

# Woody Plant Invasions into the Upper Volga Natural Communities

E. A. Borisova

Ivanovo State University, ul. Ermaka 39, Ivanovo, 153025 Russia

e-mail: [floraea@mail.ru](mailto:floraea@mail.ru)

Received September 20, 2013

**Abstract**—The questions of woody invasive plant introductions into natural communities of the Upper Volga region are considered. It is established that, of 798 alien species of the region, 119 (14.9%) are woody plants, 27 tree and shrub species successfully naturalized and intruded into natural communities of various degrees of disturbance, and 7 species are included in the Black Book of Central Part of European Russia. The majority of invasive woody plants are species of Northern American origin. Examples of invasive woody species introduced into plant communities of the region, including the specially protected natural territories, are given.

**Keywords:** invasions of woody plant species, natural communities, the Upper Volga region

**DOI:** 10.1134/S207511171602003X

## INTRODUCTION

Currently, the invasions of alien species are a global problem and cause serious evolutionary consequences (Lonsdale, 1999; Richardson et al., 2000). The studies of invasive species of trees and shrubs, the phytocenotically strongest and most habitat forming, the introduction of which leads to rapid irreversible changes in ecosystems of the region and reduction of the biodiversity, are particularly topical. Introduced arboreal plants are considered the most dangerous introduced species, causing considerable economic damage to agriculture and forestry (Ferrari, 2001; Zalba and Villamil, 2002; Weber and Gut, 2004).

Woody forms, especially trees, are long-lived; they have developed the ability for continuous renewal owing to meristematic activity; many of them have rapid growth and high seed production. Long ontogenesis describes the environmental sustainability of species and the ability to maximize the use of environmental resources. Many woody plants have effective dissemination of seeds, which contributes to their rapid expansion over long distances. Many woody plants undergo intentional introduction into botanical gardens and nurseries, and this increases their adaptation abilities.

The Upper Volga region is one of the most highly industrialized and urbanized regions of European Russia, the natural ecosystems of this region are largely anthropogenically transformed, and the flora is abundant with introduced species. Many alien species are introduced into the composition of plant communities, changing their structure. Therefore, the study of alien invasive plant species and, first of all, woody forms requires special attention.

## MATERIALS AND METHODS

Field studies were carried out by us over the period of 1990–2013 using a traditional route-reconnaissance method. The studies were performed in various parts of the Upper Volga region (Ivanovo, Vladimir, Kostroma oblasts). The different types of natural communities (forests, shrubberies, swamps, helophytic communities) were studied. Much attention was devoted to the study of protected areas (Klyazma Federal Reserve, regional reserves, nature sanctuaries, water protection zones) forming the ecological framework of the region.

The investigation of various ecotope types was accompanied by the compilation of floristic lists indicating the abundance, living conditions, features of development, damage, and abilities for seeding and vegetative propagation for each species.

A description of communities with the domination of woody invasive species was carried using the usual common method (*Polevaya geobotanika*, 1964; Mirkin et al., 2001). Plots with the size of 20 × 20 m were laid and the composition of the stand, shrub layer, and grass brushwood layer were described.

Herbarium collections of alien woody plants, including taxonomically complex species of genera *Populus*, *Crataegus*, *Cotoneaster*, and *Rosa* are stored in the herbarium of the Ivanovo State University.

## RESULTS AND DISCUSSION

As a result of our study, in the modern flora of the Upper Volga region, 798 alien species were recorded (Borisova, 2010); 119 of them are woody plants. Thirty-two species of alien trees and shrubs success-

fully naturalized in the region; they blossom every year, form viable seeds, and propagate by seed or vegetatively. Twenty-seven species were introduced into natural communities with various degrees of disturbance; seven species rapidly spread throughout the region; they successfully compete with species of the local flora and are included in the Black Data Book of Central Part of European Russia (Vinogradova et al., 2010); 11 species are included in the Black Data Book of Tver oblast (Vinogradova et al., 2011).

