

# Ecological state of some pasture differences of *Haloxylon ammodendron* of Karakalpak Ustyurt (Uzbekistan)

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**Abstract.** The article is devoted to the study of the current state of three pasture differences from the *Haloxylon* pasture type: 1. *Haloxylon ammodendron*, *Caroxylon orientale*, *Artemisia terrae-albae*; 2. *Haloxylon ammodendron*, *Artemisia terrae-albae*, *Caroxylon orientale* with *Haloxylon persicum*; 3. *Haloxylon ammodendron*, *Artemisia terrae-albae*, *Anabasis salsa* with *Haloxylon ammodendron*, *Kalidium caspicum*, *Halostachys caspica* and *Halocnemum strobilaceum* are common in the territory of Karakalpak Ustyurt (Uzbekistan). The results of field studies of plant communities with the dominance of *Haloxylon ammodendron* are presented. The area of the studied pasture differences, the nature of the soil cover, the percentage of projective coverage, landscape plant species, their placement, the yield of feed mass and the recommended seasonality of use are determined. The studied pasture differences are recommended to be used as year-round pastures.

## 1 Introduction

In the 20<sup>th</sup> century, one of the most important and acute was the problem of environmental protection due to desertification, climate warming, etc., while desertification is a global environmental and socio-economic problem. The arid territories of the world account for about 80% of irrigated land, 170 million hectares are used for rainfed agriculture and 3.6 billion hectares for pastures. According to Li Yaoming [1], in China, where the largest deserts of Central Asia are located, 80% of the desert land area is in the western part of the country (Xinjiang, Gansu, Ningxia and Inner Mongolia). Unfortunately, our country is also facing this problem. Desertification is often caused by human activities and climate change. However, due to the problem of vegetation degradation, the current state of pastures in arid regions is assessed as unsatisfactory. The degradation of natural pastures as a result of excessive anthropogenic pressure is accompanied by intense destruction of the soil cover, the appearance of dust storms, and an increase in the areas of developed sands. These processes lead to the rapid destruction of natural ecosystems, desertification of lands and further expansion of desert areas [2].

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Studies on *Haloxylon ammodendron* are carried out in different countries, mainly in the desert regions of China [3-12]. In Uzbekistan, where the desert environment sharply dominates, the processes of desertification are intensifying rapidly. One of the factors of deterioration of the ecological situation of Kyzylkum and the Aral Sea region is the influence of catastrophic drying of the Aral Sea. The impact of the Aral Sea disaster and the influence of various environmental, anthropogenic, man-made factors significantly affected the transformation of individual components, especially the vegetation cover of the Kyzylkum and Aral deserts. In recent decades, changes in climatic and environmental conditions have been taking place on the territory of the Karakalpak part of the Ustyurt Plateau, which are associated with the drying up of the Aral Sea and the development of industry. The main factors of the economic development of the Karakalpak Ustyurt are the chemical and oil and gas industries [13], as well as the most important branch of the agricultural sector – cattle breeding, where a huge number of livestock can be kept all year round.

The Republic of Karakalpakstan, located in the northwestern part of Uzbekistan, occupies 166,600 km<sup>2</sup> (28% of the territory of Uzbekistan) and is the largest region of Uzbekistan by territory. It borders Kazakhstan from the north and northwest and Turkmenistan from the south. More than 80% of the territory belongs to the desert ecosystem. The entire territory of Karakalpakstan is located in the Aral Sea region and is negatively affected by the dried bottom of the Aral Sea [14].

Ecological conditions are formed under the influence of the following factors: intense solar radiation, active air circulation and similar precipitation. The territory of Karakalpakstan is during the entire winter period under the influence of cold air of temperate latitudes and starting from mid-spring and all summer months - under the influence of hot subtropical and tropical air coming from the deserts of Southwest Asia. All this makes the climate of Karakalpakstan sharply continental, with hot dry summers and frosty winters. The Karakalpak Ustyurt with its gentle long slopes abruptly ends in the north-east to the Aral Sea, in the south-east - to the delta of the Amu Darya River and the Sarykamysh depression. The total area of the Karakalpak Ustyurt is 7.2 million hectares.

