Species composition and self-reproduction ability of trees and shrubs in Plovdiv Municipality*

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Abstract. This work presents the tree and shrub species found in Plovdiv Municipality during inventory of ornamental plants implemented in the period 2006–2013. We have identified 393 species of trees and shrubs, most of them (61%) of foreign origin. The paper also includes the observations made by the authors on the ability of the identified species to reproduce by seed or vegetatively, without human help.

Key words: Plovdiv, self-reproduction, shrubs, trees

Introduction

Trees and shrubs make up the bulk of ornamental plants in gardens and parks. They are an essential tool in the general landscaping of the green areas (Brickell & Cathey 2004; Hessayon 1983). Besides their aesthetic value, trees and shrubs are also ecologically important. They reduce the spreading of dust, noise and solid contaminants, and the woody plants are the least costly means of improving urban microclimate (Chang & al. 2007).

Because of their aesthetic importance and durability, there is a steady trend of using a growing number of species, forms and varieties (Gramatikov 1992). That is why there is a need in periodic inventory of the species composition. Moreover, there is a significant number of native species in the cities, some of which have never been used intentionally in the green areas. A comprehensive inventory of the species composition of trees and shrubs in the city of Plovdiv has not been done lately. However, valuable information for the city can be found in some works by Cheshmedzhiev & Vasilev (2009) and Gramatikov (1992). Information about the trees and shrubs could also be found in other works on the flora of Plovdiv (Pavlova & Tonkov 2005), as well as in some municipal documents (e.g. management plans of the Plovdiv hills' conservation area, the Green System Development Plan of Plovdiv Municipality, etc.).

Capacity of the tree and shrub species for self-reproduction has practical importance in the city of Plovdiv. The species of abundant seed propagation pose a problem from a practical viewpoint. They usually grow on sites that are not maintained intensively, but have certain features that are violated by the excess vegetation. Seedlings of various woody plants can damage buildings, infrastructure elements, archaeological sites and landscape. Self-reproduction is also damaging for the extensively maintained green areas; especially of the forest parks type (Pimentel & al. 2005). All this requires summarizing of the observations made on the ability of different tree and shrub species to reproduce by seeds without human intervention and which pose a problem. Once these species are identified, their use in landscaping could be limited.

The capacity of trees and shrubs to reproduce vegetatively is equally relevant. Unlike seed propagation

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in which new plants may occur at a great distance from the mother plant, in vegetative propagation the new plants are near the mother plant. This makes this mode of propagation important mainly for gardening. Plants multiplying in time on the area they occupy require regular removal. This can be done only by removing the new plants, which is very labor-consuming and often provokes even more abundant growth of new plants. An overall assessment of the ability of vegetative propagation of the tree and shrub species used in the city of Plovdiv is implemented for the first time.

Observations of invasive species indicate that a substantial number of them have been introduced deliberately by man into new territories as ornamental plants (Dehnen-Schmutz & al. 2007; Pimentel & al. 2005; Reichard & White 2001). Knowing the capacity for self-propagation of different tree and shrub species under the climatic conditions of Plovdiv, we can assess the risk posed by some of them for invading various natural habitats. In this respect, more important is the capacity for propagation by seeds, although the capacity for vegetative reproduction may have important complementary importance for the establishment of an alien species in different habitats.

The aim of this study is to determine the species composition of ornamental trees and shrubs in the Municipality of Plovdiv, and their capacity for self-reproduction with seeds and vegetatively in the environmental conditions of the city.

Material and methods

An inventory of the perennial vegetation in Plovdiv was conducted between 2006 and 2013. All public green areas and street landscaping were described. Each plant was recorded with its species affiliation, size and health status. Morphologically similar and rare species were determined by using Brickell & Cathey (2004), Cheshmedzhiev & Vasilev (2009), Deipavlov & al. (2003), Gramatikov (1992), and Rehder (1949). Special attention was paid which plants are part of the natural vegetation (in the forest parks areas) or are planted, and which are self-reproduced.

Families out of which various inter-species hybrids are cultivated, namely *Rosa*, *Rhododendron*, etc., and are difficult to distinguish from each other, were merged as hybrids (eg. *Rosa hybrida*).

Propensity of the described species to reproduce by seeds was assessed on a scale from 1 to 4. Grade 1 is given to species in which reproduction was not observed, or was observed on a very small scale. Grade 2 is given to species which seldom self-propagate by seed, judging by few found seedlings. Grade 3 is for species in which seed multiplication is observed relatively often around older fruit-bearing plants and in a suitable habitat for the particular species. Grade 4 goes for species of young plants that could be seen almost everywhere in the city of Plovdiv.

Propensity for vegetative self-propagation is also evaluated on a 4-grade scale. Grade 1 is assigned to species that never self-propagate, or only in exceptional cases form new plants. With Grade 2 are rated the species that have a capacity to propagate vegetatively, but this occurs seldom or the new plants are compact, which does not violate the general perception of the plant as a single. With Grade 3 are evaluated the species that exhibit enhanced vegetative propagation, which has allowed the plant to take up a significantly larger area than a single plant would cover. With Grade 4 are assessed the species which can form extensive monoclonal groups covering a considerable area and which have the potential for unlimited expansion of the occupied areas.

