Halophytication in Harran (Şanlıurfa) and Amik Plain (Hatay) in Turkey

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Abstract. In the studied areas of the Harran and Amik plains some halophytic species are distributed. The number of these species in the Harran Plain has started to increase due to improper irrigation after the starting of GAP (Southeast Anatolian Project). Some of these species distributed in the two plains are: *Salsola crassa, S. dendroides, S. soda, Petrosimonia brachiata, Frankenia pulverulenta, Cressa cretica, Chenopodium foliosum, Ch. vulvaria, Salicornia europaea, Aeluropus lagopoides* var. *lagopoides, Sideritis montana* subsp. *montana*, *Hordeum geniculatum, Lolium subulatum*, *Cynodon dactylon* var. *villosus*, and *Peganum harmala*. In the flatlands of Hatay, where soil salinity is either small or medium, the following new associations have been found: *Alhago manniferae-Hordetum murinumae*, *Prosopo farctae-Hordetum murinumae*, *Cresso creticae-Hordetum murinumae, Ammio visnagae-Hordetum murinumae,* and in Akçakale: *Aeluropuseto lagopoidesae-Chenopodietum vulvariae*, *Frankenieto pulverulentae-Salsoletum sodae* and *Cresso creticae-Aeluropusetum lagopoidesae*. The phytosociologic properties and productivity of these associations differ from each other and are subject to seasonal changes.

Key words: Amik Plain, association, halophytication, Harran Plain, phytosociology, Turkey

Introduction

The aim of this study was to investigate the saline habitats in the Harran (Şanlıurfa) and Amik plains (Hatay) and to identify the halophytic plants. This was carried out in the period 2000–2005.

In Turkey, pastures cover 28 % of the total land area (Anonymous 1978) and 20 % of this area is steadily destroyed because of inadvertent use and unsuitable ecological factors (Genckan & al. 1990). Production of the pastures depends on environmental factors and species composition (Agca 1999). Therefore, botanic composition has to be elucidated.

The various soil types in the studied area condition the formation of different associations in the botanic compositions. The most widespread vegetation types in the region are the steppe, meadow and water-marsh vegetation.

Salinity of soils is an important problem the world over. Every year the world loses 10 million hectares of landscape to salinity. Some 1 518 722 ha of land in Turkey face salinity and alkalinity problems. This constitutes 2 % of Turkey's soil resources. Of these, 614 657 ha have a low salinity and 504 603 ha have a high salinity level. Salinity is an ever greater problem in the dry or semi-dry climates due to water evaporation from the lower subsurface levels (Agca 1999; Akman & al. 2001). Saline areas are increasing in Turkey. In these ecosystems halophytes are the dominant species. Halophytes have developed mechanisms to avoid the stress of salinity through succulency, salt secretion glands, salt dilution capacity, osmotic adaptation, protein resistance to high salt concentrations, and selectivity in absorption through the roots (Flowers & al. 1997a, b; Ungar 1998; Ashraf 1999; Yokoi & al. 2002). Halophytes can grow by accumulating Na^+

and Cl^- ions, thus creating turgor pressure (Waisel 1972; Yeo 1983; Guray & Demir 2001).

The Harran Plain is located in Southeast Anatolia, between 36°47′–39°15′E and 36°40′–37°41′N, and covers an area of about 225000 ha bordering on Syria to the south, Urfa Mts to the north, Fatik Mts to the west, and Tektek Mts to the east. The Harran Plain and the whole region have Mediterranean climate, with hot and dry summers and rainy winters. The average annual rainfall is 30.2 mm, most of which falls in winter. Topographycally, the plain is a homogenous area, with the surrounding mountains sloping down to it to form undulating borders. The Çekçek creek partly changes the homogenity of its topography (Dinc & al. 1988). The soils are alluvial, dark-red or reddish-brown, clayey, moist and calcareous. Earlier in time the plain was dominated by steppe vegetation but recently it has been transformed into a cultivated area (Zohary 1973). After the building of the Atatürk Dam in 1995, salinity has increased in the lower parts of the plain owing to unwise irrigation and in these areas the halophytes now grow and spread out.

