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Research Article

The Impact of Changes in Forage Vegetation for Saiga (Saiga Tatarica) On Natural Pastures in The Steppe Zone of the West Kazakhstan Region

Amanay Myrzabayev[1], Zhanbolat Ibraibekov[2], Zhangeldi Ussenov[3], Marat Bodeyev[1], Bibigul Sarsenova[4], Svetlana Jangildinova[5] and Svetlana Derbush[2]

[1]Department of Zoology, E.A. Buketov Karaganda State University, Karaganda, Kazakhstan
[2]Department of Chemistry and Chemical Technologies, Abylkas Saginov Karaganda State Technical University, Karaganda, Kazakhstan
[3]Institute of Veterinary Medicine and Animal Husbandry, Zhangir Khan West Kazakhstan Agrarian and Technical University, Uralsk, Kazakhstan
[4]Department of science and international relations, M. Utemisov West Kazakhstan University, Uralsk, Kazakhstan
[5]Department of Biomedicine, Karaganda Medical University, Karaganda, Kazakhstan

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Corresponding Author:
Zhanbolat Ibraibekov
Department of Chemistry and Chemical Technologies, Abylkas Saginov Karaganda State Technical University, Karaganda, Kazakhstan
Email: jan_ai-87_86@mail.ru

Abstract: This study investigates the impact of recent climate changes and reduced anthropogenic pressure on the vegetation cover in the steppe regions of Russia and Kazakhstan, particularly focusing on the effects on saiga (Saiga tatarica) populations. By the late 1990s, a significant shift towards the dominance of grasses and the reduction of herbaceous plants in semi-arid and arid regions was observed, which has likely diminished the nutritional quality of pastures for herbivores such as saiga. Herbaceous plants generally offer higher protein and better digestibility than grasses, which contain high levels of lignin and silica, complicating digestion for ruminants like saiga. The study explores the reactions of saiga to these changes in vegetation, given their preference for herbaceous plants over grasses. Field studies were conducted from 2019 to 2022 in the steppe zone of Western Kazakhstan, employing geobotanical surveys to analyze the composition and abundance of plant species. Results showed that in grass-dominated communities, herbaceous plants made up only 10-20% of the projective cover, while grass communities reached 70-90%. Chemical analyses of forage plants indicated that grasses from the Poaceae family, although abundant, provide lower nutritional value due to their high fiber and lignin content. In contrast, certain herbaceous plants showed higher protein content, making them more beneficial for saiga. The study highlights the importance of maintaining a balance between grasses and forbs in pasture ecosystems to support the nutritional needs of saiga and ensure their long-term survival. It also emphasizes the need for continued monitoring of vegetation changes and saiga population dynamics, as increased saiga numbers may put further strain on available pasture resources. This study employs an interdisciplinary approach, utilizing modern methods for analyzing the chemical composition of forage and GIS technologies for pasture monitoring. For the first time, climate changes and their impact on the saiga's forage base are considered, along with practical solutions for sustainable use of pasture ecosystems. The introduction of bioremediation technologies enhances pasture productivity and helps preserve rare species.

Keywords: Saiga Antelope, Natural Pastures, Forage Plants, Nutritional Value

SCIENCE Publications

Introduction

In recent decades, science has made significant advancements in agriculture, including fields such as ecology, biotechnology, crop production, and livestock farming. Modern agricultural technologies have improved the efficient use of natural resources, reduced the negative impact on the environment, and enhanced the productivity of agricultural systems. In ecology, important progress has been made in understanding the mechanisms of interactions within ecosystems, which has led to the development of more sustainable and environmentally friendly farming methods (Jacobsen, 2012; United Nations Environment Programme, 2022).

In the field of biotechnology, innovative methods have been developed to improve crops and livestock products, not only increasing yields but also enhancing the resilience of plants and animals to environmental stress factors (Smith and Jones, 2015). In crop production, the focus is on optimizing soil and water use, introducing climate-resilient crop varieties, and preserving biodiversity. In livestock farming, eco-friendly technologies are being implemented, and new methods for pasture management and feeding are improving livestock productivity while minimizing the pressure on grazing lands (Brown, 2018; Food and Agriculture Organization, 2015).

