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The spread, intensity and invasiveness of the *Acer negundo* in Riga and Kaunas

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Abstract: Ashleaf Maple (*Acer negundo* L.) was first introduced in Latvia and Lithuania at the beginning of the 19th century. It is the most widely distributed alien maple species to be found in the parks and greeneries of Riga and Kaunas. In recent decades, the spread and invasion of this species has been observed. The aim of this research was to determine the extent and effects of the invasiveness *A. negundo* in Riga and Kaunas. The degree of invasion by this species' was estimated by applying the Pest Plant Prioritization Process, which is based on the Analytic Hierarchy Process method. The results showed that the invasive degree of box elder was very high (0.788); the present compared to potential distribution rating was medium high (0.71) and the social, environmental and economic impact score was low (0.23). The Final Pest Plant Score for *A. negundo* was medium (0.4506). The obtained estimates indicated that box elder was invasive and was able to spread rapidly into new riparian areas.

Addiotional key words: Ashleaf maple, spread, invasiveness, Pest Plant Score

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Introduction

Ashleaf Maple (*Acer negundo* L.) also known Manitoba Maple in Canada, and Box elder in America is native to North America and is the most widely distributed of all American maples. Its native range extends across the U.S. and from Alberta, Canada in the north and to southern Mexico and Guatemala in the south (USDA). In North western America it is found primarily in river canyons where it may form extensive riparian forests (DeWine and Cooper 2007). However, in parts of northern America it can be found outside its natural distribution range and is considered as an alien species (Planty-Tabacchi et all. 1996). Seed crops are produced annually, beginning at 8 to 11 years of age (Schopmeyer 1974). The species is dioeciously and comparing with other urban maple species, has a short life cycle. Open-grown *A. negundo* trees usually have an irregular form, with the main stem dividing near the ground, resulting in a large uneven crown. In Canada, the diameter at breast height of the main stem rarely exceeds 60 cm, and heights in excess of 15 m are uncommon (Blouin 1992). *A. negundo* develops deep roots, and stump suckers and prefers to grow in moist soils (Rauktys 1933). It has also been known to survive an inundation of water for as long as 30 days (Hosner 1960), and subsequent research indicates that established trees can tolerate being inundated for longer than 85 days (Friedman and Auble 1999). The species was deliberately introduced to different countries in Europe together with a number of other American plant species in the seventeenth century (Mędrzycki 2007; Erfmeier 2011).

Scientific literature provides different opinions about the introduction and cultivation of *A. negundo* in Lithuania. According to Gudžinskas (1998), *A. negundo* was initially cultivated in the 1930s and was first recorded as an invasive species in 1963. However, according to Rauktys (1933), *A. negundo* was grown in Lithuania long before the 20th century. Whilst Skridaila (2001) reported that *A. negundo* was growing in the Vilnius University botanical garden in 1804. As a fast-growing and winter-hardy species, it was frequently planted as an ornamental tree in both cities and farmyards (Rauktys 1933). Kowarik (1995) state's that after introduction, the naturalization of many trees takes approximately 170 years, until they began to spread. In agreement, after 150 years since its introduction, *A. negundo* was reported to be growing and bearing fruit in Lithuania (Janušauskaitė 1935; Ramanauskas 1973). In general, between 1928–1939, *A. negundo* was abundantly grown in nurseries for ornamental gardening in Lithuania. After the Second World War, it was planted in forests, however after 1960 was deemed not suitable for forestry and as a result was no longer propagated in nurseries (Kairiūkštis 1968). Subsequent descriptions mention that in Lithuania, these maples are frequently found growing near homesteads, in urban landscapes, parks, nurseries, protective plantations, along roadsides and railways (Navasaitis 1979; 2004). They have also been used for forest land reclamation – on slopes, and in more humid sandy soils. In industrial centres, they have been assessed as being fume and dust resistant, and can be used quickly to repopulate vacant areas. Further planting is not recommended for urban areas, because it is already widespread (LTSR Flora 1971). Officially in Lithuania *A. negundo* was considered an invasive alien tree species in 2004 (Anonymous 2004) and in 2013–2015 the Lithuanian Ministry of Environmental organized the ongoing project "Regulatory measures of invasive plant species abundance".

