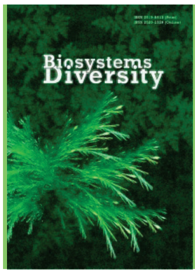

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Vegetation of the southern part of the Caspian Coast and its nutritional value

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To provide the food safety of the population around the globe, including Azerbaijan, it is relevant to develop scientific and practical basics for preservation of natural forage plants, efficient use, improvement of biodiversity, and also prevention of degradation processes in phytodiversity. From this perspective, the composition of vegetation is important for assessing the dynamics of productivity, quality of feeds, norms of cattle grazing and parameters of ecological evaluation of plants and soils which are common in the grazing area, in meadow-steppe phytocenoses, which are a valuable resource of livestock breeding on the Caspian Coast. We analyzed the parameters of meadow-steppe vegetation, common in yellow-podzolized soils. Meadow-steppe vegetation that is used as a natural feeding ground varies by species composition, structure of communities and productivity.

Keywords: vegetation dynamics; Caspian Sea; phytocenosis; plant association; dominant species; subdominant species.

Introduction

The Caspian Sea is the largest lake in the world. The studies of the composition of pollen on the Caspian coastal sediments allow one to evaluate the changes that occurred in the vegetation of this territory throughout the Holocene (Leroy et al., 2014). Pollen, spores and dinoflagellate cysts were examined in the cores of sediments at the depth of 10 m, extracted from the middle basin of the Caspian Sea. Late Dryas vegetation in this territory is characterized by open landscape with dominance of desert plants of the Amaranthaceae family with shrubs and salt-tolerant plants. In the Early Holocene, the desert vegetation in this area was enriched by various shrubs (*Ephedra* and *Calligonum*), but trees were almost absent those days (Leroy et al., 2014). After significant changes in the Middle Holocene, the vegetation preserved the traits of arid and steppe plants, but also pollen of some trees has been discovered (*Quercus* and *Corylus*). In the Late Holocene, there dominated steppe vegetation with great diversity of trees. Leroy et al. (2014) think that the level of the Caspian Sea in the Late Pleistocene and Holocene was first of all determined by the large amount of precipitations in high European latitudes (brought by the Volga and the Caspian Sea) and that lower effect was taken by the Indian summer monsoon over the Pamirs.

Fluctuations in the level of the Caspian Sea cause serious changes in the vegetative cover of the coastal ecosystems of Azerbaijan (Prilipko, 1970; Myalo & Malkhazov, 2000). In many regions, the dynamic spatial succession in the vegetation was described in relation to the land-sea gradient. Such dynamic subsequences in phytocenoses are a manifestation of successional dynamics under the influence of the Caspian Sea level. The current vegetative cover includes elements of several subsequent ecological successions that reflect the evolution of the vegetation subject to multi-years changes in the amount of precipitations (Prilipko & Agadzhanov, 1972; Czerepanov, 1995; Arpe et al., 2000; Myalo & Malkhazov, 2000). Aridity of the coastal districts of Azerbaijan is important for the dynamics of coastal soil-vegetative conditions (Molchanova et al., 1990), though rather than the multi-years moisture evaporation, more important is its influx into soil with precipitations.

Series of space images for the period of 1975–1995 allowed the analysis of the change tendency in the coastal vegetation of the Northern Coast of the Caspian Sea (Kravtsova & Myalo, 1998). The two-meter rise in the level of the Caspian Sea in that period caused flooding of the sea coasts, washout of underwater shallows, and decrease in the area of bed vegetation. Vegetation became more hydromorphic. Gradually, the *Phragmites* coastal strip and meadow-solonchak vegetation moved deep inland, and the area of thickets of *Tamarix* was reduced (Kravtsova & Myalo, 1998). Predominant fluctuations in the coastal line of the Caspian Sea determined the differences in the terrain development. Specifics of the terrain determine the orientations of migration of salts, their accumulation or loss (Glushko, 1989).

Studies of plant pollen concentrations in two lagoons on the south coast of the Caspian Sea allowed studying the changes in phytocenoses which occurred over the recent four centuries (Leroy et al., 2011). Therefore, changes were determined that have occurred in the salinity and the water level, indicating a high level of standing water during the end of the Little Ice Age (years 1620–1830) (Leroy et al., 2011).

Vegetation of aquatic-wetland areas and coastal forests supports the local biodiversity and protects the coastline from erosion, and also promotes binding of carbohydrate and maintenance of fresh water (Gu et al., 2022). The results revealed that over the last 170 years, around the Eynak lagoon (Northern Iran), there was a strong decrease in the area of alder forests, and over the recent 100 years, in the coastal zone, their area expanded. This evidences the changes in the intensity of anthropogenic impact, which shifted from the coast to the areas far from the coastline. The coastal zone of this region was flooded by brackish water of the Caspian Sea and was inappropriate for agricultural farming. The study by Gu et al. (2022) revealed that the vegetation of the coast of the southern part of the Caspian Sea is to a significant extent determined by the activity of humans, and also the global climate changes. The current status of the phytocenoses is a result of interaction of various moving forces: the global climate fluctuations, impact of humans and changes in the sea level at both regional and global levels (Gu et al., 2022).

The current soil cover of the Caspian Coast is determined by geochemical processes in the coastal landscapes and rates of soil formation (Semenkov et al., 2020). Vegetation and soils of solonchaks (loamic) in the eastern part of the Terek–Kuma Lowland (Northern Dagestan, Russia) was studied by Semenkov et al. (2020). The flora of the solonchaks comprises 32 species, mostly halophites: *Tamarix* shrubs dominate, under the crowns of which, there form dense forbes-herbaceous microcommunities with dominance of *Puccinellia gigantea*. Low halophyte plants (*Petrosimonia*, *Frankenia*, *Puccinellia*) are scattered among the shrubs. The solonchak vegetation is important for the preservation and recultivation of technogenic soils of the Caspian Coast (Semenkov et al., 2020).

