Біологічний вісник МДПУ імені Богдана Хмельницького 6 (3), стор. 430–437, 2016
Biological Bulletin of Bogdan Chmelnitskiy Melitopol State Pedagogical University, 6 (3), pp. 430–437, 2016

ARTICLE ***UDK 581.524.34***

ADVENTIVE TREE SPECIES IN URBAN FLORA OF ROSTOV-ON-DON

B.L. Kozlovsky, M.V. Kuropyatnikov, O.I. Fedorinova, M.M. Sereda,
O.A. Kapralova, P.A. Dmitriev, T.V. Varduni
Southern Federal University, Rostov-on-Don
E-mail: pressreal@gmail.com

We presented the results of study of the adventive tree species in urban flora of Rostov-on-Don (Russia). The taxonomic and typological structure of these species was determined and their ecological properties were investigated. We identified 147 species of woody adventive plants in urban flora of Rostov-on-Don. From species diversity the families Rosaceae Juss. (55 speceis), Fabaceae Lindl. (29), Caprifoleaceae Juss. (8), Oleaceae Lindl. (7), Hydrangeaceae (5), Ranunculaceae (5) and Vitaceae (5) are the dominants. In order to prevent the growth of the diversity of woody ergaziophytes species it is necessary to consider not only their ecological and biological properties, but also the regional economic value and importance. The species of *Amorpha*, *Clematis*, *Colutea*, *Crataegus*, *Swida* are potentially dangerous and should be excluded from the introduction scope. It is necessary to withdraw the species that have a set of properties suitable for naturalization, but have no economic or scientific interest from the collections of the Botanical Garden. In this regard, the collecting of sterile samples and plant forms could be extremely important. Special attention should be paid to the selection of the plant sets in small towns and rural areas, which are the places of spreading of the adventive plants and are similar to natural coenosises.
Key words: urban flora, adventive species, woody plants, plant introduction, ergaziophytes.

АДВЕНТИВНЫЕ ВИДЫ ДРЕВЕСНЫХ РАСТЕНИЙ УРБАНОФЛОРЫ РОСТОВА-НА-ДОНУ

Б.Л. Козловский, М.В. Куропятников, О.И. Федоринова, М.М. Середа,
О.А. Капралова, П.А. Дмитриев, Т.В. Вардуни
Южный федеральный университет, Россия, г. Ростов-на-Дону
E-mail: pressreal@gmail.com

Приведены результаты изучения адвентивных древесных растений урбанофлоры Ростова-на-Дону, Россия. Определен таксономический и типологический состав адвентивных видов флоры, а также изучены их эколого-биологические свойства. В урбанофлоре Ростова-на-Дону выявлено 147 видов адвентивных древесных растений. В таксономическом спектре лидируют семейства Rosaceae Juss. (55), Fabaceae Lindl. (29), Caprifoleaceae Juss. (8), Oleaceae Lindl. (7), Hydrangeaceae (5), Ranunculaceae (5) и Vitaceae (5). Приводятся списки агриофитов и эпекофитов. Предлагается изъять из коллекций Ботанического сада образцы видов, обладающих комплексом свойств, способствующим их натурализации, при этом не представляющих хозяйственного или научного интереса.
Ключевые слова: урбанофлора, адвентивные виды, древесные растения, интродукция растений, эргазиофиты.

Citation:
Kozlovsky, B.L., Kuropyatnikov, M.V., Fedorinova, O.I., Sereda, M.M., Kapralova, O.A., Dmitriev, P.A., Varduni, T.V. (2016). Adventive tree species in urban flora of Rostov-on-Don. *Biological Bulletin of Bogdan Chmelnitskiy Melitopol State Pedagogical University,* 6 (3), 430–437.
Поступило в редакцию / Submitted: 23.11.2016
Принято к публикации / Accepted: 22.12.2016
crossref http://dx.doi.org/10.15421/2016114

