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Dynamics of Vegetation of High Mountain Areas of the Northern Tian Shan under Different Protection and Economic Use Regimes

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Abstract:

The territory of Kazakhstan is located in the center of the continent of Eurasia and has a considerable area of 272.5 million ha. This geographical position predetermines a great variety of species of flora and fauna. This research presents the results of studies of the current state of vegetation of the high mountain valley Kok Zhailau, located in the central part of the Ile (Zailiysky) Alatau ridge (Northern Tian Shan), in different modes of its economic use and protection. In the process of the field survey of the territory, classical methods of route floristic and geo-botanical studies were used. The spatial structure and current state of vegetation was studied using methods of detailed path research. A brief description of distribution of the main types of vegetation in high altitude zones was provided. Particular attention is paid to the analysis of coniferous forests from relict spruce Schrenka or Tian Shan (Picea schrenkiana Fisch & C.A. Mey). Recommendations were given on the protection of vegetation and the conservation of biodiversity in the face of an increasing anthropogenic impact, in connection with the proximity of the territory to the metropolis of Almaty. The survey demonstrated that, in general, the vegetation cover in the Kok Zhailau valley was to some extent transformed, and in its natural (background) state it was preserved only in hard-to-reach areas, mainly in the upper part of the mountains (steep slopes of the Kumbel ridge, river valleys, etc.).

***Keywords*:** the territory of Kazakhstan; vegetation cover; floristic zoning; anthropogenic transformation of vegetation.

JEL Classification: Q01; Q50; Q57.

Introduction

The territory of Kazakhstan is located in the center of the continent of Eurasia and has a considerable area of 272.5 million ha. In the direction from north to south, a gradual change in latitudinal zones can be observed: forest-steppe (16%), steppe (28%), desert (44.7%), and in the east and southeast are the high mountains of Altai and Tian Shan frame the territory (11.3%). It is this geographical position that defines the wide variety of species of flora and fauna. The flora of Kazakhstan includes 5.754 species of higher vascular plants, of which 14% are endemic and 387 are listed in the Red Book (1996). Realizing the importance and significance of nature conservation, Kazakhstan, from the first years of independence, has acceded and ratified the main environmental Conventions of the United Nations, including Convention On Biodiversity (1994).

In 1999, in the country, the Ministry of Natural Resources and Environmental Protection of the Republic developed the "National Strategy and Action Plan for Conservation and Balanced Use of the Biological Diversity of the Republic of Kazakhstan" (2002). This document provides information on biodiversity of different regions of Kazakhstan, identifies problems and ways of solving them. The action plan, which provides the main directions of activity for the long-term perspective, is being implemented in stages until now, including with the participation of international organizations (the Global Environment Facility, UNDP – Kazakhstan, etc.). Special attention is paid to mountain ecosystems, where the largest number of flora is located; there are centers of endemism of many rare and useful plant species, as well as rich resources of food, pharmaceutical and other plants. In the year 2000 "The concept for the conservation and development of biological resources to 2030" (2015) was developed to contain the basic principles and requirements for their management and conservation.

The main legislative acts regulating public relations, the fundamental principles and norms in the field of conservation and sustainable use of biodiversity include: The Civil Code, The Land Code, The Environmental Code, The Forest Code, The Water Code, The Code of Administrative Offenses, The Criminal Code, The Laws of the Republic Kazakhstan "On Specially Protected Natural Territories" and the new law «On the Plant World", which is being approved by the Government of the Republic of Kazakhstan. All this demonstrates that Kazakhstan pays great attention to the protection of nature and the conservation of biodiversity. In this regard, of particular relevance are the works in which an assessment of the current state of the vegetation cover is given, including its degree of transformation / degradation in different types of environmental management; and measures are proposed to improve, restore and protect flora and vegetation (Sukhova *et al.* 2018; Dunets *et al.* 2019; Yudaev *et al.* 2019). The results of many years of research on this problem have been included in the elective courses of biological disciplines, which develops the aspects of studying the biodiversity of vegetation, environmental measures and, in general, the environmental education of undergraduate students of natural departments of universities.

1. Materials and Methods

During the field examination of the territory, classical methods of route floristic and geo-botanical studies were used. During the field research, herbarium samples of plants were collected, which are stored in the herbarium of the Institute of Natural Sciences and Geography of Kaz.NPU named after Abay, Almaty. Plants were identified using herbarium specimens and special publications: Flora of Kazakhstan (Pavlov 1967), Identifier of plants of Central Asia (Adylov and Tsukervanik 1996), and Illustrated Identifier of plants of Kazakhstan (Goloskokov 1972). The spelling of Latin names in the text, nomenclature changes of taxa were verified in accordance with S.K. Cherepanov (1995).

The spatial structure and current state of vegetation was studied using methods of detailed route research. The elementary structural units of the study and mapping of vegetation were plant communities and their various spatial combinations (complexes, series, ecological series) (Bykov 1978). Particular attention was paid to assessing the degree of anthropogenic transformation of the vegetation, based on specially developed criteria. Geo-botanical descriptions of plant communities at the observation points were carried out on test sites measuring 100 m^2, and their coordinates were recorded by GPS. When describing plant communities, we took into account: full floristic composition; the abundance and distribution of certain plant species: height and layering; life status and phases of the phenological development of species; general projective soil cover by plants, nature of species distribution, aspect, environmental conditions (topography, soil type, nature of moisture, etc.); the percentage of contribution of species – indicators of degradation. The studies were carried out in the high valley Kok Zhailau (translated from the Kazakh language – Heavenly Pasture), located in the central part of the Ile (Zailiysky) The Alatau ridge, which, according to natural physical and geographical zoning, is part of the Zailiysky Alatau region, Northern Tian Shan province, countries of the Tian Shan mountains (Veselova *et al.* 2010; Kasakova *et al.* 2019).

