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HERACLEUM SOSNOWSKYI MANDEN. MONITORING IN PROTECTED AREAS – A CASE STUDY IN RĒZEKNE MUNICIPALITY, LATVIA

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Invasive species are an important threat to the global biodiversity. *Heracleum sosnowskyi* is one of the invasive species being common in Eastern Europe, also in Latvia and threatening local ecosystems and biodiversity. The present study shows preliminary *H. sosnowskyi* monitoring results for the protected territories of Rezekne municipality. *H. sosnowskyi* was studied in 11 habitats, where seven management methods for *H. sosnowskyi* restriction were identified. The significant difference in *H. sosnowskyi* cover between 2014 and 2016 monitoring years was not found. The roadsides and grasslands were the most common habitats for *H. sosnowskyi* distribution. The geographical site location as well as habitat characteristics should be taken into account in selection of the best management method for *H. sosnowskyi* population restriction. The paper has been elaborated with the financial support of Rezekne Academy of Technologies provided through a research grant.

Key words: *Heracleum sosnowskyi*, invasive species, Rēzekne municipality.

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INTRODUCTION

Today the global biodiversity is threatened by the influence of invasive species like never before (CBD 1992). This may be explained by such worldwide globalization processes as trade and tourism ensuring more options than before for species successfully spreading and crossing large distances to new habitats becoming easily reachable by the invasive species. The degradation of natural habitats and also global climate change are promoting the establishment of alien species becoming invasive. The economic costs of invasive species may reach an enormous amount of money (IUCN 2000).

The number of alien species is annually increasing also in Latvia, and among these species there are invasive species, which are dispersing quickly and, as a result, becoming dominant species in an ecosystem. Such a dominance of invasive species results in significant biological pollution

and problems in natural ecosystems and requires the conservation of species and the traditional natural landscape (Bērziņš et al. 2007). Therefore, research studies about the distribution of alien, especially invasive species and the status and potential of invasiveness are lacking in Latvia. The lack of such research studies are causing problems in the conservation of species and nature values and in habitat management planning in a region (Priede 2008).

Heracleum sosnowskyi is a biennial or perennial 2-4 m herbaceous plant with a strong taproot system. Its stalk is cored, ribbed with hairs, and pink patches are often found on the plant's basal part. The lower leaves are large, 0.5-1.5 wide and long. The stalk leaves with sheaths (the margin is undulated with small lashes). Its umbel is 20-50 cm in diameter, petals white, buds may be pink. The plant produces aggregated fruits, the fruits are elliptical (Bērziņš et al. 2007).

Heracleum sosnowskyi Manden is included in the list of Latvian invasive species (LRMK 2008). The most common invasive species in Latvia are *Heracleum sosnowskyi* and *Solidago virgaurea* L. having the highest number of records in Latvia – 364 and 349, respectively, and being also two of the most rapidly spreading invasive species during the last 50-100 years (Priede 2008). However, *Heracleum sosnowskyi* is the most aggressive species with the highest dispersal capacity among other invasive species in Latvia (Bērziņš et al. 2007). A national programme on the distribution inventory and eradication was developed in Latvia for *Heracleum sosnowskyi* (Priede 2008).

Heracleum sosnowskyi was introduced in Latvia as a fodder plant and initially began to grow in the 1940s (Rasiņš & Fatare 1986). *Heracleum sosnowskyi* disperses rapidly due to the cultivation efforts and also biological traits, ensuring the species occurrence in a whole country, especially in semi-natural habitats, in some places also as a monodominant plant. *Heracleum sosnowskyi* distribution is more related to agricultural lands and does not show relationships with urban areas; it is rarely found in the vicinity of large cities (Priede 2008). Laiviņš and Gavrilova (2003) have found that *Heracleum sosnowskyi* prefers moderately humid, neutral soils with a high amount of nutrients.

In total, *Heracleum sosnowskyi* covered a 10640.99 ha area in Latvia, according to an inventory made between 2007 and 2012. The area covered by *Heracleum sosnowskyi* was 84.39 ha in Rēzekne municipality in 2012 (personal communication, Rezekne Municipality Council). The aim of the present study is to characterize the distribution of *Heracleum sosnowskyi* based on monitoring data in three protected areas of Rēzekne municipality.

