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Phytocenotic features of species of the genus *Salsola* L. (*Chenopodiaceae* Vent. / *Amaranthaceae* Juss.) in the desert part of the Syrdarya river valley

The study of species of the genus *Salsola* L. in the desert part of the Syrdarya river valley (Kyzylorda region) is of great importance for identifying the features of the structure of phytocenoses in this region, which will facilitate rational use of plant resources and make recommendations for the radical improvement and recultivation of pastures in this territory. Various phytocenoses are confined to this territory, including those with the participation (dominance) of species of the genus *Salsola* L. Classical botanical methods were used in the research process. Fundamental floral summaries were used to identify the collected material. Vegetation was studied applying traditional methods of field geobotanical research. According to the results of the expedition work in the desert part of the Syrdarya river valley, 24 plant communities were described with the participation and dominance of species of the genus *Salsola* L. The communities differed from each other in the composition of the species. This is due to the diversity of the combination of environmental factors: natural physical and geographical and anthropogenic. The 24 communities represented can be divided into two groups: 1) communities dominated by species of the genus *Salsola*; 2) communities containing species of the genus *Salsola*. As a result, it was found that the annual species of the genus *Salsola*: S. *nitraria, S. paulsenii* and *S. tragus* are well adapted to the habitat conditions in the study area and can be used in reclamation work in desert zones.

Keywords: genus *Salsola* L., annual species, phytocenosis, dominants, Syrdarya river valley, ecology, anthropogenic factors, succession.

Introduction

In desert regions, people's lives are usually confined to rivers as water sources. The anthropogenic impact on the territory of the Syrdarya river valley is characterized by the historical duration and the greatest intensity. In addition, floodplain landscapes are characterized by a number of features that must be taken into account when intensifying their economic use. They are dynamic, easily vulnerable, subject to destruction by water, wind, various modes of transport, intensive grazing of farm animals, etc. [1].

Ecological and biological features, seasonal and multi-annual dynamics, structure and productivity of individual plant communities of the Syrdarya river valley were studied by different researchers, among them N.P. Ogar [2] and O.M. Demina [3]. In the works of above-mentioned researchers, there is information about the seasonal development of dominant plants, their yield and biological productivity of aboveground and underground phytomass, depending on the regime of surface flooding, the level of groundwater occurrence and soil salinity.

Since the mid-90s, N.P. Ogar has been studying the dynamics of the spatial structure of the vegetation of the Syrdarya river delta [2, 4]. The sphere of her interest was studies on the structure of vegetation cover depending on the age of floodplain terraces. The author showed that all the main types of vegetation are primary: shrubby and tree-shrubby “tugai”, meadows and grass swamps, but their floral composition and areal distribution are unequal in segments of different ages [2]. On the basis of a comprehensive analysis of the relationship between vegetation and ecological conditions, N.P. Ogar compiled generalized ecological and dynamic vegetation series that characterize the sub-zonal segments of the floodplain of the Syrdarya river [4]. They are the basis of legends for vegetation maps of different scales.

The description of the tree and shrub vegetation of the Syrdaryariver is in the work of S.A. Nikitin [5]. The scientist mentions the distribution of oleaster tugai in the Terenozek region and flood willows in the Syrdarya river delta. In the course of the studies of A.B. Baibulov, these communities were not noted [6].

In 2005–2008, detailed work was carried out to study the biodiversity of wetlands in all lake systems of the Syrdarya delta under the leadership of N.P. Ogar, with the participation of A.B. Baibulov. Studies of the vegetation cover of the Aral Sea coast were carried out by L.A. Demicheva et al. (2004–2006) [7–10].

The study of species of the genus *Salsola* L. in the Kyzylorda region has both theoretical and practical significance. Thus, knowledge of the peculiarities of the structure of phytocenoses in this region will allow us to develop recommendations for optimal nature management that do not cause considerable damage to plant resources and take into account measures to radically improve the pastures of this territory.

The vegetation cover of the desert part of the Syrdarya river valley is degraded for a variety of reasons, especially due to anthropogenic activities (grazing, agriculture, various construction works, road digression, and much more).