The pastures of the Ustyurt plateau were intensively used by nomadic pastoralists in the past. A huge number of cattle annually moved from Turkmenistan and Karakalpakstan to the north and from Kazakhstan to the south. The eastern part of Ustyurt was occupied by nomads, their nomadic way (at least 2000 km in both directions) passed between Aktobe and Kungrad. In addition, nomads occupied the western part of Ustyurt, they roamed from the Guryev region to Krasnovodsk. Their nomadic way to both ends was about 3000 km. There were about 300 wells, but at the moment most of them have been destroyed, cleaning, deepening and significant restoration work are needed. Since then, the Karakalpak Ustyurt has been emptying for a long time and, in fact, has not been used until now. Due to the shortage of wells, despite the fact that many recommendations were given for their effective use [15].

The need for a comprehensive study of the pasture ecosystems of Ustyurt in conditions of progressive desertification has become an urgent and priority task today. The compilation of a cadastre of pasture differences and a series of digital maps contributes to the systematic development of cattle breeding in the Republic of Karakalpakstan and the rational use of natural pastures.

Studies conducted in recent years to study the productivity of pastures in the deserts of Uzbekistan have shown a noticeable decrease in plant biomass. This is primarily due to global warming and the catastrophic drying up of the Aral Sea, which play an important role in climate regulation in the region. In the period from 1970 to 2020, a trend of temperature increase by 2<sup>0</sup>C was observed in Ustyurt, and the amount of average annual precipitation decreased by almost 40 mm [16-18].

*Haloxylon* pasture type – is one of the most productive formations of the Earth, considered by many authors as a forest type. Due to their high edificatory properties, they create the

main vegetation cover in the desert. They have the greatest influence on the environment, which is facilitated by their longevity (30-60 years), determine the direction of shifts within the *Haloxylon* cycle of development [19]. There are three ecological and physiognomic types of *Haloxylon* deserts: *H. aphyllum*, *H. persicum*, *H. aphyllum*, *H. persicum* - Mixto-Haloxyloneta and *H. ammodendron*, and they occupy 24.3% of the area of the desert zone [15].

Taking into account the increased drying of the Aral Sea, which arose as a result of climate change and industrial development in the region, the aim of the study is to assess the current state of pasture differences of *Haloxylon* type pastures of the Karakalpak Ustyurt.

## 2 Materials and methods

The objects of the study are 3 pasture differences related to *Haloxylon ammodendron* type of Karakalpak Ustyurt: 1. *Haloxylon ammodendron*, *Caroxylon orientale*, *Artemisia terrae-albae*; 2. *Haloxylon ammodendron*, *Artemisia terrae-albae*, *Caroxylon orientale* with *Haloxylon persicum*; 3. *Haloxylon ammodendron*, *Artemisia terrae-albae*, *Anabasis salsa* with *Haloxylon ammodendron*, *Kalidium capsicum*, *Halostachys caspica* and *Halocnemum strobilaceum*. The *Haloxylon* type occupies (309,458 ha), is quite widespread in the Northwestern Ustyurt, but has economic importance only in the central and northern parts.

*Haloxylon* communities dominate in 36 Phyto chorological units identified on the "Vegetation Map of Kazakhstan and Central Asia" [19]. The genus of *Haloxylon* used in the creation of pasture protection strips is a unique desert tree with a powerful medium-forming ability. Along with the production function of *Haloxylon aphyllum*, the strips improve the environment of the population living in the arid regions of the region [20].

In Ustyurt, *Haloxylon* is located on saline plump soils, gypsum salt marshes, wet salt marshes, gypsum pseudosands, chukalaks, and in depressions of hilly gypsum sands. Typical habitats are wide inter-ridge and inter-hill depressions. On the Plateau, species of the genus *Haloxylon* cover the Churuk, Saksaulsai, Kosbulak, Barsakelmes, Karaumbet massifs and some massifs of the southern Karakalpak Ustyurt.

On the Ustyurt Plateau, *Haloxylon* occupy a significant territory among desert pasture plants. *Haloxylon* has a powerfully developed root system, thanks to which it receives water from deep layers of soil. At the same time, the water vapor content in the upper horizons of the soil increases, while the relative humidity of the air increases. As a result, a favorable microclimate is created that promotes the growth and development of pasture plants, in particular semi-shrubs and herbaceous plants.

Climatic conditions have little effect on the yield of perennial *Haloxylon*. In years when semi-shrubs and herbaceous plants remain under a thick snow cover, small livestock (sheep and goats) perfectly eat *Haloxylon* fruits, annual shoots (in autumn and winter), green twigs. The nutritional value is 52.73% of feed units.

