Neophytes in Austria: Habitat preferences and ecological effects

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Summary

Recently, the first national inventory of alien species in Austria was published, containing annotated lists of plants, fungi and animals and providing information on their distribution and habitat preferences. The present paper reviews this study, focusing on the habitat preferences and ecological effects of vascular plant species.

Most of the 1110 neophytic vascular plant species recorded for Austria occur in ruderal and segetal vegetation. Certain natural and semi-natural vegetation types, however, are also strongly invaded by neophytes. These include riparian areas, floodplain forests and dry vegetation of Pannonic eastern Austria. In contrast, the invasion success of neophytes in alpine meadows and dwarf shrub communities, in bogs, fens and moist meadows, as well as in rocks and screes is very low. The invasion success of neophytes seems to be associated with a strong anthropogenic and natural disturbance regime, excessive supply of nutrients and warm climate.

The number of neophytes that pose a threat to biodiversity is low: 17 species are classified as invasive and another 18 species as potentially invasive. Although invasive neophytes compose only a small fraction of the complete flora (0.9%) in Austria, they probably exert a significant influence on natural and semi-natural ecosystems. Ecological effects caused by invasive neophytes in Austria include changes in species composition, succession patterns, nutrient cycles via eutrophication and in evolutionary paths via hybridization.

Key words: alien species, biological invasion, ecological effects, invasive species, naturalization, vascular plants

1. Introduction

Alien species are acknowledged as a major threat to the conservation of global biodiversity (e.g. Sala et al. 2000; McNeely et al. 2001; Cronk & Fuller 2001; Sukopp 2002; Cox 2004). While detailed case studies of alien species are necessary to understand the invasion processes, inventories of alien species have proven to be useful, especially for deriving empirical hypotheses that can be tested by experimental methods and for describing invasion patterns at various scales, from global to local (Kühn & Klotz 2003; Pyšek et al. 2003).

Human activities such as agriculture, aquaculture, forestry, transportation, recreation and building activities promote the intentional and accidental spread of species across their natural boundaries. Trade and passenger traffic have increased enormously during the past centuries and especially during the last decades; this has accelerated the introduction of alien species (Jäger 1988; Kowarik 2003).

To face the conservational and economic problems caused by alien species, international cooperation is needed. Therefore, the Convention of Biological

Diversity (CBD), ratified by Austria in 1994, underlines the urgent need for well-designed studies examining patterns and processes associated with species loss at all scales around the world.

To help accomplishing this task, the Austrian Ministry of Agriculture and Forestry, Environment and Water Management, in cooperation with the Austrian Federal Environment Agency, commissioned a national inventory of alien species (Essl & Rabitsch 2002; Rabitsch & Essl 2004). The present contribution uses the compiled data and case studies to analyse patterns within vascular neophytic plants. This taxonomic group is best suited for such an approach because it is well studied and rich in neophytes. The questions addressed in this paper are (1) which habitats are colonized and (2) which ecological effects are provoked by neophytic vascular plant species in Austria.

2. Material and Methods

2.1 Definitions and Data

Alien plant species have been defined variously, with substantially different meanings (e.g. Richardson et al. 2000; Schröder 2000; Pyšek et al. 2004). We use the definitions provided in Table 1 to determine which species to include in our lists.

The present paper deals with alien vascular plant species which arrived in Austria after 1492 by direct or indirect human sup-

Table 1: Terminology and definitions pertaining to non-indigenous vascular plant species in this paper (after Scholz 1995, Schroeder 1974, 2000).

terminology	definition	reference
alien	plant taxa in a given area whose presence there is due to intentional or unintentional human involvement, or which have arrived there without the help of people from an area in which they are alien	Pyšek et al. 2004
archaeophytes	plant taxa introduced intentionally or unintentionally by humans before 1492 and occurring or having occurred in the wild	Schroeder 1974, 2000
neophytes	plant / fungi / animal taxa introduced intentionally or unintentionally by humans following 1492 and occurring or having occurred in the wild	Schroeder 1974, 2000
anecophytes	plant taxa having evolved under intentional or unintentional human selection from wild-growing non-indigenous ancestors and growing or having grown in the wild	Scholz 1995
naturalized	alien taxa that reproduce consistently in the wild (at least two spontaneous generations within at least 25 years)	Kowarik 2003
casual	alien taxa which do not form self-replacing populations in the wild (less than two generations within 25 years)	Kowarik 2003
invasive	posing a threat to indigenous biodiversity at the genetic, species or ecosystem level	IUCN 2003
potentially invasive	expected to fulfil above criterion if current spread continues	Essl & Rabitsch 2002

port and which grow or have grown in the wild (neophytes). Plant species that have evolved under human selection ("anecophytes") are included (Scholz 1995).

