Трансформация экосистем
Ecosystem Transformation

ISSN 2619-0931 Online
www.ecosysttrans.com

DOI: https://doi.org/10.23859/estr-250401
EDN: https://elibrary.ru/ycbhee
UDC 581.5; 528.94

Article

Ecosystems of the Tesiin-Gol Bulnain-Nuru National Park (Mongolia): structure and disturbance

E.V. Danzhalova[1]*, I.A. Petukhov[1], S. Khadbaatar[2], A.V. Andreev[1], E.A. Bogdanov[1], P.L. Bogomolov[1], Yu.I. Drobyshev[1], A.M. Serebryakov[1], Yu.A. Rupyshev[3], B. Munkhbat[4], S.N. Bazha[1]

[1] *A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Leninsky Prospekt 33, Moscow, 119071 Russia*

[2] *Mongolian National University of Education, Baga Toiruu St. 14, Ulaanbaatar, 2106489 Mongolia*

[3] *Institute of General and Experimental Biology, the Siberian Branch of the Russian Academy of Sciences, Sakhyanova St. 6, Ulan-Ude, Republic of Buryatia, 670047 Russia*

[4] *Institute of Plant and Agricultural Sciences, Universitetskaya St. PO Box 908, Darkhan, 45047 Mongolia*

**monexp@mail.ru*

Abstract. In 2024, a comprehensive analysis of the structure and state of the terrestrial ecosystems in the Tesiin-Gol Bulnain-Nuru National Park (Mongolia) was performed using the geoinformation mapping methods. Based on field route mapping, interpretation of modern satellite images (Landsat), expert assessments and data analysis, the ecosystems were grouped into 38 units and the degree of their disturbance was estimated. Mountain ecosystems account for about two-thirds of the study area. Tundra and yernik high-mountain ecosystems make up approximately 11% and forests over one-fifth of the territory. Shrub cryogenic ecosystems cover 10%, cryophyte (alpine) meadows 11%, and cryophyte steppes 5% of the area. Forest-steppe ecosystems occupy 11%, while steppe ecosystems more than 29% of the park's territory. Among the driving factors that destroy the natural ecosystems of the Tesiin-Gol Bulnain-Nuru National Park are uncontrolled grazing, forest fires, pests, and logging. Around 60% of the ecosystem area is in a satisfactory or slightly disturbed condition, 25% is moderately degraded, over 12% severely disturbed, and 3% is extremely severely disturbed. This study demonstrates the effectiveness of the integrated approach to assessing the dynamics of natural ecosystems susceptible to anthropogenic impacts and provides a scientific basis for developing measures on biodiversity conservation and sustainable use of natural resources.

Keywords: natural ecosystem, geoinformation mapping, anthropogenic disturbance, topo-ecological conditions, pastures, protected area, monitoring

Funding. This study was conducted within the framework of the Joint Russian-Mongolian Integrated Biological Expedition of RAS and MAS, as well as the state assignment of the Institute of Ecology and Evolution of RAS "Biogeocenology and Ecosystem Evolution" (FFER-2024-0025).

Acknowledgements. The authors express their gratitude to Administration of the Tesiin-Gol Bulnain-Nuru National Park, to M. Nyamtulga - a researcher of the Shishkhid and Delger-Muren River Basin Water Resources Department and to students from the Mongolian National University of Education for their assistance in conducting fieldworks.

ORCID:
E.V. Danzhalova, https://orcid.org/0000-0001-6805-8506
I.A. Petukhov, https://orcid.org/0009-0000-6829-0890
S. Khadbaatar, https://orcid.org/0000-0003-3797-1540
E.A. Bogdanov, https://orcid.org/0000-0002-3721-4681
P.L. Bogomolov, https://orcid.org/0000-0001-8574-8795
Yu.I. Drobyshev, https://orcid.org/0000-0002-9318-4560
Yu.A. Rupyshev, https://orcid.org/0000-0003-2305-7889
B. Munkhbat, https://orcid.org/0000-0002-7387-5495
S.N. Bazha, https://orcid.org/0000-0003-1149-6243

To cite this article: Danzhalova, E.V. et al., 2026. Ecosystems of the Tesiin-Gol Bulnain-Nuru National Park (Mongolia): structure and disturbance. *Ecosystem Transformation* **9** (2), 87–107. https://doi.org/10.23859/estr-250401

Received: 01.04.2025
Accepted: 17.05.2025
Published online: 17.04.2026

DOI: https://doi.org/10.23859/estr-250401
EDN: https://elibrary.ru/ycbhee
УДК 581.5; 528.94

Научная статья

Экосистемы национального парка «Тэсийн-Гол Булнай-Нуру» (Монголия): структура и нарушенность

Е.В. Данжалова[1]*, И.А. Петухов[1], С. Хадбаатар[2], А.В. Андреев[1], Е.А. Богданов[1], П.Л. Богомолов[1], Ю.И. Дробышев[1], А.М. Серебряков[1], Ю.А. Рупышев[3], Б. Мунхбат[4], С.Н. Бажа[1]

[1] *Институт проблем экологии и эволюции им. А.Н. Северцова РАН, 119071, Россия, г. Москва, Ленинский пр-кт, д. 33*

[2] *Монгольский государственный университет образования, 2106489, Монголия, г. Улан-Батор, ул. Бага Тойруу, д. 14*

[3] *Институт общей и экспериментальной биологии СО РАН, 670047, Россия, Республика Бурятия, г. Улан-Удэ, ул. Сахьяновой, д. 6*

[4] *Институт растениеводства и земледелия, 45047, Монголия, г. Дархан, ул. Университетская, а/я 908*

**monexp@mail.ru*

Аннотация. В ходе работы в 2024 г. проведен комплексный анализ структуры и состояния наземных экосистем национального парка «Тэсийн-Гол Булнай-Нуру» (Монголия) с использованием методов геоинформационного картографирования. Были использованы полевое маршрутное картографирование, интерпретация современных спутниковых снимков (Landsat), экспертные оценки и анализ данных, что позволило сгруппировать экосистемы в 38 единиц и оценить степень их нарушенности. Около 2/3 изучаемой территории занимают экосистемы горных территорий. Тундровые и ерниковые высокогорные экосистемы составляют около 11%, лесами покрыто свыше 1/5 территории. Кустарниковые криогенные экосистемы распространены на 10% площади, криофитные (альпийские) луга – на 11%, криофитные степи – на 5%. Площадь лесостепных экосистем составляет 11% территории. Более 29% занимают степные экосистемы. Основными факторами нарушений состояния природных экосистем национального парка «Тэсийн-Гол Булнай-Нуру» являются неконтролируемый выпас скота, лесные пожары, насекомые-вредители леса и вырубки. Около 60% площади экосистем находятся в удовлетворительном или слабо нарушенном состоянии, 25% – испытывают умеренную деградацию, более 12% – сильно нарушены и 3% – очень сильно нарушены. Проведенное исследование демонстрирует эффективность комплексного подхода к оценке динамики природных экосистем в условиях антропогенного воздействия и дает научную основу для разработки мер по сохранению биоразнообразия и обеспечению устойчивого использования природных ресурсов.

Ключевые слова: природная экосистема, геоинформационное картографирование, антропогенная нарушенность, топо-экологические условия, пастбища, природоохранная территория, мониторинг

Финансирование. Исследование выполнено в рамках программы исследований совместной Российско-Монгольской комплексной биологической экспедиции РАН и АНМ, а также государственного задания ИПЭЭ РАН «Биогеоценология и эволюция экосистем» (FFER-2024-0025)».

Благодарности. Коллектив авторов выражает благодарность дирекции национального парка «Тэсийн-Гол Булнай-Нуру», научному сотруднику Управления водных ресурсов бассейна рек Шишхид и Дэлгэр-Мурэн М. Нямтулге и студентам Монгольского государственного университета образования за помощь в проведении полевых исследований.

ORCID:
Е.В. Данжалова, https://orcid.org/0000-0001-6805-8506
И.А. Петухов, https://orcid.org/0009-0000-6829-0890
С. Хадбаатар, https://orcid.org/0000-0003-3797-1540
Е.А. Богданов, https://orcid.org/0000-0002-3721-4681
П.Л. Богомолов, https://orcid.org/0000-0001-8574-8795
Ю.И. Дробышев, https://orcid.org/0000-0002-9318-4560
Ю.А. Рупышев, https://orcid.org/0000-0003-2305-7889
Б. Мунхбат, https://orcid.org/0000-0002-7387-5495
С.Н. Бажа, https://orcid.org/0000-0003-1149-6243

Для цитирования: Данжалова, Е.В. и др., 2026. Экосистемы национального парка «Тэсийн-Гол Булнай-Нуру» (Монголия): структура и нарушенность. *Трансформация экосистем* **9** (2), 87–107. https://doi.org/10.23859/estr-250401

Поступила в редакцию: 01.04.2025
Принята к печати: 17.05.2025
Опубликована онлайн: 17.04.2026

Introduction

The Tesiin-Gol Bulnain-Nuru National Park was established in May 2019 to protect one of the representative natural landscapes of Mongolia. The park was created to conserve the diversity of natural ecosystems associated with high-mountain massifs and ridges, freshwater river systems, alpine meadows, mountain taiga forests, and mountain-steppe communities. The significance of the protected area is determined by its role as a refugium for the major natural ecosystems of the Northern Khangai region and as the headwater area of the transboundary Tesiin-Gol River. Environmental conditions within the park support the conservation and maintenance of high levels of biological diversity, including numerous species of flora and fauna listed in the Mongolian Red Book (Mongolian Red Book, 2013). Consequently, the park occupies an important position within the national system of specially protected natural areas (SPNAs).

