

## ***FRAXINUS PENNSYLVANICA* – AN INVASIVE TREE SPECIES IN MIDDLE EUROPE: CASE STUDIES FROM THE DANUBE BASIN**

**Anton DRESCHER<sup>1</sup>, Bohdan PROTS<sup>2</sup>**

<sup>1</sup>Institute for Plant Sciences, Karl-Franzens-Universität Graz, Holteigasse 6, A-8010 Graz, AUSTRIA

<sup>2</sup>State Museum of Natural History, National Academy of Sciences of Ukraine and  
WWF Danube-Carpathian Programme, 18 Teatralna Str., Lviv city, 79 008 UKRAINE

**e-mail:** anton.drescher@uni-graz.at

bohdan.prots@gmail.com

**Abstract:** The study characterizes the invasion process of the North American Green Ash (*Fraxinus pennsylvanica* Marsh.) in Europe using two areas in the Danube basin as examples: the territory of the Danube National Park and adjacent areas (Austria) and the Transcarpathia (Ukraine). The paper addresses mainly three questions: (1) what are the distribution patterns and the dynamic processes of the invasion process, (2) do natural habitats like old growth forests resist to the invasion of Green Ash and (3) are there management implications to control the spread of the invasive Green Ash?

To give a rough survey of the today distribution and to trace the invasion process of the species we used archive material, floristic data from literature and herbarium specimens. The predominately wind dispersed fruits; early maturity and the adaption to the ecological conditions in floodplains enable a rapid spread from plantations or single individuals in settlements. *Fraxinus pennsylvanica* is currently at the stage of explosive distribution in many European countries. The broad ecological plasticity allows the species to take almost any invasion opportunity, however the floodplain habitats are the favourite. Green Ash has got plant attributes both from “Ruderal” and “Competitor” functional groups. *Fraxinus pennsylvanica* is still far from having occupied all suitable stands in the investigated areas. Even natural habitats, like old-growth forest patches are vulnerable to invasion. Green Ash replaces old individuals and out-competes all tree species native to floodplain habitats in Middle Europe. The conservation management would be mostly linked to the removal single trees and seedlings of *Fraxinus pennsylvanica* as well as from plantation. In the present state of distribution in Middle Europe the eradication of the species is impossible, but there is a strong need to control areas of high conservation value.

**Keywords:** Plant invasion, distribution patterns, spread, management, *Fraxinus pennsylvanica*, Middle Europe

### **Introduction**

Many of introduced, intentionally and unintentionally plant species, provide great benefit to society. Most of non-native species cause no problems in their new environment. However, the invasive alien species (including so-called ‘problem plants’) cause big environmental problems world-wide [12, 33]. Many of them have become agricultural weeds; others have invaded native ecosystems by out competing native plants. The riverside habitats became most invaded by invasives in recent decades. The function of floodplains as a corridor for alien plant dispersal is well known. The reasons for that are:

- repeatedly disturbance as a feature of natural floodplain ecosystems;
- scattered areas with naturally open habitats;
- availability of floating water as a transport agent beside other dispersal agents;
- intensity of forest and agricultural management;

- high nitrogen input.

Many successful invasive species of Europe were first observed in the floodplains. *Fraxinus pennsylvanica* Marsh. (Green Ash, Red Ash, Swamp Ash, Water Ash and Pennsylvanian Ash) is one of these species. It is one among the most rapidly spreading woody alien species in Central Europe during the past 25 years.

The studies on *Fraxinus pennsylvanica* were carried out in two observation areas of the Danube basin:

- Eastern Austria (the Danube floodplain, east of Vienna and the Lower Morava, north of the confluence with the Danube)
- Transcarpathian region of Ukraine (upper part of Tisza basin, which is a part of Great Danube basin).

The present study addresses the following questions: (1) What are the distribution and dynamic patterns of *Fraxinus pennsylvanica* in the observation areas? (2) Do natural habitats resist to invasion of Green Ash (3) What are the management implications to control a spread of invasive Green Ash?

### Material and Methods

#### The areas of study

Before the rectification in the second half of the 19<sup>th</sup> century the Danube River located east of Vienna shows the structure of a braided river (Anonymus, Josephinische Landesaufnahme 1773-1781, Sektion 71). After catastrophic flooding events in the 19<sup>th</sup> century the Danube River was rectified in the 1870s. Today the morphological structure of the floodplain is fixed; beside the main channel there still exist cutoff former side arms. Since the beginning of 21<sup>st</sup> century several attempts have been made to gradually restore the hydrological connectivity between the river and his floodplain [5, 27, 47, 48]. The coarse grained sediment has been covered by silt in large parts of the floodplain since the establishment of several power plants. The floods are most likely in May and June (snowmelt in the Alps), but can occur all over the year.