A species is defined as "invasive" if it poses a threat to indigenous biodiversity at the genetic, species or ecosystem level (IUCN 2001). We are aware that the term "invasive" is also used with different meanings (Rejmánek et al. 2002; Pyšek et al. 2004). For the present study, however, its meaning is restricted to conservational concerns and delimited by expert judgement. Those taxa that threaten indigenous biodiversity in adjacent countries but are still rare in Austria were classified as "potentially invasive". Furthermore, the species were classified according to their status (naturalized or casual). Taxonomy and nomenclature follow Adler et al. (1994), recent taxonomic changes were incorporated.

The national inventory of alien species in Austria provided an annotated list of neophytic vascular plants with additional information on their distribution and habitat requirements (Walter et al. 2002). Additionally, case studies of the invasion history of 20 invasive or currently rapidly spreading neophytes were published (Essl & Walter 2004). Here, we use the compiled data and case studies for further analyses.

2.2 Study area

Austria is a landlocked country in Central Europe covering an area of 83,858 km^2. The population comprises slightly more than 8 million inhabitants (97 inhabitants per km^2), most of them living in the lowlands and in the major valleys of the Alps. 66 % of the population live in urban areas, 34 % in rural areas. Two-thirds of Austria are dominated by mountainous regions, and 10 % of the total area belongs to the alpine zone (Statistik Austria 2003). The country is covered to 43 % by forests and to 31 % by agricultural land. Whereas the lowlands are shaped by agriculture, the sparsely populated mountains are dominated by forests or alpine vegetation. In the eastern lowlands, the intersection of two biogeographic regions (Pannonic and Central-European region) promotes a high biodiversity (Adler et al. 1994; Ellmauer 1994).

3. Results

3.1 Habitat preferences

Ruderal and segetal vegetation

In ruderal and segetal vegetation, 792 of the 1110 neophytes recorded for Austria were documented. Favorable import routes and habitat conditions, as given in large cities (Pyšek 1998; Sukopp 2002), promote a high diversity of neophytes in these habitat types. In Austria, railway stations (e.g. Brandes 1993; Zidorn & Dobner 1999; Hohla et al. 1998, 2000), motorways (Oppermann 1998; Gerstberger 2001), large industrial areas (Geisselbrecht-Taferner & Mucina 1995) and rubbish dumps (Walter 1992) serve as focal points for neophytic ruderal species.

Certain species that prefer ruderal and segetal habitats have recently spread conspicuously. One of them is the South African *Senecio inaequidens*, having spread mainly along railways over the past 20 years. The Mediterranean *Geranium purpureum* was first recorded for Austria in 1990; it has since spread rapidly along railways and is now found in seven of Austria's nine federal states. *Duchesnea indica*, native to South- and Southeast Asia, was a rare casual in Austria up to the 1970s; it spread rapidly in the 1990s and has become widespread in the last years.

Several neophytes, e.g. grass species of the families Poaceae and Paniceae, have spread prominently in the last decades. The North American *Panicum capillare* was first recorded in Austria in 1855 but has spread remarkably since the 1970s. More recently, *P. dichotomiflorum*, *P. gattingeri*, *P. hillmanii* and *P. schinzii*, recorded since the 1950s, 1980s or 1990s, have spread mainly in maize cultures (Schröck et al. 2004). Since the mid-1990s, *Sorghum halepense* has been increasing in frequency and range in Austria (Essl in press).

Zonal forests

In Austrian zonal forests, 138 neophytic species were recorded, most of them being only locally established or casual. *Impatiens parviflora* is the only widespread herbaceous species. A few others are locally naturalized (e.g. *Doronicum pardalianches, Galeobdolon argentatum, Scutellaria altissima*). Certain rare neophytic woody species (*Cotoneaster* spp., *Mahonia aquifolium, Prunus serotina, Pseudotsuga menziesii, Quercus rubra, Spiraea japonica*) are currently spreading. Some of these species are planted for timber production (especially *Pseudotsuga menziesii, Quercus rubra*) and are therefore of high economic value. In the Pannonic region of eastern Austria the zonal xerothermic mixed oak forests are strongly affected by invasive neophytes *(Robinia pseudacacia, Ailanthus altissima;* Fig. 1). The most widespread neophytic tree is Robinia pseudacacia, comprising 0.2 % of the standing crop of forest trees (Kirchmeir et al. 2001).

