slightly inclined and relatively plain sections are mainly present in the crest of Mama-

daviti Ridge. The inclination of the slopes is mostly 20°–40°, although it increases to 50°–75° (80°) in some sections. The ravines and streams, that vertically intersect the slopes, are rare. The hydrological network of the study area is poorly developed. A perennial stream is observed near the landmark “Bulbulebis Chala”. The Varaziskhevi river flows into the Turtle Lake through the artificial tunnel. In addition to these, there are several small springs.

The climate of the area is characterized as humid and semi-humid. The average annual precipitation is about 550 mm to 650 (700) mm. As the elevation increases, the amount of precipitation and hydration coefficient increases as well, whereas the average annual temperature decreases. Such climate change is reflected in the typological composition of the vegetation cover and the patterns of its distribution.

Below is a cluster diagram based on the data of the meteorological station on Mtatsminda (Fig.).

It should be mentioned, that due to the fact that recent data is not available, relatively old data was used [1, 2].

The study area largely supports cinnamonic soils. Brown forest soils are developed on limited areas. In most cases, the soils are thin or of medium depth, and gravelly. Bedrock is frequently visible on the soil surface. Rock and scree ecotopes occupy limited areas. They are of fragmentary distribution and are found within the areas with different soil types. Such ecotopes are of different age and mostly developed as a result of erosion processes.

Bibliographical Review

Although the study area has been under the attention of researchers for a long period of time (from the mid-19th century to the present), no comprehensive data is available on its vegetation. Fragmented data is scattered throughout various fundamental papers and scholarly articles. There is limited herbarium material collected from this area, which are preserved in different Georgian herbaria (TBI, TGM, TB, TBPH). Some information about individual plants within the study area can be found in various papers [3-14]. There are also scarce data on syntaxa distributed on the Mamadaviti Ridge, including the Mtatsminda-Kustba section [7, 10, 11, 15-19].

Despite the large number of published scientific papers, the information presented in them does

not provide the overall picture of the floristic and ecosystem diversity of the study area. There are no uniform and complete data on the typological composition and distribution patterns of the vegetation.

Aim of the research

The main objectives of the present study were the following:

- identification of the typological composition of the vegetation in the study area and regularity of the distribution of recorded syntaxa;
- assessment of the degree of stress and level of modifications within the phytosociological units;
- identification of the dynamics and trends of on-going succession stages;
- study of the flora of the survey area.

Objectives and Methods

The objective of research is the study of vegetation of the eastern part of Mamadaviti Ridge - Mtatsminda-Kustba section. Phytosociological data was obtained by the route method. During the geobotanical surveys to study the structure of plant communities and identification of syntaxa, use was made of traditional geobotanical methods [20-26].

Geobotanical surveys were conducted in forests within a sample area of 400 m², whereas in shrubland and grassland communities field data was collected in plots with 25 m² area. In addition to the main vegetation characteristics for each plot, information

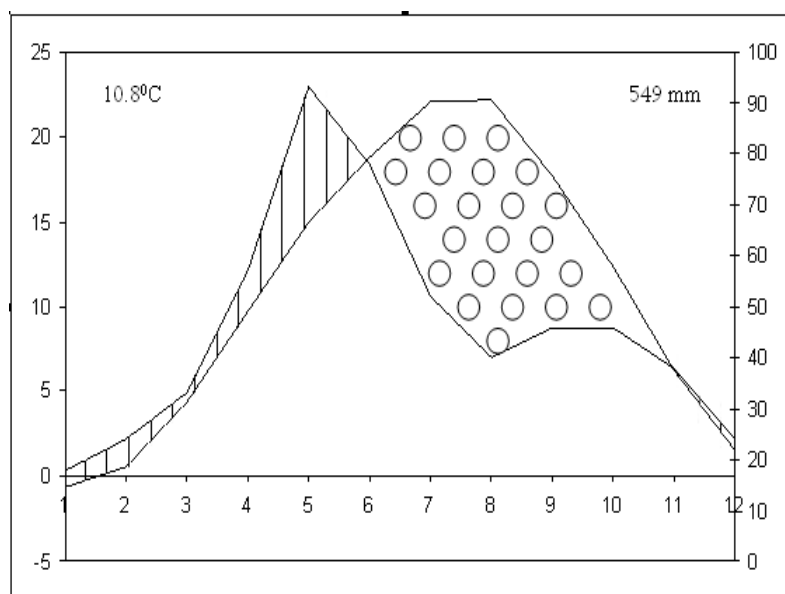


Fig. Climograph of Mtatsminda meteorological station

was collected on biotic and abiotic environments such as altitude, inclination, exposure, geographical coordinates, soil type, degree of disturbance of vegetation and causes of transformation. Instead of the term “association” that was widely used in Soviet literature, we use the term “plant community” accepted across the Europe.

Life forms of the plants follow Raunkiaer’s system [27] and Serebriakov’s classification [28].

The borders of the Ancient Mediterranean and Boreal regions are those as defined by A. Takhtajan [29]. Plant species are regarded as endemics of the Caucasus if they are found only within the borders of Caucasus Ecoregion [30].

Soil types are based on the modern classification systems [31-33].