MATERIAL AND METHODS

Field work

The mean temperature in Latvia in February is -4.7°C, in July - +17.0°C, the annual precipitation reaches 667 mm (LVGMC 2016). The field work was conducted in Rēzekne municipality, Eastern Latvia in June of 2012 and 2016 during the flowering time of *Heracleum sosnowskyi*.

In total, 33 sites with *Heracleum sosnowskyi* were studied in Rāzna National Park (16 sites), Lubāna mitrājs Nature Reserve (16 sites) and Adamova Nature Park (1 site) (Fig.1). The sites were selected based on their proximity and available *Heracleum sosnowskyi* cover data from 2012.

The sites represented 11 habitats – grassland, the roadside, shrubland, a building area, a forest, the border of a forest, a water stream bank, an electric line, a ditch edge, a coppice and a lake bank. Seven management methods were found to be applied in the studied sites – plastic sheet cover, partly mowed, mowed, partial road reconstruction, harrowed, bank strengthening and no management. Most of the sites studied represented more than 1 habitat and more than 1 management method.

The area covered by *Heracleum sosnowskyi* was marked using the GPS (marking each edge of the rectangular polygon (site)).

Data analysis

Each marked studied site area was calculated based on GPS coordinates using Arc map 10.1 version software. The comparisons of the *Heracleum sosnowskyi* site areas between 2012 and 2016 were made using a Wilcoxon signed rank test in R programme package version 3.3.1.

RESULTS

The total area of the *Heracleum sosnowskyi* sites was 39.15 ha in 2012 and 37.27 ha in 2016, showing a 4.8 % decrease in the cover (Table 1). The average area of one site studied was 1.19 ha