INTRODUCTION

Landscape gardening of settlements and sites in the steppe zone of Russia, including the Rostov region, is impossible without using the adventive species of woody plants. At the same time, the increase of species diversity of cultivated exotic plants not only contributes to the solution of problems of human settlements improvement, but also stimulates the process of invasion, carrying a threat to the biological diversity of local flora and vegetation. This is a significant environmental problem for many regions (Vasileva and Petrik, 2000; Fedyaeva, 1994; Majora and Noskoa, 2013; Godefroid and Koedam, 2003; Alvey, 2006; Breuste, 2013; Sjöman et al., 2012; Richardson et al., 2000). Rostov-on-Don is the main source of adventive tree species in the Rostov region (Fig. 1). This process is provided by expanding of adventive species area and self-resettlement of adventive species in urban floras of Rostov-on-Don outside the city. It should be noted that the penetration of adventive species of woody plants from cultured to natural phytocoenosis of the Rostov region is predominantly occurred through urban and rural flora. All such naturalized exotic species are cultivated plants, running wild (ergaziophytes). Taking into consideration that the naturalization of exotic wood species in the steppe zone may radically change the face of natural grass communities, a comprehensive study of urban flora tree species of Rostov-on-Don seems to be actual as a starting point for monitoring of invasion of adventive species.

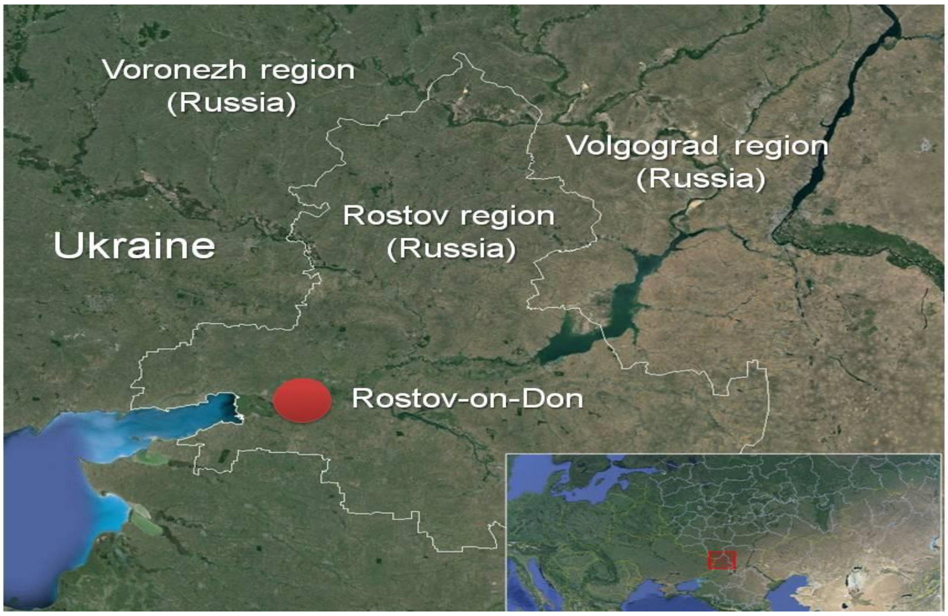

Figure 1: Map of study area.

The aim of our research was to study the process of naturalization of adventive species tree species in the city of Rostov-on-Don. The study tasks were: studying the taxonomic and typological structure of urban floras adventive tree species; studying the ecological properties of exotic wood species, which contribute to their naturalization; select adventive species with a high potential for naturalization in natural communities from urban flora.

METHODS

This research was being conducted since 1998 (Kozlovsky and Ogorodnikov, 1998). Alien species, which form self-reproducing (non-artificial) populations, were identified as adventive species of urban flora. The survey of major ecotops (Ilminsky, 1988) and the functional areas (Privalenko and Bezuglova, 2003) of the city was performed during the study. The following city objects have been surveyed: parks and gardens (selectively, the total area of 184.7 ha); city cemetery (selectively, the total area of 360 ha); railway embankment and adjacent territory (within 7 km); urban forests (selectively, the total area of 3440 ha); Botanical Garden of SFU (totally, total area of 160 ha); forest parks (selectively, the total area of 2 720 hectares); streets within residential areas (the studied length of about 20 km). Special attention was paid to the inspection of the SFU Botanical Garden, which is the center of introduction of woody exotic species in the Rostov region whose number in plantations is approximately 900 species (Kozlovsky and Pokhil'ko, 2006). Its territory covers almost the entire spectrum of mesorelief diversity, hydrological and soil conditions, vegetation diversity that is typical for the city in general. Therefore, the Botanical Garden can be considered as a test area for studying the process of naturalization of adventive species.