The Lower Morava is an example of a meandering watercourse. During 20<sup>th</sup> century several meanders have been cut off, the river course was shortened. The Morava floodplain is regularly inundated in spring but also in course of periods with heavy rainfall.

The Transcarpathian part of Ukraine (Western Ukraine, Zakarpatska Oblast) is bordering with Slovakia, Hungary, Poland and Romania. The rivers Tysa (Tisza), Borzhava, Latorytsya (Latorica), Uzh, and others, originating on the Transcarpathian slopes, form the northeastern part of the Pannonian plain, which belongs to the Danube basin. The headwater part of Danube is essential for the ecological quality of the entire region. All environmental problems in the headwaters potentially affect the population of four countries along the Danube. The increasing occurrence of devastating floods in the Transcarpathian region, and downstream in the Danube basin, has been linked to the degradation of the floodplain habitats. Within the Transcarpathian Plain alone, an area of about 13,000 ha of floodplain forests have been destroyed over the last century [15, 40].

The mountain part of Transcarpathia is an important area for river courses of the braided type with a natural runoff regime. This can surely serve as a model for the restoration of large parts of extensively used areas of floodplains (e.g. wet and moist meadow types). The old drainage channels, established during Austro-Hungarian Empire times, show a well developed

aquatic and swamp vegetation.

The sites are characterized by alluvial gley soils on quaternary sediments with a high ground water table. They are flooded periodically connected with snow melt in spring or rain periods all over the year.

### Methods

The distribution of *F. pennsylvanica* in Transcarpathia has been recorded using the grid-map approach of the Central European Mapping Project [36, 37]. The database for the distribution maps has been compiled from the available field protocols of the floristic mapping, herbarium data [Uzhgorod National University (U), Lviv National Universities (LW), State Museum of Natural History of the National Academy of Sciences of Ukraine (Lviv) (LWS), M.G. Kholodny Institute of Botany of the National Academy of Sciences of Ukraine (Kyiv) (KW)], and our field studies between 1991 and 2009. Besides the field studies we used the large number of literature records to understand better the Middle European distribution of the species [2, 6, 10, 13, 14, 17, 18, 19, 22, 25, 30, 56]. Multiple regressions have been used for statistical purposes [52].

### Taxonomy and Morphology

The nomenclature of *Fraxinus pennsylvanica* Marsh. was discussed controversially. The great variability of indumentum is among the reasons for the existence of several other names today treated as synonyms (e.g. *F. lanceolata* Borkh., *F. pubescens* Lam., *F. campestris* Britt., *F. darlingtonii* Britt.).

The species usually is up to 25 meters tall and looks very similar to the common European *F. excelsior*. Differentiating features to *F. excelsior* are:

- brown winter buds, terminal bud usually wider than long;
- samara linear to spatulate, the wing extending to the middle of the subterete body;
- bark furrowed into scaly ridges, with reddish inner layer;
- twigs becoming grey and hairless;
- leaves turning yellow in autumn.

Based on molecular data *F. pennsylvanica* is placed in the section *Melioides* together with the often confused *F. americana* and eight other American species. The likewise morphologically similar *F. excelsior* of European origin belongs as well as the American *F. nigra* Marsh. to the section *Fraxinus* [57]. Although *F. pennsylvanica*, *F. americana* and *F. excelsior* are hardly to distinguish, there exist no hybrids between species of the two sections [59]. Due to the large distribution area in North America, the Green Ash shows a high rate of morphological and phenotypical variation, which leads to differentiation in ecotypes [1]. Therefore and by reason of the great number of synonyms *F. pennsylvanica* for a long time was confused with *F. americana*. Although Green Ash is characterized by changing the colour of the leaves in autumn to bright yellow it is likely to be overlooked, especially young individuals (Fig. 1).

### The origin and distribution pattern of *Fraxinus pennsylvanica* in Europe

*F. pennsylvanica* covers the eastern part of the nemoral zone of North America as a facultative wetland species. A distribution map for North America is presented in Schmiedel 2011. Green Ash is “common in alluvial woods, stream banks and moist fields” [42, 49, 50] and in „forests of blackwater and flats“ [8].

The species was introduced to Europe in 1783 and for a long period planted in parks and gardens as an ornamental. Since the second half of 19<sup>th</sup> century it was used for plantations first predominantly in Germany [45].

The today distribution of *Fraxinus pennsylvanica* in central Europe is still unclear, because the species has been overlooked up to recent times. Moreover the collection of distribution data is difficult, because a part of the recent publications on the distribution and floras do not include neophytes at all (e.g. Zając & Zając 2001; Vicherek et al. 2000) or give no distribution data for alien species [9, 32] or only general information [20, 29]. A number of European databases on plant species, like DAISIE, GBIF, FloraWeb, Floristische Kartierung Baden-Württemberg are also far to be complete concerning the distribution of this species.



