Forestry and horticulture as pathways of plant invasions: a database of alien woody plants in the Czech Republic

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Abstract
Recent checklists, overviews and databases of alien floras for European countries do not pay special attention to woody plants. The majority of the checklists cover only taxa that occur in the wild. Woody plants are suitable subjects of studies on plant invasions because detailed records of introduction for forestry and horticultural purposes are available. This paper provides information on the database of alien woody species in the Czech Republic. Trees, shrubs and woody vines with mean height exceeding 0.5 m are included. In total, 126 characteristics covering taxonomy, geography, invasion, history of planting, biology and ecology, horticulture, and use were collected for each species. Although some characteristics in the database are specific for the Czech Republic, most information is applicable to the whole of Central Europe and potentially also to other temperate climate regions. The basic information on the structure of cultivated woody plants is presented.

Introduction

Woody species are a specific group of aliens, because they make up a substantial proportion of the most noxious alien species worldwide (Weber 2003). Many exotic trees introduced for commercial exploitation, wind protection or ornamental purposes subsequently became invaders (Reichard & Hamilton 1997, Zalba & Villamil 2002), and some change the character, condition, form or nature of invaded ecosystems (transformers *sensu* Richardson *et al.* 2000, Rejmánek *et al.* 2005). Impacts of invasive tree species are diverse (Versfeld & van Wilgen 1986, Simberloff *et al.* 2003) and include suppression of native plants (Richardson *et al.* 1989), reduction of wildlife habitat and increased water loss (Zavaleta 2000), increased fuel loads and altered fire regimes (Brooks *et al.* 2004), and nutrient enrichment (Vitousek & Walker 1989, Richardson & Higgins 1998). Invasions by alien woody plants have serious economic consequences (Zavaleta 2000, van Wilgen *et al.* 2001, Taylor & Irwin 2004) that can negate advantages gained from their commercial use (Richardson *et al.* 2004).

Recently, detailed checklists, overviews and databases of alien floras have been produced for a number of European countries (British Isles: Clement & Foster

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1994, Ryves *et al.* 1996; Czech Republic: Pyšek *et al.* 2002; Germany: Klotz *et al.* 2002; Austria: Essl & Rabitsch 2002; Hungary: Mihály & Botta-Dukát 2004; Switzerland: Wittenberg 2005). These works focus on vascular plants as a whole, hence they do not pay special attention to woody plants, and the majority of them only cover taxa that occur in the wild; cultivated plants are included only if they escape from cultivation or, if they become naturalized in a given country. Nevertheless, woody plants provide us with an excellent opportunity to study plant invasions from a known source pool of species (Prinzing *et al*. 2004, Pyšek *et al*. 2004, Křivánek *et al*. 2006), because detailed records of introduction for forestry and horticultural purposes are available. In addition, detailed data on residence time (*sensu* Rejmánek 2000, Pyšek & Jarošík 2005) and the history and extent of planting improve our ability to follow and predict invasions (Frenot *et al.* 2001, Rouget & Richardson 2003, Barton *et al.* 2004, Křivánek *et al.* 2006) and woody plants were successfully used in risk-assessment screening schemes in various regions of the world (Pheloung *et al.* 1999, Daehler & Carino 2000, Daehler *et al.* 2004, Weber & Gut 2004, Křivánek & Pyšek 2006).

However, there is no specialized database of alien woody species for a temperate area. This paper provides information on the Database of Alien Woody species with special regard to alien Invasive woody Species in the Czech Republic (DAWIS). DAWIS includes data on alien woody species that are distributed by garden centres and commonly planted in the Czech Republic. Although some characteristics covered by the database are specific for the Czech Republic, most information is applicable to the whole of Central Europe and potentially to other regions with temperate climates. In this paper, we present basic information on the structure of cultivated woody plants and how that is reflected in the structure of woody species recorded in the wild of the Czech Republic.

Methods

Species selection

The species included in the database were selected on the basis of frequency of planting in the Czech Republic. This was assessed according to the information included in national floras and atlases (Kavka 1968, 1969, 1974, Hieke 1984, 1985, Hejný & Slavík 1988, 1990-1992, Slavík 1995-2000, Koblížek 2000, Pyšek *et al.* 2002) and to how frequently a species appeared in catalogues of seed and living plants of 121 garden centres and botanical gardens, covering the period from 1852 to present.

Trees, shrubs and woody vines with a mean height of over 0.5 m are included. The database includes neither monocotyledons nor any semi-shrubs nor dwarf shrubs. Monocots were excluded because of their different ecology and very low number of species planted in Central Europe.

The species were divided into two groups according to whether they only occur in cultivation or have escaped into the wild. The former group is represented by species not escaping from cultivation, that are further classified on the basis of the purpose and frequency of planting into: (1) Species planted only in specialized col-

lections or requiring special planting treatment; those offered by garden centres and botanical gardens were included in this category. (2) Species frequently planted in parks and gardens, based on the list by Koblížek (2000). (3) Species frequently planted in parks and gardens as well as in forests, based on data from UHUL (2000).