Materials and methods

Some saline habitats in the Harran Plain (in Gürgelen, İmambakır and Toytepe villages) were visited twice a month for one year. Plant specimens were collected and preserved according to the herbarium techniques. They were identified with the help of *Flora of Turkey and the East Aegean Islands* (Davis 1965–1985; Davis & al. 1988; Güner & al. 2000) and other relevant sources (Akman & al. 2001; Cetik 1973), as well as the Floras of Syria, Iraq and Iran. Regular geobotanical trips were scheduled to the region and plants were grouped according to the dominants and edaphic species. Braun-Blanquet's method was used for the naming of phytosociologic plant groups. In the period 1999–2005, one or two trips were made monthly to Akçakale (Harran Plain) and the Amik Plain. Research materials were taken from the widespread steppe associations of these regions: *Alhago manniferae-Hordetum murinumae* ass. nova, *Prosopo farctae-Hordetum murinumae* ass. nova, *Ammio visnagae-Hordetum murinumae* ass. nova, *Cresso creticae-Hordetum murinumae* ass. nova, *Aeluropuseto lagopoidesae-Chenopodietum vulvariae* assoc. nova, *Cresso creticae-Aeluropusetum lagopoidesae* assoc. nova, *Frankenieto pulverulentae-Salsoletum sodae* assoc. nova. The amount of phytomass and the structure of fractions like *Hordeum murinum and other Poaceae, Alhagi mannifera+Prosopis farcta and other Poaceae, Ammi visnaga+Cressa cretica and other Poaceae,* according to Vagina and Shatochina methods (Coupland & al. 1974; Vagina & Satochina 1976; Sims & Coupland 1979), applied to pads of 1 m^2. Phytomass was studied five times monthly in the associations, as it was mentioned above (Ilin 1988).

Results and discussion

In the studied area (Akçakale), pH varies between 7.6 and 8.4; the total salt content is 0.4–1.14%; electric conductivity (EC) registers 4–19.5 dS/m; and the changeable sodium rate (ESP) is 1.85–39.12% (Cullu & al. 2002).

Şanlıurfa and Hatay cities are situated in a semi-arid region with Mediterranean climate. In such regions, the days are hot and arid in summer and rainy in winter. The amount of rainfall increases in the direction south-north and west-east (Figs 1, 2, 3a, 3b).

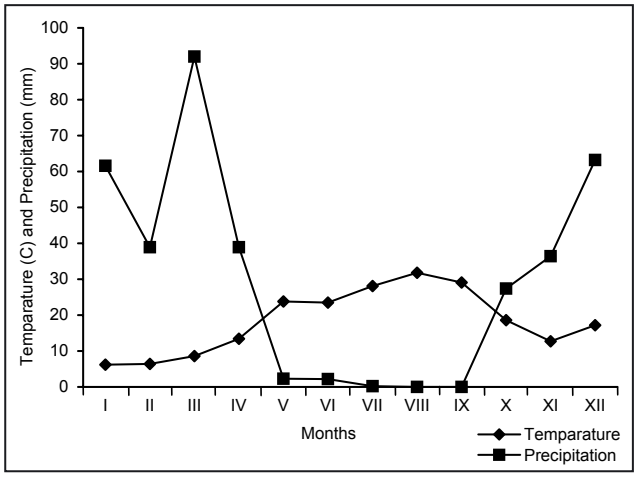

Fig.1. Climatic diagram of Akçakale.