Fig. 1: Habitus of *Fraxinus pennsylvanica* (left) and twig with ripe samaras and leaves turning yellow in autumn (right) (phot. C. Fraissl 2003-10-02; Regelsbrunner Au).

Actually the highest density of *F. pennsylvanica* stands we find along the “Mittlere Elbe” in North East of Germany [7, 44, 45], along the Tisza in Hungary and in parts of lower Danube in Romania. At least along the Elbe River the species was consequently planted since the end of 19<sup>th</sup> century [39, 44, 45]. In the Danube National Park (DNP), the species is naturalized and rapidly spreading. From Morava river course *F. pennsylvanica* is mentioned already in the early 1960s (Neumann in Janchen 1963) and was planted near Marchegg in the late 1950s [14]. Recently Green Ash is also spreading in Northeastern Central Europe [53] and Western Europe [54]. At least in parts of the reach of the Tisza in Hungary *F. pennsylvanica* is dominating the tree layer accompanied by *Amorpha fruticosa* in the shrub layer. Following the DASIE-website *F. pennsylvanica* is missing in all Skandinavian states as well as in Denmark, the Netherlands, Great Britain, Estonia, Lithuania, Belarus, the Mediterranean peninsulas, Switzerland and Slovenia. For Slovakia, Belgium, Moldova the occurrence of the species is documented in recent publications [38, 54, 56]. Anyway there exists no information about the frequency of *Fraxinus pennsylvanica* or density on the localities in the DASIE database. Performing a query in the GBIF-database ([www.gbif.org](http://www.gbif.org)) leads to amendments, but the today state of documentation does not allow to create a distribution map for Europe. No detailed distribution maps exist for single European states with the exception of Germany (“Verbreitungsatlas der Farn- Blütenpflanzen

Deutschlands”, Netzwerk Phytodiversität 2013).

In Austria the Green Ash is frequent in the Danube floodplain between Vienna and Bratislava (Fig. 2). Up to now we could not find any notes about the introduction of the species in the area of the Danube National Park (Vienna, Lower Austria). The two regional floras from the 19<sup>th</sup> century [4, 34] do not mention the species at all. We assume that the samaras have been transported from plantations along the river banks of the Schwechat River and are spreading in the floodplain along the right bank of the Danube. It is almost completely missing in the riverine forests along the left bank, because softwood stands with dominating willow and poplar in the canopy are rare. The gap on the southern bank is due to the fact, that the bluff is located very close to the river. Also along the Morava, a northern tributary of the Danube close to Bratislava, Green Ash is occurring on several localities from Markthof in the south up to the confluence with the river Thaya. The first records date back from the late 1950s (Neumann in Janchen, 1963) and early 1960s (phytosociological relevés by A. Neumann in Jelem 1974).

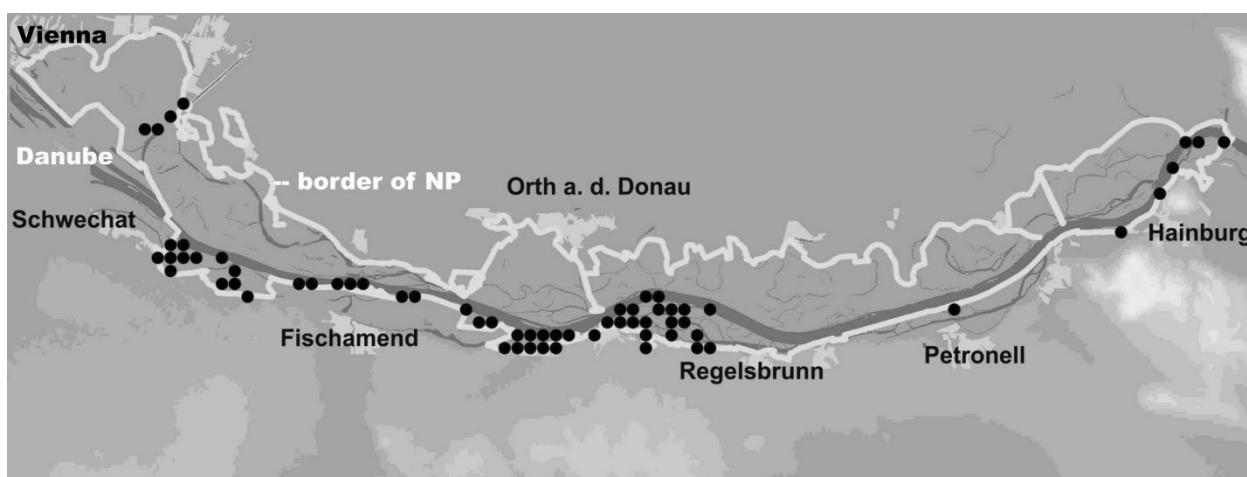


Fig. 2: Distribution of *Fraxinus pennsylvanica* Marsh. in the Danube floodplain between Vienna and Bratislava (© Nationalpark Donau-Auen).

