Distribution of selected neophytes along the main rivers of Luxembourg

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Abstract. This article presents the results of a systematic survey of the following invasive alien plant species carried out along the main rivers of Luxembourg in 2013: summer lilac (*Buddleja davidii*), Japanese knotweed, Sakhalin knotweed and their hybrid (*Fallopia japonica*, *F. sachalinensis*, *F. ×bohemica*), Jerusalem artichoke (*Helianthus tuberosus*), giant hogweed (*Heracleum mantegazzianum*), Himalayan balsam (*Impatiens glandulifera*), small balsam (*Impatiens parviflora*), staghorn sumac (*Rhus typhina*) and black locust (*Robinia pseudoacacia*). The results show that all the investigated rivers are colonized by at least one of the studied species. The rivers Alzette and Sûre (Sauer) are the most affected, with ten respectively nine out of the ten species considered, showing very dense populations in many sites. *Impatiens glandulifera* is the most common of the investigated species. Compared to a former survey back in 2006-2007, *Fallopia* spp. and *Impatiens glandulifera* continued to expand along the river network, whereas the distribution of *Heracleum mantegazzianum* sharply declined due to the eradication measures undertaken by various stakeholders.

Keywords. Biological invasions, invasive alien species, neophytes, plant invasions, vascular plants, rivers, Luxembourg.

1. Introduction

In 2006 and 2007, a systematic survey of the neophyte species giant hogweed (*Heracleum mantegazzianum*), Himalayan balsam (*Impatiens glandulifera*), Japanese knotweed, Sakhalin knotweed and their hybrid (*Fallopia japonica*, *F. sachalinensis*, *F. ×bohemica*) was carried out along the main rivers of Luxembourg. At the same time, some - but no systematic - insights about the dissemination of the Jerusalem artichoke (*Helianthus tuberosus*) were obtained.

This systematic mapping exercise was repeated and extended in the summer of 2013: in addition to the aforementioned species, occurrences of staghorn sumac (*Rhus typhina*), small balsam (*Impatiens parviflora*), black locust (*Robinia pseudoacacia*) and summer lilac (*Buddleja davidii*) were recorded.

The present article summarizes the results of the 2013 survey and analyses the developments since the 2007 survey. The nomenclature of the vascular plants follows Lambinon & Verloove (2012).

2. Methods

2.1. Study area

The survey carried out in 2013 included the rivers Aalbaach/Gander, Alzette, Attert, Black Ernz, Blees, Chiers, Eisch, Mamer, Mess, Moselle, Our, Sûre, Syre, Wark, White Ernz, Wiltz and Woltz / Clerve (Fig. 1). The river Sûre was investigated from the Belgian border to Pont Misère and, omitting the Upper Sûre lake, from the dam in Esch/Sûre to Wasserbillig.

Based on the Gauss-Luxembourg coordinate system we laid a 1 × 1 km grid over Luxembourg. Our sample (100%) consists of 704 grid cells containing at least one river section. The maps also show the grid of the *Institut Floristique Belgo-Luxembourgeois* (IFBL).

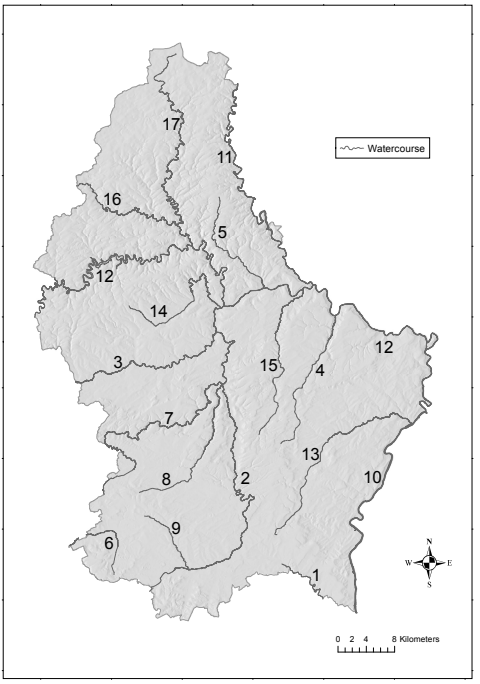

Fig. 1. Localization of the main rivers of Luxembourg: 1 Aalbaach / Gander, 2 Alzette, 3 Attert, 4 Black Ernz, 5 Blees, 6 Chiers, 7 Eisch, 8 Mamer, 9 Mess, 10 Moselle, 11 Our, 12 Sûre, 13 Syre, 14 Wark, 15 White Ernz, 16 Wiltz, 17 Woltz / Clerve.