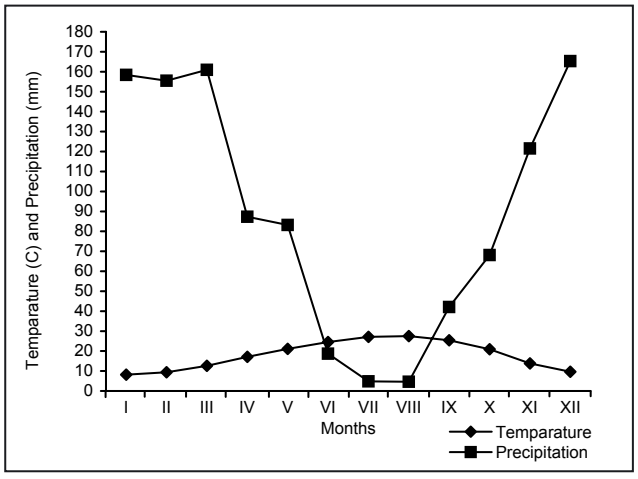

Fig. 2. Climatic diagram of the Amik Plain.

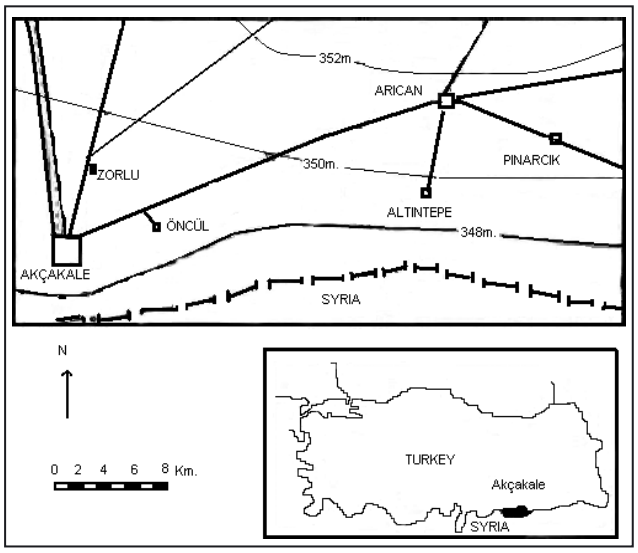

Fig. 3a. Geographical maps in the Akçakale-Syria region (Şanlıurfa).

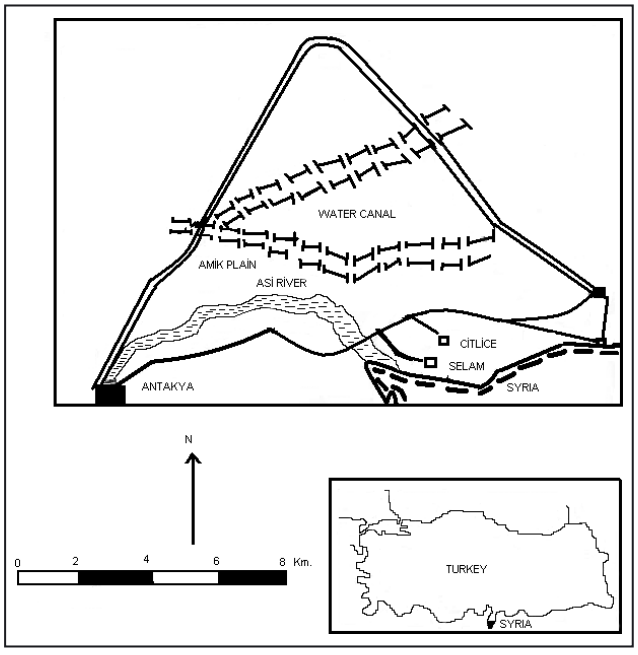

Fig. 3b. Geographical maps in the Amik Plain (Hatay).

