V. FOREST ECOLOGY AND BIOLOGY

INFLUENCE OF CLIMATE CHANGE ON THE SPREAD OF INVASIVE ALIEN PLANT SPECIES IN THE TERRITORY OF THE LOZENSKA MOUNTAIN

Plamen Glogov, Dimitar Dimitrov

Abstract: The paper presents a comparative analysis of the data on the main climatic components for three periods - 1921-1945; 1965-1975; 2000-2015 and their connection with the distribution of Invasive alien plant species (IAS) on the territory of Lozenska Mountain. Among the most important features of the mountain's climate that favorably affect the spread of IAS are the two precipitation maximums and minimums and the period of drought. In response to climate and other environmental changes, IAS on the territory of the mountain are spread in two ways - by forming monodominant communities in extreme habitats or by integrating their populations into the local communities and gradually increasing their presence in them, accompanied by changing ecological conditions of the habitat. Four potential invasive alien plant species (PIAS) have been identified: *Opuntia fragilis* (Nutt.) Haw., *Opuntia engelmannii* Salm-Dyck ex Engelmann, *Lupinus polyphylus* Lindl., *Impatiens baulfourii* Hook.f., to which population monitoring and control measures need to be implemented.

Key words: adaptation, climate change, invasive alien species, flora, vegetation.

INTRODUCTION

Anthropogenic pressure on the one hand [13]; [22] and climate change on the other have a significant impact on ecosystem components and on forest ecosystems in particular [2]; [3]; [14]; [15]; [16], and this may have an adverse effect on human health [4]. Climate change may create more favourable conditions for invasive alien species (IAS) and new opportunities for their reproduction and spread. This is the reason why the combined impact of climate change and IAS has received more attention in recent years [21]. As a result of climate change, native species and ecosystems will be less competitive and more vulnerable to the threat posed by IAS. Some habitats, such as temperate forests and freshwater ecosystems, which currently have thermal barriers limiting the spread of IAS, will become suitable for alien species as the climate changes [17].

The feedback concerning the impact of IAS on climate change is also very strong. Displacing the native species, IAS can directly alter the temperature gradient and humidity, initiating erosion processes, floods, and other; they can cause an environmental catastrophe that will drastically affect the climate of a territory. In many cases, the vector of this feedback relationship between IAS and climate is the person who intentionally, or inadvertently, transfer these species to a new favorable environment for them. There are a lot of harmful effects of the IAS introduction caused by good human stimuli. For example, in order to reduce harmful emissions, many producers have turned to the use of biomass for the production of biofuels from IAS, thereby increasing

their populations by cultivating them artificially. Another similar example is the so-called "assisted colonization" [21], in which humans intentionally move alien species into new habitats to "save" them from the climate change.

An important task for modern scientists and conservationists is to identify IAS who have the potential to become invasive due to the climate change. Regular monitoring of their populations and control measures are required before their change and expansion processes are irreversible [17]. The selection of suitable pilot areas – parts of natural territories affected by IAS, in which it is possible to monitor, evaluate and control populations of these species and subsequently to develop good practices for combating them, is key to the right management policy for IAS. Such a pilot area is the territory of Lozenska Mountain, which is involved in a number of scientific projects aimed at studying the spread of populations of IAS, its relation to climate change, the anthropogenic factor and natural successions and fluctuations of local vegetation.

In the first systematic studies of the vegetation of Lozenska Mountain, Ganchev (1961) did not report the presence of IAS [8]. Subsequently, in another phytosociological study, Bondev and Nikolov (1979) [5] also did not mention the presence of an adventive floristic elements (except for *Robinia pseudoaccacia* L.) among the vegetation in the Iskar River gorge between Plana and Lozenska mountains, although riparian habitats are preferred by many IAS. Glogov et al. (2019) [11] identified 27 IAS, representing 3.3% of the entire flora of Lozenska Mountain and about half of the IAS found in Bulgaria [20]. Seven species

are very aggressive – *Ailanthus altissima* Mill., *Amorpha fruticosa* L., *Bidens frondosa* L., *Acer negundo* L., *Falopia X bohemica*, *Opuntia humifusa* Raf. and *Robinia pseudoacacia*. The most widespread in the mountain range are the species *Robinia pseudoacacia*, *Erigeron canadensis* (L.) Cronquist and *Xanthium italicum* Moretti. The IAS with the highest cover abundance are *Elodea canadensis*, *Impatiens glandulifera*, *Falopia* × *bohemica* and *Sorghum halepense* Pers. A potential threat from the impact of the populations of IAS on the territory of the Lozenska mountain exists for the following habitats of Annex I to Directive 92/43 / EEC: 3150 (Natural eutrophic lakes with Magnopotamion or Hydrocharition – type vegetation) and 3270 (Rivers with muddy banks with *Chenopodium rubri* pp and *Bidens* pp vegetation) included in NATURA 2000.