In Latvia, *A. negundo* was first introduced in tree nurseries at the beginning of the 19th century (Zigra 1817; Wagner 1822) and was also used as an element of urban greenery in Riga. Some decades later, at the end of the 19th century, it became a popular woody species within the vicinity of Riga (Klinge 1883). In the middle of the 20th century, *A. negundo* was the second most widespread alien maple species behind the Sycamore (*Acer pseudoplatanus*) (Zariņš 1959), but only after 20 years, it was deemed the most distributed alien maple species in parks and greeneries in Latvia (Cinovskis et al. 1974). Nowadays, it is considered as a fully naturalized species in Latvia (Gudžinskas 1998; Gavrilova and Šulcs 1999). *A. negundo* forms up to several square meters large stands in non-used grasslands and ruderal areas in Riga and other urban and rural areas in Latvia.

It should be noted that not all alien plants become invasive. Williamson and Fitter (1996) estimated that approximately 10% of naturalized plant species become invasive and cause significant economic and ecological impacts. The mass spread of some introduced species has occurred only during the last few decades. In the 1980s–1990s only sporadic findings of *A. negundo* were recorded, but at the beginning of the 2000s, mass spread into vegetative communities of the Volga basin region was observed (Borisova 2011). To make informed decisions about the optimal method of weed control in urban areas, it is necessary that the relative importance of each weed be determined.

The research aim is to determine the relative importance of *Acer negundo* invasiveness in Riga and Kaunas. The invasiveness can be determined by considering: (a) how invasive they are, how fast can they spread? (b) The present and potential extent of the species; (c) what social, environmental and economic impacts does the species have?

Material and Methods

Growth and seedling distribution of *A. negundo* in Riga (56°57'05" N, 24°06'10" E), the capital of Latvia, and Kaunas (54°53'50" N, 23°53'10" E), the second largest city of Lithuania, were analysed. The climate in Riga is moderately warm and humid: the average annual precipitation is about 700 mm, the average temperature in January is –3.5°C, and in July +17.2°C. The climate in Kaunas is more continental. The average annual precipitation is 550–600 mm, the average temperature in January is –5.2°C, and in July +16.9°C (Statistical department data of 2005–2010).

Methods to calculate pest plant score

The species that are of highest risk are those that have the greatest potential to affect valuable resources. The information that is needed to enable threats to be assessed under this process includes: information about the biology of each species and its potential rate of spread; the species that could threaten the region either now or in the future; the level of impact that a species could have on social, agricultural and environmental resources; the values that land managers assign to affected resources.