These achievements are particularly important in the context of climate change and diminishing natural resources. In the steppe zones of West Kazakhstan, such innovative approaches to agriculture are crucial, as ecosystems in this region are vulnerable to shifts in temperature and precipitation patterns (Kassymov, 2020; Khanyari *et al*., 2022).

Understanding the interaction between climate change, the state of pastures, and forage availability is critically important for developing sustainable natural resource management systems and ensuring biodiversity conservation in the face of a changing climate (United Nations Environment Programme, 2022; Grace, 2021).

Recent climate changes and the reduction of anthropogenic pressure on ecosystems worldwide are leading to significant changes in vegetation cover year by year (Nurushev, 2020). These changes manifest in the alteration of species composition, pasture productivity, and the availability of forage for wild and domestic animals. In the steppe zones of Kazakhstan, where climatic conditions are often extreme, these changes are particularly noticeable (Dzhapova, 2008; Dzhapova *et al*., 2013).

Warming temperatures, shifting precipitation patterns, and prolonged periods of drought impact plant communities, leading to shifts in dominant plant species and changes in their biomass (Adaptation UNDP, 2018). The reduction of anthropogenic pressure, including decreased agricultural land use and pasture restoration, has in some cases led to the recovery of natural ecosystems. However, this also requires adaptation of grazing and conservation systems to new conditions (Food and Agriculture Organization, 2015; Dzhapova *et al*., 2013).

These changes in vegetation affect not only ecosystems but also traditional agricultural practices such as livestock grazing, as well as the diets of wild animals like saiga, whose forage base is directly dependent on the quality of vegetation (Karimova *et al*., 2020; Kamp, 2016; Hofmann, 1991).

These changes are expressed by the mesophytization of vegetation, increased dominance of grasses, and steppe formation in semi-arid and arid regions. Studies indicate that by the late 1990s, grasses had come to dominate steppe vegetation, while the proportion of herbaceous plants significantly decreased. This shift has likely negatively affected the forage quality of pastures and the status of herbivore populations such as the saiga (Van Soest, 1994; Abaturov and Dzapova, 2015).

It is well known that herbaceous plants surpass grasses in nutritional value, particularly in protein and other essential nutrients. Furthermore, grasses have lower digestibility due to their high lignin and silica content, which complicates digestion for herbivores (Kodikara, 2017).

However, the reaction of herbivorous mammals to changes in vegetation remains unclear. Animals with different digestive system morphologies respond differently to grass and herbaceous diets. For example, horses, with hindgut fermentation, better digest coarse grass, while ruminants prefer herbaceous plants. For saiga, like other ruminants, herbaceous plants are a more attractive and nutritious source of food (Nurushev, 2020).

Studies have shown that saiga avoid grazing on grasses, including the widespread feather grass species of the steppe (Pavlova, 1956–1966).

Vegetation changes associated with the dominance of grasses have likely reduced the nutritional value of pastures, worsening the status of saiga populations (Kodikara, 2017).

Consequently, modern steppe pastures are becoming less suitable for the sustainable existence of saiga populations. The saiga (*Saiga tatarica*) is a migratory species endemic to the semi-arid pastures of Central Asia and the Caspian region. Its unique physical features, such as its distinctive nose, help it survive in conditions of dust storms and cold winters (Jacobsen, 2012; Kassymov, 2020).

There are two subspecies of Saiga: *S. t. tatarica* in Kazakhstan, Uzbekistan and the Russian Federation, and *S. t. mongolica* in Mongolia. The majority of the world's saiga population inhabits Kazakhstan, where it is one of the most abundant wild ungulate species (Smith and Jones, 2015; Kamp, 2016).

The saiga has traditionally been hunted for its meat, horns, and skins since prehistoric times (Brown, 2018).

The history of saiga populations in Kazakhstan has been marked by sharp fluctuations, especially in the 20th century. At the beginning of the century, the saiga was widespread, but intense hunting and habitat changes led to a sharp decline in numbers (Van Soest, 1994; Bekenov and Grachev, 1998; Bliznyuk, 2009; Bukreeva, 2005).

