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Invasiveness risk assessment of woody plants of Armenia

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Abstract: The article presents a new scheme for assessing the invasion risk from archaeophyte and neophyte woody plants in Armenia, which has been adapted from two widely used and well known works - WEBER & GUT (2004) and MAGEE et al. (2010). Using these schemes invasion risk assessments were carried out of 153 woody plant species (mostly recommended for landscape architecture and gardening in Armenia) and the level of their invasive potential was specified for each species. The obtained results provide a good basis for further use of assessed species for different purposes, as well as for focusing scientific work on monitoring of population dynamics, development of quarantine control, elaboration of different guidelines for quarantine service, etc. Special attention should be given to their distribution under the impact of climate change. We propose to use our developed methodology of assessmentfor new species introduction, testing of growing in different conditions of Armenia or for selection of new species or forms for landscape architecture and gardening.

Keywords: invasiveness, woody plants, biodiveristy, risk assessment, Armenia.

Introduction

Armenia is an astonishing country. It occupies a very small territory (less than 30000 km^2) in the South Caucasus, but it has an extremely rich landscape and

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biological diversity. About 3800 species of vascular plants (approximately half of the Caucasus flora) are registered in Armenia (THE FIFTH NATIONAL REPORT 2014). The flora of Armenia includes 142 local endemic species! This rich biodiversity is attributed to diversity of natural ecosystems. Due to the huge variety of climates (from dry subtropics to cold alpine) and soil conditions all the main Caucasian ecosystems (besides humid subtropics) are represented in Armenia – deserts and semi-deserts, steppes, meadow-steppes, forests and open woodlands, sub-alpine and alpine vegetation as well as intrazonal ecosystems.

Such a great variety of ecosystems, natural and climatic conditions gives excellent opportunities for alien plant species to penetrate and anchor in the territory of Armenia. Virtually any species, except tropical, can find here suitable conditions for themselves. Undoubtedly, in most cases invasive alien species will not be able to occupy large areas, but even in small areas, forming monodominante communities, they can pose a serious threat to ecosystems and individual representatives of the biodiversity of the republic. From the other hand diversity of conditions can give an opportunity to some native species with invasive potential, which being better adapted to local conditions, to expend their distribution areas and supplant ecologically less flexible species.

The introduction of plants emerged spontaneously in the early stages of the development of human society and entered its highest phase since the 20th century.

In the beginning of introduction history mostly food and technical plants were introduced, then by the increasing of human requirements and opportunities for introduction a large diversity of plants from around the world has been introduced for different purposes.

Armenia, both in modern and historical borders, is considered as one of the oldest world centers of agriculture and introduction (VAVILOV 1987). The desire to expand the range of cultivated plants has arisen even in ancient times. As evidenced by archaeological data, even in the 13th-7th centuries BC in the territory of the state of Urartu chickpeas, wheat, grapes, apple, plum, cherry, peach, cherry plum, quince, pomegranate were grown, as well as during excavation, in the same territory wood remains of *Fraxinus excelsior, F. oxycarpa, Populus gracilis, Pinus kochiana, Tilia* sp., *Ulmus* sp., *Quercus* sp., *Taxus baccata* were found (VARDANYAN 2012).

Over the centuries, the introduction of plants into the territory of Armenia continued with varying intensity. It has seriously been intensified since the end of 18th century, when construction of private and public gardens was started in different regions of Armenia. During this period, numerous exotic plants were brought to Armenia, some of which have survived to these days at the age of more than 200 years. For example, there is a “green ring” around Echmiadzin (small city, center of Armenian Apostolic church), in which there are *Ulmus foliacea* and *Tilia cordata* more than 250 years old (VARDANYAN 2012). The first steps to expand the areas of both silviculture, and green construction in the cities and settlements of the republic were taken in 1925-1930. However, the assortment of woody plants used in city landscaping was mostly very poor and sometimes not successful; for example, very few evergreen species were used.