The second group consists of species that are known to have escaped from cultivation in the Czech Republic. It was divided into three classes: (4) casual, (5) naturalized and (6) invasive, following the approach and terminology of Richardson *et al.* (2000) and Pyšek *et al.* (2004). The main source of data was the Catalogue of alien plants of the Czech Republic (Pyšek *et al.* 2002).

Characteristics included in the database

In total, when available, 126 characteristics were collected for each species. They are divided into eight groups termed as follows (for details see also Appendix 1):

1. **Taxonomy** (4 characteristics) includes valid name of species and its synonyms, family and information on whether it belongs to a monotypic genus. The nomenclature used in the database follows the compendium of woody species planted in parks and gardens in the Czech Republic (Koblížek 2000). The nomenclature of rarely planted taxa not included in the previous source follows Rehder (1940, 1949).
2. **Geography** (3) includes data on the origin and distribution of the species in its native range and on the distribution in the Czech Republic. Main data sources: Rehder (1940, 1949), Kavka (1968, 1969, 1974), Hejný and Slavík (1988, 1990-1992), Slavík (1995-2000) and Koblížek (2000).
3. **Invasion** (8) covers the date of escape from cultivation, habitats occupied and number of localities in the wild in the Czech Republic. This information was extracted from the Catalogue of alien plants of the Czech Republic (Pyšek *et al*. 2002) and the related database (P. Pyšek & K. Prach, unpublished) and from the database of floristic records FLDOK held by the Institute of Botany Průhonice. Where relevant, information on invasive behaviour of the species in other parts of the world is included. Main data sources: Reichard (1997), Bingelli *et al.* (1998), Pyšek *et al*. (2002), Randall (2002), Haysom and Murphy (2003) and Weber (2003).
4. **History** (4) includes data on the first known introduction to Europe and to the Czech Republic and the location where the species was first planted in the Czech Republic. Main data sources: Svoboda (1976, 1981), Pyšek *et al.* (2002).
5. **Biology and ecology** (43) refer to morphology, reproduction and toxicity, and summarize requirements for planting in terms of soils, water regime, precipitation and temperature. Main data sources: Rehder (1940), Kavka (1968, 1969, 1974), Hejný and Slavík (1988, 1990-1992), Burns and Honkala (1990), Slavík (1995-2000), Koblížek (2000), Bruns (2004) and internet sources (CABI 2003, NCSU 2004).
6. **Horticulture** (54) summarizes how often the species appears in catalogues of seed and living plants of botanical gardens and arboreta. The data include 14 historical catalogues from 1852-1940, 93 recent catalogues from 2000 and seed catalogues of 14 botanical gardens and arboreta from 1992-2004. This information was completed from the distribution of species in 823 chateau parks in the

country and 13 city parks in Prague. Other data sources: Hieke (1984, 1985), Kavka (1968, 1969, 1974), Sortiment (2000) and internet sources (Okrasné dřeviny 2005). In some cases, imprecise nomenclature in older catalogues made it impossible to verify the identity of some offered species (for example, the name *Pinus nigra* in older catalogues often related not only to *Pinus nigra* Arnold, but also to *Picea mariana* Britt., Sterns & Poggenb.).

7. **Use** (6) relates to six categories: agro-forestry; soil conservation and erosion control; ornamental; land reclamation; windbreaks and hedges; and collections only. Main data sources: Kavka (1968, 1969, 1974), Hieke (1984, 1985), UHUL (2000), Koblížek (2000), Bruns (2004) and internet sources (CABI 2003, NCSU 2004, Okrasné dřeviny 2005).
8. **Special characteristics** (4) refer to the alien-native species relationships, i.e. whether a species has a native congener in the Czech Republic or planted congener that does not escape from cultivation. Main sources: Rehder (1940, 1949), Koblížek (2000) and Pyšek *et al.* (2002).

Results

Numbers of species, their taxonomic affiliation and origin

Based on above criteria, 1,691 alien woody species planted in the Czech Republic are included in the DAWIS database. Of these, 127 species are known to have escaped from cultivation. The remaining 1,564 aliens do not escape from cultivation in the Czech Republic; among them, 333 species are present only in specialized collections and 1,231 are commonly planted in parks and gardens. Twenty-eight species planted in gardens are also used in forestry, and 14 of those have already escaped from cultivation (Křivánek *et al*. 2006; Table 1).

Table 1. Number and distribution of alien woody species in the Czech Republic. See text for data sources. Pest species encompass aliens whose introduction and/or spread threaten biological diversity ("invasive alien species" in terms of the definition used by the Convention on Biological Diversity (2002).