Pastures located near settlements, cattle tracks in the floodplain of the river, as well as the territory where road construction works are carried out are subject to significant violations. In the composition of the vegetation cover of these territories, various phytocenoses are observed, including communities with the participation (dominance) of species of the genus *Salsola*. The main consequence of the violation of these and any other phytocenoses is a decrease in their species diversity (due to the loss of the most vulnerable, as well as forage plants and their replacement with weeds, including poisonous species).

Objects and methods of research

The objects of the study were species of the genus *Salsola* L. (*Chenopodiaceae* Vent., or *Amaranthaceae* Juss.) and phytocenoses formed with the participation of these species in the desert part of the Syrdarya river valley.

Classical botanical (route–reconnaissance; ecological–systematic; ecological–geographical) methods were used in the research process. During the work, the herbarium material of the collection funds of the Institute of Botany and Phytointroduction (AA) was studied. Fundamental floristic and the latest modern works were used to identify the collected material during the expedition. Vegetation was studied using traditional methods of field geobotanical research and the works [11–24].

For each species of the genus *Salsola*, its participation in complex plant messages of varying degrees of disturbance is printed, assessed on a three-point scale (weakly, medium, severely disturbed) [24]. Representatives of the genus *Salsola*, in the features of annual species, are considered pioneers of overgrowth of disturbed arid territories. Poorly disturbed areas are when a particular community is dominated by shrubs, semi-shrubs, shrubs or semi-shrubs with perennials, that form a more or less stable community. As we understand it, there are practical networks of undisturbed territories in the Syrdarya river valley (due to Scott grazing). The average disturbed areas are dominated by the above-mentioned life forms, but at the same time subdomination or simply an abundance of annual sinanthropic widows in this community (ephemera are not considered). Heavily disturbed areas are a community with absolute dominance of annual *Salsola* species (for the study of the territory).

The description of phytocens and the collection of materials was carried out during the expedition research in the Syrdarya River valley (2018–2019) as part of the release of the grant project “Monitoring studies of the restoration of valuable vegetation in abandoned rice fields of the Kyzylorda region, prospects for their use” (2018–2020), and is also used by data on the past grant project “Monitoring of the vegetation composition of livestock runs — a scientific approach to the sustainable use of desert pastures of Kazakhstan (on the example of the Kyzylorda region)” (2015–2017).

Results and Discussion

During the expedition work in the desert part of the Syrdarya river valley, 24 plant communities were described with the participation or dominance of species of the genus *Salsola*. Communities differed from each other in the composition of species, which is due to the diversity of environmental factors: physical and geographical (terrain elements, soil, moisture, salinization, etc.) and anthropogenic (disturbed areas due to grazing, construction and repair work, unregulated traffic, etc.) (Fig. 1).

The described communities can be divided into two groups:

– communities with the dominance of the genus *Salsola* species;

– communities containing species of the genus *Salsola*.

The 1st group of communities: Arbusculi Salsoletum, Orientali Salsoletum, Annual Salsoletum (4 different types), Hispidi Tamaretum annual salsolosum motley grass, Annual Salsoletum convolvulosum, Pseudalhagi Alhagetum arbusculisalsolosum. We divide this group of communities into 3 sub-groups (Fig. 2).