After World War II, gardening works in Armenia were more intensified, and new exotic valuable species appeared in the plantations: silvery spruce, Crimean and Eldar pines, horse chestnut, boxwood, Virginian juniper, Himalayan cedar, etc. In fact, planned and purposeful work on the introduction and acclimatization of plants in Armenia started already in the Soviet period. In 1935, the Botanical Garden of the Armenian branch of the USSR Academy of Sciences was organized, where a rich collection of woody and herbaceous plants was collected in a short period of time. Most of the species of trees and shrubs that now grow in the green plantations of the republic were originally tested in the conditions of the Yerevan Botanical Garden and its two branches - Vanadzor (since 1936) and Sevan (since 1944) (VARDANYAN 2012).

Currently, due to a long and purposeful introduction there are about 1650 species, varieties and garden forms of ornamental trees and shrubs from 207 genera and 75 families in scientific collections of botanical gardens, in arboretums and green plantations of Armenia (VARDANYAN 2012).

The spread and increasing distribution of alien invasive plant species after destroying ecosystems is the second main threat for natural ecosystems and biodiversity (CRONK, FULLER 1995). Disturbance of natural ecosystems leads to intensification of distribution of invasive plant species and to change them more and more. Global climate change can change natural ecosystems and open econiches for invasive plant species (native and alien) as well. Distribution and impact of invasive alien species are widely recognized, and article 8(h) of the Convention on biological diversity asks for measures “to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species” (CONVENTION ON BIOLOGICAL DIVERSITY 1992).

However, in Armenia until last decades, no one has been engaged in assessing the risk of invasion of introduced and native plants. As a result, some species widely used in landscape architecture and gardening (*Ailanthus altissima, Robinia pseudoacacia, Acer negundo, Amorpha fruticosa*, and some others) escape from the culture, penetrate into the natural ecosystems and destroy them. In the last two or three years, evidently, due to the manifestation of the consequences of climate change, other species spread as well, e.g. *Buddlea davidii, Clematis vitalba* etc., which were also found by our research group.

In this regard, we decided to select more or less simple method adapted to the difficult conditions of our country for assessing the risk of invasion of woody plants.

Material and methods

There are many challenges facing the field of risk assessment of species invasiveness. We studied a lot of modern literature (PHELOUNG 1995; WILGEN et al. 2001; ANDERSEN et al. 2004; GENOVESI & SHINE 2004; CROSSMAN et al. 2011; IUCN 2017; PIER 2015; SANDVIK et al. 2015; BURGIEL & MUIR 2010; VERBRUG et al. 2010; MCDOUGALL et al. 2011; PYSEK et al. 2017), and as a result, we stopped at two works, which used fairly simple criteria for assessing the risk of invasive potential of species.

The first work is paper of WEBER & GUT (2004), in which the authors used 12 criteria for the assessment. We adapted their scheme for conditions of Armenia (Tab. 1) and the following changes were made:

- The term "Europe" was changed to "Caucasus"
- In connection with the fact that in our study we confined ourselves only to woody plants, the criteria "life form" was not taken into account
- Criteria «Climatic match» also has no sense, because the territory of Armenia has great variety of eco-climatic conditions, and it is possible to find connection with almost any corner of the World (except perhaps the tropics and humid subtropics).
- The same applies to the criteria «Geographic distribution in the Caucasus» and «Range size of global distribution». The investigated species currently are globally widespread.
- Criteria «Habitats of species» should include all natural habitats, even disturbed and semi-natural.

Tab. 1. Criteria of invasiveness risk assessment of arboreal plants in Armenia (based on the scheme of WEBER & GUT, 2004).

