

Mapping of occurrence and population dynamics of invasive plant species *Heracleum mantegazzianum* in the agricultural landscape

Mapovanie výskytu a populačná dynamika invázneho druhu *Heracleum mantegazzianum* v poľnohospodárskej krajine

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ABSTRACT

In recent years, giant hogweed [*Heracleum mantegazzianum* (Somm. et Levier)], an invasive neophyte, has spread aggressively in intensively farmed agricultural landscape in the Central Europe. This toxic invasive plant prefers drier agricultural fields or grasslands. The aim of this paper was to study the distribution and population dynamics of *H. mantegazzianum* and to evaluate its management measures taken in the town of Spišská Stará Ves in the Kežmarok district located in northern Slovakia. *H. mantegazzianum* has successfully spread in the cadastral area of Spišská Stará Ves in the buffer zone of the national park of Pieniny. The total area of the PIENAP and its buffer zone invaded by *H. mantegazzianum* was approximately 457,000 m². The research took place in 2013, on an area colonized by the species (28,900 m²) located on the land of the former agricultural cooperative farm. The taxon has spread mainly on abandoned areas (64.7% of the total area occupied by *H. mantegazzianum*), on permanent grasslands (28%) and along the banks of the Dunajec river (7.3%), where it formed polycenoses with a group dispersion. The population density of *H. mantegazzianum* decreased by about 46% on the research sites after the management measures provided in July 2013. It can be concluded that the management measures were poorly effective, because as evidenced by of the area occupied by the species.

Keywords: *Heracleum mantegazzianum*, invasive plant species, mapping of occurrence, population dynamics

ABSTRAKT

K nepôvodným a invázne sa šíriacim druhom v intenzívne obhospodarovanej poľnohospodárskej krajine Strednej Európy patrí neofyt boľševník obrovský [*Heracleum mantegazzianum* (Somm. et Levier)]. Uprednostňuje suchšie poľnohospodárske pôdy a trávnaté porasty a je charakteristický toxickými účinkami. Cieľom práce bolo zmapovať výskyt a rozšírenie, populačnú dynamiku a zhodnotiť manažment v meste Spišská Stará Ves v okrese Kežmarok na severnom Slovensku. *H. mantegazzianum* sa úspešne šíri v katastrálnom území mesta Spišská Stará Ves na severnom Slovensku v ochrannom pásme Pieninského národného parku. V roku 2013 kolonizoval plochu o veľkosti 28 900 m². Taxón sa rozšíril hlavne na opustených plochách (64,7% z celkovej plochy obsadenej *H. mantegazzianum*), na trvalých trávnych porastoch (28%) a pozdĺž brehov rieky Dunajec (7,3%), kde tvoril polycenózy so skupinovou disperziou. Populačná hustota rastlín na výskumných plochách po vykonanom manažmente klesla o 46%. Dospeli sme k záveru, že manažmentové opatrenia neboli dostatočne účinné o čom svedčí plocha obsadená týmto druhom.

Klíčovú slová: *Heracleum mantegazzianum*, invázne druhy rastlín, mapovanie výskytu, populačná dynamika

INTRODUCTION

Invasive plants are defined as non-native species that spontaneously spread and displace native species from their natural biotopes and reduce the biodiversity (Ministry of Environment of Slovak Republic Act 543/2002 on Nature and Landscape Protection, 2002). The valid list of invasive plant species in Slovakia is presented in Ministry of Environment of Slovak Republic Notice 24/2003 (2003), Ministry of Environment of Slovak Republic Notice 173/2011 (2011) and Ministry of Environment of Slovak Republic Notice 158/2014 (2014).

Protected areas (PA) play a key role in biodiversity conservation, yet they face numerous pressures including the spread of invasive alien species (IAS) (Iacona et al., 2014; Braun et al., 2016; Pěkníková and Berchová-Bímová, 2016). The majority of PA in Central Europe implement a management of IAS, however they are not often very efficient (Braun et al., 2016). Invasive alien species have a broad range of environmental impacts on recipient ecosystems (Pyšek et al., 2012; Blackburn et al., 2014). Giant hogweed [*Heracleum mantegazzianum* Sommier et Levier (*Apiaceae*)] was introduced to Europe from western Caucasus as an ornamental plant in the 19th century. It is one of the most successful invasive plant in Europe (Lundström, 1989; Pyšek and Richardson, 2008, 2010; Gross, 2012; Foxcroft et al., 2013) listed among 100 worst European invasive species (DAISIE, 2017) causing serious environmental and health problems (Pyšek et al., 2007; Eliáš, 2008; Ulrych and Gojdičová, 2014). It colonizes mainly riparian zones (riversides) (Tabacchi and Planty-Tabacchi, 1994). Its ability to successfully invade new habitats might be determined high fecundity and germination capacity and opportunistic behaviour associated with limited effect of fruit position on a plant on germination characteristics (Moravcová et al., 2005). *H. mantegazzianum* is an allergenic plant containing psoralens (furocoumarins) that cause photodermatitis (Avenel-Audran and Sarre, 2016; Baker et al., 2017; Christensen and Larsen, 2017). It is reported to successfully spread in Slovakia (Žilkovanová, 2006, 2007; Kiska, 2008; Ondeková and Renčo, 2017).

