

The impact of climate change on phytocenoses in the mountainous part of Talysh

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This article examines the impact of climate change on phytocenoses (vegetation cover) in the mountainous part of Talish. As a result of research conducted during 2020-2024, endangered or rare plant species were identified in this area. The research focused on analyzing vegetation productivity, forage quality, and summer pasture capacity as one of the main indicators for assessing the impact of climate change on biodiversity. Widespread plant formations in Yardimli, Lerik, and Astara regions were studied on a methodological basis, and the impact of these changes on ecosystem stability was analyzed. The results show that climate change affects the structural and functional characteristics of phytocenoses, narrows the distribution area of some species, and creates conditions for the emergence of new species associations. The long-term ecological impacts of these changes and the need for conservation measures are discussed.

Keywords: Meteorological station, precipitation, biodiversity, phytocenosis, radiation

INTRODUCTION

The mountainous part of Talysh is considered one of the most important natural regions of Azerbaijan with its unique ecosystem and rich biodiversity (Aslanova, 2023; Aliyev et al., 2008). The unique climate and natural conditions of this region create a favorable environment for the spread of various plant species and the formation of ecosystems. However, in recent years, global warming and climate change have not left the ecosystem of the Talysh Mountains untouched (Gadzhev et al., 1979; Gurbanov & Aslanova, 2023). These changes have led to serious changes in the phytocenoses of the region, the decline of some plant species, and even their extinction.

The climatic characteristics of the mountainous part of Talysh are one of the main factors determining the ecology and natural landscape of the region. These climatic zones have a variety of conditions, such as subtropical conditions with mild winters and dry and hot summers, as well as drought and harsh mountain

climates. The climatic indicators of the Astara, Yardimli and Lerik regions, as well as the sharply continental climate of the Diabar basin, form the different vegetation and ecosystem dynamics of these areas (Safarov, 1980, Shikhlinsky, 2009; Mammadov, 2004).

This study investigates the climatic characteristics of the Talysh Mountains and the impacts of recent changes on the region's biodiversity (Hajiyev, 2004; Gurbanov & Jabbarov, 2017). The aim is to understand the impacts of climate change on ecosystems, establish a scientific basis for the conservation of endangered species, and contribute to ecological stability.

MATERIALS AND METHODS

The natural vegetation cover of the mountainous areas of Yardimli, Lerik and Astara regions, which we studied, was grazed, as well as ungrazed (protected) areas.

In the study region of the mountainous part, the productivity of the formations *Thymuseta* –

Stipetum – Festucosum; Leguminous – wheat - grassy subalpine meadows; *Trifolieta – Thymuseta – Festucosum* and Different-grassy subalpine meadows of the formation class *Thymuseta – Vicaetum – Festucosum* was determined according to the fresh and dry mass consumed (Gurbanov & Aslanova, 2024). In this regard, these formation classes were reflected in the “Ecological-geobotanical map of the vegetation of the mountainous part of Lankaran” - its legend, as well as contours No. 3, 5 and 14.

The results of our multi-year studies on the formations of vegetation types in the mountainous part of the territory are shown in Tables 1-5.

The amount of digestible nutrients (protein, fat, cellulose) in the corresponding phytocenoses was calculated based on the biochemical composition of the main fodder plants (analytical laboratory analyses) (Table 5), nitrogen-free extractive substances (NFE), feed units per 100 kg of feed and assimilated protein.

In the mountainous part of the region, it should be noted that its characteristics play an important role as an ecological factor in the formation of the flora biodiversity and phytocenoses of the territory (Aslanova, 2024).

RESULTS AND DISCUSSION

Information on the yield, quality of fodder (nutrition) and pasture capacity of formations that have important fodder importance in the mountainous part of Talish adapted to different climatic conditions is given below.

1. Productivity, feed quality and capacity of *Thymuseta – Stipetum – Festucosum* formation

The vegetation cover of the formation was recorded in the summer pasture (grazed) field No. 3 of Yardimli district in the mountain-meadow steppe soil, and the productivity was determined here. Depending on the terrain, soil and climate of the area, its productivity varies from year to year (Table 1). The average perennial air temperature in the region is usually 11.9°C and the amount of precipitation reaches 645 mm.

