The invasive plant species in the flora of Sakhalin

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Abstract. The article is devoted to the formation of modern composition of the adventive and the invasive component of flora in Sakhalin Island. More effective expansion of the alien plant species was in the 20th century during the colonization and the scale development of the island’s natural recourses. Today there is a new splash of the alien plants drifting due to development of offshore oil and gas projects and intensive traffic flows. As a result, anthropogenic transformations of many years Sakhalin natural landscapes caused the expansion of adventive flora to 240 taxa, where 26 species are the invasive and widespread on the island.

1. Introduction

The vegetation in ecosystems is an autotrophic block performing important stabilizing and producing roles. But the economic land development leads to the violation of the natural land cover, reduction of the autochthonous and plantation of the allochthonous plant species. Certainly, the alien plant species appearance is not connected with the natural way of phlorogenesis and it’s a result of the direct or indirect human activity. The expansion of the adventive elements occurs without any bounds and as a result leads to the invasive plant species appearance. Active expansion of the latter causes pollution of the genetic fund of native plant species population and poses a threat to preserving the biological diversity in general [1–3]. Besides, a sharp increase in the rate and the scales of invasion of alien plant species into the natural communities and agrocenoses, observed in the last decades in many regions and countries, cause significant economic damage, and also pose a considerable threat to human life and health [4–6].

Obviously, there is a problem of early detection of the invasive plant species composition and the features of the settlement in every region. The monitoring for expansion of the invasive species and for their number can just be important link forecasting the ecological risks and developing the measures to minimize the negative effects on the natural complexes. Because of geographical location, climatic and natural conditions and intensive connection with the countries of Asian-Pacific region in Sakhalin Island, active emigration and immigration flows of species moving not only inside but also outside the island region. Meanwhile, the composition and the settlement of the invasive and adventive plant species as a whole in Sakhalin Island remains unexplored. The authors present the research results of the adventive and the invasive components of flora of Sakhalin Island firstly; currently it is the active arena for active development of offshore oil and gas projects involving many foreign companies.

2. Material and methods

Studies of vascular plants the flora, including the adventive component, since the early 90s of the last century. With the route-reconnaissance methods were examined different parts of Sakhalin Island with detailed acts of the key land segments, certain objects, as natural as anthropogenically transformed
The invasive status became to have only 26 species of them or 11% of all composition of the adventive component of Sakhalin flora [10]. Consequently, such species as *Heracleum sosnowskyi* Manden., *Impatiens glandulifera* Royle, *Senecio vulgaris* L., *Reynoutria japonica* Houtt., *Melilotus officinalis* (L.) Pall., *Dactylis glomerata* L., *Trifolium repens* L., became the common plants of the island, many of them were successfully naturalized, steadily dominate in the secondary plant communities, annually make the significant biomass, form the seasonal aspect on the residential territories and along the roads, bloom profusely and fruit, holding new areas. Eventually, to the end of the last century the adventive flora of Sakhalin included 203 species of the vascular plants of the 195 genus and 55 families.

Today the scale development of hydrocarbon deposits, laying of the main trans-sakhalin oil and gas pipelines, intensive traffic flows from other countries and regions cause the active plant species drifting. For just short period of time the number of new taxa was appeared in island, and adventive species met just locally significantly expanded their areas [13–15]. So, the modern composition of drifted plants, considering taxa identified by us, increased to 240 species (Figure 1).

The invasive status became to have only 26 species of them or 11% of all composition of the adventive component of Sakhalin flora. The invasive plants are: *Acer negundo* L., *Aegopodium podagraria* L., *Agrostis gigantea* Roth, *Artemisia vulgaris* L., *Conyza canadensis* (L.) Cronquist, *Elsholtzia ciliata* (Thunb.) Hyl., *Dactylis glomerata* L., *Fraxinus pensylvanica* Marsh., *Helianthus tuberoses* L., *Heracleum sosnowskyi* Manden., *Hordeum jubatum* L., *Impatiens grandulifera* Royle., *Larix leptolepis* (Sieb. et Zucc.) Gord., *Lepidium densiflorum* Schrad., *Lepidodeca suaveolens* (Pursh) Nutt., *Lupinus nootkatensis* Donn, *Melilotus officinalis* (L.) Pall., *Oenothera biennis* L., *Phleum pratense* L., *Potentilla norvegica* L., *Pilosella aurantiaca* (L.) F. Schultz et Sch. Bip., *Reynotria japonica* Houtt., *Senecio vulgaris* L., *Solidago canadensis* L., *Trifolium repens* L., *Xanthocalis fontana* (Bunge) Holub. These plant species successfully adapted to the local climatic conditions, fastly spread the island and acclimatize in new type of sites, have high reproduction potencial, actively compete not
only with sinatropic and with meadow, floodplain and forest native species in the anthropogenically transformed communities.

![Graph showing the dynamics of the adventive component formation in the flora of Sakhalin Island.](image)

**Figure 1.** The dynamics of the adventive component formation in the flora of Sakhalin Island.

Certainly, the invasive plants upon taxonomic groups are organized into groups unsteadily. The richest of them is *Asteraceae* family and covers 7 species or 27% out of general number of taxa of considering by us plants category. *Poaceae* family includes 4 types (15%), *Fabaceae* – 3 (12%), *Apiaceae* – 2 (8%), *Brassicaceae, Aceraceae, Balsaminaceae, Pinaceae, Onagraceae, Polygonaceae, Lamiaceae, Oxalidaceae, Rosaceae, Oleaceae* – on one specie (4%).