Category	Number of species
Predicted number of woody species introduced into the Czech Republic	4,360
Native species	278
Species hardy in the temperate climate	5,700
Alien species included in the DAWIS database	1,691
Species escaped from cultivation	127
Casual	73
Naturalized	37
Invasive	17
Pest species	11
Species not escaped from cultivation	1,564
Planted only in collections	333
Planted commonly in parks and gardens	1,217
Planted in forestry but not escaping	14

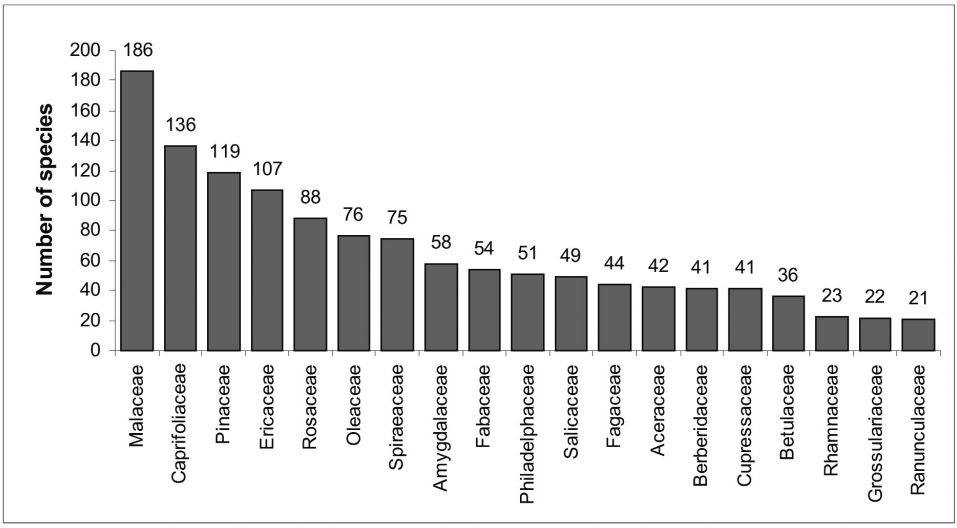

Fig. 1. Distribution in families of alien woody species planted in the Czech Republic (n = 1,691). Families with more than 20 alien species are shown.

Species from 90 families are included. Nineteen families are represented by more than 20 alien species (Fig. 1): Malaceae (186 species; with *Cotoneaster*, *Crataegus* and *Sorbus* being the genera richest in species), Caprifoliaceae (136 species; *Lonicera*) and Pinaceae (119) provide the highest numbers of species. Some families include important ornamental taxa with many cultivars although the botanical species is rarely kept in cultivation (e.g. Cupressaceae or Ericaceae).

Most species were introduced from Asia (922) and North America (439). Only few species come from very distant or/and climatically different areas like Africa or Australia (Fig. 2).

Invasion

Of the 127 woody species escaping from cultivation, at present only 73 occur in the wild as casuals, and 54 species are naturalized. Of naturalized species, 17 are considered invasive (Pyšek *et al.* 2002). Eleven invasive woody species are considered pests in the Czech Republic (Křivánek *et al.* 2004, Křivánek *et al*. 2006, Křivánek & Pyšek 2006): *Acer negundo* L., *Ailanthus altissima* (Mill.) Swingle, *Laburnum anagyroides* Med., *Lycium halimifolium* Mill., *Mahonia aquifolium* (Pursh) Nutt., *Padus serotina* (Ehrh.) Borkh., *Pinus strobus* L., *Populus* × *canadensis* Moench, *Quercus rubra* L., *Robinia pseudoacacia* L. and *Sarothamnus scoparius* (L.) Koch. Pest species are aliens whose introduction and/or spread threaten biological diversity, i.e. "invasive alien species" according to the definition of the Convention on Biological Diversity (2002).

In general, woody species escaping from cultivation are not frequent in the wild. Only *Robinia pseudoacacia* and *Sarothamnus scoparius* are common, having 615 and 754 reported localities, respectively. Sixty-eight species are rare (with only 1-50 localities) and 13 are locally abundant (50 localities and more) (Pyšek *et al*. 2002).