A classification of A.V. Chichev (Chichev, 1981) with regards to Schroeder (1969) and Pysek et al. (2004) was used to determine the extent of naturalization. It includes species that continuously remain in invasion area, but not spreading out – kolonophytes (naturalized plants); species which actively spreading over the artificial (including degraded, secondary) habitats – epekophytes (invasive plants); species which were introduced in natural communities – agriophytes (transformes). Agriophytes, as well as epekophytes, actively settle in artificial and degraded communities.

By definition, the species, the seedlings of which are located within the projection of crowns of cultivated parent species and all species of vegetatively mobile plants should be classified to kolonophytes. In regard to the exotic species cultivated in the SFU Botanical Garden, there are 481 such species in the city flora (Kozlovsky et al., 2000). Their ecological role in the urbosystem is weak and the chance of spreading beyond the plantations is low. Therefore, we didn't include woody kolonophytes in the composition of urban floras of Rostov-on-Don. Species obligately connected with fissural ecotopes (ecotopes related to fissures of rocks) of alien species (genus: Populus, Betula, Spreaea, Sorbus), since they are not able to grow inside them in for a long time (Pokhil'ko at al., 2006).

A.Y. Ogorodnikov scale (Ogo, 1993) was used to evaluate winter hardiness, drought tolerance, resistance to diseases and pests, as well as reproductive capacity. Plant properties were evaluated by the following scale points.

Winter hardiness: 1 point - plants are not winter-hardy: frosted as far as to the surface of soil or snow (often become being vegetated just before the freezing) and poorly repaired at that; 2 points - poorly winter-hardy: one- and two-year shoots and flower buds are regularly frozen over or dried up, during the cold winter as far as to the surface of the soil or snow; restored, and may bloom occasionally; 3 points - medium winter-hardy: part of the annual growth and flower buds are frozen over occasionally or skeletal branches get damaged, but are well restored and able to flower and fruit; 4 points - winter-hardy: only the tops of some shoots or, in addition, some part of the flower buds are getting damaged during harsh winters; 5 points – highly winter-hardy: no damage.

Drought resistance scale: 1 point – plants are not drought-resistant: the growth is inhibited under influence of drought, leaves and shoots are dried up, growing only under irrigation they are suffering under air drought and high temperatures; 2 points - poorly drought-resistant plants: poor growth: leafs are burned; these plants have underdeveloped kidneys and seeds and needed regular watering; 3 points - medium drought-resistant plants: developed satisfactorily in normal years, drought years the rhythm of growth is changed, leaves are getting partly damaged, periodic watering is needed in drought years; 4 points - drought-resistant plants: growing and developing well without irrigation, sustained under drought without damage of overground organs, premature shedding of leaves is possible, normally developed buds and seeds under drought; these plants growing well and are in bloom at the next year after drought; 5 points – highly drought-resistant: developed successfully without irrigation, including on very dry and warmed soils.

Resistance to diseases and pests scale: 1 point - frequent and very severe damage of the most part of the plant; depressed growth and development; 2 points - severe periodic injuries which significantly weaken~~ing~~ growth and development; 3 points - average periodic injuries, usually covering vegetative organs; 4 points - weak damages covering no more than one fourth of the plant in a small part of species that do not affect significantly to development; 5 points - damages are sporadic or missing.

Seed reproduction scale: 1 point - plants do not bloom, reaching adulthood; 2 points - plants bloom poorly, do not fruit, or the seeds are infertile; 3 points - plants moderately bloom, but the number of seeds is small, or with low germination. Such plants have vegetative reproduction, at that; 4 points - plants flower and fruit well, sometimes profusely, seeds are of high germination, but they do not self-seed under rainfed conditions; 5 points - plants fruit abundantly and regularly, they self-seed in areas without irrigation.