In the study of pasture vegetation, generally accepted methods were used [21]. The projective cover is determined visually [22]. Per-kilometer visual recording is useful for determining the percentage of associations of complexes. These records are necessary for all routes, especially where vegetation undergoes subtle changes.

The name of pasture types and differences, as well as geobotanical data, the determination of productivity, the establishment of pasture allotments are given in accordance with the "Guidelines for Geobotanical Survey of Natural Forage Lands in Uzbekistan" [23]. Adhering to this methodology, pasture areas were generated, and a classification of pastures was created on the basis of a vegetation map of the territories. Latin names of plant species are given from Plants of the World Online [24]. When identifying the species of plants, the "Key to vascular plants of Karakalpakstan" was used [25].

### 3 Result and discussion

In the course of field studies organized during 2020-2021 on the Karakalpak Ustyurt, 3 pasture differences included in the *Haloxylon* type of pastures were studied. The list of species is presented in Table 1. Below is a brief description of the studied pasture differences.

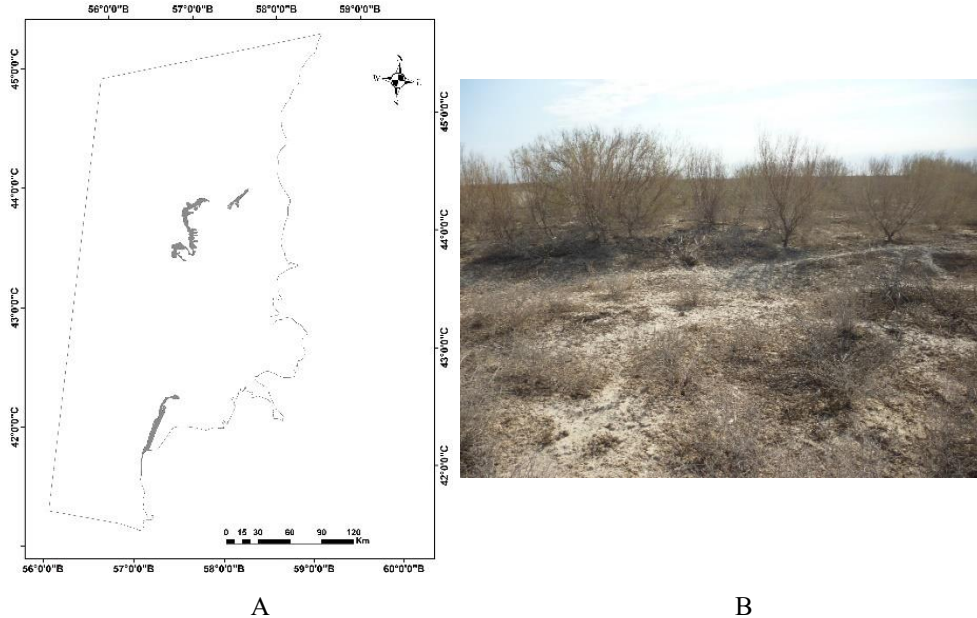
**Table 1.** List of species registered on the surveyed pasture differences.

No.	Latin name of plants	Abundance of species, %		
		<i>Haloxylon ammodendron</i> , <i>Caroxylon orientale</i> , <i>Artemisia terrae-albae</i>	<i>Haloxylon ammodendron</i> , <i>Artemisia terrae-albae</i> , <i>Caroxylon orientale</i> with <i>Haloxylon persicum</i>	<i>Haloxylon ammodendron</i> , <i>Artemisia terrae-albae</i> , <i>Anabasis salsa</i> , <i>Haloxylon ammodendron</i> , <i>Kalidium caspicum</i> with <i>Halostachys capsica</i> , <i>Halocnemum strobilaceum</i>
Trees				
1	<i>Haloxylon ammodendron</i> (C.A. Mey.) Bunge ex Fenzl	8	7	5
2	<i>Haloxylon persicum</i> Bunge	-	1	-
Shrubs				
3	<i>Tamarix elongata</i> Ledeb.	+	-	+
4	<i>Halostachys caspica</i> (M. Bieb.) C.A. Mey.	+	-	1
5	<i>Atraphaxis spinosa</i> L.	+	-	-
6	<i>Convolvulus fruticosus</i> Pall.	+	+	-
7	<i>Calligonum junceum</i> (Fisch. & C.A. Mey.) Litv.	+	-	-
8	<i>Ephedra strobilacea</i> Bunge	+	-	-
9	<i>Xylosalsola arbuscula</i> (Pall.) Tzvelev	+	+	-
10	<i>Caroxylon orientale</i> (S.G. Gmel.) Tzvelev	4	3	-
11	<i>Lycium ruthenicum</i> Murray	-	+	-
12	<i>Kalidium caspicum</i> (L.) Ung.-Sternb.	-	+	2
13	<i>Halocnemum strobilaceum</i> (Pall.) M. Bieb.	-	-	1