Results and Analysis

I. Vegetation

Typology and distribution patterns

The vegetation of the study area is under heavy anthropogenic pressure and is a mixture of near natural or semi-natural vegetation units and artificially planted woody plantations. It is characterized by rich typological composition. Vegetation units of both mesophilous and hemixerophilous ecosystems are distributed. Mesophilous vegetation is mostly represented by forest stands, while hemixerophilous vegetation - by shibliak-type shrubberies and steppes. Hemixerophilous ecosystems also include vegetation of rock and scree ecotopes. Meadow-steppe plant communities are transitional between mesophilous and hemixerophilous vegetation. Wetland communities occur locally. These vegetation units are typical for the vegetation cover of Tbilisi area. With the diverse typological composition, the artificial plantations hold an important place in the vegetation of the study area.

Different types of plant communities are diffusely distributed due to the micro- and meso-mosaic variability and anthropogenic factors of local physical-geographical conditions (altitude, terrain, exposition, substrate and degree of its hydration, micro-features of climate, etc.). Despite the mosaic and, at first glance, unsystematic distribution of vegetation, some regularity is still obvious.

The main forest area covers the western and central part of the territory (“Bulbulebis Chala”), which is characterized by a humid climate. It is distributed on the slope of the northern macro exposure of the

Mamadaviti Ridge. Forest stands are developed both on the slopes and in the ravines. Slope exposure and inclination varies considerably. The areas are characterized by the forest ash-grey, as well as cinnamonic soil types. The degree of soil moisture is different.

The forests are represented with the formations of European ash (*Fraxineta excelsior*), Georgian oak (*Querceta petraea* subsp. *iberici*) and Oriental hornbeam (*Carpineta orientalis*). The stands of the first two formations are primary, while the stands formed by oriental hornbeam are of secondary origin and represent one of the initial stages of the digressive succession of oakwoods [15]. The stands formed by oak and ash are mostly characterized by brown forest soils, while those of hornbeams are also found on cinnamonic soils. These formations are characteristic units of vegetation in the environs of Tbilisi and play an important role in establishment of natural vegetal landscapes.

Shibliak-type hemixerophilous shrubberies mostly occur on the macro slope of the northern exposure of the Mamadaviti Ridge. The plant communities are confined to the North-East, North and North-West slopes, rarely recorded on Southern and South-Eastern exposure. The inclination ranges from 15°-20° to 35°-40°. Communities are developed on gravelly cinnamonic soils. In most cases, bedrock are almost on the soil surface. The main formation of shibliak-type hemixerophilous shruberies is that of Iberian spirea (*Spiraea hypericifolia*), which covers quite large areas. It is possible, that the area covered with Iberian spirea was wider in the past and it was later replaced by artificial plantations. In addition, polidominant shrubberies are important. All these are recorded on steeper sections. Bidominant groups of Iberian spirea and Tanner’s sumach (*Spiraea hypericifolia* + *Rhus coriaria*) are rare. In some sections, along with them, the Smoketree (*Cotinus coggygria*) also appears in the dominant role. The Christ’s thorn communities (*Pa-liuretum spina-christi*) occupy relatively small area.

Meadow-steppes have the smallest area in the study area. They are distributed in the western part of the study area at the hypsometrically highest point (950-1050 m asl), which is characterized by a humid climate. Communities are found on the North-facing macro slopes of the Mamadaviti Ridge, on medium and thin gravelly cinnamonic soils. In a separate section the bedrock are exposed to the surface. Despite the small size of the area, the meadow-steppes are represented by grass-forb communities of different modifications.

The present area of steppe vegetation is fragmented, which, along with the natural physiographical conditions, is largely due to anthropogenic factors - most of the steppe area is replaced by artificial plantations.

Steppe communities are common on both South- and North-facing macro slopes of the Mamadaviti Ridge. It is clear that steppe vegetation would have been a leading vegetation type in the past in the zones of present-day artificial plantations planted on the slopes of the South-facing macro slopes. Communities are developed on medium and thin gravelly cinnamonic soils. In some sections the bedrock is exposed. Slope exposure and inclination are different. Although the steppes do not cover large areas in the study area, they are presented in different modifications. The main ones are plant communities belonging to Fescue formations (*Festuceta valesiaci*). In addition, there are plant communities dominated by Feather grasses (*Stipetum* spp.).

The vegetation of rock and scree ecotopes occupies a prominent place in the study area. They are mostly of secondary origin and are associated with different types of erosion processes. However, the existence of primary ecotopes is not excluded. They are fragmented in different parts of the study area and are associated with different types of vegetation. The typological composition of the vegetation of the rock and scree ecotopes is not formed. They are represented by floristic grouping of different species composition.

Wetland plant communities occur along the shores of Lake Kustba. They are represented by Common reed beds (*Phragmitetum australis*).

Artificial plantations are widely established almost throughout the study area. They are presented on the slopes of different exposure and inclination and on different soils. In some parts of the area, their development is fragmented and intruded into the area of natural vegetation. The artificial plantations are largely cultivated in a significant part of the area and are the key components of the phyto-landscape. Their main area is in the Northern and Eastern part of the territory, while it covers relatively small areas in the Western ones. There is a lack of systemic cultivation - artificial plantations and natural vegetation occasionally alternate diffusely and unsystematically. The typological composition of artificial plants is rich. There are both coniferous and deciduous as well as mixed plantations. Coniferous plantations are mainly composed of pine trees (*Pinus nigra* subsp. *nigra*, *P. nigra* subsp. *pallasiana*, *P.*

sylvestris subsp. *hamata*). Small areas include Deodar cedar (*Cedrus deodara*) and Oriental arborvitae (*Platycladus orientalis*) groves. Deciduous plants are cultivated in small areas and are represented by groupings of Common lilac (*Syringa vulgaris*) and Golden rain (*Laburnum anagyroides*). An extensive area is occupied by mixed plantations with both deciduous and coniferous trees and shrubs. A different variant of artificial plantations is the complex habitat composed of mixed plantations combined with natural vegetation.

