Research Article

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Plant biodiversity in Aksay gorge of Trans-Ili Alatau

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Abstrast: Trans-Ili Alatau is the central ridge of the Northern Tien Shan Mountains. It has one of the richest floras, which reflects, with a few exceptions, the flora of whole Northern Tien Shan. However, the strong anthropogenic pressure on natural biocoenoses in the region leads to the destruction of entire communities and populations of plants. The mountain forest belt, located closely to Almaty city and subjected to the most intensive development, suffers particularly from excessive human intervention. First the grassy tier, then the shrubs and undergrowth of forest trees are destroyed due to immoderate recreational load. In addition, losses of many indigenous species and their replacement by introduced weed species are observed. Therefore, the biodiversity of fruit plants was studied in the Aksay gorge of Trans-Ili Alatau. Totally 74 plant species from 58 genera and 27 families were detected at monitoring sites. The most representative family in the floodplain communities of Aksay gorge was *Rosaceae* (12 genera and 18 species), whereas from 15other families only one species was recorded. The Aksai gorge is characterized by intra-zonal plant communities, descending along the floodplain of the Aksai River.

Key words: *Rosaceae*, recreational load, flora, species

Introduction

Ecotourism is a new developing tourism industry, for which the existence and conservation of biodiversity and natural habitats are extremely important. Tourism has a particularly strong impact on the landscape and biological diversity of mountain areas, whose attractiveness is great in wide variety of species and ecosystems, including endemic flora and fauna species. Investigation of the stability of individual components and the landscape overall to a variety of anthropogenic loads, including recreational, is important all over the world for rational planning and use of territories with continuous conservation and maintenance of the natural environment in a stable equilibrium (Uakhitova et al. 2013, Lomas & Giampietro 2017). The landscape functionality in terms of tourism is associated with its attractiveness and aesthetic properties. There are different approaches to assess of landscape aesthetics. From this point of view, the landscape is the only and real "capital of tourism". If in other sectors of the economy there is the possibility of investing, losing and re-accumulating, then in tourism, once losing its main substance - the landscape, the return of "capital" is no longer possible (Müller 2007). As it is worldwide known, the damage of vegetation cover causes the destruction of populations and entire ecosystems with the destruction of rare, endemic and useful plant species. Therefore, the conservation of the vegetation, and in particular, the conservation of Trans-Ili Alatau, located near the largest metropolis of the country and experiencing ever increasing anthropogenic pressure on natural ecosystems, is of great importance for maintaining the natural balance and environmental impact on the vital activity and health of the population.

Trans-Ili Alatau is the central ridge of the Northern Tien Shan Mountains and has one of the richest floras, which reflects with a few exceptions

the flora of whole Northern Tien Shan. Strong anthropogenic pressure on natural *biocoenoses that* now leads to the destruction of entire communities and populations of plants is of special concern for the *conservation* of plant gene pools of Trans-Ili Alatau (Baitulin 2014, Akhmetova et al. 2015). The mountain forest belt, located closely to Almaty city and subjected to the most intensive development, suffers particularly from excessive human intervention.

Since the 1930s on the territory of Trans-Ili Alatau a number of botanists have conducted thematic studies of wild fruit forests because of the presence of the valuable fruit species as *Malus sieversii* (Ledeb) M. Roem and *Prunus armeniaca L.* The conducted studies showed the composition, abundance and distribution of plant *coenoses* in various habitats. The area of natural apple plantations near Almaty was no more than 5000 hectares (Popov 1940), according to other data it reached about 10 000 hectares, where over 170 000 trees were grown (Albensky1951). Kokoreva (2007, 2010) noted a sharp decline in species diversity of the fruit forest ecosystem in Trans-Ili Alatau over the last decades. Especially important among them are the wild apple forests and changes of their status. In May 2016, the International Benetton Research Foundation (Italy) awarded the XXVII *International Carlo Scarpa Prize* for gardens, in the nomination "Wild apple forests of the Tien Shan, Kazakhstan". This is the first prize of Foundation, which is awarded to wildlife objects - apple forests of the Tien Shan, which are found to be world gene pool and the center of the origin of more than 10 000 apple cultivars in the world. 25% of these forests grow in the mountains of Trans-Ili Alatau. The apple forests of the Tien Shan gave rise to all modern apple cultivars. These forests were severely damaged during the years of the Program for the development of mountain fruit growing in Kazakhstan. Along with planting of apple cultivars in Trans-Ili Alatau a massive inoculation of wild apple trees with cultivated varieties was carried out in order to extend the forest area. This led to a violation of the spatial genetic structure of the wild apple trees. Therefore, we carried the study with special attention to these trees in a larger research, aimed to reveal the influence of the level of plant communities' disturbance of the Aksay Gorge of Trans-Ili Alatau on plant biodiversity, depending on tourist routes.