One of the principal functions of SPNAs is the long-term monitoring of natural complexes and conservation objects (Mongol..., 1994[1]). In this context, ecological mapping represents one of the most informative and objective approaches for investigating terrestrial ecosystems and assessing their current condition. Ecosystem mapping makes it possible to inventory the spatial distribution of ecosystems and to obtain an integrated representation of their principal components (relief, soil cover, and vegetation communities) considered in their interrelations at a specific moment in time. Analysis of these components provides a basis for assessing the degree of anthropogenic and natural disturbance within ecosystems (Bazha et al., 2013). Therefore, maps of ecosystems and their disturbance levels represent an essential tool for planning and management of protected areas and for monitoring long-term environmental transformations.

Since the late twentieth century, the Joint Russian-Mongolian Complex Biological Expedition of the Russian Academy of Sciences and the Mongolian Academy of Sciences (JRMCBE) has played a leading role in the integrated investigation and cartographic analysis of Mongolia's natural ecosystems. As a result of these studies, a 1 : 1 000 000-scale ecosystem map of Mongolia (Gunin and Vostokova, 1995), the Atlas of Mongolian Ecosystems (Gunin and Saandar, 2019), as well as a series of medium- and large-scale maps characterizing the structure and current state of ecosystems in a number of model territories across the country were produced. However, these cartographic materials either did not cover the territory of the Tesiin-Gol Bulnain-Nuru National Park or represented its ecosystems in a highly generalized form. This circumstance necessitated a more detailed study and mapping of the park's terrestrial ecosystems in order to obtain a comprehensive understanding of their structure and present condition.

In the summer of 2024, a comprehensive field survey of the park territory was carried out in accordance with the approved research program of the JRMCBE. Based on the collected field data and subsequent analytical processing, medium-scale mapping (1 : 200 000) of the natural terrestrial ecosystems of the Tesiin-Gol Bulnain-Nuru National Park was performed, accompanied by an ecological and biological assessment of their current state. The study aims to contribute to the development of methodological approaches for evaluating the role of protected areas in Khovsgol aimag in conserving species diversity and maintaining ecosystem diversity.

[1] Mongol Ulsyn Khuuul Tusgay Hamgaalaltai Gazar Nutgiin Tuhai (15.11.1994). Web page. URL: https://legalinfo.mn/mn/detail/479 (accessed: 15.03.2025)

Fig. 1. Location of the Tesiin-Gol Bulnain-Nuru National Park.

Materials and methods

Study area

The Tesiin-Gol Bulnain-Nuru National Park is located in the southwest of Khovsgol aimag in Mongolia, at the southern boundaries of the Tsetserleg, Tsagan-Uul, Burentogtokh and Shine-Ider soums, and partially in the northeast of Zavkhan aimag, in the northern part of the Telmen and Ikh-Uul soums (Fig. 1).

The national park stretches in the latitude direction, extending 140 km from west to east with a maximum width of 50 km from north to south. The estimated area is 3700 km^2.

Most of the territory of the national park is occupied by the Bulnain-Nuru Range, specifically its northern macroslope, with absolute elevations ranging from 2000 to 2600 m a.s.l.; small medium-altitude parallel ridges in its north and separating them intermontane river valleys, i.e. a vast valley of the upper section of the Tesiin-Gol River and its source in the central part, as well as the valley of its right tributary, the Eletiin-Gol River, in the north. The highest point (2645 m a.s.l.) is located at the aimag border in the northwestern sector within the Buga-Undriin-Nuru Range, whereas the lowest elevation (1795 m a.s.l.) corresponds to the water level of the Tesiin-Gol River at the point where it crosses the park boundary. The national park also includes the intermontane basins of endorheic lakes Bust-Nur and Sangiin-Dalai-Nur with surrounding mountain structures.

According to geomorphological zoning, the study area is a part of the Bulnain-Nuru Province of the Khangai Region of the Central Asian Country. Here, high- and mid-mountain highly dissected ranges alternate, being predominantly latitudinal and having denudation-tectonic landforms separated by wide valleys and intramontane lake basins of tectonic origin (Tsegmid and Vorobyov, 1990).

In terms of seismic zoning, this territory is of high seismicity; earthquake intensity in the region reaches 9 or more on the MSK scale (Dorjgotov, 2022). For instance, a powerful earthquake of 1905 displaced the upper layers of the Earth crust. A fault line from Lake Sangiin-Dalai-Nur extends westward along the northern foothills of the Bulnain-Nuru Range, the southern base of the Buga-Undriin-Nuru Ridge, and then outside the park towards the Khan-Khuhei Ridge (Khilko et al., 1985). This line can be visually traced on the surface owing to frequent alternations of low hills and shallow depressions, some of which are filled with runoff and groundwater that form small freshwater bodies.

The entire territory of the Tesiin-Gol Bulnain-Nuru National Park is located in the zone of continuous and discontinuous distribution of permafrost. Its thickness on the northern slopes under forests is 5-20 m, reaching 20-50 m at the bottoms of valleys and basins (Isaev, 1988; Munkhdavaa et al., 2020). The depth of winter soil freezing makes up 1–3.5 m at dividing ridges and 1.3–2.5 m in the valleys and basins (Etlzemüller et al., 2006; Tsegmid and Vorobyov, 1990). In the mountains, permafrost processes manifest themselves as slope solifluction, while in the basins and river valleys like widespread permafrost mounds, polygonal formations, and cryogenic swells.

The southern boundary of the national park, running along the dividing peaks of the Bulnain-Nuru Range, simultaneously marks the boundary of two global water basins: the Arctic Ocean (including the Selenga River basin and Lake Baikal) and the Central Asian closed basin. A significant part of the hydrographic network of the national park belongs to the endorheic region (Batuyev et al., 2015).

According to climatic zoning, the Tesiin-Gol Bulnain-Nuru National Park is mostly located in the zone of moderately humid and moderately cold summers, and very harsh winters. Only a small and low-lying area in the northwest (the Tesiin-Gol valley) is characterized by moderately dry cool summers and very harsh winters (Dorjgotov, 2022). The average annual air temperature is −4... −6 °C (Tsegmid and Vorobyov, 1990). Winter temperatures can drop below −50 °C, while summer maximums rarely exceed +30 °C. A distinctive feature of the cold period is the formation of powerful inversions. Due to this, air temperature in the mountains is several degrees higher than in the basins and river valleys (Krasnoshchyokov, 2013). Annual precipitation makes up 300–400 mm. Its largest amount (70–80%) is recorded during a warm season, as throughout Northern Mongolia (Beresneva, 2006).

Permafrost-affected soils predominate in the study area. In the mountains, mountain tundra soils occupy the upper levels, followed by mountain meadow, meadow-bog, meadow-steppe, and alpine-steppe coarse-humus soils. These are underlain by soils of the taiga-forest belt: mountain permafrost-taiga ferrous soils, permafrost-taiga soils, and soddy-taiga soils with deep permafrost. Forest soils on the southern slopes alternate with mountain chernozems. Mountain dark chestnut soils predominate in the mountain steppe belt. Sub-plain analogues of mountain soils (meadow, permafrost meadow-steppe and meadow-bog soils, chernozems, and dark chestnut soils) are confined to wide intermontane valleys and intramontane basins. Here, marshy permafrost and alluvial soils develop (Dorjgotov, 1992). The structure and composition of a soil cover of the lowland and mountainous regions are fundamentally different. In lowlands, thick soils predominate on fine-grained deposits, whereas in the mountains shallow soils on dense rocks (Sokolov, 2004).

According to the botanical-geographical zoning of Mongolia, the Tesiin-Gol Bulnain-Nuru National Park belongs to the West Khangai mountain forest-steppe subprovince of the Dauro-Mongolian province within the Eurasian Steppe Region (Tsegmid, Vorobyov, 1990). The vegetation cover of the park is characterized by a distinct altitudinal zonation comprising four principal belts: the high-mountain (goltsy) belt, the forest belt, the forest-steppe belt, and the steppe belt. In addition, subplain variants of alpine and steppe vegetation occur locally. Hydromorphic vegetation is represented by cryophytic lowland meadows, marsh–meadow communities, and floodplain vegetation.