The collapse of the Soviet Union and the ensuing wave of poaching reduced the population of this species by 95% in less than 10 years, resulting in its inclusion in the 2002 IUCN Red List as "critically endangered" (Karimova *et al*., 2020). The situation worsened in 2010 with the mass die-off of saiga in their calving areas (Milner-Gulland *et al*., 2001). Despite conservation efforts and program developments, the problems of poaching and habitat loss remain pressing issues (Kock, 2018).

According to the 2022 census, the number of saiga in Kazakhstan reached 1,318,000 individuals, likely exceeding the optimal level for this species (Abaturov and Dzapova, 2015). In comparison, in the 1970–1980s, the optimal number of saiga in Kazakhstan was estimated at 800–900 thousand individuals. This sharp increase in population may place significant pressure on pasture resources and ecosystems, requiring further study to ensure balance between the saiga population and the state of their natural habitats (Abaturov and Dzapova, 2015).

In 2023, the species was removed from the endangered species list, explained by the rapid recovery of the species in recent years (Orynbayev *et al*., 2016; Grace, 2021).

It is well known that the forage base and condition of habitats have a significant impact on the number of ungulates (Kodikara, 2017). The species composition of the forage base for saiga inhabiting adjacent territories of Kazakhstan has been studied in detail (Cui, 2017; Convention Migratory Species, 2023).

It has been established that while the list of saiga forage plants is extensive, the number of key species is small, and the plant composition changes throughout the growing season (Kamp, 2016; Kühl *et al*., 2009).

Materials and Methods

Vegetation cover studies on natural pastures were conducted between 2019 and 2022 in the steppe zone of the Western Kazakhstan region, the native habitat of the Urals saiga population. Traditional geobotanical methods were employed to assess the vegetation cover, with field vegetation surveys executed through detailed route studies and phytocenosis descriptions at specific points, using GPS devices to log coordinates accurately.

Geobotanical descriptions were made on sample plots of 100 m², and phytocenosis descriptions were documented in pre-designed forms. Species abundance within the plots was estimated using the Braun-Blanquet scale (Pavlova, 1956–1966), while species identification followed established floristic references such as *Vascular Plants of Russia and Adjacent States*. The Latin names of the plants were referenced according to "The Plant List" (CMS, 2023). Plant samples, gathered during the active growing season in June, were analyzed to determine their nutritional content, covering protein, crude fiber, fat, ash, and lignin levels (Van Soest, 1994).

Nutritional and Feed Quality Analysis Methods.

To assess feed quality, the plant samples collected were analyzed for their primary nutrient composition following standardized procedures across eight categories:

Sample Collection and Preparation: Samples, including leaves, stems, and sometimes seeds, were collected during June to capture peak nutrient levels. After collection, samples were air-dried, then ground into a uniform powder for chemical analysis (Karimova *et al*., 2020).

Protein Content: Using the Kjeldahl method, the protein content was quantified by measuring nitrogen released through digestion with sulfuric acid, then converting it to protein via a factor (6.25 for plants). This method helps estimate protein levels available for animal growth and maintenance (Van Soest, 1994).

Crude Fiber: Analyzed through acid-detergent and alkaline-detergent fiber processes, the samples underwent acid and alkaline digestion to isolate fibrous components. Crude fiber content serves as a key indicator of feed digestibility and efficiency (Abaturov and Dzapova, 2015).

Fat Content: Fat content was assessed via ether extraction using a Soxhlet apparatus. This method provides a measure of the forage's energy potential, as fats contribute significantly to overall energy levels (Grace, 2021).

Ash Content: By incinerating the samples at 550°C, the organic matter burned away, leaving behind mineral-rich ash. This analysis estimates minerals like calcium, magnesium, and phosphorus, essential for livestock health (Brown, 2018).

Lignin Content: Measured by the acid-detergent lignin method, lignin content was determined by digesting the samples in a strong acid, leaving behind lignin—a

parameter affecting digestibility, especially crucial for ruminants (Kodikara, 2017).