A majority of successfully naturalized species were intentionally introduced ornamental plants. In period of 1950–1980, in regions of the Upper Volga, as in many other regions of Russia, massive planting of ornamental trees and shrubs was performed. Species of North American origin (*Acer negundo*, *Fraxinus pennsylvanica*, *Physocarpus opulifolius*, *Populus balsamifera*, *P. deltoides*, *Padus virginiana*, *Symphoricarpos albus*, and others), East Asian origin (*Malus prunifolia*, *Rosa rugosa*, and others), and Southern and Western European origin (*Berberis vulgaris*, *Syringa vulgaris*, *Tilia platyphyllos*, *Viburnum lantana*, and others) were planted everywhere.

Beginning in the 1960s, state nurseries for trees and ornamental plants were organized in major regional cities. From the 1990s, gardening and maintenance of green areas in the region was hardly performed at all, leading to the loss of many sensitive and fastidious species, and vice versa, many introductions went beyond man's control and began to settle spontaneously.

Environmental factors, especially the wind and birds and rarely mammals, contribute to the entry of seeds of woody plants into natural habitats and to their dissemination. Many seeds after the passage through the digestive tract of animals do not lose germination, penetrate into new territories together with the excrement, and successfully germinate. Favorable conditions for seed germination and development of seedlings of woody plants develop in specific ecotopes: cracks in asphalt and concrete; near walls, enclosures, and fences; along roads.

Some North American species (for example, *Acer negundo*, *Fraxinus pennsylvanica*, and *Physocarpus opulifolius*) from the end of 1990s were actively introduced into natural communities and in the early 2000s took an active position, displacing native flora species.

*Amelanchier spicata* often forms continuous undergrowth in pine, pine-birch, and spruce forests in the region, displacing native species. Often, *Amelanchier spicata* forms continuous thickets on the slopes of the coast of small rivers and on the slopes of ravines. In suburban forests of Ivanovo, pine forests and sparse spruce forests with dense undergrowth of this plant were described (Borisova, 2006, 2009). Active penetration of this plant into forest cenoses was detected in suburban forests (for example, in forests near Shuya, Ivanovo oblast; near Nerehta, Kostroma oblast; and near Melenki, Vladimir oblast) and in forest commu-

nities remote from settlements (for example, in Zavolzhsy district of Ivanovo oblast, 10 km north of the village of Dolmatovsky, and in the Klyazma Federal Reserve, located in the south of Ivanovo oblast).

*Acer negundo* and *Fraxinus pennsylvanica* were observed in forests of the region from the 2000s. Initially, they occupied open spaces (forest fringes, fire breaks, forest edges) and settled along the roads. In 2010–2013, their presence in different types of suburban forests of Ivanovo, Kineshma, Gavrilov Posad, Shuya, Zavolzhsy, and other cities was detected. These species also forms solid dense thickets along the banks of the Uvod River (Ivanovo), Irmes River (Gavrilov Posad), and Teza River (Shuya), rapidly displacing native willow species and other trees.

*Physocarpus opulifolius* forms a dense undergrowth in pine forests, pine plantations, and birch forests located close to railways and highways, where it was specially planted. In areas of the region, it is often used in landscape gardening of cities, profusely blooms every year, bears fruit, and produces self-seeding. Seeds of this shrub are eaten by many birds.

Different types of poplar (*Populus alba*, *P. balsamifera*, *P. × sibirica*) form large overgrowth in coastal communities, especially in the sand. Large poplar stands were found on alluvial sands of the left bank of Volga River (vicinity of the village of Antonovskoe, Krasnoselsky district of Kostroma oblast). Here, large *Populus balsamifera* and *P. × sibirica* trees grow sparsely; there is thick coppice regeneration. *Ulmus laevis*, *Alnus incana*, and less commonly *Betula pendula* were also detected in the stand. *Corylus avellana*, *Salix caprea*, *S. myrsinifolia*, and *Padus avium* were found among shrubs; among herbaceous plants, *Artemisia campestris*, *A. vulgaris*, *Berteroa incana*, *Calamagrostis epigeos*, *Crepis tectorum*, *Festuca rubra*, *Pimpinella saxifraga*, *Potentilla argentea*, and others were common.

