

## Occurrence and Spread after 18 Years of Invasion by *Fallopia* × *bohemica* (Slovakia)

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### ABSTRACT

At the global level, the invasion of alien organisms is considered the second largest threat to biodiversity. Hybrid Japanese Knotweed (*Fallopia* × *bohemica*) is an invasive alien species in Slovakia, which is indigenous to eastern Asia. Ragweed is a significant threat to agriculture in Central Europe. In this study, we compare the current occurrence and spread of invasive populations of hybrid *Fallopia* × *bohemica* (*Polygonaceae*) in Hlohovec town (SW Slovakia) in intensively farmed agricultural landscape after eighteen years. In 2001, it had colonized the area of 1520 m<sup>2</sup> on 54 localities and in 2011 it increased by 120% (3338 m<sup>2</sup>, 63 localities); however, in 2018 it decreased by 9% (3051 m<sup>2</sup>, 43 localities). Surprisingly, the research results in the period 2011–2018 showed that the further spread of hybrid in Hlohovec was not confirmed; even the total colonized area had decreased. The main reason for the reduction of surface area occupied by *F.* × *bohemica* is the management measures carried out on habitats railway communications, roads and extensively cultivated fields (home gardens). The size of the areas in 2018 was significantly dependent on the size of the areas in 2001 ( $r = 0.682$ ) and in 2011 ( $r = 0.907$ ).

**Keywords:** agricultural landscape, invasive plant, mapping, *Fallopia*, management.

### INTRODUCTION

Invasive plants are defined as non-native species that spontaneously spread and displace native species from their natural biotopes and reduce the biodiversity [Act No. 543/2002 on Nature and Landscape Protection]. The valid list of invasive plant species in Slovakia is presented in the regulation No. 24/2003 and No. 158/2014. In Slovakia, three taxa of the *Fallopia* genus belong to the invasive plant species, which have to be eliminated, according to the law. Successfully spreading species in Slovakia include *F. japonica* (Japanese knotweed), *F. sachalinensis* (Giant knotweed) and their hybrid *F.* × *bohemica*.

This paper presents the results of spread of invasive plant populations *Fallopia* × *bohemica* in the urban area of Hlohovec town (SW Slovakia) after eighteen years, evaluation of the selected population-biological characteristics and performance of the plant management. The release of invasive plant species from urban area into undeveloped area is possible. It can threaten

biodiversity and cause farmers and policy holders to bear the cost of its removing. With this study, we want to help to reconstruct the expansion of selected invasive neophyte on a local level, because there is a lack of detailed studies based on plants-mapping in the chosen location.

### MATERIAL AND METHODS

The *F. japonica* (Houtt.) Ronse Decraene [syn.: *Polygonum cuspidatum* Sieb. et Zucc] and *F. sachalinensis* (F. Schmidt) Ronse Decraene [syn.: *Polygonum sachalinense* F. Schmidt, *Reynoutria sachalinensis* (F. Schmidt) Nakai] species were introduced to Europe from eastern Asia as an ornamental plant in the middle of the 19<sup>th</sup> century and very quickly began to invade [Bailey and Wisskirchen 2006]. Parental species, as well as their hybrid *F.* × *bohemica* [(Chrtková) J.P. Bailey] belong to the plants with clonal growth [Bailey and Wisskirchen 2006,