The Ile Alatau ridge forms a wide arc, convex to the south. Its length is about 300 km, width is 35-40 km. The Kok Zhailau valley is located in the central part of the northern macro slope of the ridge, in the altitude range from 1800 to 3230 m above sea level and is a mountainous, highly rugged terrain (plateau) with numerous rivers and streams. This position of the valley determines the specific features of the microclimate, topography, soil, and vegetation. In the lower, foothill-lowland part, the largest city in Kazakhstan – Almaty is located. The territory has a complex geological structure, due to wide development of Precambrian and Lower Paleozoic metamorphic formations, as well as intense, repeatedly manifested, tectonic processes (Bekzhanov *et al.* 2010; Ibragimov *et al.* 2014). The bottoms of the valley are composed of alluvial-proluvial deposits. The relief features are mainly due to tectonic dislocations and water erosion in valleys of mountain rivers. Here significant areas are occupied by gorges and deeply incised river valleys. Slope processes are developed in places: screes, landslides, avalanches, rockfalls.

The climate is temperate continental, with minimal daily and annual fluctuations in the temperature and humidity. The total solar radiation per year, with clear sky, is 7439 MJ/m^2 . The duration of sunshine is 2348 hours per year. The number of days without sun is 49. The minimum average temperature varies from – 43°C to the lower boundary – 9.7°C on the upper maximum range it is respectively +18.1 and +10. 6°C. The frost-free period lasts 145 days at the bottom and 90 days at the top (Gvozdetsky and Nikolaev 1971). The territory under consideration, according to floristic zoning, is part of the floristic region Zailiysky- Kungey Alatau. This is a typical flora of the North Tian Shan floristic province (Kamelin 1973). According to the latest data (Baitulin *et al.* 2017), the total composition of flora of the Ile Altau ridge includes 2321 species of higher vascular (ferns, gymnosperms and flowering) plants belonging to 688 genera and 128 families, of which 64 are rare and endangered and 164 are endemic. In the Kok Zhailau valley and on adjacent mountain slopes, the diversity of flora species is quite large (approximately 700-800 species), within different altitude zones, in the range of 1800-3230 m above sea level (Ibragimov *et al.* 2019).

Assessment of floristic diversity was carried out in spring and at the end of summer of 2016. The study was not aimed at identifying the complete composition of flora species. Basically, in the process of research, species characteristic of different types of vegetation were fixed. They give an idea of the key species of flora, which include plants that dominate plant communities, as well as rare, endangered, including relict and endemic species listed in the Red Book of Kazakhstan (1996), which determine the uniqueness of the region's flora; species – indicators of specific environmental conditions; useful plants for humans and animals. The same species may be included in several of these groups. In general, in the valley Kok Zhailau to the number of main types, include 240 plants from which 85 are dominant, rare – 34, relict – 9 endemic – 6, indicator – 20 having economic value – 86 species. At the same time, it should be mentioned that the greatest number of species is characterized by their rare occurrence and low abundance in plant communities of the lower, accessible part of the valley, in comparison with similar places of growth in hard-to-reach areas. This is evidence of a fairly strong anthropogenic impact, especially on mountain pastures.

2. Results and Discussion

2.1. Characteristics of Vegetation in the Territory of the Ile Alatau Ridge

The Ile Alatau ridge, according to the latest system of botanical and geographical zoning of Kazakhstan and Central Asia, is located within the Zailiysky mountain sub-province, as part of the Dzungar-North Tian Shan province, Iran-Turan sub-region, Sahara-Gobi Desert region (Volkova *et al.* 2006). According to the physiognomic classification, 5 types of vegetation are widespread in the Ile Alatau mountains: woody, shrubby, grassy meadow, grassy steppe, grassy marsh, low shrub and semi-shrub. Flora and vegetation of Ile (Zailiysky) Alatau are quite well studied (Goloskokov 1949; Rubtsov 1956; Bykov 1950; Baitenov 1985; Roldugin 1989; Ivashchenko 2012; Baitulin *et al.* 2015), but no special studies have been done in the Kok Zhailau valley. This study gives a brief description of the altitudinal-zonal distribution of vegetation within the Kok Zhailau valley, including a mountain elevation – the Kumbel ridge (3230 m above sea level) (Figure 1). In connection with more humid conditions, in comparison with other ridges of the Northern Tian Shan, in Ile Alatau, E.A. Volkova (2003) distinguishes a special Zailiysko-Severo-Dzhungarsky type of mountain zone of vegetation, which is part of the Dzhungar-Severo-Tyanshansky group of zone types, characteristic of mountain ranges located within the North Turanian (subboreal) deserts. Moreover, we share the opinion of V.B. Sochava (1979), who believes that "alpine" stencils should not be transferred to the highlands of continental regions and suggests that they use the terms "alpinotype" and "subalpinotype" belts, which are specific for the composition of the flora in the mountains of Kazakhstan and Central Asia.

