The current state and biodiversity of steppe phytocenoses in the territory of the Kabardino-Balkarian Republic

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Abstract. In connection with the importance of preserving and restoring steppe landscapes, the purpose of the study was to monitor the state and biodiversity of steppe phytocenoses in the territory of the Kabardino-Balkarian Republic. Geobotanical survey was carried out in the steppe and foothill zones of the republic in 2018-2020. According to the monitoring results, it was found that an increase in pasture digression correlates with a depletion of the floristic composition, a decrease in the projective cover, the height of the herbage and the productivity of aboveground phytomass, an increase in the level of synanthropization and a simplification of the vertical structure. With an increase in anthropogenic influence in plant communities, the level of synanthropization increases to 78.6%. The decrease in the projective cover in 1.5-3.3 is a consequence of the long and irrational use of pastures. As a result of intensive grazing, the productivity of the aboveground phytomass decreases by 9-12 times, and the height of the grass stand - by 2.5-5.0 times compared to the reference steppe phytocenoses. To preserve steppe phytocenoses, a set of measures is needed, including the ecologization of agriculture, the development of measures for the ecological restoration of disturbed steppe ecotopes, the prevention of negative phenomena of invasion, the creation of nurseries of steppe flora and steppe reserves, the inclusion of species that are in danger of complete extinction in the Red Book of the flora of Kabardino-Balkaria.

1 Introduction

The territories occupied by steppe landscapes are among the most significant in the agricultural sector. Due to the active use in agricultural production, natural steppe biogeocenoses with fertile chernozem soils under steppe vegetation have survived only in small areas that are inconvenient for economic use. Despite the uniqueness of the steppes and the threat of their complete disappearance, the area of reserved zonal steppe areas is only 0.15% of the total area of specially protected territories in Russia. Steppe biogeocenoses of the Central Ciscaucasia are currently recognized as endangered ecosystems, which is mainly due to the agricultural system of management [1, 2] and, as a consequence, synanthropization of vegetation. Synanthropic vegetation is a hotbed of

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distribution of harmful and quarantine invasive species, it has a huge impact on local natural phytocenoses [3, 4]. In the foothill zone of the Kabardino-Balkarian Republic (KBR), the steppes are located on the plain and gentle slopes of the Chalk Ridge up to 600 m above sea level. Currently, most of the foothill steppes are plowed up. Reference steppe communities are found in separate fragments in the valleys of the Baksan, Cherek, Chegem, and Lesken rivers. Excessive grazing of livestock has led to severe degradation of herbage and depletion of its floristic composition [5]. Given the limited natural conditions for steppe phytocenoses in the North Caucasus, there is not a single reserve for the preservation of steppe ecosystems. In connection with the importance of preserving and restoring steppe landscapes exposed to anthropogenic factors, the purpose of this study was to monitor the state and biodiversity of the foothill steppe phytocenoses of the KBR.

2 Materials and methods

Geobotanical survey was carried out on the territory of Prokhladnensky, Baksansky, Maysky, Chegemsky and Tersky districts of the KBR in 2018-2020. Geobotanical descriptions were carried out on accounting areas of 10x10 m^2. The association was named after the dominant species. The projective cover of the species was assessed as a percentage of the total area of the registration area (RA). The grass stand was disassembled into economic groups (cereals, sedges, legumes, herbs, poisonous herbs). The proportion of cereals and forbs, as well as the productivity of aboveground phytomass in dry matter (kg / m^2) was determined by the gravimetric method. The level of synanthropization was assessed by the proportion of synanthropic species: less than 10% - natural vegetation, 11-30% - weakly synanthropic communities, 31–50% - moderately synanthropic, 51-80% - strongly synanthropic, above 80% - synanthropic communities [6]. In the course of performing geobotanical descriptions, the total projective cover of the grass stand (%) and its average height (cm) were determined on each RA. The degree of floristic similarity of the descriptions was assessed by the Koch Biotic Dispersion Index (IBD).