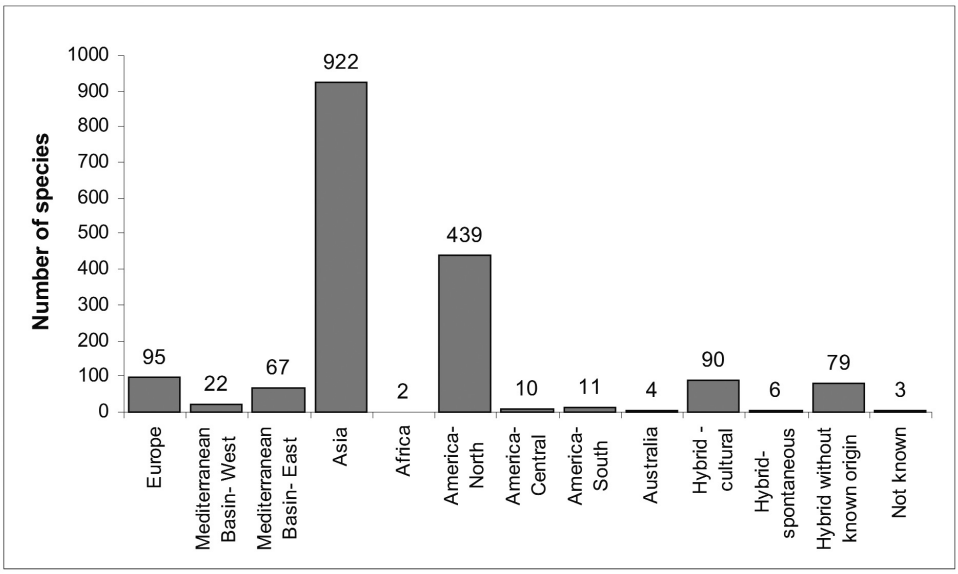

Fig. 2. Distribution of alien woody species planted in the Czech Republic (n = 1,691) according to the region of origin. The Mediterranean Basin was divided into the western part, including Europe and northern Africa, and eastern part, including Europe and western Asia. Cultural hybrids are those produced in the culture, spontaneous are products of hybridization in the wild. For 79 hybrid species the origin is unknown. Species with origin in more than one region are considered in each of them.

Casual species are most abundant in human-made habitats (in the sense of Chytrý *et al.* 2001). This type of habitat harbours 53 of the 73 casual species. Fifteen casual species are relics of former cultivation (Pyšek *et al*. 2002). The 37 naturalized species are fairly evenly distributed among human-made (22 species), semi-natural (defined as a managed landscape except settlements, communications and arable land: 31 species) and natural habitats (i.e. natural forests and naturally treeless habitats: 23 species). The same holds true for the 17 invasive species: 14 occur in natural, 15 semi-natural and 13 human-made habitats (Pyšek *et al.* 2002).

Of the woody species invasive in the Czech Republic, 41.2% (7 species) are reported as invasive elsewhere. However, 68.6% (81) of species reported as invasive elsewhere have not escaped from cultivation in the Czech Republic (Fig. 3).

History of introduction and residence time

The oldest data on introductions to the Czech Republic come from the second half of the 16th century. The year of first introduction into the Czech Republic is known for 674 species, however the year of first introduction into other parts of Europe is available only for 414 species. The country lagged in the rate of introductions to Europe until approximately the 1750s. Most species were introduced to Europe between 1650-1900 (85.3%), while in the Czech Republic between 1800-1950, 88.6% of the introduced plants arrived. The abrupt change in the pattern of intro-

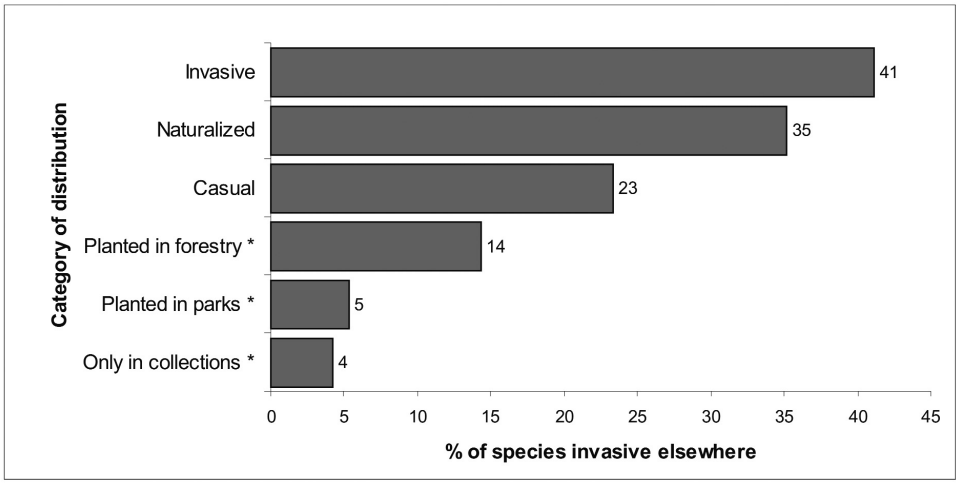

Fig. 3. Percentage of alien woody species in the Czech Republic, classified according to the planting purpose and invasion status, that are reported as invasive in other parts of the world. Categories marked * include species not escaping from cultivation.

duction of plants since the second half of the 18th century is obvious; introductions peaked between 1850 and 1900 (Fig. 4). The mean lag of introduction to the Czech Republic, behind that into Europe is 65.7 years (n = 375; S.D. = 59.7). However, 25 species were introduced to the Czech Republic earlier than to other parts of Europe.

The relationship between the time of introduction and current abundance of the species is obvious. Species that are invasive were introduced on average earlier (mean = 1789; S.D. = 50.8; n = 15) while those planted only in collections and not escaping from cultivation were introduced later (mean = 1867; S.D. = 42.4; n = 584). Species widely used in landscape planning, urban areas and forestry were introduced over the whole period, mostly from 1550 to 1900. On the other hand, species used only as ornamentals have been introduced mainly since the end of the 19th century (Fig. 5).