Figure 1. Vegetation of the Kok Zhailau mountain valley

Elfin form of Picea schrenkiana in highlands

Spruce woodlands with juniper

Subalpine meadows

Malus sieversii in bushes

1. Meadow-shrub-coniferous-forest (spruce) belt – 1800-2700 (2800) m above sea level belt, in combination with meadow-steppe, on the southern slopes. It is characterized by differentiation of vegetation along the slopes of different exposure. On the northern slopes, coniferous forests from the relict spruce Schrenka or the Tian Shan (Picea schrenkiana) in combination with mountain meadows dominate. Petrophytic steppes are formed on the southern slopes in combination with bushes. In the lower part of this belt (1800-2200 m above sea level), grow the coniferous spruce forests (Picea schrenkiana), with undergrowth from the Tian Shan birch (Betula tianschanica), Tian Shan mountain ash (Sorbus tianschanica), willow Iliysky (Salix iliensis), rarely aspen (Populus tremula) and shrubs (Rosa laxa, Lonicera altmanii, L. karelinii). In the grass layer, medium-sized herbs (Aegopodium alpestre, Brachipodium pinnatum, Geranium rectum, Cicerbita azurea) dominate. In open areas, large areas are occupied by mountain meadows (Dactylus glomerata, Avenastrum tianschanicum, Agropyron curvatum, A.turkestanicum, Festuca alatavica, Poa calliopsis, Anthoxanum odoratum, Alchemilla retropilosa, Polygonum songaricum colum, leontopium campumum, Tenola, Geontolia, Tenola shrubbery (Lonicera altmanii, L. karelinii, Spiraea tianshanica).

Deciduous forests are not widespread and are found on slopes adjacent to river valleys. Birch forests (Betula tianschanica) predominate, often with spruce (Picea schrenkiana), less often aspen-birch (Betula t ianschanica, Populus tremula). They are usually composed of Iliya willow (Salix iliensis) and Tyan mountain ash (Sorbus tianschanica), as well as abundant shrubs (Rosa albertii, Rosa laxa, R. platyacantha, Spiraea lasiocarpa, Lonicera altmanii, L. karelinii, Cotoneas teriflorata multiflora) Floodplain forests are confined to the valleys of rivers flowing from the mountains. They are different from mountain forests in the composition of flora with a predominance of mesophytic species. Forest-forming species are: Tian Shan birch (Betula tianschanica), willow (Salix iliensis, S. alatavica, S. tianschanica), Tian Shan mountain ash (Sorbus tianschanica), hawthorn species (Crataegus altaica, C. turkestanica) with Schrenka spruce (Picea schrenkiana). Single trees of the wild apple tree of Kirghiz (Malus kirgisorum) and the apple tree of Sievers (Malus sieversii) are rarely found, here they are at the

limit of their altitudinal distribution. There are many shrubs in the undergrowth: meadowsweet species (Spiraea tianschanica, S. hypericifolia), rose hips (Rosa laxa, R. platyacantha), cotoneaster (Cotoneaster multiflorus), honeysuckle (Lonicera altmanii, L. karelinii), drumaris a (Berberis heteroda).

In the middle part of the belt (2200-2600 m above sea level), the only forest-forming species, in fact, is spruce (Picea schrenkiana), there are areas of closed grass and mossy spruce forests (Thudium abietinum, Hylocomium proliferum, Poanemorosa, Pyrola rotun difolia , Cystopteris fragil is). The Tyan Shan mountain ash (Sorbus tianschanica) and bushes are abundant in the undergrowth: Meyer currants (Ribes meyeri), species of honeysuckle (Lonicera stenantha, L.altmannii), cotoneaster (Cotoneaster melanocarpus, C. multiflorus), wild rose (Rosa albertii,) and euonymus Semenov (Euonymus semenovii). In the upper part of the belt (2 600-2800 m above sea level) predominate park-like spruce forests (Picea schrenkiana) with juniper (Juniperus pseudosabina, J.sabina) and grass cover from undersized species of forbs (Alchimilla sibirica, A. retropilosa, A.tianschanica Geranium saxatile, Trollius dshungaricus, Phlomis oreophyla). Depending on the relief elements and the moistening regime, they form various combinations with high-mountain subalpinotypic cuff-grass meadows (Alchemilla retropilosa, Polygonum songaricum, Leontopodium campestre, Festuca alatavica, Poa calliopsis) and cryopetrophytic steppes. The soils of the coniferous forest belt are mountain forest chernozem-like and dark-colored peaty.

In Kok Zhailau valley, large areas are occupied by grass-rich-herb-and-grass-grass-middle-mountain meadows on the plains of the plateau and forest glades. They are transformed to a strong and medium degree as a result of cattle (mainly horses) grazing. The cocksfoot (Dactylis glomerata) dominates in the grass from grasses, and large ranunculus (Ranunculus grandifolius), cuff species (Alchemilla sibirica, A. retropilosa, A. tianschanica, etc.) and oregano (Origanum vulgare) do not eat cattle. In variable abundance there are typical Ile Tau types of grasses (Poa pratensis, Alopecurus pratensis, Hedisarum neglectum, Iris ruthenica, Geranium saxsatile, G. albiflorum, Allium samenovii , Astragalus alatavicus, Vicia semenovii, Lomatogonium carinthiac um, Nepeta transiliensis, Campanula glomerata, Adenophora hymalaena, Inula helenium, Plagiobasis cent auroides, Aconitum songoricum).

The mountain slopes and elevations are associated with upland meadows with a multidominant cereal grass from the Phleum phleoides, downy oat-grass (Helictotrichon pubescens), smooth bromegrass (Bromopsis inermis), and Poa angustolia. Forbs are represented by species Phlomis pretense, Ph. Tuberosa, Ligularia alpigena, L. heterophylla and others. Soils are meadow podzolized and meadow humus-carbonate. Mountain steppes are confined to the slopes of the southern exposure, which form combinations with shrubs with dominance of xerophytic species (Juniperus pseudosabina, Spiraea hypericifolia, Cotoneaster multiflorus, Cerasus tianschanica). Petrophytic steppes, which are confined to cliffs and thin gravelly-stony soils, are dominant, with dominance of turfy cereals: types of feather grass (Stipa zalesskii, St.lessingiana, St. kirghisorum), alpine oatgrass (Nonlictotrichon pubescens, H.shellesesta, type) Cirrus peduncle (Brachipodium pinnatum), as well as petrophytic forbs (Polygala hybrida, Sedum hybridum, Dianthus turkestanicus, Chenopodium botrys, Hypericum scabrum, Ziziphora clinopodioides, Patrinia intermedia, Hedysarum neglectum, H. songaricaprophis nepetris, Neparicephritis nepetris, Neparicum nephris, Nepetrophis nectrum, frutescens, A. eryrifolia, Cotoneaster melanocarpa, C. uniflora, Spiraea hypericifolia). The soils are mountain-meadow-steppe and meadow-steppe peaty.