No	Criteria	Question	Answer	Points
1	Status of species in Caucasus	Is the species native to Caucasus?	• Yes • No	0 2
2	History as an agricultural weed elsewhere	Is the species reported as a weed from somewhere else?	• No • Yes	0 3
3	Taxonomy	Does the species have weedy congeners?	• No • Yes	0 3
4	Seed viability and reproduction	How many seeds do the species approximately produce?	• Few seeds or no viable seeds • Many seeds	1 3
5	Vegetative growth	Allocate species to one of the following.	• Species has no vegetative growth that leads to lateral spread • If a tree or shrub, species has the ability to resprout from stumps or stem layering, or stems root if touching the ground • Species has bulbs or corms • Species has well developed rhizomes and/or stolons for lateral spread • Species fragments easily, fragments can be dispersed and produce new plants • Other	0 2 1 4 4 2
6	Dispersal mode	Allocate species to one of the following.	• Fruits are fleshy and smaller than 5 cm in diameter • Fruits are fleshy and larger than 10 cm in length or diameter • Fruits are dry and seeds have well developed structures for long-distance dispersal by wind (pappus, hairs, wings) • Fruits are dry and seeds have well-developed structures for long-distance dispersal by animals (spikes, thorns) • Species has mechanisms for self-dispersing • Other	2 0 4 4 1 2

Tab. 1. – cont.

No	Criteria	Question	Answer	Points
7	Habitats of species	Allocate species to one of the following.	• Riparian habitats • Bogs/swamps • Wet grasslands • Dry (xeromorphic) grasslands • Closed forests • Lakes, lakeshores, and rivers • Other	3 3 3 3 3 3 2
8	Population density	What is the local abundance of the species?	• Species occurs as widely scattered individuals • Species forms occasionally patches of high density • Species forms large and dense monocultures	0 2 4

By eliminating or changing some of the criteria from the risk assessment scheme, additional criteria were used in place from the second work (MAGEE et al. 2010) (Tab. 2).

According to the authors, the species receives the sum of points corresponding to the number of criteria for which a positive response is given.

Tab. 2. Criteria of invasiveness risk assessment (based on the scheme of MAGEE et al. 2010).

No	Life history	Ecological amplitude	Ecosystem alteration
1	Strongly clonal — perennials able to spread aggressively via features such as rhizomes, tillers, or stolons	Drought tolerant—described as drought or xeric adapted, growing in dry soil or in rangeland habitat; or growing where annual Precipitation <500 mm	Alters hydrology—changes flooding patterns; raises or lowers water table or surface water levels; changes seasonal availability of water in rooting zone
2	Large propagule crop—1,000 seeds/plant or 1,000 seeds/m^2, classified as prolific or highseed producers	Wide moisture regime—described as growing in conditions that range from xeric to saturated, xeric to mesic, or mesic to saturated	Alters nutrient cycling—depletes or adds nutrients, alters nutrient cycling patterns
3	Small seeds/fruits - <5 mm in longest dimension	Flooding/saturation tolerant—described as growing in wet conditions, or adapted to intermittent flooding	Alters fire regime—increases or decreases fire frequency, intensity, or fire type; changes fuel-loading patterns
4	Wind dispersal—presence of specialized structures or traits that facilitate movement in wind, and observation of movement in wind	Wide nutrient or soil texture ranges—described as growing on a wide range of soil types, or across low to high nutrient ranges	Alters soil stability—either facilitates erosion or enhances stability
5	Animal dispersal—presence of specialized structures or traits that facilitate attachment, survives consumption and excretion by animals	Wide light regime—described as shade tolerant or able to grow under multiple light conditions, e.g., from bright sun to partial or deep shade	Excretes salts or toxins—produces salts or toxins that are known or suspected to alter soil chemistry or act as allelopathic compounds

Tab. 2. – cont.