Table 1. Invasiveness criteria used in intensity rating assessment

Group/ Criteria	Intensity rating: Lowest threat (L)	Medium low (LM)	Medium high (MH)	Highest threat (H)
Establishment				
Germination/ propagules requirements	Requires specific environmental factors that are not part of an annual cycle of the system to germinate	Requires unseasonal or uncommon natural events for germination, eg (flooding, fire.)	Requires natural seasonal disturbances such temperatures for germination / striking/ set root	Opportunistic germinator, can germinate or strike/ set root at any time whenever water is available
Seedling/ Propagule Establishment requirements	Requires additional and very specific factors such as nutrient and water that are deliberately added	Requires more specific requirements to establish eg open space or bare ground with access to light and direct rainfall	Can establish under moderate canopy/ litter cover	Can establish without additional factors.
How much disturbance is required for seedling establishment	Major disturbance required with little or no competition from other plant species	Establishes in highly disturbed natural ecosystems or in overgrazed pastures/poorly growing or patchy crops	Establishes in relatively intact or only minor disturbed natural ecosystems; in vigorously growing crops OR in well-established pastures	Establishes in healthy and undisturbed natural ecosystems .(eg mallee, alpine, heathlands)
Growth/ competitive ability				
Life form	Others	Geophytes, Climber or creepers	Grasses, Leguminous plants	Aquatic and semi aquatic
Allelopathic properties	None	Minor properties	Allelopathic properties affecting some plants	Major allelopathic properties inhibiting all other plants
Ability to tolerate herbivory pressure	Preferred food of herbivores. Eliminated by moderate herbivory or reproduction entirely prevented	Consumed and recovers slowly. Reproduction strongly inhibited by herbivory but still capable of vegetative propagule production	Consumed but non-preferred or consumed but recovers quickly; Capable of flowering under herbivory pressure	Favoured by heavy grazing pressure **as not eaten** by animals/ insects
Normal growth rate	Slow growth, will be exceeded by many other species	Maximum growth rate less than many species of same life-form	Moderately rapid growth that will equal competitive species of same life form	Rapid growth rate that will exceed most other species of same life form
Stress Tolerance of established plants to frost, drought, water logging, fire	Maybe tolerant of 1 stress, susceptible to at least 2	Tolerant to at least 2 and susceptible to at least 2	Highly tolerant of at least 2 of (Drought, Frost, Fire and Waterlogging). Susceptible to at least 1	Highly resistant to at least 2 of (Drought, Frost, Waterlogging, Fire) not susceptible to more than 1
Reproduction				
Reproductive system	Sexual but either cross OR self pollination	Sexual (self and cross pollination)	Vegetative reproduction	Both vegetative and sexual reproduction
Number of propagules	Less than 50	50–1000	1000–2000	Above 2000
Seed longevity	Seeds survive <5 yrs, or lower viability but survive 5–10 yrs OR vegetatively reproduces	> 25% of seeds survive 5–10 yrs in soil, or lower viability but survive 10–20 yrs	>25% of seeds survive 10–20 yrs in soil, or lower viability but survive 20+ yrs	>25% of seeds can survive >20 yrs in the soil
Reproductive period	Mature plant produces viable propagules for only 1 yr.	Mature plant produces viable propagules for only 1–2 yrs.	Mature plant produces viable propagules for 3–10 yrs	Mature plant produces viable propagules for >10 yrs
Time to reach reproductive maturity	Greater than 5 yrs to reach sexual maturity	2–5 yrs	Produces propagules between 1–2 yrs after germination	Reaches maturity and produces viable propagules in under a year
Dispersal				
Number of dispersal mechanisms	Propagules mainly spread by gravity	Propagules can also be spread by attaching to humans or animals	Propagules spread by wind, water, animals (not birds) or light vehicular traffic	Very light, wind, or bird dispersed seeds; Or has edible fruit
How far do propagules disperse	Very unlikely to disperse greater than 200 m most will be less than 20 m	Very few to none will disperse to 1 km, most 20–200 m	Few propagules will disperse greater than 1 km but many will reach 200–1000 m	Very likely that some propagules will disperse greater > 1 km

According to PPPP methodology (http://vro.depi.vic.gov.au/dpi/vro/vrosite.nsf/pages/invasiveness_criteria)

Table 2. Impact score criteria and weight for evaluating influence of the plant

Criteria	Weight
Social (Tourism, Visual aesthetics, Experience, Cultural sites)	
1. To what extent does the weed restrict human access?	0.025988
2. To what level does this weed reduce the 'tourism / aesthetics/ recreational use of the land?	0.047162
3. To what level is the plant injurious, toxic, or spines affect people?	0.01435
4. How much damage is done to indigenous or european cultural sites?	0.0125
Natural resources – soil, water & processes	
5. To what extent does this weed impact on water flow within watercourses?	0.041625
6. To what extent does the weed impact on water quality (ie. Dissolved 02, water temperature)?	0.083375
7. To what extent does the weed increase soil erosion?	0.075
8. To what extent does this weed reduce the biomass of the community? (nb. Biomass acting as a carbon sink)	0.005
9. To what extent does the weed change the frequency or intensity of fires?	0.045
Fauna and flora / vegetation & EVCs	
10. To what extent does this weed impact on the vegetation composition on the following:	
a. High value EVCs	0.081991
b. Medium value EVCs	0.049780
c. Low value EVCs	0.014641
11. To what extent does this weed effect the structure of a vegetation community?	0.069062
12. What effect does the weed have on threatened flora spp.?	0.060775
13. What effect does the weed have on threatened fauna spp.?	0.05474
14. What effect does the weed have on nonthreatened fauna spp.?	0.026329
15. To what extent does this weed provide benefits or facilitates the establishment of indigenous fauna?	0.023056
16. To what extent is the plant toxic, its burrs or spines affect fauna?	0.01666
Flora and fauna/ fauna /pest animal	
17. To what extent does this weed provide a food source to assist in success of pest animals?	0.011186
18. To what extent does this weed provide habitat / harbor for serious pests?	0.016779
Agriculture – quality, quantity, cost to production, effect on land value	
19. To what extent does this weed impact on the yield of agricultural produce?	0.0189
20. To what extent does the weed impact on agricultural quality?	0.0324
21. To what extent does this weed affect land value?	0.054675
22. To what extent does this weed cause a change in priority of land use?	0.1008
23. To what extent the presence of the weed increases the cost of harvest?	0.011925
24. To what extent does this weed act as an alternative host for diseases?	0.0063