2. The subalpinotype juniper -meadow-steppe belt – 2700-2800 (3000) m above sea level is distinguished by the greatest floristic and phytocenotic diversity. The main cover is formed by medium grass, cryophyte, subalpinotipnye meadow with dominance of cereals (Dactylis glomerata, Alopecurus soongoricus, Aveastrum pubescens, Poa sibirica, Hierochloe odorata, Agropyron ugamicum) and grasses (Rhodiola linearifolia, Doronicum turkestanicum, Pyrethrum karelinii, Phlomis oreophila, Trollius dschungaricus, Delphinium confusum, Aquilegia glandulosa) and others. Cryophytic steppes predominate on the south slopes. Of the cereals, the most abundant species are fescue (Festuca musbelica, F. alatavica F. kryloviana), alpine oatgrass (Helictorichon hookeri, H. altaicum, H. tianschanicum), chimgan scaly (Elymus tschimganicus). Wormwood species (Artemisia ashurbaevii, A. rupestris, A. borotalensis) and forbs (Aster alpinus, Dragocephallum altaense, D.integrifolium, Goniolimon o rthocladum, Thymus marschallianus) also play a dominant role. Considerable areas are occupied by juniper thickets (Juniperus pseudosanina, J. sabina), with a dwarf shape. Spruce forests (Picea schrenkiana) with juniper and rich forbs in the lower tier are confined to the northern slopes. On the upper boundary of this belt, on the northern slopes, there are small groups or single spruce trees (Picea schrenkiana), while they often have a flag-shaped crown, and at the top they develope a dwarf shape (Picea schrenkiana, f.prostrata) and are almost pressed to the ground. The soils are the mountain meadow subalpine and the alpine meadow-steppe leached.

3. The alpinotype cryophytic-steppe-meadow belt – (2800 – 3100 (3230) m above sea level) is characterized by the alternation of surface levels, rocks and steep slopes. In the vegetation cover, according to the relief elements, low-grass cryophytic alpinotype meadows and steppes alternate. They differ in floristic diversity and mosaic structure of vegetation. The groups are dominated by cold-resistant species of cereals (Stipa regeliana, Festuca alatavica, F. kirilovii, Poa calliopsis, P. alpina, Anthoxanthum alpinum, Phleum alpinum, Deschampsia caespitosa), cotton grass (Eriophorum scheuchzeri). Abundantly present are sedges (Carex pamirensis, C. tianschanica, Carex melanantha). Among herbs prevail (Polygonum nitens, P. viviparum, Erigeron aurantiacus, Saussurea involucrata, Gentiana algida, G. kaufmanniana, Anemone protracta, Viola altaica, Papaver croceum, P. tianschanicum, Euphorbia alatavica). Kobresia meadows (Kobresia humilis, K. capilliformis) are very rare here. Mountain small-soddy cryophytic steppes are formed by grass turfs (Festuca alatavica, Roa glauca) and forbs (Minuartia verna, Androsace s ericea, Eri trichium villosum). Along the gravelly ridges there are Alatavian rutovnik (Callianthemum alatavicum) and edelweiss (Leontopodium leontopodine). At rock outcrops and rocks, groupings of lithophytes are common: lithophytes: onion (Allium schpenoprasoides), violet podice (Pedicularis violascens), two-flowered cinquefoil (Potentilla biflora). Soils on the steep slopes of the northern, northeastern and northwestern slopes are mountain-meadow alpine, and on the southern slopes are alpine thin.

2.2. Factors of Anthropogenic Transformation of Vegetation

The research showed that, in general, the vegetation cover in the Kok Zhailau valley is to some extent transformed, and in its natural (background) state it was preserved only in hard-to-reach areas, mainly in the upper part of the mountains (steep slopes of the Kumbel ridge, river valleys, etc.). The main factors of vegetation transformation are: long-term use of the territory for high mountain pastures; lumbering in the Tian Shan in the Soviet period; fires in spruce forests and in the surrounding area; use of the territory for tourist and recreational purposes. The distinctiveness of the Kok Zhailau valley is that here, at different periods of time, the regimes of economic use of the territory radically changed, and the vegetation became an indicator of these changes. Due to its proximity to the city of Almaty and its fairly good accessibility, for a long time, over 100 years, the Kok Zhailau valley was intensively used as high mountain summer pasture (jailau) for grazing cattle, especially sheep and horses. The greatest pasture load was observed here in the Soviet period (1950-1991) which continued until the organization of the Ile-Alatau State National Natural Park (1996), which included the Kok Zhailau Valley. During the same period, forest harvesting was carried out on a large scale, mainly the relict spruce Shrenka or Tian Shan (Picea schrenkiana) was cut down.