Other Feed Quality and Zootechnical Parameters: Additional analyses included dry matter, Nitrogen-Free Extract (NFE), and Total Digestible Nutrients (TDN), contributing to the energy content and suitability of each species as forage (Karimova *et al*., 2020; Nurushev, 2020).

Standardized Data Recording and Quality Control: All analyses were performed according to established standards, ensuring reliability through calibration, control samples, and quality logs (Kühl *et al*., 2019). The findings documented variations across species and locations, providing a robust database on the nutritional quality of natural pastures for saiga grazing.

Through these methods, the study accurately quantified the nutritional profiles of the Western Kazakhstan steppe plants, enabling an assessment of their feed quality for supporting the Urals saiga population.

Results

The vegetation cover in the study area was represented by communities dominated by herbaceous plants, wormwood, and grasses (Fig.1).

The projective cover of the herbaceous vegetation in the community dominated by forbs and grasses was 65-70%. A total of 18 species were recorded in the studied community. The predominant species were *Alopecurus pratensis* L. (15-20%), *Poa bulbosa* L., and *Poa pratensis* L. Representatives of the family Compositae were also noted, including *Taraxacum officinale* (L.) Weber ex F.H.Wigg., and *Artemisia austriaca* Jacq. *Fritillaria ruthenica* Wikst., a protected species listed in the Red Book of Kazakhstan, was found in abundance.

In the community dominated by wormwood and *Poa bulbosa*, the projective cover of the herbaceous layer was 15-20%. A total of 12 species were recorded in this community. The most abundant were *Artemisia lercheana* Weber ex Stechm., *Poa bulbosa*, and *Limonium gmelinii* (Willd.) Kuntze. In this community, species such as *Festuca valesiaca* Schleich.ex Gaudin, *Eremopyrum orientale* (L.) Jaub.and Spach, and *Agropyron pectinatum* (M.Bieb.) P.Beauv. were also present in relatively high density.

The projective cover of the herbaceous layer in the community dominated by *Poaceae* species was 70-75%. A total of 17 plant species were identified in this community. The dominant plants were *Festuca valesiaca* and *Agropyron pectinatum* (35-45%). Representatives of the family Leguminosae, including *Medicago falcata* L. and *Astragalus physodes* L., as well as Compositae species *Artemisia austriaca* and *Achillea millefolium* L., were also noted in the community.

The diversity and abundance of species were also studied in the community dominated by forbs and grasses. The projective cover of the herbaceous layer in this community was 65-70%. The highest abundance and projective cover were recorded for members of the family Poaceae: *Poa bulbosa*, *Festuca valesiaca*, *Stipa lessingiana* Trin. & Rupr., and *Stipa capillata* L., as well as members of the family Compositae: *Artemisia austriaca*, *Taraxacum officinale*, and *Linosyris villosa* (L.) DC. In this community, species from the family Leguminosae, such as *Medicago falcata* and *Astragalus physodes*, were also present in significant numbers. A total of 27 plant species were identified in this community.

It is well known that, among the vast diversity of grasses, the primary forage mass for saiga is usually composed of a few families: *Poaceae*, *Compositae*, *Chenopodiaceae*, and *Brassicaceae*. To determine the nutritional value, 12 plant species belonging to these families and frequently encountered in the surveyed area were selected (Fig. 2).

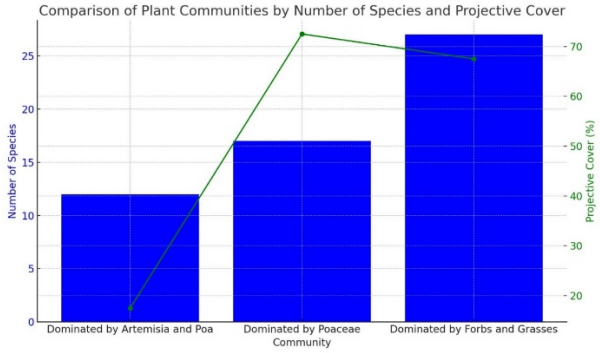

Fig. 1: Vegetation cover of natural pastures in the steppe zone of western kazakhstan