The Pest Plant Prioritisation Process (PPPP) is a prioritization process or risk assessment, based on the Analytic Hierarchy Process (AHP) (Saaty 1995; Weiss and McLaren 2002) that ranks weeds by: assessing the plant invasiveness; comparing the present and potential distribution of plants; assessment of plant impact on social, economic, and environmental values. The PPPP is therefore expressed as a hierarchy, the components of which are weighted (using AHP) to allow the determination of a Pest Plant Assessment score for individual species. Experts determined a preliminary ranking of the three subcomponents of the PPPP (Weiss and McLaren 2002). The basis of the weighting was that invasiveness was considered less important than distribution, which in turn was considered less important than impact. The Pest Plant Assessment score is expressed as: PPS = α (Invasiveness score) + β (Present:Potential Distribution) + γ (Impact), where α (0.12), β (0.32), γ (0.56) are weightings of the subcomponents (Weiss and McLaren 2002).

The scored intensity ratings for each criterion and their weightings where calculated to produce a final invasiveness score (eqn. 1):

$$\text{Invasiveness score} = \Sigma\ ((\text{Group weighting} \times \\ \times \text{Criterion weighting}) \times \text{Intensity rating})$$

Criteria weights were rated by experts, valuation fixed. Assessment of plant invasiveness was done by evaluating biological and ecological characteristics such as germination requirements, growth rate, competitive ability, reproduction ways and dispersal mechanisms. Intensity rating for every group is defined by assessment of species characteristics (Table 1). Assessments have been done by literature analysis, observation of urban greenery and riparian zones in Riga and Kaunas, where *Acer negundo* grows and spreads.

Present distribution was determined based on the results of inventory data of urban parks in Riga (Pūka et al. 1988) and field assessments during summer 2014, as well as inventory data collected on woody plants in the green areas of Kaunas in 2011–2014.

The ratio of present to potential distribution provides an indication as to the stage that the spread of alien tree species has reached.

Assessment of plant impacts was determined by the extent to which a species affects environmental, economic and social resources. Species influence was evaluated according to 24 criteria (Table 2), rating them by intensity differences (Weiss and McLaren 2002), based on the following formula (eqn. 2):

$$\text{Impact Score} = \Sigma\ (\text{Rating} \times \text{Weight})$$

Assessments were based on literature analysis, field observations in Riga and Kaunas, as well consultations with ecologists, biologists and foresters.

The final stage of PPPP is to apply the results of invasiveness, distribution and impact assessments to determine the relative importance of weeds by calculating a Pest Plant Score. The formula (eqn. 3) for calculating the Pest Plant Score is:

$$\text{Pest Plant Score} = \alpha\ (\text{Invasiveness score}) + \beta\ (\text{P/P Distribution}) + \gamma\ (\text{Impact})$$

To assess plants for invasiveness and impact, information from our and other research results were used. Where some information was missing, likely responses were estimated.

Results and discussion

Invasiveness score of *Acer negundo*

Invasiveness can be defined as the ability to establish, reproduce, and disperse within an ecosystem. Plant propagules arrive at a new site with certain inherent characteristics that previously enabled their successful survival and continued reproduction throughout their evolutionary history (Table 3).

The studies reveal that *A. negundo* suffers from polluted urban air, has higher crown defoliation and is less healthy in Kaunas city (Stravinskienė 2010). Because of these properties, this maple is not suitable for urban greening and planting along roads. However, it quickly spreads and is healthy in riparian zones. The spread of *A. negundo* on the banks of the Kaunas Reservoir were observed at low (<1.5 m) bank heights (Žalkauskas 2000). Seedlings can establish and grow in shaded environments (Wilson 1970).