No	Life history	Ecological amplitude	Ecosystem alteration
6	Water dispersal—observation of floating or long distance water dispersal or seed or plant fragments	Alkaline or saline tolerant—documented as salt tolerant, or growing in alkaline soils, saline soils, or coastal habitats	Forms monocultures or near-monocultures—forms dense patches, excludes other species
7	Specialized dispersal—unique dispersal traits such as explosive dehiscence, tumbling of seed laden dead plants	Grazing tolerant or increaser—documented as resilient to direct grazing impacts; increases with grazing due to low palatability, to toxicity, or release from competition	Invades in absence of human disturbance—able to establish and spread into relatively intact natural vegetation
8	Dispersal over time—Persistent seed bank, long seed life, staggered germination, staggered dispersal from inflorescence	Increases post-fire—able to expand aerial coverage and biomass following fire events	
9	Plasticity—high morphological, phenological, or genetic variability		

The criteria of Tab. 2 were grouped and by their number the score for the risk assessment was determined (Tab. 3).

Tab. 3. Counting scheme of points from different criterias of risk assessment.

No	Criteria / points	1	2	3	4
1	For Life history:	1, 2	3, 4	5, 6	7, 8, 9
2	For Ecological amplitude:	1, 2	3, 4	5, 6	7, 8
3	For Ecosystem alteration:	1	2, 3	4, 5	6, 7

In general, the number of points for each species was determined by the sum of the two schemes.

RA (Risk Assessment) = Score 1 + Score 2,

Where "Score 1" refers to points received according to WEBER & GUT (2004) scheme (Tab. 1); "Score 2" refers to points received according to MAGEE et al. (2010) scheme (Tab. 2).

Using these criteria we assessed 153 species of the most ornamental woody plants, currently used and proposed for use in landscape architecture and gardening of settlements in different regions of Armenia (VARDANYAN et al. 2015). It has to be noticed, that among them were the species already known in Armenia as invasive and expanding species (FAYVUSH & TAMANYAN 2014).

Results and discussion

According to the presented schemes and criteria, we have evaluated all selected 153 species. Among them there were 62 native (including possible archaeophytes) and 91 introduced species of plants (Tab. 4 and Tab. 5).

Tab. 4. Invasiveness risk assessment of native woody plant species

No	Native species or archaephytes	Sum of points
1	*Rubus armeniacus* Focke	34
2	*Rubus idaeus* L.	33
3	*Amygdalus fenzliana* (Fritsch) Lipsky	30
4	*Paliurus spina-christi* Mill.	30
5	*Salix caprea* L.	30
6	*Halimodendron halodendron* (Pall.) Woss	29
7	*Clematis orientalis* L.	29
8	*Corylus avellana* L.	28
9	*Elaeagnus angustifolia* L.	28
10	*Fagus orientalis* Lipsky	28
11	*Jasminum fruticans* L.	28
12	*Punica granatum* L.	28
13	*Tamarix ramosissima* Ledeb.	28
14	*Hippophae rhamnoides* L.	27
15	*Pinus hamata* (Stev.) Sosn.	27
16	*Pyrus salicifolia* Pall.	27
17	*Salix alba* L.	27
18	*Tilia cordata* Mill	27
19	*Cotinus coggygria* Scop.	26
20	*Platanus orientalis* L.	26
21	*Viburnum lantana* L.	26
22	*Berberis vulgaris* L.	25
23	*Betula litwinowii* Doluch.	25
24	*Cotoneaster integerrimus* Medik.	25
25	*Juniperus polycarpos* K.Koch	25
26	*Periploca graeca* L.	25
27	*Quercus macranthera* Fisch. et C.A.Mey. ex Hohen.	25
28	*Sambucus nigra* L.	25
29	*Cornus mas* L.	24
30	*Crataegus monogyna* Jacq.	24
31	*Hedera helix* L.	24
32	*Ligustrum vulgare* L.	24
33	*Taxus baccata* L.	24
34	*Viburnum opulus* L.	24
35	*Amelanchier ovalis* Medik.	23
36	*Cercis griffithii* Boiss.	23
37	*Corylus colurna* L.	23
38	*Euonymus europaeus* L.	23
39	*Sorbus torminalis* (L.) Crantz	23
40	*Lonicera caprifolium* L.	23
41	*Philadelphus caucasicus* Koehne	23
42	*Populus euphratica* Olivier	23
43	*Populus gracilis* Grossh.	23
44	*Pyrus caucasica* Fed.	23
45	*Quercus iberica* Stev.	23
46	*Fraxinus excelsior* L.	22
47	*Diospyros lotus* L.	22
48	*Tilia caucasica* Rupr.	22
49	*Juniperus sabina* L.	21
50	*Ulmus foliacea* Gilib.	21
51	*Rosa hemisphaerica* Herrm.	21
52	*Acer platanoides* L.	21
53	*Juniperus foetidissima* Willd.	21
54	*Padus avium* Mill.	21
55	*Sorbus aucuparia* L.	20
56	*Sambucus tigranii* Troitzk	20
57	*Euonymus latifolia* (L.) Mill.	20
58	*Celtis caucasica* Willd.	19
59	*Staphylea pinnata* L.	18
60	*Sorbus hajastana* Gabrielian	18
61	*Grossularia reclinata* (L.) Mill.	18
62	*Sorbus dualis* Zinserl.	17