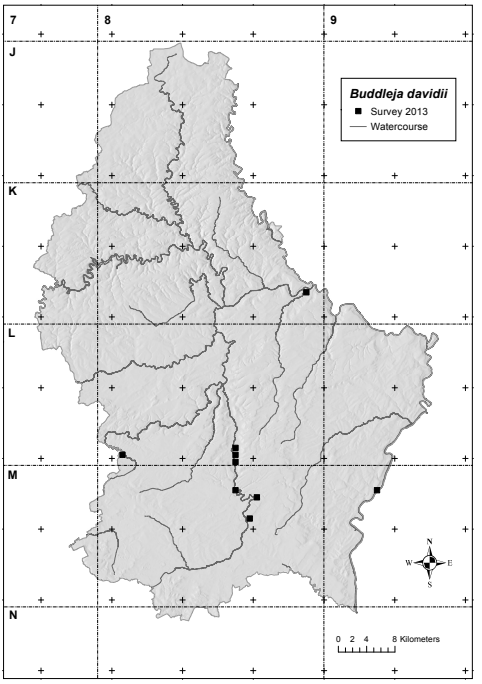

Fig. 2. Distribution of *Buddleja davidii* along the main rivers of Luxembourg (2013).

2.2. Survey

From August 6th to September 3rd 2013 a systematic survey of the different neophyte species was conducted along the rivers listed above. During the survey, the entire length of the watercourses was inspected for the presence of neophytes. Those parts of the river banks that were not directly accessible (private gardens, industrial areas, etc.) were examined from the distance with the help of binoculars. Inaccessible areas were for example encountered along the Attert (industrial area) and the Blees (military area).

Coordinates of neophyte populations were determined by GPS (Garmin Geko™ 301). In locations where the reception of satellite signals was too weak to use the GPS device, the position was indicated approximately on a topographic map. One of the four GPS units seemed to have some kind of technical problem. The values given by that device are located between 100 and 175 meters away from the riverbeds. Because the type of error could not be reproduced, the original data have not been modified. However, the presentation and interpretation of the results based on a 1 × 1 km grid makes it possible to use all the collected data.

3. Results

3.1. *Buddleja davidii*

Summer lilac (*Buddleja davidii)* is commonly planted in gardens, from where it can make its way into the wild. At present, the species can be found only sporadically along the main rivers of Luxembourg. In the course of the inventory populations of summer lilac have been found in nine grid cells (1,3%) (Fig. 2).

The species occurred along the Sûre in Reisdorf and the Eisch in Steinfort. It also bordered the Alzette north of Hesperange and close to Gantebeensmillen, in Luxembourg–Grund and between Walferdange

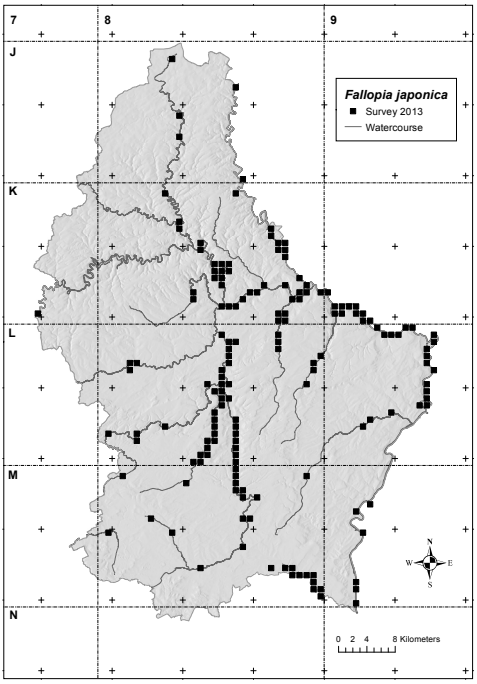

Fig. 3. Distribution of *Fallopia japonica* along the main rivers of Luxembourg (2013).