In the study area, four main zoocomplexes are distinguished: high-mountain, mountain-forest, steppe, and near-water ones. According to the published information on habitats (Mongolian Red Book, 2013) and databases (GBIF.org[2]; iNaturalist.org[3]), the following species of high-mountain faunal complexes of the Tesiin-Gol Bulnain-Nuru National Park are included in the Red Data Book:

[2] GBIF. Web page. URL: https://www.gbif.org (accessed: 12.12.2024).

[3] iNaturalist. Web page. URL: https://www.inaturalist.org (accessed: 12.12.2024).

Uncia uncia (Schreber, 1775)[4], *Tetraogallus altaicus* (Gebler, 1836), *Lagopus muta* (Montin, 1781), *Pyrrhocorax pyrrhocorax* (Linnaeus, 1758).The mountain-forest faunal complex is represented by *Martes foina* (Erxleben, 1777), *Moschus moschiferus* (Linnaeus, 1758), *Strix nebulosa* J.R. Forster, 1772; the steppe zoocomplex by *Mustela eversmanni* Lesson, 1827 and *Aquila heliacal* Savygny, 1809; the near-water complex by *Haliaeetus albicilla* (Linnaeus, 1758), *Aquila clanga* Pallas, 1811, *Larus relictus* Lönnberg, 1931 and *Grus grus* (Linnaeus, 1758).

Geoinformation mapping

Maps of terrestrial ecosystems and their anthropogenic disturbance were built using the geoinformation environmental mapping method (Bazha et al., 2013; Berlyant, 1997). Field mapping of ecosystems of the Tesiin-Gol Bulnain-Nuru National Park was performed using the route-key method, as well as 1 : 200 000 scale topographic maps and colour multispectral transformed current satellite images (Landsat) upscaled to 1 : 200 000 with plot boundaries of preliminary ecological-geomorphological delineations. Field mapping routes run through as many typical ecosystem sites as possible, including unusual and rare natural formations, taking into account vehicle and pedestrian accessibility.

Key sites, intended for full geobotanical and soil descriptions during field study, were selected along the route. The boundaries of the preliminary delineated plots were adjusted by means of satellite images. During field mapping, both homogeneous and combined ecosystem types were identified—stable uniform combinations and complexes of fragments of various ecosystems formed under varying topo-ecological conditions (primarily in ecotone zones) and ecological microseries (serial, microbelt). Along the way, brief descriptions of ecosystems and their assessment were kept in a field diary. When necessary, stops were made to complete full descriptions, including topo-ecological parameters (hemomorphological position, microrelief, soil), ecological features (degree and nature of edaphic moisture, salinity), and vegetation. Particular attention was paid to changes in the composition and structure of plant communities as the most physiognomic and sensitive landscape features (Myalo and Goryainova, 1980). By interpreting the satellite images for ecosystem maps compilation, route survey materials and field descriptions were extrapolated to the areas with similar topo-ecological conditions and imagery.

During the description of natural ecosystems, an expert assessment of their current condition was carried out, and the principal anthropogenic and natural drivers responsible for ecosystem disturbance and degradation were identified. These included population density, livestock numbers, pasture availability, the area of dead forest stands, and other indicators reflecting the intensity of human impact and natural disturbances.

The theoretical framework and the key parameters used to assess the condition of natural ecosystems were summarized in the methodological guidelines of the Joint Russian-Mongolian Complex Biological Expedition (JRMCBE) (Gunin and Vostokova, 1989; 1993). These approaches have been widely applied in the compilation of maps depicting anthropogenic disturbance of ecosystems, including those covering the entire territory of Mongolia (Gunin and Saandar, 2019; Gunin and Vostokova, 1995).

Results and discussion

Ecosystems

In accordance with mapping scales, terrestrial ecosystem units are chiefly represented by mesoecosystems with combinations and complexes of plant associations or their groups on heterogeneous mesoforms of the relief. Less commonly, these are monoecosystems with phytocenoses and their micro-series on elementary landforms. Many ecosystems, formed in the regional and local ecotones, dynamically develop and are highly unstable under human impacts (Bazha et al., 2013). The map legend is based on geomorphological and zonal-belt principles.

[4] The Latin names of animals and plants are provided by GBIF.org.

Alpine vegetation is widespread on goletz peaks of the Bulnain-Nuru Range (above 2350–2400 m). Communities of dry dryad and yernik tundra are confined to large-stone placers on flat summits. On the near-summit slopes with numerous kurums, dense yernik thickets are found with sparse alpine meadow grass and small groups of bushy larches. *Betula glandulosa* Michx. Predominates; among shrubs, there are many *Spiraea alpine* Pall., *Juniperus communis* var. *saxatilis* Pall., *Salix glauca* L., and *Rhododendron parvifolium* Adams. Well-grassed summits and slopes are occupied by grass-kobresia alpine meadows and heaths (*Carex myosuroides* Vill., *C. macroprophylla* (Y.C. Yang) S.R. Zhang, *C. ledebouriana* C.A. Mey. ex Trevir., *C. rupestris* All., *Festuca altaica* Trin., *F. airoides* Lam., *F. kryloviana*Reverd., *Ptilagrostis mongolica* (Turcz. ex Trin.) Griseb.). Often, these tundra and alpine phytocenoses form complex combinations (Appendices 1, 2).

On well-lit treeless southern slopes (2250–2400 m a.s.l.) in the "alpine meadows – mountain steppe" ecotone, high-mountain steppe communities of kobresia-bunchgrass (*Festuca lenensis* Drobow, *Koeleria altaica* (Domin) Krylov, *Carex myosuroides*, *C. borealipolaris* S.R. Zhang) develop.

The mountain forest belt is located at 2000–2400 m a.s.l., along the slopes predominantly facing north, only occasionally reaching gentle southern slopes near the upper limits of the belt.

Forest vegetation in the mountains also exhibits distinct vertical zonation. The forest vegetation belt corresponds to a class of of forest types, uniting them into a system of ecological series and reflecting specific zonal-provincial and altitudinal features of climate and soils. Each altitudinal landscape complex (AZC) class is distinguished by a composition of main forest-formers, potential productivity of forests, and a soil formation type (Nazimova et al., 1987). Within Mongolia, the following forest vegetation belts and corresponding AZC classes have been identified: forest-steppe, sub-taiga, mountain-taiga, dry-moss pseudo-taiga, sub-goltsy, and subalpine-taiga (Zhukov et al., 1978). Features of vertical zonation of forest vegetation form the basis for forest vegetation zoning when identifying large regions - forest areas and provinces; the first is characterized by a group of zonation types, while the second by a zonation type (Smagin, 1973).

In terms of forest zoning, forests (predominantly larch) belong to the Central Khangai Province of the Khangai Region (Zhukov et al., 1978). In the Tesiin-Gol Bulnain-Nuru National Park, forests of sub-alpine, mountain-taiga, and sub-taiga AZCs are most fully represented, while the pseudo-taiga and forest-steppe AZCs are encountered only fragmentary. *Larix sibirica* Ledeb. is the only forest-forming species here. Regeneration of lost stands occurs also exclusively due to larch, without the presence of other small-leaved tree species or shrubs (Undraa et al., 2024). In forests of the mountain-taiga AZC, other tree species (i.e. single low specimens of *Pinus sibirica* Du Tour) are noted. Individual trees or small groups of *Salix taraikensis* Kimura can be found along the lower periphery of the forested slopes.

The upper levels of the forest belt on the Bulnain-Nuru Range are occupied by woods of the subalpine ecosystem complex – yernik larch forests (*Betula glandulosa*, *B. fruticosa* Pall., *Dasiphora fruticosa* (L.) Rydb., *Spiraea alpina*) with green moss (Appendices 1, 2).

Forests of the mountain-taiga AZC are predominantly represented by lingonberry (pyrola-lingonberry) and green-moss larch forests, interspersed with shrub-herbaceous green-moss communities with participation of *Lonicera caerulea* subsp. *altaica* (Pall.) Gladkova. These forests are widespread on the northern slopes of the ridge system. Similar forest communities also occur on the northern slopes of the western sector of the ridge separating the valleys of the Tesiin-Gol and Eletiin-Gol rivers, particularly within the Ikh-Elet-Ula Range, whose maximum elevation reaches 2238 m a.s.l.

In the eastern part of this ridge, sub-taiga herb and shrub-herb larch forests predominate. On dry rounded summits and steep slopes, fragments of pseudo-taiga communities are present, including rhytidium (*Rhytidium rugosum* (Hedw.) Kindb.) and fescue (*Festuca ovina* L.)-rhytidium larch forests belonging to the pseudo-taiga altitudinal landscape complex.

Northern spurs of the western part of the Bulnain-Nuru Range acquire a forest-steppe appearance. Here, the scattered island forests migrate strictly to the northern slopes; other exposures belong to mountain steppes. Stable combinations of small (by mapping scale) fragments of forest and steppe vegetation allow to identify forest-steppe units on the ecosystem map. Forest-steppes are also present on the mountain ranges around lakes Bust and Sangiin-Dalai-Nur, the range separating the Tesiin-Gol Depression from the ancient lake basin in the northwest and the ridge in the northern Eletiin-Gol valley. Most of the herbage in the island sub-taiga forests is regularly used for grazing, which prevents full regeneration of the forest stand.