MATERIALS AND METHODS

Lozenska Mountain is part of the Sredna Gora floristic region. The mountain falls into the Transitional Climate Zone [23]. The predominant soil types are Chromic Luvisols (in the area of xerothermic oaks) and Dystric-Eutric Cambisols (in the area of beech forests) [18]. The Mountain is part of the floristical region Sredna Gora, subregion Western Sredna Gora. The vascular flora of the mountain consists of 875 species from 379 genera and 91 families [9]. The vegetation is dominated by broad leaved deciduous forests and shrubs. The vegetation type is represented by xerothermic oak forests (including communities from the alliance *Quercion frainetto*), mesophytic oak forests (*Quercion roburis petraeae*), hornbeam forests (*Carpinion betuli moesiicum*) and beech forests (*Fagion moesiicum*). Shrub communities belong to alliances *Syringo-*

Carpinion orientalis and *Crataego-Corylion* [7]; [8]. Part of the mountain area (12944.2 dka) has the status of BG0000165 Protected Area under Council Directive 92/43/ EEC for the Conservation of Natural Habitats and Wild Flora and Fauna, adopted by Council of Ministers Decision No 122 / 02.03.2007 [6].

A comparative analysis of the data on the main climatic elements – temperature, precipitation, atmospheric humidity on the territory of Lozenska Mountain for three periods – 1921-1945 [8], 1965-1975 [5], 2000-2015 [10]. Glogov et al. (2019) analyzed the established IAS on the territory of the Lozenska Mountain by biomorphological, ecological and phytogeographic characteristics [11]. The connection between the peculiarities and the dynamics of the climatic indices during the different periods and the occurrence and spread of IAS on the territory of the mountain was sought. On the basis of their degree of naturalization and ecological strategy, potential invasive alien species (PIAS) have been identified, whose populations may spread to the territory of Lozenska Mountain due to climate change and other factors with cumulative impact.

RESULTS AND DISCUSSION

The comparison of temperature data for the three investigated periods (Table 1) shows that for the last 100 years the average annual temperature in the mountain area has increased by 1 degree. The values of maximum and minimum temperatures do not differ significantly. There is no change in the months in which these temperature extremes occur. These indicators are fully consistent with the spread of IAS over the thermoclimatic gradient. 77.4% of them are microtherms, ie plants of moderately cold areas [19].

Table 1. Comparison of temperature data on the territory of the Lozenska Mountain

Period (years)	Average annual temperature (°C)	Average temperature minimum (°C)	Month with temperature Minimum	Average temperature maximum (°C)	Month with temperature Maximum
1921-1945 г.	9.06	-2.1	January	20.0	July
1960-1980 г.	9.8	-1.9	February	20.6	July
2000-2015	10.5	-2.5	January	21.5	July

The results from the comparison between the values of precipitation amounts are similar to those concerning the temperature (Table 2). The annual

rainfall has decreased by 10 mm in the last period and there is a shift in the precipitation minimum at the beginning of the winter season.

Table 2. Comparison of the precipitation data on the territory of Lozenska Mountain

Period (years)	Mean annual precipitation sum (mm)	Average precipitation minimum (mm)	Month with precipitation minimum	Average precipitation maximum (mm)	Month with precipitation maximum
1921-1945	594	23.0	February	98.0	May- June
1960-1980	600	22.5	February	88.0	May- June
2000-2015	590	22.8	December	81.5	May- June

An important feature of the precipitation regime on the territory of Lozenska Mountain is the presence of a second maximum – in June and the second minimum in August. The presence of primary and secondary precipitation maximums is a sign of the Mediterranean climate impact on the mountain [12], which together with the temperature distribution determines a long period of vegetation. These features favor the spread of IAS, which, for the most part, are polycarpic plants with a long flowering period and a strong environmental strategy that allows them to tolerate droughts slightly.

In the biological spectrum of the IAS identified, the presence of phanerophytes, chaemicryptophytes and therophytes is equal – 29% of all species [11], which shows that the ecological and in particular climatic conditions of the mountain are equally favorable for species with different duration of their life cycle.

Lozenska Mountain is characterized by a small number of days without sunshine (61 days a year), especially during the growing season (April-September). This favors the spread of light-loving plants (heliophytes and heliosciophytes) to which ecological groups 90.3% of the established IAS belong.

With regard to the atmospheric humidity factor, the distribution of the climate elements over the three studied periods per month clearly outlines two hydrothermal phases – wet and cool (late autumn, winter and early spring) and dry and hot (summer). The period of atmospheric humidity starts from mid-July and lasts until the end of September. The driest period, characterized by humidity between 65 and 68% in the period 1921-1945 was observed in September, and in the other two periods – in the second half of August. In terms of their affinity for atmospheric humidity, the percentage distribution of IAS on the territory of the Lozenska mountain is the following [11]: 41.9% are attached to high atmospheric humidity, 35.5% to medium and 22.6% to low humidity. The species in the first group are distributed near water

bodies (rivers, lakes and dams located around the mountain).