In its native region, establishment of box elder is strongly dependent on high flows and is adversely affected by river regulation that reduces peak flows (DeWine and Cooper 2007). Rivers in Latvia and Lithuania have high peak flows every spring (data according to State Ltd "Latvian Environment, Geology and Meteorology Centre"). The water level in

Table 3. Invasiveness rating for *Acer negundo*, according to criteria

Criteria	Comments	Rating*
	Establishment	
1. Germination requirements	Seeds germinate in spring. Seeds show dormancy (Roe 1941; Irving 1968; Olson & Gabriel 1974; Cram 1983)	MH
2. Establishment requirements	Occurs in moderate litter, herbal cover.	MH
3. Disturbance requirements	Establishes in riparian zone, abandoned farms, derelict house land	MH
	Growth/competitive ability	
4. Life form	Low tree form, often have multiple stems, average age of 60 years, sometimes – 100 years (Green 1934).	L
5. Allelopathic properties	Roots, leaves made moderate effect (Kolesnichenko and Spakhov 1969)	M
6. Tolerates herbivory pressure	Not eaten by animals	H
7. Normal growth rate	Shoots rapid growth in the young, increasing 1.5–2 meters. Gap colonising tree	H
8. Stress tolerances	Highly resistant of frost, drought, tolerates many soil types, pH range 4.4–7.9 pH (USDA). Survive inundation for as long as 30 days (Hosner 1960). But suffer from polluted urban air (Stravinskienė 2010)	MH
	Reproduction	
9. Reproductive system	Reproducing by seeds, after cutting, abundant stump suckers. Monosexual	MH
10. Propagule production	70 thousand seeds (Valantinaitė et al. 2011).	H
11. Seed longevity	Seed viability maintained for 1–2 years in hermetic storage at 2°C to 5°C with 10–15% mc (Olson & Gabriel 1974)	L
12. Reproductive period	Mature female tree produce new growth each spring, more fertile years is repeated every few years	H
13. Time to maturity	Tree does not flower until 8–11 years old (Schopmeyer 1974)	L
	Dispersal	
14. Number of mechanisms	Propagules spread by wind, water. Thousand seed weight is 40 g to 70 g	MH
15. How far do propagules disperse	River could disperse seeds many km	H

*Rating: L – lowest threat, ML – medium low, M – medium, MH – medium high, H – highest threat.

Table 4. Determination of Invasiveness score in Riga and Kaunas

Group	Criteria	Rating	Weight*	Impact
Establishment				
	Germination requirements?	0.75	0.0425	0.0319
	Establishment requirements?	0.75	0.3355	0.2516
	Disturbance requirements?	0.75	0.122	0.0915
Growth/competitive ability				
	Life form?	0	0.00576	0
	Allelopathic properties?	0.5	0.00864	0.0043
	Tolerates herbivory pressure?	1	0.0456	0.0456
	Normal growth rate?	1	0.018432	0.0184
	Stress tolerances?	0.75	0.01776	0.01332
Reproduction				
	Reproductive system?	0.75	0.005593	0.004195
	Propagule production?	1	0.05474	0.05474
	Seed longevity?	0	0.030464	0
	Reproductive period?	1	0.012019	0.012
	Time to reproductive maturity?	0	0.016184	0
Dispersal				
	Number of mechanisms?	0.75	0.094572	0.070929
	How far do propagules disperse?	1	0.189428	0.1894
				0.788

* Weight valuation fixed, evaluated by experts.

the Nemunas River fluctuates constantly due to the impact of the Kaunas hydroelectric station. This indicates that in the future, box elder will spread to new riparian zones.

Another factor which affects the spread of box elder in urban territories is wind. It is difficult to clearly distinguish the effect of wind only, as birds and animals also spread seeds. The impact of wind is smaller than that of water, as the furthest detected seedling was 100 meters distant from the parent tree, and water carries seeds for longer distances (Valantinaitė et al. 2011). The spread of alien species is assisted not only by water, wind, animal and birds, but also is accelerated by growing trade, tourism and cross-border freight transport. Invasion of *Acer* species is enhanced by soil biota associated with dominant native species and the soil biota effect becomes more inhibitory as the *Acer* species becomes established (Reinhart and Callaway 2004). Determination of Invasiveness score is shown in Table 4.

Results show that the invasiveness score of 0.8 for *A. negundo* is very high.