Large areas with a predominance of balsam poplar were found in 2013 in Komsomolsk district of Ivanovo oblast, 5 km to the north of Komsomolsk along a dirt road, probably on the site of a former village. The area of the plot was 70 × 40 m<sup>2</sup>. Here, old high balsam poplars were encountered; many plants have multistems, often with caves. Young sprouting individuals and uneven-aged seedlings form a dense undergrowth. In the second layer, *Frangula alnus*, *Padus avium*, *Sorbus aucuparia*, and *Tilia cordata*, as well as a large undergrowth of *Sorbaria sorbifolia* and single *Grossularia reclinata*, *Malus domestica*, and *Prunus spinosa*, were found. The herbaceous cover was greatly thinned and consisted of *Antriscus sylvestris*, *Artemisia vulgaris*, *Dactylis glomerata*, *Geum urbanum*, *Prunella vulgaris*, *Elymus caninus*, *Urtica dioica*, and others (a total of 18 species).

Large poplar thickets consisting of *Populus alba*, *P. balsamifera*, and *P. × sibirica* were noted in the sand along the coastline on Asafovy Islands, located in the

Gor'kovskoe Reservoir, 5 km to the north of Yurievets in Ivanovo oblast (Borisova et al., 2012).

Fruit trees (for example, *Cerasus vulgaris*, *Grossularia reclinata*, *Malus domestica*, *Pyrus communis*, and *Ribes rubrum*) were often found in the forests near settlements.

*Hyppophae rhamnoides* is a species widely distributed in open habitats; often, it was detected along rivers, including protected areas. Large thickets of the species were found on the banks of Lake Plescheevo (Yaroslavl oblast), on the banks of the Uvodsky Reservoir (vicinity of the village of Ivantsevo, Ivanovo oblast), and on the slope of the Volga River 2 km above Yurievets.

*Aronia mitschurinii*, grown in the region as a valuable fruit species from the 1960s, from the end of the 1990s was repeatedly recorded in the composition of the undergrowth of pine forests and on forest edges. It frequently grows on the banks of large lakes—Lakes Rubskoye and Svyatoye (Ivanovo oblast) and Bologoye and Seliger (Tver oblast)—and in peat quarries (Vinoogradova et al., 2011). In recent years, the species was introduced into the undisturbed sphagnum swamps of Ivanovo and Tver oblasts (for example, it was found in the Tsensky swamp in Ilyinsky district, in the Andreev swamp in Komsomolsk district of Ivanovo oblast, and in the large Lamskoe swamp in Tver oblast (Notov, 2009)).

North American species started to spread in the region: liana *Parthenocissus inserta*, rarely grown ornamental species of bird cherry trees (*Padus pensylvanica* and *P. virginiana*).

*Parthenocissus inserta* was found in Vladimir oblast in ravines along the banks of the Klyazma River as a ground-cover plant, forming continuous dense groups on the soil surface (Vladimir); many plants that grow by wrapping around pine trunks were found in light sparse forests (vicinity of Gus-Khrustalny). *Padus pensylvanica* was found in Ivanovo oblast in the undergrowth of birch forests with spruce (vicinity of the village of Bunkovo), on the edge of a spruce-pine forest in the village of Lomy (Lezhnevsky district), and in sparse pine forests and pine plantations near the village of Mugreevsky Bor (Pestyakovsky district).

*Padus virginiana* owing to seed and vegetative reproduction forms small thickets of undergrowth in pine forests on the banks of the Kharinka River and Talka River (vicinity of Ivanovo) and on the slopes of the Taha River (Privolzhsk).

Ornamental shrubs, for example, *Caragana arborescens*, *Cotoneaster lucidus*, *Crataegus monogina*, *Crataegus nigra*, *Symphoricarpos albus*, *Rosa dumalis*, *R. rugosa*, *Sorbaria sorbifolia*, and *Tilia platyphyllos*, were rarely found in the forests of the region.