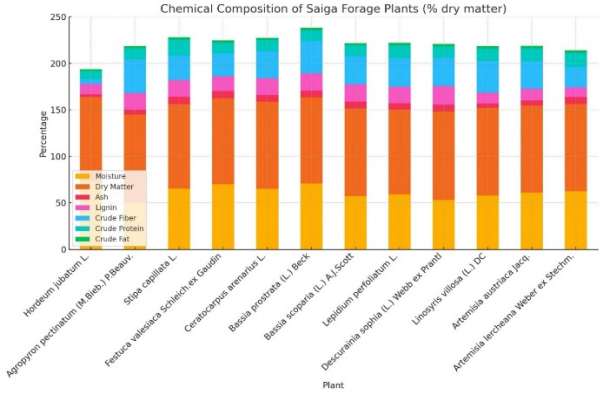

Fig. 2: Chemical Composition of Saiga Forage Plants (% of dry mass)

According to Figure 2, plants from the Poaceae family (grasses) exhibit relatively high moisture content, such as *Hordeum jubatum* L. with 72.7% moisture. The dry matter content varies slightly between species, ranging from 90.7 to 95.4%. The highest ash content was recorded in *Festuca valesiaca* (8.0%) and *Stipa capillata* L. (7.9%), which may indicate a higher mineral content in these plants. High lignin content was observed in *Descurainia sophia* (20.1%) and *Agropyron pectinatum* (17.9%), which may reduce the digestibility of these plants for saiga. Crude fiber content was highest in *Agropyron pectinatum* (36.0%) and *Linosyris villosa* (34.2%), which also affects digestion. The highest crude protein content was noted in *Stipa capillata* L. (16.9%) and *Artemisia lercheana* (14.9%), making these plants valuable sources of protein for saiga. The crude fat content varies slightly, ranging from 2.1 to 2.9%, with slightly higher fat content in *Stipa capillata* L. (2.9%) and *Lepidium perfoliatum* L. (2.8%). Grasses (Poaceae family) have high crude fiber and lignin content, which may hinder their digestibility by saiga. However, some grasses, such as *Stipa capillata* L., have high protein content.

Plants from the Amaranthaceae family exhibit moderate values across all parameters, making them a stable component of the diet. Representatives of the Brassicaceae and Compositae families are characterized by increased levels of crude protein and lignin. Botanical families such as *Lepidium perfoliatum* L. and *Artemisia lercheana* are particularly rich in protein, which is crucial for the nutrition of saiga.

The chemical composition of forage plants significantly influences their nutritional value for saiga. Plants with high crude protein content and moderate fiber levels are the most valuable for these animals' diets. Grasses with high lignin and fiber content may be less preferable due to digestion challenges. Understanding these differences helps assess pasture quality and develop strategies for saiga conservation and population management.

In the mid-1990s, herbaceous plant communities predominated in the vegetation of the region. As early as 1996, forbs accounted for more than 60% of the aboveground phytomass in the plains of Western Kazakhstan, while the share of grasses did not exceed 40% (Fig. 3).

The diagram visualizes changes in the composition of phytomass across various areas where forbs dominate against the backdrop of a decrease in the proportion of grasses in different seasons and years. Figure 2 illustrates the ratio of grasses (Grasses) to forbs (Forbs) in the aboveground phytomass of pastures in the steppe zone of Western Kazakhstan across different years (1996, 2006, 2007) and months (May, June, July).

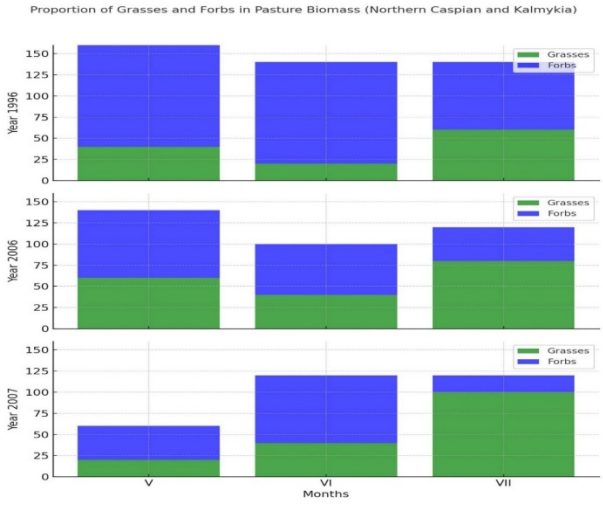

Fig. 3: Proportion (%) of Grasses (1) and Forbs (2) in the Aboveground Phytomass of Pastures in the Steppe Zone of Western Kazakhstan