Although a considerable part of the mountain forests has been destroyed by fires, insect pests and logging, forest restoration is progressing well. Initially, clear-cut areas are overgrown with pioneer forest-meadow and meadow-steppe forbs and shrubs followed by larch (Dorjsuren, 2009). In places, the undergrowth of *Larix sibirica* forms dense impenetrable thickets.

Wide deluvial aprons of the mountain valleys of the forest belt, gentle gullies, and the lower ecotone edges of the forested areas are occupied by dense thickets of *Betula fruticosa* with cryogenic meadow and marshy-meadow grassland.

Mountain-steppe vegetation is encountered below 2250–2200 m a.s.l. At the forest belt level, it is confined to southern and steep slopes of eastern and western orientation (Appendices 1, 2). The dominant vegetation is sedge (*Carex pediformis* C.A. Mey.)-forb (*Galium verum* L., *Bupleurum multinerve* DC., *Pulsatilla turczaninovii* Krylov & Serg., *Potentilla fragarioides* L., *P. sericea* L., *Sanguisorba officinalis* L., *Leontopodium leontopodinum* (DC.) Hand.-Mazz., *Aster altaicus* Willd.)-grass (*Sibirotrisetum sibiricum* (Rupr.) Barberá, *Festuca lenensis*, *Koeleria macrantha* subsp. *macrantha*, *Helictochloa hookerii* (Scribn.) Romero Zarco) mountain meadow steppes and shrubs (*Dasiphora fruticosa*, *Spiraea media* Schmidt) with meadow-steppe grass stands. On slopes facing the intermontane basins and extensive mountain valleys, where vegetation is subjected to excessive grazing pressure, many valuable forage species disappear from the herbaceous layer of meadow-steppe communities. As a result, the vegetation becomes dominated by *Carex pediformis* and *Festuca lenensis*, as well as by grazing- and trampling-tolerant short-herb species, including *Veronica incana* L., *Potentilla acaulis* L., *Potentilla sericea*, *Leontopodium leontopodinum*, *Artemisia frigida* Willd., and *Carex duriuscula* C.A. Mey. As in all grass communities, which undergo strong grazing load, the productivity of the above-ground phytomass sharply reduces, a threat of the flora depletion arises, derivative communities are formed in place of the native ones, and the stability of phytocenoses weakens (Bazha et al., 2018; Kazantseva et al., 2015; Safronova and Narantuya, 2016).

On the south point slopes (below 2000 m) of the Tesiin-Gol Depression and the Sangiin-Dalai-Nur Basin, as well as on the slopes of low mountains, isolated hills and hillocks in the ancient lake basin, the communities of moderately dry and predominantly petrophytic fescue (*Festuca lenensis*) steppes with *Agropyron cristatum* (L.) Gaern., *Poa attenuata* Trin., *Stipa krylovii* Roshev., the species composition of which is also dominated by pasture short-herbs because of overgrazing, are formed.

Complex combinations of meadow-shrub and forest-shrub communities are confined to the bottoms of narrow intermontane valleys. In the upper part of the forest belt, these combinations are dominated by shrub thickets of *Betula humilis* Schrank, *Dasiphora fruticosa,* together with cryophilic forb-kobresia-hygrophilous sedge meadows. In the lower parts of the valleys, they are replaced by mountain-valley herbaceous green-moss larch forests, thickets of *Dasiphora fruticosa*, meadow–steppe herbage developed on pebble alluvial deposits, and riverine willow communities. Vegetation of the valley bottoms with steppe slopes is represented by continuous mountain-valley cryophilic meadows: grass-shrub (*Salix rosmarinifolia* L., *Dasiphora fruticosa*)-kobresia (*Carex simpliciuscula* Wahlenb., *C. macroprophylla*) mesophilic meadows on the gently sloping part of the valley floor and forb (*Sanguisorba officinalis, Parnassia palustris* L.)-grass-sedge wet meadows along the riverbed thalweg of the valleys.

Altitudinal zonation is evident in sub-plain areas as well. At the lowest levels (below 1850 m a.s.l.) of the Tesiin-Gol Depression, the Elatiin-Gol valley and the ancient lake basin, fescue and bunchgrass (*Festuca lenensis*, *Agropyron cristatum*, *Stipa krylovii*) moderately dry steppes are widespread on proluvial and lacustrine deposits. Due to excessive grazing pressure, the grass stand of these steppes is dominated by tolerant-to-damage forbs (*Artemisia frigida*, *Veronica incana*, *Potentilla acaulis*, *Aster altaicus*, *Convolvulus ammannii* Desr., *Ephedra monosperma* J.G. Gmel. ex C.A. Mey) and *Carex duriuscula*.

Above 1850 to 1950–2000 m a.s.l., extensive gentle and flat proluvial aprones, as well as alluvial fans of the Bulnain-Nuru Range are intersected by numerous damp hollows with shallow groundwater and rocky beds of temporary streams. Here, forb-fescue-sedge (sedge-fescue) meadow steppes alternate with differently moistened meadow and shrub cryophyte communities. As a rule, steppe and meadow phytocenoses experience strong pasture degradation; in their herbage, pasture short-herbs prevail.

Above 1950 m a.s.l., graded and gently sloping proluvial bottoms of the Tesiin-Gol Depression, the basin of Lake Gandan, and the valley of the Elatiin-Gol River is occupied by cryophytic meadows of the alpine type: sedge (*Carex ledebouriana*, *C. pediformis*)-grass (*Poa sibirica* Roshev., *Ptilagrostis mongolica*)-kobresia (*Carex myosuroides*, *C. macroprophylla*, *C. simpliciuscula*) and forb (*Bistorta vivipara* (L.) Delarbre, *Sanguisorba officinalis*, *Galium verum*)-grass (*Sibirotrisetum sibiricum*, *Poa sibirica*, *Festuca kryloviana*)-sedge (*Carex pediformis*, *C. myosuroides*) meadows with *Dasiphora fruticosa* and *Salix rosmarinifolia*.

Shrub communities of various levels (altitude-zonal and ecological) are widespread and characteristic of the Tesiin-Gol Bulnain-Nuru National Park vegetation. *Betula glandulosa* forms the basis of tundra and alpine yernik and its understory in the subalpine larch forests. Dense and waterlogged (because of frozen meltwater) yerniks in the gentle valleys of the forest belt, the northern slope aprones of the Bulnain-Nuru Range and the Ikh-Elet-Ula Mountains are composed of *Betula fruticosa*, often with a large admixture of *Dasiphora fruticosa*, with herbage of alpine and marshy meadows. Under the canopy of sub-taiga forests, the understory is dominated by *Lonicera caerulea* subsp. *altaica*. In the forest belt, some steep meadow-steppe slopes of intermontane valleys are thickly overgrown with *Spiraea media* shrubs (Appendices 1, 2).

On gentle moist proluvial aprons, where groundwater and frozen meltwater saturate the soil profile, *Dasiphora fruticosa* brakes with herbage of alpine meadows are common. *Dasiphora fruticosa* is present in the majority of high-mountain, mountain-steppe, steppe, and hydromorphic meadow communities; on aprons with a close presence of groundwater (together with *Salix rosmarinifolia*), the shrub layer of cryophytic meadow and meadow-steppe phytocenoses develops. Among shrubs covering the bottoms of mountain valleys, waterlogged communities of *Betula humilis* and riverine hygrophilous willow stands play a significant role.

The largest massif of hydromorphic shrub willow stands with marshy meadow grasses on heavily moss-covered cryogenic mounds and gravel beds is located on the flat site in the center of the Tesiin-Gol Depression, where groundwater emerges at the confluence and inflow of several mountain rivers from the Bulnain-Nuru Range to the Tesiin-Gol River. A complex of various hydromorphic (marshy meadow, marsh, meadow) communities, meadow-steppe phytocoenoses, and temporary groupings develops on powerful pebble alluvial fans, forming distinctive deltas with numerous rocky channels of temporary streams where they flow into catchment rivers and lakes.

Most of the hydromorphic vegetation is confined to floodplains and lakeside depressions of sub-plain areas. Vegetation in thalwegs of small watercourses running down from the mountains along piedmont aprons, near-channel depressions and narrow floodplains of small rivers are cryophytic meadow and marshy-meadow sedge (*Carex enervis* C.A. Mey., *C. simpliciuscula*)-forb (*Parnassia palustris*, *Leontopodium leontopodinum*, *Potentilla sericea*)-grass (*Agrostis vinealis* Schreb., *Hordeum brevisubulatum* (Trin.) Link, *Ptilagrostis mongolica*, *Poa sibirica*) and grass-sedge communities in habitats with cryogenic microrelief (permafrost mounds, hummocks, etc.). Since such meadows are intensively used as pastures being overgrazed, their grass stands, along with *Carex enervis*, are usually dominated by small, disruption-tolerant species (*Argentina anserina* (L.) Rydb., *Plantago media* L., *Halerpestes sarmentosus* (Adams) Kom.).