A brief description of the natural and near to natural vegetation

The coverage of canopy layer ranges from 0.5 to 0.7 (0.8). The undergrowth is developed distinctively in different groves. Its coverage is between 3-5% and 30-40%. Characteristic shrubs are *Ligustrum vulgare*, *Lonicera caprifolium*, *Euonymus verrucosus*, *Swida australis*, *Cornus mas*, *Crataegus kyrtostila*, *Lonicera caucasica*. The floristic composition of the grass cover is dissimilar in different stands. The main species are as follows: *Melica uniflora*, *Melica picta*, *Poa nemoralis*, *Brachypodium sylvaticum*, *Brachypodium pinnatum*, *Carex humilis*, *Viola alba*, *Viola odorata*, *Silene italica*, *Primula macrocalyx*, *Primula woronowii*, *Aegonychon purpurea-coeruleum*, *Campanula rapunculoides*, *Vincetoxicum amplifolium*, *Klasea quinquefolia*, *Alliaria petiolata*, *Albovia tripartita*, *Physospermum cornubiense*, *Vicia truncatula*, *Laser trilobum*, *Anthriscus nemorosa*, *Lapsana grandiflora*, *Polypodium vulgare*, *Tamus communis*, *Corydalis angustifolia*, etc.

The floodplain forest derivative occurs locally on the southern macro slope of the Mamadaviti Ridge in the vicinity of Okrokana village. Despite the small size of the area and the natural structure disturbed by the influence of anthropogenic factors, it occupies a drastically different place in the surrounding vegetation. It is characterized by the diversity of woody plant species (up to 20 species). Their composition is complex - typical representatives of the floodplain ecosystems, trees and shrubs characteristic to foothill, lower mountain and middle mountain belt forests are present. The typical layer structure of the forest is disrupted. The canopy layer is not uniform and is composed of trees of different height. The height of canopy varies from 8 to 16m. Its coverage also ranges from 0.6 to 0.7. It is composed of *Salix* sp., *Quercus petraea* subsp. *iberica*, *Fraxinus excelsior*, *Acer laetum*, *Prunus*

avium, *Prunus malaheba*, *Ulmus minor*, *Crataegus kyrstostyla*. The undergrowth is characterized by a similar heterogeneous structure and uneven height - it is composed of shrubs of different height and bio-ecology (*Carpinus orientalis*, *Berberis vulgaris*, *Rubus* sp., *Salix caprea*). The average coverage of the undergrowth is up to 70%, although it is unevenly distributed. Important components of this ecosystem are lianas (*Hedera helix*, *Smilax excelsa*, *Vitis* sp.), which are characteristic to the floodplain forest.

Woodland-like plant communities are developed in relatively moist ravines. Under such ecological conditions, along with trees, mesophilous and xerosophilous shrubs are widely represented. Consequently, the floristic composition of this vegetation unit is complex. Due to the increased humidity, the cover of both trees and shrubs is high. The structure of these types of plant communities is not stable and well-established. In some sections, shrubs play a dominant role. The floristic composition of different ravines is distinct. The main species are *Fraxinus excelsior*, *Acer campestre*, *Acer laetum*, *Swida australis*, *Celtis caucasica*, *Prunus avium*, *Ulmus minor*, *Rosa* spp., *Rubus* spp., *Cotoneaster meyeri*, *Clematis vitalba*, *Hedera helix*, *Ligustrum vulgare*, *Crataegus* spp., *Berberis vulgaris*, etc.

In addition to the dominant species, shibliak-type hemixerophilous shrubberies are composed of the following species: *Prunus incana*, *Jasminum fruticans*, *Cotoneaster* spp., *Cytisus caucasicus*, *Rhamnus pallasii*, *Ephedra major* subsp. *procera*, *Amelanchier ovalis*, *Astragalus cornutus*, *Crataegus kyrstostyla*, *Ligustrum vulgare*, *Berberis vulgaris*, *Colutea orientalis*, *Rosa canina*, *Ligustrum vulgare*. The grass cover is more or less complex - along with the characteristic species of shrubbery, steppe and meadow-steppe species are also distributed. Almost all life forms of herbaceous plants (hemicryptophytes, geophytes, annuals) are represented. Characteristic plant species are *Thalictrum collinum*, *Potentilla recta*, *Salvia nemorosa*, *Filipendula vulgaris*, *Silene italica*, *Onobrychis cyri*, *Melica transsilvanica*, *Galium verum*, *Dactylis glomerata*, *Valeriana officinalis*, *Potentilla adenophylla*, *Muscari szovitsianum*, *Veronica multifida*, *Astragalus brachycarpus*, *Thesium arvense*, *Dictamnus caucasicus*, *Fragaria* sp., *Phleum phleoides*, *Erysimum leptophyllum*, *Euphorbia boissieriana*, *Fritillaria caucasica*, *Seseli grandivittatum*, etc. The composition is enriched with characteristic species of stony and gravelly ecotopes, both semi-shrubs and undershrubs, as well as herbaceous plants (*Teucrium*

nuchense, *Artemisia caucasica*, *Scutellaria orientalis*, *Psephellus carthalinicus*, *Sedum oppositifolium*, *Sempervivum transcaucasicum*, *Oxytropis pallasii*, etc.). Forest elements (*Cyclamen vernalis*, *Primula macrocalyx*) are also recorded in some communities. Representatives of the family *Orchidaceae* (*Dactylorhiza romana* subsp. *georgica*, *Ophrys caucasica*, *Neotinea ustulata*, *Anacamptis morio*) are rather common in the above communities.