In May (V) and June (VI) of 1996, a significant predominance of forbs (blue) compared to grasses (green) is observed. In July (VII), the ratio of grasses to forbs remains relatively stable, with forbs still dominating.

In 2006, forbs also dominate in May and July, but the gap between grasses and forbs narrows. June (VI) shows a slight decrease in the proportion of forbs.

In 2007, grasses make up a larger portion of the phytomass in May (V), which differs from previous years. In June and July, forbs increase again, especially in July, where their share noticeably rises.

The diagram demonstrates seasonal and annual fluctuations in the composition of the vegetation cover of pastures. In 1996 and 2006, forbs dominate throughout the season, whereas in 2007, grasses occupy a larger proportion early in the season, but forbs regain dominance later. These changes may be linked to weather conditions and anthropogenic impacts on the pastures.

By the late 1990s, a transformation in vegetation occurred, expressed by the expansion and dominance of grass communities. Between 1983 and 2012, the diverse communities dominated by wormwood (*Artemisia lerchiana*, *A. pauciflora*), prostrate summer cypress (*Kochia prostrata*), and other plants were replaced by grass communities: feathergrass (*Stipa spp.*), crested wheatgrass (*Agropyron fragile*), ephemeroids (*Poa bulbosa*), and annuals (*Anisantha tectorum*, *Eragrostis minor*). According to our data, in 2006 and 2007, the

proportion of grasses in the vegetation of natural phytocenoses in the steppe zone of Western Kazakhstan exceeded 90%, while forbs accounted for less than 10% for most of the year (Figure 3). These changes led to a significant reduction in the mass of forbs, which are preferred by saiga, and an increase in the proportion of grasses, including feathergrasses, which have lower nutritional value [28-33].

In the extensive lake-saline phytocenoses, plant communities consisting of forb-saline-wormwood associations still dominate. In the diet of the wild saiga population inhabiting this region, forbs make up more than 90%, while grasses account for no more than 15% (Fig. 4).

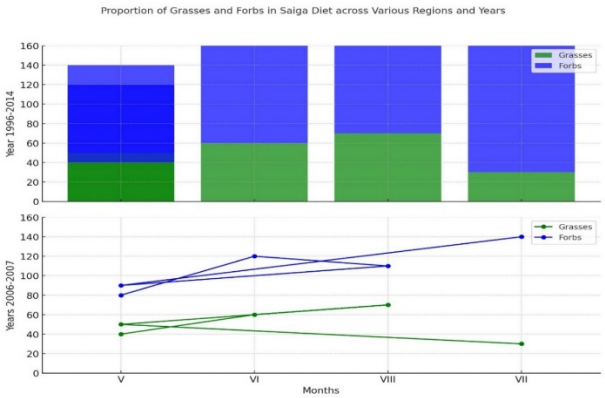

Fig. 4: Proportion (%) of Grasses (1) and Forbs (2) in the Diet of Saiga on Pastures of the Northern Pre-Caspian Semi-Desert (a), the Steppe Zone of Western Kazakhstan (b), and the Lake-Saline Lowlands of Aralsor (c)

Figure 4 represents the ratio of grasses (Grasses) to forbs (Forbs) in the diet of saiga on pastures in different regions across various years and months.

From 1996 to 2014, forbs made up a significantly larger portion of the saiga diet compared to grasses (green). Throughout all the months studied, the proportion of grasses remained below 40%, while forbs comprised more than 60% of the phytomass.