Information given on the seed and vegetative reproduction of the described species is based on their observed behavior in the city of Plovdiv during the study period. For species introduced to the city recently and represented by a small number of young plants, as well as for some species represented by single adult plants, we have no data for their capacity for self-reproduction.

Results

Three hundred and ninety-three species of trees and shrubs were identified in the city of Plovdiv (Table 1). The majority of identified species are of foreign origin: 61 %. Most of them originate from Asia – 142 species (37 %), followed by North America – 67 species (17 %) and the Mediterranean with 17 species (4.5 %). Identified in cultivation were also eight European species that do not grow naturally in Bulgaria and one from South America [*Caesalpinia gilliesii* (Wallich ex Hook.) Wallich ex D. Diet.].

Trees and shrubs belonging to 67 botanical families, with only 18 of them represented by more than two genera were identified in the city of Plovdiv.

Rosaceae Juss family was represented with the largest number of trees and shrubs: 64 belonging to 27 genera. The second largest number of species of trees and shrubs was from *Fabaceae* Lindl: 24 species, belonging to 18 genera. Third came two families: *Cupressaceae* Bartlett. (incl. *Taxodiaceae*) with 22 species from 11 genera, and *Caprifoliaceae* Juss. also with 22 species, belonging to 7 genera. *Oleaceae* Hoffmannsegg & H.F. Link was also represented by a significant number of species: 21 species from 7 genera. Thirty-six botanical families were represented by tree and shrub plants from single genera, and a considerable number of them with only one species.

The 393 species of trees and shrubs identified in the city belong to 177 genera and an intergeneric hybrid (only one plant of X *Machoberberis neuberti* located on Bunardzhika Hill). Genus *Prunus* L. was represented by the highest number of species – 16, followed by: *Pinus* L. – 11; *Acer* L. – 10; *Lonicera* L. – 9; *Juniperus* L. – 8; *Salix* L. – 8; *Quercus* L. – 7; *Populus* L. – 6; *Jasminum* L. – 5; *Fraxinus* L. – 5, etc. (Table 1).

Ligustrum ovalifolium Hassk. has shown the highest number of plants, followed by *Fraxinus americana* L. and *Rosa* sp. (*hybrida*). Among the 10 species with the highest number of plants in the city are only two tree species, *Fraxinus americana* and *Tilia tomentosa* Moench, the rest are shrubs (information on the number of plants refers only to the public green areas without the hills and forest park areas).

We have not observed any natural seed self-propagation in 195 species (51.3 %) in the environmental conditions of Plovdiv. For another 101 species (25.8 %), we have observed such reproduction only in a few cases. Only for 61 (15.8 %) species there were fairly often observed spontaneous seed offspring, mostly around older plants or places that provide particularly suitable conditions for the specific species. Species with very aggressive seed propagation from which young plants can be found everywhere in the city were only six (1.6 %). Although the species that propagate by seed actively constituted a relatively small proportion (17.2 %) of all identified species in the city, they included the widest used species and those forming the bulk of the trees. Species for which there was insufficient information with respect to their capacity for reproduction by seeds alone were 23 (approximately 6 %) of all identified species.

In terms of vegetative self-reproduction, we have found that more than half of the species (66.8 %) do not form a vegetative progeny, or such can be seen as an exception. Of the identified species on the territory of Plovdiv, 17.2 % gave vegetative progeny seldom, or it was compactly situated around the older plants. Species often observed with vegetative progeny as newly formed plants, which can cover a significantly larger area than that of the mother plant, accounted for 14.1 %. The most aggressive species were capable to cover large areas by vegetative propagation. Their number in Plovdiv was small, only eight and they constituted 2.1 % of all trees and shrubs.

For some species, such as *Robinia pseudoacacia*, *Syringa vulgaris*, etc., their capacity for vegetative or seed propagation (*Zizyphus jujuba*) was affected by the conditions of the habitat.

Discussion

The species composition of trees and shrubs in Plovdiv is relatively rich (Gramatikov 1992; Vakarelov & Anisimova 2010) (Table 1). The species composition identified by Cheshmedzhiev & Vasilev (2009) includes some species we have not found.

This could be explained by the presence of these plants in areas not covered by this study (private courtyards and suburban areas). Some species found by us but not described by Cheshmedzhiev & Vasilev (2009) are represented by single specimens, which might be the reason for their remaining unnoticed earlier. The identified species composition can be defined as a product of deliberate human enrichment. Indicative of the human contribution is the fact that 61 % of the identified species are non-native, on top of the fact that many native species do not occur naturally in the city (Deipavlov & al. 2003; Gramatikov 1992; Vakarelov & Anisimova 2010).

Historically, the city of Plovdiv is one of the first Bulgarian towns in which construction and maintenance of the public green areas was organized. For the purpose of landscaping, one of the first ornamental nurseries was established here. Nearby is situated the historical park of the Krichim Palace, very rich in species composition, part of which was brought to Plovdiv. A botanical garden had functioned for about 40 years in the city, whose main activities primarily included active introduction of new trees and shrubs (Gramatikov 1992). An important consequence of this is the enriched assortment of ornamental trees, shrubs and their various ornamental varieties and forms.

The obtained data have shown that the largest share of non-native species have been introduced from Asia, followed by those coming from North America. The obtained data confirm those of the earlier studies on the tree and shrub species introduced in Bulgaria (Cheshmedzhiev & Vasilev 2009; Gramatikov 1992). The very small number of Mediterranean species identified in the city could be explained with the lack of targeted introduction in the past. In recent years, there is a clear tendency of using more Mediterranean and subtropical species, including in public green areas (some of the new species are not included in this study, because of being planted after its completion).