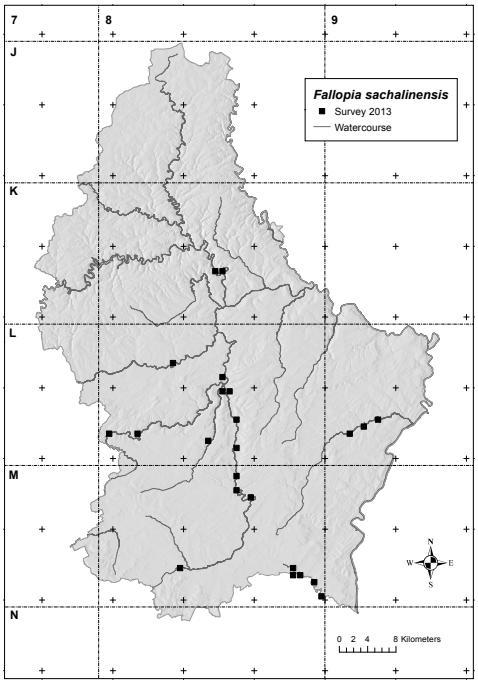

Fig. 4. Distribution of *Fallopia sachalinensis* along the main rivers of Luxembourg (2013).

and Steinsel, and was found on the banks of the Moselle close to Wormeldange.

3.2. *Fallopia japonica*, *F. sachalinensis* and *F. ×bohemica*

Japanese knotweed (*Fallopia japonica*) was found in 162 grid cells (23,0%) (Fig. 3). Most of the rivers were included in its distribution area. Only the Wiltz and Blees rivers were free of the species. Most populations occurred along the lower Sûre, the Alzette north of Luxembourg City, the Mamer, the Gander and parts of the Moselle.

The distribution of Sakhalin knotweed (*Fallopia sachalinensis*) is much sparser than that of Japanese knotweed. Sakhalin knotweed was found in twenty-three grid cells (3,3%) along the rivers Sûre, Attert, Eisch, Mamer, Alzette, Syre and Gander (Fig. 4).

Bohemian knotweed (*Fallopia ×bohemica*), a hybrid of *F. japonica* and *F. sachalinensis*, is generally an under-recorded component of the knotweed populations, because it is not easily identified. Usually, a genetic analysis is required to identify it without doubt. It occupies the same sort of habitats as the Japanese knotweed. During the inventory along the main rivers of Luxembourg the hybrid was not recorded. However, because of the aforementioned identification problems, it cannot be excluded that some of the populations of Japanese knotweed are in fact occurences of its hybrid Bohemian knotweed.

3.3. *Helianthus tuberosus*

Jerusalem artichoke (*Helianthus tuberosus*) occurred in sixty-three grid cells (9,0%), distributed almost exclusively along the lower Sûre, the Moselle and the Alzette (Fig. 5).

3.4. *Heracleum mantegazzianum*

Giant hogweed (*Heracleum mantegazzianum*) occurred in twelve grid cells (1,7%) along the Our, Sûre, Attert, Black Ernz, Alzette and Mamer (Fig. 6).

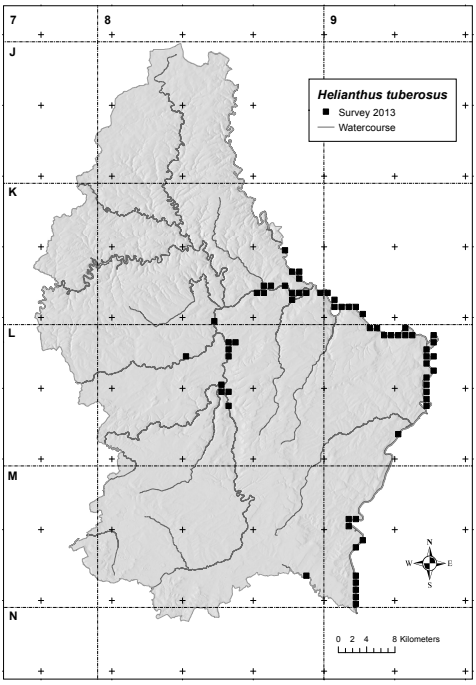

Fig. 5. Distribution of *Helianthus tuberosus* along the main rivers of Luxembourg (2013).