Observations of plants have been conducted no less than for 12 years. The classification of life forms is given by the system proposed by G.N. Zozulin (Zozulin, 1996), where: restative species - perennials, renewable via the dormant buds. This allows them to keep the territory of their habitat in spite of the destruction of their above-ground parts; irrumptive species - perennials renewable after destruction of the above-ground part. They have underground or above-ground organs for vegetative reproduction. They form colonies and constantly expand their habitat area displacing other species.

RESULTS AND DISCUSSION

147 adventive tree species were found as a part of the urban flora of Rostov-on-Don, which belong to the 49 genus of 27 families. In taxonomic spectrum, the leaders are the families of Rosaceae Juss. (55), Fabaceae Lindl. (29), Caprifoleaceae Juss. (8), Oleaceae Lindl. (7), Hydrangeaceae (5), Ra-nunculaceae (5) and Vitaceae (5). All of them are ergaziophytes in terms of the way of introduction – i.e. a species introduced into the culture at a given territory, and then spreading on the anthropogenic and natural habitats.

Analysis of the detected species was provided in accordance to the degree of naturalization and showed that there are 29 agriophytes among the adventives species of urban floras of Rostov-on-Don: *Acer negundo* L., *Acer pseudoplatanus* L., *Ailanthus altissima* (Mill.) Swingle, *Amorpha fruticosa* L., *Armeniaca vulgaris* Lam., *Caragana arborescens* Lam., *Celtis occidentalis* L., *Cerasus mahaleb* (L.) Mill., *Cerasus vulgaris* Mill., *Cotinus coggygria* Scop., *Elaeagnus angustifolia* L., *Fraxinus americana* L., *Fraxinus angustifolia* Vahl, *Fraxinus pennsylvanica* Marshall, *Gleditsia triacanthos* L., *Halimodendron halodendron* (Pall.) Voss, *Juglans regia* L., *Lonicera tatarica* L., *Lonicera xylosteum* L., *Lycium barbarum* L., *Malus domestica* Borkh., *Morus alba* L., *Parthenocissus quinquefolia* (L.) Planch. ex C. DC., *Populus deltoides* Bartl. ex Marshall, *Prunus cerasifera* Ehrh., *Ptelea trifoliata* L., *Ribes aureum* Pursh, *Robinia pseudoacacia* L., *Syringa vulgaris* L. These species were found previously (Kozlovsky and Pokhil'ko, 2006) in the floodplain ravine forests, and as a part of floodplain meadow vegetation. Among them there are 9 species (ubiquists) which are finding in ecotopes of the city; – *Acer negundo* L., *Ailanthus altissima* (Mill.) Swingle, *Armeniaca vulgaris* Lam., *Fraxinus americana* L., *Fraxinus angustifolia* Vahl, *Fraxinus pennsylvanica* Marshall, *Morus alba* L., *Parthenocissus quinquefolia* (L.) Planch. ex C. DC., *Robinia pseudoacacia* L.