In Akçakale the highest temperature is 40 °C in July, the lowest is 0.9 °C in February. While the average annual temperature peak is 24.8 °C, the average annual temperature low is 17.2 °C (Fig. 1). The highest average humidity is 81.5 % in December and the lowest average humidity is 39.3 % in June. Average annual humidity amounts to 62.9 %. The average rainfall reaches its peak in March (92 mm), falling down to 0.2 mm in June. No rain falls in Akçakale in July and August. Annual rainfall totals 363.1 mm (DMI, State Meteorology Office). In the first part of the year, from November to April, the season is rainy and humid (i); in the second part, from May to September, the season is arid (h). The probable frosty months are (r) from November to March (Fig. 1).

The driest months are July (4.8 mm) and August (4.6 mm) in Antakya (Hatay). Besides the studies carried out during these months, precipitation was also registered in Akçakale. Climatic data on Antakya give the highest monthly precipitation in December (165.3 mm), January (158.4 mm), February (155.5 mm), and March (160.9 mm). Climatic data on the investigated area are given in a table and a diagram below (Table 1; Figs 1, 2).

The structure of this area differs significantly from the other parts. This difference is best explained by the soil analysis. The soil analysis from a depth of 0–50 cm has shown a low humus value of 1.01–1.69 % and pH 7.51–7.80 (Table 2). $CaCO_3$ was found to amount to 47–50 %; Ca^{++}, Mg^{++} to 19.52–22.10 me/100 gr, and Na^{+} to 2.29–4.31 me/100 gr (the amount of Na^{+} was increasing with depth).

Chemical content of the soils under the investigated plant associations are given in Table 3. In the soils under the associations *Cresso creticae-Aeluropusetum lagopoidesae* the total amount of salt was 0.800 %. In the areas under the associations *Frankenieto pulverulentae-Salsoletum sodae* and *Aeluropuseto lagopoidesae-Chenopodietum vulvariae* the total amount of salt was double that under the first associations (between 1.050–1.150 %).

Table 1. Climate data on the investigated areas.

Station	H (m)	Meteorological elements	Months												
			1	2	3	4	5	6	7	8	9	10	11	12	Annual
Akçakale	350	Mean temperature (°C)	6.2	6.4	8.6	13.4	23.5	28.1	31.8	29.1	23.8	18.6	12.7	8.8	17.2
		Mean presipitation (mm)	61.6	38.9	92.0	38.9	2.2	0.2	–	–	2.3	27.4	36.4	63.2	363.1
Antakya	85	Mean temperature (°C)	8.2	9.4	12.6	17.1	21.1	24.5	27.1	27.5	25.4	20.9	13.8	9.6	18.1
		Mean presipitation (mm)	158.4	155.5	160.9	87.3	83.2	18.7	4.8	4.6	42.1	68.1	122	165.3	89.2

Table 2. Chemical characteristics of the soil of the Amik Plain.

Associations	pH	Salt (%)	Lime (%)	Changeable Sodium		Useful Kalium	
				mg/100gr	me/100gr	mg/100gr	me/100gr
Alhago manniferae-Hordetum murinumae	7.48	0.080	43.3	18.1	0.79	42.1	1.08
Prosopo farctae-Hordetum murinumae	7.59	0.088	41.8	21.3	0.93	34.0	0.87
Ammio visnagae-Hordetum murinumae	7.80	0.056	47.1	11.9	0.52	24.0	0.62
Cresso creticae-Hordetum murinumae	7.59	0.058	50.4	7.9	0.34	29.8	0.76

Table 3. Chemical characteristics of the soil of Akçakale (Harran Plain).