As can be seen from table 1, the approximate

coefficient of conversion of the wet mass of the grass to the air-dry edible mass and vice versa for the determination of productivity in *Thymuseta – Stipetum – Festucosum* phytocenosis fluctuated in the range of 2.3-2.6.

Thus, in the first year of the study (July 2020), the average annual productivity was 15.6 cwt/ha in wet and 6.5 cwt/ha in dry mass, including wheat-grassy - 3.2 cwt /ha (49.2%), leguminous-grassy 1.5 cwt/ha (23.1%) and different-grassy 1.8 cwt/ha (27.7%).

In the summer of 2022 (July 15-20), the productivity increased compared to the previous year, i.e. 18.9 cwt/ha according to the wet mass; including wheat-grassy 10.2 cwt/ha, leguminous-grassy 3.0 cwt/ha and 5.7 cwt/ha different-grassy as well as 8.2 cwt/ha (4.4 cwt/ha wheat-grassy, 1.3 cwt/ha leguminous-grassy and 2.5 cwt/ha different-grassy) were noted. In the summer of 2024, the productivity (due to the heavy rainfall in the region) increased in contrast to previous years. In this regard, the average annual indicator in that year was 24 c/ha in wet mass (wheat-grassy – 13.3 c/ha, leguminous-grassy 4.5 c/ha, different-grassy – 6.2 c/ha) and 9 in dry mass. 6 c/ha (wheat-grassy – 5.1 c/ha, leguminous-grassy 2.6 c/ha and different-grassy 1.9 c/ha) changed.

The research results show that the three-year average yield of *Thymuseta – Stipetum – Festucosum* formation was 15.6-24.0 c/ha (wet) and 6.5-9.6 c/ha dry mass (table 1).

According to biochemical analyses of phytocenoses (Table 4) belonging to subalpine-meadow and frigana formations of the region, hygroscopic moisture is 13.0%, protein in absolute dry matter is 9.0%, fat is 2.1%, cellulose is 31.0% and NFE – corresponds to 36.9% (Gurbanov, 2004). According to the obtained results, 44.7 units of feed and 4.9 assimilated proteins are obtained in 100 kg of feed according to the feed quality of the formation, including its nutritional value.

Table 1. The average annual yield of the *Thymuseta – Stipetum – Festucosum* formation formed in the Yaharyurd summer pasture area No 3 of Yardimli district

Years and months	Botanical herb groups	Wet mass		Dry edible mass	
		cwt/ha	%	cwt/ha	%
2020 (10-15.VII)	Wheat-grassy	7.7	49.3	3.2	49.2
	Leguminous-grassy	3.6	23.1	1.5	23.1
	Different-grassy	4.3	27.6	1.8	27.7
	Average annual productivity	15.6	100.0	6.5	100.0
2022 (15-20.VII)	Wheat-grassy	10.2	54.0	4.4	53.7
	Leguminous-grassy	3.0	15.9	1.3	15.8
	Different-grassy	5.7	30.1	2.5	30.5
	Average annual productivity	18.9	100.0	8.2	100.0
2024 (20-25.VII)	Wheat-grassy	13.3	55.5	5.1	53.1
	Leguminous-grassy	4.5	18.7	2.6	27.1
	Different-grassy	6.2	25.8	1.91.9	19.8
	Average annual productivity	24.0	100.0	9.6	100.0

2. Productivity, feed quality and capacity of *Trifolieta* – *Thymusetum* – *Festucosum* formation

The change of the multi-year average yield of this formation (in the territory of the Lerik district in grassy mountain-meadow lands) was found to be 9.4-12.4 cwt/ha during the years 2020-2022-2024 (in the summer season) (Table 2).

It can be seen from the table that the drying coefficient of phytomass in determining the productivity of the formation is equal to 2.3-2.8.

In the first year of the study (2020), the wet mass was 28.6 cwt/ha - wheat-grassy 11.4 cwt/ha (39.9%), leguminous-grassy 9.2 cwt/ha (32.2%), different-grassy 8.0 cwt/ha (27.9%); in dry mass 5.4 cwt/ha (43.5%), wheat-grassy 3.7 cwt/ha (29.9%), leguminous-grassy and 3.3 cwt/ha (26.6%) different -grassy.