Despite the great diversity of tree and shrub species in Plovdiv, it does not prompt a conclusion of an existing trend towards greater inequality in the quantity in which they are used in the city. Almost one-third of the identified trees and shrubs are introduced as single specimens, and another one-third can be seen rarely. This also explains the large number of botanical genera and families in the city. And not always the frequency of their use is justified by their ornamental qualities in Plovdiv conditions. Some of the families represented with a large number of species incorporate native or economically valuable species. An example is the genus *Prunus* with the greatest number of species (including *Amygdalus, Armeniaca, Cerasus, Laurocerasus, Padus,* and *Persica*) represented by wild (3), cultured and fruit trees (6), and ornamental species (7).

The identified trees and shrubs belong to 67 botanical families, just over half of them (35) represented by one genus, and 22 by only one species, 13 families are represented by two genera, six by three genera, there are five families with five genera, and two families with six and seven genera. Two families are represented by the greatest number of species, namely the families *Rosaceae* and *Fabaceae*. This species diversity can be explained primarily by the fact that they are among the largest and most common botanical families, with a great number of tree and shrub species in the temperate climate zones. On the other hand, the trees and shrubs species that are part of them have a variety of morphological and ecological features, which allow many of them to be used as ornamental plants. Furthermore, a great number of the identified species from the *Rosaceae* family are of local origin or cultivated as fruit plants (11 species).

Of all identified species, 51.3 % do not show signs of seed self-reproduction, while for 25.8 % it has been seldom observed (Table 1). They represent approximately 3/4 of all species. Although the species showing aggressive seed self-propagation constitute less than 1/5 of all identified species, they claim a significant share of the total number of ornamental plants. This means that they will continue to cause problems in maintaining the green areas in the city in the future. Many of these species pose a significant risk to the natural habitat around the city too.

Such species as *Acer negundo* L., *Ailanthus altissima* (Mill.) Swingle, *Amorpha fruticosa* L., *Fraxinus americana* L., *Gleditsia triacanthos* L., *Lycium barbarum* L., *Maclura pomifera* (Raf.) C.K. Schneid., *Morus alba* L., *Parthenocissus quinquefolia* (L.) Planch., etc. can now be seen outside of the city, some with considerable density in certain spots. It is still possible to limit the potential damage, both in the city and outside, from any species with a great capacity for seed reproduction represented by a small number of specimens, for example: *Celastrus orbiculatus* Thunb., *Colutea orientalis* Mill., *Flueggea suffruticosa* (Pall.) Baill., *Fontanesia phillyreoides* Labill., *Lonicera maackii* (Rupr.) Maxim., *Prinsepia sinensis* (Oliv.) Oliv. ex Bean, *Rhus potaninii* Maxim., and *Zanthoxylum bungeanum* Maxim.

Our observations have shown that many of the species not tending to seed self-reproduction have normally developed seeds with satisfactory germination (unpublished data). Their low natural seed reproduction can be explained by the unfavorable conditions for seed germination or by inappropriate conditions for growth, development and survival of the young plants. For some species, we have observed lack of appropriate distributors of seeds, which leads to concentration of young plants in the vicinity of the elderly. By the identified tendency for seed self-reproduction of the species of trees and shrubs cultivated in the city of Plovdiv, it can be concluded that this aspect of the behavior of a new species is difficult to predict. Species commonly reported as invasive in other parts of the world with similar to Plovdiv conditions do not have a high capacity for seed self-reproduction. Good examples are *Albizia julibrissin, Melia azedarach, Paulownia tomentosa,* etc. (Essl 2007; Jordaan & al. 2012; Landenberger & al. 2007; Gómez-Aparicio & Canham 2003; Webster & al. 2006). We have observed self-seeding for *Albizia julibrissin,* but rarely. This can be attributed to the strong insect attacks, lowering the number of viable seeds (Stojanova 2006; Shu-Mei & al. 2010). For *Melia azedarach,* the

reasons probably are complex. The seeds of this species do not spread over long distances, they are difficult to incorporate into the soil and young plants are very sensitive to low winter temperatures. A probable reason for lack of seed self-reproduction of *Paulownia tomentosa* is the relatively dry and hot weather in late spring and summer that kills the delicate seedlings of the species. Good examples are also *Syringa vulgaris* L. and *Fraxinus ornus* L. These two species have similar ecological requirements and an overlapping area on the territory of the country. The hills are close to their natural habitats, but only seedlings of *Fraxinus ornus* L. occur. Some local species, such as *Prunus cerasifera, Rhamnus sp., Rosa canina,* etc., are referred to the species showing moderate or strong tendency for seed self-propagation. Their ability for self-reproduction is mostly negative in terms of landscaping. Not all native species show high ability for seed reproduction.

In terms of independent vegetative reproduction, we have found that more than half of the trees and shrubs species (66.8 %) do not form vegetative offspring, while for 17.2 % of them such offspring were observed, but the plants do not take up new areas. The species that can cause problems with their ability to propagate vegetatively account for only 16.2 %. Many species that form vegetative progeny are commonly used in green areas, for example: many forms of *Syringa vulgaris* L., *Prunus cerasus* L., *Broussonetia papyrifera* (L.) L'Hér. ex Vent., etc. Particularly noteworthy are the species for which the ability to form vegetative progeny is combined with their capacity for seed reproduction, such as: *Ailanthus altissima, Amorpha fruticosa, Lycium barbarum, Parthenocissus quinquefolia, Rhus potaninii,* etc.