The history of invasion of *F. pennsylvanica* in the Transcarpathia (Ukraine) is an example of this process in less dense populated areas of Middle Europe. It started at the end of 1940s after the Second World War. The note on planted specimens of the species has been found in the archive of the State Forest Resource Agency of Transcarpathia. The first records for Varievo forest area (near the villages of Vary and Chetfalva, Beregovo County) date from 1949. Our reconstruction till 1991 is based on archive data as no published records nor herbarium material are available [41].

Up to now *F. pennsylvanica* occupies just 11% of the total number of the Transcarpathian mapping grid squares (Fig. 3). The Transcarpathian Lowland is occupied by 41% already. However, only around 50% of all grid squares, which potentially can be colonised, are occupied by the species. The number of localities decreases with increasing elevation, the major number of records (about 90%) has been reported between 98 and 199 metres above sea level (a.s.l.), the highest localities are up to 350 metres a.s.l. However, the process of global warming, raising tourism, poor agricultural and forest management might contribute to an increase of the distribution range of *F. pennsylvanica* towards higher altitudes [41].

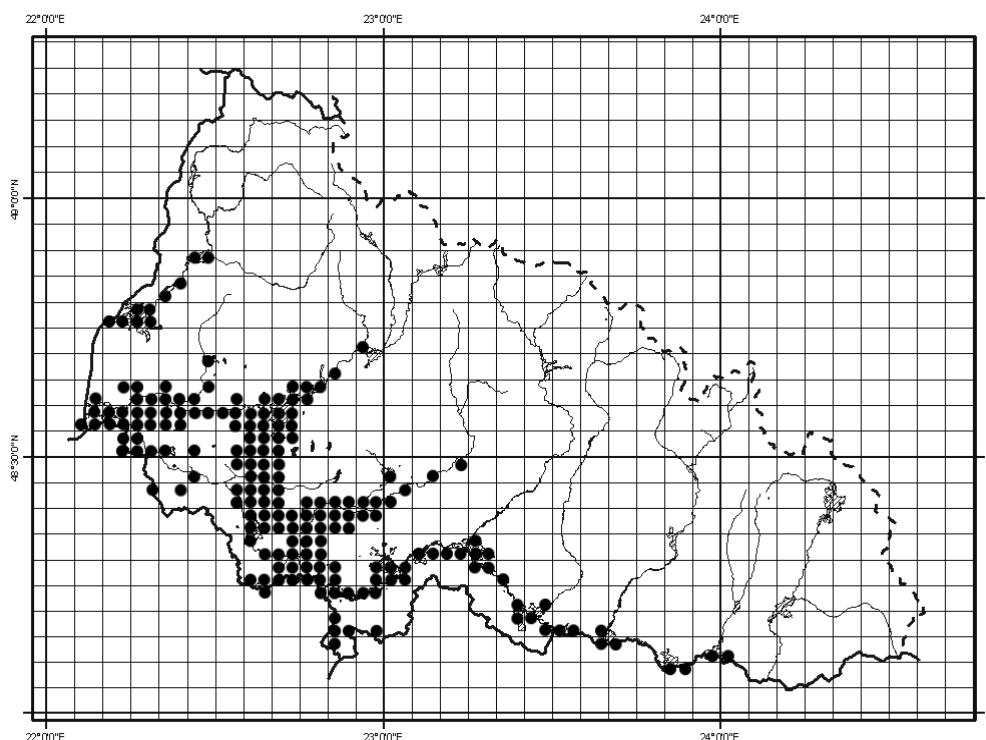


Fig. 3: Grid map with the distribution of *Fraxinus pennsylvanica* Marsh. in Transcarpathia (Ukraine).

Around 43% of the total populations recorded of were found in riparian habitats along rivers (semi-natural). The melioration channels, road ditches and embankments are to be found in 24% of total. The share of records in natural riparian habitats (mixed forests with dominance of *Salix*, *Fraxinus* or *Quercus*) with a very low human impact is around 22%. The broad ecological plasticity allows the species to take almost any invasion opportunity, however the floodplain habitats are the favourite.

### The ecological preferences of *Fraxinus pennsylvanica*

One of the vernacular names in North America “Swamp Ash” explains the ecological niche pretty well: the species prefers moist alluvial soils (fluvisols, gleysols) along streams in floodplain forests [31]. But also less moist stands are settled. *F. pennsylvanica* can survive longer dry periods. In Europe in depressions of frequently flooded areas it is most competitive compared with native species. Along Elbe River it is spreading subsponaneous in these depressions as it is at least as flood tolerant as *Quercus robur*.

