Transport Routes as a Factor in the Transformation of Flora (for the Example of the Khabarovsk Territory)

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Abstract. In the article the peculiarities of the flora of transport lines (road and railways) of Khabarovsk Territory and their influence on flora of adjoining communities are considered. The authors analyzed the peculiarities of flora formation on various structural elements of roads such as roadway; embankments and slopes; negative elements of relief (side drain and drainage ditches); adjoining phytocenoses. The particularities of roadside flora of roads and railways are considered in comparison. The authors give examples of road participation in the distribution of native and alien species. Peculiarities of roadside flora formation are described in the article taking into account ecological characteristics of the region: climatic factors and zonal types of communities. The main trends in the distribution of alien species are indicated. The authors analyzed the existing approaches to assessing the potential danger of quarantine species and concluded their potential threat to the region.

1. Introduction

The development of the region's transport network is an essential characteristic of its economic potential. Road construction is the largest anthropogenic impact in the area. It’s most important consequences are distribution of alien species, fragmentation of biotopes, transformation of biocenoses as a result of unorganized recreation and maintenance of roads in proper condition, loss of habitats for a number of species, change of abiotic and biotic factors in the adjacent to the roads communities, modifying of microclimatic conditions [1].

The study of roadside flora is common in Russian and foreign botany. The objectives of such studies are mainly to monitor the distribution of alien species; particularities of alien and aboriginal components of road flora description; identification of factors which are contributing to preventing or to naturalization and the further diffusion of distribution of alien species out of transport routes; determination of the influence of roads and rail transport on biodiversity of regions, in particular, on losses in native flora [2-11]. An integral component of such studies is the description of regional peculiarities of roadside flora formation.

The purpose of our work is the description of some peculiarities of the flora of transport routes (road and railways) of Khabarovsk Territory and its influence on flora of adjoining communities.

2. Materials and methods

Since 2003 the authors are studying the anthropogenic flora of Khabarovsk Territory, in particular, in the cities of Amursk, Nikolaevsk-na-Amure, Sovetskaya Gavan', Komsomolka-na-Amure; settlements
of Komsomolsky, Solnechny and Amursky municipal districts of Khabarovsk Territory, and also on separate road objects outside of settlements. Collection of materials is carried out by the route method taking into account all possible types of habitats in the territory and the method of model shares. As a result, lists of local flora of settlements and partial flora of different types of habitats, in particular, partial flora of transport routes were formed and analyzed. For each partial flora the native and alien component was analyzed.

3. Results and discussion

The conditions of plant dwellings on road and railways are unlike on different zones within the locality:

- horizontal part of roadway (roadway and roadside);
- inclined part (embankments or backfalls);
- negative elements of relief (side drain and ditches);
- adjoining areas of various forms of relief (phytocenoses of natural or anthropogenic origin).

Each of these zones is characterized by a specific combination of abiotic, biotic and anthropogenic conditions that affect the formation of species richness within the zone.

The degree of growth of the roadway zone is determined by the traffic intensity, the nature of the substrate, the frequency of maintenance and repair of roads. This zone has the greatest chemical (petrol, lubricants, pesticides, etc.) and mechanical impact. Asphalted roads with a safe coating are overgrown only on the roadsides. Gravel and natural roads can be overgrown on the roadway. Country roads are represented by natural soil, and in case of low intensity of movement are actively occupied by plants. On the canvas of such a road (in 10 m from the federal highway) we found blooming copies of Liparis japonica (Miq.) Maxim., listed in the Red Book of Khabarovsk Territory. The presence of rare and endangered plants in the flora is also noted for the Middle Urals [4]. But if the species given by the researchers [1], linear corridors of roads contribute not only to the drift of alien species, but also to the settlement of native. The railways primarily contribute to the spread of species of Taraxacum to the north, such as T. dissectum Kitag., T. multisectum Kitag., T. stenolobium Sttcheq, T. ussuriense Kom. etc. Taraxacum as originally petrophyte genus perfectly adapted to the conditions of the railway embankment, and its anemohory facilitates the transfer of seeds by means of

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transport over a long distance. On the railroad track in Komsomolsk-on-Amur *Lathyrus japonicus* Willd was found, a typical seaside species, probably imported from the coast of the Strait of Tartary.

Typical roadside communities are usually formed on the inclined part of roads. At first glance, the rubbly mound contains insufficient mineral substances, and the drainage structure leads to a lack of moisture. Traditionally, this type of habitat is indicated by high illumination, as a consequence warming of the substrate increases, reduced humidity [2]. But environmental studies [3] show that rail embankments are characterized by optimal hydration, sufficient mineral wealth, and PH close to subacid, which is normal for most temperate plants. Mineral wealth and acidity of the substrate is provided by wastewater and biogenic garbage. Similar characteristics are described for backfall [9]. In conditions of moist climate at shallow occurrence of ground waters moistening of embankments is provided by a capillary feed. Due to the monsoon climate with sufficient rainfall in the Khabarovsk territory expressed xerophytization flora of road embankments is not observed. Actually xerophytes in flora of roads are absent or sporadic. Xeromesophites make up to 10% of the corresponding partial flora (for comparison in different of ruderal partial flora the share of xeromesophites is from 2% to 7.5%). The leading position is mesophytes (30-40%).