Associations, date and location		Total soil (%)	Saturation with water (%)	pH	$CaCO_3$ (%)	P_2O5 (kg/da)	K_2O (kg/da)	Organic mass (humus) (%)
Frankenieto pulverulentae-Salsoletum sodae	11.10.2004 Arıcan village	1.05	55	8.09	10.2	4.9	233.2	1.88
	19.04.2005 Altıntepe village	1.05	63	8.27	14.0	6.8	183.6	2.03
Cresso creticae-Aeluropusetum lagopoidesae	16.03.2005 Syria	0.80	72	8.38	13.6	3.4	129.6	3.19
	19.04.2005 Öncül village	1.15	50	8.45	7.9	0.7	29.1	1.01
Aeluropuseto lagopoidesae-Chenopodietum vulvariae	19.10.2004 Öncül village	1.05	64	8.22	7.2	0.5	58.3	1.74

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Cresso creticae-Aeluropusetum lagopoidesae	16.03.2005 Syria	0.80	72	8.38	13.6	3.4	129.6	3.19
	19.04.2005 Öncül village	1.15	50	8.45	7.9	0.7	29.1	1.01
Aeluropuseto lagopoidesae-Chenopodietum vulvariae	19.10.2004 Öncül village	1.05	64	8.22	7.2	0.5	58.3	1.74

Steppe vegetation is one of the types found in the Hatay region. It was composed mainly of the following plants: *Petrosimonia brachiata*, *Salicornia europaea*, *Hordeum murinum, Prosopis farcta,* and *Cressa cretica*. These halophytic species are widely spread. The floristic composition, phytosociologic and seasonal features of the region differ from the other steppes. *Hordeum murinum* was identified as a widespread dominant species. In late spring, individuals of this species turn yellow and begin to wither. This continues until the end of autumn when the phytocoenoses completely dry up. In spring, the green plants are grazed by sheep, goats and cattle, but after withering they become rough and the animals do not eat them. This community occasionally maintains associations with codominant individuals, such as *Cressa cretica* with *Cresso creticae-Hordetum murinumae*, *Alhagi mannifer*a with *Alhago manniferae-Hordetum murinumae*, *Petrosimonia brachiata* with *Petrosimono brachiatae-Hordeum murinumae,* and *Prosopis farcta* with *Prosopo farctae-Hordetum murinumae*. The phytosociologic composition and structural features of the widespread species of this associations are shown in Tables 6–8.

After irrigation from the Atatürk Dam began in the period 1995–1999, excessive watering (espe-

cially for cotton farming) further increased salt levels in the soil (Cullu & al. 2002). Cultivated areas were occupied by the secondary halophytes due to these high salt levels. Out of the 225 000 ha total area of the Harran Plain, 8513 ha were classified as highly saline (Ozkutlu & Ince 1999). Especially in the areas around Akçakale, the total salinity level varies between 0.075–1.450 % (Dinc & al. 1988). Topographycally, the Harran Plain is lower than its surroundings and therefore the accumulated water cannot be drained. The soils of the plain are clayey and the base water easily rises to the surface and evaporates (Ungar 1982; Bertnes & al. 1992; Cullu & al. 2002), thus conditioning the saline areas.

The soil analysis of the Harran Plain in the period 1987–2000 shows that in 1987, 30 617 ha out of the total of 36 166 ha had no salinity problems, but in 2000 that area had shrunk to 24 674 ha (a drop of 19 %). In 13 years the soils have become salinized and changed category among the salinized groups (Figs 4a, 4b; Table 4).

Halophytic areas have been increasing owing to excessive irrigation (Figs 4a, 4b, 5). According to soil analysis, in the last 13 years (1987–2000) saline soils have increased by 394 % (Cullu & al. 2002).

In our study, the following species were found to dominate in the area: *Prosopis farcta, Alhagi mannifera, Polygonum arenastrum*, *P. aviculare*, *Rumex pulcher*, *Chenopodium album* subsp. *album* var. *album, Peganum harmala*, *Amaranthus retroflexus*, *Cressa cretica*, *Salsola dendroides*, *Phragmites australis, Tamarix smyrnensis*, *Glycyrrhiza glabra* var. *glabra*, and *G. glabra* var. *glandulifera.* Among these, the following species were secondary over a wide area: *Prosopis farcta*, *Alhagi mannifera*, *Peganum harmala*, *Phragmites australis*, *Aeluropus lagopoides* var. *mesopotamica,* and *Cynodon dactylon* var. *villosus*. According to Zohary (1973), there was steppe vegetation in the area. However, under the impact of ecological changes imposed by the anthropogenic factor the vegetation of the region has undergone a successional change. After 1995, uncontrolled and excessive watering caused some species, such as *Salsola dendroides*, *Cressa cretica*, *Phragmites australis,* etc., migrate into the area, while others, such as *Stipa holosericea, Artemisia herba-alba*, *A. ab-*