The changes that have occurred in the vegetation on the coast of Kalmykia and Astrakhan Biosphere Nature Reserve were studied by Kucheryavenkova et al. (2000). Space imagery taken in May, June and July were analyzed. Kucheryavenkova et al. (2000) revealed that multitemporal data of cosmic observations could be used for classification of coastal vegetative cover, as well as monitoring of their seasonal dynamics.

Young soils of the Caspian Coast are characterized by high spatial non-homogeneity and in general remain poorly studied. The Caspian Coast – due to constant changes in the level of this enclosed water body – has been formed by young soil landscapes (Konyushkova et al., 2021). The spatial pattern of salinization of soils was studied on the coast of Russia (Northern Dagestan) and Iran (Northern Golestan) at the altitude of 15.5 m above sea level, or 2.5 m above the current level of the Caspian Sea. The age of the surficial deposits is 50–70 years on the Iranian coast and 293 ± 13 years on the Russian coast. Soils in both key areas are weakly developed strongly saline soils (gleyic solonchaks). By early autumn, variability of soil salinization increases. Formation of spatial non-homogeneity of soil salinization chronologically precedes the spatial distribution of vegetation and microrelief of the coastal zone of the Caspian Sea (Konyushkova et al., 2021).

Tabelinova (2016) studied the main stages and influence of the fluctuations of the Caspian Sea on the terrains of the northeast coast (coastal zone of Mangystau and Atyrau Regions of Kazakhstan) for the period of 1978–2014. The spread of salinity and flooding were determined based on multispectral Landsat satellite images for the period of 1977–2013. The intensity of the impact of fluctuations of the sea level on the coastal landscapes depends greatly on the terrain that has formed over long transgressive phases, which are also related to depth of growndwater, zone of influence of wind waves and the main characteristics of soil cover. Similar studies help researchers to determine "zone of flooding risk", levels of danger for various types of agricultural activities in the territory (Tabelinova, 2016).

Lazareva & Bananova (2018) distinguished the Tertiary and Quaternary periods in three ecological-historical stages of the formation of vegetative cover: the Ancient Caspian, the New Caspian and the Latest Caspian. They correspond to the periods of fluctuations of the Caspian Sea level in response to the global climate changes, which altered the vegetation in this territory. We found first-class ecotone in the Caspian Lowland, second-class ecotone – in the Ancient Caspian terraces, third-class – in the transition zones between the terraces. Each terrace corresponds to a certain geological epoch: Early Khvalin, Late Khvalin and New Caspian. Vegetation – as an indicator of ecological conditions – reflects the evolution of landscapes of the Caspian Region in the gradient of groundwater level and degree of soil salinity (Lazareva & Bananova, 2018).

Maiski et al. (2018) studied the vegetative cover, floristic and phytocenotic specifics of the territory on the northeast coast of the Caspian Sea, where oil and gas are being extracted. The authors have developed a program of monitoring, which can reveal the level of technogenic impact on the ecosystems of the Caspian Lowland. The oil and gas industry is the main cause of negative changes in the structures of phytocenoses on the Caspian Coast (Maiski et al., 2018).

Chronology of loess sediments in Golestan province in Northern Iran is well studied, while no studies deal with the time during which the dunes formed (Rahimzadeh et al., 2019). Those dunes formed over several thousand years, in the range of 10.6–8.4 thou years ago, in the Holocene. The development of the dune sediments was found to be clearly affected by the nearest river systems. Locations of dunes reflect the fast regression of the Caspian Sea in the Early Holocene, probably after the so-called Mangyshlak regression (Rahimzadeh et al., 2019).

In the territory of the Shirvan National Park, established in 2003 – the first National Park in the history of Azerbaijan and the Center of Protection of Biodiversity of the South Caspian , there are coastal, semi-desert and steppe habitats. 14 plant communities and 4 types of soils have been described (Schmidt, 2007). Spatial distribution of soils and plant communities were analyzed by Schmidt (2007) using satellite images of Landsat 7 ETM+.

Tirgan et al. (2022) distinguished five vegetation zones in the territory of the southern part of the Caspian Sea (Iran), located in the climate gradient, the distances to sea and pH, salinity of soils. The authors distinguished two main gradients of salinity and alkalinity, which form the floristic composition. They were more important than climate, distance to the sea and impact of anthropogenic factors. Tirgan et al. (2022) think that anthropogenic factors explain the variability of vegetation partly, though their influence on the composition of plant communities strengthens in the west parts of the Caspian Coast.

Baldina & Labutina (2002) used different-time aero- and satellite images for the evaluation of ecological conditions in aquatic-wetland areas of the delta of the Volga on the northern coast of the Caspian Sea. The authors analyzed the data of aerocosmic survey, covering the period from 1951 up until the elevation and the highest level of the sea in 1996–1999. Using GIS analysis of maps, the researchers determined the specifics of the reaction of vegetation in the delta to falls and rises in the sea level (Baldina & Labutina, 2002).

Aquatic-wetland areas have great biodiversity of vegetation and complex ecological structure. Those ecosystems are constantly changing under the influence of natural and anthropogenic factors, being in relatively healthy condition, as well as at the destruction stage (Shokri et al., 2006). Study of aquatic-wetland areas in Northern Iran, located on the south coast of the Caspian Sea, conducted in 1995–2005, determined changes in relaltive density of vegetation on the water surface and that *Azolla filiculoides*, *Nympha alba*, *Phragmites australis*, *Nelumbiym nuciferum*, *Juncus articulatus*, *Scirpus maritimus* and *Utricularia ignoreta* were expanding their range, whereas the ranges of *Lemna minor*, *Butomus umbelatus*, *Sparganium erectum*, *Salvinia natans* and *Iris pseudacorus* in aquatic-wetland areas of Northern Iran were contracting. Plants that are spreading prevent the light from reaching the water, affecting the food chains, decreasing the diversity of fauna and flora and are creating conditions for eutrophication and drying of aquatic ecosystems (Shokri et al., 2006).