No.	Latin name of plants	Abundance of species, %		
		<i>Haloxylon ammodendron</i> , <i>Caroxylon orientale</i> , <i>Artemisia terrae-albae</i>	<i>Haloxylon ammodendron</i> , <i>Artemisia terrae-albae</i> , <i>Caroxylon orientale</i> with <i>Haloxylon persicum</i>	<i>Haloxylon ammodendron</i> , <i>Artemisia terrae-albae</i> , <i>Anabasis salsa</i> , <i>Haloxylon ammodendron</i> , <i>Kalidium caspicum</i> with <i>Halostachys capsica</i> , <i>Halocnemum strobilaceum</i>
14	<i>Anabasis salsa</i> (Ledeb.) Benth. ex Volkens	-	-	2
Semishrubs				
15	<i>Artemisia terrae-albae</i> Krasch.	3	4	2
16	<i>Artemisia kemrudica</i> Krasch.	-	+	-
17	<i>Anabasis brachiata</i> Fisch. & C.A. Mey. ex Kar. & Kir.	-	+	+
18	<i>Ephedra intermedia</i> Schrenk & C.A. Mey.	-	+	-
19	<i>Caroxylon dendroides</i> (Pall.) Tzvelev	-	-	+
Herbaceous perennials				
20	<i>Capparis spinosa</i> L.	+	-	-
21	<i>Carex physodes</i> M. Bieb.	+	-	-
22	<i>Limonium suffruticosum</i> (L.) Kuntze	-	+	-
Annuals				
23	<i>Eremopyrum bonaepartis</i> (Spreng.) Nevski	+	-	-
24	<i>Atriplex pratovii</i> Sukhor.	+	-	-
25	<i>Strigosella scorpioides</i> (Bunge) Botsch.	+	-	-
26	<i>Caroxylon scleranthum</i> (C.A. Mey.) Akhani & Roalson	-	+	+

Note: (+) – community member; (-) – absent in the community

*Haloxylon ammodendron*, *Caroxylon orientale*, *Artemisia terrae-albae* pasture difference is located in the Kungrad region, geographical points: the Sarykamysh basin, the Tumryksay tract, Karakidir, the Tumryuk salt marsh, Aktailak, Akchukur, Butakhan, Karakidir, Koskbulak, Kuanyshkazgan, Markabay, Urumbaykazgan, Tasastaukuduk, Shaharkazgan wells (Fig. 1 A, B). The area of the pasture difference is 67,941 ha.



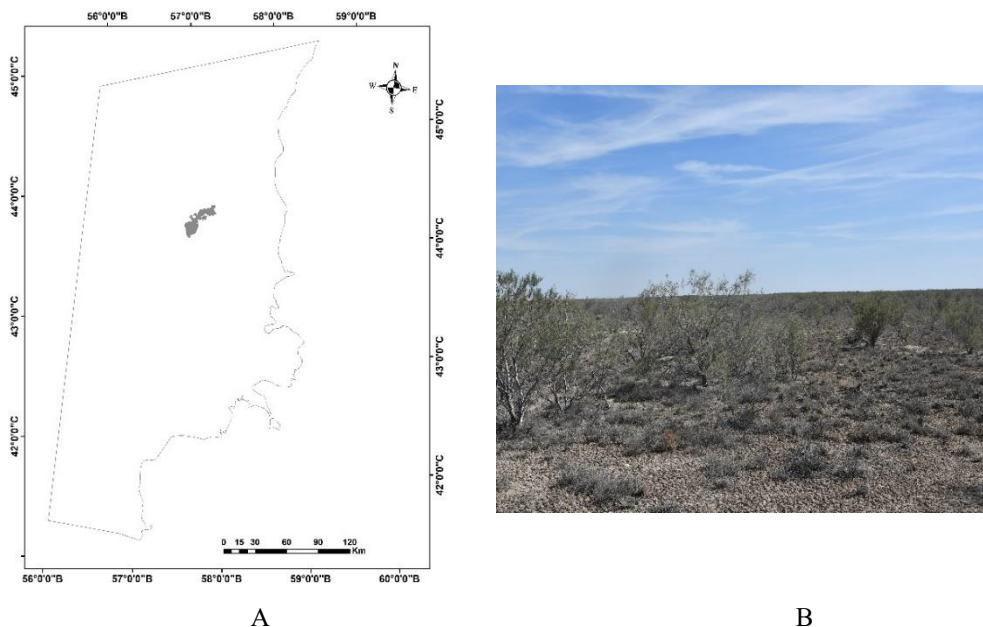
**Fig. 1.** Locations of the (A) *Haloxylon ammodendron*, *Caroxylon orientale*, *Artemisia terrae-albae* pasture difference (B).