The mound is a place of accumulation of alien species. Communities of embankments are more competitive than sparse community roadways. Alien species are opposed by native species. In the case of anthropogenic habitats they are apophytes. In the natural environment they are phytocoenotic explerents. Therefore, at the stage of penetration into the community of embankments from the roadway there is the first selection of alien species. On the other hand, in comparison with the indigenous communities, the conditions of the embankment are less competitive. For some species which for various reasons are in a depressed state in the indigenous phytocenosis, the conditions of the embankment may be favorable. For example, *Aralia elata* (Miq.) Seem, being in Khabarovsk Territory on the northern border of distribution, actively forms growth on slopes of highways. Another example of the thermophilic species to the north on the backfall of roads is *Cuscuta japonica* Choisy. This parasite is also located in the Khabarovsk Territory on the northern limit of its area, and well warmed slopes of highways contribute to its advancement to the north.

In some works [1-10] it is noted that in roadside flora the share of coastal and aquatic plants decreases in comparison with natural communities. But side drain and ditches often turn into temporary or permanent standing reservoirs. The construction of roads can lead to a violation of natural flow. As a result, there is damming drainage watercourses and water logging territory. Anthropogenic flooding with the subsequent water logging isn’t a rare phenomenon in anthropogenic landscapes of Khabarovsk Territory [13]. Presence of such habitats leads to inclusion hydrophytes in roadside flora, and sometimes heloophytes and hydatophytes. The share of riverside and aquatic plants in the roadside flora of Khabarovsk Territory reaches 10-15%.

Biodiversity of adjacent to roads phytocenosis conservation is the main task of biologists and environmental activists. Plant communities suffer from mechanical (repair work) and recreational impact. Particular concern is the resettlement of alien species. It should be noted that the danger of resettling alien species inversely proportional to the saturation of surrounding phytocenosis. Most of the territory of the European part of Russia and the south of Siberia are occupied with cultivated land and secondary forests. These communities are opened to the penetration of alien species. The same can be said about the ruderal community of cities and towns. In Khabarovsk Territory settlements are strongly removed from each other. Long-distance transport highways surround relatively low-disturbed highly-saturated plant communities. Moreover, the ecological conditions of zonal communities of Khabarovsk Territory (mixed coniferous-broad leaved forest and taiga forests) differ greatly in characteristics from the conditions of open roadside communities [14]. It is noted in the studies that the share of alien species decreases from the removal of the city centers, reaching a minimum in the Green Zone, and expand with the increase in the wealth of habitats. In the middle part of the Khabarovsk Territory alien species mainly penetrate the synanthropic meadows, disturbed riversides and cultivated lands. Sustainable grassy communities, which are formed after multiple fires,
are also close in their conditions to roadside communities, but because of the highly-turfness soils, they are less accessible to alien species.

The factors determining the risk of aggressive reproduction of alien species are considered in the work of G. Moskalenko [15]. To understand whether a species poses a threat in a given geographical location, he proposes to assess the climatic characteristics of the territories where the species is currently being distributed. From comparison of these characteristics with the new territory it is possible to estimate its conformity to ecological range of a species. The importance of climatic indicators in comparison with the factors of habitat as a factor of resettlement of alien species was also proved by Polish scientists [16]. The leading importance of the climate for the formation of roadside flora has also been noted in other works ([17, 18]. In addition to the potential range, G. Moskalenko proposes to assess the peculiarities of species distribution in similar climatic conditions and their competitive properties. The importance of these characteristics for the distribution of alien species was also noted V. Païaro, M. Cabido, E. Pucheta [17]. Most of the alien species, in one way or another naturalize in the Khabarovsky Territory, hailing from Europe or the temperate zone of North America. The sharply continental climate of the central part of the Khabarovsky Territory creates significant problems for their naturalization and reduces the risk of introduction of invasive species in the community. According to the research of L. Antonova [5], 18 invasive alien species from 21 ones are aggressive only in the southern part of the region. Destructive influence of these species is timed to ruderal habitats, as well as sinantropic meadows and floodplains of small rivers.

Monitoring of distribution of alien species, first of all-quarantine, is necessary. Assessment of potential ecological range is conditional. There is a possibility that the ecological range of the invasive species is not fully realized at the present time. When the centers of quarantine weeds are detected, their physical destruction is necessary [19], in order to avoid their negative impact on ecosystems.

4. Conclusion
At the modern level of industrial development of Khabarovsky Territory transport routes have mainly localized influence on its flora. Roads are linear corridors for the distribution of active species of native and alien flora. Transport routes, first of all railways, are the main suppliers of neophytes in the region. The distribution of alien species is a random process, so the taxonomic structure of the alien component in different areas differs. On the greater territory of the region due to the harsh climate and unfriendly ecological conditions of zonal communities, the settlement of alien species is limited to disrupted and anthropogenic communities. Natural and climatic conditions of the region impose a mark on the formation of flora of roadside habitats. They are not expressed xerophytization, they have rather high proportion of hydrophytes. Roadside habitats are favorable for the development of a number of local species, including some rare and protected.

This conclusion sounds tautologic, but to preserve biodiversity of Khabarovsky Territory it is necessary to preserve its biodiversity. A number of researchers [20, 21] note the need to preserve the pockets of natural communities along highways. In our region, the preservation of natural communities is the best protection against the expansion of alien species.

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