INFLUENCE OF UNDERGROUND WATER CHANGES ON STRUCTURE AND QUALITY OF VEGETATION

Ivan Ilʼko[1], Viera Peterková[1], Slavomír Vojtilla[2], Marcel Račekˇ[3]

[1]Department of Biology, Faculty of Education, Trnava University in Trnava, Priemyselná 4, 918 43, Trnava, Slovak Republic

[2]Tatravagónka a.s., Štefánikova 887/53 Poprad, Slovak Republic

[3]Institute of Landscape Architecture, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic

https://doi.org/10.11118/978-80-7509-963-1-0178

Abstract

Among the main ecological factors of soft floodplain forests are regular flooding with surface water lasting several days. Changes in groundwater levels and the transport capabilities of watercourses can cause the decline of soft floodplain forest trees and the gradual transition to communities of hardwood floodplain forest. In the event of changes in water supply occurring over a short period of time, there is a significant increase in the risk of spreading non-native invasive plant species. The aim of the study was to determine the impact of the transport capacity of the Hron River watercourse on the habitats of Willow-Poplar lowland floodplain forests and Oak-Ash-Elm lowland floodplain forests in the study area. Field surveys and data collection were conducted in selected sections of the Hron River near the villages of Pohronský Ruskov and Čata in southern Slovakia. The results indicate that the tree layer consists of individuals of *Salix alba L*. and *Populus sp.* The understory is almost 80 % composed of the invasive species *Negundo aceroides Moench*., which aggressively displaces remnants of original habitats. Considering the age of the oldest individuals, we assume that the changes in habitats began 40-50 years ago. Young individuals of *Salix sp.* and *Populus sp.* are missing in the stand. Similarly, species typical of hardwood floodplain forest communities are absent. It follows that the floodplain forest at the study site is very species-poor, which may have an extremely negative impact on the ecosystem services provided by the forest.

Keywords: invasive plants, forest ecosystem services, river bed, biotope

Introduction

Human beings live in an environment on which they are fully dependent. The concept of ecosystem services as benefits of ecosystems has its roots in efforts to identify the significance of nature for human life and human society (Eliáš, 2010). Knowledge about vegetation, which plays a significant role in maintaining or restoring the 'biological balance of the landscape,' began to be applied in the preparation of landscape biological plans. Forests are among the most significant landscape-ecological stabilization elements. The interest in utilizing all functions of the forest led to their detailed categorization and evaluation, quantification of functions, and development of methodologies for their valuation (Papánek, 1978). Anthropogenic activity is associated with damaging original ecosystems and their colonization by invasive species. Many studies describe the impact of human activity on the alteration of original ecosystems (Vasekova & Stefunkova, 2019; Vasekova, 2019; Rendeková et al., 2019; Pauková, 2019). Invasive plants are characterized by high regenerative potential and negative impact on populations of our native species and habitats. They are often perennial species with vegetative propagation and regenerative ability. The occurrence of these plant taxa in a given locality is not natural, and their presence outside their natural habitat is most commonly caused by anthropogenic activities (Vasekova, 2019). A decrease in groundwater level leads to changes in ecosystems and possible replacement by invasive plants (Ponomareva et al., 2021). Among the main ecological factors of soft floodplain forests are regular flooding by surface, slowly flowing water for several days, or occasionally weeks several times during the growing season, as well as increased groundwater levels (Eliáš, 2010). Regulation of watercourses and drainage prevents regular flooding of the original floodplain forest, thereby weakening its health status and improving conditions for the spread of non-native species. The aim of this study was to determine the impact of the Hron River's transport capacity on floodplain forest habitats in the

study area. The paper also focused on the occurrence of invasive woody plants and their impact on riparian vegetation.