During the period from 2006 to 2007, forbs predominated as well, although a substantial increase in their share was observed in July (VII). The proportion of grasses in May (V) and June (VI) remained stable, decreasing in July.

This graph shows the dynamics of NDVI (normalized difference vegetation index) in the steppe zone of the West Kazakhstan region from 2018 to 2022. The NDVI index, which depends on different sites (designated as regions A, B, C, D and E), allows you to assess the state and changes of vegetation, which is important for analyzing the external food supply and the general state of the ecosystem. On such an English graph, you can see how the vegetation cover changes in each fraction during this time, which is crucial for pasture management and planning measures to preserve the ecosystem in the face of climate change.

The remote sensing results for the West Kazakhstan Region are shown in Figure 6.

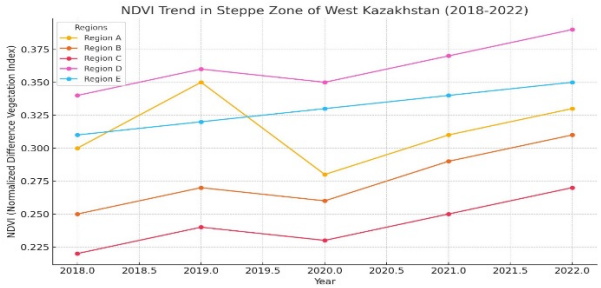

Fig. 5: Dynamics of NDVI (normalized difference vegetation index) in the steppe zone of the West Kazakhstan region from 2018 to 2022

Fig. 6: Remote sensing results for the West Kazakhstan Region

Digestibility and absorption of nutrients in the diet by young saigas depend not only on the nutrient levels in the diet but also on the species composition of the phytocenosis in the pastures.

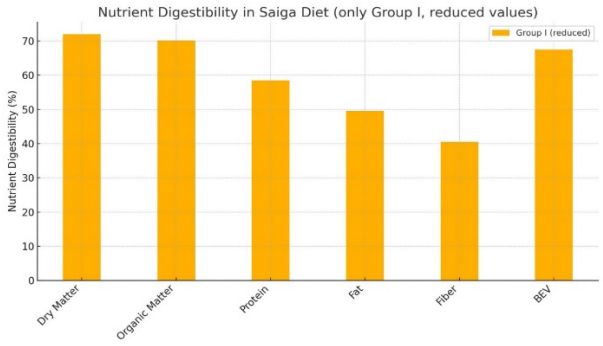

Fig. 7: Nutrient digestibility in the diet, %

Discussion

The results of this study provide valuable insights into the significant changes that have occurred in the vegetation cover of the steppe zone of Western Kazakhstan, particularly concerning the dominance of grasses over forbs, and its impact on the nutritional quality of pastures for saiga populations. The findings highlight a critical shift in plant composition, which has likely affected the forage base for saiga, an essential factor for the species' survival and well-being.

Firstly, the dominance of grasses in many of the studied communities, as well as their high content of lignin and crude fiber, presents a challenge for saiga nutrition. Grasses, such as *Agropyron pectinatum* and *Festuca valesiaca*, while abundant, exhibit low digestibility due to their high fiber content, which makes them a less preferable food source for saiga. This is consistent with previous studies that have shown saiga to actively avoid grasses, favoring herbaceous plants that are higher in protein and more digestible. The high lignin content observed in some species, such as *Descurainia sophia* and *Agropyron pectinatum*, further complicates digestion for saiga, limiting the nutritional value of these plants.

Secondly, the study confirms that forbs, despite their declining proportion in the overall phytomass, remain a critical component of the saiga diet, making up over 90% of their forage intake in various regions. Forbs provide higher levels of crude protein, particularly species like *Stipa capillata* and *Artemisia lercheana*, which are essential for meeting the saiga's nutritional needs. This preference for forbs underscores the importance of maintaining plant communities that are rich in herbaceous species to support healthy saiga populations.

The seasonal and annual fluctuations in the proportions of grasses and forbs further illustrate the dynamic nature of the steppe ecosystem. The dominance of grasses, especially during certain years such as 2007, appears to be linked to changes in weather conditions and anthropogenic factors, including grazing pressure and land use changes. The transformation of vegetation cover since the 1990s, with the replacement of diverse communities by grass-dominated associations, has likely contributed to the reduced quality of pastures for saiga.