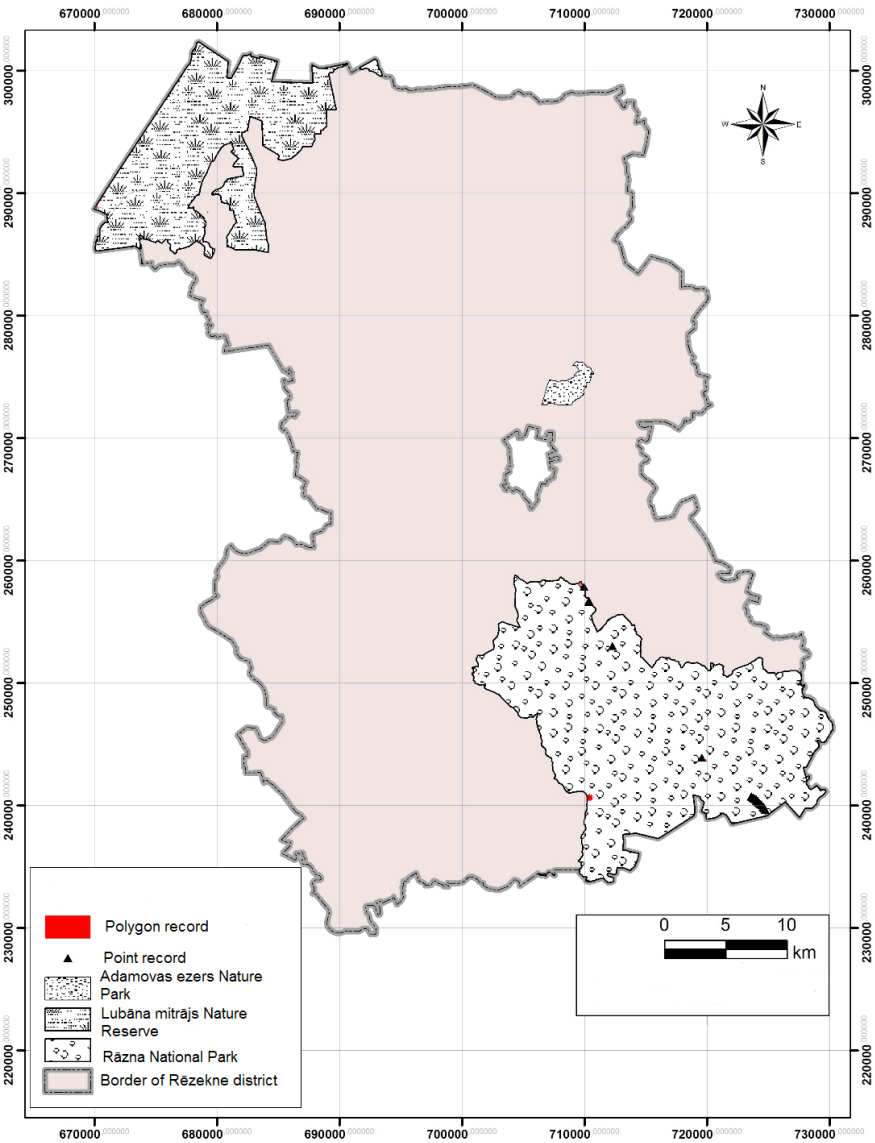

Fig. 1. Studied sites in Rēzekne municipality. LKS-92 coordinate system. Due to the large differences among the studied sites, small sites are not visible in the map (Author: E. Tripāne).

Table 1. Basic statistics of the studied sites

Site characteristics	Area (ha)				
	Years		Sites		
	2016 (N=33)	2012 (N=33)	New (N=11)	Increased sites (N=10)	Decreased sites (N=11)
Total area	37.27	39.15	0.78	4.73	7.40
Minimum site area	0.001	0	0.001	0.08	0.001
Maximum site area	18.11	16.23	0.33	18.11	5.11
Average site area	1.13±3.23	1.19±2.99	0.071±0.11	2.72±5.49	0.62±0.61
Rāzna total	27.10	27.14	0.45	3.05	1.46
Rāzna avg	1.57±4.23	1.70±4.56	0.06±0.12	4.28±7.03	1.32±2.53
Lubāna total	13.21	10.03	0.33	1.68	5.18
Lubāna avg	0.83±0.92	0.63±0.81	0.08±0.11	1.16±1.04	0.56±0.30

in 2012 and 1.13 ha in 2016. The total area and the average site area in Rāzna National Park were larger than in Lubāna mitrājs Nature Reserve in 2012 and also in 2016. Minimal and maximal site areas in 2012 and 2016 were similar.

Explanations – the first column denotes the studied site categories, where Rāzna total – the total area with *H. sosnowskyi* studied in Rāzna National Park, Rāzna avg - the average area of the site with *H. sosnowskyi* studied in Rāzna National Park, Lubāna total - the total studied area with *H. sosnowskyi* in Lubāna mitrājs Nature Reserve, Lubāna avg - the average area of the site with *H. sosnowskyi* studied in Lubāna mitrājs Nature Reserve. Average values with standard deviations. The second and third columns denote the sites studied in 2016 and 2012 separately; the fourth, fifth and sixth columns denote the area with *H. sosnowskyi* in new sites (sites where *H. sosnowskyi* was found in 2016 only), in increased sites (sites where the cover of *H. sosnowskyi* increased from 2012 to 2016), decreased sites (sites where the cover of *H. sosnowskyi* decreased from 2012 to 2016). The fourth, fifth and sixth columns show data for 2016 only (Adamova ezers Nature Park was excluded due to the lack of site replications).

New sites were smaller than the sites where the cover of *Heracleum sosnowskyi* was decreasing or increasing. We did not find any significant differences in *Heracleum sosnowskyi* cover among the sites in 2012 and 2016 (Wilcoxon test, $p>0.05$).

The highest increase (from 16.23 ha in 2012 to 18.11 ha in 2016) or 10.38 % of *H. sosnowskyi* cover among sites was found in Rāzna National Park, where six habitat types (grassland, the roadside, the border of a forest, shrubland, a building area, a water stream bank) were found and management – partly mowed – was applied (Fig. 2). The largest new site (0.32 ha) with *H. sosnowskyi* was found in 2016 in grassland and shrubland habitats without management. The highest decrease of *H. sosnowskyi* cover among sites from 2012 (2.10 ha) to 2016 (0.739 ha) or 64.76 % was found in Lubāna mitrājs Nature Reserve in the roadside and Lubāns lake bank habitats, where bank strengthening and partial road reconstruction were applied (Table 2).