Invasiveness of woody plant species in disturbed landscapes is associated with small seed mass (<50 mg), a short juvenile period (<10 years) and short intervals between large seed crops (1–4 years) (Rejmánek and Richardson 1996). *A. negundo* have all these characteristics; seed mass is small (thousand seed weight is 40 g to 70 g), trees have a short juvenile period (they start to flower at age 8–11), and short intervals between large seed crops. Winged samara enables long distance dispersal of seeds. Long reproductive periods also seem to be associated with invasiveness (Reichard 1994). *A. negundo* have long reproductive periods, with trees on average living 60 years, with some trees living up to 100 years.

Evaluating the present compared to potential distribution

Current and potential distributions are another major component required in the decision support system and AHP to predict the status of a weed. All species are more invasive in regions that are climatically similar to their native environment. *A.negundo* USDA hardiness zones are 2–7. The territory of Riga and Kaunas is located in the 5^{th} to 6^{th} hardiness zones. This means that the winter climate in Riga and Kaunas is very suitable for this species. According to the Riga inventory data, *A. negundo* is distributed throughout most of the city areas and is recorded in 43% of the parks (Fig.1).

Fig. 1 present the distribution of all trees, planted as ornamental and unassisted spread. Most of new seedlings grow near the Daugava River in sparsely covered areas, where they have a high potential for spread of propagules. In Kaunas (Fig. 2), a high abundance of *A. negundo* individuals grow in the riparian zones of the Nemunas and Neris rivers. As an ornamental tree, this species has a very frequent occurrence (58%) in public parks and squares. During the last years, *A. negundo* has been eradicated in some riparian parks of Kaunas. However, during spring following removal, a new infestation of *A. negundo* propagules was observed, as not all female riparian trees had been eradicated.

Fig. 1. Present distribution of *Acer negundo* in Riga (Raster 1×1 km)

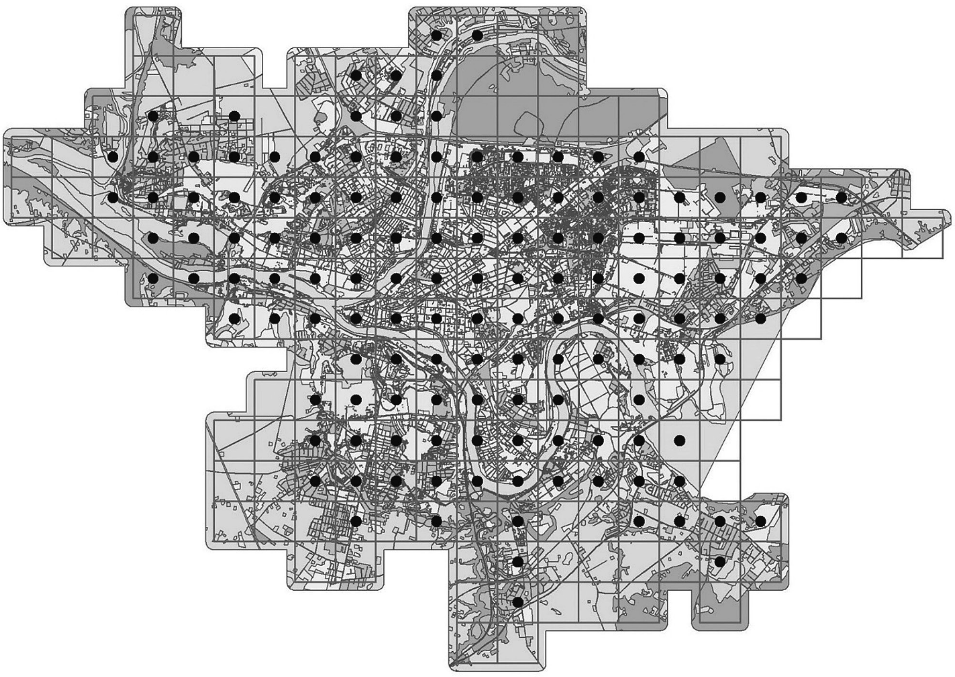

Fig. 2. Present distribution of *Acer negundo* in Kaunas (Raster 1×1 km)

Table 5. Intensity rating for evaluating the present compared to potential distribution