The floristic composition of meadow-steppes is complex; along with the typical components of steppes and meadow (*Phleum phleoides*, *Dactylis glomerata*, *Koeleria cristata*, *Bothriochloa ischaemum*, *Stipa* spp., *Poa bulbosa*, *Festuca valesiaca*, *Filipendula vulgaris*, *Coronilla orientalis*, *Echium rubrum*, *Euphorbia iberica*, *Galium verum*, *Onobrychis cyri*, *Potentilla adenophylla*, *Potentilla recta*, *Seseli grandivittatum*, *Origanum vulgare*, *Plantago media*, *Thalictrum collinum*, *Veronica multifida*, *Dianthus subulosus*, *Rumex tuberosus*, *Fragaria* sp., *Muscari szovitsianum*, etc.), plants characteristic to gravelly soils and scree ecotopes are also present (*Scutellaria orientalis*, *Alyssum tortuosum*, *Thymus* sp., *Bromus biebersteinii*, *Teucrium nuchense*, *Helianthemum nummularium*, *Psephellus carthalinicus*, *Petrorhagia saxifraga*, *Alopecurus tiflisensis*, etc.) due to the specific soil conditions. One of the key characteristics of the vegetation is the occurrence of the species of the *Orchidaceae* family (*Anacamptis morio*, *Neotinea ustulata*, *Dactylorhiza romana* subsp. *georgica*).

Steppes are species-rich plant communities. Along with the grasses (*Festuca valesiaca*, *Bothriochloa ischaemum*, *Stipa capillata*, *Stipa lessingiana*, *Stipa arabica*, *Dactylis glomerata*, *Koeleria cristata*, etc.), the following forbs are well-represented: *Salvia nemorosa*, *Carex bordzilowski*, *Galium verum*, *Dianthus subulosus*, *Potentilla adenophylla*, *Potentilla recta*, *Seseli grandivittatum*, *Euphorbia iberica*, *Veronica multifida*, *Filipendula vulgaris*, *Plantago media*, *Rumex tuberosus*, *Onobrychis cyri*, *Medicago caerulea*, *Trifolium tumens* and others. The involvement of hemixerophilous semi-shrubs and undershrubs (*Thymus coriifolius*, *Teucrium polium*, *Teucrium nuchense*, *Scutellaria orientalis*, etc.) is directly related to gravel content in soils. Annuals also play an important role in the floristic composition, among which are weed and widespread plant species (*Alyssum alyssoides*, *Draba nemorosa*, *Erodium cicutarium*, *Medicago minima*, *Helianthemum lasiocarpum*, *Hirschfeldia incana*, *Carthamus lanatus*, *Bromus squarrosus*, *Crepis sancta*, etc.).

Steppe vegetation is mostly of secondary origin in the study area. However, the existence of primary communities is also possible. At present, it is impossible to clearly distinguish between the primary and secondary communities. The formation of secondary communities has a long history, which is primarily related to the anthropogenic factors (deforestation and burning of forests and shrubberies, grazing, etc.).

Despite the extreme conditions, the floristic composition of the vegetation of the rock and scree ecotopes is diverse. The main characteristics of the vegetation structure are not well-defined. Plants of different life forms are diffusely and unsystematically distributed. In addition to the typical petrophytes, components of different types of vegetation (mostly shibliak-type hemixerophilous shrubberies, arid birch forests and steppes) are distributed, which are characterized by a relatively wide ecological amplitude. Part of them belongs to the so-called coenotic relics and is remnants of the previously existed vegetation; other part penetrated into this vegetation and became well-established. The composition of life forms is also diverse - almost all life forms are represented. Shrubs include *Atraphaxis caucasica*, *Rhamnus pallasii*, *Paliurus spina-christi*, *Ephedra major* subsp. *procera*, *Cotinus coggygrea*, *Colutea orientalis*, *Pyrus salicifolia*, *Spiraea hypericifolia*, *Rhus coriaria*. Shrub layer is marked by the presence of dwarf shrub *Fumana procumbens*. The composition of herbs is rich. The main hemicryptophytes are *Centranthus longiflorus*, *Hyssopus angustifolius*, *Alyssum tortuosum*, *Asperula glomerata*, *Agropyron cristatum*, *Nepeta mussini*, *Alopecurus tiflisiensis*, *Festuca valesiaca*, *Stipa arabica*, *Oxytropis pallasii*, *Centaurea ovina*, *Psephellus carthalinicus*, *Botriochloa ischaemum*, *Isatis iberica*, *Poterium polygamum*, *Astragalus bungeanus*, *Minuartia woronowii*, *Petrorhagia saxifraga*, *Campanula alliariifolia*. The participation of succulents is noteworthy - *Sedum oppositifolium*, *Sempervivum transcaucasicum*, *Sedum pallidum*. Characteristic plants of this vegetation are the semi-shrubs and undershrubs (chamaephytes) - *Artemisia caucasica*, *Artemisia incana*, *Artemisia marschalliana*, *Teucrium polium*, *Teucrium nuchense*, *Helianthemum nummularium*, *Thymus coriariifolius*, *Scutellaria orientalis*, *Ziziphora serpyllacea*, *Dianthus orientalis*, *Cerastium argenteum*, etc. Of annuals, *Astrodaucus orientalis* is a characteristic species. The floristic composition is enriched with introduced and subsequently naturalized plant

species (*Cercis siliquastrum*, *Ailanthus altissima*, *Amygdalus communis*, *Spartium junceum*, *Pinus nigra* subsp. *pallasiana*).