Epekophytes are presented with 118 species. Most of them are cultivated within the city and Botanical Garden. Therefore, it is likely that in the case of a wider cultivation in the region and their penetration into the relevant environmental phytocenoses these species would be referred as agriophyres. They are: *Acer ginnala* Maxim., *Acer pseudoplatanus 'Purpureum', Aesculus hippocastanum* L., *Amorpha canescens* Pursh, *Amorpha glabra* (Pers.) Poir., *Amorpha paniculata* Torr. & A. Gray, *Ampelopsis aconitifolia* Bunge, *Ampelopsis brevipedunculata* (Maxim.) Trautv., *Berberis nummularia* Bunge, *Berberis vulgaris 'Atropurpurea', Caragana aurantiaca* Koehne, *Caragana boisii* C. K. Schneid., *Caragana decorticans* Hemsl., *Caragana densa* Kom., *Caragana tragacanthoides* (Pall.) Poir., *Catalpa speciosa* (Warder ex Barney) Warder ex Engelm., *Celastrus orbiculatus* Thunb., *Celastrus scandens* L., *Celtis australis* L., *Celtis tenuifolia* Nutt., *Cerasus tomentosa* (Thunb.) Wall. ex T. T. Yu & C. L. Li, *Clematis brevicaudata* DC., *Clematis orientalis* L., *Clematis serratifolia* Rehder, *Clematis vitalba* L., *Clematis viticella* L., *Colutea × media* Willd., *Colutea arborescens* L., *Colutea istria* Mill., *Colutea orientalis* Mill., *Colutea persica* Boiss., *Cotoneaster acuminatus* Wall. ex Lindl., *Cotoneaster acutifolius* Turcz., *Cotoneaster bullatus* Bois, *Cotoneaster bullatus var. floribundus* (Stapf) L. T. Lu & Brach, *Cotoneaster dielsianus* E. Pritz. ex Diels, *Cotoneaster divaricatus* Rehder & E. H. Wilson, *Cotoneaster foveolatus* Rehder & E. H. Wilson, *Cotoneaster harrysmithii* Flinck & B. Hylmö, *Cotoneaster hebephyllus* Diels, *Cotoneaster kitaibelii* J. Fryer & B. Hylmö, *Cotoneaster laxiflorus* Jacq. ex Lindl., *Cotoneaster lucidus* Schltdl., *Cotoneaster megalocarpus* M. Pop., *Cotoneaster moupinensis* Franch., *Cotoneaster multiflorus* Bunge, *Cotoneaster nitens* Rehder & E. H. Wilson, *Cotoneaster nitidus* Jacques *var. nitidus, Cotoneaster pekinensis* (Koehne) Zabel, *Cotoneaster rehderi* Pojark., *Cotoneaster roborowskii* Pojark., *Cotoneaster roseus* Edgew., *Cotoneaster wilsonii* Nakai, *Cotoneaster zabeli* C. K. Schneid., *Crataegus × dsungarica* Zabel ex Lange, *Crataegus × tianschanica* Pojark., *Crataegus anomala* Sarg., *Crataegus arnoldiana* Sarg., *Crataegus canadensis* Sarg., *Crataegus engelmannii* Sarg., *Crataegus fecunda* Sarg., *Crataegus ferganensis* Pojark., *Crataegus flabellata* (Bosc ex Spach) K. Koch, *Crataegus hissarica* Pojark., *Crataegus mollis* (Torr. & A. Gray) Scheele, *Crataegus nitida* (Engelm. ex Britton & N. E. Br.) Sarg., *Crataegus pringlei* Sarg., *Crataegus songarica* K. Koch, *Crataegus stevenii* Pojark., *Crataegus submollis* Sarg., *Crataegus turcomanica* Pojark., *Crataegus turkestanica* Pojark., *Crataegus wattiana* Hemsl. & Lace, *Cytisus elongatus* Waldst. & Kit., *Cytisus hirsutus* L., *Cytisus lindemanii* V. I. Krecz., *Cytisus podolicus* Błocki, *Cytisus ratisbonensis* Schaeff., *Elaeagnus umbellata* Thunb., *Flueggea suffruticosa* (Pall.) Baill., *Fontanesia fortunei* Carrière, *Fraxinus ornus* L., *Fraxinus oxycarpa* Willd., *Genista florida* L., *Genista patula* M. Bieb., *Genista tinctoria* L., *Gleditsia triacanthos var. inermis* (L.) Castigl., *Lembotropis nigricans* (L.) Griseb., *Lonicera chrysantha* Turcz. ex Ledeb., *Lonicera demissa* Rehder, *Lonicera korolkowii* Stapf, *Lonicera maackii* (Rupr.) Maxim., *Lonicera morrowii* A. Gray, *Lycium dasystemum* Pojark., *Lycium flexicaule* Pojark., *Mespilus germanica* L., *Padus asiatica* Kom., *Padus virginiana* (L.) Mill., *Philadelphus × lemoinei* Lemoine, *Philadelphus californicus* Benth., *Philadelphus incanus* Koehne, *Philadelphus inodorus* L., *Philadelphus pubescens* Loisel., *Physocarpus opulifolius* (L.) Maxim., *Physocarpus opulifolius 'Luteus', Prunus domestica* L., *Pyrus elaeagnifolia* Pall., *Rhamnus davurica* Pall., *Rhamnus tinctoria* Waldst. & Kit., *Robinia luxurians* (Dieck) Rydb., *Swida alba* (L.) Opiz, *Swida meyeri* (Pojark.) Soják, *Symphoricarpos albus* (L.) S. F. Blake, *Ulmus androssowii* Litv., *Ulmus pumila* L., *Viburnum lantana* L., *Vitis labrusca* L., *Vitis vinifera* L.