Dimeyeva (2011) studied the spatial-temporal successions of vegetation of the Novo-Caspian plain, distinguishing three types of primary successions (psammosere, halosere, and meadow sere), which are different by specifics of dynamics and stages of the formation. Stages of successions were designated based on properties of soil and composition of dominant species of plants (Dimeyeva, 2011).

Rad & Shafiei (2010) analyzed the structure of groups of plants in beech forests of the south coast of the Caspian Sea (North Iran). They determined that the distribution of four ecological groups of plants in the studied territory is mostly related to type of soil, clay content in soil, total nitrogen, organic substances, phosphorus and exchangeable bases; lower effects on the vegetation composition were exerted by height above sea level, surface angle, percentages of sand and silt, C/N ratio and pH (Rad & Shafiei, 2010).

Sobhani et al. (2018) studied the seasonal changes in the vegetative cover of Iran using Enhanced Vegetation Index (EVI). Based on the analysis of almost 10 billion cells for 2002–2015, 16-days EVI was calculated. The study revealed territorial and seasonal differences in plant communities in the Khuzestan plains, and also in the southern part of Iran (Sobhani et al., 2018).

Changes in vegetation phenology result from large-scale and regional climatic fluctuations (Araghi et al., 2019). For the territory of Iran, there were found interrelations in phenological parameters of the vegetation and six large-scale climate oscillations [the Arctic Oscillation (AO), the Dipole Mode Index (DMI), the Multivariate El Niño Southern Oscillation Index (MEI), the North Atlantic Oscillation (NAO), the North Sea-Caspian Pattern (NCP), and the Pacific Decadal Oscillation (PDO)]. The strongest relation was seen for NCP and NAO had, whereas the lowest correlation was for AO and MEI with phenological parameters of various types of vegetation in Iran. The parameter of NCP significantly correlated with 25–41% pixels for the different vegetation types (Araghi et al., 2019). The results have significance for the ecological prediction and tendencies of further development of vegetation in the dry and semidry climate of Iran (Araghi et al., 2019).

Analysis of aerocosmic images of the Sulak River delta (Kravtsova et al., 2000) from 1978–1997 allowed the researchers to find the processes of "new" and "old" washouts of the delta, washout of the accumulative sandspit and formation of the barrier that has isolated the Sulak Bay, formation of lagoons along the sea coast. Those processes were most intense in 1978–1991, when the sea level rapidly elevated. The intensity of those processes decreased in 1991–1997. The processes of hydromorphization of the vegetation during the rise in the groundwater level were analyzed (Kravtsova et al., 2000).

The Hyrcanian forests stretch from Talish in Azerbaijan and are represented by mostly deciduous forests with relic Tertiary species: *Parrotia persica*, *Gleditsia caspica*, *Zelkova carpinifolia* and *Pterocarya fraxinifolia* (Hossein et al., 2010). Tree diversity increases at elevations where the forests and low shrub thickets transit into Alpine meadows and Iranian-Turanian steppes. Hossein et al. (2010) indicates the spread of 3,234 species of vascular plants from the northern provinces of Iran and Talysh of Azerbaijan. In this territory, there are: 1) sand dune vegetation along the Caspian Sea coasts; 2) C_4-dominated grass communities on rocky outcrops; 3) aquatic vegetation on wetlands; 4) riverine and valley forests; 5) alluvial and lowland deciduous forests; 6) submontane and montane deciduous forests; 7) subalpine deciduous forests (*Quercus macranthera*); 8) successional and transitional scrub and woodlands; 9) *Cupressus sempervirens* and *Thuja orientalis* woodlands; 10) juniper woodlands; 11) subalpine and alpine meadows; 12) montane steppe dominated by xerophytic and thorn-cushion species; 13) rock cliff communities; 14) halophytic communities; 15) *Artemisia spicigera* steppe and desert like dunes; 16) ruderal habitats and 17) cultivated landscapes and planted forests. In the early Pleistocene, at least part of this territory was covered by steppe vegetation, and the climate was warmer than it is today (Hossein et al., 2010). In the early Holocene, in the southern part of the Caspian region, there was drought period, occurring at the same time as the climatic optimum in Europe.

The Samur-Divichi Lowlands in North Azerbaijan is represented by the largest continuous complex of actively moving sand dunes (Tegetmeyer et al., 2007). Those dunes may be affected by some construction projects in the near future. The coastal lagoons are monitored as the places where migrating birds rest. The vegetation comprises 50 species of plants, including endangered psammophytes. Shallow lagoons with *Phragmites* and *Juncus* are located near the sand beach, near the thickets of *Elaeagnus* and *Agriophyllum arenarium*. The valleys have a hilly terrain with *Artemisia arenaria* on hummocks and *Erianthus ravennae* on wet sites (Tegetmeyer et al., 2007).

Bitumen concentration in the soil had a significant influence on the growth of plants (Vostokova et al., 1961). By comparing the vegetation in well-known bitumen-bearing areas with the "control" areas in the West Kazakhstan on the north coast of the Caspian Sea, the plants were classified depending on abnormalities. Irregular size without changes in the initial form in the areas with high bitumen content in soil was determined for 28 species of plants, notably intensified ramification in 8 species, second flowering in 12 species. In general, plants are reliable identifiers of oil bitumens in soil (Vostokova et al., 1961).