Rating	Weight	Regional Rating
Very high	1	Infestation(s) that are able to be eradicated with no chance of reinvasion from outside of area of control.
High	0.85	Infestation(s) that are able to be eradicated with some chance of reinvasion
Medium high	0.71	Several small infestations beyond eradication
Medium	0.57	A large partially dispersed infestation or few widely scattered small infestations
Medium low	0.42	Numerous large dispersed infestations or lots of scattered small infestations.
Low	0.28	The majority of region infested with some large areas still "clean" (more "clean" areas than infested)
Very low	0.14	The majority of region infested with some smallish areas still "clean" (less "clean" areas than infested)
Extremely low	0	Reached full potential – but may increase in density within infested area

Potential distribution of *A. negundo* in the both cities could be characterized as medium high with an intensity rating weight 0.71. A characteristic feature of this species is reinvasion, especially in riparian zones, after cutting. Intensity ratings for evaluating the ratio of present to potential distribution are shown in Table 5.

According Höfle et al. (2014), the probability of occurrence for *A. negundo* was higher in areas with a close proximity to water and in areas which were located in softwood floodplain forests. Kaunas and Riga have areas with these characteristics.

The spread of many alien species is heavily dependent on human activity (Panetta and Scanlan 1995). Newly sprouted *A. negundo* seedlings were found in high abundance in waterside areas of Kaunas, which are influenced by different types of human activity: creating an embankment, dumping of sand dredged from the Nemunas River. These activities facilitate *A. negundo* to replenish its potential distribution. Disturbance increases plant invasions by providing suitable microsites for germination and seedling establishment and by increasing light and nutrient availability that enhance seedling survival and growth (Hobbs and Huenneke 1992). Some riparian weeds may oc-

Table 6. Social, environmental and economic impact rating

Criteria	Comments	Rating
1. Restrict human access?	Would not hinder human access	L
2. Reduce tourism?	The species is cultivated as ornamental tree in cities	L
3. Injurious, toxic, or spines affect people?	Not toxic and spines	L
4. Damage to cultural sites?	Riparian spread of maples create a negative visual impact on cultural sites	LM
5. Impact on water flow?	Established trees on inundation can stay longer 85 days (Friedman & Auble 1999)	M
6. Impact on water?	Can effect on water quality	M
7. Increase soil erosion?	Not increase soil erosion	L
8. Reduce the biomass of the community?	Biomass of the community may increase on the slopes of the riversides	L
9. Change fire regime?	Not impact on fire in cities	L
10. To what extent does this weed impact on the vegetation composition on the following:		
a. High value EVCs	EVC = Floodplain Riparian Woodland. Major displacement of some dominant sp.	MH
b. Medium value EVCs	EVC= Sedgy Riparian Woodland. Gradual displacement of some dominant sp.	M
c. Low value EVCs	EVC= Riparian Scrub Minor displacement of some dominant sp.	ML
11. Impact on vegetation community structure?	Affects all levels – ground cover, shrubs,	M
12. Effect on threatened flora?	Not recorded in the cities flora	L
13. Effect on threatened fauna?	Effect unsighted	L
14. Effect on nonthreatened fauna?	Unknown negative effect	L
15. Benefits fauna?	Provides some food and shelter for birds, mammals	MH
16. Injurious to fauna?	No effect	L
17. Food to pest animals?	Provides the minimal food for pest animals.	ML
18. Provide harbour?	Provide harbour for rabbits, foxes	H
19. Impact yield?	Little impact on quantity of yield.	L
20. Impact on agricultural quality?	Negligible impact on quality of yield.	L
21. Affect land value?	Not affect land value	L
22. Change land use?	No change	L
23. Increase harvest cost?	Minor increase, if need to cut shoots	ML
24. Disease host?	No host	L

cur along small rivers, streams and water channels. This is a major limitation when predicting their potential distribution. Other non-riparian weeds are recorded as occurring along roadsides and in forest gaps. The present compared to potential distribution of *Quercus rubra* in Lithuania was evaluated with a medium intensity rating (weight 0.57) (Riepšas and Straigytė 2008). The spread of this species is limited by soil fertility and density of grass cover.

Determining the social, environmental and economic impacts

The next stage of the PPPP, before calculating a Pest Plant Score, is to determine the social, environmental, and economic impacts of pest species. Criteria ratings for determining *A. negundo* impact are show in Table 6.