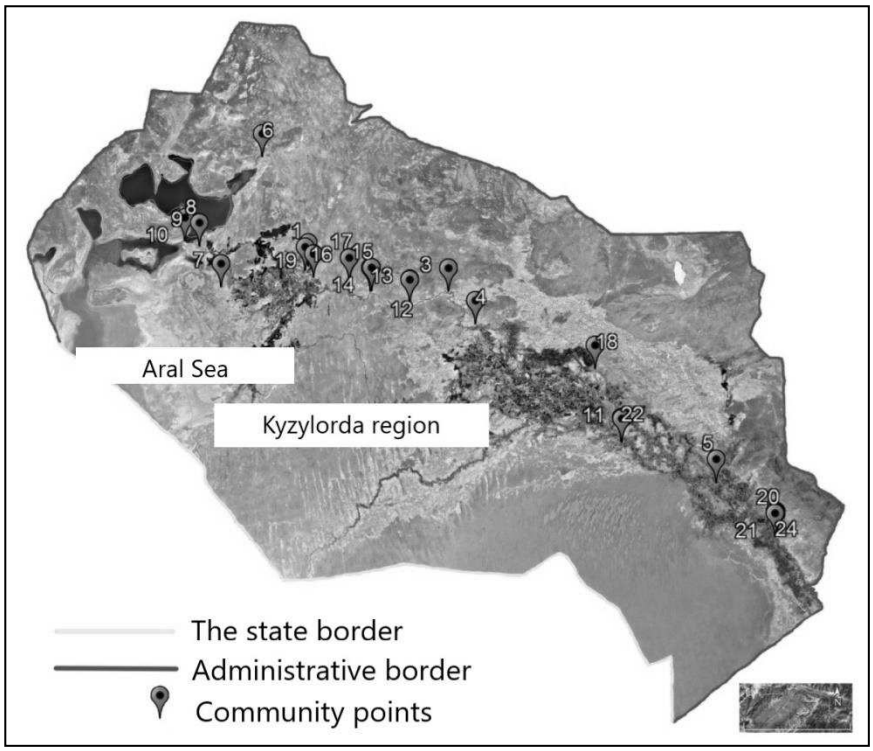

Figure 1. Map-scheme of the Kyzylorda region with the points of description of communities

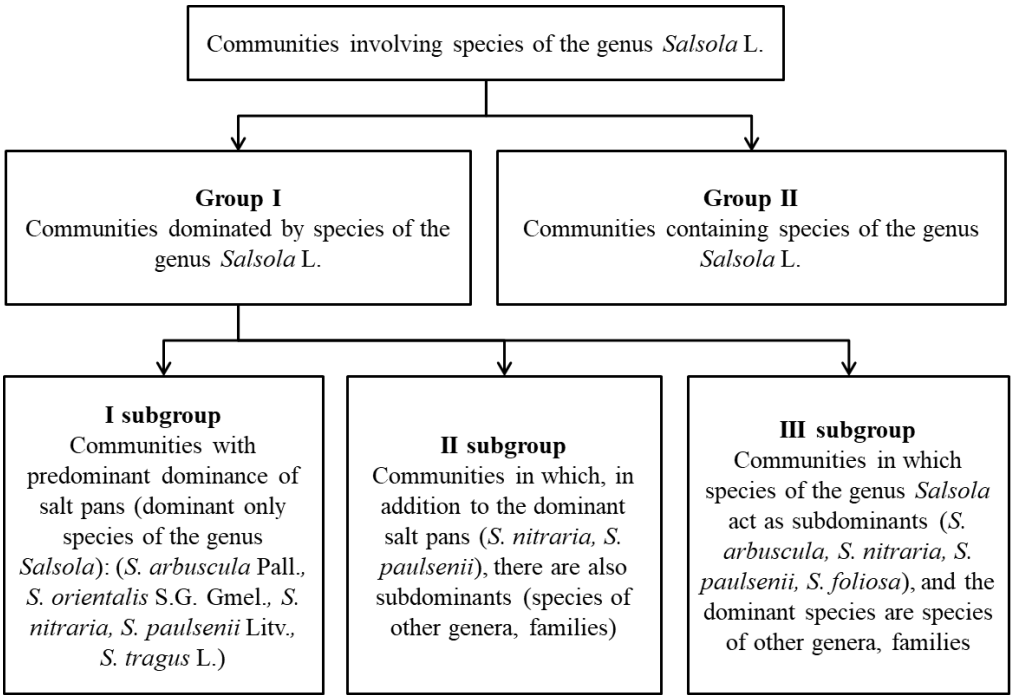

Figure 2. Scheme of the sub-division of communities with the participation of species of the genus *Salsola* L. according to the degree of their participation in the composition of the vegetation of the desert part of the Syrdarya river valley

I sub-group

The first sub-group includes *Arbusculi Salsoletum*, *Orientali Salsoletum,* and *Annual Salsoletum* communities. The total number was 6 communities. These communities were dominated by shrubs (*S. arbuscula*), semi-shrubs (*S. orientalis*), and annuals (*S.tragus, S. nitraria, S. paulsenii*).