To protect the biodiversity (Ovington et al., 1963; Yaroshenko, 1969; Bykov, 1973; Aliyev et al., 2008), effectively use the vegetations and soil cover of natural feeding grounds, study the productivity and nutrition, and also manage and monitor pastures, it is important to ecologically control winter pastures in the coastal zone of the Caspian Sea and ecologically evaluate the rural meadows (Isayev, 2007; Mamedov et al., 2008; Naqinezhad et al., 2008; Gurbanov & Huseynova, 2011). Therefore, parameters of meadow-steppe vegetation, common in yellow-podzolized soils were studied. Meadow-steppe vegetation used as a natural feeding area is different by species composition, structure of communities and productivity (Gadzhiyev et al., 1995). In meadow-steppe vegetation, which forms on the Caspian Coast in the territory of Azerbaijan, 4 classes, 16 formation groups and 31 associations were distinguished.

Materials and methods

In the Law "On the state land cadastre, monitoring of lands and construction", "Rules of creating electronic data system of land-cadastre account in the Azerbaijan Republic and charting digital cadaster map", and also in the President's Decree as of July 13, 2016, there are indicated tasks, specified in the plan of measures for implementation of the "State 2016–2020 program of the development of the cadastre system in the Azerbaijan Republic, increasing the efficiency of land use and their protection" and the Order on carrying out ecological-geobotanical or phytocenological studies in winter pastures and agricultural pastures of the region (in autumn, winter and spring seasons of 2019–2021). At the same time, we studied some phytoecological parameters of *Paliuruseta-Sambucetum-Cynodonosum* formation according to productivity, forage quality, soil-climatic factor (Safarova, 2000). The spread of this vegetation formation is demonstrated in the contours of the map we charted – the "Ecological-geobotanical map of the southern part of the Caspian Coast" (Fig. 1).

The data on the productivity of feeding grounds in Azerbaijan and quality of forage are to a certain extent given in reports by other authors (Yusifov, 1988; Mozaffarian, 1994; Asri & Eftekhari, 2002). In this sense, Mamedov et al. (2008) noted various aspects of intensification of productivity of winter pastures of Azerbaijan, evaluated landscapes based on ecological parameters of soil-vegetative cover and agroindustrial group of soils according to bonitet site class. However, those studies do not mention yield, forage quality, norms of weed control, and also phytoecological parameters characteristic for meadow-steppe formations of the Caspian Coastal Zone. Therefore, we have for the first time performed the ecological evaluation of the earlier discovered formations based on the parameters of fertility of soils in which the plant communities are spread.

We analyzed the productivity dynamics of winter pastures on the studied Caspian Coast based on the data of the Lankaran-Astara meteorological station for the recent three years (Safarova, 2000). The studied phytocenoses are spread in clayey podzolized-yellow soils (Prilipko & Agadzhanov, 1972).

Results

The total productivity of the vegetation on the South Caspian Coast was determined by studying the productivity and nutritional value (quality of forages) of phytocenoses that are characteristic for the territory. Respective geobotanical parameters of those phytocenoses change depending on soil-climatic conditions. Vegetation of various associations was noted in the south part of the Caspian Coast – in the meadow area in the outskirts of Ərçivan, Şiyəkəran and in Astara Rayon (Fig. 1).

Their vegetation compositions contain 28 species (Table 1). Those include 4 species (14.3%) of shrubs, 11 species (39.3%) of perennial herbs, 2 species (7.1%) of biennial herbs, and 11 species (39.3%) of annual herbs. Those plants include 16 mesophites (57.1%), 7 mesoxerophytes (25.0%), 4 xerophytes (14.3%), and 1 psammophyte (3.6%). The dominating species in this formation (association) was *Cynodon dactylon* (L.) Pers. (abundace accounted for 3–4 points), subdominant were *Sambucus ebulus* L. (2 point abundance) and *Paliurus spina-christii* Mill. (2–3 points). Composition-wise, in the first stratum of the phytocenosis, there are represented *P. spina-christii*, *Rubus persicus* Boiss. and some other shrubs. In the second stratum, there are *Centaurea hyrcanica* Bornm., *Plantago lanceolata* L. and other perennial herbs, and also *C. dactylon*, *Lolium persicum* Boiss. et Hohen. As edificator species, in the third stratum, there are annual herbs. The average height of the herbaceous cover reaches 20–40 cm. *Poa masenderana* Freyn & Sint., *C. hyrcanica* and *Veronica ceratocarpa* C. A. Mey are new species identified for the flora of the Caspian Coast, based on the distribution range in the vegetative formation of *Paliuruseta-Sambucetum-Cynodonosum* in the pasture of Şiyəkəran village of Astara Rayon. *Rubus persicus* Boiss. was recorded in the phytocenosis composition; it is a subendemic and rare plant of Azerbaijan. In particular, *Centaurea hyrcanica* Bornm. is included in the Red Book of Azerbaijan.

Dominating species of the abovementioned formation, characteristic of herbaceous-grass vegetation of rural meadow of Şiyəkəran municipality, are *C. dactylon* and grasses. Those are feed plants that are actively consumed by cattle in spring and summer. Productivity of the formation is 8.2 cwt/ha according to edible dry mass, unlike *P. spina-christii*, the shoots of which get stuck in sheep wool and decrease its quality.

Climatic conditions are some of the main ecological factors in growth of typical shrub-grass vegetation in the territory of Astara Rayon (Table 2). The climate in this region is close to moderate-hot (eastern) type with dry summer and moderate-hot (western) type with approximately equal amounts of precipitations.