The lag phase, in the sense of Kowarik (1995), defined as the time between the first introduction and first escape from cultivation, is known for 44 species. The mean lag phase was 112 years (S.D. = 54.9; n = 44), 110 years for shrubs (S.D. = 57.7; n = 26) and 116 years for tree species (S.D. = 52.1; n = 18). The shortest lag phase (20 years) was recorded for the naturalized shrub *Alnus rugosa* (Duroi) Sprengel, the longest in the casual shrub *Philadelphus coronarius* L. (257 years). The mean lag for invasive species was 100 years (S.D. = 43.1; n = 9), for naturalized and casual species 101 (S.D. = 45.8; n = 6) and 122 (S.D. = 58.2; n = 28) years, respectively. The lag phase was the shortest for species of hybrid origin (mean = 75 years; S.D. = 53.0; n = 3) and for those from North America (mean = 89; S.D. = 45.5; n = 16). On the other hand, Eurasian and eastern Mediterranean species had lag times of 122 (S.D. = 46.2; n = 16) and 149 (S.D. = 65.8; n = 9) years, respectively.

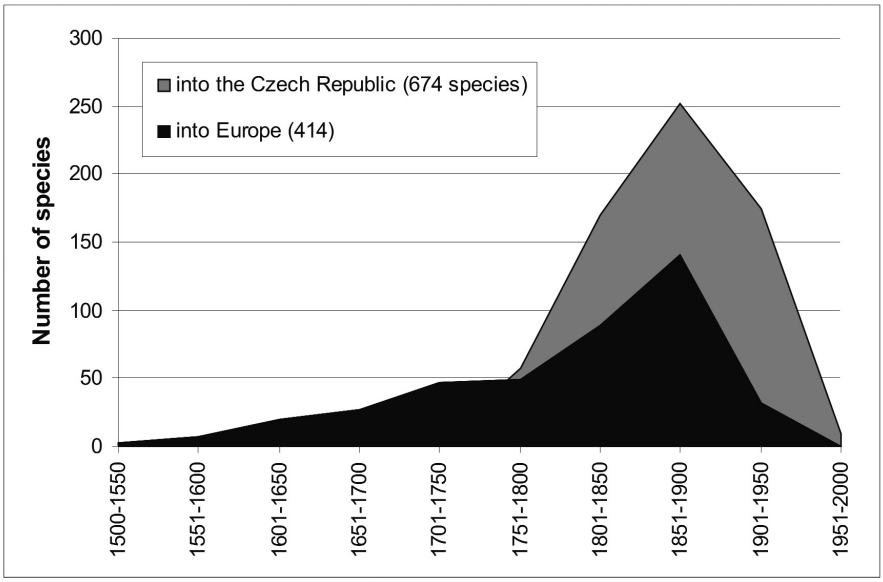

Fig. 4. Distribution of the dates of introduction of woody species to Europe and the Czech Republic.

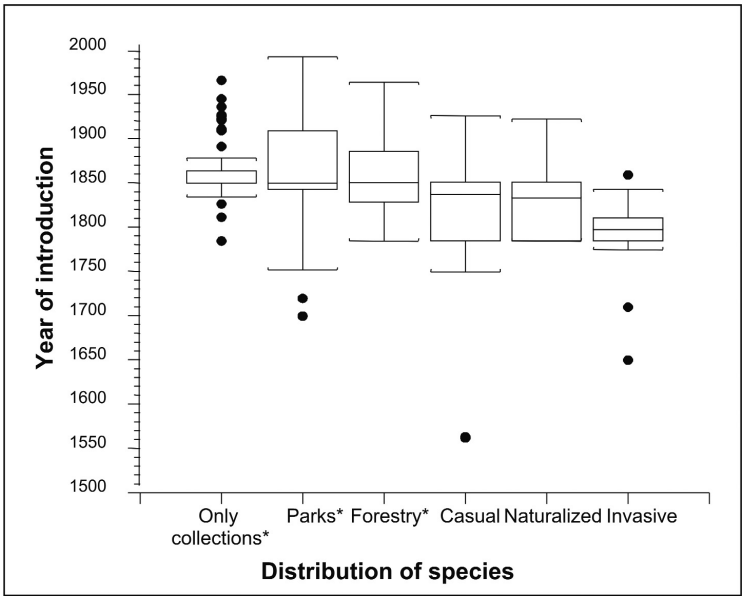

Fig. 5. Mean residence time of alien woody species in the Czech Republic classified according to the planting purpose and invasion status (n = 674). Categories marked * include species not escaping from cultivation (see text for details).

Biology and ecology

Life forms of 56% of the species (947 species) are shrubs, 26% (444) are trees and 4% (65) are woody vines; with 14% (235) of species having an intermediate life form between tree and shrub, i.e. both growth forms occur with similar frequency (e.g. *Acer ginnala* Maxim., *Cotinus coggygria* Scop., *Laurocerasus officinalis* Roem., *Laburnum anagyroides*, *Rhus typhina* L., *Syringa vulgaris* L.).