In contrast *F. excelsior* cannot stand longer flooding periods with following standing shallow water. Especially young trees up to 15-20 years are dying (own observations along Danube near Wallsee in 2002). Because of rapid growth in youth *F. pennsylvanica* is outcompeting *Quercus robur*. Some other features like (1) high and regular production of a high number of fruits, (2) light wind dispersed diaspores, (3) strong and fast vegetative resprouting of cutted individuals, (4) wide range of ecological demands / withstanding extreme floods provides a competitive advantage in floodplain habitats. The high demands on light during the juvenile period, fast growing when young and a maximum age of 120 to 150 years are characters of

pioneer species. Anyway in North America it also penetrates into climax forests. It is fruiting already with 7 to 10 years (8-10 cm d.b.h), when resprouting even earlier. It is very light demanding and rapidly spreading in gaps. Trees are fruiting every year; the fruits survive no longer than one year in the seed bank. After cutting it is rapidly resprouting and therefore difficult to control [46].

Most sensitive to the penetration by *F. pennsylvanica* are open ruderal stands along roads, railroad tracks (associations included in the alliances *Atriplicion*, *Senecionion fluviatilis*, *Impatienti-Stachyon sylvaticae*, *Geo urbani-Alliarion petiolatae*, *Aegopodion podagrariae*). Also the pioneer stages of succession along rivers are predisposed to be invaded by Green ash (associations of the alliances *Bidention tripartitae*, *Dauco carotae-Melilotion*, *Salicion triandrae*, *Salicion elaeagno-daphnoidis* and *Salicion albae*). The early stages of poplar plantations with an open canopy are extremely vulnerable. Beside that also association of the alliance *Alnion incanae* are affected in particular *Fraxino pannonicae-Ulmetum* along the Morava River north of the confluence with Danube.

Overall the species shows broad ecological requirements and a high degree of plasticity. *F. pennsylvanica* stands low to high light intensity and soils of high to medium nitrogen level and soil moisture content.

These features allow a fast settlement of bare new sediments and the migration into more or less dense woodland stands. Despite Phil Grime [23, 24] has included this species within the above mentioned attributes in the “Ruderal” functional group, however *F. pennsylvanica* is not clearly fitting in this scheme and shows also the strategy of “Competitors”.

### **The invasion dynamics of *Fraxinus pennsylvanica***

The invasion of the species in the study area started with plantations in forest areas for wood production and for ornamental purpose in the cities, later also to stop erosion along melioration channels and rivers. After around 7 years, when the first fruits are ripe, it escaped and naturalised on adjacent areas preferably on floodplain habitats. The increasing use of *F. pennsylvanica* for plantations and the use to stop erosion decisively supported the adaptation, establishment and expansion of this species in Transcarpathia.

The spontaneous invasion of Green Ash in the Transcarpathia (Ukraine) may be divided into two separate phases due to differences in the rate of spread (Fig. 4).

The ‘lag’ phase (A) of the invasion process lasted 53 years (1949–2002) and can be described by the equation A:  $y = 1E-53e^{0,0632x}$  ( $R^2 = 0,9457$ ). During this phase the species occurred in a limited range of habitats, notably forest areas around plantations of the species along rivers.

The ‘exponential’ phase (B) lasts just over 8 years (started from 2003) and refers to the equation B:  $y = 4E-29e^{0,0351x}$  ( $R^2 = 0,8697$ ). This remarkable increase in the number of occupied mapping squares could be caused by the catastrophic floods of 1998 and 2001 and anti-erosion planting. The exponential phase supposes to continue, because many riversides, channels and damp roadside habitats potentially could be invaded by the species [41]. However, it must be kept in mind that this exponential phase starts at the same time as our intense studies on riverine forests [15, 16] which provided an enormous number of new records.

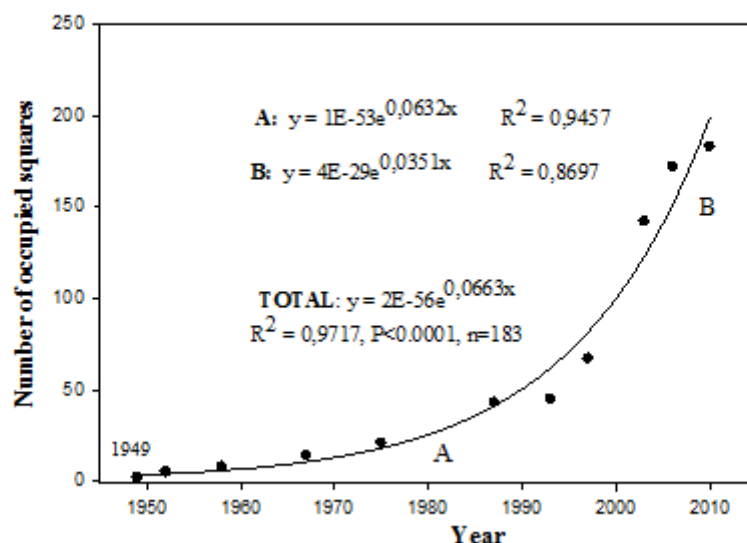


Fig. 4: The cumulative number of squares occupied by *Fraxinus pennsylvanica* Marsh. in the Transcarpathia, Ukraine (A - 'lag' phase and B - 'exponential' phase) [41].