As a result of long-term exploitation as pastures, in areas not covered by forest, the floristic composition of the grass has significantly deteriorated due to the loss of valuable, fodder plant species, mainly from the families: Pooideae (Poaceae Barnhart), Faboideae (Fabaceae Lindl.), Rosaceous (Rosaceae Juss.) Asteraceae (Astera ceae Dumort.) And others. Representatives of the Ranunculaceae Juss., Nettle (Urticaceae Juss.), Lamiaceae (Lamiaceae Lindl.), Celery (Apiaceae Lindl.), figwort (Scrophylariaceae Juss.) and others began to play a dominant role in plant communities. This led to the loss of the forage value of pastures and biodiversity as a whole. Moreover, excessive cattle grazing destroyed seedlings of woody and shrubby plants, which negatively affected the reproduction of forests. In addition, forests often burned out from fires; the fire was especially strong and large in the area in 1972, when the largest masses of forests burned out (Kshi Kumbelsky Gar).

In 1996, the situation changed entirely after creating in the Trans-Ili Alatau mountains of the Ile-Alatau State National Natural Park, a total area of 202 292 hectares, in the context of the state program on the development of a network of specially protected natural territories of the Republic of Kazakhstan (Ivashchenko 2006). The national park includes the mountain valley Kok Zhailau, within which, on an area of more than 2500 hectares, a conservation regime for the protection of natural complexes and biodiversity (ecological stabilization zone) was established in combination with a regime of tourist and recreational activities on individual sites and tourist routes. This, to some degree, contributed to the natural restoration of flora and vegetation, both as a whole throughout the park and in the Kok Zhailau valley (Nevkrytaya *et al.* 2020). At the same time, in the most accessible areas, as a result of active tourist activity, an extensive network of paths was formed, which became local concentrations of erosion and planar soil erosion.

The protection regime in this territory was sustained for 20 years, but due to the proximity of the city of Almaty and difficulty of controlling unorganized tourism, as well as the continuous grazing of horses, a complete restoration of natural vegetation has not yet been observed. At the same time, there is a positive trend, in particular in forests where cuttings were stopped and there is a good natural regeneration of spruce and other tree species, shrub undergrowth and grass cover. Consequently, the vegetation of forests is currently in satisfactory condition. Evidence of a insufficient degree of transformation of natural spruce forests is the presence

and dominance of weed and ruderal species in the grass layer, as well as low rates of projective soil cover by plants (40-60%) compared with untouched forests (80-100%). This contributes to washing away of the fertile soil layer during heavy rains, which negatively affects the settlement and seed regeneration of plants. In some areas, these processes are aggravated by hiking trails, which are foci of water erosion.

In the vegetation cover of alpine, subalpine, and true meadows, despite their floristic richness, dominance of cattle and poisonous plant species (Origanum vulgare, Ranunculus grandifolius, Alchemilla sibirica, A. retropilosa, A. tianschanica) remains intact. This is the legacy of the past long-term use for pastures, as a result of which niches were occupied by non-eatable and poisonous plants, which, thanks to their environmental strategy, hold their positions in plant communities for a long time, preventing other plants from multiplying. Hence, it can be stated that alpine-type and subalpine-type meadows are slightly transformed, and background, undisturbed communities are preserved only in inaccessible areas. Real meadows, which prevail in the intermountain valley of Kok Zhailau, were transformed to a moderate degree and to a strong degree, since their composition remains dominated by many weeds and non-cattle plant species; also the horse grazing still continues. Everywhere, in the best condition, steppe communities were preserved in areas confined to the slopes of the southern exposure. Only in local areas adjacent to the Kok Zhailau valley, they were transformed to a moderate and small degree, and in the highlands, after the organization of the national park, they recovered almost to their natural state. This is due to the fact that turf cereals dominate in the composition of the communities, which reproduce well both in the vegetative and seed ways. In addition, they are resistant to trampling, and moderate grazing is necessary for the normal development of vegetation, in particular forbs. Shrubs everywhere remain in satisfactory state and are practically not affected by the transformation, as they are impassable, often prickly and poorly eaten by cattle (Espenbetov *et al.* 2017; Pashtetskiy *et al.* 2020).

In 2015 the lower part of the valley Kok Zhailau (1002 ha), adjacent to the city Almaty was withdrawn from the territory of Ile-Alatau State National Natural Park, since this area was planned for construction of a large ski resort (Decree of the government of the Republic of Kazakhstan No. 1267…2014). Still this area certainly it will not be used as pasture, since this land is near the city Almaty, but its availability for recreational and other purposes will increase many times, due to developing infrastructure. So, at present, the acute question is what will be more preferable from an environmental point of view: a ski resort with developed infrastructure and aesthetics of the landscape as a whole, or wildlife, which, as the experience of the adjacent territories shows, can be littered with garbage in quite short time, the slopes will be cut by paths, traces of ATVs, etc. Preserving wildlife in its original form near a metropolis with a population of more than 2 million people is not realistic, judging by the surrounding territory, outside the national park. In this regard, it is necessary to direct all efforts to the maximum conservation, in a natural state, of natural ecosystems and biodiversity. This is especially true for the conservation of unique forests from the Shrenka spruce (Picea schrenkiana), which grow exclusively in the Tian Shan mountains, more than 70% of their range is in Kazakhstan, and a pronounced forest spruce belt is characteristic only for the Ile Alatau ridge.

2.3. Current State of Spruce Forests

Significant areas in the Kok Zhailau valley are occupied by coniferous forests, the main forest-forming species is a relict species – Schrenka spruce or Tian Shan. Spruce Schrenk (Picea schrenkiana Fisch & C.A.Mey) is a slender evergreen tree with a dense narrow-cylindrical or conical crown. Under the best conditions, growth sometimes reaches a height of more than 45 meters and a diameter of 2 m. The needles are dark green or pale bluish green up to 40 mm long, life expectancy of 20 years or more. Branches are slightly dangling or horizontal (especially in the upper part of the crown), less often upward directed. Young branches, as a rule, are not pubescent. The bark of the tree is dark gray, less often reddish. Cones are cylindrical 8-12 (from 2 to 18 cm) in length and up to 2.0-2.5 cm (with unopened scales) width, glossy black, less often green. Seeds and their wings are brownish. In the fruit – a double set of chromosomes 2n = 24. In the upper part of the spruce belt, Schrenka spruce can reproduce vegetatively, the lower branches lying on the soil give additional roots. Trees live up to 200 – 400 years. The age limit in alpine habitats is 550 years (Pavlov 1967).

