The impact of climate change on the taxonomic composition of the Zagatala State Nature Reserve

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Abstract. Zagatala State Nature Reserve is one of the first reserves created in the South Caucasus. The territory of this reserve, organized in 1929, is 47349 ha. The fact that the Zagatala Reserve is bordered by the Lagodekhi Reserve (Georgia) and the Tiyarta Ban (Russia) further increases its natural conservation importance. The main four factors that influence the climate of the reserve are geographical latitude, the protection of the area from the north by mountain ranges, the presence of a strongly fragmented relief and the height amplitude of the area to be high (up to 360-3600 m). Because the soil is rich and the relief is complex, the flora and vegetation are also diverse. Only 1.6% of its area covered by forest is mainly coniferous *Pinus* hamata (Steven) Sosn., *Taxus baccata* L., *Juniperus oblonga* M.B. species. *Pinus hamata* (Steven) Sosn., which grows naturally only in Balakenchay basin in Azerbaijan it is sparsely distributed in the not very high mountain range up to 1000 m in height between Balakenchay and Filizchay, at an altitude of 1200 m above sea level. In the Zagatala State Nature Reserve, the main composition of the flora is petrophytes, i.e., rock plants consisting of stony soil.

1 Introduction.

Global climate changes in the atmosphere have not left the vegetation of Zagatala State Nature Reserve unaffected. Thus, as a result of the influence of climate changes, the upper climatic boundary of the forest has undergone a great change. At present, it can be said that the natural boundary of the forest has been violated everywhere as a result of the influence of climatic factors. Partial thinning, changes in areas compared to previous years were recorded. The reasons for the shrinking of the areas of the plants were determined, the danger criteria, biological characteristics, and the reasons for the change in the natural resources were investigated. Climate change not only determines the distribution and growth of plants, but also affects the species composition of plants [1].

Monitoring was carried out in the study area, the taxonomic composition of plants was investigated. In plain forests - Alnus subcordata, Pterocarya pterocarpa Michx., Populus hybrida M.Bieb., Quercus longipes Steven Steven., in steppe plateau areas - *Juniperus communis L., Pistacia mutica* Fisch. & C.A. Mey., *Quercus iberica M*. Bieb species were recorded by us. On the banks of the Katex River in the study area - *Fagus L., Carpinus L., Platanus L., Tilia L., Ulmus L., Quercus L., Alnus Mill., Juglans L., Morus L., Acer L., Fraxsinus L., Eiser L.* and other species such as Fagus orientalis lipsky., Quercus macranthera *Fisch., Carpinus caucasica A.Grossh., Betula platyphylla Sukacz., Fraxinus excelsior L., Acer laetum C.A. Mey, Tila cordata Mill., Tila caucasica Rupr., Diospyros lotus L., Ulmus caprinifolia Rupp., Carya illinoinensis (Wangenh.) K.Koch, Pterocarya pterocarpa Michx., Pinus kochiana klotzsch ex k. koch., Castanea sativa Mill., Corylus colurna L., Alnus barbara C.A. Mey, etc. species have been recorded. Shrub plant species belonging to the genera Crataegus L., Mespilus L., Rubus L., Prunus L., Rosa L., Juniperus L., Euonymus L.* were analyzed [2].

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2. Materials and methods

The current state of the vegetation of the Zagatala State Nature Reserve was analyzed, and an inventory of natural and cultivated plant species was made. The impact of climate change on biodiversity, the taxonomic composition of tree and shrub plants, dominant species, and distribution areas of plants were comprehensively studied. During the studies, the plants characteristic of the studied area were divided into dominant, relict, endemic, rare, "vulnerable to extinction" groups.

Vegetation and elevations of Zagatala State Nature Reserve were determined with Garmin GPS. The change in temperature [1], identification of plants was specified using S.K. Cherepanov and "Azerbaijani flora" [2]. State Nature Reserves [3], endemic, relic species [4], vegetation [5], climatic factors [6, 7], assessment of natural resources [8, 9], dominant species [10], plant classification APG III [11], (Modern Taxonomic System of Flowering Plants) system.

3 Results and discussion

The flora of the base of the reserve consists of mountain forests and mountain meadows. More than a thousand species of modern flora are observed here. The territory of the reserve has changed many times and is currently 28844 hectares. More than 300 species of higher plants are spread in the reserve, which makes up 1/6 of the flora of Azerbaijan. More than 60% of the reserve area consists of broad-leaved forests. Among them, mainly *Platanus* L., *Quercus* L., *Carpinus* L., *Juglans* L., *Castanea* Mill., *Acer* L., *Tilia* L., *Fraxinus* L., etc. [3]. During the research, numerous geobotanical descriptions of vegetation in different areas were given and herbariums of rare species were collected (Figure 1).