In the northwest of the Tesiin-Gol Bulnain-Nuru National Park, the floodplain of the Tesiin-Gol River and its major tributaries (distinct above-the floodplain terraces) are well developed. Vegetation consists of continuous communities, the original floristic composition of which has been greatly altered by pasture degradation. Fescue-short-herb-*Leymus chinensis* steppe of the low floodplain terrace (with fragments of fescue-short-herb moderately dry steppe) is replaced by *Agrostis vinealis*-*Carex enervis*-short-herb meadows with insignificant presence of reed (*Phragmites australis* subsp. *australis*)-sedge hydrophilic meadows in shallow backwaters.

Large mineralized lakes (Sangiyn-Dalai-Nur and Bust) dry out, leaving coastal "beaches" with clay, sand and rocky deposits, which gradually become covered by sparse groups of pioneer halophilic plants (*Puccinellia tenuiflora* (Griseb.) Scribn. & Merr., *Suaeda corniculata* (C.A. Mey.) Bunge, *Salicornia europaea* L., *Artemisia anethifolia* Weber ex Stechm.) at the upper periphery.

According to ecological mapping of the Tesiin-Gol Bulnain-Nuru National Park, the area of terrestrial natural ecosystems accounts for 3465.99 km^2 (or 94.53% of the territory). The ecosystem map legend includes 38 terrestrial ecosystem units (Appendix 2). Ecosystems are divided into mountainous, including high-mountain (alpine belt – 6 units/plots), mid-mountain (forest belt – 7 units, steppe and forest-steppe belt – 4 units), mountain-valley complexes (3 units), and sub-plain ecosystems: automorphic and semi-hydromorphic ecosystems of inermontane basins and wide river valleys (13 units), as well as hydromorphic ecosystems of lowlands, floodplains, river deltas, and terraces (5 units).

From our estimations it follows that approximately 2/3 of the Tesiin-Gol Bulnain-Nuru National Park is occupied by the mountain ecosystems. Tundra and yernik high-mountain ecosystems make up approximately 11%, and forests (excluding forest-steppe ecosystems) with the cleared areas cover over 1/5 of the territory.

Shrub cryogenic ecosystems (comprising all mountain and sub-plain ecosystems), where shrubs act as the absolute dominants and edificators of plant communities, are distributed over an area of 381.35 km^2 (more than 10% of the territory). This figure does not include the ecosystems with well-developed but not dominant shrub layer (e.g., subalpine yernik forests).

Owing to permafrost, the mountain and sub-plain cryogenic ecosystems are widespread throughout the study area: cryophyte (alpine) meadows account for 11% and cryophyte steppes 5% of the territory.

According to natural zoning, the Tesiin-Gol Bulnain-Nuru National Park is located within the mountain-forest-steppe region of Khangai (Yunatov, 1954). However, due to its location at absolute altitudes above 1800 m, forest-steppe ecosystems make up only 11% of the park's territory. Forest-steppe areas are confined to upper levels of slopes of the steppe and forest-steppe belts, as well as to steep and gently sloping well-lit slopes (not of northern exposures) of the mountain valleys within the forest belt at the lower elevations of the northern macroslope of the Bulnain-Nuru Range. A visual assessment of the ratio of steppe, forest and shrub communities in the forest-steppe combinations reveals a slight predominance of forests and shrubs (on shady slope bends) in certain forest-steppe sites of the forest belt. Within the steppe and forest-steppe belts, the area of insular forests is significantly smaller than that of steppe communities, especially as the absolute altitude of the terrain decreases. Overall, steppe ecosystems account for more than 29% of the national park's territory.

Ecosystem disturbance

The main factors responsible for disturbance of the natural ecosystems of the Tesiin-Gol Bulnain-Nuru National Park are uncontrolled livestock grazing, forest fires, pests, and logging (Appendix 3).

During warm seasons, yaks, horses and cows graze primarily on high-mountain, mountain-valley, cryophytic meadow, mountain shrub and sub-plain pastures. In cold seasons, small cattle herds migrate to the mountain and sub-plain steppe pastures. Animals often graze in the forest-steppe island grass forests that leads to larch undergrowth destruction. More than 50% of all terrestrial ecosystems, or more than 85% of the ecosystems' area affected by negative factors are used for livestock grazing (Table 1). Unregulated livestock grazing is a real environmental threat to Mongolia. If the load on pastures exceeds their forage capacity, grass stands degrade, and the natural balance of the whole ecosystem begins to deteriorate (Bazha et al., 2018; Boykov et al., 2002; Danzhalova et al., 2023).

Crown forest fires are prevalent in the Tesiin-Gol Bulnain-Nuru National Park. Impacts of crown fires and insect pests are very similar in their effect: dead wood remains in place of the previously existing trees making the negative influence on health of the lower forest layers insignificant (Sharagin, 2011). In fact, during field mapping, it is impossible to accurately determine from photographs or with binoculars at a distance in remote areas whether the origin of dead forest stands is natural (insects) or natural-anthropogenic (fires). Therefore, these destructive factors that have equal impacts on forest ecosystems are combined on the map representing ecosystem disturbance. Appropriate preventive measures are expected to reduce the scale of their spread in the future.

Dead forest stands are primarily subject to logging, often selectively, i.e. in the areas where logging roads can be built. In the forest belt, only 39% of larch woods damaged by fires or insects has been almost completely cleared (Table 1).

Table 1. Principal drivers of terrestrial ecosystem disturbance in the Tesiin-Gol Bulnain-Nuru National Park.

Ecosystems	Factors	Area (km^2)	% of terrestrial ecosystems
Pasture	Livestock grazing	1964.07	56.67
Forest belt	Fires and insect pests	21.49	0.62
	Clear-cutting	22.68	0.65
	Selective salvage logging (post fire/ insect damage)	57.71	1.67
Forest-steppe belt	Combined of grazing and selective logging	113.20	3.27
	Combined of grazing and fire or insect damage	23.31	0.67
	Combined of grazing, selective logging, and damage from fire or insects	97.64	2.82
Sub-plains	Timber storage	0.11	0.003
	Total	**2300.21**	**66.37**

Mountain forest-steppe ecosystems, including meadow steppes and island forests, as well as fragments of shrub and meadow phytocenoses undergo different-level impacts of negative factors. These are livestock grazing (including in herb forests), destruction of forest stands by fires and insects, and selective logging. Here, not only deadwood is cut down, but also healthy trees for firewood and outbuildings construction (sheep yards, cattle-pens, log cabins, and fences). In forest-steppe stands, such an impact is recorded on 57% of the total mountain forest-steppe area (including the forest belt) (Table 1).

In the Tesiin-Gol Bulnain-Nuru National Park, a third of the terrestrial ecosystems (33.63%) does not demonstrate any noticeable transformations, and their disturbance is assessed as very insignificant (practically background). These primarily concern the high-mountain tundra and yernik forests, which are difficult to access for economic use; subalpine, taiga, and sub-taiga mountain forests; shrubs of the forest belt and waterlogged lowlands unsuitable for grazing. Table 2 presents the ratio of the areas of large geomorphological and zonal-belt natural terrestrial ecosystems of the national park by the degree of disturbance caused by main exogenous factors.

Approximately a quarter of all terrestrial ecosystems (25.23%) are classified as low disturbed. Weak pasture degradation of grasslands is generally observed in the forest-steppe ecosystems, mountain-valley and sub-plain cryophyte meadows, shrub and herbage layers on the outskirts of sub-taiga forests, including the still-undeveloped herbage of drying lake shores (Table 2). In some places, forests are only slightly damaged by selective logging, insect pests, or crown fires. Forests that recover very well from strong exogenous influences, traces of which are still visible, are also considered as weakly disturbed.

Another quarter of terrestrial ecosystems (25.30%) are in the moderate state of degradation. This category involves most of the meadow-steppe pastures of slope fans of the Bulnain-Nuru, Buga-Undriin-Nuru, and Telyin-Nuru ranges and deluvial aprons of wide intermontane valleys (including the Elatiin-Gol one), the upper reaches of lake basins, low forest-steppe mountains, hills and piedmont aprons of the Sangiin-Dalai-Nur basin. The state of cryophyte meadow and steppe pastures in aprons of the eastern Tesiin-Gol Depression is moderately degraded. All of these lands are used primarily for summer and summer-autumn grazing.

Severe degradation is characteristic of intensively employed pasture ecosystems in the northwestern sub-plain. Here, due to excessive grazing pressure on the meadow-steppe and moderately dry steppe flattened low levels of the Tesiin-Gol Depression, floodplains, and river terraces of the Tesiin-Gol, Elatiin-Gol and Dzharantayn-Gol, the productivity and forage value of grass stands has sharply declined. For instance, instead of sod grasses and forage forbs, inedible species of tolerant-to-damage short-herbs and sedges have become dominant.