In the highlands, on the upper border of the forest, the dwarf form of Schrenka spruce (Picea schrenkiana f.prostrata K. Isakov) is rare and occasional, many researchers consider it as an independent species, therefore it is listed in the Red Book of Kazakhstan (1996) plants. Such spruce grows in single occasions along crest ridges and rocky valleys, has a rounded squat shape, up to 1.5 m high, since its growth in high mountains is limited by severe climatic conditions (strong winds, long periods under snow, etc.). I.I. Roldugin (1983) made experiments on its transplantation into the belt of a natural spruce forest and showed that an ordinary Schrenka spruce grows out of this form, despite this, the issue remains an arguable point to this day.

Artificial plantations of Schrenk spruce. In Kok Zhailau valley there are some artificial spruce plantations (forest plantations), their total area is 19.2 ha. The main hiking trails and the forestry road pass through them. During the field examination, there were no signs of plant inhibition, both in the immediate vicinity of the paths and at different distances from them. In the plantations, a steady increase in height was noted, which is characteristic of the size of normal forest plantations of Schrenka spruce. In some areas of planting, it is dense, so there are dry trees. In general, the overall state of forest crops can be assessed as satisfactory. Spruce forests have great water control, water conservation, soil protection and anti-mudflow significance, they also serve as the habitat for many species of plants, animals and birds. Their water conservation value lies in the fact that loose and water-intensive soils accumulate incoming rainfall, turning usually fast surface runoff into a slow, subsoil. As a result of this, instead of destructive and useless spring floods, the accumulated moisture for a long time feeds the mountain rivers, supplying agricultural land at the foothills of the plains.

The protective role of spruce forests is also expressed in a very strong bonding of soil cover with closed and even spruce root systems in the upper soil horizon. In the space occupied by forest, the roots form a kind of very strong “skeleton of forest soil”, which protects it from erosion and drift. The recreational role of spruce forests is determined by phytoclimatic features: a temperate forest climate, cleanliness of forest air (with a minimum number of bacteria), and its saturation with bio lines and phytoncides. Spruce forests on the steep northern slopes (210-350) are represented by medium-closed (P = 0.5-0.7, rarely 0.8 or more) moss-grass and (lithophytic) spruce forests of III- IV class *bonitas*. On the gentle slopes of the valley grow grass-moss spruce forests of class II *bonitas* and, to a much lesser extent (leveled areas along the Teresbutak river), a bush of arnica-willow-mountain ash I (II) -III class *bonitas*. In the upper strip of the spruce belt, even on the slopes of northern exposures, spruce forests are represented by natural open spaces (P = 0.1-0.2. 2) and meadows with spruce trees standing separately.

The steady state of the spruce forest is always characterized by a rather stable state of the dominant coenopopulation of Schrenk spruce. According to the results of research B.A. Bykov (1950) this is ensured by the continuous maintenance of the entire range of age spectrum of spruce samples from young to mature and old, and by the gradual replacement of dying trees with new ones. It is this life strategy that ensures the stability of the substance cycle, soil-forming processes, the optimal distribution of ecological niches, the stable state associated with the dominant biota species, the balanced biomass production at all trophic levels and steady energy flow, that is, the normal functioning of the entire spruce forest ecosystem as a whole. In this steady state, the spruce forest ecosystem can exist for centuries, despite the fact that it annually experiences a variety of processes that are related to climate change. Under normal conditions, the process of spruce formation (syncogenesis) is ongoing, which proceeds rather quickly, on the basis of types that already exist in nature, due to the programming in the spruce genomes (Bykov 1950). In this regard, it is especially important to preserve natural spruce forest and maintain it in good condition. There is a slow process of restoration of spruce forests after destructions (fires, logging, damage by diseases and pests, etc.). With prolonged directed negative impact of various factors, the restoration of the spruce forest may slow down or stop completely.

In the 60-80s of the Soviet period, as a result of a strong frontal impact of anthropogenic factors (logging, cattle grazing, and frequent fires), the areas of spruce forests in the Northern Tian Shan as a whole and in the Kok Zhailau valley in particular decreased significantly. In large areas, the spruce forest was completely reduced for various reasons, and in its place, in the first stages, meadow phytocenoses were formed with the dominance of digression-active species of flora: rosebay willowherb (Chamaenerium angustifolium) in the former burnt areas, species in grazing areas buttercup (Ranunculus repens, R. grandifolius), forest cuttings – types of lady’s mantle (Alchimilla retropilosa, A . retropilosa, A. sibirica, A. tianschanica). In the conditions of maintaining the regime of intensive use of forests in the Kok Zhailau valley, these succession stages could be long, but due to the creation of the national park and cessation of intensive economic activity, the rate of vegetation restoration was faster than in areas where it did not stop. Presently, there are spruce trees that sprout naturally, as well as recovering from landslides, felling and fires. According to most researchers, one of the main causes for the weak regeneration of Schrenk spruce in the Northern Tian Shan is the summer grazing of livestock (Bykov 1950; Roldugin 1983). Our studies have confirmed this and have demonstrated that the effect of cattle grazing on the southernmost insulated slopes, especially during the decay of plantations, that is, when the seedlings and young adolescents were still sparse and stunted, is especially detrimental.