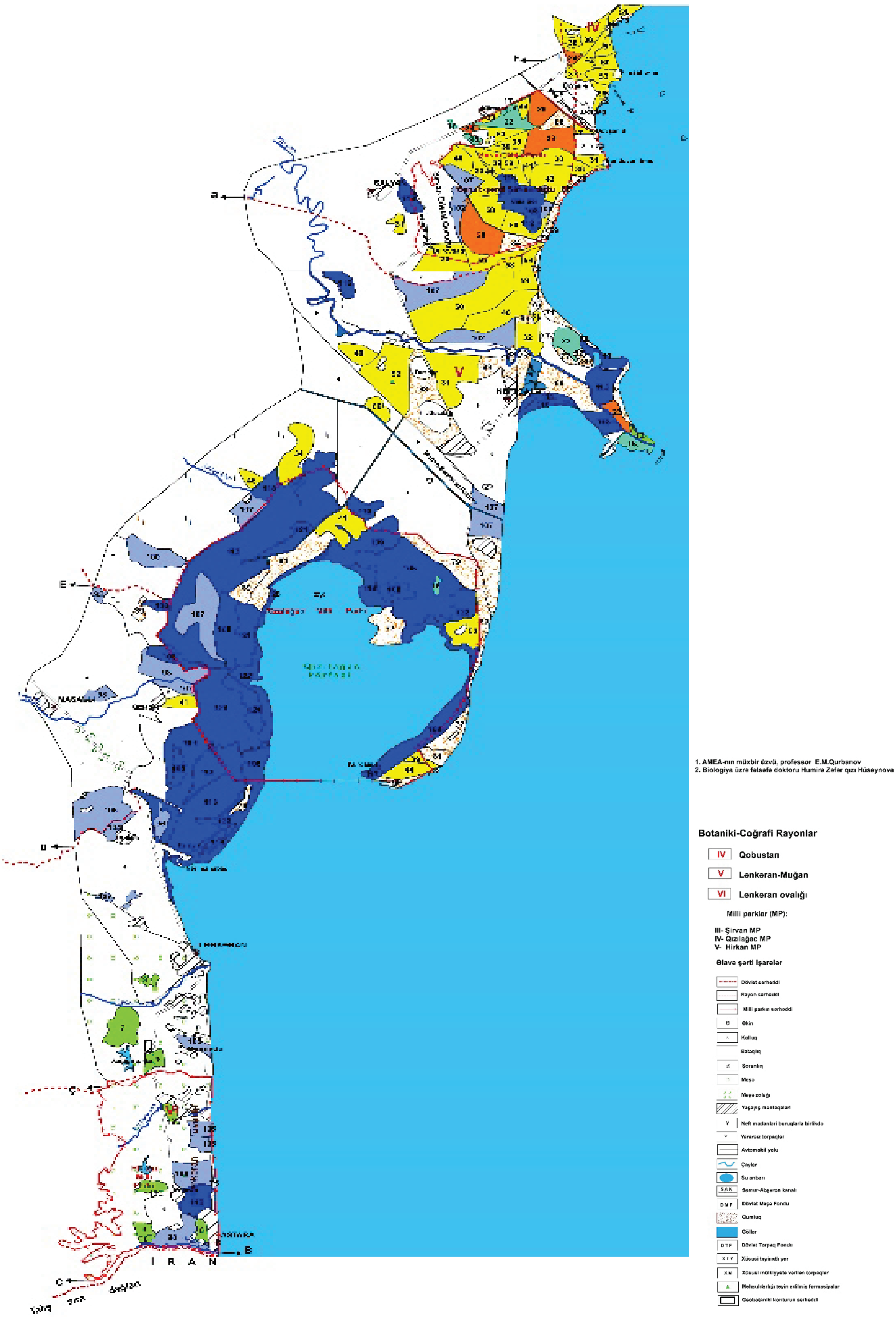

Fig. 1. Ecological-geobotanical map of the south part of the Caspian Coast in Azerbaijan (scale of 1:10, 000):

I. Vegetation zone of the Primorie forests has formed in meadow-brown, irrigated meadow-brown, auburn-yellow, alluvial meadow-forest and irrigated alluvial-meadow soils (green indicates groups of the formations of *Querceta*, *Ulmusetum-Quercosum*, *Dryopterisetum-Quercosum, Carpineta*, Palıdlı-vələslik (*Quercetum-Carpinosum*), *Carexetum-Carpinosum*, *Parrotieta*, *Alnuseta-Carpinetum-Parrotiosum*, *Ulmeta*, *Populeta*, *Ulmetum-Populosum*, *Salixeta-Alnusetum-Populosum*, *Alnuseta*, *Smilaxetum-Alnusosum*, *Carexetum-Alnusosum*);

II. Vegetation of the zone of forests and mixed thickets, spread in podzolized-meadow, meadow-grey and grey soils (grey indicates the groups of formations of *Tamarixeta*, *Elaeagnuseta*, *Elaeagnusetum-Tamarixosum*, *Grataeguseta*, *Rubuseta*, *Tamarixetum-Rubusosum*, *Tamarixeta-Elaeagnusetum-Rubusosum*);

III. Vegetation of dry subtropic and semiarid zone, spread in grey, grey-meadow and grey-brown soils (light blue indicates groups of the formations of *Artemisieta*, *Artemisietum-Ephemerosum*, *Ephemereta-Salsoletum-Artemisiosum*, *Ephemereta-Petrosimonietum-Artemisiosum*, *Pertosimonieta-Salsoletum-Artemisiosum*, *Salsoletum-Artemisiosum*, *Salsoletum-Artemisiosum*);