The prevalent mechanism of vegetative reproduction observed for the tree species is the formation of root offshoots. Bushes and some types of remontant species fairly often resort to rooting from surface stems lying on the soil.

It was found that some species showed different ability for vegetative reproduction in the hills. It was most noticeable in *Zizyphus jujuba* and *Robinia pseudoacacia*, which show much higher ability to form shoots. The reasons for this are probably the more extreme conditions under which the plants grow. The older plants of *Robinia pseudoacacia* are smaller than those growing in the flat parts of the city, and almost without exception they are in poor health. This probably provokes the formation of shoots to replace the mother plant. Similarly, in *Zizyphus jujuba* all plants in the hills grow more like shrubs, and form more shoots further away from their mother plants. It is typical of *Zizyphus jujuba* in the hills that it does not produce fruits or does it seldom (not reported here), unlike the plants in the flat parts of the city. Plants of *Syringa vulgaris* in the hills show no or scanty vegetative reproduction and do not extend their occupied area.

With regard to the capacity for self-reproduction, we have observed some differentiation as well. For example, species of which we have found the greatest number of young seedlings in the hills are: *Ailanthus altissima* (Mill.) Swingle, *Celtis australis* L., *Cotoneaster* sp., *Fraxinus ornus* L., *Gleditsia triacanthos* L., *Koelreuteria paniculata* Laxm., *Rhamnus* sp., etc. In the former botanical garden, located on flat terrain close to groundwater and less than 1 km off river Maritza, we have observed a large number of young plants of *Acer negundo* L., *Ailanthus altissima* (Mill.) Swingle, *Amorpha fruticosa* L., *Fraxinus americana* L., *Maclura pomifera* (Raf.) Schneid., etc. Some poorly known species also spread aggressively in the former botanical garden, for example: *Rhus potaninii* Maxim., *Flueggea suffruticosa* (Pall.) Baill., *Prinsepia sinensis* Oliv. ex Bean, *Zanthoxylum bungeanum* Maxim., *Colutea orientalis* Miller, etc.

Conclusions

Almost ¾ of the identified species showed no inclination to aggressive seed propagation. They should be evaluated further for their ornamental qualities and those appropriate to be used more widely in landscaping. The species with the most aggressive seed propagation on the territory of Plovdiv are: *Acer negundo* L., *Ailanthus altissima* (Mill.) Swingle, *Fraxinus americana* L., *Gleditsia triacanthos* L., *Prunus cerasifera* Ehrh., and *Rosa canina* L. Particular attention should be paid to non-native species.

There are eight species that have shown a high ability for vegetative propagation in green areas and three of them are represented in single groups in the city, namely *Clerodendrum bungei* Steud., *Maclura tricuspidata* (Carrière) Bureau and *Vinca herbacea* Waldst. & Kit. Wider distributed in the city are: *Broussonetia papyrifera* (L.) Vent., *Hedera helix* L., *Phillostachys viridiglaucescens* (Carrière) Rivière & C. Rivière, *Populus alba* L., and *Ziziphus jujuba* Mill.

Table 1. List of tree and shrub species found in the city of Plovdiv, their geographical origin and evaluation of their ability for seed and vegetative self-propagation