Materials and methods

According to the regional geomorphological classification of Slovakia, the area of interest and its wider surroundings belong to the region of the Danubian Lowland, the Podunajská Hills unit, the Hronská Hills subunit, the Hronská Floodplain, and the Ipeľ Hills (Minár & Machová, 2010). Geographically, the evaluated area is located on the lower course of the Hron River, at river kilometer 23.500, between the municipalities of Čata and Pohronský Ruskov, cadastral area of Čata, district of Levice, Nitra region (47°57'55.3"N 18°39'52.9"E) (Fig. 1). The Hron River is characterized by meanders with the formation of local shoals, deep pools mainly in concave bends, random gravel deposits – locally extensive, which change in response to sudden and steep changes in water flow in the river. The groundwater level fluctuates depending on the state of the Hron River and the intensity of precipitation. In most of the area it is at depths of about 3.5- 4 m. As a result of the modifications of the river in previous periods, which ultimately led to the straightening of the river and its acceleration at higher flows, the Hron River has deepened by 0.5- 1.8 m. As a consequence, the groundwater level in the vicinity of the river has dropped, which has also had an impact on the plant communities occurring in the riparian zone (Pikus, 2011).

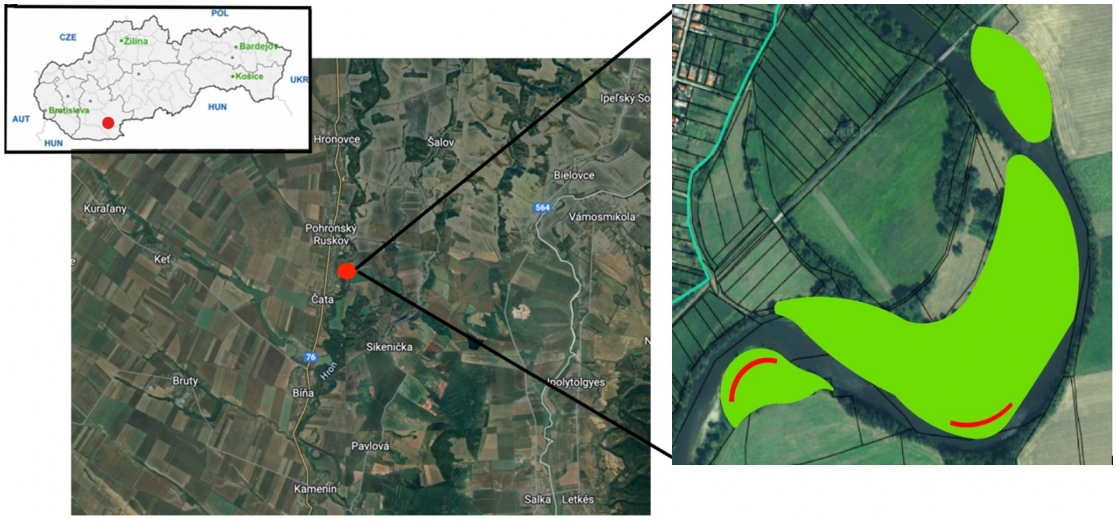

Fig. 1: Location of study area in Slovakia (red dot- study area, red line- original bank 50- 70 years ago, green area- assessed area)

The area in question is classified as a first-degree protected area according to Act No. 543/2002 Coll. on Nature and Landscape Protection, as amended (hereinafter referred to as the "Act") (§ 11 and § 12). The area in question is not included in the national list of protected bird areas or in areas of European significance. Field surveys were conducted during the growing season. The boundaries of the area of interest were established and based on the terrain features it was divided into smaller area units. During the assessment, the occurrence of individual species and their abundance in the stand were recorded. Species identification was carried out directly on site using identification keys. Taxon nomenclature followed Marhold (1998). The occurrence of individual species was recorded in tables using Microsoft Excel software. The obtained dataset was further evaluated, and dominant species representation was determined.