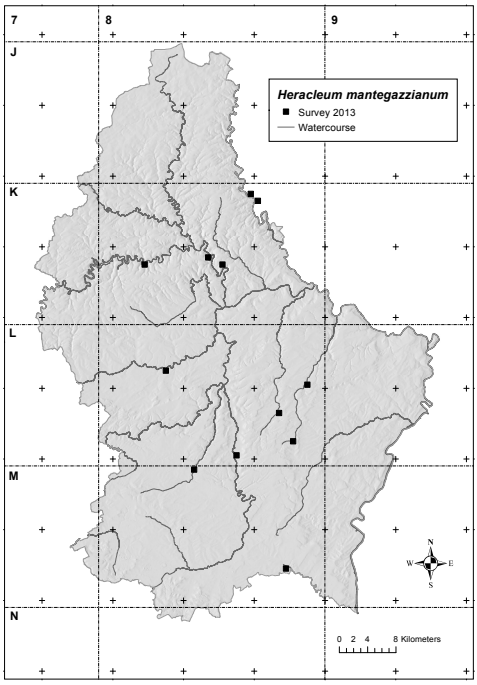

Fig. 6. Distribution of *Heracleum mantegazzianum* along the main rivers of Luxembourg (2013).

3.5. *Impatiens glandulifera*

Himalayan balsam (*Impatiens glandulifera*) is by far the most common invasive species along the main watercourses of Luxembourg. It occurred in 397 grid cells (56,4%) (Fig. 7). On the scale of the 1x1 km grid, the species colonizes almost the entire Woltz/Clerve, Our, Sûre, Attert, Eisch and Gander as well as large parts of the Black and White Ernz and the Alzette.

3.6. *Impatiens parviflora*

Small balsam (*Impatiens parviflora*) is an annual herbaceous plant from the family of the Balsaminaceae. The species is native to some areas of Eurasia and naturalized in Luxembourg. It is usually found in damp shady places and prefers moist soils. In Luxembourg the plant grows most frequently along forest roads and forest edges. Because it is so common and of no particular botanical interest, data about its national distribution is scarce even though the species is found in most forest areas.

During the survey, the species was found in sixty-seven grid cells (9,5%) and was particularly common along the rivers Attert, Eisch and Mamer (Fig. 8). Its occurrence was mostly related to the presence of forests on the rivers' edge.

3.7. *Rhus typhina*

Staghorn sumac (*Rhus typhina*) is native to eastern North America. It is primarily found in Southeastern Canada, the Northeastern and Midwestern United States and the Appalachian Mountains, but is widely cultivated as an ornamental plant throughout the temperate world.

Staghorn sumac occurred in seven grid cells (1,0%) along six different rivers (Fig. 9).

3.8. *Robinia pseudoacacia*

Black locust (*Robinia pseudoacacia*) is a tree of the pea family Fabaceae. It is native to the southeastern United States, but has been widely planted and naturalized elsewhere in temperate North America, Europe, South-

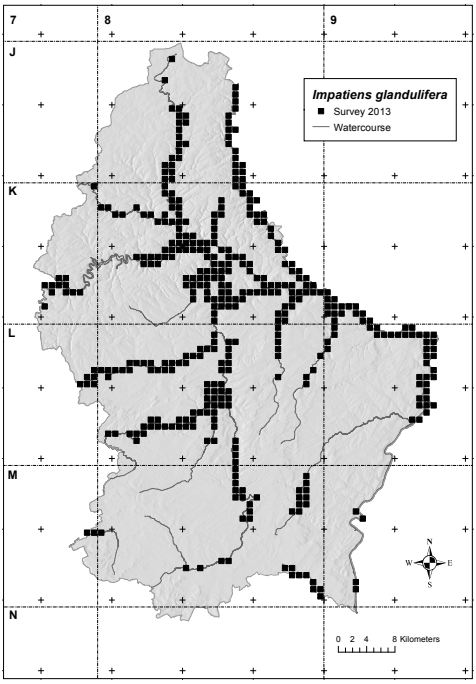

Fig. 7. Distribution of *Impatiens glandulifera* along the main rivers of Luxembourg (2013).