Most IAS originate in America (64.5%) and 54.8% are from North America. IAS of Asian origin represent 12.9%, followed by European-Asian (9.7%), Cosmopolitan (6.5%), Sub-Mediterranean (3.2%) and European (3.2%) elements [11]. Geographically the outermost and isolated IAS prove to be the greatest threat to native species, as they have few or no natural enemies (pests and pathogens) on the territory of the mountain (as well as across the country) to regulate their numbers. Climatic barriers are not a problem for them, as they usually come from harsher conditions (desert areas – *Opuntia humifusa* or above 3000 m a.s. l. in the Himalayas – *Impatiens glandulifera*).

On the territory of Lozenska Mountain, climate change in constant synthesis with anthropogenic factor provokes two approaches to the action of IRF. The first approach is the formation of monodominant communities from populations of an invasive species (*Sorghum halepense* Pers., *Opuntia humifusa*, etc.) in restricted habitats where conditions are more extreme than in most places in the mountain, but and most favorable to this species. In them, competition from native species is poor. The other approach is the competitive struggle of IAS and the formation of mixed phytocenoses of them with native species (*Acer negundo*, *Falopia X bohemica*, *Amaranthus retroflexus*, *Impatiens glandulifera*). In which the IAS gradually began to dominate and change the habitat, worsening the conditions for the native species. With regard to the so-called. potentially invasive species (PIAS) at this stage have been identified the following plants:

Opuntia fragilis (Nutt.) Haw. and *Opuntia engelmannii* Salm-Dyck ex Engelmann – two representatives of the Cactaceae family, registered in one location of a steep naked scree above the Pancharevo Dam with southwestern exposure. Their population is several hundred individuals planted there intentionally and naturalized long ago.

Populations of both species are slowly spreading, but there is a risk that local populations of species that grow near and fall under the protection of the Biodiversity Act (2002) – *Orchis purpurea* Huds. and *Stipa epilosa* Martinovský are in the area [1]. The most appropriate measure to combat at this stage is the mechanical removal of individuals.

Lupinus polyphylus Lindl – a North American species of the Fabaceae family. It has been established in three localities on the territory of Lozenska Mountain – near the villa zones of the villages of Pasarel and German, where it occupies an approximate total area of 500 m². The species has certainly spread from the gardens of abandoned old houses. It has long since become naturalized and at this stage coexists with native species, but with each passing year the size of its populations increases with its projective coverage among other species in the communities. Given that *Lupinus polyphylus* is a strong melliferous plant, it is most appropriate to limit seed propagation by cutting off the flowering part of the stems before fruiting. Thus the population of the species can only be controlled by its vegetative propagation.

Impatiens baulfourii Hook.f. – a species native to Asia from the Balsaminaceae family. A population of about 300 individuals has been identified in the land of the village of Dolni Lozen. The plant is ornamental, has escaped from the gardens and has naturalized. It forms monodominant coenoses, withstands shade and hides a potential risk of uncontrolled spread due to its beautiful habitat. Given the high invasiveness of his dangerous relative, *Impatiens glandulifera*, proactive measures are needed to limit its population. In this case, too, like the previous ones, mechanical controls are most appropriate.

CONCLUSIONS

The climate acts jointly and reciprocally with other environmental and anthropogenic factors on the spread of the IAS in the Lozenska Mountain.

Among the most important features of the climate of the mountain that contribute favorably to the distribution of the IAS are the two precipitation maximums and minimums and the period of drought;

In response to climate and other environmental changes, the IAS on the territory of the mountain are spread in two ways – by forming monodominant communities in extreme habitats or by integrating their populations into the local communities and gradually increasing their presence in them,

accompanied by changes in the ecological conditions of the habitat.

Four potentially invasive species have been identified and need to be implemented for population monitoring and control measures.