About 50 species of endemic and relic species in Zagatala State Nature Reserve - *Rhododendron luteum* Sweet, *Rhododendron caucasicum* Pall., *Vaccinium arctostaphylos* L., *Acer velutinum* Boiss., *Dryopteris filix-mas* Schott, rare and belonging to the category "Vulnerable to extinction" - *Achillea millefolium* L., *Antennaria dioica* (L.) Gaertn., *Hyoscyamus niger* L., *Thymus nummularius* M.B., *Urtica dioica* L., etc. there are also medicinal plants [4].

Fig.1. Herbariums collected from Zagatala State Nature Reserve.

The reserve has a unique vegetation according to Prilipko's divisions, the reserve: in the lower mountain belt - 400-1800 m; 600-1800m to the middle mountain belt; belongs to the upper mountain belt -1800-2000 m (2200) parts. In the lower mountain zones, the *Carpinus caucasica* A.Grossh., *Prunus divaricata* Led., *Pyrus caucasica* Fed., *Mespilus germanica* L., *Cornus mas* L., *Grataegus* Tourn. ex L., *Vaccinium myrtillus* L., *Tilia cordata* Mill., *Ulmus elliptica* C.Koch., *Sambucus nigra* L., *Evenymus latifolia* (L.) Mill. and shrubs belonging to plant genera - *Periploca graeca* L., *Smilax exselsa* L., *Hedera Pastuchovii* Woronow, *Vitis sylvestris* subsp. sylvestris (C.C.Gmel.), *Lonicera caprifilum* L., *Clematis vitalba* L., from herbs - *Athyrium* filix femina (L.) Roth, *Melampyrum arvense* L.,*Thymus caucasicus* W., *Trifolium pratense* L., etc. [5] (Figure 2).

Fig.2. *Clematis vitalba* L., *Sambucus nigra* L., *Hedera pastuchowii* G. Woron., *Hedera helix* L.

The following climate types have formed in the territory of the Zagatala State Nature Reserve: mountainous tundra climate, wet cold climate in winter, mild warm climate with almost even distribution of precipitation, mild warm climate with dry winters, dry mild warm semi-desert winters, and dry desert climate [6].

Multi-year monitoring data (water consumption, precipitation and temperature data) were widely used to study the influence of climate changes on the annual regime of the Zagatala State Nature Reserve in the study areas. These data mainly cover observation periods from 2019 to 2023.

The recurrence of various anomalous weather conditions, the increase in the number of natural disasters occurring in connection with this, including the fact that the hottest years starting from 2019 to 2023, the drought in 2000, and the absolute maximum temperature observed in the territory of our republic during the entire observation period, are are visual examples that confirm the changes.

In the territories of the Zagatala State Nature Reserve, as a result of 0.5 °C warming in 2019, in the foothill regions, on average 5-7%, in 2020, as a result of 0.7 °C warming, 6-8%, as a result of 0.9 °C warming, 8-10 %, in 2021 at a warming rate of 1°C, in 2022 at a warming rate of 1.2°C, 10-12%, in 2023 at a warming rate of 1.4°C, the forest cover decreased by 14-16%. The increase in temperature in the territory of the Zagatala State Nature Reserve is explained by the fact that its rivers are relatively weak as a result of the effects of climate change. In recent times, it can be seen more clearly in the increase of extreme temperatures, droughts, floods and floods, various local hurricanes, natural forest fires, river water resources and regime change in rivers.

2019 and 2023 were the hottest years in the world, and record temperatures were observed in our country, and the number of continuously hot days over 35°C was more than one month [7].

In Zagatala State Nature Reserve, the average monthly difference between the amount of sunshine and the air temperature in July is 5-6°C. During the year, the evaporation deficit reaches 100-200 mm for these areas. The average annual air temperature in the foothills is 10 °C, and in the highlands is below 0 °C. In the highlands, the average monthly temperature in January is below -14 °C, while the average monthly temperature in July is below 5 °C. In the low mountains, thi the figures are 0-3°C and 15-20°C respectively. During the year, the absolute minimum air temperature in the high mountains is -22-30°C, and the absolute maximum temperature reaches 10°C.

As a result of climate change, forests, forest-shrub, forest-dry vegetation, and desert landscapes appeared in the areas of the lower mountain belt. In these areas, natural regeneration is impossible, because the soils are less fertile, extremely dry, and grasses are the majority. There are some forest areas where the sparseness of the forest is surrounded by open spaces and a series of bushes. As a result of climate change, in some areas of the reserve, forest-producing tree species have been replaced by shrubs.