Barney et al. 2006]. *Fallopia* × *bohemica* is considered as the most troublesome species of the *Fallopia* genus [Sołtysiak and Brej 2012]. The first data about the occurrence of *F. japonica* in Slovakia came from the 1920s and 1930s [Eliáš 2004, Eliáš 2008]. *F. japonica* is a perennial, dioecious plant. The stems are 1.5 m to 3.5 m high, straight, branched at the top, often arcuate, hollow. The base of lower leaves is truncate, apex acuminate, and undersides entirely glabrous. They form an extensive root system, richly branched, reaching up to a width of 15 m to 20 m from the parent plant and a depth of 2 m to 3 m [Bailey and Wisskirchen 2006, Barney et al. 2006, Vinogradova et al. 2010, Rendeková et al. 2018]. It was found for the first time in 1982 near town Náchod in the Czech Republic and described as *Reynoutria* × *bohemica* [Chrtěk and Chrtěková 1983]. All plants have got morphologically androgynous flowers, but functionally unisexual flowers predominate. The fruit is black to black-brown coloured triangular achene. The base of lower leaves is weakly to moderately cordate at base, apex acuminate, and undersides of larger leaver with numerous short stout hairs. The leaves of the hybrid are intermediate in size: between the 15 to 40 × 7 to 25 cm leaves of *F. sachalinensis* and the 15 × 8–10 cm leaves of *F. japonica* [Haines 2011, Invasive Species Compendium 2018].

Hlohovec is located in south-western Slovakia in the Trnava Self-Governing Region. It stretches in a dell between the southern part of mountain range Považský Inovec and a part of the Nitra hill range. River Váh and its alluvium separate it from the Trnava hills. The area of the cadastre is 6412 ha. The urban area is 7 375 677 m<sup>2</sup>, while the number of inhabitants is 22 396. The altitude of the town square is 156 m. Hlohovec belongs to the hot and dry climate zone, with mild winters. A common soil type is brown Luvisol, locally Luvisol from loess and near the river Fluvisol [Šály and Šurina 2002]. Richards et al. [2008] reported Knotweed taxa from saline habitats of The United States. Additionally, they can tolerate sulphurous soils.

The crux of this work is the field research performed during the period May-September 2018, using the mapping method. We recorded taxon, location and type of biotope according to Ružičková et al. [1996]. We measured the size of vegetation area (m<sup>2</sup>) and the height of the highest stems (m). Every shoot with leaves or with side branches and inflorescence was considered as an individual (ramet, i-individual). We found out the

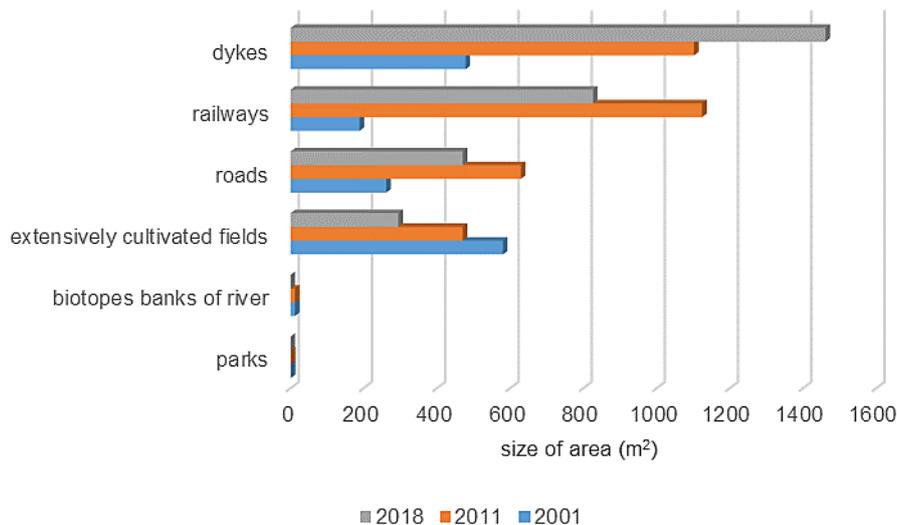
average density of individuals (low 1–15 i.m<sup>-2</sup>, medium 16–30 i.m<sup>-2</sup>, high 31 and more i.m<sup>-2</sup>) with the method of counting individuals, always on a 1×1 m square inside the population in order to avoid the edge effect. The evaluation of ramet density was realized in June, when the number of individuals is highest. We determined the percentage of areas with non-regulated populations, in which the plants have been not removed and regulated ones, where the management measures were performed regularly. The nomenclature of species in communities is referred according to Marhold and Hindák [1998].