ACKNOWLEDGMENTS. *This work has been carried out in the framework of the National Science Program "Environmental Protection and Reduction of Risks of Adverse Events and Natural Disasters", approved by the Resolution of the Council of Ministers № 577/17.08.2018 and supported by the Ministry of Education and Science (MES) of Bulgaria (Agreement № Д01-322/18.12.2019).*

REFERENCES

1. Biodiversity Act., 2002, SG, issue 77. (Last amended, SG No. 98 of November 27, 2018). (In Bulgarian).
2. Bogdanov S., Restoration of Forests on Soils Influenced by Forest Fires in Bulgaria. Journal of Balkan Ecology, 2008, vol. 11, No 4, p. 413-419.
3. Bogdanov S., Forest fire influence on soil texture in burned forests in Bulgaria. Forestry Ideas, 2012, Vol. 18, 2(44): 155-162.
4. Bogdanova K., Milikina D., Bogdanov S., Soil degradation -major factors and health consequences. 44th Scientific and Technological Session "Contact", Sofia (25 October, 2019). Civic idea in action. Conference proceedings. Temto, ISSN 1313-9134, 2019, pp. 151-158. (In Bulgarian).
5. Bondev I., Nikolov V., The vegetation cover in the Iskar River gorge between the Plana and the Lozen mountains, *Phytology*, 1979, 13, 3-30. (In Bulgarian).
6. Council Directive 92/43/EEC of 21 May 1992 *On the conservation of natural habitats and of wild fauna and flora* OJ L 206, 1992, 7–50.
7. Dimitrov M., Glogov P., Characteristic syntaxa of forest phytocenoses in Lozenska Mountain. In: Kostov G. (ed.): *Collection of Scientific Reports "50 Years University of Forestry, Forest Management and Landscape Architecture"*. University of Forestry, Sofia, 2003, 15–20. (In Bulgarian).
8. Ganchev I., *Vegetation of the Lozen mountain and peculiarities in its development*, BAS, Sofia, 1961, 193 pp. (In Bulgarian).
9. Glogov P., Delkov A., Results from investigation of vascular flora on the territory of Lozen mountain. *Forest Science*, Sofia, 2016, 52(1–2), 5–46. (In Bulgarian).

10. Glogov P., *Study of the Vascular Flora and Analysis of the Dendroflora of the Lozenska Mountain*. PHD thesis. Specialty Forestry (incl. Dendrology). Forest Research Institute – BAS, 2017, 120pp. (In Bulgarian).
11. Glogov P., Pavlova D., Georgiev M., Dodev Y., Gyudorova S., A survey of invasive alien species in the flora of Lozenska Mountain, Bulgaria. *Botanikai Közlemények*, 2019, 197-216.
12. Gurov G., Artinova N., *Soil knowledge*. Ed. Intellespert-94, 2015, 200-201. (In Bulgarian).
13. Hristov B., The soils of Botevgrad valley. *Ecological Engineering and Environment Protection*, 2020, No 2, pp. 52-62.
14. Ilinkin V. M., Statistical Assessment of Alluvial-Meadow Soils Located in Busmantsi Sand and Gravel Mining Field, Sofia, Bulgaria. *Ecologia Balkanica*, 2019a, 11(1), pp. 75-84.
15. Ilinkin V. M., Landscape Planning for" Kubratovo 1" Sand and Gravel Deposit Located on Alluvial Meadow Soil, Sofia Region, Bulgaria. *Ecologia Balkanica*, 2019b, 11(2), pp. 1-11.
16. Ilinkin V., & Dimitrova V., Forestry Reforestation vs. Spontaneous Revegetation-Soil Changes in Coal Mining Spoil Heaps Across Bulgaria. *Ecologia Balkanica*, 2019, 11(2), pp. 25-36.
17. IUCN, *Invasive alien species and climate change*, 2020, <https://www.iucn.org/resources/issues-briefs/invasive-alien-species-and-climate-change>.
18. Ninov N., Soils. In: Galabov Zh. (Ed.). *Geography of Bulgaria*, 1, Publ. House BAN, Sofia, 1997, 225-257. (In Bulgarian).
19. Pavlov D., *Phytocoenology*. Publishing house of LTU. 2006, 252 pp. (In Bulgarian).
20. Petrova A., Vladimirov, V. & Georgiev V., *Invasive Alien Species of Vascular Plants in Bulgaria*, IBER - BAS, Sofia, 2013, 320 pp.
21. Scalera R., The impacts of invasive alien species in Europe. *EEA Technical report No 16/2012. European Environment Agency Luxembourg: Publications Office of the European Union*, 2012, doi: 10.2800 / 65864.
22. Tsoleva V., Hristov B., Nikova I., Zdravkov A., & Ruskov K., Pedogeochemical hallmarks of chromium, nickel and vanadium distribution in bobov Dol valley, Bulgaria. *Silva Balcanica*, 2018, 19, 1, pp. 43-55.
23. Velez S., Climatic regionalization. In: Jordanova, M. Dochev D. (Eds.). *Geography of Bulgaria*. Publ. House BAN, Sofia, 1997, 127-130. (In Bulgarian).

Plamen Stankov Glogov, PhD

Dimitar Dimitrov

Forest Research Institute,
Bulgarian Academy of Sciences
132 „Kliment Ohridski” Blvd,
1756 Sofia, Bulgaria

e-mail: plglogov@abv.bg

e-mail: mitkomit@mail.bg