Floodplain forests

In Austria, floodplain forests are strongly invaded by neophytes: a high proportion of the 49 neophytes recorded here are widespread. Of particular conservational concern is *Acer negundo*, which forms a dense understorey in willow forests of eastern Austria, e.g. in the national park

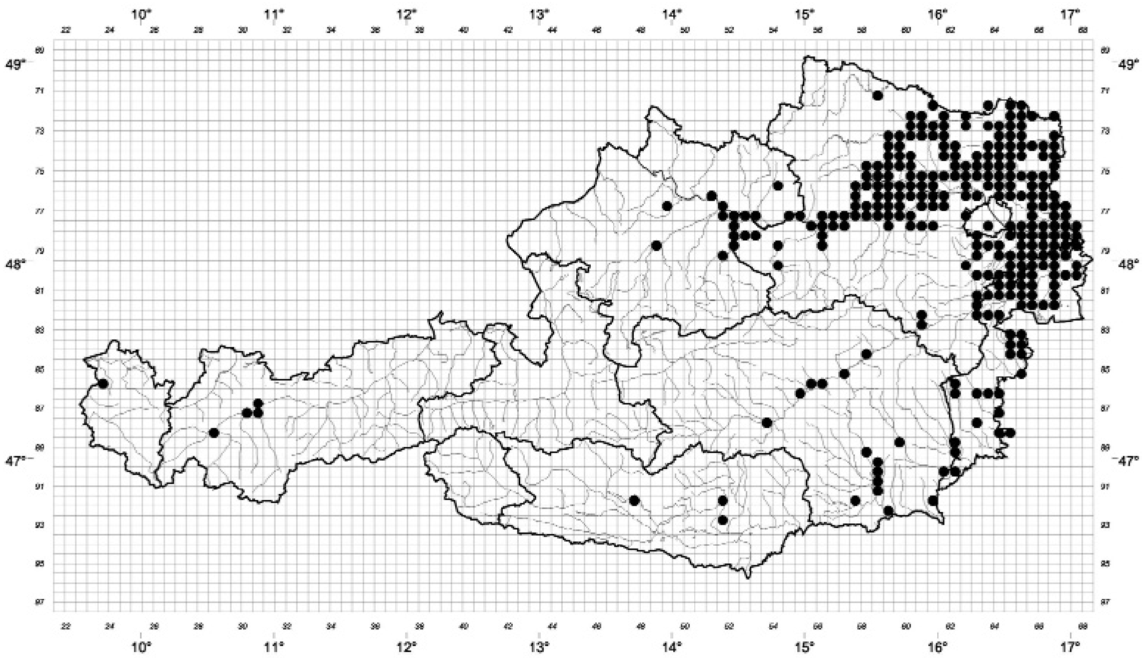

Fig. 1: Distribution map of *Robinia pseudacacia* woodlands in Austria (Essl et al. 2002 and supplementary unpublished data).

Donau-Auen (Drescher et al. 2004). *Fraxinus pennsylvanica* spreads in floodplain forests of the March and Danube rivers east of Vienna and outcompetes the rare native *Fraxinus angustifolia* (Lazowski 1999; Drescher et al. 2004). Furthermore, perennial tall herbs (*Aster lanceolatus, Fallopia japonica, Helianthus tuberosus, Solidago gigantea*) and the annual *Impatiens glandulifera* heavily invaded Austrian floodplain forests (e.g. Feráková 1994; Drescher & Prots 2000; Drescher et al. 2004).