This paper presents the results of distribution of invasive neophyte *H. mantegazzianum* in the agricultural landscape in the buffer zone of the national park of Pieniny (PIENAP) (northern Slovakia). The study tries to help to reconstruct the expansion of the selected invasive neophyte on a local level, because there is a lack of detailed studies based on plant-mapping in the studied location.

The aim of this paper was to map the occurrence and population dynamics of *H. mantegazzianum* during a field research performed from May to October 2013.

MATERIALS AND METHODS

Figure 1 shows the mapping of the occurrence of the studied alien plant species took place in the administrative area of the town of Spišská Stará Ves in the Kežmarok district (northern Slovakia). The total area of the PIENAP and its buffer zone invaded by *H. mantegazzianum* was approximately 457,000 m².

The altitude of the town is about 505 m.a.s.l. The area belongs to the cool, slightly warm and humid climate zone. Figure 2 presents the average annual temperature is 6-7 °C and the annual rainfall is 750 mm. The soils include cambisols, pseudogleys and rendzinas. The area belongs to the Alpine flora region. From the zoo-geographic point of view, the area may be included into Palearctic region (Jedlička and Kalivodová, 2002). Climadiagram based on the monthly average temperature (°C) and the average monthly atmospheric precipitation (mm) measured in town of Poprad in 2013 was created (Walter and Leith, 1967; Slovak Hydrometeorological Institute, 2014a, b).

H. mantegazzianum is a perennial monocarpic plant. The stems are 2 m to 5 m high, with a thick tap root up to length 0.45 – 0.6 m, and leaves up to 3 m. Flowers are arranged in compound umbels (Tiley et al., 1996; Cvachová and Gojdičová, 2008; Pauková, 2013). A single plant is capable of producing 5,000 up to more than 100,000 fruits (Pyšek et al., 1995; Tiley et al., 1996). *H. mantegazzianum* is hemicryptophyt (Ellenberg et al., 1991) with low or zero level of edibility (Fehér et al., 2016).