As the number of records in the Danube National Park, located east of Vienna is too small for calculations we tried to find out the pathways of penetration and invasion with mapping seed bearing trees and the density of seedlings and young plants. The checked area of around 2 square kilometres along the confluence of the river Schwechat shows that the spread starts with single Green Ash individuals in mature stands with the seed transport by wind when the trees are bare during winter. Despite frequent predominantly wind from west and northwest only a few partial areas show a share of more than 20 percent of woody seedlings (Figs. 5, 6) below a closed canopy. In parts with intensive forest management in the 1990s the share of fruiting trees in the stands was higher than in less intensive managed areas [28].

The reproductive capabilities of *F. pennsylvanica* are an important factor in the increase of the number of localities. Depending on the height of trees and the velocity of winds the seeds are dispersed up to 40 meters off the seed producing individual.

On slopes most of the seeds could be washed out of the stands by frequent rains or heavy floods at least few metres down and move against the gravitation is hardly possible. Size and weight of the seeds enable them to penetrate through the vegetation cover, reach the soil surface and to be picked up by the different dispersal agents, like water, man or probably animals.



Fig. 5: Dominance of *Fraxinus pennsylvanica* in the regeneration stage (field layer). (Danube National Park, Austria: Mannswörther Au, Revier Poigenau. [28]).

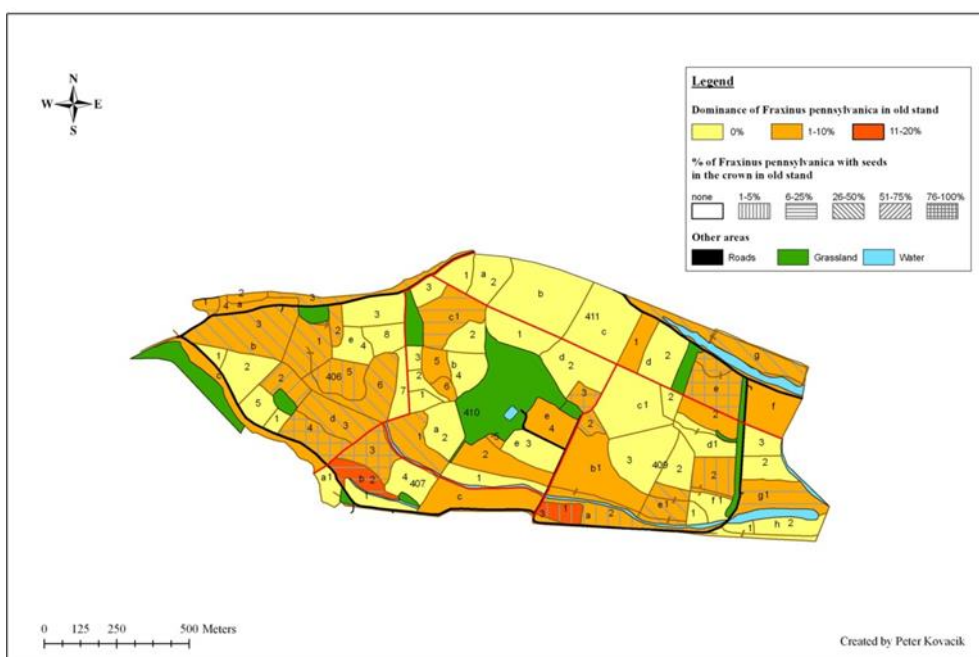


Fig. 6: Dominance of *Fraxinus pennsylvanica* in old growth stands and share of fruiting trees in the canopy (Danube National Park, Austria: Mannswörther Au, Revier Poigenau. [28]).

Large scale forestry plantations in floodplain habitats can initiate an expansion of the species. There are plenty evidences about using Green Ash as forestry plant in the lowlands with following escape on neighbouring habitats. Long distance dispersion of *F. pennsylvanica* in the hilly landscape with a raise of altitude is supported by unintentional spread of the species,

including transportation of top soil with the seed bank from the river to the upper part of the hill or upstreams by cars, trucks and caterpillars for house building and river channelization. Furthermore, the seeds could be transported attached to people's shoes and vehicle wheels. Intentional ornamental use of the species in the cities like Beregove, Vynogradiv also can contribute to further invasion. In general the seeds are collected at the autumn and winter in many Eastern European cities in course of street cleaning and are deposited at the garbage dumps, where it can naturalise easily and distribute further [41].