Pasture difference is common on gypsum pseudo sands, salt marshes and on the coast of Sarykamysh. Along the shores of this Salt Lake lie vast arrays of salt marshes developed on gypsum sandy deposits, with strongly salty groundwater. The soil of the pasture difference is confined to gray-brown, gypsum pseudo-scales, the polygonal surfaces are fractured. There are mounds formed by deposits of gypsum sand compacted from the surface, which are covered with a thin layer of loam. The percentage of projective cover of pasture difference is 15%. The landscape is dominated by *Haloxylon ammodendron*, acting as a subdominant of *Artemisia terrae-albae*. The participation of *Caroxylon orientale* has a mosaic character. The condition of the plants is generally quite good, but there are many dry and semi-dry bushes of this species. In spring, due to the gray vegetative annual shoots of *Caroxylon orientale*, *Artemisia terrae-albae* and dark green - *Haloxylon ammodendron*, the landscape acquires gray green. In summer, the background is formed by a single plant - *Haloxylon ammodendron* since there is no period of summer dormancy in its development. In addition to the three main types of pasture differences, there is a solitary *Atraphaxis spinosa* and *Convolvulus fruticosus*. *Eremopyrum orientale* is predominantly represented by young, small specimens. There are single specimens of *Carex physodes*, *Strigosella scorpioides*, *Atriplex pratovii*. On the banks of the Sarykamysh, in addition to *Haloxylon ammodendron*, halophytic plants are found: *Halostachys caspica* and *Tamarix elongata*. It should be noted that the abundance of pure thickets of *Haloxylon* is located mainly on the banks of the Sarikamysh, in places it occurs with *Halostachys caspica* or *Tamarix elongata*, especially in places where water is close.

The arid climate and low rainfall adversely affect the productivity of desert pastures. The maximum increase in the productivity of the above-ground mass of *Haloxylon*

*ammodendron*, as well as the entire association, is observed at the end of the second decade of July (44.96 centner/ha). In autumn, the yield of this association decreases somewhat and at the end of October it is 43.75 c/ha. The highest accumulation of aboveground plant mass occurs in *Haloxylon ammodendron*, *Caroxylon orientale*, *Artemisia terrae-albae* (47.0 c/ha) pasture difference. According to the data, the eaten part of *Haloxylon ammodendron*, *Caroxylon orientale*, *Artemisia terrae-albae* of pasture difference ranges from 3.9 to 7.9 c/ha. The maximum value falls on the autumn and winter period, the dominants reach their maximum growth in this period.

*Haloxylon ammodendron*, *Artemisia terrae-albae*, *Caroxylon orientale* pasture difference with the participation of *Haloxylon persicum* is located in the Kungrad region, geographic points: Kartpaikum sands, Agayn and Tyumryuk salt marshes, Aktailak, Kosbulak, Karashinrau, Koshbaikazgan wells (Fig. 2 A, B). The area of pasture difference is 28,082 ha. It is common on slopes and in depressions of finely hilly gypsum sands, in some places on the tops of strongly fixed sandy hillocks. The soil is gray-brown, gravel and sandy loam. Under *Haloxylon*, the process of formation of desert-sandy soils is observed, the sands contain a lot of gypsum. The soil near the salt marshes Agayn and Tyumryuk is loamy and sandy loamy sandy saline. The percentage of projective cover of pasture difference is 15%. The species composition is quite rich in comparison with other differences. The landscape is dominated by *Haloxylon ammodendron*, *Caroxylon orientale* and *Artemisia terrae-albae* act as subdominants and are combined with *Haloxylon persicum* characteristic of sandy deserts. In addition to dominants and subdominants, *Lycium ruthenicum*, *Ephedra intermedia*, *Convolvulus fruticosus*, *Limonium suffruticosum*, *Xylosalsola arbuscula*, *Anabasis brachiata*, etc. are found here. *Artemisia kemrudica* is an indicator of heavily gypsum soils. Single specimens of *Kalidium caspicum* are found on salt marshes.