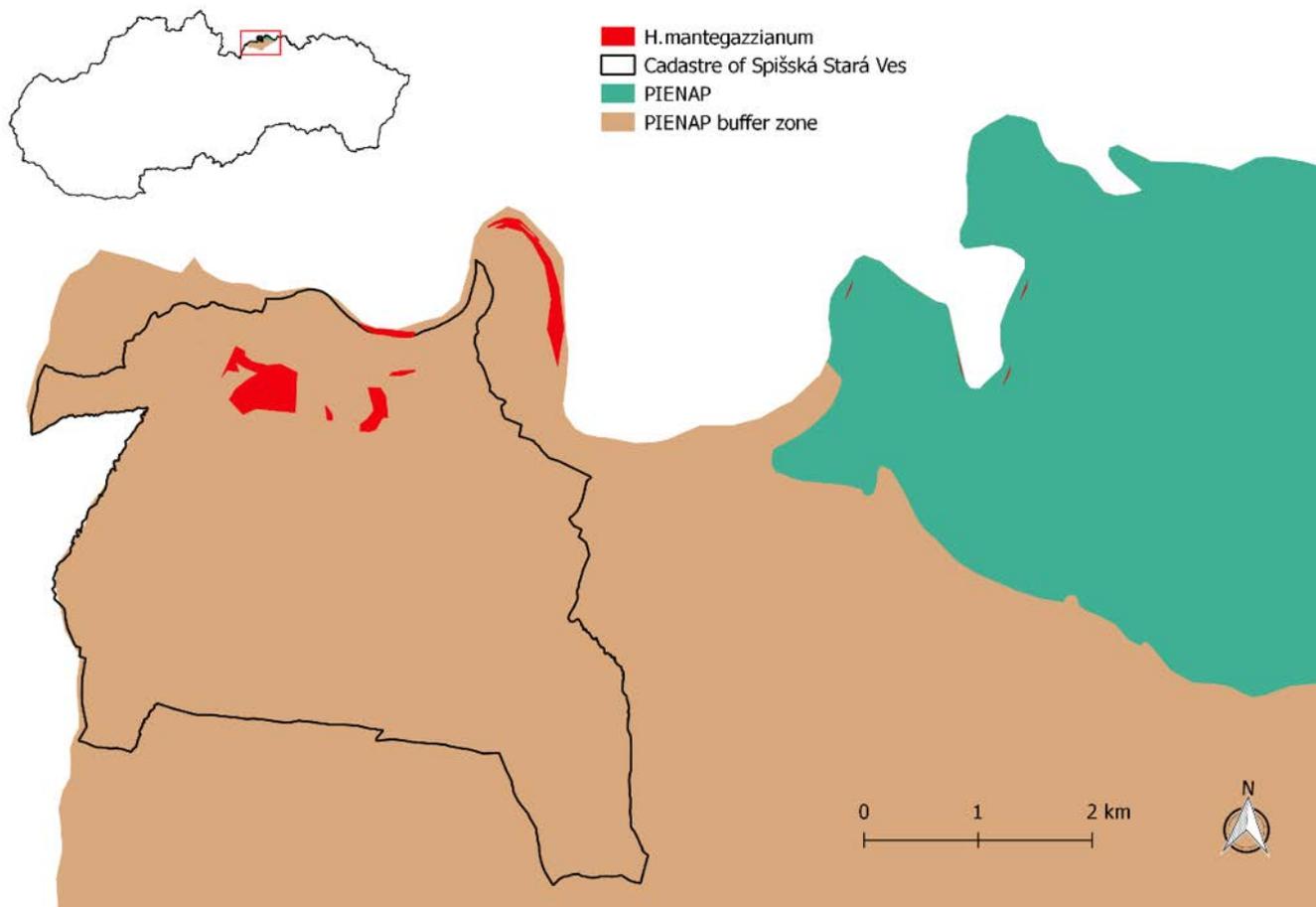


Figure 1. Distribution of *Heracleum mantegazzianum* in the national park of Pieniny and its buffer zone

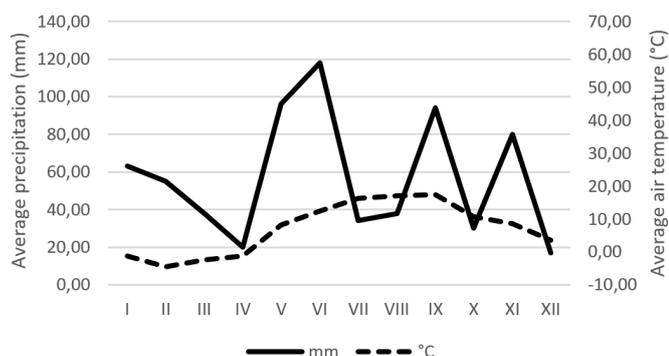


Figure 2. Climadiagram of the study area in 2013 (Slovak Hydrometeorological Institute, 2014a, b)

The occurrence of *H. mantegazzianum* was recorded by field mapping from May to October 2013. The data were collected on an area covering of *H. mantegazzianum*. The exact location invaded by the species was determined by GPS unit. Location and type of biotope were recorded according to Ružičková et al. (1996). The nomenclature of species in communities is referred according to

Marhold and Hindák (1998). Size of the vegetation area (m^2) was measured. Average density of shoots (low 1-5 i/m^2 , medium 16-30 i/m^2 , high 31 and more i/m^2) per individuals was recorded on a square 1×1 m inside the population. Stem heights (m), thickness on the base (cm), number of internodes on the main stem and number of leaves on the main stem were measured in sites on abandoned areas (1×1 m).

The map of the *H. mantegazzianum* distribution was created in QGIS software (version 2. 18. 15). The data on *H. mantegazzianum* distribution were taken from the Map browser of the State Nature Conservancy of the Slovak Republic (<http://maps.sopsr.sk/mapy/invazky/map.html>).