Obviously, the sum of scores of 25 or more indicates a high risk of invasion, the sum of 17-24 - indicates an average risk, and less than 17 points - most likely indicates minimal risk or lack thereof (Fig. 1).

An interesting fact is that the invasive potential is more pronounced in native species. Almost 100% of the species in this group have a high or medium invasive potential, and in the introduced species 22% have a rather low potential. In the first case, such a high percentage can be explained by the high adaptability to the natural conditions and different habitats of Armenia. A significant number of species with a low invasive potential among the introduced species can be the result of different factors (for example, recent drift, not successful adaptation, etc.). These species need further research and, despite the level of invasiveness, monitoring of the dynamics of their distribution should be carried out in the future.

Tab. 5. Invasiveness risk assessment of introduced woody plant species

No	Introduced species or neophytes	Sum of points
1	*Ailanthus altissima* (Mill.) Swingle	33
2	*Robinia pseudoacacia* L.	32
3	*Acer negundo* L.	29
4	*Caragana arborescens* Lam.	28
5	*Salix babylonica* L.	28
6	*Syringa vulgaris* L.	28
7	*Gleditsia triacanthos* L.	27
8	*Robinia viscosa* Vent.	27
9	*Clematis vitalba* L.	26
10	*Syringa persica* L.	26
11	*Spiraea japonica* L.f.	25
12	*Campsis radicans* (L.) Seem.	24
13	*Spiraea chamaedryfolia* L.	24
14	*Spiraea x vanhouttei* (Briot) Zabel	24
15	*Cercis siliquastrum* L.	23
16	*Euonymus japonicus* Thunb.	23
17	*Parthenocissus quinquefolia* (L.) Planche	23
18	*Platanus acerifolia* Willd.	23
19	*Populus alba* L. (*introduced as Populus bolleana* Lauche)	23
20	*Spiraea douglasii* Hook.	23
21	*Thuja occidentalis* L.	23
22	*Amorpha fruticosa* L.	22
23	*Cornus alba* L.	22
24	*Deutzia scabra* Thunb.	22
25	*Hibiscus syriacus* L.	22
26	*Juglans nigra* L.	22
27	*Laburnum anagyroides* Medic.	22
28	*Parthenocissus tricuspidata* (Siebold. et Zucc.) Planche	22
29	*Picea abies* (L.) Farst.	22
30	*Pinus strobus* L.	22
31	*Ribes nigrum* L.	22
32	*Vitex agnus-castus* L.	22