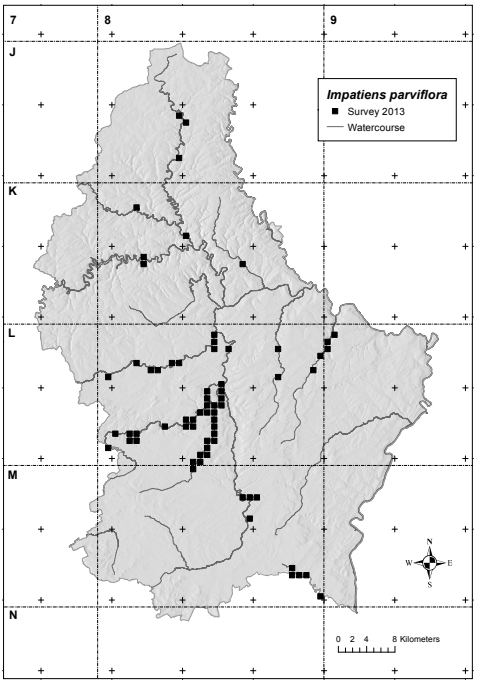

Fig. 8. Distribution of *Impatiens parviflora* along the main rivers of Luxembourg (2013).

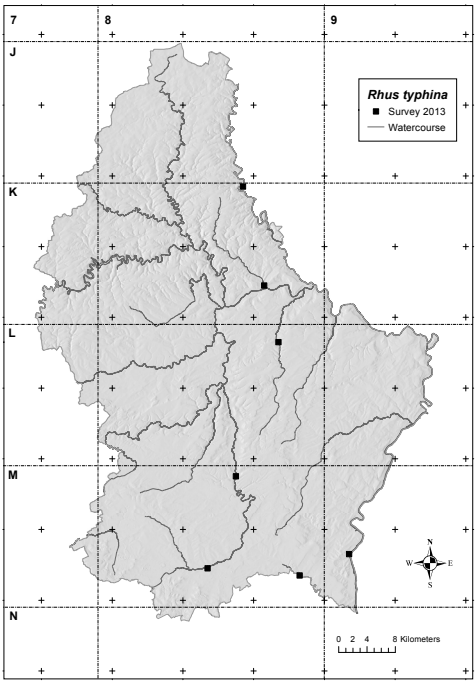

Fig. 9. Distribution of *Rhus typhina* along the main rivers of Luxembourg (2013).

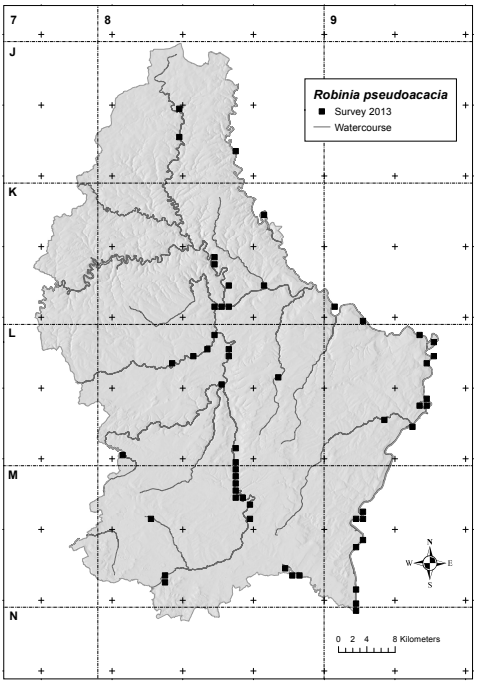

Fig. 10. Distribution of *Robinia pseudoacacia* along the main rivers of Luxembourg (2013).

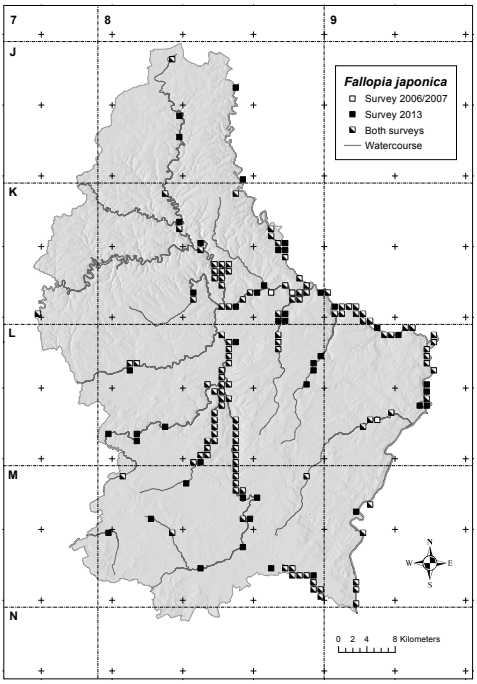

Fig. 11. Distribution of *Fallopia japonica* along the main rivers of Luxembourg in 2006/2007 and 2013.