Nonetheless, it turned out that in some areas moderate grazing is useful and even necessary, for example, at the lower border of the middle strip of the spruce belt, in mixed-moss and grass-mixed grass phytocenoses, where Schrenka spruce renews quite well. This is due to the fact that animals disrupt, or partially knock out, the grass cover, especially rhizome cereals, making depressions in the moss cover to the mineralized

layer. As a result, conditions are created for the successful fixing of spruce seeds and their germination. The negative impact of cattle grazing was noted in meadow areas, which were formerly cattle camps. Here, mass overgrowth by ruderal nettle species (Urtica dioica, U. cannabina) is observed. This stage is quite long in time, since tall and dense thickets of nettles do not allow other plants to settle.

Another, new, for the Zailiysky Alatau type of transformation of spruce forests can be termed “windfall”. This is the only case of windfall in the entire history of the spruce forests of the Tian Shan. It was observed on May 17, 2011 in the Medeo tract, during the strongest hurricane, with gusts of wind over 40-45 m/s, as a result, in 2–4 hours, 11.4 hectares of valuable forest were destroyed. Huge centuries-old spruces fell like matches, the roots were naturally uprooted and laid bare. So far, cleaning the clutter and restoration of forests in these areas has been carried out on a small scale, the main reason is the steep slope and lack of special equipment. The features of the restoration of spruce forests, damaged or completely destroyed as a result of hurricanes and windbreaks, are practically not described in the literature. Currently, the recovery process is going on as a natural renewal. In areas where centuries-old spruce trees are uprooted, deep funnels were formed that quickly grow with tall herbs and shrubs that obscure the spruce seedlings; therefore, the restoration stage through shrubs can be long.

In the period when this territory was a part of the Ile-Alatau National Park, in some areas, changes of non-forest ecosystems to forest ones were observed, with Schrenka spruce dominating. For example, in some sections of mountain meadows, deep potholes from intensive grazing of cattle began to grow with spruce. In the upper part of the spruce belt (2600-2900 m above the sea level), in many areas, the formation of spruce forest in the place of juniper shrubs (Jniperus pseudosabina, J. turkestanica) is observed. This is accompanied by the formation of sparse shrub spruce forests (Picea schrenkiana, Jniperus pseudosabina) with abundance of forbs (Phlomis oreophila, Poa nemoralis, Poligonum viviparum, Anthoxanthum odoratum). In the Kok Zhailau valley, such recovery successions cab be observed mainly on the slopes of the western exposure.

2.4. Impacts from Tourist and Recreational Activities in the Kok Zhailau Valley

Since 2015, when almost half of the valley (the lower part) was withdrawn from the national park and spontaneous tourism has intensified here, accompanied by the development of a network of trails and, accordingly, the intensification of water erosion and planar soil erosion, which hinders plant settlement (Decree of the government of the Republic of Kazakhstan No. 1267…2014). The relief features in the areas of spruce forest growth, to a large extent, limit the possibility of free movement of tourists along them. Despite the uncontrolled flow of hikers, strong recreational degradation of spruce forests here is not observed. Tourists are transported along permanent paths with a width of no more than 0.5 m. Intensive multiple mechanical damage to plants is noted in the area of the mouth of the river. Terisbutak (over about 500 m upstream of the Kazashka River). There are several constantly operated parking places and sites for short-term tourist recreation. The total area of spruce forests subject to recreational degradation does not exceed 4-5 ha. In this situation, regardless of whether or not a ski resort will be built, tourism and recreation will be a priority, since the accessibility, unlike the territory of the national park, has become unlimited. In this regard, the city authorities must timely take care of the development of ecological tourism here. The basic principles of ecological tourism are: conservation of biological diversity and ethnographic status of recreational areas; improving the ecological culture of participants in ecotourism.

When using the site for recreational purposes, it is very important to estimate the allowable recreational load and the recreational capacity of the territory. The sustainability of each natural complex, including relation to recreational loads, varies depending on a number of environmental factors:

- soil moisture (balanced soils are most stable; with drying or moistening, resistance decreases);
- soil mechanical composition (light loamy soils are the most stable; with weighting or lightening of the mechanical composition, stability decreases);
- thickness of the humus horizon of the soil (the thicker it is, the higher is the stability);
- the thickness of loose soil deposits (if the rocky base comes close to the surface, stability decreases significantly);
- surface slope (the larger it is, the lower is the stability);
- the composition of the trees and the structure of the root system of the main tree species (for the temperate zone of the northern hemisphere, the most stable are small-leaved species, the least stable are coniferous species, especially spruce);
- the average age of the stand (the higher it is, the greater the resistance, but this is only up to the age of maturity – then the resistance falls again);
- natural forests (with rare exceptions) have higher sustainability than artificial ones.

In this regard, recreational loads should be estimated separately for each type of vegetation, taking into account the varying degrees of their resistance to different types of exposure.

During visiting natural sites (forests, floodplains), there is a strong chaotic trampling of areas, both areal and linear. In this regard, it is necessary to provide for the creation of a network of paths and trails, especially in the most visited areas, to prohibit the movement of pedestrians on natural soil and vegetation cover, and to develop special routes that should be shown on maps. When calculating the load norm for a route, it is important to consider the degree of "aggressiveness" of visitors in relation to nature. As a rule, short-term excursions are considered as the least aggressive type (National strategy and plan of action…2002; The concept of the conservation…2015; Mityaev 2014). If we are talking about amateur tourism, the load standards should be 6-7 times lower than excursion ones. At the same time, the indicators of aggressiveness are understood as consequences that do not depend much on the behavior of visitors (for example, trampling the territory), and the results of their direct actions in violation of environmental regulations. These include the formation of bonfires unplanned by tourism organizers, the collection of berries, flowers, mushrooms, as well as various "souvenirs" of nature such as geological rocks, snags, etc. as well as making noise, littering, etc. To correct the areas of recreational capacity and load, it is necessary to carry out annual monitoring of the state of natural complexes in the territory and to limit and temporarily close disturbed areas until the restoration is complete.