Riparian areas

Riparian areas (banks of rivers, edges of lakes and ponds) are strongly affected by neophytes in Austria, containing 88 such species. Several neophytes (*Aster lanceolatus*, *Solidago canadensis*, *Fallopia japonica*, *Helianthus tuberosus*) form dense stands mostly by clonal growth. Recently, *Bidens frondosa*, *Epilobium ciliatum* and *Heracleum mantegazzianum* spread rapidly, whereas *Echinocystis lobata* is invading the riparian vegetation of the March River (Feráková 1994). Several ruderal species frequently grow on gravel banks (e.g. *Oenothera* spp., *Conyza canadensis*, *Erigeron annuus*). Some rare naturalized neophytes (e.g. *Acorus calamus, Mimulus guttatus, Typha laxmannii*) mainly occur in reeds of standing water bodies. Only the riparian vegetation of the upper reaches of undammed rivers in the Alps (e.g. Lech in Tyrol) lack neophytes (Müller & Bürger 1990).

Water vegetation

Aquatic habitats were invaded by 20 neophytes in Austria. In nutrient-poor open-water ecosystems, hardly any neophytes were recorded. In nutrient-rich water bodies, one invasive neophyte (*Elodea canadensis*) occurs. There is evidence that another species of the genus (*E. nuttallii*) is now becoming naturalized. Certain neophytes with a restricted distribution are casuals (e.g. *Azolla filiculoides*).

A thermal spring in Carinthia near Villach provides a habitat for some (sub)-tropical aquatic plants (e.g. *Myriophyllum aquaticum, Sagittaria latifolia, Salvinia natans, Shinnersia rivularis, Vallisneria spiralis, Hydrilla verticillata, Lagarosiphon major*). This is the only site where frost-sensitive aquatic species are able to survive the harsh Austrian winter.

Bogs, fens and moist-soil meadows

Only five neophytes were recorded in bogs, fens and moist-soil meadows. *Euthamia graminifolia* (= *Solidago graminifolia*) grows in fens and moist meadows of the Rhine Delta in Vorarlberg. In raised bogs and transition bogs, only the North American *Kalmia angustifolia* is naturalized (at one site in Upper Austria), and *Erica tetralix* was found recently in Salzburg and Upper Austria.

Fertilized meadows and pastures

In these nutrient-rich grasslands, 32 neophytes were recorded, two of them being naturalized. *Lolium multiflorum* is widespread in lowland regions and also cultivated as a valuable forage crop in fodder meadows. *Veronica filiformis* occurs in nutrient-rich meadows and lawns. The invasion process of this species started in humid areas of Austria, but the plant has since invaded all lowlands except for the Pannonic region.

Dry, semi-dry grassland and nutrient-poor meadows

These habitats contain 32 neophytes in Austria. Especially in Pannonic eastern Austria, however, dry and semi-dry grassland is invaded by *Robinia pseudacacia* and *Ailanthus altissima* (Fig. 1). Only one other species (*Phedimus spurius* [= *Sedum spurium*]) is rather widespread and naturalized.

More neophytes regularly invade ruderalized semi-dry grassland (e.g. *Erigeron annuus, Solidago canadensis*).

Rocks and screes

In rocks and screes at high altitudes, neophytes are absent in Austria. In sites neighbouring settlements at lower altitudes, some of the 61 neophytes recorded occur regularly. A few taxa (e.g. *Robinia pseudacacia, Cymbalaria muralis*) are naturalized at many sites, whereas a larger number (e.g. *Syringa vulgaris, Thuja orientalis*, *Antirrhinum majus, Erysimum cheiri*, *Phedimus spurius, Pseudofumaria lutea* [= *Corydalis lutea*]) are casuals or locally naturalized.

Alpine grasslands and dwarf shrub communities

In the alpine zone of Austria, only one taxon has been recorded as persisting for a while after intentional introduction at one site (*Sanguisorba dodecandra*).

3.2. Ecological effects

Of the total 1110 neophytes recorded in Austria, 17 taxa are considered to be invasive and another 18 species have been classified as potentially invasive (Table 2). These species are causing detrimental ecological effects for the conservation of biodiversity.

Change in species composition of vegetation types is thought to be the most important effect of plant invasions in Austria. All invasive and potentially invasive neophytes are reported to fulfil this criterion. Changes in succession patterns have been recorded for 17 invasive and potentially invasive species. These changes include the formation of new vegetation types and altered succession velocity because dense stands of neophytic tall herbs impede the regeneration of trees (Kowarik 2003).