RESULTS AND DISCUSSION

Distribution of Heracleum mantegazzianum

The study sites ($n = 7$) with the occurrence of *H. mantegazzianum* were in the area of former agricultural cooperative farm located in the cadastral area of the town of Spišská Stará Ves. The size of the study area was 28,900 m² in Table 1. The taxon was distributed mainly in abandoned areas (64.7% of the total area occupied by giant hogweed), permanent grasslands (28%) and river banks (7.3%). On the site 1 located on abandoned areas, *H. mantegazzianum* formed polycoenosis with *Urtica dioica* L., *Taraxacum officinale* F.H. Wigg. and *Fragaria vesca* L. that covered 10%. On the site 2 located on abandoned areas, *H. mantegazzianum* formed polycoenosis with *Urtica dioica* L. (30% coverage). The site 3 located on abandoned areas was bordered from sides by shrub *Salix cinerea* L. and *Sambucus nigra* L. The major accompanying species in the *H. mantegazzianum* populations on the site 3 were *Urtica dioica* L. and other species (60% coverage). *H. mantegazzianum* populations penetrated into the stands of *Sambucus nigra* L. Müllerová et al. (2005) recorded that mean rate of areal spread was 1,261 m²/year from aerial photographs in the Slavkovský les, Czech

Republic. According to Pěkníková and Berchová-Bímová (2016) the most important ecological factors predicting distribution of invasive species at the local scale are soil type, elevation and habitat type.

The first occurrence of *H. mantegazzianum* in Slovakia was reported in 1963 (Darola, 1965; Medvecká, et al., 2012). *H. mantegazzianum* occurred in the northwest of Slovakia (Javorníky, Kysuce), northern Slovakia (Low Tatras, Fatra, Chočské vrchy) and northwest of Eastern Slovakia (High Tatras) at 55-60 sites (Eliáš, 1997). Gradually, however, the occurrence of *H. mantegazzianum* was recorded in lowland edaphic-climatic conditions (Fehér, 2000). The first report of invasive alien plants in the PIENAP provided Benčatová and Kontriš (1999). The authors recorded 5 invasive plant species including *Impatiens parviflora* DC., *Impatiens glandulifera* Royle, *Heracleum mantegazzianum* Somm. et Levier, *Fallopia japonica* (Houtt.) Ronse Decr. and *Solidago canadensis* L. Klíč and Kunštárová (2008) recorded 14 invasive plant species [*Aster lanceolatus* Willd., *Fallopia japonica* (Houtt.) Ronse Decr., *Heracleum mantegazzianum* Sommier et Levier, *Impatiens parviflora* DC., *Impatiens glandulifera* Royle, *Solidago canadensis* L., *Tanacetum vulgare* L., *Helianthus tuberosus* L., *Echinocystis lobata* (F. Michx.)

Table 1. Occurrence, area and population density of *Heracleum mantegazzianum* in Spišská Stará Ves

Biotope number	Biotope type	Area (m ²)	Population density (i/m ²)	Biocoenosis
1.	A410000 Abandoned areas	13,200	Low	Polycoenosis
2.	A410000 Abandoned areas	5,500	Low	Polycoenosis
	Total area of abandoned areas	18,700		
3.	3520000 Permanent grasslands	1,400	Low	Polycoenosis
4.	3520000 Permanent grasslands	6,700	Low	Polycoenosis
	Total area of permanent grasslands	8,100		
5.	5000000 Banks of river	500	Low	Polycoenosis
6.	5000000 Banks of river	1,300	Low	Polycoenosis
7.	5000000 Banks of river	300	Low	Polycoenosis
	Total area of the river banks	2,100		
	Total area in the town	28,900		

Torr. et A. Gray, *Lupinus polyphyllus* Lindl., *Rhus typhina* L., *Parthenocissus quinquefolia* (L.) Planch., *Negundo aceroides* Moench and *Veronica filiformis* Sm.] and 4 expansive plant species [*Pteridium aquilinum* (L.) Kuhn, *Calamagrostis epigeos* (L.) Roth, *Sambucus ebulus* L. and *Phalaroides arudinacea* var. *picta* (L.) Tzvelev] during the period of 2007-2008 in the national park and its buffer zone. Braun et al. (2016) recorded that the most widely managed species in protected areas of Central Europe were *Fallopia japonica* (23 protected areas), *Heracleum mantegazzianum* (20), and *Impatiens glandulifera* (16). They also pointed out that the management is often insufficient to reduce the spread of IAS, mainly due to lack of funding and a lack of coordinating response among protective areas.

Plant height growth

Figure 3 shows the highest average plant height growth (1.69 m) was recorded in July. Mechanical removal of generative organs (inflorescence) was conducted in July. As a consequence of the management, the plant growth was reduced. Lundström (1989) reported that seed of *H. mantegazzianum* can be viable for 15 years. Trottier et al. (2017) suggested that late-fall and, especially, spring floods are the most efficient dispersal vectors for seeds of giant hogweed and are likely responsible for the establishment of populations kilometres downstream from introduction points along river systems.