*Tilia platyphyllos* was found in the undergrowth of sparse birch forests in suburban forests of Ivanovo (Kotelnitsy district) and in the deciduous forests on

slopes of the Volga River in Zavolzhsky district near the old manor Studenye Kluchi.

It is interesting to note the presence of rare exotic species in the forests of the region. For example, in a slightly disturbed pine-fir forest with dense undergrowth (village of Gorino, Ivanovo region), a tall fruit-bearing *Junglans mandshurica* tree was found. In a sparse pine forest near the Sortirovochnaya railway station, multiple young trees and groups of *Cerasus maximowiczii* were found; on the edge of a mixed pine-birch forest (near the Strokinoye railway station), young *Cerasus avium* trees were noted; on the slope of the left bank of the Talka River, uneven-aged *Phellodendron amurense* seedlings were recorded. These species are very rarely found in urban landscaping.

A large group of abundantly flowering *Spiraea × pseudosalicifolia* shrubs was found in a grassy marsh among dense thickets of *Typha latifolia* (vicinity of Kineshma, Ivanovo oblast).

Groups of *Cerasus tomentosa* were found in the scrub thickets on the left bank of the Solonitsy River (Nerehta, Kostroma oblast).

Multiple uneven-aged *Pinus strobus* seedlings and single *Thuja occidentalis* plants were found in the spruce-pine-birch forests near the manor park in the vicinity of the village of Holkovo in Vladimir oblast (Borisova et al., 2011).

Natural factors, such as birds and the wind, contribute to the distribution and naturalization of alien tree species in the region.

The highest diversity of invasive woody species was observed in different types of suburban forests. Introduction of alien trees in protected areas causes concern. In 2000–2012 in forests and coastal communities of protected areas, 14 woody alien species were found. For example, six species were observed in the forests of the Klyazma Federal Reserve (Borisova and Kurganov, 2011), and five species were recorded in the territory of the Asafovy Islands Nature Sanctuary (Borisova et al., 2012).

In recent decades, interest in the landscape gardening of private lands increased significantly. Many exotic woody plants were uncontrollably imported and grown in the cities of the region. The network of private nurseries, the assortment of which is not controlled, is rapidly growing. Currently, the introduction is acquiring a spontaneous character. This has led to a significant increase in the species composition of ornamental species. Many exotic woody plants (for example, *Buddleja davidii*, *Myricaria alopecuroides*, *Celastrus orbiculata*, *Robinia pseudoacacia*, *Buxus sempervirens*, *Cotinus coggygria*, and *Aralia elata*) are grown in the region. The ecological and biological characteristics of the new species are poorly understood; in addition, various species of pathogens, pests, and weeds can be delivered together with the planting material. It should also be taken into account that the quarantine service is unable to check the mass flow of

planting material supplied to private nurseries and markets.

The main political, legislative, and administrative anti-invasive species measures are determined according to the Convention on Biological Diversity. The prevention of new unwanted introductions and eradication of aggressive species were proposed.

Ornamental species of local flora (for example, *Acer platanoides*, *Betula pendula*, *Populus nigra*, *Rosa majalis*, and *Sorbus aucuparia*) should be chosen for landscape gardening. Among exotic species, the use of plants incapable of seed reproduction and spontaneous resettlement can be recommended.

## CONCLUSIONS

Of 798 alien species identified in the Upper Volga region, 119 (14.9%) are woody plants; 27 woody species penetrated into natural communities with various degrees of disturbance, seven of them are included in the Black Book of Central Part of European Russia. Most of the successfully naturalized species are intentionally introduced ornamental plants commonly used in landscaping of the region in the period of 1950–1980.

North American species (for example, *Acer negundo*, *Fraxinus pennsylvanica*, and *Physocarpus opulifolius*) at the end of the 1990s began to be actively introduced in the natural communities of the region. The greatest diversity of alien woody species was observed in different types of suburban forests. The presence of invasive species in the communities of protected areas is warning sign. The investigation of invasions of woody plants in the region requires special attention.