In terms of the time period of introduction there are 146 neophytes and 1 arhiophyte (*Elaeagnus angustifolia* L.) among woody ergaziophytes. Shrubs dominate in the biomorphological spectrum of adventive species (96 species) followed by the trees (49 species). Woody and semi-woody lianes are represented by 12 species. There are 112 restative species and 35 irrumptive among adventive species. Urban flora is mostly represented by the North American, East Asian, Central Asian and European exotes. Species of woody plants originated from more southerly areas dominates in the flora of Rostov-on-Don. That is due to their higher drought resistance as compared with other species. Moreover, mesophytes dominate among the tree species of Rostov-on-Don urban flora - 150 species and xeromesophytes are represented with only 4 species. Oligothrophes have a high proportion (42%) whereas megatrophes are almost not presented in terms of soil fertility. The way of spreading of diasporas and the presence of agents of their spreading in new conditions are of great importance for the settlement of adventive species.

There are the largest number of species of zoochores – 88; anemochores - 40 and the minimal number of ballistas – 15 represented in the composition of the urban flora as well as anthropochores – 2 species and barachore – 1 species. Zoochores spread over long distances, but their self-seeding density is low. Anemochore seeds are carried over shorter distances, however, the number of their seedlings in some areas can reach 20000 pieces per 1 hectare. Among adventives species of urban flora the plants with physiological, physical and combined types of seed dormancy dominate as it provides zoochory and prevents germination in fall in spring. There are only 4% species that have no seed dormancy. Weight of seeds is usually directly related to the speed of growth and size of seedlings and is inversely related to their spreading range. Analysis of the distribution of zoochores and anemochores by weight of seeds showed that the optimal weight of 1000 for the seeds of the first type is in the range from 5 to 35 g, the second ones - from 3 to 15 g.

We picked out from epekophytes a group of species that have a potential to eventually become agriophytes (potential agriophytes). They actively settle outside the places of the primary introduction, have the highest or high rate of winter hardiness, drought tolerance, resistance to diseases and pests, producing a large number of high-grade seeds (spread by wind or animals). These species are presented in the form of annotated list, which consistently indicate: homeland, life form, the size in the point of study, winter hardiness, drought tolerance, disease resistance and pests, seed reproduction, durability, skid terms, the way of seed spread, the type of seed dormancy:

Acer ginnala Maxim. - Far East, North-Eastern China, Korea. Tree bushy type. Restativny. Up to 6 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 40–45 years Neophyte. Anemochory. Seed dormancy - physiological.

Amorpha canescens Pursh - North America. Bush. Irrumptive. Up to 1 m. Winter-hardiness 4, drought resistance 5, resistance to pests and diseases 4, seed production 5. Durability 20–25 years Neophyte. Hydrochory. Seeds dormancy – missing.

Amorpha glabra (Pers.) Poir. - North America. Bush. Irrumptive. Up to 2 m. Winter-hardiness 4, drought resistance 5, resistance to pests and diseases 4, seed production 5. Durability 30 years. Neophyte. Hydrochory. Seeds dormancy – missing.

Amorpha paniculata Torr. & A. Gray - North America. Bush. Irrumptive. Up to 4 m. Winter-hardiness 4, drought resistance 5, resistance to pests and diseases 4, seed production 5. Durability 25–30 years Neophyte. Hydrochory. Seeds dormancy – missing.

Celastrus orbiculata Thunb. - Far East, Japan, China. Liana-shaped bush. Irrumptive. Up to 7 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 5, seed production 5. Durability 30–35 years Neophyte. Zoochory. Seeds dormancy – physiological.

Celastrus scandens L. - North America. Liana-shaped bush. Irrumptive. Up to 6 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 5, seed production 5. Durability 30–35 years Neophyte. Zoochory. Seeds dormancy –physiological.