So, in July of that year (according to the multi-year data of the meteorological station of the region), the average monthly air temperature rose

to 30-37°C and the average annual amount of precipitation was 640 mm.

In 2022, the average annual productivity of the formation based on dry edible mass is set at 9.4 cwt/ha; of which wheat-grassy 5.2 cwt/ha (55.3%), leguminous-grassy 2.8 cwt/ha (29.8%) and different-grassy 1.4 cwt/ha (14.9%) were recorded.

In the third year of study (July 20-25; 2024), it had a higher yield (10.8 cwt/ha) in the same phytocenosis (Table 2), including 4.9 cwt/ha (45.4%) wheat-grassy, 2.4 cwt/ha (22.2%) leguminous-grassy and 3.5 cwt/ha (32.4%) different-grassy.

As shown in Table 4, the biochemical composition of the formation - hygroscopic moisture 14.5%, ash 7.8%, crude protein 10.4%, crude fat - 2.7%, crude cellulose 22.4% and NFE 42.2%. At the same time, 55.3 feed units and 5.6 assimilated protein per 100 kg of dry feed were calculated in the feed quality of vegetation (Gurbanov & Aslanova, 2024).

Table 2. The average annual yield of the *Trifolieta* – *Thymusetum* – *Festucosum* formation, which is distributed in the moist mountain-meadow soils in the territory of the Lerik region.

Years and months	Botanical herb groups	Wet mass		Dry edible mass	
		cwt/ha	%	cwt/ha	%
2020 (10-15.VII)	Wheat-grassy	11.4	39.9	5.4	43.5
	Leguminous-grassy	9.2	32.2	3.7	29.9
	Different-grassy	8.0	27.9	3.3	26.6
	Average annual productivity	28.6	100.0	12.4	100.0
2022 (15-20.VII)	Wheat-grassy	12.5	55.4	5.2	55.3
	Leguminous-grassy	6.7	29.6	2.8	29.8
	Different-grassy	3.4	15.0	1.4	14.9
	Average annual productivity	22.6	100.0	9.4	100.0
2024 (20-25.VII)	Wheat-grassy	12.7	42.1	4.9	45.4
	Leguminous-grassy	7.7	25.5	2.4	22.2
	Different-grassy	9.8	32.4	3.5	32.4
	Average annual productivity	30.2	100.0	10.8	100.0

Trifolieta – *Thymusetum* – *Festucosum* is superior to other formations in terms of

productivity and feed quality. This can be clearly seen from table number 2. In 2020, wheat-grassy 5.4 cwt/ha (43.5%), leguminous-grassy 3.7 cwt/ha (29.9%), different-grassy 3.3 cwt/ha (26.6%); In 2022, wheat-grassy was different (0.2 cwt/ha) compared to the previous year, 5.2 cwt/ha (55.3%), leguminous-grassy 2.8 cwt/ha (29.8%) and different-grassy 1.4 cwt/ha (14.99%) was recorded; In 2024, compared to the previous two years, productivity (due to high rainfall) increased. Wheat-grassy (decreased compared to 2020 and 2022) 4.9 cwt/ha (45.4%), leguminous-grassy 2.4 cwt/ha (22.2%) and different-grassy 3.5 cwt/ha (32.4%).

Trifolieta – Thymusetum – Festucosum formation three-year average productivity (10.9 cwt/ha), feed unit (55.3 kg), as well as phytocenosis usage period (120 days) and acceptance of 1.3 feed units of daily feed rate of small horned animals it is possible to determine the capacity (1154 small horned cattle) in summer pasture "Gizyurdu" (No. 12) (on 296 ha) of conventional pasture area load (3.9).

In general, taking into account the average annual productivity of the corresponding formation, the capacity of fodder quality per hectare, this phytocenosis can be attributed to the group of good-quality pasture. First of all, effective use of vegetation and implementation of surface improvement measures is appropriate.