The roadside was the most common habitat (in 20 sites) with *H. sosnowskyi*, followed by grassland habitat - the second most common studied habitat (in 12 sites). Coppice and forest habitats both were present in only one *H. sosnowskyi* site.

Ten out of 11 studied new *H. sosnowskyi* sites had no management (Table 2). Partial mowing was the method of management used in eight out of ten sites where the cover of *H. sosnowskyi* increased.

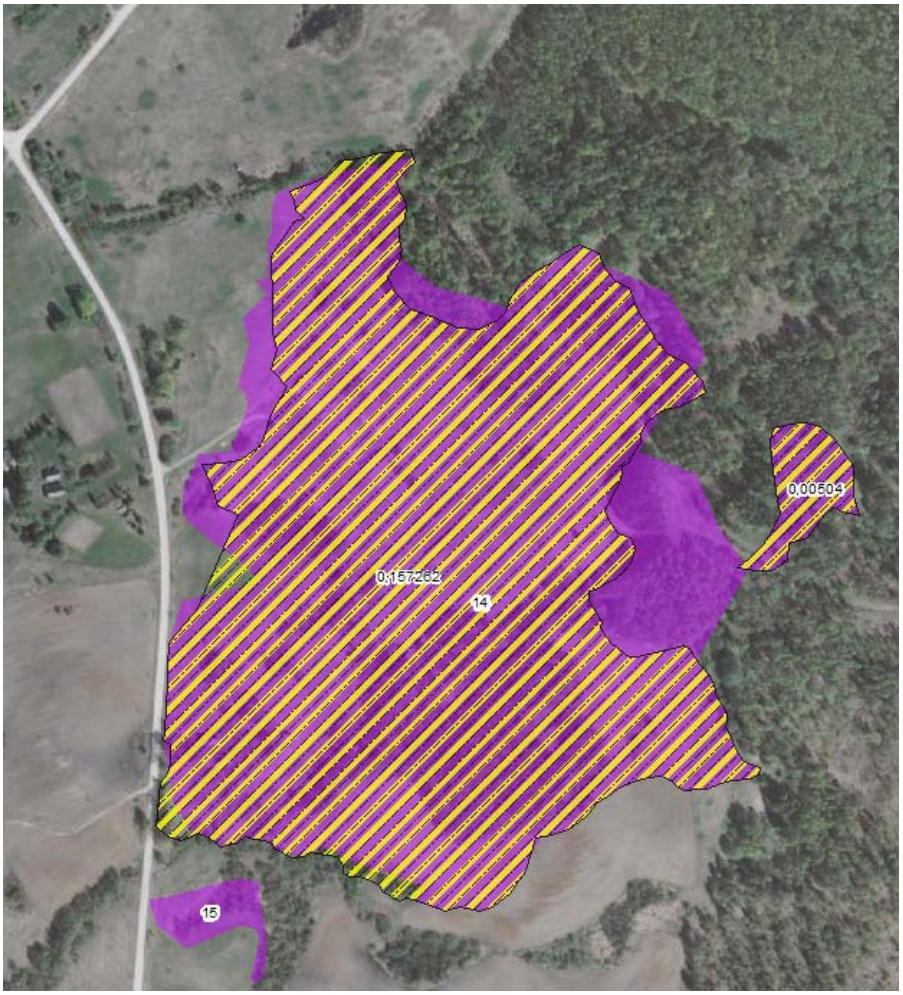

Fig. 2. Two studied sites in Rāzna National Park in Rēzekne municipality, Mākoņkalna village, Jegorova. Polygon No. 14 - the largest increase of *Heracleum sosnowskyi* cover from 2012 to 2016 among the studied sites, Polygon No. 15 – the largest new site found in 2016 (Table 2). Yellow stripes - *H. sosnowskyi* cover in 2012, purple colour – *H. sosnowskyi* cover in 2016 (Author: Elīna Tripāne).