Species	Capacity for seed propagation	Capacity for vegetative propagation	Origin
Abelia × *grandiflora* (André) Rehd.	1	1	Hybrid
Abies alba Mill.	1	1	Native
Abies cephalonica Loudon	1	1	Europe
Abies concolor (Gordon) Lindl. ex Hildebr.	1	1	North America
Abies nordmanniana (Steven) Spach	1	1	Asia
Abies pinsapo Boiss.	1	1	Europe
Acer buergerianum Miq.	1	1	Asia
Acer campestre L.	3	1	native
Acer ginnala Maxim.	2	1	Asia
Acer japonicum Thunb.	1	1	Asia
Acer monspessulanum L.	nd	nd	Native
Acer negundo L.	4	1	North America
Acer palmatum Thunb.	1	1	Asia
Acer platanoides L.	3	1	Native
Acer pseudoplatanus L.	3	1	Native
Acer saccharinum L.	1	1	North America
Acer tataricum L.	2	1	Native
Actinidia deliciosa (A.Chev.) C.F.Liang & A.R.Ferguson	1	1	Asia
Aesculus hippocastanum L.	2	1	Native
Aesculus flava Sol.	1	1	North America
Aesculus parviflora Walter	2	1	North America
Aesculus × *carnea* Zeyh.	1	1	Hybrid
Ailanthus altissima (Mill.) Swingle	4	3	Asia
Akebia quinata (Houtt.) Decne.	nd	1	Asia
Albizia julibrissin Durazz.	2	1	Asia
Alnus glutinosa (L.) Gaertn.	2	1	Native
Amelanchier ovalis Medik.	2	1	Native
Amorpha fruticosa L.	4	2	North America
Ampelopsis aconitifolia Bunge	2	2	Asia
Aronia melanocarpa (Michx.) Elliott	1	1	North America
Aucuba japonica Thunb.	1	1	Asia
Berberis aggregata C.K.Schneid.	3	1	Asia
Berberis julianae C.K.Schneid.	1	1	Asia
Berberis thunbergii DC.	2	1	Asia
Berberis vulgaris L.	3	1	Native
Betula pendula Roth	1	1	Native
Broussonetia papyrifera (L.) L'Hér. ex Vent.	1	4	Asia
Buddleja alternifolia Maxim.	1	1	Asia
Buddleja davidii Franch.	1	1	Asia
Buxus sempervirens L.	1	1	Mediterranean
Caesalpinia gilliesii (Hook.) D.Dietr.	1	1	South America
Callicarpa bodinieri H.Lév.	1	1	Asia
Calocedrus decurrens (Torr.) Florin	1	1	North America
Calycanthus floridus L.	1	1	North America
Calycanthus occidentalis Hook. & Arn.	1	1	North America
Campsis radicans (L.) Seem.	2	2	North America
Caragana arborescens Lam.	1	1	Native
Carpinus betulus L.	1	1	Native
Carpinus orientalis Mill.	nd	1	Native
Carya illinoinensis (Wangenh.) K.Koch	nd	1	North America
Caryopteris incana (Thunb. ex Houtt.) Miq.	3	2	Asia
Castanea sativa Mill.	2	1	Native
Catalpa bignonioides Walter	2	1	North America
Catalpa ovata G.Don	2	1	Asia
Catalpa speciosa (Warder ex Barney) Warder ex Engelm.	2	1	North America
Cedrus atlantica (Endl.) Manetti ex Carrière	1	1	Mediterranean
Cedrus deodara (Roxb. ex D.Don) G.Don	1	1	Asia
Cedrus libani A.Rich.	2	1	Mediterranean
Celastrus orbiculatus Thunb.	3	1	Asia
Celtis australis L.	3	1	Native
Celtis occidentalis L.	nd	1	North America
Cephalotaxus harringtonii (Knight ex J.Forbes) K.Koch.	1	1	Asia
Cercis canadensis L.	2	1	North America
Cercis siliquastrum L.	3	1	Native
Chaenomeles japonica (Thunb.) Lindl. ex Spach	1	1	Asia
Chaenomeles × *superba* (Frahm) Rehder	1	1	Hybrid
Chamaecyparis lawsoniana (A.Murray bis) Parl.	1	1	North America
Chamaecyparis pisifera (Siebold & Zucc.) Endl.	1	1	Asia
Chimonanthus praecox (L.) Link	1	1	Asia
Cionura erecta (L.) Griseb.	3	3	Native
Clematis vitalba L.	3	3	Native
Clematis viticella L.	1	1	Native
Clematis × *jackmanii* T. Moore	1	1	Hybrid
Clematis × *patens* C.Morren & Decne.	1	1	Hybrid
Clerodendrum bungei Steud.	1	4	Asia

Table 1. Continuation

Species	Capacity for seed propagation	Capacity for vegetative propagation	Origin
Colutea arborescens L.	3	1	Native
Colutea orientalis Mill.	3	1	Asia
Cornus alba L.	2	2	Asia
Cornus florida L.	nd	nd	North America
Cornus mas L.	2	1	Native
Cornus sanguinea L.	3	3	Native
Coronila emerus L.	2	1	Native
Cornus sericea L.	1	2	North America
Corylus avellana L.	nd	2	Native
Corylus colurna L.	1	1	Native
Corylus maxima Mill.	nd	3	Asia
Cotinus coggygria Scop.	2	3	Native
Cotoneaster dammeri C.K.Schneid.	2	2	Asia
Cotoneaster horizontalis Decne.	2	2	Asia
Cotoneaster integerrimus Medik.	3	2	Native
Cotoneaster niger (Thunb.) Fr.	3	2	Native
Crataegus mollis (Torr. & A.Gray) Scheele	2	1	North America
Crataegus monogyna Jacq.	3	1	Native
Crataegus rhipidophylla Gand.	nd	1	Native
Cryptomeria japonica (Thunb. ex L.f.) D.Don	1	1	Asia
Cupressus arizonica Greene	1	1	North America
Cupressus sempervirens L.	2	1	Asia
Cupressus × *leylandii* A.B.Jacks. & Dallim.	nd	1	Hybrid
Cydonia oblonga Mill.	2	3	Asia
Cytisus hirsutus L.	nd	nd	Native
Deutzia crenata Siebold & Zucc.	1	1	Asia
Deutzia gracilis Siebold & Zucc.	1	1	Asia
Deutzia scabra Thunb.	1	1	Asia
Diospyros kaki L.f.	1	1	Asia
Diospyros lotus L.	2	1	Asia
Elaeagnus multiflora Thunb.	2	3	Asia
Elaeagnus angustifolia L.	2	3	Asia
Elaeagnus pungens Thunb.	2	1	Asia
Erica herbacea L.	1	1	Europe
Eriobotrya japonica (Thunb.) Lindl.	1	1	Asia
Eucommia ulmoides Oliv.	2	1	Asia
Euonymus europaeus L.	3	2	Native
Euonymus fortunei (Turcz.) Hand.-Mazz.	1	3	Asia
Euonymus japonicus Thunb.	2	1	Asia
Exochorda racemosa (Lindl.) Rehder.	1	1	Asia
Fagus sylvatica L.	1	1	Native
Fallopia aubertii (L.Henry) Holub	2	2	Asia
Fatsia japonica (Thunb.) Decne. & Planch.	1	2	Asia
Ficus carica L.	2	2	Asia
Flueggea suffruticosa (Pall.) Baill.	3	1	Asia
Fontanesia phillyreoides Labill.	3	2	Mediterranean
Forsythia suspensa (Thunb.) Vahl	1	2	Asia
Forsythia × *intermedia* Zabel	1	1	Hybrid
Fraxinus americana L.	4	1	North America
Fraxinus excelsior L.	3	1	Native
Fraxinus ornus L.	2	1	Native
Fraxinus angustifolia subsp. *oxycarpa* (Willd.) Franco & Rocha Afonso.	3	1	Native
Fraxinus pennsylvanica Marshall	nd	1	North America
Genista germanica L..	nd	2	Native
Genista rumelica Velen.	2	2	Native
Genista tinctoria L.	nd	2	Native
Ginkgo biloba L.	2	1	Asia
Gleditsia triacanthos L.	4	2	North America
Gymnocladus dioica (L.) K.Koch.	2	3	North America
Hamamelis japonica Siebold & Zucc.	1	1	Asia
Hedera helix L.	3	4	Native
Hibiscus syriacus L.	2	1	Asia
Hovenia dulcis Thunb.	1	1	Asia
Humulus lupulus L.	3	3	Native
Hydrangea arborescens L.	1	3	North America
Hydrangea cinerea Small	nd	nd	North America
Hydrangea macrophylla (Thunb.) Ser.	1	2	Asia
Hypericum androsaemum L.	nd	3	Native
Hypericum calycinum L.	1	3	Native
Ilex aquifolium L.	1	1	Native
Indigofera gerardiana Baker	1	1	Asia
Jasminum fruticans L.	3	2	Native
Jasminum nudiflorum Lindl.	1	3	Asia
Jasminum officinale L.	1	1	Asia
Jasminum mesnyi Hance.	1	1	Asia
Jasminum humile L.	1	1	Asia
Juglans mandshurica Maxim.	2	1	Asia
Juglans nigra L.	2	1	North America
Juglans regia L.	3	1	Native
Juniperus chinensis L.	1	2	Asia
Juniperus communis L.	1	1	Native
Juniperus excelsa M.Bieb.	1	1	Native
Juniperus horizontalis Moench	1	2	North America