3 Results and discussion

Reference steppe phytocenoses have been preserved in the Prokhladnensky (RA 1, 2), Chegemsky (RA 3) and Tersky (RA 4) districts of the KBR. They are represented by sagebrush-cereal, forb-cereal communities, Beard-grass steppes**.**

RA 1 (river terrace of the Malka river). *Artemisia absinthium*, *A. vulgaris*, *A. scoparia*, and *A. austriaca* dominate in the sagebrush-cereal steppe. The dominants of the second tier are *Stipa capillata*, *Setaria viridis*, and *Cynodon dactylon*. Forbs from *Cichorium intybus*, *Sisymbrium loeselii*, *Xeranthemum annuum*, *Achillea millefolium*, *Verbena officinalis*, *Hypericum perforatum* predominate. Legumes are represented by *Medicago minima*, *M. sativa*, and *M. lupulina*. The projective cover is 100%. The height of the herbage is 20-50 cm. The productivity of the aboveground phytomass is 0.17 kg / m^2.

RA 2 (riverside terrace of the Baksan river). *Bothriochloa ischaemum* dominate in the beard formation. The subdominants are *Cynodon dactylon*, *Festuca valesiaca*, *Setaria pumila*, *Koeleria macrantha*, and *Stipa capillata*. Other cereals include *Bromopsis inermis*, *B. riparia*, *Elytrigia repens*, *Stipa lessingiana*, *Bromus arvensis*, *Eragrostis minor*, *Agropyron desertorum*, and *A. fra*gile. Legumes are represented by *Trifolium repens*, *T. pratense*, *T. fragiferum*, *Medicago lupulina*, *M. falcata*, *Lotus caucasicus*, *Melilotus officinalis*, and forbs - *Cichorium intybus*, *Achillea nobilis*, *A. millefolium*, *Daucus carota*, *Origanum vulgare*, *Leontodon autumnalis*, *Euphorbia boissieriana*, *Tragopogon graminifolius*, *Artemisia austriaca*, *Verbascum phoeniceum*, *Astragalus onobrychis.* The

projective cover is 100%. The height of the herbage is 20-45 cm. The productivity of the aboveground phytomass is 0.19 kg / m^2.

RA 3 (environs of the village of Chegem II, floodplain of the Chegem river). The dominant of the bearded-forb meadow steppe is *Bothriochloa ischaemum*. Subdominants - *Bromopsis riparia*, *Cynodon dactylon, Elytrigia repens*. *Bromus squarrosus*, *B. hordeaceus*, *Festuca valesiaca*, *Koeleria macrantha*, *Phleum phleoides*, and *Calamagrostis epigeios* were assigned to accompanying cereals. Among leguminous herbs Trifolium repens, *T. fragiferum*, *T. pratense*, *Medicago lupulina* are abundant. Multispecies forbs: *Achillea millefolium*, *Cichorium intybus*, *Inula britannica*, *Origanum vulgare*, *Salvia verticillata*, *Galium verum*, *Linum austriacum*, *Plantago lanceolata*, *P. media*, *Thalictrum minus*, *Daucus carota*, *Onopordum acanthium*, *Convolvulus arvensis*, *Thymus marschallianus*, *Lappula squarrosa*. The projective cover is 100%. The height of the herbage is 10-50 cm. The productivity of the aboveground phytomass is 0.15 kg / m^2.

RA 4 (environs of the village of Arik). The herb-grass steppe phytocenosis has projective cover of 90% and herbage height of 45-50 cm. Among the grasses, steppe species are noted: *Koeleria cristata*, *Phleum phleoides*, *Poa angustifolia*, *Festuca valesiaca*, *Helictotrichon pubescens*, *Bromopsis riparia*, *Bothryochloa ischaemum*. In spring, ephemeral cereals abundantly develop in the communities: *Anisantha tectorum*, *A. sterilis*, *Bromus japonicus*, *Poa bulbosa*. Forbs are rich in species. Its basis is *Salvia verticillata*, S. *tesquicola*, *Filipendula vulgaris*, *Agrimonia eupatoria*, *Galium verticillatum*, *Centaurea dealbata*, *Scabiosa ochroleuca*, *Polygala anatolica*, *Fragaria viridis*, *Ajuga orientalis, Poterium polygamum, Thymus marschallianus*. Among the rare species are *Paeonia tenuifolia* (included in the Red Books of Russia, North Ossetia and Kabardino-Balkaria), *Paeonia biebersteiniana*, *Asparagus verticillatus*, *Dictamnus caucasians*, *Clematis lathyrifolia*, *Adonis flammea*, *Amygdalus nana*. The productivity of the aboveground phytomass is 0.14 kg / m^2.