3. Productivity, feed quality and capacity of *Thymuseta – Vicaetum – Festucosum* formation

The vegetation cover of the formation was recorded in the summer (ungrazed) pasture field No. 8 "Turksoba" in the territory of the Astara region in the mountain-brown soils that emerged from under the forest. The average annual temperature of the air typical of the climate of this region is 10-14°C, and the annual amount of precipitation reaches 1400-1600 mm.

The research shows that the vegetation of this formation belongs to the Leguminous-wheat-grassy subalpine meadows formation class. The productivity of the *Thymuseta – Vicaetum – Festucosum* formation of this formation class in the summer season of 2020-2022-2024 ranges from 19.5-29.6 cwt/ha in wet mass and 7.8-12.9 cwt/ha in dry mass (Table 3). According to calculations, the coefficient of conversion of wet mass to dry

mass of productivity corresponds to 2.3-2.5.

As seen in Table 3, the productivity of the formation was 19.5 cwt/ha in the summer of 2020; wheat-grassy - 9.0 cwt/ha (46.1%), leguminous-grassy 6.8 cwt /ha (34.9%), different-grassy 3.7 cwt /ha (19.0%); in dry edible mass - wheat-grassy 3.6 cwt/ha (46.1%), leguminous-grassy 2.7 cwt /ha (34.7%) and different-grassy 1.5 cwt /ha (19.2%).

In the summer of 2020 (July 20-25), the average annual productivity of the formation (wet mass was 25.5 cwt/ha and dry mass) partially increased, that is, it reached 10.2 cwt /ha, including wheat-grassy 6.1 cwt/ha (59.8%), leguminous-grassy 2.5 cwt /ha (24.5%) and different-grassy 1.6 cwt /ha (15.7%).

On June 25-30, 2024, the productivity of phytocenosis increased compared to previous years due to favorable climatic conditions and rich soil fertility (humus). According to the productivity indicators of this year, 29.6 cwt /ha was found in the age group, of which wheat-grass 16.6 cwt /ha (56.1%), leguminous-grass 7.3 cwt /ha (24.7%) and distinct-grassy 5.7 cwt/ha (19.2%); 12.9 cwt/ha was determined in dry mass, including wheat-grassy 6.7 cwt /ha (51.9%), leguminous-grassy 3.8 cwt /ha (29.5%) and 2.4 cwt /ha (19.6%) different-organized grassy.

In the biochemical composition of the vegetation of the *Thymuseta-Vicaetum-Festucosum* formation, hygroscopic moisture - 14.7%, ash 7.0%, crude protein 11.1%, crude fat 2.8%, crude cellulose 23.5% were determined and based on these indicators 45.8 feed units and 4.6 assimilated protein were calculated per 100 kg (dry) feed (Table 4).

As can be seen from Table 3, the average annual productivity of the blueberry-grass-limp formation is variable for botanical groups. So, in the summer of 2020 (dry mass) - 7.8 cwt /ha- wheat-grassy 3.6 cwt/ha (46.1%), leguminous-grassy 2.7 cwt/ha (34.7%), different-grassy 1.5 cwt /ha (19.2%); In 2022 (summer) 10.2 cwt /ha – wheat-grassy 6.1 cwt /ha (59.8%), leguminous-grassy 2.5 cwt /ha (24.5%), different-grassy 1.6 cwt/ha (15.7%) and in 2024, 12.9 cwt /ha– wheat-grassy 6.7 cwt/ha (51.9%), leguminous-grassy 3.8 cwt /ha (29.5%), and different-grassy fluctuated at the limit of 2.4 cwt /ha (18.6%).

Table 3. The average annual productivity of the *Thymuseta – Vicaetum – Festucosum* formation spread in the summer pasture area No. 8 "Turkesoba" of the Astara region

Years and months	Botanical herb groups	Wet mass		Dry edible mass	
		cwt/ha	%	cwt/ha	%
2020 (10-20.VII)	Wheat-grassy	9.0	46.1	3.6	46.1
	leguminous-grassy	6.8	34.9	2.7	34.7
	different-grassy	3.7	19.0	1.5	19.2
	Average annual productivity	19.5	100.0	7.8	100.0
2022 (20-25.VII)	Wheat-grassy	15.2	59.6	6.1	59.8
	leguminous-grassy	6.3	24.7	2.5	24.5
	different-grassy	4.0	15.7	1.6	15.7
	Average annual productivity	25.5	100.0	10.2	100.0
2024 (25-30.VII)	Wheat-grassy	16.6	56.1	6.7	51.9
	leguminous-grassy	7.3	24.7	3.8	29.5
	different-grassy	5.7	19.2	2.4	18.6
	Average annual productivity	29.6	100.0	12.9	100.0