Table 4. Salinity levels of the Harran Plain soils (36 166 ha).

Salinity level (ha)	Years			Difference from 1987
	1987	1990	2000	
None saline	30.617	28.669	24.764	– % 19,2
Slightly saline	2.788	3.150	4.814	+ % 72,7
Moderately saline	2.219	2.219	3.912	+ % 76,3
Strongly saline	542	2.128	2.676	+ % 394

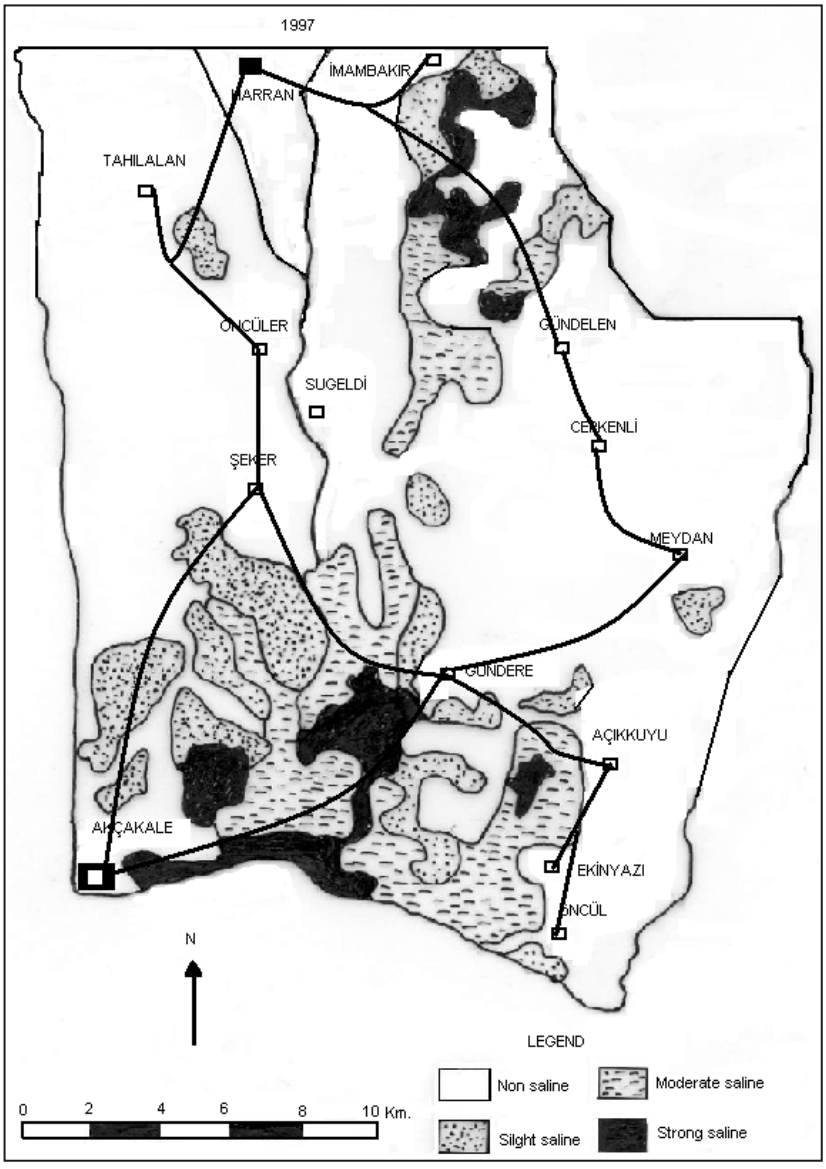

Fig. 4a. Map of salinization for 1990 in the Harran Plain.