Table 2. Studied site characteristics

Nr	SPT	Area (ha)		Habitat	Coordinates		Management
		2012	2016		N	E	
1	Adamova	0.84	0.089	GL	707133	273458	PSC
2	Rāzna	6.50	5.108	GL,RS, SL, B, F, BF	709660	258142	PM
3	Rāzna	0	0.016	GL	709494	257995	No
4	Rāzna	0	0.002	RS, BF	709473	257990	No
5	Rāzna	0.01	0.001	GL, RS, SL	709814	258074	M
6	Rāzna	0.02	0.006	GL, RS	709843	258036	M

Nr	SPT	Area (ha)		Habitat	Coordinates		Management
7	Rāzna	0	0.002	RS	710035	257756	No
8	Rāzna	0.03	0.083	GL, SL	708265	254978	No
9	Rāzna	0.18	0.373	SL, GL, WB	712386	253968	PRR
10	Rāzna	0	0.045	GL, SL	719627	243937	No
11	Rāzna	0.16	0.153	RS, GL, BF	723111	241102	PM
12	Rāzna	0	0.025	SL	719665	243766	No
13	Rāzna	0.86	1.635	GL, SL, BF, EL	719883	243672	PM
14	Rāzna	0	0.033	GL, RS, BF, SL, B, WB	723199	241115	No
15	Rāzna	16.23	18.113	GL, SL	710452	240627	PM
16	Rāzna	0	0.329	GL, SL	710255	240360	No
17	Rāzna	1.07	1.219	GL, SL, RS	701342	250767	PM, H
18	Lubāna	0	0.066	DE, BF	679084	288211	No
19	Lubāna	0.14	0.054	BF	678924	288314	M
20	Lubāna	0.61	0.563	C, EL	679222	288461	PM
21	Lubāna	0	0.013	RS, C	679252	288429	No
22	Lubāna	0	0.014	RS DE	675681	290275	No
23	Lubāna	0.05	0.198	RS, LB	675136	290321	PM
24	Lubāna	0	0.238	RS, LB	674170	290057	PM
25	Lubāna	2.39	2.408	RS, LB	673370	290177	PM
26	Lubāna	0.60	0.426	RS, LB	673614	290150	PM
27	Lubāna	0.22	0.232	RS, LB	673172	290141	PM
28	Lubāna	0.07	0.241	RS, LB	672601	289872	PM
29	Lubāna	1.40	2.732	RS, LB	671871	288887	PM
30	Lubāna	1.47	0.462	RS, LB	672028	289101	BS, PRR
31	Lubāna	2.10	0.739	RS, LB	670451	288831	BS, PRR
32	Lubāna	2.05	0.615	RS, LB	670325	288874	BS, PRR
33	Lubāna	2.10	1.039	RS, LB	670198	288812	BS, PRR

Abbreviations: SPT - specially protected territory, Adamova - Adamova ezers Nature Park, Rāzna - Rāzna National Park, Lubāna - Lubāna mitrājs Nature Reserve, the third and fourth columns show the site area with *Heracleum sosnowskyi,* in ha. Habitat - GL - grassland, RS - roadside, SL - shrubland, B - building, F - forest, BF -border of a forest, WB - water stream bank, EL - electric line, DE - ditch edge, C - coppice, LB - Lubāns lake bank, Management - PSC - plastic sheet cover, PM - partly mowed, M - mowed, PRR - partial road reconstruction, H - harrowed, BS - bank strengthening, No – no management observed.

In total, five management methods were applied in the sites where the cover of *H. sosnowskyi* was decreasing, among them – partly mowed, bank strengthening and partial road reconstruction – were the most common management methods (each method was applied in four sites).

Plastic sheet cover was applied for grassland management in Adamova Nature Park only, where *H. sosnowskyi* cover decreased by 84 % from 0.84 ha in 2012 to 0.089 ha in 2016.

DISCUSSION

The total area of *Heracleum sosnowskyi* did not change significantly in the studied sites from 2012 to 2016. However, the total cover of *H.*

sosnowskyi decreased by 4.8 % ha at the studied sites during four years. The sites studied differed in size, management regime applied and habitat composition, as in some sites the area of *H. sosnowskyi* was increasing (management was not applied), in others it was decreasing (management was applied). For a more precious *H. sosnowskyi* distribution trend, species monitoring is necessary for at least several decades (Müllerová et al. 2007). Tripāne (2013) suggested that small *H. sosnowskyi* spots, within several years, can invade several m^2 wide areas. Baležentienė et al. (2013) found that *H. sosnowskyi* spread at a rate of 60 m/year by roadside slopes.