1. The *Arbusculi Salsoletum* community dominated by *S. arbuscula* (cop1 — abundant) was observed by us in a fixed sandy desert, as is typical for this species. GPS coordinates N 45°44'59.2"; E 62°52'03.6", height 83 m above sea level. Habitat: near the highway, from slightly disturbed to moderately disturbed areas. There were 18 species in the community. This community also included other species of salt marsh (*S. nitraria* (sol (solitariae) — plants are rare), *S. paulsenii* (sol), which are represented only by individuals. Significant species of this community included: *Kraschenninnikovia ceratoides* (L.) Gueldenst. and *Alhagi pseudalhagi* (M. Bieb.) Fisch. The addition of the community also involves *Ceratocarpus utriculosus* Bluket, *Atriplex tatarica* L., *Zygophyllum fabago* L., and others.

2. The *Orientali Salsoletum* community dominated by *S. orientalis* (sp (sparsae) — plants are found occasionally, scattered, in small numbers) was noted by us in the clay desert. GPS coordinates N 45°45.728'; E 61°12.748'; height 62 m above sea level. Habitat is pasture, also from slightly disturbed to moderately disturbed areas. The total projective coverage (TPC) was 35 %. There were 12 species in the community. From family *Chenopodiaceae* also participated in the community: *Anabasis salsa* (C.A. Mey.) Benth. ex Volkens, *Climacoptera brachiata* (Pall.) Botsch., *Petrosimonia sibirica* (Pall.) Bunge, *Girgensohnia oppositiflora* (Pall.) Fenzl, *Ceratocarpus utriculosus* et al.

3. *Annual Salsoletum* communities:

– We found a *Nitraria Salsoletum* community with the dominants *S. nitraria* (cop1), *S. paulsenii* (sp) in a fixed sandy desert in the Aral Sea region (the coast of the Small Aral Sea). GPS coordinates N 45°50'51.66"; E 62°13'53.61"; height 93 m above sea level. Habitat: heavily disturbed areas. TPC was 30 %. There were 5 species in the community.

We have observed a *Tragusi Salsoletum* community dominated by *S. tragus* (sp) in the clay desert, not only in the valley of the Syrdarya River but also in the eastern Aral Sea region (in the area separating the Small and Large Aral Sea, on the dried-up bottom of the sea). GPS coordinates N 46°6.930'; E 60°46.280'; height 27 m above sea level. Habitat: heavily disturbed areas. TPC was 15 %. There were 8 species in the community. In this community, *S. nitraria* (sp) was found, which, like *Alhagi pseudalhagi*, participated in the addition of the community.

The listed *Annual Salsoletum* communities served as an example of successions that occur as a result of water withdrawal from a given territory. The species *S. nitraria, S. paulsenii*, and especially *S. tragus* were very characteristic of such habitats. In the absence of competition, these species quickly master this territory.

According to our observations, another clear example of succession was a community with the participation of *S. nitraria* (sp) and *S. paulsenii* (sp.), on a fixed sandy desert. GPS coordinates N 46°4.049'; E 60°56.860'; height 35 m above sea level. Habitat: along roads in the Kyzylorda region, from medium to severely disturbed areas. TPC was 30 %. There were 6 species in the community. *S. nitraria* and *S. paulsenii* are adapted to disturbed places and grow well on the slopes of roads where rainwater flows. They formed small-species annuals of the *Salsoletum* community.

Nitrari Salsoletum community dominated by *S. nitraria* (cop1) with the participation of S. tragus (sp), on a fixed sandy desert. GPS coordinates N 45°39'33.0"; E 63°18'26.4"; height 103 m above sea level. The habitat was heavily disturbed lands. There were 11 species in the community.

II sub-group

We included the *Annual Salsoletum convolvulosum* community in the subgroup of the joint dominance of *S. nitraria* (cop 1) and *S. paulsenii* (cop1). This community is located on a fixed sandy desert. GPS coordinates N 45°44'57.8"; E 62°52'53.8"; height 67 m above sea level. The habitat was also heavily disturbed lands. There were 15 species in the community.

III sub-group

The sub-domination sub-group included *Pseudalhagi Alhagetum arbusculi salsolosum* and *Hispidi Tamaretumannual salsolosum* motley grass communities.

In the first *Pseudalhagi Alhagetum arbusculi salsolosum* community, the sub-dominant was *S. arbuscula* (cop1), and the dominant was *Alhagi pseudalhagi*. Fixed sandy desert. GPS coordinates N 44°15.236'; E 66°38.131'; height 139 m above sea level. Habitat: near the highway, moderately disturbed areas. TPC was 35 %. There were 7 species in the community: *Kraschenninnikovia ceratoides, Ceratocarpus utriculosus, Atriplex tatarica, Zygophyllum fabago, Salsola nitraria* (sol) are present in the community.