In these cases, *Rosa canina* L., *Lonicera caprifolium* L., *Sorbus caucasigena* Kom., *Euonymus verrucosus* Scop. L. bushes and *Dryopteris* filix mas (L.) Schott, *Valeriana officinalis* L., *Smyrnium perfoliatum* L., *Hippomarathrum crispum* (Pers.) Boiss., *Vaccimium vitis-idaea* L., and other herbs [8].

As you go up to the middle mountain belts, the bushes are relatively less, and they are replaced by tall tree species. Caucasian botanists call the middle mountain belt the pistachio belt. The beech belt (*Fagus orientalis* Lipsky) on the northern slopes, the Georgian oak (*Quercus iberica* Steven ex M.Bieb.) on the southern slopes, the eastern hornbeam (*Carpinus orientalis* Mill.), a component of both, several species of maple - *Acer campectre* L., *Acer Trautvetteri* Medv., from sycamores - *Dryopteris filix-mas* Schott, *Polystichum lobatum* (L.) Roth, *Asplenium scolopendrium* (L.) Newman, *Pteridium tauricum* Grossh., *Asplenium trichomanes* L., *Asplenium adiantum-nigrum* L., *Polypodium vulgare* L., from grass plants - Festuca drymeja Mert. & W.D.J. Koch., *Galium odoratum* (L.) Scop, *Salvia glutinosa* L., *Fragaria vesca* L., etc. is widespread. As the height above sea level decreases, under the influence of xerophytic forests, brown mountain-forest soils have developed on carbonate clayey, calcareous and sandy rocks (Figure3.).

(before) (after)

Fig.3. Impact of climate variability on forest areas in the lower mountain belt.

In the upper mountain belts, *Pinus hamata* (Steven) Sosn. is densely distributed in some places and sparsely in some places in the mountain range with a length of up to 1000 m between Balakenchay and Filizchay, which is not too high. *Quercus macranthera* Fisch. & C.A.Mey. on southern slopes, *Betula pendula* Roth on northern slopes, *Vaccinum myrtillis* L., *Rosa* L., *Cotoneaster Integerrima* Medik. on dry slopes *Juniperus oblonga* M.B. and *Brachypodium sylvaticum* (Huds.) P.Beauv., *Agrostis tenuis* L., *Dactylis glomerata* L., *Trifolium repens* L., *Doronicum macrohyllum* L., *Senecio platyphyles* (Bieb.) DC., *Urtica* L., tall grasses are widespread. Brown mountain forest soils have mainly formed under the mesophilic forests of the upper zone. Climate change may increase the availability of fertile habitat for the development of widespread species. Dominant, endemic species may not adapt to the changing environmental conditions of their habitat, leading to species succession, as well as ecosystem dysfunction and resource depletion after species interbreeding [9,10].

50% of the species composition of Zagatala State Nature Reserve is *Fagus orientalis* Lipsky, 26.5% is *Carpinus orientalis* Mill. 8.5%-I, 7.5% *Quercus macranthera* Fisch. & C.A. Mey., *Quercus iberica* Steven ex M.Bieb., 1.7% *Tilia caucasica* Rupr., 1.6% *Pinus hamata* (Steven) Sosn., *Juniperus oblonga* M.B., 1% *Fraxinus excelsior* L .and other breeds [11].

Monitoring was carried out in the study area, the taxonomic composition of plants was investigated [12] **(**Table1.).

Table 1. Taxonomic composition, life form and origin of vegetation of Zagatala State Nature Reserve

№	Family	Genus	Species	The life form of a plant	Distribution area
1	2	3	4	5	6
1	*Taxaceae* S.F.Gray	*Taxus* L.	*Taxus baccata* L.	tree	Western, Central Europe
2	*Pinaceae* F.Rudolphi	*Pinus* L.	*Pinus hamata* (Steven) Sosn.	tree	Greater, Lesser Caucasus
3	*Pinaceae* F. Rudolphi	*Pinus* L	*Pinus Sosnowsckyi* Nakai	tree	Greater Caucasus, Georgia
4	*Cupressaceae Gray*	*Juniperus L.*	*Juniperus oblonga* M.B.	tree	Northern and Southern Hemispheres
5	*Sapindaceae* Juss.	*Acer* L.	*Acer platanoides* L.	tree	Europe, Asia, Scandinavia
6	*Sapindaceae* Juss.	*Acer* L.	*Acer campectre* L.	tree	Europe, North America
7	*Betulaceae* Gray	*Alnus Mill.*	*Alnus incana* (L.) Moench	tree	South America, Asia
8	*Ulmaceae* Mirb., nom. cons.	*Ulmus L.*	*Ulmus elliptica* C.Koch.	tree	Caucasus, Russia
9	*Betulaceae* Gray	*Alnus Mill.*	*Alnus barbata* C.A.Mey.	tree	Asia Minor, Transcaucasia
10	*Fagaceae* Dumort. nom. cons.	*Quercus* L.	*Quercus macranthera* Fisch.	tree	North Caucasus, Azerbaijan
11	*Betulaceae* Gray	*Carpinus* L.	*Carpinus caucasica* A.Grossh.	tree	Greater, Lesser Caucasus
12	*Fagaceae* Dumort. nom. cons.	*Fagus* L.	*Fagus orientalis* Lipsky	tree	Europe, Asia, North America.
13	*Ulmaceae* Mirb.	*Ulmus* L.	*Ulmus elliptica* K.Koch	tree	Caucasus, European part of Russia