Herbage of the moderately dry steppes of the residual low mountains and hills within the sub-plain zone in the northwest have been also severely damaged. A similar degree of deterioration is observed in the mountain petrophytic moderately dry steppe pastures of the lower parts of the southern slopes towards the Tesiin-Gol River and Lake Sangiin-Dalai-Nur.

Complex dynamic ecosystems of delta-shaped alluvial fans, some forests damaged by natural and anthropogenic factors, individual pasture areas in forest-steppe zones, intermontane valleys, etc. are severely disturbed. Around 12.75% of the total terrestrial area falls on such ecosystems (Table 2).

Only 3.09% of the terrestrial ecosystem area of the national park is extremely severely disturbed (Table 2). These are primarily forested sites that have not yet recovered from fire, insects and selective logging or large-scale clear cut in the initial stages of forest recovery. The most damaged forests are concentrated on the northeastern periphery of the Bulnain-Nuru Range.

Pasture ecosystems of sub-plain areas in places of herders' camps (usually near major transport routes and water sources) demonstrate the highest level of disturbance. In the northwest, such areas of severe pasture degradation are confined to moderately dry steppe ecosystems with sandy and sandy loam soils on the floodplain terraces of the Dzharatain-Gol River and in the hollows of dry lakes with adjacent gentle foothill slopes in the western sector of the Tesiin-Gol Depression. The pasture vegetation is extremely sparse, and the herbaceous layer is almost entirely dominated by small groups of grazing-resistant short-herbs, including several psammophytic species. However, the observed transformations cannot be considered irreversible since the steppe and meadow grasslands surrounding these small degraded sites still contain sufficient forage plant species for successful migration to the disturbed areas. To restore the forage potential, severely disturbed pastures require lengthy rest. Livestock grazing is reasonable to implement in other, less crowded pastures. Very severely disturbed meadow-steppe pasture ecosystems are located next to major highways and yurts, i.e. along the upper reaches of the Tesiin-Gol River and in the rocky valley of the Chulutyn-Gol River.

Many highly and moderately disturbed steppe pastures are readily colonized by the vole *Lasiopodomys brandtii* (Radde, 1861); this species begins to reproduce rapidly and forms large burrowing colonies thus exacerbating land degradation.

At the slope aprone near the outlet of the Udzhigiyn-Gol River from the mountains into the Tesiin-Gol Depression, an 11-ha timber storage site for felled trees was established. Although most of the timber had already been removed by the time of the field survey, the depot area remained heavily littered with rotting wood debris.

The major radical transformations of the natural ecosystems occurred in the beginning of the last century. A powerful earthquake displaced the upper crust along the tectonic fault line running in the latitude direction throughout the central part of the Tesiin-Gol Bulnain-Nuru National Park that caused new small landforms appearance. In due course, the ecosystems – with soil and vegetation cover similar to that spread in analogous ecotopes adjacent to the fault line – have developed here.

The most substantial human-induced alterations of the park’s ecosystems are associated with unpaved roads construction. The main roads crossing the territory from south to north connect the Zavkhan and Khovsgol) aimags: Uliastai - Muren runs via the western part of the park; Tosontsengel - Tsagan-Uul is laid in difficult terrain through the central part; Ikh-Uul - Muren crosses the park in the east and passes through the Sangiin-Dalai basin. The longest roads run in a latitudinal direction, intersect meridional roads and connect the eastern and western natural areas. These include the road along the northern shore of Lake Sangiin-Dalai-Nurna to the west and further along the northern side of the Elatiin-Gol River valley; the road from Lake Gandan to the west along the right bank of the Tesiin-Gol River; the road along the northern foot of the Bulnain-Nuru Range from the mouth of the Ujigiin-Gol River to the basin of Lake Bust-Nur. In addition, numerous unpaved roads leading to campsites, individual yurts, winter roads, pastures and clearings have been built within the territory of the national park.

Table 2. Ecosystem distribution by disturbance degree within zonal–altitudinal groups in the Tesiin-Gol Bulnain-Nuru National Park.

Ecosystems	Area (km^2)	Distribution of ecosystem mapping units by disturbance degree (%)				
		I	II	III	IV	V
High-mountain	609.13	81.47	13,79	4.41	0.21	0.12
Forest belt	894.07	67.71	20.11	4.01	0.66	7.51
including:						
Forests (without forest-steppe area)	697.67	77.36	18.88	3.71	0.05	-
Felled areas and standing dead wood	72.83	–	–	0.45	7.36	92.19
Valley shrublands	80.08	79.14	20.41	0.45	–	–
Forest-steppe area	43.49	5.17	72.98	21.39	0.46	–
Steppe and forest-steppe belts	785.01	2.77	47.13	37.32	12.78	–
including:						
Forest-meadow steppes	363.84	5.97	69.38	22.68	1.97	–
Meadow steppe	308.12	0.02	38.14	56.04	5.80	–
Moderately dry steppes	113.05	–	–	33.39	66.61	–
Mountain-valley	103.67	18.89	53.69	25.70	1.72	–

Ecosystems	Area (km^2)	Distribution of ecosystem mapping units by disturbance degree (%)				
		I	II	III	IV	V
Automorphic sub-plains	936.38	0.77	14.91	49.49	31.16	3.67
including:						
Cryophyte meadows	185.24	3.41	42.64	48.40	5.55	–
Shrublands	5.34	16.10	83.90	–	–	–
Cryophyte steppes	93.63	–	5.95	90.34	3.71	–
Meadow steppes	343.95	–	11.64	55.72	28.27	4.37
Moderately dry steppes	308.22	–	3.43	31.66	58.64	6.27
Hydromorphic sub-plains	137.73	11.38	33.10	22.24	29.65	3.63
including:						
Shrublands	17.43	85.14	14.86	–	–	–
Cryophyte meadows	18.76	–	–	53.75	46.25	–
Floodplains	55.59	–	4.00	29.16	57.85	8.99
Lakeside vegetation assemblages	45.95	1.81	88.77	9.42	-	–
TOTAL of the area of terrestrial ecosystems	**3465.99**	**33.63**	**25.23**	**25.30**	**12.75**	**3.09**
including:						
Forest-steppe area(all belts)	407.33	5.88	69.76	22.55	1.81	–

When making the survey, the natural complexes of the Tesiin-Gol Bulnain-Nuru National Park were in a relatively good condition of (July 2024): about 60% of ecosystems were slightly or fairly disturbed, while a quarter was in a satisfactory state (moderate disturbance). Irreversible changes in the study ecosystems caused by destructive human settlement induced or anthropogenic factors were not observed.

Conclusion

Due to the conducted study, the structure and degree of disturbance of terrestrial ecosystems of the Tesiin-Gol Bulnain-Nuru National Park was described. The findings suggest that despite the resilience of some ecosystems, a significant part of the territory is negatively affected by anthropogenic factors (intensive grazing, forest fires, insect pests, and selective logging) that leads to vegetation degradation, reduced ecosystem productivity, and, consequently, a decline in biodiversity.

The identified ecological zones demonstrate the intricate interaction of geomorphological, climatic, soil and biotic factors that determine the distribution of plant and animal communities. The applied integrated geoinformation methods have provided in-depth analysis of the current state of ecosystems that can serve as a reliable basis for developing specific measures on biodiversity conservation and sustainable management of the park's natural resources in the near future.

Based on the data obtained, the following practical recommendations can be formulated:

• <u>Strengthening of grazing control and grazing load management</u>. To prevent overgrazing, a monitoring and planning system should be implemented to ensure more balanced and even distribution of livestock across the park. It is recommended to develop and approve special regulations limiting the number of animals in vulnerable areas, as well as to create alternative grazing zones to reduce the pressure on particularly sensitive ecosystems.

• <u>Restoration and rehabilitation of damaged ecosystems</u>. In the areas showing signs of disturbance, programs to restore vegetation cover should be implemented. Priority should be given to planting native tree species (e.g., larch) and shrubs, as well as to agronomic practices (furrowing) to accelerate the ecosystems' natural restoration. Such measures will restore biodiversity and strengthen the resilience of ecosystems to further negative impacts.

• <u>Application of modern geoinformation technologies</u>. Regular data updating based on the GIS analysis and remote sensing will enable to monitor the dynamics of ecosystem transformations. The creation of a centralized database combining satellite imagery, field research results, and forecasting models are important tools for rapid identification of deterioration and timely implementation of corrective measures.

• <u>Development of educational and awareness-raising programs.</u> Improving environmental awareness among local residents and park staff is crucial for biodiversity conservation. Seminars, trainings, and information campaigns will help develop understanding of the need for sustainable use of natural resources and encourage active participation of people in protection and restoration of ecosystems.

• <u>Strengthening of legal and regulatory frameworks; creation of additional protected areas</u>. To ensure the long-term ecosystem protection, it is necessary to develop and implement new regulations on economic activities within the Tesiin-Gol Bulnain-Nuru National Park. The territory zoning and creating a special protection area with strictly limited human activity will help preserve the most vulnerable natural communities and provide their future sustainability.