To establish the influence of anthropogenic load on steppe phytocenoses, descriptions of vegetation on steppe fallow lands and pastures (RA 5-10), which serve as feeding grounds, were carried out. The main purpose of the forage lands is to graze all types of livestock in the spring-summer-autumn period. The territory occupied by the primary steppes is plowed up. The feather-grass steppes, which previously occupied huge upland areas, are not found at present. The result of intensive pasture digression in the surveyed areas is the absence of zonal types of vegetation, which can serve as standards of indigenous steppe vegetation.

RA 5 (Prokhladnensky district, environs of the vil. Proletarskoye). *Cynodon dactylon-Artemisia taurica* association has projective cover of 70%, a herbage height of 25 cm. The dominants of the phytocenosis are *Cynodon dactylon* and *Artemisia taurica*. Codominants - *Elytrigia repens*, *Asperula prostrata*, *Bromus squarrosus*. Harmful herbs - *Ambrosia artemisiifolia*, *Carduus nutans*, *Carlina vulgaris* - are less common. The share of cereals in the composition of the herbage is 10%, forbs - 5%, *Artemisia taurica* - 85%. The economic state is characterized by contamination with harmful herbs. The productivity of the aboveground phytomass is 0.07 kg / m^2.

RA 6 (Prokhladnensky district, pasture of the «Stepnoy sheep farm»). Associations with *Cynodon dactylon*, *Elytrigia repens and Cynodon dactylon-Elytrigia repens* have formed on the territory. The main cereals are Cynodon dactylon and Elytrigia repens. Poisonous (*Xanthium strumarium*, *Onopordum acanthium*) and harmful plants (*Hordeum leporinum, Lappula squarrosa*, *Carduus nutans*, *Cirsium vulgare*, *Silaum silaus*) were noted. Forbs are represented mainly by *Artemisia taurica*. The projective cover is 30%, the height of the herbage is 20 cm. The productivity of the aboveground phytomass is 0.06 kg / m^2.

RA 7 (Prokhladnensky district, environs of the vil. Zarechny along the Podkumok river). The preserved areas of natural vegetation are represented by knotweed, weedy (*Lappula squarrosa*, *Carduus nutans*), *Ceratocarpus arenarius-Artemisia taurica*, *Ceratocephala orthoceras- Poa bulbosa- Cynodon dactylon* associations. Associated plants are *Hordeum leporinum*, *Bromus squarrosus*, *Medicago minima.* Harmful plants are represented by *Carduus nutans* and *Onopordum acanthium*, poorly eaten - *Ceratocarpus arenarius*, poisonous - *Xanthium strumarium*. Ephemeres, which, depending on the conditions of the year, give a more or less closed herbage, are represented by *Ceratocephala orthoceras* and *Poa bulbosa*. The projective cover varies from 30 to 50%, the height of the herbage is 7-10 cm due to constant grazing. The productivity of the aboveground phytomass is 0.015 kg / m^2. The main purpose of the forage lands is sheep grazing in the spring-summer-autumn period.

RA 8 (Baksan district, environs of the vil. Psykhurei). The vegetation is represented by grasses: *Cynodon dactylon*, *Bromopsis variegata*, *Bothriochloa ischaemum*, *Setaria pumila*, *Lolium perenne*, *Phleum phleoides*. Among the forbs, *Cichorium intybus*, *Salvia verticillata*, *Plantago lanceolata*, *Potentilla anserina*, *Leontodon hispidus* were recorded. Among the harmful herbs, *Setaria pumila* and *Cirsium obvallatum* were noted. The projective cover is 55%. The height of the herbage is 15 cm. The productivity of the aboveground phytomass is 0.065 kg / m^2. The main purpose of the forage lands is sheep grazing in the spring-summer-autumn period.