Results

The results of the field survey of flora revealed the presence of heterogeneous communities of trees in the vicinity, which are differentiated in terms of age, vertical, and partially horizontal distribution. The age composition of trees in the inner part of the meander clearly indicates the eastward shift of the river. Old tree specimens form linear features in the shape of arcs,

indicating that they formerly constituted riparian stands. With increasing distance from the river, tree specimens are older. Within approximately 100 meters from the current riverbank, the stand is predominantly composed of representatives of the genus *Salix sp.* The tree vegetation is almost exclusively comprised of individuals of *Salix alba L.* Due to the unstable substrate, most trees are unstable, and the angle of their trunks with the terrain plane ranges from 50 to 70°. The understory in this area is predominantly composed of *Negundo aceroides Moench.,* constituting about 80 %, along with approximately 28 % of *Sambucus nigra L., and Salix sp.,* with very few individuals of *Euonymus europaeus L., Robinia pseudoacacia L., and Prunus avium L. Occasionally*, shoots of *Acer campestre L.* were observed. The lower herbaceous layer is almost continuously covered by Urtica dioica L., with a mixture of *Humulus lupulus L., Rubus caesius, Solidago canadensis*, and the spreading invasive plant *Fallopia japonica Houtt*. Additionally, we observed old specimens of *Populus sp.,* which, according to the inclination of their trunks towards the river, evidently formed riparian stands. The estimated age of these poplars is approximately 60- 70 years. From this, it can be inferred that the river shifted in the furthest part of the meander by almost 120 meters eastward during the given period. Furthermore, the area is surrounded by a tree stand almost exclusively comprised of senescent individuals of *Populus sp*. Identifying the species of the *Populus genus* is not straightforward, as they are overaged individuals with reduced vitality and health condition. It is most likely euro-American technical hybrids of poplars, as almost 95 % of floodplain forests in the vicinity of larger rivers have been replaced by these fast-growing individuals since 1950. The fact that the forest stand is species-poor is concerning. Young specimens of *Salix sp.* and *Populus sp.* are found only on unstable gravel bars near the watercourse. However, they are absent in the stand. Similarly, there is a lack of more significant representation of indigenous species characteristic of this habitat, such as Fraxinus excelsior L., Ulmus laevis Pall., species of the genus *Quercus sp.* and *Alnus glutinosa L.,* or *Populus alba L*. and *Populus nigra L.* As a result, the floodplain forest in this area is species-poor. It suffers from the spread of invasive species, which displace indigenous trees typical for this region. Old specimens of dying poplars are mere relics of the original floodplain forests that were once found here, and new shoots of poplars have almost disappeared from the stand. In this area, invasive species *Negundo aceroides* and *Fallopia japonica* are spreading uncontrollably. These invasive species are not native, have few natural pests, and aggressively outcompete indigenous species from their original habitats.

Discussion

Analyses of fauna in Slovakia, in areas influenced by human activity, have recorded a significant occurrence of invasive species taxa (Rendeková, Mičieta & Randáková, 2020; Vaverková et al., 2019). Plants from the genus *Solidago* can have a serious impact on the ecosystems they inhabit. Results have revealed that the invasion of *S. gigantea* has significantly altered several soil properties and is associated with various soil characteristics. Soil acidity has increased, while the content of organic carbon and moisture has decreased (Bobuľská et al., 2019). Vasekova et al. (2019) focused on the riparian occurrence of invasive plants and their negative impact on native ecosystems in Slovakia. The authors recorded the presence of *Fallopia japonica*, leading to a loss of natural vegetation in the vicinity. Rendeková & Mičieta (2017) demonstrated a decline in archaeophytes due to urbanization. Pauková et al. (2018) documented the occurrence of the invasive tree *Negundo aceroides* in floodplain forests in Bratislava (Slovakia). According to Hrivnák et al. (2019), increased invasiveness and the spread of alien species into new habitats can be expected due to climate change and intensified land use. Medvecká et al. (2018) investigated the impact of invasive species on forest ecosystems used for logging. They found that these forests are more sensitive to the occurrence of invasive species compared to forests where logging does not take place. Our survey demonstrated the negative impact of anthropogenic changes in the Hron River watercourse on floodplain forest habitats in the studied area. The aforementioned studies also indicated the negative impact of anthropogenic activities on forest ecosystems, leading to the spread of invasive plants. The spread of invasive species can negatively affect ecosystem services, making it important to pay attention to this issue.