The most common habitats among studied sites were the roadside and grassland, similar as in a research study by Baležentienė et al. (2013) in Lithuania, who found the highest *Heracleum sosnowskyi* invasion in roadsides, abandoned grasslands and wastelands, as herbaceous communities in these habitats were not resistant to *H. sosnowskyi* invasion. The overall distribution of *H. sosnowskyi* in Latvia is mostly related with roadside habitats (~45 % of all Latvian records) (Laiviņš, Gavrilova 2003). Tripāne (2013) also noted that the transport network in Razna National Park was the main factor facilitating the *H. sosnowskyi* invasion in combination with the wind current. Animals and water streams also play an important role in *H. sosnowskyi* dispersal.

Forest and coppice habitats were present only in one *H. sosnowskyi* site each. The present research study partly agrees with the research study by Baležentienė et al. (2013), where such natural habitats as forests represented the smallest colonies of *H. sosnowskyi*. However, a coppice is not strictly a natural habitat, but it represents the habitat's historical management influencing the present state of the habitat's quality and potential for the distribution of *H. sosnowskyi*. Due to the lack of coppice habitat replications in the present study, it is difficult to make generalizations and future studies with more coppice replications are needed in relation to *H. sosnowskyi* dispersal ability in this habitat.

Most of the new sites, where *H. sosnowskyi* was found for the first time, had no management activity. This confirms the essential need for limiting the *H. sosnowskyi* distribution through management in Latvia (Bērziņš 2007).

Partial mowing was the most common management method in the sites where the cover of *H. sosnowskyi* was increasing. Most of the studied sites were only partly managed, and this method, if not applied for the whole site and applied regularly (every 2-3 weeks), was not effective. Bērziņš et al. (2007) suggested applying the mowing method in roadsides, sites with bushes and in forests. Sowing perennial grains in combination with mowing was suggested for controlling *H. sosnowskyi* close to water habitats. Harrowing, growing crops in the next year in combination with mowing and chemical methods are suggested for open grassland habitats (Bērziņš et al. 2007). Tripāne (2013) mentioned also problems with different landowners, whose opinions about management also differ, thereby interfering with complex and effective site management. A study by Zvaigzne et al. (2016) found that Latvian Nature Conservation experts also suggest applying the combined method as the most effective in *H. sosnowskyi* population restriction.

The site with the greatest *H. sosnowskyi* area decrease was found at Lubāna mitrājs Nature Reserve, where similar methods to harrowing – bank strengthening and partial road reconstruction, which effectively limit the growth and distribution of *H. sosnowskyi* – were applied (Bērziņš et al. 2007). Most of the sites where the area of *H. sosnowskyi* was decreasing represented different management regimes applied to a similar extent. This may give some indication about the combined management method that is probably the most effective approach for limiting the *H. sosnowskyi* population growth. However, the method selection should be based on particular site habitat characteristics. We found the black plastic sheet method also an appropriate approach for limiting the growth of *H. sosnowskyi* in an Andrupene Nature Park grassland site, as

mentioned in other research studies (Bērziņš et al. 2007). Dalke et al. (2015) has found that the most important factors for the formation of *H. sosnowskyi* in monostand invaded areas are early growth, fast formation of a dense canopy, high light efficiency as well as water use during photosynthesis, an ability of young plants to survive under limited light conditions, fast recovery after being damaged and high density of a soil seed bank, which are important criteria for selecting the most appropriate method for *H. sosnowskyi* management.

Our results show a preliminary research study on *Heracleum sosnowskyi* dynamics in relation to its habitat and management regime in Rēzekne municipality in three nature protected territories. In future, it is necessary to increase the number of sites monitored for more objective results, as we studied only 33 sites. More detailed studies on the habitat type, vegetation in relation to testing the specific management method are needed for at least several decades.

CONCLUSIONS

The cover of *Heracleum sosnowskyi* did not changed significantly from 2012 to 2016 in the studied specially protected territory sites in Rēzekne municipality. However, a longer monitoring period – at least several decades – is necessary for more objective results. Roadsides and grasslands were the most common habitats, where *H. sosnowskyi* was found. The management method selection for *H. sosnowskyi* population restriction should be based on particular site geographical and habitat characteristics as well as on historical management activities.

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