## RESULTS AND DISCUSSION

The first record of the collection of *F. japonica* in the form of herbarium sheet in Hlohovec comes from 1966 from the park on the Dilongova street [Ješko and Vavro 1966, Feráková and Ješko 1969]. The occurrence of *F. japonica* and *F. sachalinensis* was not recorded in 2018. During the eighteenth year of research, it 43 localities of hybrid *F. × bohemica* in Hlohovec on the area of approximately 3 051 m<sup>2</sup> have been registered. At the recent spreading, the area colonized by the hybrid in 2018 decreased by 9% in comparison to year 2011 (3338 m<sup>2</sup>, 63 localities). In 2018, has already spread on occupied sites, especially along dykes of the river Váh (48% of the total area occupied by hybrid) and along the railways (27%), less frequently used road (15%) and extensively cultivated fields (10%) (Fig. 1).

Although there is little data on the *F. × bohemica* hybrid, it is likely that they are much more frequent than it is reported in Slovakia. The lack of data must be taken into account in the interpretation of the abundance and distribution of these hybrids [Medvecká et al. 2012]. Hybrid *F. × bohemica* was spread not only in Slovakia [Eliáš 2004, Pauková 2013, Beniák et al. 2015, Fehér et al. 2016], but also in many other countries such as Czech Republic [Chrtěk and Chrtěková 1983], in Poland [Sołtysiak and Brej 2012, Sołtysiak and Brej 2014], Belgium [Tiébré et al. 2008], Austria, Germany, Netherlands, Ireland, Norway [Bailey and Wisskirchen 2006, Follak et al. 2018], USA [Lavoide 2017, Strassel and Connolly 2018] and other.

The comparison of the obtained data on the surface representation of *F. × bohemica* along dykes showed that during the first year of research,



**Figure 1.** Area representation of *Fallopia × bohemica* according to biotope types

the observed plants colonized an area of 478 m<sup>2</sup> Váh [Pauková 2013] and eighteen years later, the area was three times larger (1461 m<sup>2</sup>). The area of localities spreading along the roads and railways decreased by up to 25% and 27% for the last eight years. It was found a significant decrease of the area extensively cultivated fields (home gardens) by 49% (Fig. 1).

In the last years, mainly the invasive species *Helianthus tuberosus* has spread along the river Váh [Pauková 2013], which we can also confirm with our research in 2018. One population of *F. × bohemica* on the banks of the river Váh on the left side was removed. The significance of water flows is variable for different types of invasive plants found other authors [Beniak et al. 2015, Fehér et al. 2016]. It is less significant for the species of the *Fallopia* genus, which corresponds well with our results. In the Moscow area, the species occur mainly on river banks, in the European

part of Russia on ruderal sites [Vinogradova et al. 2010]. The presence of knotweeds was confirmed in over 23.0% of urban areas of the one of the Polish cities [Sołtysiak and Břej 2014]. In Belgium, *F. × bohemica* spreads in cities (70%), along roads and rivers. The overgrowth area increased within a year by more than 30% [Tiébré et al. 2008].