Celtis australis L. – Caucasus, North Afghanistan, Middle Asia. Forest-type tree. Restative. Up to 15 m. Winter-hardiness 5, drought resistance 5, resistance to pests and diseases 4, seed production 5. Durability 70–75 years. Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Celtis tenuifolia Nutt. – North America.Forest-type tree. Restative. Up to 15 m. Winter-hardiness 5, drought resistance 5, resistance to pests and diseases 4, seed production 5. Durability 70–75 years. Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Clematis vitalba L. – Europe, Caucasus. Liana-shaped bush. Restative. Up to 10 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 5, seed production 5. Durability 35–40 years Neophyte. Anemochory. Seeds dormancy – morphological and physiological.

Colutea arborescens L. –Asia Minor. Bush. – South Europe, North Africa. Restative. Up to 2 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 3, seed production 5. Durability 20–25 years Neophyte. Anemochory. Seeds dormancy – physiological.

Colutea istria Mill. Bush. Restative. Up to 1,5 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 20–25 years Neophyte. Anemochory. Seeds dormancy – physiological.

Colutea × *media* Willd. – South Europe, North Africa. Bush. Restative. Up to 1,5 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 20–25 years Neophyte. Anemochory. Seeds dormancy – physiological.

Colutea orientalis Mill. – Caucasus. Bush. Restative. Up to 2 m. Winter-hardiness 5, drought resistace 4, resistance to pests and diseases 4, seed production 5. Durability 20–25 years Neophyte. Anemochory. Seeds dormancy – physiological.

Colutea persica Boiss. – Iran. Bush. Restative. Up to 1,5 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 20–25 years Neophyte. Anemochory. Seeds dormancy – physiological.

Crataegus × *anomala* Sarg. – North America. Bush. Restative. Up to 4 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 35–40 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus arnoldiana Sarg. – North America. Forest-steppe type, deciduous. Restative. Up to 5 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 35–40 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus canadensis Sarg. – North America. Forest-steppe type, deciduous. Restativny. Up to 6 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 35–40 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus × dsungarica Zabel ex Lange – Minor Asia. Bush. Restative. Up to 4 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 35–40 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus engelmannii Sarg. – North America. Forest-steppe type. Restative. Up to 6 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 25–30 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus fecunda Sarg. – North America. Bush. Restative. Up to 3 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 35–40 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus ferganensis Pojark. – Middle Asia. Forest-steppe type. Restative. Up to 6 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 25–30 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus flabellata (Bosc ex Spach) K. Koch – North America. Forest-steppe type, deciduous. Restative. Up to 4 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 30–35 years. Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus hissarica Pojark. – Middle Asia. Forest-steppe type. Up to 6 m. Restative. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 30–35 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus mollis (Torr. & A. Gray) Scheele – North America. Forest-steppe type. Restative. Up to 6 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 40–45 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus nitida (Engelm. ex Britton & N.E. Br.) Sarg. – North America. Forest-steppe type. Irrumptive. Up to 8 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 35–40 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus pringlei Sarg. – North America. Bush. Restative. Up to 4 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 35–40 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus songarica K. Koch – Iran, Afghanistan, Kazakhstan, China. Forest-steppe type. Restative. Up to 7 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 25–30 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus stevenii Pojark. – Crimea. Forest-steppe type. Restative. Up to 3 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 25–30 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus submollis Sarg. – North America. Neophyte. Forest-steppe type. Restative. Up to 6 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 35–40 years Zoochory. Seeds dormancy –exogenous and physiological.

Crataegus × tianschanica Pojark. – Middle Asia. Forest-steppe type, deciduous. Restative. Up to 6 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 25–30 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus turcomanica Pojark. – Middle Asia. Forest-steppe type. Restative. Up to 5 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 30–35 years Neophyte. Zoochory. Seeds dormancy –exogenous and physiological.

Crataegus turkestanica Pojark. – Middle Asia, Iran. Forest-steppe type. Restative. Up to 5 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 30–35 years Neophyte. Zoochory. Seeds dormancy – exogenous and physiological.

Crataegus wattiana Hemsl. & Lace – Central Asia. Forest-steppe type. Restative. Up to 3 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 4. Durability no less than 30 years. Neophyte. Zoochory. Seeds dormancy –exogenous and physiological.

Fontanesia fortunei Carrièri – China. Bush. Restative. Up to 3 m. Winter-hardiness 4, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 30–35 years Neophyte. Anemochory. Seeds dormancy – missing.