In *Hispidi Tamaretumannual salsolosum* motley grass community, the sub-dominants were annuals *S. nitraria* (cop 1), *S. foliosa* (sp), and *Tamarix hispida* dominated. Clay desert. GPS coordinates N 45°30.147'; E 64°02.722'; height 99 m above sea level. Habitat: near the highway, moderately disturbed areas. TPC was 30 %. There were 15 species in the community. The herbal composition is represented by the following types:

Climacoptera brachiata, *C. lanata* (Pall.) Botsch., *C. crassa* (M. Bieb.) Botsch., *Petrosimonia sibirica*, there were also isolated *Anabasis aphylla* L., *Halostachys belangeriana* (Moq.) Botsch., *Halocnemum strobilaceum* (Pall.) M. Bieb. et al.

Communities contained species of the genus *Salsola: Aphyllumi Haloxyletum* (*Haloxylon aphyllum* (Minkw.) Iljin), *Pseudalhagi Alhagetum* (*Alhagi pseudalhagi* (M. Bieb.) Fisch.), *Strobilaceumi Halocnemetum* (*Halocnemum strobilaceum* (Pall.) M. Bieb.), *Hispidi Tamaretum* (*Tamarix hispida* Willd), *Aphyllumi Haloxyletumhispidi tamarosum, Terrae-albi Artemisetum* (*Artemisia terrae-albae* Krasch.), *Harmali Peganetum* (*Peganum harmala* L.), H*alodendroni Halimodendetumhispidi tamarosum* (*Halimodendron halodendron* (Pall.) Voss), *Alopecuroidi Pseudosophoretum fabagizygophyllosum* (*Pseudosophora alopecuroides* (L.) Sweet, *Zygophyllum fabago* L.), *Fabagi Zygophylletum hispidi tamarosum* et al.

Among the studied species of the genus *Salsola*, all of the above communities included: *S. nitraria, S. paulsenii* and *S. tragus*, while *S. nitraria* scarce is presented. All communities in which these three species were noted, but they did not dominate, are found on weakly or less frequently on medium disturbed lands (near roads, settlements and pastures).

In undisturbed communities, these species occupied the sub-ordinate role, not dominated. However, in places of violation of the soil and vegetation cover, annual pickles dominated as pioneers of overgrowth of disturbed lands. And for several years they prevailed over perennial species. As vegetation recovers, annual species moved to a sub-ordinate position.

It was noted, there were no species of the genus *Salsola* on the deposits of rice fields (which have ceased to be used due to secondary salinization). There are several reasons for this phenomenon. So, in the spring, abandoned rice fields still receive water, and species of the genus *Salsola* prefer drier soil. The degree of salinization of abandoned rice fields exceeds the limit of ecological plasticity of species of the genus *Salsola* [25–27].

Conclusions

The annual species of the genus *Salsola*: *S. nitraria, S. paulsenii,* and *S. tragus* are well-adapted to the habitat conditions in the studied area. In undisturbed and almost undisturbed phytocenoses. These species, as a rule, are not dominant or subdominant. So, on undisturbed lands, they occur only once or several dozen, depending on the characteristics of the habitat. Meanwhile, in disturbed areas, these annuals can form temporary communities in which they act as dominants. Of all the presented annual salt pans, *S. nitraria* is characteristic and dominates on strongly, medium and slightly disturbed lands. Two other species of annual salt pans (*S. paulsenii* and *S. tragus*) act as dominants only occasionally in severely disturbed territories, but they feel good on medium disturbed lands. It should also be added that the shrub species *S. arbuscula* and *S. orientalis*, depending on the growing area, can occur and even dominate in weakly and moderately disturbed lands. Annual species of salt pans are oligotrophic plants, which allows them, unlike other species, to grow in disturbed areas poor in organic compounds. Dying, they enrich the soil with organic matter necessary for perennial species, thereby contributing to the restoration of vegetation. Consequently, annual species of the genus *Salsola* (*S. nitraria, S. paulsenii* and *S. tragus*) are promising in terms of their use in reclamation works in the desert zone.