• <u>Development of partnerships between scientific institutions, government agencies and local communities</u>. Collaboration between scientists, the park administration, and local communities will contribute to experience exchange and development of joint conservation strategies. The implementation of pilot projects on restoration of the degraded areas may serve as a model for scaling up similar measures at the regional level.

Thus, the study results provide a scientific basis for developing biodiversity conservation measures in the Tesiin-Gol Bulnain-Nuru National Park. The integration of modern geoinformation technologies, grazing management, restoration activities, educational initiatives, and strengthened regulatory oversight can significantly improve the resilience of natural systems. The proposed measures will contribute to conservation of the unique biodiversity of the park and ensure the long-term sustainability of ecosystems in the face of dynamically changing economic activity and climate challenges.

References

Batuev, A.R., et al. (eds.), 2015. Ekologicheskii atlas basseina ozera Baikal [The Ecological atlas of the Baikal basin]. Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia, 145 p. (In Russian).

Bazha, S.N., Vostokova, E.A., Gunin, P.D., Dugarzhav, Ch., Danzhalova, E.V. et al., 2013. Geoinformatsionnoe kartografirovanie nazemnykh ekosistem basseina Selengi na primere model'nykh uchastkov (metodicheskie rekomendatsii) [Geoinformation mapping of terrestrial ecosystems of the Selenga basin using model sites as an example (methodological recommendations)]. Russian Academy of Agricultural Sciences, Moscow, Russia, 109 p. (In Russian).

Bazha, S.N., Danzhalova, E.V., Drobyshev, Yu.I., Khadbaatar, S., 2018. Transformatsiia nazemnykh ekosistem iuzhnoi chasti basseina Baikala [Transformation of terrestrial ecosystems in the southern part of the Baikal basin]. KMK Scientific Press Ltd, Moscow, Russia, 402 p. (In Russian).

Beresneva, I.A., 2006. Klimaty aridnoi zony Azii [Climates of the Arid Zone of Asia]. Nauka, Moscow, Russia, 287 p. (In Russian).

Berlyant, A.M., 1997. Geoinformatsionnoe kartografirovanie [Geoinformation Mapping]. Astreia, Moscow, Russia, 64 p. (In Russian).

Boykov, T.G., Kharitonov, Yu.D., Rupyshev, Yu.A., 2002. Stepi Zabaikal'ia. Produktivnost', kormovaia tsennost', ratsional'noe ispol'zovanie i okhrana [Steppes of Transbaikalia. Productivity, forage value, rational use and protection]. Publishing House of the Buryat Scientific Center SB RAS, Ulan-Ude, Russia, 230 p. (In Russian).

Danzhalova, E.V., Ariunbold, E., Dorofeyuk, N.I., Myagmarsuren, D., Bazha, S.N., 2023. The Palatability of plant communities as one of the criteria for the qualitative assessment of pastures in Mongolia. *Arid Ecosystems*, **13** (2), 208–216. https://doi.org/10.1134/S207909612302004X

Dorjgotov, D., 1992. Pochvy Mongolii (genezis, sistematika, geografiia, resursy i ispol'zovanie) [Soils of Mongolia (genesis, systematics, geography, resources and use]. *Doctor of Sciences in Biology thesis abstract.* Moscow, Russia, 53 p. (In Russian).

Dorjgotov, D. (ed.), 2022. National atlas of Mongolia. Institute of Geography and Geoecology of the Mongolian Academy of Sciences, Ulaanbaatar, Mongolia, 251 p.

Dorjsuren, Ch., 2009. Antropogennye suktsessii v listvennichnykh lesakh Mongolii [Anthropogenic successions in larch forests of Mongolia]. Russian Academy of Agricultural Sciences, Moscow, Russia, 260 p. (In Russian).

Etzelmüller, B., Heggem, E.S., Sharkhuu, N., Frauenfelder, R., Kääb, A., Goulden, C., 2006. Mountain permafrost distribution modelling using a multi-criteria approach in the Hövsgöl area, northern Mongolia. *Permafrost and Periglacial Processes* **17**, 91–104. https://doi.org/10.1002/ppp.554

Gunin, P.D., Saandar, M. (eds.), 2019. Ecosystems of Mongolia. Atlas. Admon, Ulaanbaatar, 264 p.

Gunin, P.D., Vostokova, E.A. (eds.), 1989. Metodicheskie rekomendatsii po otsenke i kartografirovaniiu sovremennogo sostoianiia ekosistem [Methodical recommendations for assessing and mapping the current state of ecosystems]. Main Directorate of Geodesy and Cartography of the Mongolian People's Republic, Ulaanbaatar, Mongolia, 107 p. (In Russian).

Gunin, P.D., Vostokova, E.A. (eds.), 1993. Metodologiia otsenki sostoianiia i kartografirovaniia ekosistem v ekstremal'nykh usloviiakh [Methodology for assessing the state and mapping ecosystems in extreme conditions]. Pushchino Scientific Center RAS, Pushchino, Russia, 203 p. (In Russian).

Gunin, P.D., Vostokova, E.A. (eds.), 1995. Ecosystems of Mongolia. Map. 1 :1000000. EKOR, Moscow, Russia, 15 p.

Isaev, A.S. (ed.), 1988. Lesa Mongol'skoi Narodnoi Respubliki. Listvennichnye lesa Vostochnogo Khenteia [Forests of the Mongolian People's Republic. Larch forests of Eastern Khentei]. Nauka, Moscow, Russia, 177 p. (In Russian).

Kazantseva, T.I., Bazha, S.N., Gunin, P.D., Danzhalova, E.V., Dedkov, V.P. et al., 2015. Mnogoletniaia dinamika rastitel'nykh soobshchestv sukhikh i pustynnykh stepei Tsentral'noi Mongolii (na primere Uverkhangaiskogo aimaka) [Long-term dynamics of plant communities of dry and desert steppes of Central Mongolia (on the example of Uverkhangay aimag]. *Botanicheskii zhurnal* **100** (3), 249–270. https://doi.org/10.1134/S0006813615030047 (In Russian).

Khilko, S.D., Kurushin, R.A., Kochetkov, V.M., Misharina, L.A., Melnikova, V.I. et al., 1985. Zemletriaseniia i osnovy seismicheskogo raionirovaniia Mongolii [Earthquakes and the basics of seismic zoning of Mongolia]. Nauka, Moscow, Russia, 224 p. (In Russian).

Krasnoshchekov, Yu.N., 2013. Pochvennyi pokrov i pochvy gornykh lesov Severnoi Mongolii [Land cover and soils of mountain forests of Northern Mongolia]. Nauka, Novosibirsk, Russia, 195 p. (In Russian).

Mongolian Red Book, 2013. Shiirevdamba, Ts. (ed.).Admon, Ulaanbaatar, Mongolia, 535 p.

Munkhdavaa, M., Gansukh, Ya.,Yamkhin, J., Menzel, L., 2020. Ground surface temperature variability and permafrost distribution over mountainous terrain in northern Mongolia. *Arctic, Antarctic, and Alpine Research* **52**, 13–26. https://doi.org/10.1080/15230430.2019.1704347

Myalo, E.G., Goryainova, I.N., 1980. Sovremennye problemy geobotanicheskoi indikatsii, mesto geobotanicheskoi indikatsii v indikatsionnykh geograficheskikh issledovaniiakh [Current problems of geobotanical indication, the place of geobotanical indication in indication geographical studies]. *Itogi nauki i tekhniki (seriia biogeografiia)* [*Results of Science and Technology (Biogeography Series)*] **3**, 25-56. (In Russian).

Nazimova, D.I., Korotkov, I.A., Cherednikova, Yu.S., 1987. Osnovnye vysotno-poiasnye podrazdeleniia lesnogo pokrova v gorakh Iuzhnoi Sibiri i ikh diagnosticheskie priznaki [The main altitudinal-belt subdivisions of forest cover in the mountains of Southern Siberia and their diagnostic features]. *Sbornik nauchnykh trudov po materialam konferentsii «Chteniia pamiati V.N. Sukacheva» [Collection of scientific papers based on the materials of the Conference "Readings in memory of V.N. Sukachev"].* Nauka, Moscow, Russia, 30–64. (In Russian).

Safronova, I.N., Narantuya, N., 2016. O sovremennom sostoianii pastbishch v Zavkhanskom aimake (Mongoliia) [On the current state of pastures in the Zavkhan aimag (Mongolia)]. *Sbornik nauchnykh statei po materialam 15-i Mezhdunarodnoi konferentsii «Problemy botaniki Iuzhnoi Sibiri i Mongolii» [Collection of scientific articles based on the materials of the 15th International Conference"Problems of botany of Southern Siberia and Mongolia"].* Altai State University Publishing House, Barnaul, Russia, 34–37. (In Russian).

Sharagin, A.M., 2011. Vliianie lesnykh pozharov na ekologicheskuiu situatsiiu [The influence of forest fires on the ecological situation]. *Uspekhi sovremennogo estestvoznaniia [Advances In Modern Natural Science]* **7**, 236–236. (In Russian).