33	*Weigela floribunda* (Sieb. et Zucc.) K.Koch	22
34	*Ampelopsis aconitifolia* Bunge	21
35	*Berberis julianae* C. K. Schneid.	21
36	*Buddleja davidii* Franch.	21
37	*Crataegus macracantha* Lodd. ex Loud.	21
38	*Forsythia* x *intermedia* Zab.	21
39	*Juniperus chinensis* L.	21
40	*Pyracantha coccinea* (L.) M.Roem.	21
41	*Ribes rubrum* L.	21
42	*Styphnolobium japonicum* (L.) Schott (=*Sophora japonica* L.)	21
43	*Symphoricarpos albus* (L.) S. F. Blake	21
44	*Symphoricarpos orbiculatus* Moench.	21
45	*Syringa* x *chinensis* Willd.	21
46	*Syringa josikaea* J. Jacq.	21
47	*Cupressus arizonica* Greene	20
48	*Acer palmatum* Thunb.	20
49	*Acer pseudoplatanus* L.	20
50	*Acer tataricum* L.	20
51	*Cedrus deodara* (Roxb. ex D. Don) G. Don	20
52	*Chaenomeles japonica* (Thunb.) Lindl. ex Spach	20
53	*Cryptomeria japonica* (L.f.) D.Don	20
54	*Weigela florida* (Bunge) A.DC.	20
55	*Forsythia suspensa* (Thunb.) Vahl	20
56	*Magnolia wilsonii* (Finet et Gagnet) Rehder	20
57	*Metasequoia glyptostroboides* Hu et Cheng	20
58	*Juglans mandshurica* Maxim.	20
59	*Parrotia persica* C.A.Mey.	20
60	*Vitis amurensis* Rupr.	20
61	*Quercus castaneifolia* C.A.Mey.	19
62	*Aesculus hippocastanum* L.	19
63	*Chamaecyparis lawsoniana* (A.Murr.) Parl.	19
64	*Cotoneaster horizontalis* Decne.	19
65	*Cupressus sempervirens* L.	19
66	*Maclura pomifera* (Raf.) C. K. Schneid.	19
67	*Picea pungens* Engelm.	19
68	*Berberis aquifolium* Pursh	18
69	*Aristolochia manshuriensis* Kom.	18
70	*Liriodendron tulipifera* L.	18
71	*Lonicera japonica* Thunb.	18
72	*Lonicera maackii* Rupr.	18
73	*Wisteria sinensis* (Sims) Sweet	17
74	*Buxus sempervirens* L.	17
75	*Fraxinus pennsylvanica* March.	17
76	*Juniperus virginiana* L.	17
77	*Koelreuteria paniculata* Laxm.	16
78	*Albizia julibrissin* Durazz.	16
79	*Buxus balearica* Lam.	16
80	*Catalpa bignonioides* Walt.	15
81	*Catalpa ovata* G. Don	15
82	*Fraxinus ornus* L.	15
83	*Lonicera flava* Sims	15
84	*Ribes aureum* Pursh	15
85	*Yucca filamentosa* L.	15
86	*Pinus pallasiana* D.Don	14
87	*Cercis canadensis* L.	13
88	*Diospyros kaki* L. f.	13
89	*Platycladus orientalis* (L.) Franco (=*Biota orientalis*)	12
90	*Pistacia vera* L.	12
91	*Quercus robur* L.	12