Altered nutrient cycles were recorded for two species. *Lupinus polyphyllus* (Fig. 2)

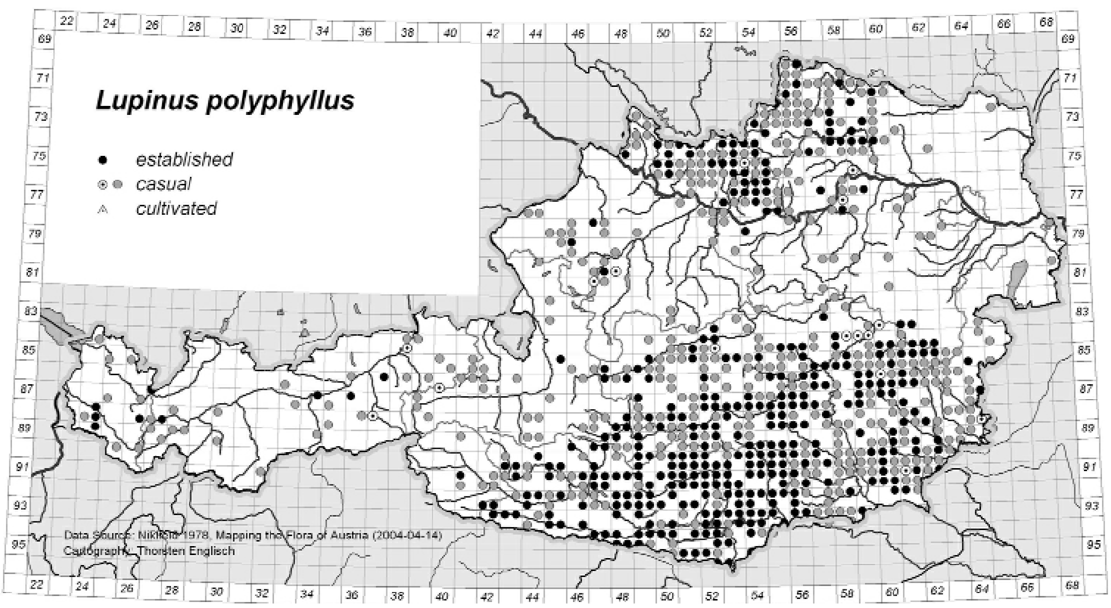

Fig. 2: Distribution map of *Lupinus polyphyllus* in Austria (unpublished data from "Mapping the Flora of Austria", database kept at Inst. of Botany, Univ. of Vienna).

Table 2: Habitat preferences and ecological effects of invasive and potentially invasive neophytes in Austria. + = main occurrence; (+) = accessory occurrence; data taken from Essl & Rabitsch (2002). Invasiveness: * = invasive, ° = potentially invasive; Family: Ace. = Aceraceae, Api. = Apiaceae, Ast. = Asteraceae, Bal. = Balsaminaceae, Ber. = Berberidaceae, Ela. = Elaeagnaceae, Fab. = Fabaceae, Hyd. = Hydrocharitaceae, Ole. = Oleaceae, Ona. = Onagraceae, Pin. = Pinaceae, Pol. = Polygonaceae, Ros. = Rosaceae, Sal. = Salicaceae, Sim. = Simaroubaceae. Ecological Effects: 1 = changes in species composition, 2) changes in succession pattern, 3) changes of nutrient cycles, 4) hybridization (based on literature and field experience of the authors).