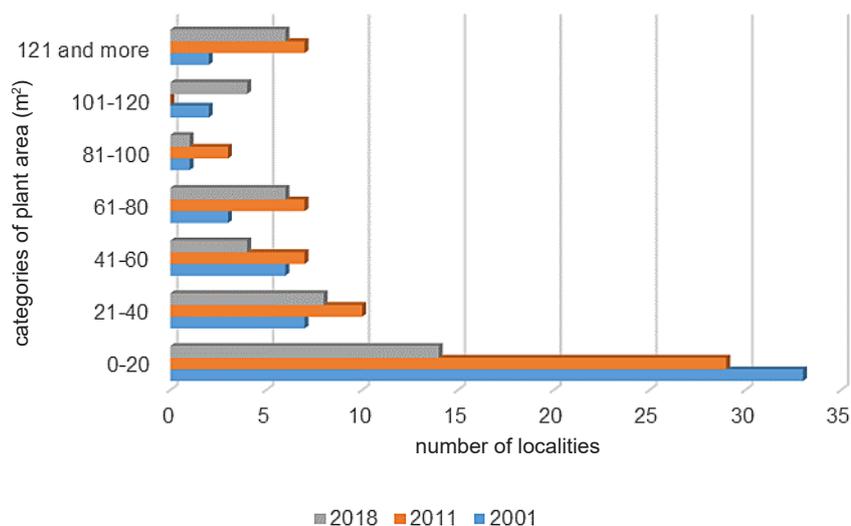
The field survey shows that the greatest danger comes from of the largest populations of *F. × bohemica* (Table 1).

Figure 2 shows that the number of populations (especially over 120 m<sup>2</sup>) decreased within the observed years 2011–2018, which indicates a successful management measures of *F. × bohemica*.

In 2011, the hybrid formed mainly monocenoses (75% of localities), but ten years later, was their proportion only one-third (35%) [Pauková 2013]. In 2018, *F. × bohemica* formed mainly polycenoses (70%). We think this is because of

**Table 1.** Population-biological characteristics of the largest populations of *Fallopia × bohemica* in town Hlohovec (Slovakia)

Type of biotope	area (m <sup>2</sup> )			population density (i·m <sup>-2</sup> )			height of shoots (m)		
	2001	2011	2018	2001	2011	2018	2001	2011	2018
A610000 Dykes									
River Váh	60	161	169	high	high	medium	3.5	3.8	3.9
River Váh	80	180	180	high	medium	high	3.7	3.7	4.0
River Váh	51	147	130	high	high	high	3.5	3.5	3.7
River Váh	139	312	360	high	medium	medium	3.6	3.8	4.2
A510000 Railways									
Železničná street	27	307	115	medium	high	high	3.0	3.6	3.5
Železničná street	42	505	462	medium	high	medium	3.2	3.7	3.9
A520000 Roads									
Mierova street	-	169	115	-	high	high	3.8	3.9	3.9



**Figure 2.** Frequency of *Fallopia × bohemica* localities depending on the size of the overgrowth area

an increase in the vegetation surface and gradual displacing of other species of the undergrowth (sub-canopy), but also through the periodical regulation on the extensively cultivated fields, which created approximately 52% of the total localities occupied by *F. × bohemica*. In other phytocenoses, the most frequently occurring species were *Ailanthus altissima* Mill. (Swingle), *Elytrigia repens* L. Desv., *Urtica dioica* L., *Convolvulus arvensis* L., *Capsella bursa pastoris* (L.) Medik. and others.

The obtained results concerning the size of *F. × bohemica* areas show that their size in 2018 was highly significantly dependent on the size of the areas in 2011 ( $r = 0.907$ ,  $P < 0.01$ ) (Fig. 3) and 2001 ( $r = 0.682$ ,  $P < 0.01$ ) (Fig. 4) and the trend has a power character. This means that the size of the overgrowth areas in 2001 and 2011 had a statistically significant effect on the size of the areas in 2018 at the selected level of significance.

### Regulated and unregulated populations

The removal of *F. × bohemica* plants in Hlohovec was carried out on 72% of the total number of localities, in the so-called regulated populations. However, in terms of area, 1590 m<sup>2</sup> represents 52% of the total area colonized by the hybrid. In July 2018, the average height of the plants in regulated populations ranged from 0.2 to 0.8 meter. The plants were regularly cut three times during the growing season. The number of unregulated populations along the dykes in Hlohovec represented 28% of the total populations colonized by the hybrid. The average height of

plants in summer 2018 ranged from 3.5 to 4.2 meters. The population density of ramets was characterized by a medium density (16–30 i.m<sup>-2</sup>). We conclude that the area of unregulated populations (Fig. 5) occupied decreased from 80 to 48% (1461 m<sup>2</sup>) of the total area occupied by the hybrid. Regular monthly cutting of plants reduces the spread of the vegetation, but does not eliminate it [Barney et al. 2006].