The distribution of *F. pennsylvanica* downstream is obvious. River dynamics is responsible for seed transport spread together with the sediment material along the water course. Geomorphology of river, structure of the bank, duration of flood, speed of water flow and type of the sediment material create different possibilities for dispersal and establishment of the species. The dominant part of the seeds will be floating downstream during floods and will have a chance to germinate and be established in a new habitat.

### Conservation and management implications

The management implications for *F. pennsylvanica* in managed forests, plantations and near natural forests are (1) keep a high cover of the tree layer to avoid too much light on the surface, that brings benefit compared to slowly growing hardwood species, (2) the loss of hydrologic and especially morphologic dynamics along upper Danube, upper and middle Tisza brings advantages for *F. pennsylvanica* compared with hardwood species (strong need for removal of seedlings and young trees), (3) plantations of *F. pennsylvanica* should be removed as the high number of seeds supports fast expansion of the species in the neighbouring landscape.

The role of *F. pennsylvanica* in old growth stands of hardwood forests is important and disturbing. The observation of gaps in the lowland riverine old growth forests of "Atak", a small scaled Nature Reserve shows, *F. pennsylvanica* has got the highest renewal potential compared to the native species *Fraxinus angustifolia* and *Acer campestre* (Fig. 7). Just the still high productivity of *F. angustifolia* still keeps away the invasion by *F. pennsylvanica* in the gaps of old-growth forests [41].

In the Danube National Park the orographic right river bank and the young stands have been penetrated during the past 50 years. The management with clear cutting of *Salix-Populus* stands and subsequent afforestation with poplar hybrids offer in the first years enough light for the optimal growth of seedlings of *F. pennsylvanica*. From single trees established from the beginning of the 1960s an intense seed rain puts pressure on neighbouring stands. There facing higher cover of the tree layer they are waiting for the next cutting to start with fast growing and to outcompete native tree species.

In near natural old growth forests in the southern part of Morava River course, which is located north of Marchegg, another "tactics was applied" by *F. pennsylvanica*. In these stands observed since the 1970s during the past 25 years old individuals of *Quercus petraea*, *Populus alba* and *Ulmus laevis* have been broken down because they reached their maximum age. In the canopy gaps *F. pennsylvanica* subsequently replaces *Quercus*, *Populus* and *Ulmus*. Unfortunately *Fraxinus angustifolia* subsp. *danubialis* (Small Leaved Ash) is growing to slow and is therefore almost completely outcompeted by *F. pennsylvanica* [14].

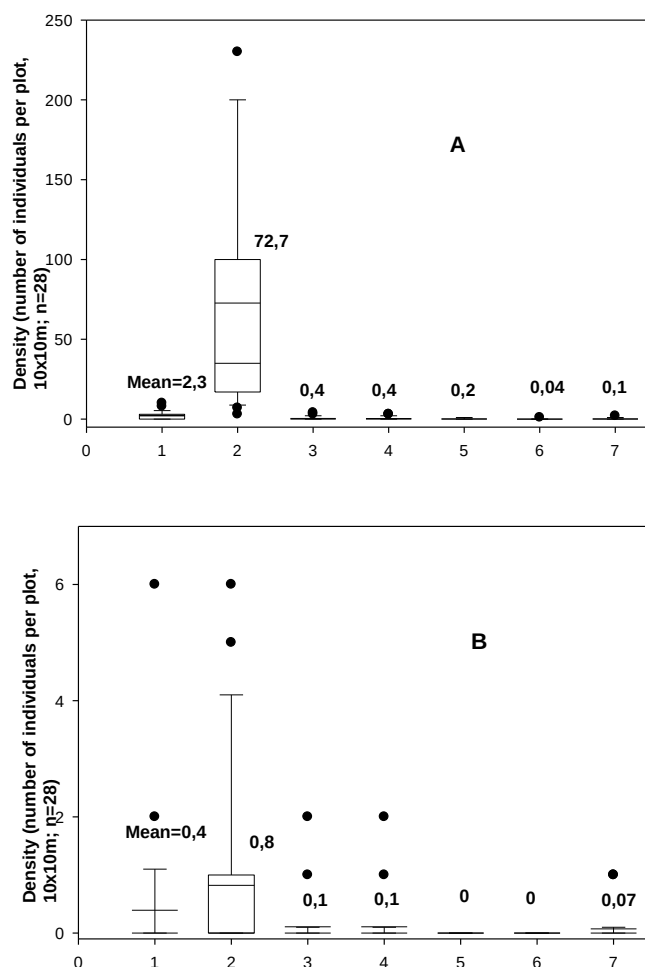


Fig. 7: The survivorship of woody species in the gaps of the old-growth floodplain forest stands in the Atak forest massif (Beregovo County, Transcarpathia, Ukraine): A- for individuals less than 1 meter high, B – for individuals 1-2 m high; species: 1: *Acer campestre*; 2: *Fraxinus angustifolia*; 3: *F. pennsylvanica*; 4: *Carpinus betulus*; 5: *Quercus robur*; 6: *Prunus avium*; 7: *Ulmus minor*.