Most tree species have a juvenile period of 20-40 years. For 1,563 species (92%), generative reproduction is the main mode, 36% (603 species) also reproduce vegetatively by runners and 57% (964) by cuttings. Among the generatively reproducing species, 70% are hermaphrodites, 21% monoecious and only 9% dioecious. Insect pollination prevails for 76% of the species, 21% of species are pollinated by wind and the remaining 3% have both modes reported. The distribution of pollination modes reflects preferences for ornamental species with attractive flowers.

In the Czech Republic, mean annual temperature is 7.3ºC (min. 0.4ºC, max. 10.1ºC), mean annual precipitation is 672.6 mm (min. 384.6, max. 1497.8) (CHMI 2005). Most species included in the database persist successfully in areas with a mean annual temperature of 5ºC (31.7% of 442 species for which this information is available); only 10.6% require temperatures higher than 7ºC. On the other hand, 57 (12.9%) species grow well in areas with a mean annual temperature of 0ºC. In terms of annual precipitation, 81% (324 species of 399 for which this information is available) of the species require only 400 mm, which is considerably less than the country average.

Horticulture

Of the 1,252 taxa offered by garden catalogues, 37% are included only as recent offers (as of 2000) but are absent from the historical catalogues (1852-1940). On the other hand, 41% of species that were covered by the historical catalogues are no longer offered (Table 2). This pattern perhaps reflects an absence in the Czech Republic of former institutions such as the Dendrological Society in Průhonice. This society was very active in the beginning of the 20th century and introduced a number of species; its activities ceased after World War II. Only 22% of species were included in both historical and recent catalogues.

Many species have a large number of ornamental cultivars (Okrasné dřeviny 2005), only a small fraction of which are distributed by garden centers. As many as 1,651 species are offered in five ornamental cultivars. More than 30 cultivars are only offered for *Thuja occidentalis* L. (60 cultivars), *Chaenomeles speciosa* (Sweet) Nakai (57 cultivars) and *Chamaecyparis obtusa* S. & Z. (49 cultivars).

In total, 523 species are planted in chateau and city parks (Table 1, 2), but only a few are widely distributed. The most abundant woody plants in the 823 chateau parks and 13 city parks in Prague are *Thuja occidentalis* (present in 99% of parks), *Picea pungens* Engelm. (84%), *Syringa vulgaris* (83%) and *Aesculus hippocastanum* L. (75%).

The extent of planting, which is a convenient proxy for propagule pressure resulting from human activities (Křivánek *et al*. 2006) is related to the frequency of species in the wild and to their invasion success (Table 2). All species considered invasive, at

Table 2. Distribution of species in garden catalogues, parks and as monumental trees, related to their invasion status (sensu Pyšek *et al*. 2004). Monumental trees are those that are considered important aesthetically or biologically and protected by the national legislation. Historical catalogues are those from 1852-1940, recent catalogues relate to 2000.

	Species number	Historical catalo-gues	Recent catalo gues	Total catalo-gues	Chateau parks	Prague parks	Monu-mental trees
Total number of sources	-	14	107	121	823	13	53
Not-escaped	1,564	819	732	410	429	80	34
Casual	73	57	55	47	48	15	11
Naturalized	37	25	24	20	17	8	4
Invasive	17	17	15	15	15	9	4

present, were included in historical catalogues, and 88% of them are in recent catalogues. In addition, 88% and 53% are planted in chateau and city parks, respectively. On the other hand, 78% of casual species can be found in historical catalogues and 75% in recent ones, with 66% planted in parks. Of species not escaping from cultivation, only 47% and 52% are found in historical and recent catalogues, respectively, and only 27% and 5% are planted in chateau and city parks, respectively (Table 2).

In total, 53 alien species are among officially declared monumental trees. Monumental trees are related to aesthetically or biologically remarkable individuals that are protected by national legislation (the law for landscape protection and natural conservation; Table 2). The most often protected species among aliens is the casual *Platanus* × *hispanica* Mill. with 87 individuals country wide.

Use of species

Invasive species are widely used, and unfortunately, often also recommended for use (Table 3). Most invasive species are used as ornamentals, in agro-forestry and for soil conservation purposes. Averaged across categories of use, invasive species account for 53% of all species.

Species that are used only for horticultural collections rarely escape, but two naturalized species, *Fallopia aubertii* (L. Henry) Holub and *Alnus rugosa*, recruit from this group (Table 3). Both species are relatively common, but only little used as ornamentals and/or in landscape planning.

Table 3. The use of species and their invasion status (sensu Pyšek *et al*. 2004). Multiple uses are considered in each category.