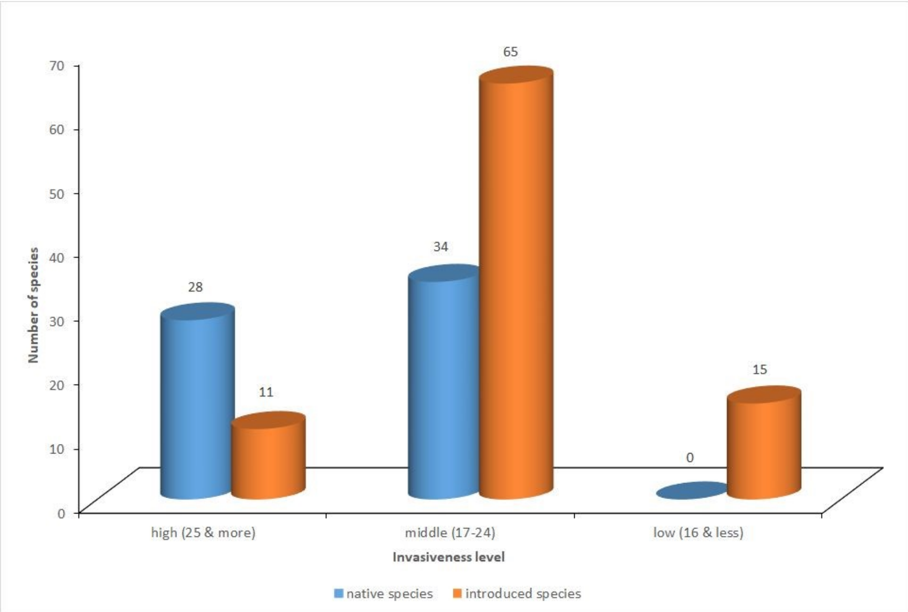

Fig. 1. Distribution of investigated woody species to different invasiveness levels.

Analysis of the obtained data on risk assessment of native species shows that species already have been registered as expanding in Armenia (*Rubus armeniacus, Rubus idaeus, Clematis orientalis*) and registered as an invasive species in most of the temperate world (FAYVUSH & TAMANYAN 2014) are located at the top of ranking list. These are the species with the largest invasive potential, and/or species, which are the dominants of different plant communities. At the bottom of this ranking list, are rare species confined to one or two plant communities and playing not significant, dominant role. This confirms the significant objectivity of our new joint scheme of invasiveness risk assessment for woody plants of Armenia. Obviously, considering the ecological features of the assessed species, 25 or more points scored indicate a high invasive potential of these species.

During assessment of introduced species, the following picture emerged: the first three places in the ranking list (Tab. 5) are occupied by the species *Ailanthus altissima, Robinia pseudoacacia* and *Acer negundo* (Tab. 5), species that we have already marked as invasive species in Armenia and that are well known as being invasive in many other countries (FAYVUSH & TAMANYAN 2014; KLEINBAUER et al. 2010). The next 7 places are occupied by species that are not yet registered as invasive in Armenia, but for some of themare recorded cases of self-reproduction, escaping from culture and growing in disturbed habitats (*Caragana arborescens, Salix babylonica, Gleditsia triacanthos, Spiraea japonica*). Three other species (*Syringa vulgaris, Robinia viscosa, Syringa persica*) have a very wide ecological amplitude, can be found in different regions and altitudinal belts of Armenia, therefore these species theoretically can escape from culture and become invasive. .

On the other hand, several species (*Buddleja davidii, Hibiscus syriacus, Amorpha fruticosa*), located in the middle part of the table (the sum of scores is less than 25), can be found on disturbed habitats near their typical habitats.This means that most likely, we do not know all ecological features of these species, and as a result, they did not receive enough points in assessment, although they behave as more aggressive, invasive species.

Conclusion

The distribution of invasive and expanding plant species in natural ecosystems can significantly change the biological diversity of native flora, and underestimation of this fact can lead to irreversible environmental consequences.

Currently, the field of risk assessment for invasive potential of species is in its infancy, but has a great importance for species introductions and wide use in landscape architecture, afforestation and gardening, even in horticulture.

The study of invasive species is a field with a great need for synthesis, with big opportunities for theoretical development, and for direct contribution of those developments to management methodology.

Based on the results of invasiveness risk assessment of 153 species of ornamental woody plants (native and introduced) according to the adapted scheme and criteria, the level of invasive potential for each species was specified. The obtained results are good basis for further use of assessed species for different purposes, as well as for focusing scientific work on monitoring of population dynamics, development of quarantine control, elaboration of different guidelines for quarantine service, etc. Special attention should be given to their distribution under the impact of climate change. We propose to use developed methodology of assessment for new species introduction, testing of growing in different conditions of Armenia or for selection of new species or forms for landscape architecture and gardening.

This scheme can also be used, with small additions, for assessing herbaceous plants. The experience of carrying out this type of work can be useful for neighboring countries, where the problems of invasive and expanding species are also acute, and the necessary amount of data, studies and methods for assessing invasive and expanding species are lacking.

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