14	*Malvaceae* Juss.	*Tilia* L.	*Tilia caucasica* Rupr.	tree	Greater Caucasus
15	*Malvaceae* Juss.	*Tilia* L.	*Tilia cordata* Mill.	tree	Western Siberia, Caucasus, Bulgaria.
16	*Juglandaceae* DC. ex Perle	*Juglans* L.	*Juglans regia* L.	tree	Central Asia, Transcaucasia.
17	*Oleaceae* Hoffmanns.	*Fraxinus* L.	*Fraxinus excelsior* L.	tree	Europe, Transcaucasia
18	*Fagaceae* Dumort. nom. cons.	*Castanea* Mill.	*Castanea sativa* Mill.	tree	Western Transcaucasia
19	*Juglandaceae* DC. ex Perleb	*Pterocarya* Kunth.	*Pterocarya pterocarpa* (Michx.) Kunth ex Iljinsk.,	tree	Russia, Georgia, Azerbaijan, Iran, Turkey.
20	*Betulaceae* Gray	*Corylus L.*	*Corylus iberica* Vittm. Et Kem.-Nat.	tree	Greater Caucasus
21	*Rosaceae* Juss.	*Sorbus* L.	*Sorbus caucasigena* Gatsch.	tree or shrub	Greater Caucasus
22	*Rosaceae Juss.*	*Sorbus* L.	*Sorbus torminalis* (L.) Crantz	tree or shrub	Greater Caucasus
23	*Betulaceae* Gray	*Carpinus* L.	*Carpinus orientalis* Mill.	tree	Hungary, Europe, Crimea.
24	*Anacardiaceae* R.Br.	*Rhus* L.	*Rhus coriaria* L.	tree or shrub	North America
25	*Rosaceae* Juss.	*Mespilus* Bosc ex Spach	*Mespilus germanica* L.,	tree or shrub	Southwest Asia, Southeast Europe
26	*Cornaceae* Bercht. & J.Presl	*Cornis* L.	*Cornis mas* L.	tree or shrub	Eastern Europe
27	*Rhamnaceae* Juss.	*Frangula* Mill.	*Frangula alnus* Mill.	tree or shrub	Crimea, Caucasus
28	*Rhamnaceae* Juss.	*Frangula* Mill.	*Frangula alnus* Mill.	tree or shrub	Crimea, Caucasus

4 Conclusion

The scale of threats caused by global climate changes is expanding year by year. Due to climate change, the increase of precipitation, the excessive rise of temperature in summer months may reduce oak forests by 3.0-3.5%, hazelnut forests by 15%, and the area of walnut forests is predicted to decrease by 19%. The total area of broad-leaved tree species (*Carpinus caucasica* A.Grossh., *Fagus orientalis* Lipsky., *Quercus macranthera* Fisch., *Fraxinus excelsior* L., etc.) is 17 thousand ha, soft-leaved - *Tilia caucasica* Rupr., *Tilia cordata* Mill. *Alnus incana* (L.) Moench, *Acer campestre* L., and the total area of tree species is 4 thousand ha (20%), and the area of shrub plants is likely to decrease to 13-14 thousand ha (70%). In general, the forest area is likely to decrease by 7.6 thousand ha. Threats caused by climate change have led to acceleration of erosion processes, reduction of river waters and occurrence of undesirable natural phenomena. The purpose of the study is to expand specially protected natural areas, protect and efficiently use the biological diversity of forests, protect and restore rare and endangered plant species outside their natural habitats (ex-situ conditions), and educate the population about ecology. The main goal in working out these problems is to implement the comprehensive preservation of biodiversity, to prevent processes that will lead to serious consequences.

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