Current condition of vegetation cover, degree of modification and level of disturbance

Both heavily and partially modified and natural and near natural ecosystems are present in the study area. The level of ecosystem disturbance varies in different parts of the study area. The main determining factors of the levels of disturbance are anthropogenic impacts (grazing, tree and shrub felling, recreational use, pollution).

The level of disturbance in natural and near natural ecosystems is mostly observed in forests and the least - in shibliak-type hemixerophilous shrubberies and meadow-steppes.

Although the disturbance levels of forests varies in most parts of the area, their current overall condition can be assessed as satisfactory. The structure of forest canopy in most cases corresponds to the mean characteristics of forests in the vicinity of Tbilisi. In the stands and their edges there are seedlings and young individuals of key dominant species (especially *Fraxinus excelsior*). However, the condition of the undergrowth and grass cover varies in different stands, which is related to anthropogenic factors (recreational use).

The condition of shibliak-type hemixerophilous shrubberies in most parts of the area is satisfactory or good, with an expressed floristic diversity. Their level of disturbance in most parts of the area is negligible, or none. However, some degraded groupings are also present (especially in the vicinity of residential areas and trails).

The disturbance level of meadow-steppes is low. Their structure corresponds to the physiographical conditions in which they are established. Consequently, their current condition can be assessed as satisfactory.

In steppe ecosystems, the plant communities on the macro slopes of the southern exposure of the Mamadaviti Ridge, village Okrokana surroundings, are characterized by a high level of disturbance and are affected by heavy anthropogenic pressure (grazing). The structure of plant communities in this area is disrupted which is especially reflected in its floristic composition – increased number of weed species were recorded. The disturbance level in the rest of the area is insignificant and therefore their structure is satisfactory.

The condition of the rock and scree ecotope vegetation is different in various parts of the area, which is due to the different natural and anthropogenic factors.

The current condition of artificial plantations is different in various parts of the area. A significant part of the plantations is degraded and need large-scale restoration. Particular attention should be paid to the condition of pines and pine stands - their massive decline is caused by, on the one hand, climate fluctuations (prolonged droughts) and, on the other hand, mycological and entomological diseases. This process could be described as plant disease epidemics. It is irreversible today in not only in most parts of the study area, but also in Tbilisi and its immediate environs as well. The disease is rapidly transmitted to newly planted young pines. As a result, there are died back or dying pine stands. The disease progresses intensively and affects other coniferous species (cypress, thuja, cedar). In addition, the high disturbance level of artificial plantations is noteworthy, which is a result of the adverse impact of anthropogenic factors (primarily recreation and related processes). Young pine specimens have been noted adjacent to some pine stands, although they only appear as single individuals and natural regeneration of pine plantations is not expected.

Dynamics of successive processes of vegetation - direction and trends

Although the disturbance level of forests varies in most parts of the area, they are represented in the climax and near-climax stages. Their structure is sustainable and compatible with soil, terrain and climatic conditions.

Shibliak-type hemixerophilous shrubberies, in most parts of the area, are represented in the climax and near-climax stages. Their structure is well-established and sustainable, adapted to soil, terrain and climatic conditions. These communities mostly grow on moderate and steep slopes and fully perform their anti-erosion function.

In the steppes there are plant communities in the climax and near-climax stages, as well as at the stage of digressive succession. The existence of different stages is related to the intensity of anthropogenic factors (grazing, recreational load, establishment of artificial plantations). Plant communities of the first ecological stage are found mostly in the crest part of the Mamadaviti Ridge, at the macro slopes of northern exposure. Plant communities in the stage

of digressive succession are widespread on the macro slope of the southern exposure of the Mamadaviti Ridge (e.g., village Okrokana surroundings). Steppe communities are mostly established on thin soils and have an important anti-erosion function.

Despite their complex floristic composition, meadow-steppes are in the climax and near-climax stages. The structure is stable and corresponds to the transitional vegetation type. At this stage no tendencies of successive vegetation change are observed. It is distributed on gentle and moderate slopes, on thin and medium depth soils and performs anti-erosion function.

The vegetation of rock and scree ecotopes is more or less dynamic due to the substrate instability. The floristic composition varies in different parts of the area, which is due to the variability of terrain and soil conditions. Invasive plants were also recorded expanding their area of distribution. Nevertheless, the core of the floristic composition is more or less expressed. Such variable and dynamic vegetation is generally characteristic to rocky and especially sedimentary ecotopes. Due to the above mentioned, the vegetation of these ecosystems can not be attributed to the vegetation of the climax stage, especially the floristic grouping of scree and easily shredded sandy clays and sandstones. Vegetation formation processes are clearly seen on relatively newly formed bare slopes. The vegetation of long-formed rocky ecotopes is more or less stable and close to the climax stage.