IV. Vegetation of solonchaks and coastal psammophite deserts, spead on salinated, loamy, meadow-grey, grey-brown, sandy and sabulous soils: IV.1. Solonchak (halophyte) deserts (yellow indicates groups of the formations of *Halecnemeta*, *Halostachysetum-Halocnemosum*, *Suaedaetum-Halocnemosum*, *Halostachyseta*, *Tamarixetum-Halostachysosum*, *Salsoletum-Halostachysosum*, *Suaedaetum-Halostachysosum*, *Kalidieta*, *Halostachysetum-Kalidiosum*, *Ephemeretum-Kalidiosum*, *Suaedaeta*, *Halostachysetum-Suaedaosum*, *Salsoletum-Suaedaosum*, *Eremopyreta-Salsoletum-Suaedaosum*, *Ephemereta-Artemisietum-Suaedaosum*, *Salsoelta*, *Tamarixetum-Salsolosum*, *Artemisietum-Salsolosum*, *Ephemereta-Suaedaetum-Salsolosum*, *Ephemereta-Alhagietum-Salsolosum*, *Salsoleta*, *Artemisietum-Salsolosum*, *Petrosimonieta*, *Ephemeretum- Petrosimoniosum*, *Climacepteretum-Petrosimoniosum*, *Salicornietum-Petrosimoniosum*, *Salicornieta*, *Petrosimonietum-Salicorniosum*, *Climacoptereta*, *Ephemeretum-Climacepterosum*, *Artemisietum-Petrosimoniosum*, *Artemisieta-Eremopyretum-Petrosimoniosum*, *Salsoletum-Artemisiosum*, *Salsoletum-Artemisiosum*, *Suaedaeta-Salsoletum-Artemisiosum*, *Suaedaetum-Artemisiosum*, *Puccinelieta-Limonietum-Artemisiosum*, *Limonietum-Artemisiosum*, *Eremopyreta-Poaetum-Artemisiosum*); IV.2. Coastal sandy / psammophyte deserts (light green indicates groups of the formations of *Argusieta*, *Suaedaetum-Argusiosum*, *Juncusetum-Argusiosum*, *Canvolvuletum-Argusiosum*, *Elaeagnietum-Argusiosum*, *Ephemereum-Convolvulosum*, *Argusietum-Convolvulosum*, *Artiplexeta*, *Puccinileta*, *Elytrigeta*, *Plantageta*, *Foeniculeta*, *Elymisetum-Artemisiosum*, *Junguseta-Argusietum-Artemisiosum*, *Jungusetum-Artemisiosum*, *Tamarixeta-Juncusetum-Artemisiosum*), *Alhagietum-Artemisiosum*, *Melilotusetum-Artemisiosum*, *Astracanthetum-Artemisiosum*, *Ephemereta*, *Limonieta-Melilotusetum-Ephemerosum*, *Centauretum-Ephemerosum*, *Alhagietum- Ephemerosum*);

V. Introzonal vegetation is developed in meadow-forest, light-grey, meadow-brown, carbonate alluvial-meadow and meadow-grey soils (violet indicates groups of the formations of *Cynodoneta*, *Alhagietum-Cynodonosum*, *Alhagieta-Artemisietum-Cynodonosum*, *Medicagoetum-Cynodonosum*, *Glycyrrhizaetum-Cynodonosum*, *Irisetum-Cynodonosum*, *Centauretum-Cynodonosum*, *Aeluropuseta*, *Alhagietum-Aeluropusosum*, *Limonietum-Aeluropusosum*, *Limonieta-Petrosimonietum*, *Alhagieta-Glycyrrhiretum-Ephemerosum*, *Rubuseta-Alhagietum-Cynodonosum*, *Rubuseta-Centauretum-Cynodonosum*, *Paliuruseta-Sambucusetum-Cynodonosum*, *Tamarixeta-Alhagietum-Cynodonosum*);

VI. Introzonal vegetation, spread in irrigated alluvial-meadow, meadow-grey, meadow-grey, meadow-wetland soils (dark blue indicates groups of the formations of *Phragmiteta*, *Juncusetun-Phragmitosum*, *Arundoetum-Phragmitosum*, *Puccineletum- Phragmitosum*, *Bolboschoenetum-Phragmitosum*, *Typhaetum-Phragmitosum*, *Calamagrosetum-Phragmitosum*, *Carexeta*, *Phragmitetum-Carexosum*, *Juncuseta*, *Typhaetum-Juncusosum*, *Phragmiteta-Elytrigetum*, *Phragmiteta-Artemisetum-Juncusosum*, *Tamarixeta-Phragmitetum-Juncusosum*, *Potamogeta*, *Spargamieta*, *Bathrachieta*, *Ceratophyleta*)

After the comparative analysis of the researches - according to geobotanical, soil-climatic parameters of the Caspian Coast – there could be distinguished "vegetative" and "soil" blocks of natural feeding grounds, and also parameters of soil fertility taking into account their productivity, amount of forage units, pasture-sowing loading (grazing norm) and phytoecological parameters. Measures have been developed for superficial improvement (taking care of grass stand) of the phytodiversity of the studied formation of *Paliuruseta-Sambucetum-Cynodonsum* in Astara Rayon in natural feeding grounds of the Caspian Coast based on the productivity, nutritional value, volume of sowing areas, and quality groups. Therefore, other than increasing yield of the studied agricultural crops, effective use of their phytodiversity, the following recommendations have been developed for measures of superficial improvement of vegetative cover. The main goal of superficial improvement of natural vegetation is preserving valuable feeding plants that grow in the wild, creating a favourable ecological environment for enrichment of vegetation by valuable and productive forage plants. At the same time, those measures should be implemented for the formation of *Paliuruseta-Sambucetum-Cynodonsum* (in districts of countryside pastures), where vegetative cover in phytocenoses is significatly thinned-out and low-productive.