Lonicera korolkowii Stapf – Turkestan. Deciduous bush. Restative. Up to 3 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 25–30 years Neophyte. Zoochory. Seeds dormancy – physiological.

Lonicera maackii (Rupr.) Herder – China, Japan. Bush. Restative. Up to 4 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 30–35 years Neophyte. Zoochory.

Seeds dormancy – physiological.

Padus virginiana (L.) Mill. – North America. Forest-steppe type. Irrumptive. Up to 4 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 25–30 years Neophyte. Zoochory. Seeds dormancy – physiological.

Ulmus pumila L. – Eastern Siberia, North China. Forest type, deciduous. Irrumptive. Up to 20 m. Winter-hardiness 5, drought resistance 4, resistance to pests and diseases 4, seed production 5. Durability 60–65 years Neophyte. Anemochory. Seeds dormancy– missing.

Among these species irruiptive species may be especially dangerous, as well as the species which form hybrids with native species (*Lonicera maackii* (Rupr.) Herder, *Ulmus pumila* L.) and life forms which are not presented in the native flora (*Clematis vitalba* L.). We connect the absence of these species in natural communities by the fact that they are not cultivated in large quantities in the region – they can be found singularly in the landscaping of cities, in the collection of the SFU Botanical Garden and in some regional nursery-gardens. That is why their diasporas has not yet had an opportunity to get into the natural communities. They may pose a great threat to the regional flora and vegetation, so their cultivation should be prohibited, the samples should be taken out from the collections and destroyed in the areas of cultivation.

CONCLUSIONS

Thus, the study of naturalization process of exotic wood species, performed to predict long-term ecological consequences of their invasion, is a priority of the regional dendrology. The naturalization of exotic wood species is an inevitable phenomenon, accompanying introduction in the treeless zone, while the process of woody ergaziophytes naturalization in the region can no longer be controlled and localized. Therefore, the main task of the future research is to provide the accurate prediction of the environmental consequences of invasion of exotic woody species.

In that regard, the monitoring of the process of woody ergaziophytes naturalization and invasion should be organized taking into account the existing experience (Barrios et al., 2011) and a regular update of the list of potential agriophytes. The main threats of naturalization are the high degree of drought resistance and winter hardiness and high drought tolerance. We observed that the naturalization potential increases from forest type trees to geoxile shrubs in a range of life forms. Moreover, irrumptive life forms are more competitive in comparison with restative forms. Zoochores and anemochores have the greatest opportunities for naturalization by the method of seeds and fruits spreading, while the small- and medium-sized species have greater naturalization potential by the size of diasporas; the types with mechanical, physiological and combined dormancy - by the type of seed dormancy; the oligotrophes – due to soil fertility.

We identified 147 species of woody adventive plants in urban flora of Rostov-on-Don. From species diversity the families Rosaceae Juss. (55 speceis), Fabaceae Lindl. (29), Caprifoleaceae Juss. (8), Oleaceae Lindl. (7), Hydrangeaceae (5), Ranunculaceae (5) and Vitaceae (5) are the dominants. In order to prevent the growth of the diversity of woody ergaziophytes species it is necessary to consider not only their ecological and biological properties, but also the regional economic value and importance.

The species of *Amorpha*, *Clematis*, *Colutea*, *Crataegus*, *Swida* are potentially dangerous and should be excluded from the introduction scope. It is necessary to withdraw samples of species that have a set of properties suitable for naturalization, but have no economic or scientific interest from the collections of the Botanical Garden. In this regard, the collecting of sterile samples and plant forms could be extremely important. Special attention should be paid to the selection of the plant sets in small towns and rural areas, which are the places of spreading of the adventive plants and are similar to natural coenosises.

ACKNOWLEDGEMENT

The project is supported by grant from the Southern Federal University N 213.01-07-2014/06PChVG and performed with the equipment of Laboratory of plant physiology and ecology, Laboratory of cellular and genomic plants` technologies of Botanical Garden of Southern Federal University.

ETHICS

No part of manuscript reporting original work is being considered for publication in whole or in part elsewhere. The corresponding author affirms that all of the other authors have read and approved of the manuscript.

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