The floodplain forest derivative cannot be regarded as vegetation in climax stage. As already mentioned, its structure is severely degraded and far from the typical floodplain forest structure. In addition, digression successive processes continue under the influence of anthropogenic factors.

Significant successive processes take place in artificial plantations as well, especially in some pine stands. Particularly in the western part of the study area, the abundant growth of saplings and young individuals of the key dominants (*Fraxinus excelsior*), *Quercus petraea* subsp. *iberica*, *Carpinus orientalis*) of the deciduous forest characteristic to the Tbilisi environs, is observed. Young specimens of other species (*Carpinus betulus*, *Tilia begoniifolia*, *Acer campestre*, *Lonicera caucasica*, etc.) were also observed. It is obvious that there is an on-going restoration process of deciduous forests. Seedlings and young individuals of European ash and Georgian oak are also observed in other artificial plantations, especially in the mixed deciduous stands.

II. Floristic composition

General composition and plant life forms

Despite the small territory, the study area is distinguished by its floristic richness. About 750 species of vascular plants are distributed.

The richness of floristic composition is not expressed in just taxonomic diversity. Almost all life forms of plant [28] are observed in the study area - trees, shrubs, semi-shrubs and undershrubs, perennials, biennials and annuals. In terms of species, the most diverse is the herb composition, which forms the core of the floristic composition (about 635 species). The composition of woody plants (trees and shrubs) is also rich (about 100 species). The lowest number of species (about 15 species) are semi-woody plants (semi-shrubs and undershrubs).

Herbaceous plants are not only distinguished by their species richness, but also by their different bio-ecology and forms. According to Raunkier classification [27], hemicryptophytes, cryptophytes (geophytes and helophytes) and therophytes are recorded. It is important to note that herbaceous plants are the core of almost all types of vegetation. The hemicryptophytes recorded on the study area are mostly characteristic plants of steppes and meadow-steppes. They are also the key plants forming ground vegetation in forests (*Melica uniflora*, *Melica picta*, *Poa nemoralis*, *Brachypodium sylvaticum*, *B. pinnatum*, *Carex humilis*, *Viola* spp., *Primula macrocalyx*, *Primula woronowii*, *Campanula rapunculoides*, etc.) and various types of shrubs. The geophytes distributed in the study area are mostly characteristic to hemixerophilous vegetation (shibliak-type hemixerophilous shrubberies and steppes) (*Gagea taurica*, *Gagea chlorantha*, *Muscari szovitsianum*, *Iris pumila*, *I. reticulata*, *Anacamptis morio*, *Dactylorhiza romana* subsp. *georgica*, *Ophrys caucasica*, *Neotinea ustulata*, *Anacamptis morio*, etc.). The small part of them is the components of forests and forest edges (*Cyclamen vernalis*, *Ficaria ledebouri*, etc.). *Iris caucasica* is a plant of a very gravelly soil and stony ecotopes. The participation of helophytes is small (*Phragmites australis*, *Typha* spp.). Therophytes (annual plants) that are common in all types of vegetation are not characterized by high constancy. However, they enrich the floristic composition of different communities.

Trees and shrubs (phanerophytes) are among the main vegetation-forming plants in the study area. They are dominant and associate plants of forests and various types of shrubberies. They also play an

important role in forming vegetation cover of rock and scree ecotopes. Consequently, they are priority plants in forming the vegetal landscapes.

Despite the low number of species, semiwoody plants (semi-shrubs and undershrubs) hold a special place. In the study area they are mostly associated with rock and scree ecosystems and very gravelly soils (*Artemisia caucasica*, *A. incana*, *A. marschalliana*, *Scutellaria orientalis*, *Dianthus orientalis*, *Thymus coriifolius*, *Ziziphora serpyllacea*, *Teucrium nuchense*, *T. polium*, *Cerastium argenteum*, *Helianthemum nummularium*, etc.). According to Raunkier classification [27], the semi-shrubs and undershrubs distributed in the target area are mostly chamaephytes.

Endemics and species of high conservation value

Forty-eight endemic species of the Caucasus were recorded in the study area. The families of *Asteraceae* (9 species), *Fabaceae* (7) and *Caryophyllaceae* (5) are represented by the largest number of endemic species (Table 1). They are characteristic plants of different types of vegetation. However, most endemic species are the components of hemixerophilous vegetation, including scree and rock ecotopes.

Some Caucasian species also irradiate mainly in eastern and northeastern Anatolia and northeastern Iran. They are as follows: *Astragalus brachycarpus*, *A. stevenianus*, *Cotoneaster meyeri*, *Onobrychis radiata*, *Erysimum leptophyllum*, *Scutellaria orientalis*, *Scorzonera biebersteinii*. These species can be considered as sub-endemics of the Caucasus.

The number of endemics and sub-endemics is quite high for such a small area. They are plants of different bio-ecology and are common in almost all natural and near natural ecosystems.

The study area supports two species included in the Red List of Georgia; they are *Ulmus minor* and *Juglans regia*. *Ulmus minor* is represented by few individuals and/or small groups and is scattered almost throughout the study area. *Juglans regia* is recorded only in the floodplain forest derivative, where it likely penetrated from adjacent private land plots of village Okrokana.

Rare species also include *Astragalus cornutus*. It is not included in the Red List of Georgia, however its distributional area in Georgia is very limited and is mainly confined to Mamadaviti Ridge [34], where it is sporadically distributed in small groups.