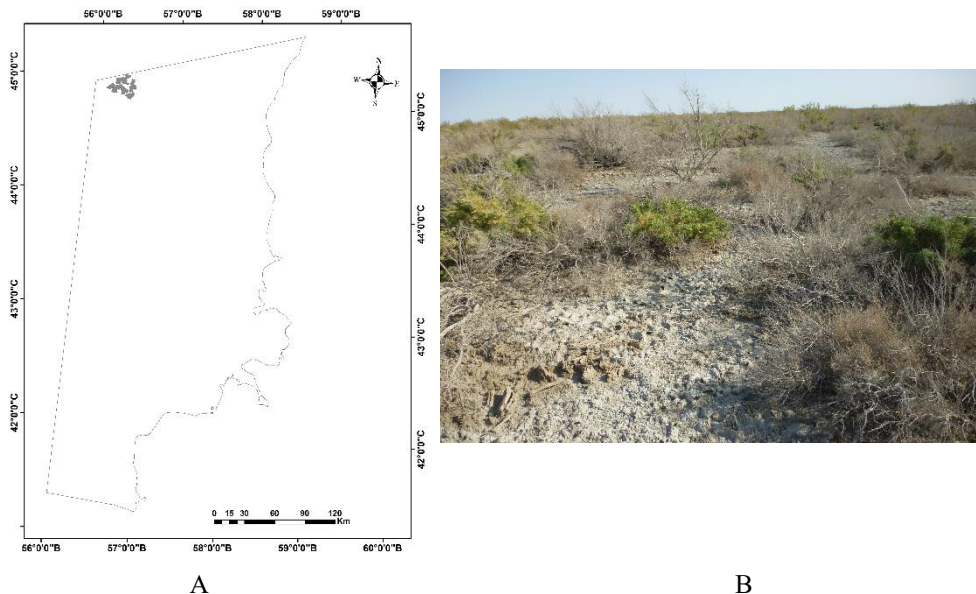


**Fig. 2.** Locations of the (A) *Haloxylon ammodendron*, *Artemisia terrae-albae*, *Caroxylon orientale* pasture difference (B)

*Haloxylon* forms up to 10-30 c/ha in *Artemisia terrae-albae*-ephemeral desert, depending on age, density of standing and soil conditions. The yield of *Haloxylon ammodendron*, *Artemisia terrae-albae*, *Caroxylon orientale* of pasture difference ranges from 4.2 to 8.2 c/ha. The yield of the aboveground mass of the pasture difference depends on the development of

*Haloxylon ammodendron*, *Haloxylon persicum*, *Caroxylon orientale* and *Artemisia terrae-albae*. The part of *Haloxylon* forage species eaten in autumn and winter is higher (40-45%) than in spring and summer, and this affects the increase in the yield of this pasture difference in these seasons.