RA 9 (Maisky district, watershed of the Chernaya river). Meadow steppes are represented by medium-sized communities dominated by forb, *Bothriochloa ischaemum* and *Cynodon dactylon*. They are characterized by an almost complete absence of leguminous herbs, infestation with harmful and poisonous herbs (*Centaurea georgica*, *Ambrosia artemisiifolia*). The projective cover is 60%. The height of the herbage is 20 cm. The productivity of the aboveground phytomass is 0.08 kg / m^2.

RA 10 (Maisky district, environs of the vil. Prishibo-Malkinskoye). The meadow steppe is represented by forb-cereal, Beard-grass, weed-herb communities. The herbage is dominated by weeds (*Cirsium vulgare*, *Ambrosia artemisiifolia*, *Amaranthus retroflexus*, *Chenopodium album*, *Setaria viridis*). The most common type of meadows is herb-cereal. It is based on *Stipa capillata*, *Calamagrostis epigeios*, *Setaria viridis*, *Elytrigia repens*. Associated species - *Glycyrrhiza glabra*, *Salvia verticillata*, *Euphorbia virgata*, *Cynanchum acutum*, *Ambrosia artemisiifolia*. The share of cereals in the herbage is 82%, legumes - 1%, forbs - 17%. The projective cover is 85%, the height of the herbage is 20-35 cm. The productivity of the aboveground phytomass is 0.10 kg / m^2.

The floristic similarity of the aggregate of the described phytocenoses is very low (IBD = 10%). The relatively low similarity of the native steppe vegetation (IBD = 15.4%) indicates a high level of biodiversity in each of the preserved steppe fragments, which was formed under the influence of orographic and soil factors of steppe ecotopes. In anthropogenically transformed phytocenoses, the floristic similarity increases to 28.5%, which indicates a decrease in biodiversity and a simplification of the structure of plant communities.

One of the features of steppe vegetation is its limited buffer capacity for overgrazing. An increase in pasture digression (RA 5-10) correlates with the depletion of the floristic composition, a decrease in the projective cover, the height of the herbage and the productivity of aboveground phytomass, an increase in the level of synanthropization and a simplification of the vertical structure (Table 1).

Table 1. Results of monitoring of steppe phytocenoses of the KBR

RA	Level of pasture digression	Species richness	Share of synanthropic species,%	Projective cover,%	Height of the upper tier of the grass stand, cm	Productivity of aboveground phytomass, kg / m²
1	Weak	24	8.3	100	50	0.17
2	Weak	27	7.4	100	45	0.19
3	Weak	37	9.1	100	50	0.15
4	Absent	35	2.9	90	50	0.14
5	Strong	22	50.0	70	25	0.07
6	Strong	23	56.5	30	20	0.06
7	Strong	16	64.0	40	10	0.015
8	Strong	14	78.6	55	15	0.065
9	Strong	20	70.0	60	20	0.08
10	Moderate	32	28.1	85	35	0.10

The depletion of the floristic composition (a decrease in species diversity by 1.7-2.5 times) indicates a decrease in the resistance of anthropogenic steppe phytocenoses to unfavorable environmental factors. According to the level of synanthropization, weakly, moderately and strongly synanthropized syntaxa are established. On the counting sites with native steppe vegetation, the proportion of synanthropic species varies from 1 to 8%. With an increase in anthropogenic influence (excessive grazing) in plant communities, the level of synanthropization increases to 78.6%. The evolutionary consequences of the synanthropization process are a decrease in the genetic heterogeneity of individual species, fragmentation of plant populations and their increasing isolation, introgressive hybridization between previously separated taxa, and the emergence of endemics of technogenic substrates and contaminated sites. The consequences of the synanthropization process are also the replacement of indigenous plant communities with derivatives, the replacement of endemic plants with cosmopolitan, eurytopic ones, and the convergence of plant communities. All this leads to the depletion and unification of phytocenoses, a decrease in the stability and productivity of the vegetation cover.