Table. *Caucasian endemic plants recorded on the survey area*

Family	Species	Life form	
		according to Raunkiaer, 1934	according to Serebriakov, 1964
<i>Angiospermae</i>			
<i>Dicotyledoneae</i>			
<i>Apiaceae</i> (<i>Umbelliferae</i>)	<i>Seseli grandivittatum</i> (Sommier & Levier) Schischk.	Hemicryptophyte	Perennial herb
<i>Asteraceae</i> (<i>Compositae</i>)	<i>Centaurea ovina</i> Pall. ex Willd.	Hemicryptophyte	Perennial herb
	<i>Cousinia orientalis</i> (Adams) K.Koch	Hemicryptophyte	Perennial herb
	<i>Jurinea blanda</i> (M.Bieb.) C.A.Mey.	Hemicryptophyte	Perennial herb
	<i>Psephellus carthalinicus</i> Sosn.	Hemicryptophyte	Perennial herb
	<i>Scorzonera biebersteinii</i> Lipsch.	Hemicryptophyte	Perennial herb
	<i>Taraxacum grossheimii</i> Schischk.	Hemicryptophyte	Perennial herb
	<i>Taraxacum praticola</i> Dahlst.	Hemicryptophyte	Perennial herb
	<i>Tragopogon serotinus</i> Sosn.	Hemicryptophyte	Perennial herb
	<i>Tragopogon tuberosus</i> K.Koch	Geophyte	Perennial herb
<i>Boraginaceae</i>	<i>Nonea setosa</i> Roem. & Schult.	Therophyte	Annual
	<i>Symphytum caucasicum</i> M.Bieb.	Hemicryptophyte	Perennial herb
<i>Brassicaceae</i> (<i>Cruciferae</i>)	<i>Isatis iberica</i> Steven.	Therophyte	Annual
<i>Campanulaceae</i>	<i>Campanula alliariifolia</i> Willd.	Hemicryptophyte	Perennial herb
	<i>Campanula sibirica</i> L. subsp. <i>hohenackeri</i> (Fisch. & C.A.Mey.) Damboldt	Hemicryptophyte	Biennial
<i>Caprifoliaceae</i> (<i>Dipsacaceae</i>)	<i>Cephalaria media</i> Litv.	Hemicryptophyte	Perennial herb
	<i>Scabiosa georgica</i> Sulak.	Hemicryptophyte	Perennial herb
<i>Caryophyllaceae</i>	<i>Cerastium argenteum</i> M.Bieb.	Chamaephyte	Undershrub
	<i>Dianthus inamoenus</i> Schischk.	Hemicryptophyte	Perennial herb
	<i>Dianthus subulosus</i> Conrath & Freyn	Hemicryptophyte	Perennial herb
	<i>Gypsophila stevenii</i> Fisch. ex Schrank	Hemicryptophyte	Perennial herb
<i>Celastraceae</i>	<i>Euonymus leiophloeus</i> Steven	Phanerophyte	Shrub
<i>Cornaceae</i>	<i>Swida iberica</i> (Woronow) Pojark. ex Grossh.	Phanerophyte	Shrub or tree
<i>Crassulaceae</i>	<i>Sedum caucasicum</i> (Grossh.) Boriss.	Geophyte	Perennial herb
	<i>Sedum oppositifolium</i> Sims.	Hemicryptophyte	Perennial herb
	<i>Sempervivum transcaucasicum</i> Muirhead	Hemicryptophyte	Perennial herb
<i>Euphorbiaceae</i>	<i>Euphorbia boissieriana</i> (Woronow) Prokh.	Hemicryptophyte	Perennial herb
<i>Fabaceae</i> (<i>Leguminosae</i>)	<i>Anthyllis lachnophora</i> Jus.	Hemicryptophyte	Biennial
	<i>Astragalus bungeanus</i> Boiss.	Hemicryptophyte	Perennial herb
	<i>Cytisus caucasicus</i> Grossh.	Phanerophyte	Shrub

	<i>Lotus caucasicus</i> Kuprian.	Hemicryptophyte	Perennial herb
	<i>Onobrychis cyri</i> Grossh.	Hemicryptophyte	Perennial herb
	<i>Onobrychis iberica</i> Grossh.	Hemicryptophyte	Perennial herb
	<i>Onobrychis kachetica</i> Boiss. et Buhse	Hemicryptophyte	Perennial herb
Lamiaceae (Labiatae)	<i>Hyssopus angustifolius</i> Bieb.	Hemicryptophyte	Perennial herb
	<i>Teucrium nuchense</i> K.Koch	Chamaephyte	Undershrub
	<i>Thymus coriifolius</i> Ronniger	Chamaephyte	Undershrub
Polygalaceae	<i>Polygala mariamae</i> Tamamsch.	Hemicryptophyte	Perennial herb
	<i>Polygala transcaucasica</i> Tamamsch.	Hemicryptophyte	Perennial herb
Ranunculaceae	<i>Delphinium ochroleucum</i> Steven ex DC.	Geophyte	Perennial herb
	<i>Ficaria ledebourii</i> Grossh. et Schischk.	Geophyte	Perennial herb
Rosaceae	<i>Cotoneaster saxatilis</i> Pojark.	Phanerophyte	Shrub
	<i>Pyrus georgica</i> Kuth.	Phanerophyte	Tree or shrub
	<i>Rubus ibericus</i> Jus.	Phanerophyte	Shrub
Scrophulariaceae	<i>Verbascum formosum</i> Fisch. exSchrank	Hemicryptophyte	Biennial
Monocotyledoneae			
Iridaceae	<i>Iris caucasica</i> Hoffm.	Geophyte	Perennial herb
Liliaceae	<i>Gagea commutata</i> K.Koch	Geophyte	Perennial herb
Orchidaceae	<i>Ophrys caucasica</i> Woronow ex Grossh.	Geophyte	Perennial herb