Table 4. Biochemical compositions of the formations belonging to the subalpine meadow and frigana phytocenoses of the mountainous part of Talish

№	Formations	Hygroscopic moisture, %	In absolute dry matter, in %					In 100 kg	
			Ash	Crude protein	Crude oil	Crude cellulose	NFE	Feed unit	Absorbed protein
1.	<i>Thymuseta – Stipetum – Festucosum</i>	13.0	8.0	9.0	2.1	31.0	36.9	44.7	4.9
2.	<i>Trifolieta – Thymusetum – Festucosum</i>	14.5	7.8	10.4	2.7	22.4	42.2	55.3	5.6
3.	<i>Thymuseta – Vicaetum – Festucosum</i>	14.7	7.0	11.1	2.8	23.5	40.9	45.8	4.6

Table 5. Duration of use of phytocenoses, average productivity, feed quality and pasture capacity in some plant formations in the summer season of 2020-2022-2024

№	Formations	Duration (in days)	Average yield (in edible dry mass), kg	In 100 kg		Number of grazing cattle per hectare (load)	area (ha)	Pasture capacity
				Feed unit	Absorbed protein			
1.	<i>Thymuseta – Stipetum – Festucosum</i>	120	8.1	44.7	4.9	2.3	333	766
2.	<i>Trifolieta – Thymusetum – Festucosum</i>	120	10.9	55.3	5.6	3.9	296	1154
3.	<i>Thymuseta – Vicaetum – Festucosum</i>	120	10.1	45.8	4.6	3.0	90	270

In our studies, the pasture capacity was determined mainly by taking into account the period of use of *Thymuseta – Stipetum – Festucosum* phytocenosis, productivity, feed unit and daily feed rate of cattle (Table 5). As can be seen from the table, the average productivity of the formation is 8.1 cwt/ha, the feed unit is 44.7 kg per 100 kg of feed, and the daily feed rate is 1.3 feed units and the pasture capacity was found to be 766 animals.

The average annual yield (in 2020-2022-2024) of the *Trifolieta – Thymusetum – Festucosum* formation is 10.9 cwt/ha, feed unit (in

100 kg of dry feed) - 55.3 kg, vegetation use or grazing period - 120 days. Based on the daily feed rate of small horned animals - 1.3 feed units, it was found that 1154 cattle were grazing on 296 ha.

As can be seen in Table 5, the three-year average productivity of the *Thymuseta – Vicaetum – Festucosum* formation (10.1 cwt/ha), feed unit per 100 kg of dry fodder (45.8 kg), duration of phytocenosis (120 days) and daily consumption of small horned animals taking into account the fodder norm (1.3 fodder units), 3.0 cattle per hectare, and the pasture capacity (270 small horned cattle can be grazed) was determined in the total

area (90 ha).

Thus, based on the characteristics of the climatic conditions in the mountainous part of Talys, we conclude that due to the decrease in precipitation and the increase in temperature, the productivity of summer pastures decreases, the degradation of phytodiversity and the desertification of soil-vegetation cover continue.

Therefore, it is appropriate to implement measures to protect, efficiently (correctly) use and improve phytocenoses in natural summer pastures of the region. Therefore, recommendations on comprehensive measures for protection, efficient use and improvement of flora biodiversity in the ecosystem of the territory were prepared on a scientific basis.

In the mountainous part of the region, it is proposed to create a buffer strip on the border of summer pastures and forests of the Yardimli region in order to protect the flora of the area, as well as endemic, rare and endangered plants, and to use the recommendations made by the State Ministry of Ecology and Natural Resources of the Republic of Azerbaijan for the protection of phytocenoses. The implementation of these recommendations will allow the protection of the area's biodiversity and vegetation.

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