Conclusion

Regulatory interventions on the watercourse of the Hron River have increased the longitudinal slope and the transport capacity of the flow, leading to incision of the riverbed and a decrease in

surface groundwater levels. The decline in groundwater levels results in the decline of floodplain forests and their replacement. Our survey highlighted the fact that the studied forest stand is species-poor. There is also a lack of more significant representation of indigenous species characteristic of this habitat. Furthermore, the habitat suffers from the spread of invasive species, which displaces indigenous trees typical for this region. In the studied area, invasive species such as *Negundo aceroides* and *Fallopia japonica* are spreading uncontrollably. These invasive species are not native, have few natural pests, and aggressively outcompete indigenous species from their original habitats. The presented study can provide information on the impact of regulatory mechanisms on watercourses on native floodplain forests and their replacement by invasive species, which can have an extremely negative impact on forest ecosystem services.

References

Bobuľská, L., Demková, L., Čerevková, A., & Renčo, M. (2019). Invasive goldenrod (Solidago gigantea) influences soil microbial activities in forest and grassland ecosystems in central Europe. Diversity, 11(8), 134.

Eliáš, P. (2010). Ekosystémové služby a kvalita života ľudí vo vidieckych oblastiach. Životné prostredie, 44(2), 88-91.

Hrivnák, R., Medvecká, J., Baláži, P., Bubíková, K., Oťaheľová, H., & Svitok, M. (2019). Alien aquatic plants in Slovakia over 130 years: historical overview, current distribution and future perspectives. NeoBiota, (49).

Marhold, K. (1998). Ferns and flowering plants. In K. Marhold & F. Hindák (Eds.), Checklist of non-vascular and vascular plants of Slovakia (pp. 333–687). Veda.

Medvecká, J., Jarolímek, I., Hegedüšová, K., Škodová, I., Bazalová, D., Botková, K., & Šibíková, M. (2018). Forest habitat invasions–Who with whom, where and why. Forest Ecology and Management, 409, 468-478.

Minár, J. a Machová, Z.: Učebné texty z geomorfológie [online]. Bratislava: Univerzita Komenského v Bratislave, Prírodovedecká fakulta, 2010. [cit. 2024-03-25]. Dostupné z: http://fns.uniba.sk/geomorfoskripta.

Papánek, F. (1978). Teória a prax funkčne integrovaného lesného hospodárstva. Lesnícke štúdie 29, VÚLH.

Pauková, Ž. (2019). Occurrence and spread after 18 years of invasion by Fallopia × bohemica (Slovakia). Journal of Ecological Engineering, 20(3), 85-90.

Pauková, Ž., Buchta, T., Vykouková, I., Karlik, L., & Hriník, D. (2018). Contribution to the knowledge on composition phytocoenoses floodplain forests in the Dunajske ostrovy Nature Reserve (Slovakia). Zprávy Lesnického Výzkumu, 63(1), 53-60.

Pikus, M. 2011: Vodné dielo Čata, štúdia. Hydroenergia, s.r.o., Bratislava Hegeduš P., Pikus M., Tarbajovský L. 2012: Vodné dielo Čata - Zámer činnosti podľa zákona č.24/2006 Z.z. o posudzovaní vplyvov na životné prostredie, Hydroenergia, s.r.o., Bratislava.

Ponomareva, T., Shtang, A., Yarygina, O., & Selyanina, S. (2021, April). An assessment of the impact of the groundwater level decline during the open-pit extraction on the state of the subarctic wetlands. EGU General Assembly Conference Abstracts, EGU21-4358.