Material and methods

The observations of the main plant communities of the Aksay Gorge of Trans-Ili Alatau within the Ile-Alatau National Park were conducted in accordance with the methods of vegetation study used currently in Kazakhstan. The following generally accepted criteria were applied to assess anthropogenic disturbance (Saparov et al. 2006): A) species composition; B) phytocoenotic role of species (projective coverage, abundance and productivity); C) vitality, generativity, phenological state, habitus, degree of damage to shoots, disturbance of cereal turf; D) the state of leaf litter; E) number and share of participation of synanthropic species in the community.

The assessment of vegetation disturbance (VD) was made according to the following five levels: 0 - background, unchanged vegetation; 1 - low level of VD: weak external manifestations of changes in the habitus of individual species, disappearance of rare or particularly sensitive species, decrease in the number of lichens and leaf litter; 2 - intermediate level of VD: the composition of dominant species was preserved, but certain structural and physiognomic characteristics of communities were changed (e.g. the species composition with enhancing the role of more xerophytic species and the loss of xeromesophytes, mesoxerophytes, dense grass and grasses; the vitality of species was deteriorating; there were morphological changes in the organs of plants); 3 - high level of VD, expressed by changes in the species composition of dominants and edificators, where taproot plant, rootstock, vegetative-mobile species dominated and the species composition of communities was highly modified and depleted but with increased number of juvenile and synanthropic species; the disappearance of old and the emergence of new communities were observed and leaf litter was absent; 4 - very high level of VD.

The trampled area, destroyed undergrowth, damaged trees, the change of forest grasses to meadows and then to weeds were accepted as major signs of recreational impact. Five stages of digression were distinguished (Polyakov 1987). The first stage - the forest leaf litter was not disturbed, there was a complete set of herbaceous plants species inherent in this type of forest, and numerous uneven-aged undergrowth, understory and undergrowth damage was not more than 5% of the total; the area with the soil trampled to the mineral layer did not exceed 1% of the total area. The second stage was characterized by the presence of paths with the initial stage of leaf litter trampling and penetration of the woodland edge species under the forest canopy; the mineral soil layer wss exposed to 1.1-5.0% of the area. At the third stage of digression, the area with soil trampled down to the mineral horizon was 5.1-10.0%, the stand of trees was thinned (up to 10%), understory and undergrowth damages increased to 50-90% and

the increased illumination lead to the introduction of the meadow grasses and weeds under the forest canopy. The fourth stage was characterized by the further thinning of the stand of trees, the clumps of the weakened undergrowth and the understory were among the glades and pathways, the forest leaf litter was completely destroyed in the glades, meadow grasses grow; there was a formation of turf; the area with soil trampled down to the mineral layer was 10.1-25.0%. For the fifth stage of digression, the weakening of woody vegetation was typical –the roots of most trees were exposed and located on the surface, and the trees were sick or have mechanical damages. Most of the area was devoid of vegetation, only fragments of the grass cover were observed; territories completely devoid of grass cover constituted 25- 80% of the total area; the mineralized soil surface was more than 25%.

The following methods were used to determine recreational loads: the plot sampling method was intended to characterize the territorial variation of recreational loads in forest natural complexes and was based on selection of sample plots by the method of stratified sampling; transect method was intended to identify the stages of recreational digression, depending on the ratio of the surface of the ground cover trampled to the mineral horizon to the total area of the surveyed site. More or less homogeneous territory of size 20x20 meters was selected in the forest to conduct geobotanical research. The sample plots survey data were registered in special forms. Standard forms of geobotanical descriptions have been modified for studying recreational disturbances of vegetation.

A total of 13 sample plots (monitoring sites, abbreviated as MS hereafter) located in the shrub-forest-meadow belt (deciduous forests, 1200-1500 m a. s. l. – Baitulin et al. 2015) within the main ecosystems of the Aksay Gorge of Trans-Ili Alatau were studied in 2012-2016. The assessment of the vegetation state on the sample plots was carried out at different stages of vegetation during the whole season. Coordinates of sample plots were installed using the GPS Garmin Trex 30. Data were recorded on geobotanical forms, which were modified to determine recreational loads.