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Б.Б. Осмонали, П.В. Веселова, Г.М. Кудабаева, Н.З. Ахтаева

Сырдария өзені аңғарының шөлді бөлігіндегі *Salsola* L. туысы (*Chenopodiaceae* Vent. / *Amaranthaceae* Juss.) түрлерінің фитоценотикалық ерекшеліктері

Сырдария өзені аңғарының (Қызылорда облысының аумағы) шөлді бөлігіндегі *Salsola* L. туысы түрлерін зерттеу өсімдік ресурстарын ұтымды пайдалануға және осы өңірдің фитоценоздары құрылымының ерекшеліктерін анықтау аумақтың жайылымдарын түбегейлі жақсарту және рекультивациялау жөнінде ұсынымдар жасауға мүмкіндік беретін үлкен маңызға ие. Қарастырылып отырған аумаққа әртүрлі фитоценоздар топтастырылған, соның ішінде *Salsola* тұқымдас түрлеріне де қатысты (басым болу). Зерттеу барысында классикалық ботаникалық әдістер қолданылды. Жиналған материалды сәйкестендіру үшін негізгі флористикалық мәліметтер қолданылды. Өсімдіктер далалық геоботаникалық зерттеулердің дәстүрлі әдістерін қолдана отырып зерттелді. Экспедициялық жұмыстардың нәтижелері бойынша Сырдария өзенінің аңғарының шөлді бөлігіндегі 24 өсімдік қауымдастығы *Salsola* L. тұқымдасының түрлерінің қатысуымен және басымдығымен сипатталған. Қауымдастықтар бір-бірінен түрлердің құрамымен ерекшеленген. Бұл қоршаған орта факторларының әр түрлі үйлесуіне байланысты: табиғи физикалық-географиялық және антропогендік. Ұсынылған 24 қауымдастықты екі топқа бөлуге болады: 1) *Salsola* туысы түрлерінің үстемдігі (доминант) бар қауымдастықтар; 2) құрамында *Salsola* тұқымының түрлері бар. Нәтижесінде *Salsola* туысының біржылдық түрлері: *S. nitraria, S. paulsenii* және S. *tragus* зерттелген аумақта орта жағдайларына жақсы бейімделген және оларды шөлді аймақтарда қалпына келтіру жұмыстарында қолдануға болады.

Кілт сөздер: Salsola L. туысы, біржылдық түрлер, фитоценоз, доминанттар, Сырдария өзені аңғары, экология, антропогендік факторлар, сукцессия.

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Фитоценотические особенности видов рода *Salsola* L. (*Chenopodiaceae* Vent. / *Amaranthaceae* Juss.) в пустынной части долины р. Сырдарьи

Исследование эколого-географической приуроченности видов рода *Salsola* L. пустынной части долины реки Сырдарьи (в пределах Кызылординской области) имеет большое значение для выявления особенностей структуры фитоценозов этого региона. Критический анализ его результатов позволит разработать эффективные рекомендации по устойчивому использованию растительных ресурсов, в том числе и по коренному улучшению и рекультивации пастбищ данной территории. К рассматриваемой территории приурочены различные фитоценозы, в том числе с участием (доминированием) видов рода *Salsola*. В процессе исследований были применены классические ботанические методы. Для идентификации собранного материала использовались фундаментальные флористические сводки. Растительность изучалась при помощи традиционных методов полевых геоботанических исследований. В результате экспедиционных работ в пустынной части долины р. Сырдарьи было описано 24 растительных сообщества с участием и доминированием видов рода *Salsola*. Сообщества отличались друг от друга составом видов, что обусловлено разнообразием сочетания факторов среды обитания: естественных физико-географических и антропогенных. Представленные 24 сообщества можно разделить на две группы: 1) с доминированием видов рода *Salsola*; 2) в составе которых присутствуют виды рода *Salsola*. В ходе исследований было выявлено, что однолетние виды рода *Salsola*: *S. nitraria, S. paulsenii*и *S. tragus* хорошо приспособлены к условиям обитания на изучаемой территории, их можно использовать в рекультивационных работах в пустынных зонах.

Ключевые слова: род *Salsola* L., однолетние виды, фитоценоз, доминанты, долина р. Сырдарьи, экология, антропогенные факторы, сукцессия.

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