Table 1
Species composition and phytocenologic structure of the formation of *Paliuruseta-Sambucetum-Cynodonsum* with domination of *Cynodan dactylon* (Astara Rayon)

No.	Biomorphic species	Ecological groups	Abundance, points	Stratum and height above soil surface, cm	Phenological phases
			Shrubs		
1.	*Paliurus spina-christi* Mill.	xerohyte	2	I (300)	flowering
2.	*Rubus persicus* Boiss.	psammophyte	1–2	I (150)	fruit-bearing
3.	*Crataegus lagenaria* Fisch. and C. A. Mey.	mesophyte	1	I (200)	fruit-bearing
4.	*Prunus divaricate caspica* Browiez.	mesoxerohyte	1	(150)	fruit-bearing
			Perrenial herbs		
5.	*Cynodon dactylon* (L.) Pers.	mesophyte	3-4	III (30)	flowering
6.	*Poa masenderana* Freyn & Sint.	mesophyte	1-2	I	flowering
7.	*Centaurea hyrcanica* Bomm.	mesoxerohyte	1-2	II (80)	flowering
8.	*Eryngium caucasicum* Trautv.	mesoxerohyte	1	II (70)	flowering
9.	*Cichorium intybus* L.	mesophyte	1	II (65)	flowering
10.	*Paspalum dilatatum* Poir.	mesophyte	1	II (60)	flowering
11.	*Plantago lanceolata* L.	mesophyte	1	II (50)	flowering
12.	*Potentilla supina* L.	mesophyte	1	II (40)	flowering
13.	*Elymus repens* (L.) Gould	mesophyte	1	II (35)	flowering
14.	*Tragopon graminifolius* DC.	mesoxerohyte	1	III (30)	flowering
15.	*Aeluropus relexiaristata* (Nevski) Nevski	mesophyte	1	III (20)	flowering
			Annual and biennial herbs		
16.	*Cirsium ciliatum szovitsii* (K. Koch) Petr.	mesoxerohyte	1-2	II (40)	flowering
17.	*Melilotus officinalis* (L.) Pall.	mesophyte	1	II (35)	flowering
18.	*Lolium persicum* Boiss. et Hohen.	xerohyte	1-2	III (30)	flowering
19.	*Bromus japonicus* Thunb.	xerohyte	1-2	III (25)	flowering
20.	*Amoria spumosa* (L.) Roskov	mesophyte	1-2	III (20)	flowering
21.	*Hordeum geniculatum* All.	mesoxerohyte	1	II (5)	flowering
22.	*Lathyrus aphaca* L.	mesophyte	1	II (40)	flowering
23.	*Medicago arabica* (L.) Huds.	mesophyte	1	III (30)	flowering
24.	*Veronica ceratocarpa* C. A. Mey.	mesophyte	1	III (25)	flowering
25.	*Euphorbia helioscopia* L.	mesophyte	1	III (20)	flowering
26.	*Ranunculus scleratus* L.	mesoxerohyte	1	III (15)	flowering
27.	*Cardomine hirsuta* L.	mesophyte	1	III (10)	flowering
28.	*Erodium cicutarium* (L.) L'Her ex Aiton	xerohyte	1	III (5)	flowering

Table 2
Distribution and relative change in climatic parameters according to average temperature and norm of precipitations in administrative districts (2019–2021) in coastal regions of the Caspian Sea (according to meteorological stations of Lankaran-Astara)

Period of survey (month, season, year)	Average air temperature, ºC		Amount of precipitations, mm	
	Lankaran	Astara	Lankaran	Astara
IX.2019	20.9	20.7	170	217
X.2019	15.5	14.8	251	325
XI.2019	10.6	9.9	170	238
Average for the season	15.7	15.1	591	780
XII.2019	6.2	5.3	103	163
I.2020	3.7	2.8	96	143
II.2020	4.2	3.4	105	156
Average for the season	4.7	3.8	304	462
III.2020	7.1	6.3	99	153
IV.2020	12.2	12.0	56	120
V.2020	17.6	17.7	46	99
Average for the season	12.3	12.0	201	372
VI.2020	22.1	22.4	44	117
VII.2020	24.9	25.3	14	30
VIII.2020	24.4	24.6	52	75
Average for the season	23.8	24.1	110	222
Average for the year	14.1	13.8	1206	1836
IX.2020	21.3	21.2	156	204
X.2020	15.9	15.3	158	213
XI.2020	11.0	10.5	92	140
Average for the season	16.1	15.7	406	557
XII.2020	7.7	11.8	59	96
I.2021	5.2	8.2	52	81
II.2021	5.7	7.1	61	94
Average for the season	6.2	9.0	172	271
III.2021	7.2	6.5	54	88
IV.2021	12.3	12.2	31	82
V.2021	17.7	17.9	34	84
Average for the season	12.4	12.2	119	254
VI.2021	22.5	22.8	43	334
VII.2021	25.3	25.7	24	45
VIII.2021	24.8	25.0	48	79
Average for the season	24.2	24.5	115	204
Average for the year	14.7	15.4	931	1,405
IX.2021	22.8	22.7	111	163
X.2021	17.4	16.9	113	170
XI.2021	12.5	12.1	68	118
Average for the season	17.8	17.3	292	451
XII.2021	8.2	12.5	46	84
I.2022	5.7	8.7	40	90
II.2022	6.2	7.5	47	96
Average for the season	6.7	9.6	133	270
III.2022	9.4	8.3	36	76
IV.2022	14.5	13.9	22	77
V.2022	19.9	19.6	26	79
Average for the season	14.6	13.9	84	232
VI.2022	24.0	23.6	33	70
VII.2022	26.0	26.3	18	44
VIII.2022	25.7	25.6	37	72
Average for the season	25.2	25.2	85	186
Average for the year	16.1	16.5	597	1,139

One of the measures for improving the surface is enrichment of low-productive, trampled sowing area by perennial mesophyte plants (in the phytocenosis of *Paliuruseta-Sambucetum-Cynodonsum*). Sowing of plant seeds on the soil surface can be done using fragmentation (*Cynodon dactylon* – 10–12 kg/ha, *Melilotus albus* Medik – 6–9 kg/ha and other). In mesophyte, relatively moist conditions of the area, seeds of forage plants are recommended to be sown in November and April.