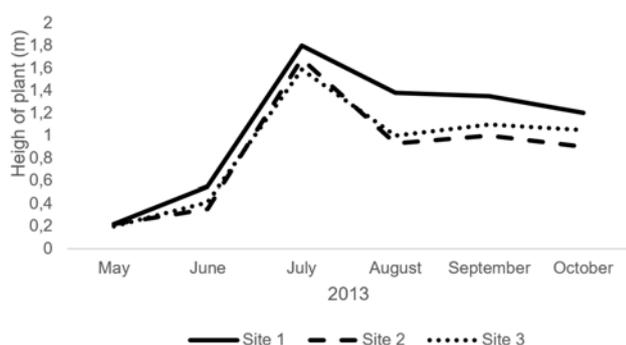


Figure 3. Plant height growth of *Heracleum mantegazzianum* on the research sites in northern Slovakia

Plant growth dynamics

Figure 4 shows the largest thickness of stems on a base (on average 2.93 cm) was recorded at the lowest density of individuals (7) at the end of the growing season.

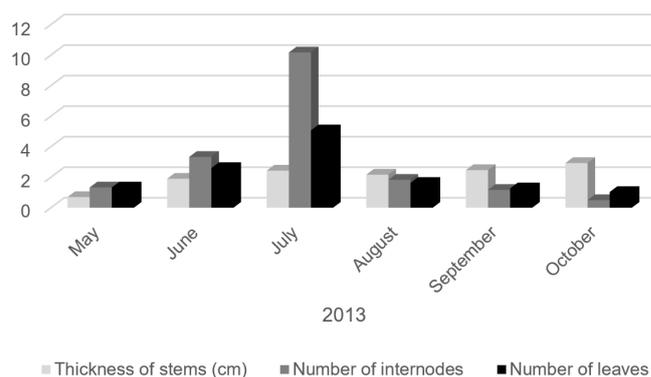


Figure 4. Population dynamics of *Heracleum mantegazzianum* on the research plots in northern Slovakia

The smallest thickness of stems (0.7 cm) was observed at the beginning of the growing season. The highest number of internodes (10) and the number of leaves of the main stem (5) were recorded at the highest of the plants in July.

Population density (number of individuals per m²)

At the beginning of the growing season, self-infilling of ramets of *H. mantegazzianum* on abandoned areas in town of Spišská Stará Ves were observed reaching the maximum density in July (from 7 to 9 i/m²) mainly due to favourable conditions (high level of precipitation) (Figure 1). Figure 5 presents the population density decreased by about 46% after the management measures taken in July.

Management measures of *H. mantegazzianum* were implemented for the first time in the studied area (PIENAP buffer zone) in 2004 (PIENAP, 2002-2004). The management included mechanical and chemical eradication method (PIENAP, 2005-2012).

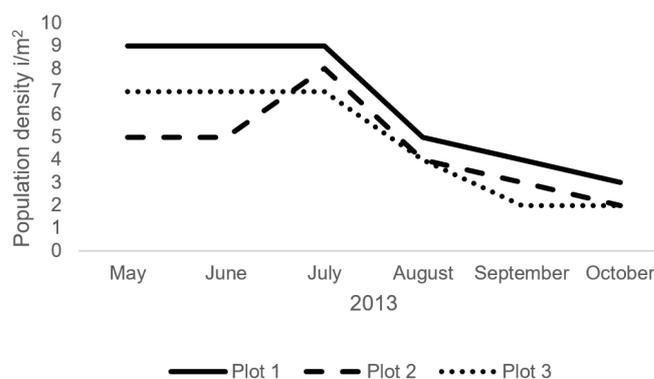


Figure 5. Population density of *Heracleum mantegazzianum* on the research plots in northern Slovakia

Management measures of *H. mantegazzianum* (mechanical removal of generative organs) taken for the purpose of this article were implemented in July 2013 in the most abundant area of its occurrence (area of the former agricultural cooperative farm) in Spišská Stará Ves. Since the implementation of the first management measures in this area, the population of *H. mantegazzianum* were gradually decreasing (PIENAP, 2009-2011). The management measures taken in 2013 were resulted in a decrease of the population density of *H. mantegazzianum*. It can be concluded that the management measures were poorly effective, because as evidenced by of the area occupied by the species.

CONCLUSIONS

Heracleum mantegazzianum is a successfully spreading invasive species in the town of Spišská Stará Ves located in the buffer zone of the national park of Pieniny (northern Slovakia). The total area of the PIENAP and its buffer zone invaded by *H. mantegazzianum* was approximately 457,000 m². In 2013, the study area colonized by *H. mantegazzianum* covered 28,900 m². The taxon spread mainly in abandoned areas (65% of total area occupied by *Heracleum mantegazzianum*) and permanent grasslands (28%).

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