Table 1. Continuation

Species	Capacity for seed propagation	Capacity for vegetative propagation	Origin
Juniperus oxycedrus L.	1	1	Native
Juniperus sabina L.	1	2	Native
Juniperus scopulorum	1	1	North America
Juniperus squamata Buch.-Ham. ex D.Don	1	1	Asia
Juniperus virginiana L.	1	2	North America
Kerria japonica (L.) DC.	1	2	Asia
Koelreuteria paniculata Laxm.	3	1	Asia
Kolkwitzia amabilis Graebn.	1	1	Asia
Laburnum anagyroides Medik.	2	2	Europe
Lagerstroemia indica L.	1	2	Asia
Laurus nobilis L.	1	1	Native
Lavandula angustifolia Mill.	1	1	Mediterranean
Lespedeza bicolor Turcz.	1	1	Asia
Ligustrum japonicum Thunb.	1	1	Asia
Ligustrum ovalifolium Hassk.	2	3	Asia
Ligustrum vulgare L.	3	3	Native
Liquidambar styraciflua L.	1	1	North America
Liriodendron tulipifera L.	1	1	North America
Lonicera caprifolium L.	1	2	Europe
Lonicera fragrantissima Lindl. & J. Paxton	1	2	Asia
Lonicera japonica Thunb.	2	2	Asia
Lonicera korolkowii Stapf.	2	1	Asia
Lonicera maackii (Rupr.) Maxim.	3	1	Asia
Lonicera ligustrina var. *yunnanensis* Franch.	1	2	Asia
Lonicera pileata Oliv.	1	2	Asia
Lonicera tatarica L.	2	2	Asia
Lonicera xylosteum L.	2	1	Native
Lycium barbarum L.	3	3	Asia
× *Machoberberis neuberti* (Lem.) Schneider	1	1	Hybrid
Maclura pomifera (Raf.) C.K.Schneid.	3	1	North America
Maclura tricuspidata Carrière	1	4	Asia
Magnolia grandiflora L.	1	1	North America
Magnolia kobus DC.	1	1	Asia
Magnolia liliiflora Desr.			
Magnolia stellata (Siebold & Zucc.) Maxim.	1	1	Asia
Magnolia stellata × *M. liliiflora*	1	1	Hybrid
Magnolia × *soulangeana* Soul.-Bod.	1	1	Hybrid
Mahonia aquifolium (Pursh) Nutt.	3	1	North America
Mahonia japonica (Thunb.) DC.	1	1	Asia
Malus baccata (L.) Borkh.	2	1	Asia
Malus domestica Borkh.	3	1	Asia
Malus niedzwetzkyana Dieck ex Koehne	2	1	Asia
Malus sylvestris (L.) Mill.	2	1	Native
Melia azedarach L.	2	2	Asia
Menispermum dauricum DC.	nd	3	Asia
Mespilus germanica L.	1	1	Native
Metasequoia glyptostroboides Hu & W.C.Cheng	1	1	Asia
Morus alba L.	3	1	Asia
Morus nigra L.	2	1	Asia
Nandina domestica Thunb.	1	1	Asia
Olea europaea L.	1	1	Mediterranean
Ostrya carpinifolia Scop.	1	1	Native
Paeonia × *suffruticosa* Andrews.	1	1	Asia
Paliurus spina-christi Mill.	2	1	Native
Parrotia persica C.A.Mey.	1	3	Asia
Parthenocissus quinquefolia (L.) Planch.	3	3	North America
Parthenocissus tricuspidata (Siebold & Zucc.) Planch.	1	2	Asia
Paulownia elongata S.Y. Hu	1	nd	Asia
Paulownia tomentosa Steud.	1	2	Asia
Periploca graeca L.	2	nd	Native
Phellodendron amurense Rupr.	1	1	Asia
Philadelphus coronarius L.	1	1	Europe
Philadelphus grandiflorus Willd.	1	1	North America
Philadelphus × *lemoinei* Auct.	1	1	Hybrid
Photinia bodinieri H.L,V.	1	1	Asia
Phyllostachys viridiglaucescens (Carrière) Rivière & C.Rivière	1	4	Asia
Physocarpus opulifolius (L.) Maxim.	1	2	Asia
Picea abies (L.) H.Karst.	1	1	Native
Picea glauca (Moench) Voss (Conica)	1	1	North America
Picea omorika (Pancic) Purk.	1	1	Europe
Picea orientalis (L.) Peterm.	1	1	Asia
Picea pungens Engelm.	1	1	North America
Pinus halepensis Mill.	1	1	Mediterranean
Pinus mugo Turra	1	1	Native
Pinus nigra J.F.Arnold	1	1	Native
Pinus peuce Griseb.	1	1	Native
Pinus pinaster Aiton.	1	1	Mediterranean
Pinus pinea L.	1	1	Mediterranean
Pinus wallichiana A.B.Jacks.	1	1	Asia
Pinus ponderosa Douglas ex C.Lawson	1	1	North America
Pinus radiata D.Don	1	1	North America
Pinus sylvestris L.	1	1	Native