Use	Not-escaped	Casual	Natura-lized	Invasive	Total
Agro-forestry	64	6	3	10	83
Soil conservation and erosion control	191	18	10	10	229
Ornamental	1,492	73	35	17	1,617
Land reclamation	86	4	3	6	99
Windbreaks and hedges	63	1	1	2	67
Only in collections	72	0	2	0	74

Discussion

The total number of alien woody species introduced to the Czech Republic is unknown. However, based on the number of species known to have escaped from cultivation and number of pests in the Czech Republic, probabilities predicted by Tens Rule (Williamson 1996, Williamson & Fitter 1996) and the number of species hardy in temperate climate (Úradníček & Maděra 2001), the number of alien woody species that were introduced into the Czech Republic can be estimated to 4,360 species (Křivánek *et al.* 2006, Křivánek & Pyšek 2006; Table 1). The presented DAWIS database includes species commonly planted in the country and distributed by garden centres for at least the last 150 years. In the light of this, the 1,691 species included are a highly representative sample, making the information on the structure of alien woody flora rather robust.

Species with colourful hermaphroditic flowers fertilized by insects prevail among cultivated woody plants. This pattern reflects the predominant purpose of planting, which is ornamental use. Hermaphroditic species are also easier to reproduce than monoecious or dioecious taxa. The primary ornamental use has a context with the history of introduction and actual use of species (Fig. 5). Most species with a wide use were primarily introduced as ornamentals, and only later was it found out that they can also be used in forestry, land reclamation or windbreaks.

Fairly precise data are available for the distribution and ecology of species escaped from the cultivation (Pyšek *et al.* 2002). However, the number of species and their status, especially that of casuals, change over time and few other taxa could presently be evaluated as casual additions to that list.

The number of introduced species varies largely among genera and families (Fig. 1). Although many invasive woody species belong to genera containing a single invasive species, membership to a large genus becomes a sort of "mark of Cain", for all its representatives in risk assessment screening schemes. The probability that a large genus includes an invasive species is greater than for small genera (Křivánek & Pyšek 2006), hence the presence of an invasive representative in the genus should not be taken as a strict indication of the potential danger imposed to the other species of the same genus.

Many invasive species in the Czech Republic are also reported as invasive in other parts of the world. However this criterion needs to be applied with species' climatic requirements in mind, because many species invasive in areas with a different climate cannot grow in Central Europe without special care provided by gardeners. Such species only occur as casuals or have not yet escaped from cultivation.

Although for most species, the introduction to the Czech Republic was later than to Europe as a whole, at least for 25 species it seems that the Czech Republic was the country of the first introduction to Europe. The mean lag phase of alien woody species in Brandenburg, Germany was 147 years (Kowarik 1995), i.e. 35 years longer than in the Czech Republic. Similarly the lag phase for trees was 54 years greater (170 years in Brandenburg) and for shrubs 21 years longer (131) in Brandenburg. The two regions are, however, difficult to compare in terms of lag phases because of different sizes. Evaluated for the whole area of the Czech Republic, the probability that an earlier escape from cultivation is recorded is higher than for the geographically limited area of Brandenburg in Germany.

There are two possible explanations for the close relationship between the invasion success of a woody plant and its residence time. Species introduced earlier can be better adapted due to their longer residence time (Rejmánek 2000, Pyšek & Jarošík 2005), and/or species with pre-adaptation to the temperate climate of Central Europe were selected first for planting by gardeners. The former concept is documented in Fig. 5: most invasive species were introduced earlier than naturalized and casual species, or those that have not yet escaped from cultivation. Even if the introduction of new taxa ceased, it is likely that the number of escaping and invasive taxa would increase because of the lag phase (Kowarik 1995).

Although some characteristics covered by the DAWIS database are specific for the Czech Republic, most information is applicable to the whole Central Europe and potentially also to other regions with temperate climates. The information on ecology, geography and use of species has been used for testing the efficiency of risk assessment screening systems developed in other parts of the world (Křivánek & Pyšek 2006).

The DAWIS database was developed with MS Access software. The application allows researchers to both visit fact sheets of species and search species according to their specific characteristics. The database is freely available at the web pages of the Institute of Botany, Academy of Sciences of the Czech Republic (http://www.ibot.cas.cz/invasions).

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Appendix 1: List of characteristics included in the DAWIS database:

Trait	Comments
	TAXONOMY
Species	Scientific name of the species.
Family	Scientific name of the family.
Monotype genus	In total 32 species are the only representative of the genus.
Synonyms	Taxonomic synonyms for the valid name of the species.
	GEOGRAPHY
Origin	Geographical location of the origin of the species.
Native region	Detailed characteristics of the geographical area of origin.
Vegetation type	Vegetation types in the Czech Republic, where the species grows well or where its planting is recommended.
	INVASION
First escape	Year of the first known escape from cultivation (only given for neophytes).
Lag phase	Time between the first known introduction into cultivation and the first known escape from cultivation.
Landscape type	Natural/seminatural/human made habitats.
Syntaxa	Alliances of the Zürich-Montpellier phytosociological system.
Abundance	Abundance categories in the wild in the Czech Republic.
Number of localities	Number of localities of the species in the wild (excluding parks, gardens and urban landscapes).
Invasiveness elsewhere	Information on the invasion outside Central Europe.
Invasiveness in the world	Number of regions (32 in total, following classification of Weber 2003) where the species is considered invasive.
	HISTORY
Introduction mode	Deliberately/accidentally/both ways.
First in EU	Year of the first known introduction into Europe.
First in the CR	Year of the first known introduction into the Czech Republic.
Period of introduction	Archaeophyte (introduced before 1500 A.D.) or neophyte (after 1500 A.D.).
First place	Location of the first cultivation in the Czech Republic.
	ECOLOGY
Life form	Life form in Central Europe: shrub, tree, vine.
Leaf persistence	Deciduous/semi-deciduous/evergreen.
Roots	Quality of roots and stability: deep/flat root system.
Height	Mean height under the conditions of Central Europe.
Crown average	Diameter of tree crown or of the whole shrub in Central Europe.
Juvenile period	Age at first flowering.
Flowering period	Length of flowering period (only for dicotyledonous species; I-XII).
Breeding system	Type of spatial separation of generative organs (hermaphroditic, monoecious, dioecious).
Pollination	Pollination syndrome: wind, insects or both.
Flower colour	
First fruit	Age at first fruiting.
Fruit character	Dry or fleshy fruits.
Fruit type	Morphological type of fruit: achene, berry, capsule, cone, drupe, follicle, nut, or pome.
Seed weight	Mean weight of one seed (mg)
Fruit maturity	Period of fruit maturity (I-XII).
Germination (%)	Mean germination (%).

Appendix 1: *Continued.*

Reproduction	Three types of reproduction are included: generative, vegetative by runners and vegetative by cuttings.
Calcium	Relationship to the calcium contents in the soil: growth favoured on Ca-rich soils/neutral/growth restrained on Ca-rich soils.
Ecological tolerance	Six characteristics describing the tolerance to exhalations, frost, shade, drought, water-logging and wind.
Quick regeneration	Regeneration after disturbance (quick-good/medium/slow-poor).
Damage by animals	High/medium/low.
Nitrogen fixation	Capability to fix aerial nitrogen.
Soil requirements	Eight characteristics describing the relationship (positive/neutral/negative) to sandy, loamy, clay, permeable, staunch, very acid, acid and neutral soils.
Optimum temperature	Expressed as mean annual temperate (ºC).
Minimum temperature	Minimum mean annual temperature necessary for good growth (ºC).
Optimum precipitation	Expressed as mm/year.
Minimum precipitation	Minimal mean annual precipitations necessary for good growth (mm/year).
Toxicity	Toxicity of organs: extremely toxic/very toxic/toxic/slightly toxic.
Toxic parts	All parts/fruits (fruit and seed)/seeds (only seeds).
	HORTICULTURE
Historical garden catalogues	List of historical garden catalogues that contain the species (n = 14 catalogues).
Catalogues of botanical gardens and arboreta	List of seed catalogues of botanical gardens and arboreta including the species (n = 14).
Distribution: Sortiment 2000	Number of garden centres distributing the species in 2000 (programme Sortiment 2000). In total 93 garden centres.
Distribution: no. of cultivars	Number of actually distributed ornamental cultivars of the species.
Actual distribution: total	Total number of garden centres and botanical gardens currently distributing the species (1992-2004).
Distribution: total	Three categories are distinguished: distributed only at present (1992-2004) / only in the past (1852-1940) / in both periods.
Important horticultural species	Horticulturally important, i.e. of a high ornamental quality, often used and planted.
Chateau parks in CR	Number of chateau parks where the species is planted in the Czech Republic (n = 823 parks).
Prague city parks	List of city parks in Prague where it is planted in (n = 13 parks).
Parks in CR: total	Total number of parks in the Czech Republic, where the species is planted (n = 836).
Monumental trees	Number of individuals declared as monumental trees and protected by law in the Czech Republic.
	USE
Use	Recommended for use in forestry, landscape architecture, urban greenery or only planted in specialized collections.
Use: categories	Five categories: (i) agro-forestry; (ii) soil conservation and erosion control; (iii) ornamental; (iv) land reclamation, (v) windbreaks and hedges.
	SPECIAL CHARACTERISTICS
Congeneric species	Congener escaping from cultivation is present / absent in CR.
Number of congeners	Number of alien congeners included in the DAWIS database.
Native genus in the CR	Presence / absence of a native congener.
Distribution level	(A) not escaping from cultivation: 1 - planted only in specialized collections, 2 - frequently planted in gardens and parks, 3 - planted in gardens and parks as well as in the forestry. (B) escaping from cultivation: 4 - casual, 5 - naturalized, 6 - invasive.

Pseudotsuga menziesii (Mirbel) Franco, naturalized north American species. The oldest individual in the Czech Republic introduced in 1843 from Flottbeck, Germany. Protected area American garden near Chudenice, south-west Bohemia. Photo: M. Křivánek, 2004.