The woody-shrubby vegetation disturbance, caused by various factors, was assessed according to the following parameters: A) a background condition, or a low level of disturbance - the effect of disruption factors was reflected in the morphological state of forests or shrub thickets which retained their floristic composition and structure but changes took place on local sites (up to 30% of the area); B) intermediate level of disturbance – when the transformation of the vegetation cover (shift of forest species, degradation of the shrub or grass layers, loss of biodiversity, reduction of productivity) occurred on a large area (more than 30%); C) high and very high level of disturbance - most of the territory was characterized by the degradation of the soil-vegetation cover, expressed in the tree stand destruction, soil deflation, and the structure and functional connections of the vegetation cover were completely disturbed (Polyakov 1987).

Results

Totally 74 plant species from 58 genera and 27 families were detected at monitoring sites in the Aksay Gorge of Trans-Ili Alatau. The richest among them was the family *Rosaceae* (12 genera and 18 species) and 15 families were represented by a single species (*Pinaceae, Betulaceae, Ulmaceae, Berberidaceae, Urticaceae, Guttiferae, Celastraceae, Campanulaceae, Plantaginaceae, Polygonaceae, Rhamnaceae, Cyperaceae, Urticaceae, Veronicaceae, Violaceae*). The Aksay Gorge is characterized by the intra-zonal plant communities, descending along the floodplain of the Aksay River. In its the middle course the typical wild fruit forest communities were recorded, the first layer of which was formed by *Malus sieversii* (Ledeb.) M. Roem*, Armeniaca vulgaris* Lam., *Crataegus almaatensis* Pojark. and *Crataegus songorica* C. Koch, intermixed with *Acer semenovii* Regel & Herd. and *Padus avium* Mill. Among shrubs typical were *Berberis heteropoda* Kar. & Kir., *Rhamnus cathartica* L., *Lonicera stenantha* Pojark*., L. tatarica* L., *Rosa alberti* Regel*, R. laxa* Retz. and *Cotoneaster multiflorus* Bunge, while *Picea schrenciana* Fisch & C. A. Mey*, Populus tremula* L*., Sorbus tianschanica* Rupr*., Juniperus sibirica* Burgsd. were sporadically found. *Hippophae rhamnoides* L. occurred sometimes in the wild fruit communities.

As a result of field research on vegetation cover, the following communities were registered at the monitoring sites on the leached chernozem: **MS-1**: Dandelion-bluegrass (*Taraxacum officinalis* Wigg*., Poa bulbosa* L.) - Rachkovskaya et al. (2003); **MS-2**: Grass-forb *(Dactylis glomerata* L*., Aegopodium podagraria* L*., Veronica chamaedrys* L*., Alcea rosea* L*., Geranium divaricatum* DC*, Plantago major* L*., Ligularia macrophylla* (Ledeb.) DC, *Taraxacum officinalis);* **MS-3** Grass-forb (*T. officinalis, V. chamaedrys, Trifolium pratensis* L*., Achillea millefolium L., Artemisia absinthium* L., *D. glomerata, P.bulbosa*); **MS-4** Grass-forb (*Arctium tomentosum*

Mill., *Urtica dioica* L., *Geum urbanum* L., *Seseli buchtormense* (Fisch. ex Hornem.) Koch., *G. divaricatum, Vicia cracca* L., *Artemisia absinthium, V. chamaedrys, D. glomerata, P. bulbosa*); **MS-6**: Apple-Shrub (*Salix alba* L., *C. songorica, Lonicera tatarica* L., *Spiraea hypericifolia* L., *Berberis heteropoda* Kar. & Kir., *R. alberti, M. sieversii*); **MS-7**: Barberry - hawthorn (*B. heteropoda, C. almaatensis*); **MS-8:** Forb - Shrub - Apple (*M. sieversii, C. almaatensis, P. avium, L. stenantha, L. altmannii* Regel & Schmalh., *B. heteropoda, R. alberti*); **MS-9**: Forb - Shrub - Apple (*M. sieversii, L. stenantha, L. altmannii, B. heteropoda);* **MS-10**: Forb-Shrub-Apple (*P. bulbosa, P. major, T. pratensis, T. repens* (L.) C. Presl, *V. chamaedrys, Brachypodium silvaticum (*Huds.) Beauv., *Aegopodium alpestre* Ledeb., *G. urbanum, G. divaricatum, T. officinalis, Picea schrenkiana* Fisch et C. A. Mey, *M. sieversii, C. almaatensis, P. avium, P. tremula, L. stenantha, L. altmannii, B. heteropoda, R. cathartica*); **MS-11**: Forb-bluegrass (*P. bulbosa, T. repens, T. officinalis, D. glomerata, Carex melanantha* C. A. Mey); **MS-12:** Forb - hawthorn - Apple (*M. sieversii, C. almaatensis, P. avium, P. tremula, Sanguisorba officinalis* L., *A. alpestre, U. dioica, Aconitum leucostomum* Worosch., *V. cracca, V. chamaedrys, G. urbanum, C. melanantha, Ranunculus acer* L., *Fragaria vesca* L., *B. silvaticum, Lamium album* L., *D. glomerata, G. divaricatum, L. stenantha, L. altmannii, B. heteropoda, R. cathartica, R. alberti, Rubus idaeus* L, *Euonymus semenovii* Regel & Herd.). On the boulder-pebble sediments (**MS-5**) the Forb - Shrub - Apple community (*Rosa platyacantha* Schrenk, *L. tatarica, S. hypericifolia, B. heteropoda, A. tomentosum, G. urbanum, S. buchtormense, G. divaricatum, V. chamaedrys, M. sieversii)* was found.