Table 1. Continuation

Species	Capacity for seed propagation	Capacity for vegetative propagation	Origin
Pinus strobus L.	1	1	North America
Pistacia terebinthus L.	2	1	Native
Platanus × *acerifolia* (Aiton) Willd.	2	1	Hybrid
Platanus occidentalis L.	2	1	North America
Platanus orientalis L.	2	1	Native
Platycladus orientalis (L.) Franco.	2	1	Asia
Poncirus trifoliata (L.) Raf.	1	1	Asia
Populus alba L.	2	4	Native
Populus deltoides Marshall	2	3	North America
Populus nigra L.	2	3	Native
Populus simonii Carrière	1	2	Asia
Populus tremula L.	1	3	Native
Populus × *euramericana* (Dode) Guinier	2	3	Hybrid
Dasiphora fruticosa (L.) Rydb.	1	1	Native
Prinsepia sinensis (Oliv.) Oliv. ex Bean	3	1	Asia
Prunus armeniaca L.	2	1	Asia
Prunus avium (L.) L.	3	1	Native
Prunus cerasifera Ehrh.	4	1	Native
Prunus cerasus L.	2	3	Native
Prunus domestica L.	2	1	Native
Prunus dulcis (Mill.) D.A.Webb	2	1	Asia
Prunus glandulosa Thunb.	1	2	Asia
Prunus insititia L.	2	3	Native
Prunus laurocerasus L..	2	2	Native
Prunus mahaleb L.	3	1	Native
Prunus persica (L.) Batsch	3	1	Asia
Prunus padus L.	2	1	Native
Prunus serrulata Lindl.	1	1	Asia
Prunus spinosa L.	2	3	Native
Prunus tenella Batsch	2	3	Native
Prunus virginiana L.	1	3	North America
Pseudosasa japonica (Steud.) Makino	1	3	Asia
Pseudotsuga menziesii (Mirb.) Franco	1	1	North America
Ptelea trifoliata L.	2	1	North America
Pterocarya fraxinifolia (Poir.) Spach	1	1	Asia
Punica granatum L.	2	1	Asia
Pyracantha coccinea M.Roem.	2	2	Native
Pyrus communis L.	2	1	Native
Pyrus elaeagnifolia Pall.	1	1	Native
Pyrus pyraster (L.) Burgsd.	2	1	Native
Quercus frainetto Ten.	2	1	Native
Quercus ilex L.	2	1	Mediterranean
Quercus palustris Münchh.	1	1	North America
Quercus petraea (Matt.) Liebl.	2	1	Native
Quercus pubescens Willd.	2	1	
Quercus robur L.	3	1	Native
Quercus rubra L.	2	1	North America
Rhamnus cathartica L.	3	2	Native
Rhamnus frangula L.	3	1	Native
Rhododendron ponticum L.	1	1	Native
Rhododendron sp. (hybrids)	1	1	Hybrid
Rhodotypos scandens (Thunb.) Makino.	2	1	Asia
Rhus chinensis Mill.	1	3	Asia
Rhus potaninii Maxim.	3	3	Asia
Rhus trilobata Nutt.	1	2	North America
Rhus typhina L.	1	3	North America
Ribes aureum Pursh	3	2	North America
Ribes nigrum L.	1	1	Native
Ribes sanguineum Pursh	1	1	North America
Robinia hispida L.	1	1	North America
Robinia pseudoacacia L.	2	3	North America
Robinia viscosa Vent.	nd	3	North America
Rosa canina L.	4	1	Native
Rosa kasanlika V. T.	1	1	Native
Rosa pendulina L.	3	1	Native
Rosa rugosa Thunb.	1	3	Asia
Rosa sp. (hybrids)	1	2	Hybrid
Rosmarinus officinalis L.	1	1	Mediterranean
Rubus caesius L.	3	3	Native
Rubus sanctus Schreb.	2	3	
Rubus idaeus L.	1	3	Native
Ruscus aculeatus L.	1	2	Native
Ruscus hypoglossum L.	1	2	Native
Ruta graveolens L.	2	1	Native
Salix alba L.	2	3	Native
Salix babylonica L.	1	2	Asia
Salix caprea L.	2	1	Native
Salix cinerea L.	2	2	Native
Salix × *fragilis* L.	2	2	Native
Salix integra Thunb.	nd	1	Asia
Salix matsudana Koidz.	1	2	Native
Salix purpurea L.	2	2	Native
Salvia officinalis L.	2	1	Mediterranean
Sambucus nigra L.	3	1	Native
Sambucus racemosa L.	1	1	Native
Santolina chamaecyparissus L.	1	2	Mediterranean
Santolina rosmarinifolia L.	1	2	Mediterranean
Sequoiadendron giganteum (Lindl.) J.Buchholz	1	1	North America
Smilax excelsa L.	2	1	Native
Solanum dulcamara L.	3	3	Native
Sophora davidii (Franch.) Pavol.	1	1	Asia