The shift toward grass dominance, particularly the increase in feathergrass (*Stipa spp.*) and other less nutritious species, has reduced the availability of high-protein plants that saiga require for optimal health and reproduction. The decrease in the proportion of forbs, which are more digestible and nutritious, suggests that the current state of steppe pastures may not be sustainable for supporting large saiga populations over the long term. This is particularly concerning given the rapid population growth of saiga in recent years, which may place additional pressure on these already fragile ecosystems.

Additionally, the findings on plant species diversity across different communities reinforce the importance of plant variety for ecosystem health. Communities with higher species richness, such as those dominated by forbs and grasses, offer a more balanced and nutritious forage base for saiga. However, the trend toward grass monocultures reduces this diversity, potentially compromising the resilience of pastures to environmental changes and overgrazing.

The chemical analysis of the forage plants also emphasizes the necessity of preserving forb-rich pastures. Forbs not only provide essential nutrients like crude protein but also have moderate fiber levels, making them a more digestible food source compared to grasses. The presence of high-protein species such as *Stipa capillata* and *Artemisia lercheana* in the diet is particularly beneficial for saiga, especially during the critical growing season when their nutritional needs are heightened.

In conclusion, the dominance of grasses in the steppe zone of Western Kazakhstan has likely decreased the nutritional quality of pastures for saiga, while the reduction of forbs has diminished the availability of essential nutrients. This situation highlights the need for targeted conservation efforts aimed at preserving and restoring forb-rich plant communities to ensure the long-term sustainability of saiga populations. Effective management strategies, including the monitoring of plant composition and the balance between saiga population growth and pasture capacity, are crucial to avoid overgrazing and to maintain the health of both the saiga and their habitat. The results of this study can inform future conservation programs and guide decision-making processes to achieve a balance between saiga population recovery and ecosystem sustainability.

Conclusion

As a result of the study, it was established that the vegetation cover of the steppe zone in Western Kazakhstan underwent significant changes, with an increase in the dominance of grasses and a decrease in the proportion of forbs. The projective cover of herbaceous vegetation in the community dominated by grasses and forbs was 65-70%, with 18 plant species identified. In the community dominated by wormwood and Poa bulbosa, the projective cover of the herbaceous layer was significantly lower, at 15-20%, with 12 plant species recorded. In the community dominated by grass species, the projective cover was 70-75%, with 17 plant species identified.

The analysis of the chemical composition of forage plants showed that grasses from the Poaceae family have high crude fiber and lignin content, which complicates their digestion by saiga. For example, Agropyron pectinatum contained up to 36% crude fiber, and Descurainia sophia had up to 20.1% lignin. At the same time, some plants from the Poaceae family exhibited relatively high crude protein content, such as Stipa capillata (16.9%), making this species an important source of nutrients for saiga. Studies of saiga diet in various regions revealed that forbs account for more than 90% of their diet, while grasses make up no more than 15%. On the pastures of the Northern Pre-Caspian semi-desert region and the lake-saline lowlands of Aralsor, forbs consistently dominate the diet of saiga. This emphasizes the importance of preserving forb-dominated communities to maintain favorable conditions for saiga habitat.

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Authors Contribution

Amanay Myrzabayev: Provided overall leadership for the research, conceptualized the study design, and contributed substantially to manuscript preparation.
Zhanbolat Ibraibekov: Developed the methodological framework, conducted data analysis, and contributed to the writing of the manuscript.
Zhangeldi Usenov: Performed data analysis, prepared visualizations, and contributed to manuscript drafting.
Marat Bodeev: Managed the project, prepared visualizations, and contributed to manuscript editing.
Bibigul Sarsenova: Conducted peer review of the manuscript and contributed to editing.
Svetlana Jangildinova: Contributed to manuscript editing and prepared a visualization.
Svetlana Derbush: Contributed to manuscript editing.

Ethics

This article is composed of original content and does not include any material previously published elsewhere.

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