Species	Invasiveness	Family	Ecological effects	Segetal, ruderal vegetation	Zonal formation	Flood-plain formation	Riparian areas	Open water habitats	Bogs, fens, moist meadows	Fertilized grassland	Dry, nutrient-poor grassland	Rocks, screes	Alpine meadows, dwarf shrub vegetation
Acer negundo	*	Ace.	1, 2	(+)		+	(+)						
Ailanthus altissima	*	Sim.	1	+	+						+		
Ambrosia artemisiifolia	°	Ast.	1	+									
Amorpha fruticosa	°	Fab.	1, 2	+			+						
Asclepias syriaca	°	Asc.	1	+							+		
Aster lanceolatus	*	Ast.	1, 2	(+)		+	+		(+)				
Aster novi-belgii	*	Ast.	1, 2	(+)		+	+						
Bidens frondosa	*	Ast.	1				+						
Buddleja davidii	°	Bud.	1	+			+					(+)	
Duchesnea indica	°	Ros.	1	(+)	+					(+)			
Elaeagnus angustifolia	°	Ela.	1	(+)							+		
Elodea canadensis	*	Hyd.	1, 2					+					
Elodea nuttallii	°	Hyd.	1, 2					+					
Epilobium ciliatum	*	Ona.	1, 4	(+)			+		(+)				
Fallopia japonica	*	Pol.	1, 2	(+)		+	+		(+)				
Fallopia × bohemica	°	Pol.	1, 2	(+)		+			(+)				
Fallopia sachalinensis	°	Pol.	1, 2	(+)		+			(+)				
Fraxinus pennsylvanica	*	Ole.	1			+							
Glyceria striata	°	Poa.	1				+		(+)				
Helianthus tuberosus	*	Ast.	1, 2	(+)		+	+						
Heracleum mantegazzianum	°	Api.	1	(+)		(+)	+		(+)				
Impatiens glandulifera	*	Bal.	1	(+)		+	+		(+)				
Impatiens parviflora	*	Bal.	1	(+)	+								
Lupinus polyphyllus	°	Fab.	1, 3	(+)							+		
Mahonia aquifolium	°	Ber.	1		+								
Pinus strobus	°	Pin.	1		+				(+)				
Populus × canadensis	*	Sal.	1, 2, 4	(+)		+	+						
Prunus serotina	°	Ros.	1		+								
Pseudotsuga menziesii	°	Pin.	1, 2		+								
Robinia pseudacacia	*	Fab.	1, 2, 3		+						+	(+)	
Rudbeckia laciniata	*	Ast.	1, 2	(+)		+	+						
Senecio inaequidens	°	Ast.	1	+							(+)		
Solidago canadensis	*	Ast.	1, 2	+						(+)	+		
Solidago gigantea	*	Ast.	1, 2	(+)		+	+						
Syringa vulgaris	°	Ole.	1, 2		+						+		

and *Robinia pseudacacia* live in symbiosis with nodule bacteria. Both species therefore severely alter nutrient cycles and increase the productivity of the nutrient-poor habitats they primarily invade (Kowarik 1995; Neuhauser 2001).

Hybridization events involve two invasive or potentially invasive neophytes. In Austria, crosses of the naturalized North American *Epilobium ciliatum* with six related native species have been recorded until now. *Populus* x *canadensis* includes various hybrids of a North American (*P. deltoides*) and a European (*P. nigra*) poplar species, cultivated for their fast growth (Heinze 1998a, 1998b). Molecular studies show that up to 10 % of poplar regeneration in Austria consists of back crosses between *P.* x *canadensis* and *P. nigra* (Heinze 1998b), threatening the native poplar species (Niklfeld 1999).

4. Discussion

4.1 Habitat preferences

In general, invasion success in Central Europe seems to be associated with strong anthropogenic or natural disturbance regimes along with an abundant supply of nutrients and a warm climate (Lohmeyer & Sukopp 1992; Pyšek 1998; Kowarik 1999; Pyšek et al. 2002a). Our data seem to confirm this hypothesis for Austria. Accordingly, neophytes are distributed unevenly in Austria. Lowland regions and habitats centered in lowlands (riparian vegetation, floodplain forests, ruderal and segetal vegetation) are strongly affected by invading neophytes, whereas the vegetation of the montane and alpine zone of the Alps (e.g. rocks and screes, alpine grasslands) harbours low numbers of neophytes.

The habitat preferences of neophytes in Austria show the same pattern as in neighbouring countries of Central Europe. Most neophytes in Germany (Kühn & Klotz 2003) and the Czech Republic (Pyšek et al. 2002b, 2003) also occur in ruderal and segetal vegetation. High levels of anthropogenic disturbance seem to promote the spread of neophytes in these habitats (Kowarik 1999, 2003). Human settlements serve as focal points for plant invasions, and there is a clear positive correlation between size and age of towns and the number of neophytes (Sukopp 1976; Pyšek & Pyšek 1991; Pyšek 1998).

Floodplain forests are characterized by natural disturbances, regularly creating open gravel and sand banks. Moreover, most large rivers in Austria were strongly altered by human disturbance (e.g. eutrophication, damming, water management). River valleys therefore generally serve as important corridors for neophytes (Sukopp 1976; Kowarik 1992, 1999; Müller 1995, 1997) and are also strongly affected by neophytes in Austria.

In Central Europe, riparian areas show the highest number of neophytes of all natural and semi-natural vegetation types (Lohmeyer & Sukopp 1992, 2001; Pyšek et al. 2002b). This finding also holds true for Austria: floodplain forests and riparian areas are the natural vegetation types most prone to invasions.