Table 1. Continuation

Species	Capacity for seed propagation	Capacity for vegetative propagation	Origin
Sorbaria sorbifolia (L.) A.Braun	1	1	Asia
Sorbaria tomentosa (Lindl.) Rehder.	1	1	Asia
Sorbus aria (L.) Crantz	2	1	Native
Sorbus aucuparia L.	2	1	Native
Sorbus domestica L.	2	1	Native
Sorbus torminalis (L.) Crantz	1	1	Native
Spartium junceum L.	2	1	Mediterranean
Spiraea cantoniensis Lour.	1	1	Asia
Spiraea douglasii Hook.	1	2	North America
Spiraea japonica L.f.	1	1	Asia
Spiraea × *bellardii* hort.	1	2	Hybrid
Spiraea × *vanhouttei* (Briot) Zabel	1	1	Hybrid
Staphylea pinnata L.	1	1	Native
Stephanandra tanakae Franch. & Sav.	nd	nd	Asia
Styphnolobium japonicum (L.) Schott.	2	1	Asia
Symphoricarpos albus (L.) S.F.Blake	1	1	North America
Symphoricarpos × *chenaultii* Rehder	1	2	Hybrid
Symphoricarpos orbiculatus Moench	1	1	North America
Syringa reticulata subsp. *amurensis* (Rupr.) P.S.Green & M.C.Chang	3	1	Asia
Syringa oblata Lindl.	1	1	Asia
Syringa × *persica* L.	1	1	Hybrid
Syringa vulgaris L.	1	3	Native
Tamarix gallica L.	1	1	Mediterranean
Tamarix ramosissima Ledeb.	1	1	Native
Tamarix tetrandra Pall. ex M.Bieb.	1	1	Native
Taxodium distichum (L.) Rich.	1	1	North America
Taxus baccata L.	2	1	Native
Tetradium daniellii (Benn.) T.G.Hartley.	2	1	Asia
Thuja occidentalis L.	1	1	North America
Thuja plicata Donn ex D.Don	1	1	North America
Tilia cordata Mill.	1	2	Native
Tilia × *euchlora* K.Koch	1	2	Europe
Tilia platyphyllos Scop.	2	3	Native
Tilia tomentosa Moench	2	3	Native
Trachycarpus fortunei (Hook.) H.Wendl.	1	1	Asia
Ulmus glabra Huds.	3	2	Native
Ulmus laevis Pall.	2	1	Native
Ulmus minor Mill.	3	3	Native
Ulmus pumila L.	nd	nd	Asia
Viburnum lantana L.	1	1	Native
Viburnum opulus L.	1	1	Native
Viburnum rhytidophyllum Hemsl.	2	1	Asia
Viburnum tinus L.	1	1	Mediterranean
Vinca herbacea Waldst. & Kit.	3	4	Native
Vinca major L.	1	3	Asia
Vinca minor L.	1	3	Asia
Vitex agnus-castus L.	1	1	Native
Vitex negundo L.	1	1	Asia
Vitis sylvestris C. C. Gmelin	2	1	Native
Vitis vinifera L.	1	1	Native
Weigela florida (Bunge) A. DC.	1	1	Asia
Wisteria sinensis (Sims) Sweet.	2	1	Asia
Yucca filamentosa L.	1	2	North America
Yucca flaccida Haw.	1	3	North America
Yucca gloriosa L.	1	2	North America
Yucca gloriosa var. *tristis* Carrière	1	2	North America
Zanthoxylum armatum DC.	1	1	Asia
Zanthoxylum bungeanum Maxim.	3	1	Asia
Ziziphus jujuba Mill.	2	4	Asia

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