Furthermore, to improve the appropriateness of pastures, *Paliurus spina-christii*, *Sambucus ebulus* and other poisoness plants we found prior to flowering could be eradicated manually, and also by spraying butyl herbicide ether, 2.4 D on large distance from forest and settlements.

One of the main conditions for superficial improvement of phytosanitary diversity of examined agricultural lands is regulation of water regime of soils. After respective measures, in sowing areas in the territory of Siyazan Rayon, the yield may be increased one-two-fold by watering, and also creating irrigation network Baseyn. At the same time, it is important to preserve endemic, rare and endangered species that occur in the plant formations, and also species included in the Red Book of Azerbaijan. Biochemical compositions of samples of the main feed plants, gathered during the field studies, were examined in the laboratory of Soil-Geobotanical Reasearch of the former State Committee of Real Estate of the Azerbaijan Republic, the Cadastre and Geostructure, Project-Research Center (Yusiffov, 1988). As a result, there content of grey ash, grey protein, raw oil, raw cellulose and nitrogen-free extracted substances was found and the number of forage units and concentration of digestible protein were determined (Table 3).

Table 3
Biochemical indicator for the formation of *Paliuruseta-Sambucetum-Cynodonosum* meadow-steppe phytocenosis of the southern zone of the Caspian Sea (2019–2021)

Formation	Hygroscopic moisture, %	Concentration in absolute dry substance, %				
		grey ash	grey protein	grey oil	grey cellulose	nitrogen-free extractive substance
Paliuruseta-Sambucetum-Cynodonosum	14.0	7.7	8.5	2.6	27.0	40.2

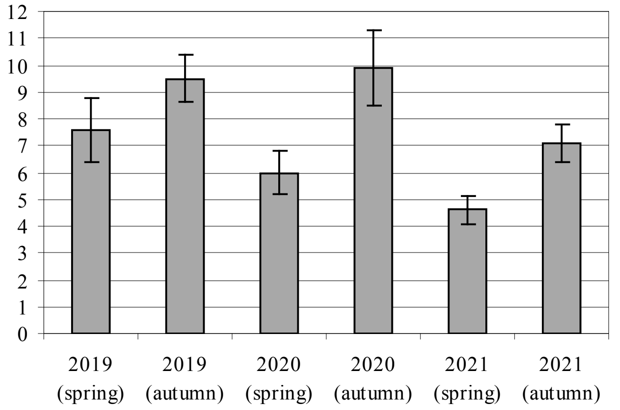

Fig. 2. Mean annual yield by seasons (cwt/ha of dry mass, x ± SD, n = 10) formation of *Paliuruseta-Sambucusetum-Cynodonosum* phytocenosis

Table 4
Period of use, productivity, quality and capacity of natural feeding grounds (winter pastures and countryside lands) over three years (2019–2021) in the Caspian coastal zone

Formation	Period of validity	Yield, cwt/ha of dry mass	Content per 100 kg of fodder		Number of cattle, which could be fed per 1 ha
			forage units	digestible protein, kg	
Paliuruseta-Sambucetum-Cynodonosum	245	7.5	50.2	5.1	1.20 caprines / 0.40 bovine cattle

As with ecological parameters of subpasture yellow-litter soils, we should note bioclimatic potential (3.0–4.4% humus). The main fertility indicator – humus content – is higher in this area than in other soils (3.0% on average). From this perspective, by ecological evaluation, the yellow-podzolized soils were assigned 78 points, and according to bonitet productivity class (VII–VIII).

Discussion

Therefore, we determined the dynamics of yield and coefficients of the structure of the formation of the *Paliuruseta-Sambucetum-Cynodonosum* phytocenosis according to seasons and years, which was recorded in winter pastures and near-city fields at the border of the examined administrative districts of Astara. As we see in the tables, the yield of the formation by botanical groups (grain crops, legumes, various herbs) are determined in autumn, winter and spring seasons of 2019–2021 (Yaroshenko, 1969).

To preserve biodiversity, it is important to study rational use of plant and soil cover of natural feeding grounds, their productivity, nutritional value for management and monitoring of pastures. To assess and predict the conditions of ecosystems, ecological assessment of winter pastures and agricultural lands in the Caspian Lowland is greatly important. Therefore, we analyzed the ecosystems of semidesert, desert and shrub vegetation, spread in grey, salinated, grey-brown and yellow-podzolized soils.

Models of soil-ecological fertility, and also the soil-plant block in an agroindustrial group for ecological assessment of lands, were developed by academic Mamedov et al. (2008). During the "implementation of ecoethic problems" and ecological assessment of using pastures, according to the remark of this author, there should be taken into account pasture's productivity, the amount of forage units, norm of cattle grazing. Based on his idea, ecological assessment of the studied formation (northern and southern) has been made for the first time for the Caspian phytocenoses, and the results of respective studies were correlated based on the new methods.

Aliyev et al. (2008) noted that intensive degradation of pastures leads to decrease in the richness of their vegetation: instead of domestication and changes in species composition of plants in grazing places, there emerge harmful and poisonous herbs, and the processes of erosion increase, and native ecosystems degrade. In this sense, over 50% of vegetation of winter pastures of the Azerbaijan Republic is composed of inedible, harmful and poisonous plants.

Conclusions

The parameters we analyzed may be used when taking measures for creating a land cadastre. Ecological assessment of natural feeding grounds of the Caspian coastal zone is an important state goal. Drawing from the ecological assessment of pastures, there should be creation, effective use, and improvement of agrophytocenoses for enrichment of the forage base of livestock, increase in productivity and quality of feeds in Azerbaijan, including phytoameliorative measures and control.

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