The highest rating is for the criterion that *A. negundo* provides shelter and benefits for fauna. The influence of this species on soil is unknown, as leaf litter decomposes faster than other leaf litter of other maple species (Janušauskaitė and Straigytė 2011). The influence of *A. negundo* on other plants seems not to differ too much from the impact of other trees.

Our results revealed (Table 7) that the impact score is low (0.23).

Pest Plant Score

The final stage of the PPPP is to apply the results of invasiveness (Table 4), distribution (Table 5), and impact (Table 7) assessments to determine the relative importance of weeds by calculating a Pest Plant Score.

$$\text{Pest Plant Score} = 0.12 \times 0.788 + 0.32 \times 0.71 + 0.56 \times 0.23 = 0.4506$$

Table 7. Group and criteria ratings for determining impact of *Acer negundo*

Criteria	Rating	Impact
Social (tourism, visual aesthetics, experience, cultural sites)		
1. To what extent does the weed restrict human access?	0	0
2. To what level does this weed reduce the recreational use of the land?	0	0
3. To what level is the plant injurious, toxic, or spines affect people?	0	0
4. How much damage is done to indigenous or European cultural sites?	0.25	0.003
Natural resources – soil, water & processes		
5. To what extent does this weed impact on water flow within watercourses?	0.5	0.0208
6. To what extent does the weed impact on water quality?	0.5	0.0417
7. To what extent does the weed increase soil erosion?	0	0
8. To what extent does this weed reduce the biomass of the community?	0	0
9. To what extent does the weed change the frequency or intensity of fires?	0	0
Fauna and flora / vegetation & EVCs		
10. To what extent does this weed impact on the vegetation composition on the following:		
a. High value EVCs	0.75	0.0615
b. Medium value EVCs	0.5	0.025
c. Low value EVCs	0.25	0.0037
11. To what extent does effect the structure of a vegetation community?	0.5	0.0345
12. What effect does the weed have on threatened flora spp.?	0	0
Flora & fauna/fauna		
13. What effect does the weed have on threatened fauna spp.?	0	0.
14. What effect does the weed have on nonthreatened fauna spp.?	0	0
15. To what extent does this weed provide benefits or facilitates the establishment of indigenous fauna?	0.75	0.017
16. To what extent is toxic, its burrs or spines affect indigenous fauna?	0	0
Flora and fauna/ fauna /pest animal		
17. Does this weed provide a food source to pest animals?	0.25	0.0028
18. To what extent does provide habitat / harbor for serious pests?	1	0.017
Agriculture – quality, quantity, cost to production, effect on land value		
19. To what extent does this weed impact on the quantity of produce?	0	0
20. To what extent does the weed impact on agricultural quality?	0	0
21. To what extent does this weed affect land value?	0	0
22. To what extent does this weed change in priority of land use?	0	0
23. To what extent weed increases the cost of harvest?	0.25	0.003
24. To what extent does this weed act as a host for diseases of agriculture?	0	0
		Impact score: 0.23

The obtained index of 0.4506 shows that *A. negundo* has a medium Pest Plant Score. However, this index is one of the highest compared with the results of previous studies on various alien tree species in Lithuanian forests, e.g., *Quercus rubra* – 0.3626 (Riepšas and Straigytė 2008) and *Acer pseudoplatanus* – 0.3537 (Straigytė and Baliuckas 2012).

Rating may differ depending on habitant category, status of protected territories, historical places and etc. If invasive plants grow near protected territories, they can cause additional threats other than those in urban areas. In national parks, alien plants are generally undesirable. Rating priorities should be determined for separate regions taking into account the prevailing functions of the territories.

Conclusion

Acer negundo is the most distributed alien maple species in parks and greeneries in Riga and Kaunas and it has a very high invasiveness score. Dispersal is facilitated by movement along rivers. Their ability to survive spring flooding makes them successful competitors with other tree species. After cutting, they have the ability to regenerate from the stump, forming multi-stemmed trees. The obtained estimates indicated that box elder was spreading rapidly into new riparian habitats. Box elder has a low social, environmental and economic impact in the Riga and Kaunas, and does not have a large influence on agriculture: quality, quantity, cost to production, effect on land use and value currently. However the rapid dispersal of *A. negundo* could significantly influence flora, plant species composition and biological diversity in Riga and Kaunas in the future. In general, after evaluating all characteristics this species has a medium importance pest plant score.

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