## REFERENCES

- Borisova, E.A., Floristic contamination of suburban forests near the city of Ivanovo, *Russ. J. Ecol.*, 2006, vol. 37, no. 3, pp. 152–155.
- Borisova, E.A., Adventive plant species in the suburb forests of Ivanovo city, in *Gorod. Les. Otdykh. Rekreatsionnoe ispol'zovanie lesov na urbanizirovannykh territoriyakh* (City. Forest. Rest: Recreational Use of Forests in Urban Territories), Moscow: KMK, 2009, pp. 9–11.
- Borisova, E.A., Patterns of invasive plant species distribution in the Upper Volga basin, *Russ. J. Biol. Invasions*, 2011, vol. 2, no. 1, pp. 1–5.
- Borisova, E.A. and Kurganov, A.A., Adventive plant species in the flora of Klyaz'minskii nursery okantation, in *Rol' botanicheskikh sadov i okhranyaemykh prirodnykh territorii v izuchenii i sokhranении raznoobraziya rastenii i gribov* (Role of Botanical Gardens and Protected Nature Territories in the Study and Protection of Diversity of the Plants and Fungi), Yaroslavl: Yarosl. Gos. Pedagog. Univ., 2011, pp. 214–216.
- Borisova, E.A., Shilov, M.P., Kurganov, A.A., Mishagina, D.A., and Begakk, N.D., Asaph islands in the Volga River in Ivanovo oblast: modern status of flora and protection, in *Ekologicheskie problemy unikal'nykh prirodnykh i antropogennykh landshaftov* (Ecological Problems of Unique Natural and Anthropogenic Landscapes), Yaroslavl: Yarosl. Gos., 2012, pp. 63–67.
- Borisova, E.A., Shilov, M.P., and Tsadkina, A.A., Ecological and biological characteristics of flora in Khol'kovskii park, Vladimir oblast, in *Resursno-ekologicheskie problemy Volzhskogo basseina* (Resource-Ecological Problems of the Volga River Basin), Vladimir: Vladimir. Gos. Univ., 2011, pp. 180–182.
- Ferrar, D.R., Exotic and invasive woody plant species in Iowa, *J. Iowa Acad. Sci.*, 2001, vol. 108, no. 4, pp. 154–157.
- Lonsdale, W.M., Global patterns of plant invasions and the concept of invisibility, *Ecology*, 1999, vol. 80, pp. 1522–1536.
- Mirkin, B.M., Naumova, L.G., and Solomeshch, A.I., *Sovremennaya nauka o rastitel'nosti* (The Modern Science about Vegetation), Moscow: Logos, 2001.
- Polevaya geobotanika* (Field Geobotany), Moscow: Akad. Nauk SSSR, 1964, vol. 3.
- Richardson, D.M., Pyšek, P., Rejmanek, M., et al., Naturalization and invasion of alien plants: concepts and definitions, *Div. Definitions*, 2000, vol. 6.
- Vinogradova, Yu.K., Mayorov, S.R., and Khorun, L.V., *Chernaya kniga flory Srednei Rossii: chuzherodnye vidy rastenii v ekosistemakh Srednei Rossii* (The Black Data Book of Flora in Central Russia: Alien Plant Species in the Ecosystems of Central Russia), Moscow: GEOS, 2010.
- Vinogradova, Yu.K., Mayorov, S.R., and Notov, A.A., *Chernaya kniga flory Tverskoi oblasti: chuzherodnye vidy rastenii v ekosistemakh Tverskogo regiona* (The Black Data Book of Flora in Tver Oblast: Alien Plant Species in the Ecosystems of Tver Region), Moscow: KMK, 2011.
- Weber, E. and Gut, D., Assessing the risk of potentially invasive plant species in central Europe, *J. Nat. Conserv.*, 2004, vol. 12, pp. 171–179.
- Zalba, S.M. and Villamil, C.B., Woody plant invasion in relictual grassland, *Biol. Invasions*, 2002, vol. 4, pp. 55–72.

*Translated by V. Mittova*