The proximity of Almaty city, the accessibility of the Kok Zhailau valley and uncontrolled tourism and recreational activities over time will undoubtedly be accompanied by the transformation of vegetation and the transformation of the territory into an urban landscape. In this regard, in order to preserve areas of untouched nature, their altitude zones and standards of biodiversity, it is necessary to take care of the concentration of tourists and vacationers in certain areas. At the same time, it is essential to provide various alternative opportunities for recreation, leisure, sports, etc., which will allow to concentrate the mass of visitors in certain places (recreation areas, resort, sports grounds, tourist routes, etc.

Conclusion

At present, the spruce forests and woodlands of the Kok Zhailau valley are in relatively good condition, since in the last 20 years there have been virtually no fires nor felling. Despite the fact that this territory is no longer a part of the national park, it remains in its protective (buffer) zone, where, according to the Law of the Republic of Kazakhstan "On Specially Protected Territories", the state of forests is monitored by safety inspectors from the park. But at the same time there are no prohibitions and restrictions on the number of visitors, which will contribute to an increase in the recreational load with all other consequences that are not favorable for the wildlife. Therefore, risks and threats to spruce forests will increase over time.

An analysis of recreational resources and their usage shows that most of the population prefers organized recreation (Medeo Park, Shimbulak ski resort) and only small groups visit the nearby Kok Zhailau Valley, nonetheless tourist flows here will undoubtedly increase. Thus, it is necessary at this stage to single out the most valuable areas in the Kok Zhailau Valley, in terms of landscape structure, different types of vegetation and biodiversity in general, in order to maintain them in the natural state as wildlife standards. In the rest of the territory, we should create tourist routes and calculate the recreational capacity and load for them. This will reduce the anthropogenic load on the adjacent undamaged territories of the valley and preserve the integrity of natural complexes as standards of floristic and phytocenotic diversity.

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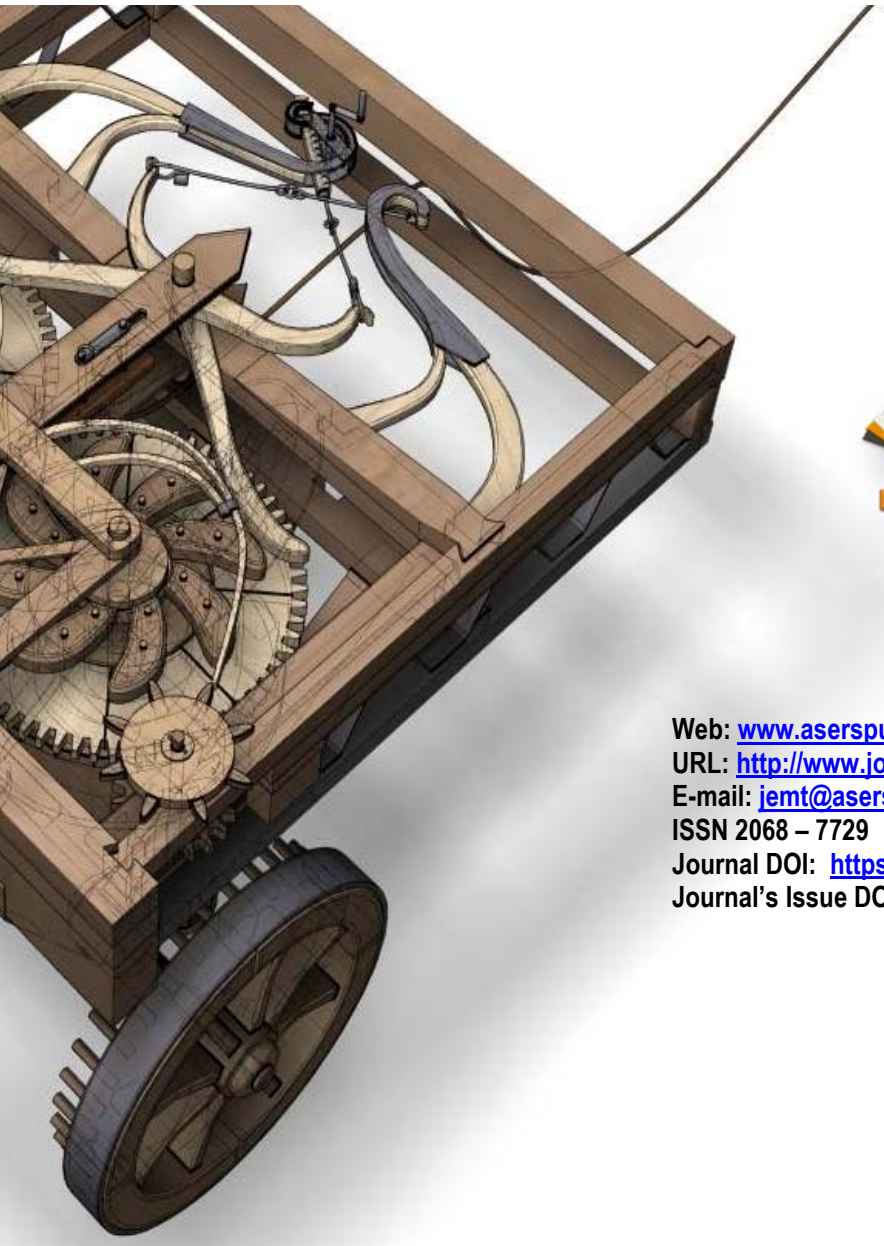

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