Particularly dangerous for steppe ecosystems are invasive species that must be included in the “Black” list of Kabardino-Balkaria: biocenotic transformers (*Ambrosia artemisiifolia*, *Elytrigia repens*, *Sorghium halepence*) capable of displacing less competitive species and acting as edificators and dominants; phytocenotic transformers (*Erigeron canadensis*, *Amaranthus retroflexus*), actively spreading and naturalizing in disturbed semi-natural and natural habitats; segetal-ruderalotrasformers (*Xanthium spinosum*), which disperse and naturalize in disturbed habitats and are able, in the course of further naturalization, to penetrate into semi-natural and natural communities; potentially invasive (*Euphorbia virgate*), capable of renewal in the places of introduction and manifested themselves in adjacent regions as invasive species. Invasive species compete with native species, simplify the structure of phytocenoses, play the role of new host plants for parasites and pathogens, hybridize with native species, and displace them from natural phytocenoses. The appearance of invasive alien species causes serious damage to the economy and health and is one of the main reasons for the loss of biological diversity [3].

The projective cover of herbage with native steppe vegetation is 90-100%, and in anthropogenically transformed phytocenoses it decreases to 30-40%. The decrease in the projective cover in 1.5-3.3 is manifested in the downsizing of pastures and is a consequence of the prolonged and irrational use of steppe phytocenoses. As a result of intensive grazing,

the productivity of the aboveground phytomass decreases by 9-12 times, and the height of the grass stand - by 2.5-5.0 times compared to the reference steppe phytocenoses.

Due to the fact that an increase in the intensity of grazing in pasture meadows leads to a decrease in the productivity of the aboveground phytomass, a simplification of the structure, a decrease in species diversity, an increase in the role of digression-resistant synanthropic herb species, soil compaction and drying, the protection of steppe meadows with their constant economic use should be directed to maintain high productivity, restore and preserve biodiversity [7-13]. Ecological restoration of degraded steppe ecosystems is possible subject to the introduction of normalized pasture loads and observance of the grazing time [14, 15].

Phytomelioration with the use of perennial valuable forage grasses [16, 17] and short-term isolation of pastures from grazing, which makes it possible to increase the yield of herbage and the species diversity of legumes and cereal components [18], are important methods for restoring steppe phytocenoses and preventing erosion processes. The application of the reserved regime of individual sections of steppe pastures should be determined by the productive capacity of vegetation, soil cover and the state of the landscape as a whole. The nature of the protected use will not only preserve forage lands, but also improve them by preventing erosion processes.

To limit the negative consequences of the process of synanthropization of steppe ecosystems, it is necessary to conduct annual monitoring of plant communities, assess the degree of their anthropogenic transformation, study the successional processes occurring in plant communities, constant monitoring of the state of populations of rare plants and plants included in the Red Book, and mapping of their location. According to the monitoring results, the phytocenosis on the Arik ridge is the richest in rare and endangered species. To preserve it, it is advisable to create a steppe reserve here. The endangered steppe species (*Stipa pennata* L., *Stipa lessingiana* Trin. & Rupr., *Asparagus verticillatus* L.. *Papaver bracteatum* Lindl., *Tulipa bicbersteiniana* Schult. & Schult. f.,*T. suaveolens* Roth, *Iris halophilla* Pall., *I. pontica* Zapał., *I. graminea* L.).

4 Conclusion

As a result of a geobotanical survey of reference and anthropogenically transformed steppe phytocenoses on the example of the plain and foothill steppes of the Kabardino-Balkarian Republic, their low floristic similarity was established. An increase in pasture digression correlates with the depletion of the floristic composition, a decrease in the projective cover, the height of the herbage and the productivity of the aboveground phytomass, an increase in the level of synanthropization, and a simplification of the vertical structure. To preserve steppe phytocenoses, a set of measures is needed, including the ecologization of agriculture, the development of measures for the ecological restoration of disturbed steppe ecotopes, the prevention of negative phenomena of invasion, the creation of nurseries of steppe flora, steppe reserves, including pasture ones with a partially protected regime, and the inclusion in the Red Book of the flora of Kabardino-Balkaria of endangered species.

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