An appropriate method to remove *F. pennsylvanica* is girdling [58], which was partly successfully applied to *Ailanthus altissima* and *Robinia pseudacacia* in the Danube National Park. This old method to remove woody species was used in former times to clear highland pastures. Especially easily resprouting woody species have been treated with this technique, which stops the transport of assimilates into the root system. Simple cutting of the trees reinforces the ability of resprouting. The best time for girdling is probably the early summer after sprouting. A disadvantage of this method is that the resprouting needs to be controlled for several years.

## Conclusions

*Fraxinus pennsylvanica* is currently at the stage of explosive distribution in many European countries due to high intensity of forestry and agriculture and extensive tourism in the floodplain habitats. The broad ecological plasticity allows the species to take almost any invasion opportunity, however the floodplain habitats are the favourite. The natural flooding regimes as well as a number of human disturbances support the penetration of the species into

new landscapes. The lack of data on the species distribution for Europe is obvious; there is no detailed distribution map available for Europe except for Germany.

Green Ash shows attributes of the “Ruderal” and “Competitor” functional groups [23] almost equally. Ruderal species prosper on sites of frequent and intense disturbance. Like these species it is fast-growing and produces a large amount of seeds. Competitors are out-competing other plants by most efficiently tapping available resources. *F. pensylvanica* shows this ability when colonizing gaps in old-growth forests. It has got a high capacity for phenotypic plasticity and is capable to adjust the allocation of resources throughout the various parts of the plant as needed over the course of the growing season.

The absence of human disturbance as well as natural habitats and are only slowing down the invasion by *Fraxinus pensylvanica*. River dynamics like the natural flooding regime (especially flash floods) supports penetration of the species into old-growth forests. Canopy gaps formed in course of cyclic succession or as a consequence of natural disturbance provide the opportunity for Green Ash to replace old individuals and to out-compete all tree species native to floodplain habitats in Middle Europe.

The conservation management would be mostly linked to the removal of *F. pensylvanica* both single trees as well as seedlings and plantations. An appropriate method to eliminate the species is girdling. Simple cutting of the trees reinforces the ability of resprouting. The city green planning should avoid the use of Green Ash as seeds are transported into the surrounding nature by man and cars to be spread subsequently.

In the present state of distribution for Middle Europe the eradication of the species is impossible, but there is a strong need to control areas of high conservation value.

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**FRAXINUS PENNSYLVANICA – O SPECIE INVAZIVĂ ÎN CENTRUL EUROPEI:  
STUDIUL DE CAZ ÎN BAZINUL DUNĂRII**

**(Rezumat)**

Studiul relatează procesul de invazie a frasinului nord-american (*Fraxinus pennsylvanica* Marsh.) în Europa, luând ca exemplu două zone din bazinul Dunării: suprafața Parcului Național Lunca Dunării și zonele adiacente (Austria) și Transcarpatia (Ucraina). Articolul abordează trei aspecte principale: (1) care sunt modelele de distribuție și procesele dinamice ale invaziei, (2) rezistă habitatele naturale, precum pădurile seculare, la invazia frasinului nord-american și (3) există măsuri de management care să controleze răspândirea frasinului invaziv?

Pentru a avea informații cât mai concrete asupra distribuției actuale și a urmări cât mai exact procesul de invazie, s-au folosit materiale de arhivă, date floristice din literatură și specimene de herbar. Dispersia fructelor predominant anemofilă, maturarea precoce și adaptabilitatea la condițiile ecologice din zona de luncă face posibilă răspândirea rapidă din plantații sau a indivizilor solitari de frasin nord-american. În prezent, *Fraxinus pensylvanica* se află în plină expansiune în multe țări europene. Plasticitatea ecologică extinsă permite speciei să profite de orice oportunitate de invazie, însă habitatele favorite sunt cele de luncă. Frasinul nord-american are atribute atât din grupul funcțional al "ruderaletelor", cât și al "competitoarelor". *Fraxinus pennsylvanica* este încă departe de a ocupa toate suprafețele disponibile din zonele studiate. Chiar și habitatele naturale, precum grupurile de arbori seculari, sunt vulnerabile. Frasinul nord-american înlocuiește indivizii senescenti și concurează toate speciile arborescente native ale habitatelor de luncă din Centrul Europei. Măsurile de management conservativ ar trebui să constea în îndepărtarea arborilor solitari și a semințișului de *Fraxinus pensylvanica* din zonele afectate, dar și din plantații. În stadiul actual al distribuției din Europa Centrală, eradicarea speciei este imposibilă, însă este o nevoie absolută de a ține sub control zonele cu grad ridicat de conservare.

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