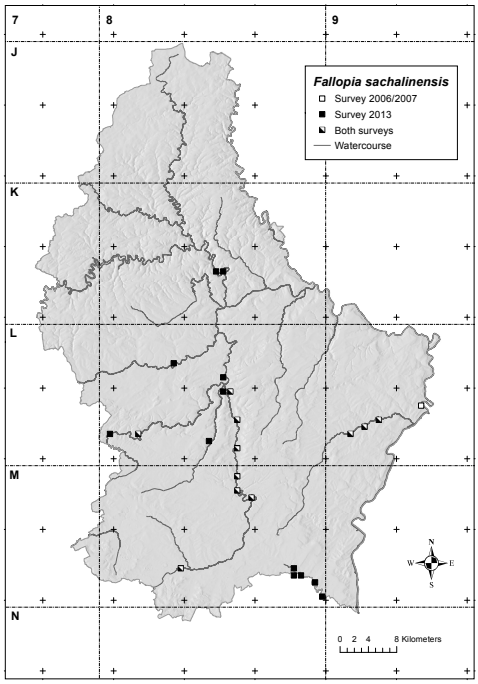

Fig. 12. Distribution of *Fallopia sachalinensis* along the main rivers of Luxembourg in 2006/2007 and 2013.

ern Africa and Asia and is considered an invasive species in some areas.

Black locust occurred in fifty-five grid cells (7,8%), most of which are situated along the rivers Alzette, Moselle and Eisch (Fig. 10).

4. Discussion

4.1. *Fallopia japonica* and *F. sachalinensis*

Both knotweed species continue to spread rapidly along the rivers of Luxembourg. If one considers the 1×1 km grid, the Japanese knotweed distribution area has increased by 36% (from 119 to 162 grid cells) whereas the distribution area of Sakhalin knotweed has almost doubled (+92%: from 12 to 23 grid cells) between 2006/2007 and 2013 (Figs 11 and 12)!

For Japanese knotweed changes occurred mainly along the Black Ernz, the Attert and the lower Alzette; most heavily affected are the rivers Gander, Mamer, Alzette and lower Sûre. A first population along the Chiers was discovered in 2013; new occurrences on the banks of the Our, Mess and Woltz will probably contribute to a further spread of the species during the coming years.

A few sites, those where the species was found in 2007, but from which it was not reported in the 2013 survey have been cross-checked at the end of 2013. In 80% of these cases, either the existing populations had been overlooked or the data had not been transmitted. Populations have only disappeared from a few stations, where massive changes occurred at the rivers' edges due to inundations and/or erosion.

New populations of Sakhalin knotweed have been discovered in 2013 along the rivers Sûre, Attert, Mamer and especially the Gander. Even if the species' distribution is much sparser than that of Japanese knotweed, the trend from the last six years indicates that it will continue to expand.

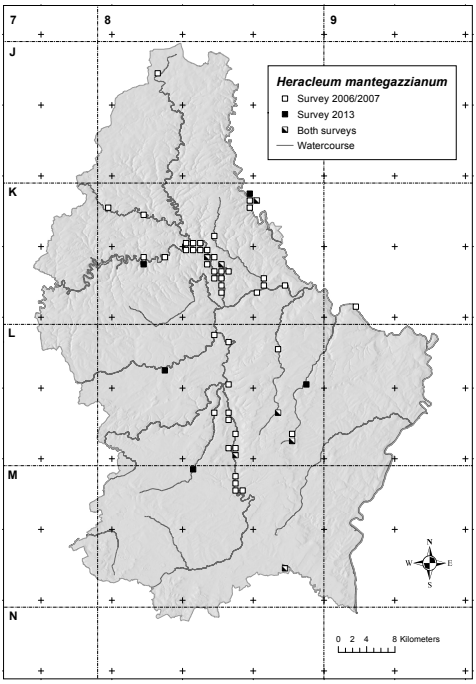

Fig. 13. Distribution of *Heracleum mantegazzianum* along the main rivers of Luxembourg in 2006/2007 and 2013.