Although aquatic habitats in warmer climates are heavily invaded by neophytes (e.g. Bossard et al. 2000; Cronk & Fuller 2001), only few neophytes have invaded these habitats in Austria. This finding is true for other temperate Central European countries as well (Pysek et al. 2002b; Kühn & Klotz 2003). This may indicate that climate strongly influences invasiveness in aquatic habitats.

In Central European dry and semi-dry grassland and nutrient-poor meadows, few neophytes were recorded (Lohmeyer & Sukopp 1992; Kowarik 2003). Although the number of neophytes in dry habitats in Austria is low as well, dry meadows and forests in Eastern Austria are heavily invaded by *Robinia pseudacacia* (Wendelberger 1955). This is similar to the situation in adjacent Hungary, where this species is one of the most problematic neophytes for nature conservation (Török et al. 2003).

Rocks and screes of the montane and alpine zone, alpine grasslands and dwarf shrub communities are not colonized by neophytes.

Climate change – e.g. annual mean temperature in Austria increased by 0.5 °C since 1980 (Lexer et al. 2002), leading to prolonged growing seasons and less severe winters (Walther 2002) – may be decisive for the rapid spread of several late-flowering species, which are probably limited by climatic factors in Austria: *Ambrosia artemisiifolia*, native in North America, was a rare casual in the early decades of the 20th century but became naturalized mainly in the lowlands of the Pannonic region in the second half of the 20th century. Several American *Amaranthus* taxa (e.g. *Amaranthus hybridus, Amaranthus blitum* ssp. *emarginatus*) are currently becoming naturalized in the climatically most favourable southern and eastern regions of Austria (Walter & Dobeš 2004).

4.2 Ecological effects of neophytes

Taking country size and varying definitions of the term "invasive" into account, our results correspond well with data from other European countries: Germany: 35 invasive neophytes (Kowarik 2002); Hungary: approx. 35 invasive neophytes (Török et al. 2003). In Switzerland, 11 species are classified as invasive and 16 as potentially invasive (SKEW 2002). On the British Isles, 39 species are considered "pests", 11 of which have severe ecological impacts (Williamson 2002).

Several case studies demonstrate that invasive vascular plant species can change native ecosystems in different ways: Competitive tall herbs (e.g. *Fallopia japonica, Helianthus tuberosus*) in nutrient-rich, well-watered sites form dense stands, outcompete native taxa (Walser 1995; Kowarik 1999), change succession patterns, and form new vegetation types (Sukopp & Sukopp 1994; Hartmann & Konold 1995; Walser 1995, Wadsworth et al. 2000; Bimova et al. 2004). Most of these species show vegetative growth and are able to store nutrients in tubers or rhizomes in winter, allowing fast growth in the subsequent vegetation period. Invasion of the neophytic *Acer negundo* in stands of *Salix alba* changes succession patterns and species composition in floodplain forests of the lowlands of eastern Austria (Drescher et al. 2004). This impedes the regeneration of native willow species by creating a second tree-layer (Kunstler 1999).

Invasion of *Robinia pseudacacia* changes dry grasslands in multiple ways: Species numbers decrease, and the spatial structure and microclimatic situation are changed by the formation of a tree-layer (Böcker et al. 1995; Kowarik 1995, 2003; Neuhauser 2001). *Robinia pseudacacia* also severely alters nutrient cycles and increases productivity (Kowarik 1995). Dense stands of *Robinia pseudacacia* are currently widespread in eastern Austria (Fig. 1). The species also invades areas of high conservation value, e.g. the National parks Thayatal and Donau-Auen (Essl & Hauser 2003; Drescher et al. 2004).

Hybridization between native and alien species is one of the most important aspects of biotic homogenisation worldwide (Vila et al. 2000, Daehler & Carino 2001). Of special concern for nature conservation are crosses involving neophytes and native parental taxa, especially if the offspring is viable and hybridization events are frequent (Daehler & Carino 2001). In Austria, few taxa (*Populus* x *canadensis*, probably crosses of *Epilobium ciliatum* with native taxa) fulfil these criteria, which may have serious consequences for the native taxa involved (e.g. Ellstrand et al. 1996; Heinze 1998a; Vila et al. 2000). In the neighbouring Czech Republic, crosses between *Epilobium ciliatum* and native taxa of different sections were documented (Krahulec 1999).

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