*Haloxylon ammodendron*, *Artemisia terrae-albae*, *Anabasis salsa* with *Kalidium caspicum*, *Halostachys caspica* and *Halocnemum strobilaceum* pasture difference is located in the Kungrad region (Fig. 3 A, B), geographical point: Zharynkuduk salt marsh. The area of pasture difference is 26521 ha. The pasture difference is typical of the salt-marsh soils, on gypsum sands, and on chukalaks. The soil is takyr-saline, heavily gypsum. Under the *Haloxylon* bushes, there are usually aeolian tubercles. The surface is polygonal- fractured. Among the saline soils of *Anabasis salsa* and *Haloxylon ammodendron*, spots of bosyngens are often found, as usual, somewhat elevated above the surrounding surface, more crushed, with single specimens of *Anabasis brachiata*. The soil cover of large closed depressions is more distinct. Here, the saline soils of *Anabasis salsa* are joined by spots of washed away soils and outcrops of bedrock (along the slopes), and at the bottom of the lowlands – takyrs. The percentage of projective cover of pasture difference is 10%. The landscape of saline *Haloxylon* dominates with significant participation of *Artemisia terrae-albae*, *Anabasis salsa* complexes and saline takyrs with annual halophytes. The landscape is mainly formed by mosaic varieties of *Haloxylon ammodendron*, *Artemisia terrae-albae*, *Anabasis salsa* by pasture difference on takyr saline soils. On gypsum sands, *Haloxylon ammodendron* occurs with *Kalidium caspicum* and *Halostachys caspica*. Chukalak salt marshes with *Halocnemum strobilaceum* are developed in depressions. Edificators include several life forms. The first-tier forms *Haloxylon ammodendron*. *Anabasis salsa* plays a significant role in the difference. The main edificator is *Artemisia terrae-albae*, which forms the second tier. Along the way, extremely depressed specimens of undersized *Haloxylon ammodendron* were noted, only a few specimens of which entered the vegetative phase. The length of annual "twigs" did not exceed 1 - 1.5 cm. Plant height from 1 m to 135 cm. Harvest of eaten mass according to seasonal yield in autumn from 3.9 c/ha, and in winter - 3.6 c/ha (table 2).



**Fig. 3.** Locations of the (A) *Haloxylon ammodendron*, *Artemisia terrae-albae*, *Anabasis salsa* pasture difference (B)



Especially in autumn, the eaten part of *Haloxylon ammodendron* and *Artemisia terrae-albae* reaches 45-50% and this has a positive effect on increasing the yield of pasture varieties. Thanks to these two plants, this pasture variety is a good year-round pasture. *Anabasis salsa* is practically not eaten by sheep in the spring and summer. In autumn, the consumption of annual twigs with fruits is 20%, and in winter 35% of the total stock of fodder mass.

**Table 2.** Forage mass yield (by seasons) of pasture differences.

Pasture difference	Seasonal yield (c/ha)			
	Spring	Summer	Autumn	Winter
<i>Haloxylon ammodendron</i> , <i>Caroxylon orientale</i> , <i>Artemisia terrae-albae</i>	3.9	4.1	7.9	6.6
<i>Haloxylon ammodendron</i> , <i>Artemisia terrae-albae</i> , <i>Caroxylon orientale</i> with <i>Haloxylon persicum</i>	4.2	4.3	8.2	6.8
<i>Haloxylon ammodendron</i> , <i>Artemisia terrae-albae</i> , <i>Anabasis salsa</i> with <i>Haloxylon ammodendron</i> , <i>Kalidium caspicum</i> and <i>Halostachys capsica</i> , <i>Halocnemum strobilaceum</i>	2.1	2.1	3.9	3.6

## 4 Conclusion

The study of the ecological state of some pasture differences of *Haloxylon ammodendron* of Karakalpak Ustyurt (Uzbekistan) shows that the type of pasture *Haloxylon* is evenly distributed throughout Ustyurt (northern, central, southern parts). Significant areas of *Haloxylon* are found in the vicinity of the Agyin salt marsh, Churuk, Kartpaikum sands and around the Sarykamysk and Assakeaudan depressions. This type of pasture is common on gray-brown gypsum salt marshes, on crusty-plump salt marshes, bumpy gypsum sands and on taky saline soils. *Haloxylon* are chukalaks, which are considered to be the original eolian occurrences in the depressions in the south of Ustyurt.

There are almost no permanent watercourses (rivers, streams) on Ustyurt. Groundwater is found shallow from the daytime surface. There is a Sarykamysk lake and several dry or filled wells on the surveyed territory. The watering of new pasture areas will allow the use of additional feed resources and will contribute to an increase in the total number of livestock.

Due to unfavorable weather conditions, this year the regrowth of *Haloxylon ammodendron* shoots is up to 3 cm and in some places, there are dry *Haloxylon*. Often rodents dig up *Haloxylon* and damage the taproot. The value of *Haloxylon* increases on chukalaks. In spring and summer *Haloxylon ammodendron* is eaten poorly (10%), in autumn and winter it increases sharply (30-45%). Fresh one-year-old shoots are readily eaten by sheep and camels, fruit-bearing twigs and *Haloxylon* fruits are fattening food. The eaten part of the fodder mass of this type of pasture ranges from 2.1 to 8.2 c/ha. According to estimates of the yield of the eaten part (c/ha), the studied pasture differences are recommended to be used as year-round pastures.

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