Invasive plants

Several invasive species were identified in the study area. They are plants of various bio-ecological characteristics and life forms. These species are *Opuntia humifusa*, *O. phaeacantha*, *Ambrosia artemisiifolia*, *Xanthium spinosum*, *X. strumarium*, *Ailanthus altissima*, *Cercis siliquastrum*, *Laburnum anagyroides*, *Spartium junceum* and *Koelreuteria paniculata*. These species are represented by micro-groups as well as single individuals.

The source, area of occupancy, abundance and invasion potential in the study area are different. The woody plants escaped from artificial plantations. The cacti species (*Opuntia* spp.) escaped from the collections at the National Botanical Garden of Georgia and became established in adjacent areas (Tabori, Narikala, Teleti, Mamadaviti ridges, etc.); they are rapidly expanding their distributional area. The annual invasive species (*Ambrosia artemisiifolia*, *Xanthium spinosum*, *X. strumarium*) are widespread in the vicinity of Tbilisi and appear as weeds in different habitats.

Invasive species are most abundantly and intensively established in habitats with heavily modified structure. Their penetration in both natural and near natural plant communities, as well as in well-established artificial plantations, is rare. Their

individuals are sometimes found in the forest edges, shrubberies and artificial plantations. Some of them (*Ailanthus altissima*, *Cercis siliquastrum*, *Spartium junceum*) are also becoming well-established in scree and rock ecotopes.

Conclusion

1. The target area is characterized by heterogeneous physiographical conditions, which contributes to the high level of biodiversity. Both ecosystem and floristic diversity was recorded.
2. Vegetation represents a mixture of, on the one hand, natural and near natural and, on the other hand, artificial plantations. No regularity in the spatial distribution of vegetation was observed. In most cases different ecosystems alternate unsystematically and diffusely with one another. However, the concentration of natural and near natural vegetation was detected in the western and central parts of the north-facing macro slope of the Mamadaviti Ridge. Artificial plantations are mostly established in the eastern and northern parts of the study area, as well as on the southern macro slope of the Mamadaviti Ridge.
3. Natural and near natural vegetation is represented by both mesophilous and semi-xerophilous and xerophilous variants. The rapid and often

mosaic interchangeability of terrain and -soil conditions causes their diffuse distribution. In such distribution of vegetation anthropogenic factors also played an important role. Wetland plant groupings occur locally along the shores of Lake Kustba.

The deciduous forests of the foothills and the lower mountain form the major part of mesophilic vegetation. They are represented by the European ash (*Fraxineta excelsior*), Georgian oak (*Querceta petraea* subsp. *iberici*) and Oriental hornbeam (*Carpineta orientalis*) forests. Shibliak-type hemixerophilous shrubberies are the main units of hemixerophilous vegetation. Steppes occupy smaller areas. Meadow-steppes are transitional communities between mesophilous and hemixerophilous vegetations. They occur at the highest altitudes. Despite the fact they occupy limited area, their role is important in terms of ecosystem biodiversity.

The vegetation of the rock and scree ecotopes is of fragmentary distribution in different parts of the survey area. These ecotopes are established as a result of erosion process, although the existence of their primary origin areas are also possible. The floristic grouping of these ecotopes significantly enrich the biodiversity of the target area.

Common reed beds (*Phragmitetum australis*) occur locally along the shores of Lake Kustba.

4. Artificial plantations are represented by both coniferous and deciduous stands, as well as mixed plantations. The largest area is covered by the pine stands (*Pinus nigra* subsp. *nigra*, *Pinus nigra* subsp. *pallasiana*, *Pinus sylvestris* subsp. *hamata*). The extensive area is also covered by mixed plantations, with both deciduous and coniferous trees and shrubs. A special variant of artificial plantations is the complex habitats of mixed plantations and natural (wild) vegetation. A significant part of artificial plantations are declined and need to be restored and replaced. With this regard, mass drying of conifers (especially pines) is noteworthy.
5. The main part of natural and near natural vegetation (forests, shibliak-type hemixerophilous shrubberies, steppes and meadow-steppes) is in the climax stage, their structure is sustainable and self-regenerating in the majority of the survey area. Regarding this, the vegetation of rock and scree ecotopes is different, the structure of which is more or less dynamic in most parts of the area due to the instability of the substrate.

Significant succession processes are observed in artificial plantations, especially in the western part of the area. Particularly, mass regeneration of major species of native deciduous forests (*Fraxinus excelsior*, *Quercus petraea* subsp. *iberica*, *Carpinus orientalis*) is taking place in pine stands and there is a replacement tendency of pine stands with native deciduous forests.

6. The flora of the study area is rich and complex. About 750 species of vascular plants are found. All major life forms of different bio-ecology and plants of different phenologies are present. The floristic composition is enriched with introduced plants, some of which were naturalized. Forty-eight endemic species of the Caucasus were recorded. Besides, 7 other native species are known to occupy limited area outside the Caucasus Ecoregion and can be considered as Caucasian sub-endemic species.

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