### CONCLUSIONS

*F. × bohemica* is a successfully spreading invasive hybrid in the Hlohovec town in Slovakia. In 2018, it had colonized the area (3051 m<sup>2</sup>), and decreased by 9% in relation to 2011 (3338 m<sup>2</sup>). The size of the areas in 2018 was highly significantly dependent on the size of the areas in 2001 ( $r = 0.682$ ) and 2011 ( $r = 0.907$ ). The hybrid has spread mainly along the dykes of the river Váh (48% of the total area occupied by the hybrid) and railways (27%), less frequently used roads (15%) and extensively cultivated fields (10%). The area of regulated populations increased from 20% to 52% of the total area occupied by the hybrid, but it is still necessary to carry out management measures.

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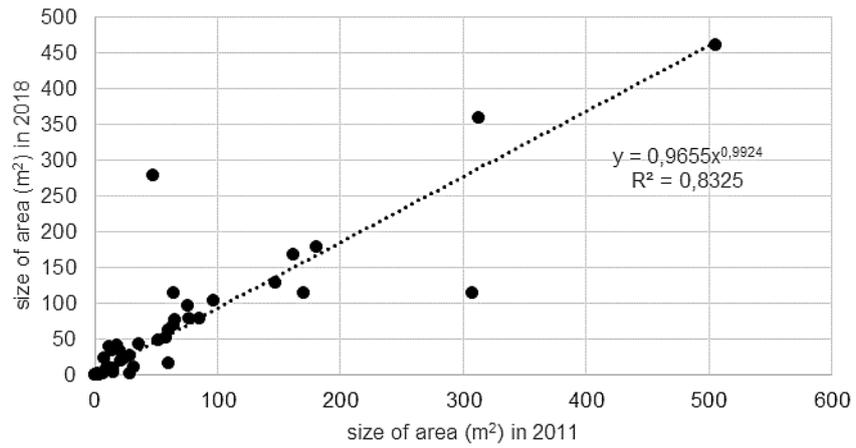


Figure 3. Power dependence of the *Fallopia × bohemica* areas

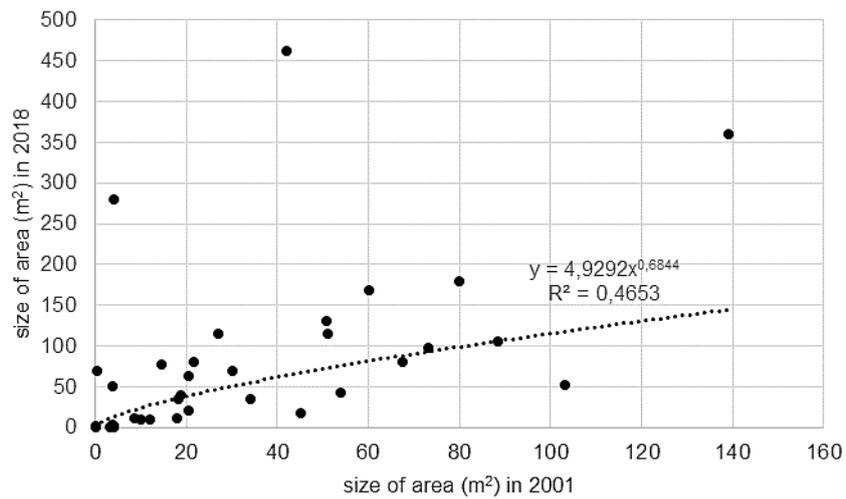


Figure 4. Power dependence of the *Fallopia × bohemica* areas



Figure 5. Unregulated population of the *Fallopia × bohemica* in town Hlohovec

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