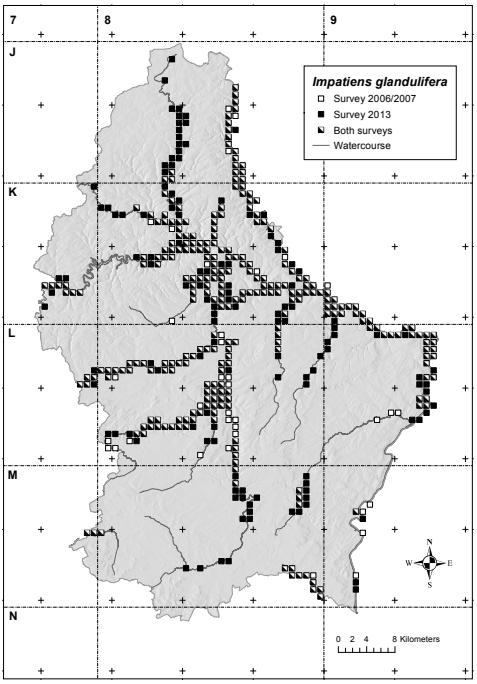

Fig. 14. Distribution of *Impatiens glandulifera* along the main rivers of Luxembourg in 2006/2007 and 2013.

4.2. *Heracleum mantegazzianum*

If one compares the distribution of giant hogweed along the main rivers of Luxembourg during the two surveys of 2006/2007 and 2013 respectively, it becomes apparent that the species is much less common in 2013 than it was six years before (Fig. 13). This is definitely a result of the different eradication campaigns related to public health issues. Various administrations, local authorities and other organisations are known to conduct more or less systematic management measures in order to fight giant hogweed: Administration de la gestion de l'eau, Administration de la nature et des forêts, Parc naturel de la Haute-Sûre (Krippel & Richarz 2013), several municipalities, e.g. Luxembourg City, etc.

Independently of the systematic survey along the main rivers, twenty-five sites that were not located on rivers and where the occurrence of giant hogweed had been documented in 2006/2007 (Pfeiffenschneider & Ries 2007) were visited in August 2013. Fourteen (56%) of these known populations have vanished since 2006/2007. This is a further indication of the success of the different management and awareness-raising campaigns. Known sites where the species still occurs can be found for example in Ernster, Grünewald, Roeser and Windhof (Pfeiffenschneider et al. 2014).

The results show that it is not impossible to eradicate giant hogweed if management measures are coordinated on a national scale and implemented systematically.

4.3. *Impatiens glandulifera*

Whereas Himalayan balsam has disappeared from some formerly occupied areas in Luxembourg - a result which is consistent with observations from a separate monitoring study (Gräser 2014) - it is generally still expanding. Especially along the rivers Woltz/Clerve, Wiltz, Black Ernz and the Alzette south of Luxembourg-Dommeldange the portion of the river banks populated by the species has increased considerably (Fig. 14). At present, the Mess is the only main river without any populations of Himalayan balsam.

5. Conclusions

The 2013 survey results show that every main river in Luxembourg is populated by one or more of the investigated neophytes, most of which are considered invasive alien species. This is consistent with observations in other European countries where neophytes are frequently found in riparian vegetation (Essl & Rabitsch 2002, Kowarik 2010).

If one considers the 1x1 km grid, only a few river stretches of a certain length - found along the rivers Wark, White and Black Ernz, Syre, Mamer, Mess and Moselle - remain free of any of the investigated species. Since all the populations seem still to be expanding, the length of affected riverbanks will continue to increase if no management measures are implemented. The fact that giant hogweed, the only species which has been the subject of active management efforts in the recent past in Luxembourg, is also the only species that declined along the main rivers, speaks in favor of such management. However, one has to keep in mind that giant hogweed is more easily removed than most of the other species considered in this survey.

All species considered in the present survey have been evaluated in relation to their potential impact on biodiversity using the ISEIA protocol (Branquart 2009) in 2012 and 2013: four species are listed in the black list, three species in the watch list (Ries et al. 2013). The spatial distribution of some of these species, as evaluated in 2012/2013, might have to be reconsidered based on the results documented in the present article and other recent studies (Pfeiffenschneider et al. 2014, Krippel & Richartz 2013); mainly, the distribution of the giant hogweed might have to be downgraded from "widespread" to "isolated populations".

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