The most part of invasive plants (54%) is an herbal polycarpic. They are followed by the annual plants (27%) as a biotype which are characterized with fast development cycle that provides these plants the competition advantage over others penetrating into different plant communities. 11% of the invasive species is presented by trees, and the share of herbal monocarpic and biennial plants is 8% out of general composition of this plant category (Figure 2).

The significant number of the invasive plant species is from the North America. European, Asian, East-Asian and Euro-Asian species are met more rarely. On the way of immigration, among the invasive plants of region dominates xenophytes – unintentionally or accidentally drifted species, the share of them is 65.4% and the rest of them is ergaziophytes (Table 1). The latter is generally ornamental introductions used to green the human settlements or they are food and feed plants.

The level of naturalizing in Sakhalin is divided into three groups: agriophytes, epecophytes, colonophytes. Steady floral «core» is formed by epecophytes (*Heracleum sosnowskyi, Helianthus tuberosus, Solidago canadensis*, etc.), which are actively settled along the damaged areas and agriophytes – the types which settled the natural ecotope. Prevailing epecophytes over agriophytes means the most part of the invasive plants isn't still invaded into the natural phytocenosis and continues to settle on the secondary habitats. It explains a lot of reasons, particularly, their failure to compete agriophytes with the representatives of the aboriginal flora on the modern stage. Nevertheless, the share of agriophytes (*Acer negundo, Dactylis glomerata, Agrostis gigantea*, etc.) is over 40% out of the total number of the invasive types. Small share (7.7%) is colonophytes (*Phleum pratense, Fraxinus pennsylvanica, Larix lepotelepis*, etc.), which are included into the composition of the invasive fraction of flora in that cases when rather massively and steadily multiply in the places of forming the crop alien (Table 1).
The invasive plant species are occupied in Sakhalin with different ecotopes but it's observed the tendency of their localization to the damages of habitats. The most active forming of local coenopopulation of the invasive species takes place on the ruderal habitats, vacant places and damaged meadows (Lupinus nootkatensis, Solidago canadensis, Helianthus tuberosus, Reynoutria japonica, Heracleum sosnowskyi); along the ravines and ditches (Impatiens glandulifera, Heracleum sosnowskyi, Artemisia vulgaris); along the gardens and arable lands (Trifolium repens, Phleum pratense, Agrostis gigantea, Heracleum sosnowskyi); along the roadsides and railways (Heracleum sosnowskyi, Hordeum jubatum, Conyza canadensis, Oenothera biennis, Lupinus nootkatensis, Reynoutria japonica).

| Group of species on a way | Quantity of species | % of the total number of invasive species |
|--------------------------|---------------------|------------------------------------------|
| Naturalizations:         |                     |                                          |
| Epecophytes              | 13                  | 50,0                                     |
| Agriophytes              | 11                  | 42,3                                     |
| Colonophytes             | 2                   | 7,7                                      |
| Total:                   | 26                  |                                          |
| Xenophytes               | 17                  | 65,4                                     |
| Ergaziophytes            | 9                   | 34,6                                     |
| Total:                   | 26                  |                                          |

Certainly, the invasive plants are spread the island territory un steadily. The most part of species of them is met only in the south part of Sakhalin, which is characterized by rather high level of urbanization, transport and economic development and better climatic conditions. At the same time, in the middle part of Sakhalin, where focused the main agricultural grounds and agrocomplexes, high level of the invasive species and expanding the occupied territories is observed. The invasive plants of the North Sakhalin where the soil and climatic conditions significantly differ from the rest areas of local grouping.

The group of widespread invasive species are Heracleum sosnowskyi, Acer negundo, Hordeum jubatum, Conyza canadensis, Trifolium repens, Phleum pratense, Artemisia vulgaris, Impatiens glandulifera. They grow not only in anthropogenically transformed habitats, but often appear in the derived plant communities. For the last half a century Heracleum sosnowskyi (Figure 3) as a
representative of North Caucasus, grows everywhere. This species was brought to Sakhalin in 1962 for creating highly productive silage culture and improvement the feed base of livestock complex [16]. Having the powerful energy of growth, rich seed bearing and high competitiveness, it fast covered the damaged areas and formed rich one типed coenopopulation, forced out native species and caused the changes of vegetation structure and natural landscapes in general. In conditions of humid Sakhalin climate with high soil moisture *Heracleum sosnowskyi* found favorable ecological niche.

Besides currently else 6 drifted species are actively settled, which in future could show yourself as the invasive plant. While they form just local invasions on the private subsidiary farms, garden plots vacant grounds and surroundings of Yuzhno-Sakhalinsk, Kholmsk and Korsakov.

![Figure 3. Characteristic thickets *Heracleum sosnowskyi* in Sakhalin.](image)

4. Conclusions
Before the active settling of people, the Sakhalin Island was covered with natural vegetation with taking part the autochthonous species. Appearance and spreading of the alien plant species happened according to island’s colonization and practical development. At the end of the 19th century adventive component included 18 species and in 1940 it increased to 63 species. The greatest number of adventive plants (203 species) in Sakhalin appeared in 20th century in result of the scale industrial felling, building the cities and creating agricultural grounds.

The last two centuries one can observe the active drifting of alien plant species and gaining their role in forming the appearance of local landscapes. It’s connected with further transformation of natural vegetation upon the building of trans-sakhalin trunk pipelines and other associated infrastructure object of oil and gas complex.

Currently in Sakhalin 240 species of adventive plants are revealed, among them 26 species are the invasive ones. The invasive plants are focused predominantly in the south part of Sakhalin where it’ observed the highest level of transportation of the original root vegetation conditioned agricultural development, urbanization, building the industrial objects and transport highways. Favorable climatic conditions contribute the active development and forming steady coenopopulation of the invasive plant species.
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