Rendeková, A., & Mičieta, K. (2017). Changes in the representation of alien taxa in ruderal vegetation of an urban ecosystem over 50 years. A case study from Malacky city, Slovakia, Central Europe. Urban Ecosystems, 20, 867-875.

Rendeková, A., Micieta, K., Hrabovsky, M., Eliasova, M., & Miskovic, J. (2019). Effects of invasive plant species on species diversity: implications on ruderal vegetation in Bratislava City, Slovakia, Central Europe. Acta Societatis Botanicorum Poloniae, 88(2).

Rendeková, A., Mičieta, K., Randáková, Z., et al. (2020). Flora of the tram tracks of Bratislava. Urban Ecosystems, 23, 875–891. https://doi.org/10.1007/s11252-020-00952-0.

Vasekova, B., & Stefunkova, Z. (2019, November). Negative Impact of Invasive Plants on Riverbank Vegetation. IOP Conference Series: Earth and Environmental Science, 362(1), 012072. https://doi.org/10.1088/1755-1315/362/1/012072.

Vasekova, B., Nemetova, Z., Keszeliova, A., & Stefunkova, Z. (2019). Mapping invasive plants in riverbank vegetation. IOP Conference Series: Earth and Environmental Science, 221(1), 012109. https://doi.org/10.1088/1755-1315/221/1/012109.

Vaverková, M. D., Maxianová, A., Winkler, J., Adamcová, D., & Podlasek, A. (2019). Environmental consequences and the role of illegal waste dumps and their impact on land degradation. Land Use Policy, 89, 104234.

Acknowledgement
This paper is an outcome of the educational project KEGA 004SPU-4/2023 KR:EK:IN - Landscape Economy for Innovative and Sustainable Interdisciplinary University Education in Slovakia supported by the Ministry of Education, Science, Research and Sport of the Slovak Republic (MŠVVŠ SR) within the Cultural and Educational Grant Agency (KEGA).

Souhrn
Mezi hlavní ekologické faktory měkkých lužních lesů patří pravidelné několikadenní záplavy povrchovou vodou. Změny hladiny podzemní vody a transportní schopnosti vodních toků mohou způsobit úbytek dřevin měkkého lužního lesa a postupný přechod ke společenstvům tvrdého lužního lesa. V případě změn v zásobování vodou, ke kterým dochází v krátkém časovém období, se výrazně zvyšuje riziko šíření nepůvodních invazních druhů rostlin. Cílem studie bylo zjistit vliv transportní kapacity vodního toku Hron na stanoviště lužních lesů studovaném území. Terénní průzkum a sběr dat byl proveden na vybraných úsecích řeky Hron u obcí Pohronský Ruskov a Čata na jižním Slovensku. Výsledky ukazují, že stromové patro tvoří jedinci *Salix alba L.* a *Populus sp.* Podrost je téměř z 80 % tvořen invazním druhem *Negundo aceroides Moench.* který agresivně vytlačuje zbytky původních stanovišť. Vzhledem ke stáří nejstarších jedinců předpokládáme, že změny stanovišť začaly před 40- 50 lety. Mladí jedinci *Salix sp*. a *Populus sp.* v porostu chybí. Stejně tak chybí druhy typické pro společenstva tvrdých lužních lesů. Z toho vyplývá, že lužní les na studované lokalitě je druhově velmi chudý, což může mít mimořádně negativní dopad na ekosystémové služby, které les poskytuje. Námi provedený průzkum prokázal negativní vliv antropogenní změny vodního toku řeky Hron na stanoviště lužních lesů ve zkoumané oblasti. Šíření invazních druhů může negativně ovlivnit ekosystémové služby, proto je důležité věnovat této problematice pozornost.

Contact:
PaedDr. Ivan Ilko, PhD.
E-mail: ivan.ilko@truni.sk