Smagin, V.N., 1973. Printsipy i skhema lesorastitel'nogo raionirovaniia Sibiri [Principles and scheme of forest vegetation zoning of Siberia]. *Materialy nauchnykh trudov Vtorogo Vsesoiuznogo soveshchaniia po lesnoi tipologii [Materials of scientific papers of The Second All-Union Conference on Forest*

Typology]. Institute of Forestry and Timber of the Siberian Branch of the USSR Academy of Sciences, Krasnoyarsk, Russia, 120–122. (In Russian).

Sokolov, I.A., 2004. Teoreticheskie problemy geneticheskogo pochvovedeniia [Theoretical problems of genetic soil science]. Gumanitarnye tekhnologii, Novosibirsk, Russia, 297 p. (In Russian).

Tsegmid, Sh., Vorobyov, V.V. (eds.), 1990. Natsional'nyi atlas Mongol'skoi Narodnoi Respubliki [National Atlas of the Mongolian People’s Republic]. USSR Main Directorate of Geodesy and Cartography – Main Directorate of Geodesy and Cartography of the Mongolian People's Republic, Moscow – Ulaanbatar, 144 p. (In Russian).

Undraa, M., Bazha, S.N., Oyunsanaa, B., Dorjsuren, Ch., 2024. Post-fire succession of pseudo-taiga larch forest in the Tarvagatai Mountain range, Mongolia. *Geography, Environment, Sustainability* **2** (17), 139–149. https://doi.org/10.24057/2071-9388-2024-3121

Yunatov, A.A., 1954. Kormovye rasteniia pastbishch i senokosov Mongol'skoi Narodnoi Respubliki [Forage plants of pastures and hayfields of the Mongolian People’s Republic]. USSR Academy of Sciences Publishing House, Moscow – Leningrad, USSR, 131 p. (In Russian).

Zhukov, A.B. et al. (eds.), 1978. Lesa Mongol'skoi Narodnoi Respubliki [Forests of the Mongolian People’s Republic]. Nauka, Moscow, Russia, 128 p. (In Russian).

Список литературы

Бажа, С.Н., Востокова, Е.А., Гунин, П.Д., Дугаржав, Ч., Данжалова, Е.В. и др.,2013. Геоинформационное картографирование наземных экосистем бассейна Селенги на примере модельных участков (методические рекомендации). Россельхозакадемия, Москва, Россия, 109 с.

Бажа, С.Н., Данжалова, Е.В., Дробышев, Ю.И., Хадбаатар, С.,2018. Трансформация наземных экосистем южной части бассейна Байкала. Товарищество научных изданий КМК, Москва, Россия, 402 с.

Батуев, А.Р. и др. (отв. ред.), 2015. Экологический атлас бассейна озера Байкал. Издательство ИГ СО РАН, Иркутск, Россия, 145 с.

Береснева, И.А.,2006. Климаты аридной зоны Азии. Наука, Москва, Россия, 287 с.

Берлянт, А.М.,1997. Геоинформационное картографирование. Астрея, Москва,Россия, 64 с.

Бойков, Т.Г., Харитонов, Ю.Д., Рупышев, Ю.А.,2002. Степи Забайкалья. Продуктивность, кормовая ценность, рациональное использование и охрана. Издательство БНЦ СО РАН, Улан-Удэ, Россия, 230 с.

Гунин, П.Д., Востокова, Е.А. (ред.), 1989. Методические рекомендации по оценке и картографированию современного состояния экосистем. ГУГК МНР, Улан-Батор, Монголия, 107 с.

Гунин, П.Д., Востокова, Е.А. (ред.), 1993. Методология оценки состояния и картографирования экосистем в экстремальных условиях. Издательство ПНЦ РАН, Пущино, Россия, 203 с.

Данжалова, Е.В., Ариунболд, Э., Дорофеюк, Н.И., Мягмарсурэн, Д., Бажа, С.Н., 2023. Поедаемость растительных сообществ как один из критериев качественной оценки пастбищ Монголии. *Аридные экосистемы* **29** (95), 98–108.

Доржготов, Д.,1992. Почвы Монголии (генезис, систематика, география, ресурсы и использование). *Автореферат диссертации на соискание ученой степени доктора биологических наук*. Москва, Россия, 53 с.

Доржсурэн, Ч.,2009. Антропогенные сукцессии в лиственничных лесах Монголии. Россельхозакадемия, Москва, Россия, 260 с.

Жуков, А.Б. и др. (ред.), 1978. Леса Монгольской Народной Республики. Наука, Москва, СССР, 128 с.

Исаев, А.С. (ред.), 1988. Леса Монгольской Народной Республики. Лиственничные леса Восточного Хэнтэя. Наука, Москва, СССР, 177 с.

Казанцева, Т.И., Бажа, С.Н., Гунин, П.Д., Данжалова, Е.В., Дедков, В.П. и др.,2015. Многолетняя динамика растительных сообществ сухих и пустынных степей Центральной Монголии (на примере Увэрхангайского аймака). *Ботанический журнал* **100** (3), 249–270. https://doi.org/10.1134/S0006813615030047

Краснощёков, Ю.Н., 2013. Почвенный покров и почвы горных лесов Северной Монголии. Наука, Новосибирск, Россия, 195 с.

Мяло, Е.Г., Горяинова, И.Н.,1980. Современные проблемы геоботанической индикации, место геоботанической индикации в индикационных географических исследованиях. *Итоги науки и техники* (*серия биогеография)* **3** ,25–56.

Назимова, Д.И., Коротков, И.А., Чередникова, Ю.С., 1987. Основные высотно-поясные подразделения лесного покрова в горах Южной Сибири и их диагностические признаки. *Сборник научных трудов по материалам конференции* «*Чтения памяти В.Н. Сукачева».* Наука, Москва, СССР, 30–64.

Сафронова, И.Н., Нарантуяа, Н.,2016. О современном состоянии пастбищ в Завханском аймаке (Монголия). *Сборник научных статей по материалам 15-й Международной конференции «Проблемы ботаники Южной Сибири и Монголии».* Издательство АлтГУ, Барнаул, Россия, 34–37.

Смагин, В.Н., 1973. Принципы и схема лесорастительного районирования Сибири. *Материалы научных трудов Второго Всесоюзного совещания по лесной типологии.* Институт леса и древесины СО АН СССР, Красноярск, Россия, 120–122.

Соколов, И.А.,2004. Теоретические проблемы генетического почвоведения. Гуманитарные технологии, Новосибирск, Россия, 297 с.

Хилько, С.Д., Курушин, Р.А., Кочетков, В.М., Мишарина, Л.А., Мельникова, В.И. и др., 1985. Землетрясения и основы сейсмического районирования Монголии. Наука, Москва, СССР, 224 с.

Цэгмид, Ш., Воробьев, В.В. (ред.), 1990. Национальный атлас Монгольской Народной Республики. ГУГК СССР - ГУГК МНР, Москва – Улан-Батор, 144 с.

Шарагин, А.М.,2011. Влияние лесных пожаров на экологическую ситуацию. *Успехи современного естествознания* **7**, 236–236.

Юнатов, А.А.,1954. Кормовые растения пастбищ и сенокосов Монгольской Народной Республики. Издательство АН СССР, Москва – Ленинград, СССР, 131 с.

Dorjgotov, D. (ed.), 2022. National atlas of Mongolia. Institute of Geography and Geoecology of the Mongolian Academy of Sciences, Ulaanbaatar, Mongolia, 251 p.

Etzelmüller, B., Heggem, E.S., Sharkhuu, N., Frauenfelder, R., Kääb, A., Goulden, C., 2006. Mountain permafrost distribution modelling using a multi-criteria approach in the Hövsgöl area, northern Mongolia. *Permafrost and Periglacial Processes* **17**, 91–104. https://doi.org/10.1002/ppp.554

Gunin, P.D., Saandar, M. (eds.), 2019. Ecosystems of Mongolia. Atlas. Admon, Ulaanbaatar, 264 p.

Gunin, P.D., Vostokova, E.A. (eds.), 1995. Ecosystems of Mongolia. Map. 1 :1000000. EKOR, Moscow, Russia, 15 p.

Mongolian Red Book, 2013. Shiirevdamba, Ts. (ed.).Admon, Ulaanbaatar, Mongolia, 535 p.

Munkhdavaa, M., Gansukh, Ya.,Yamkhin, J., Menzel, L., 2020. Ground surface temperature variability and permafrost distribution over mountainous terrain in northern Mongolia. *Arctic, Antarctic, and Alpine Research* **52**, 13–26. https://doi.org/10.1080/15230430.2019.1704347

Undraa, M., Bazha, S.N., Oyunsanaa, B., Dorjsuren, Ch., 2024. Post-fire succession of pseudo-taiga larch forest in the Tarvagatai Mountain range, Mongolia. *Geography, Environment, Sustainability* **2** (17), 139–149. https://doi.org/10.24057/2071-9388-2024-3121