These communities were characterized by different level of VD. The low VD level was recorded for the community MS-9, which was exposed to anthropogenic impact (broken branches, bonfire, paths), but 85-90% of vegetation remained natural. There was a degradation of zonal vegetation with introduction of weed species. Minor changes in the habitus of individual species and projective coverage of the community were observed. Species - indicators of disturbance (weeds) were quite widespread. The soil profile was destroyed by 0-5 cm. The intermediate level of VD was detected for the communities MS-3, MS-4, MS-6 and MS-7. At the intermediate level of the VD, the composition and structure of the communities was changing, although the dominant composition was preserved. The indicator species became more abundant, the projective coverage was reduced, but could remain the same due to indicator species. Biological karst was not preserved, the vegetation cover was disturbed by 10-30%, road network, fireplaces, paths, locally areas devoid of vegetation, places of spontaneous rest, compaction of surface soil horizons by 5-10 cm. The high level of the VD was noted for the communities MS-1 and MS-10, in which the synanthropic species was *Taraxacum officinale.* There the natural vegetation was less than 5% of the original vegetation, except some areas protected from spontaneous rest. Changes in the species composition of dominants were noted, the disruption indicator (the synanthropic species – *T. officinale*) acted as a subdominant in each of the both communities. An extensive road network, fireplace, paths, locally areas devoid of vegetation, places of spontaneous rest; soil compaction were noted.

At the low level of communities' disturbance, the species composition was represented by at least 18 plant species (18-26 plant species), at the intermediate level of disturbance - the community included not less than 9 species (9-20), and at the high level - less than 9 species (2 -5) were recorded. Thus, an increase in the level of plant communities' disturbance leads to a decrease in the species composition of plants.

Discussion

The analysis revealed that among the communities of wild fruit forests with varying levels of disturbance caused by the recreation in the spring-summer-autumn period, the richest in species was the family *Rosaceae* - 18 species, representing 24,3% of the total number of species. The same family contained also the biggest number of trees and shrubs (13 species). Among the herbaceous plants, the biggest number of species (7) belonged to the family *Asteraceae*. According to the number of genera, again the richest was *Rosaceae* – 12 genera from the total of 55 genera found.

The study revealed that one of the characteristic features of the vegetation cover of Trans-Ili Alatau was the presence of wild fruit communities in which *Malus sieversii*, *Armeniaca vulgaris*, *Crataegus songorica*, *C. almaatensis* and many species of food berry *shrubs*: *Padus racemosa* (Lam.) Gilib., *Cerasus tianschanica* Pojark., *Rubus idaeus*, etc. were found. They are an invaluable gene pool, relatives of cultivated fruit and berry plants. All of them have the gene of resistance to many adverse environmental factors and the fruit quality. The fruits of wild apple trees contain a lot of biologically active substances and microelements, which

are of great value for the food industry, because cultivars lost a number of valuable qualities of their wild predecessors. Therefore, we want to stress here the necessity of protection of the of wild apple forests trough reduction of the anthropogenic impact. All MS of the Aksay Gorge were characterized by varying levels of the vegetation cover disturbance VD with relevant decrease in the plant biodiversity. Doubtless, it is strongly recommended to reduce the anthropogenic load on the plant biodiversity of the Aksay Gorge of Trans-Ili Alatau and one of the possible ways for this is to organize the resting in specially designated places and not to allow the further creation of spontaneous rest sites.

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