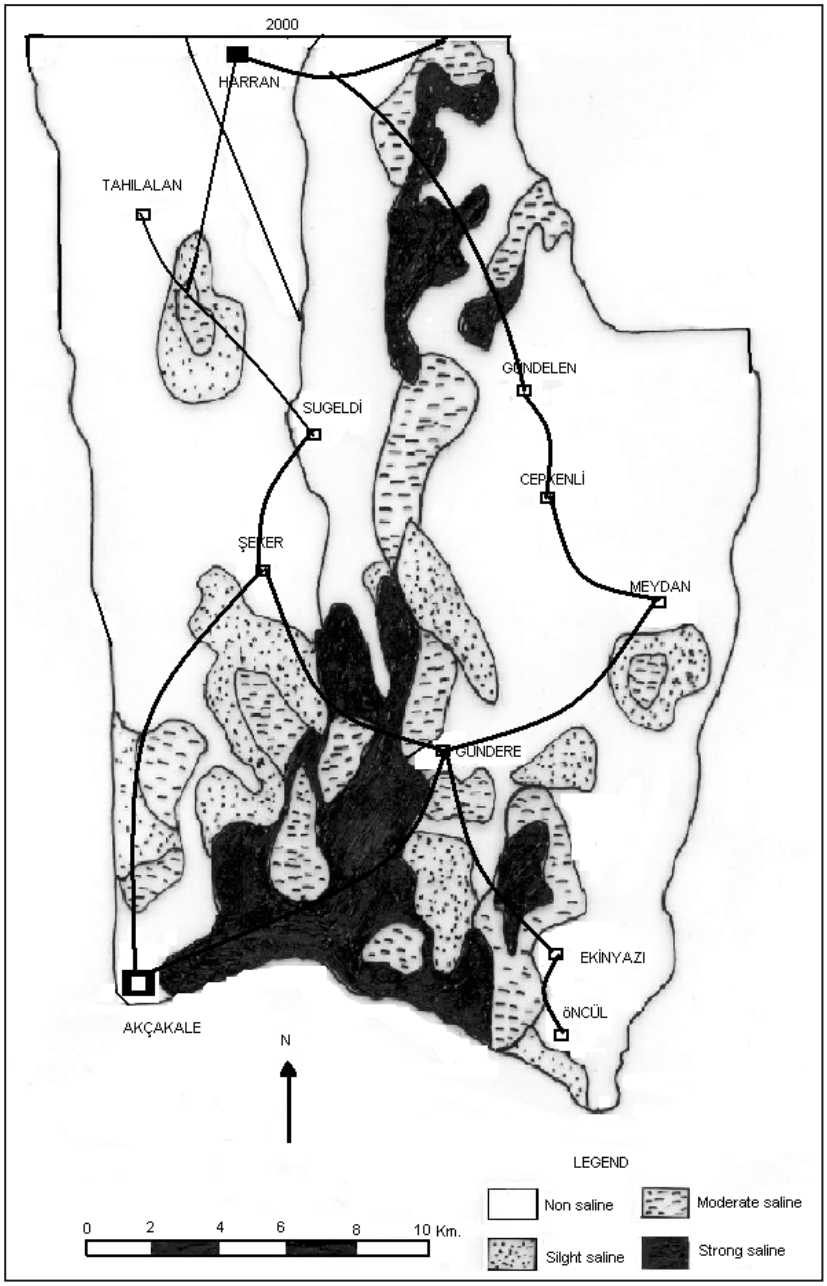

Fig. 4b. Map of salinization for 2000 in the Harran Plain.

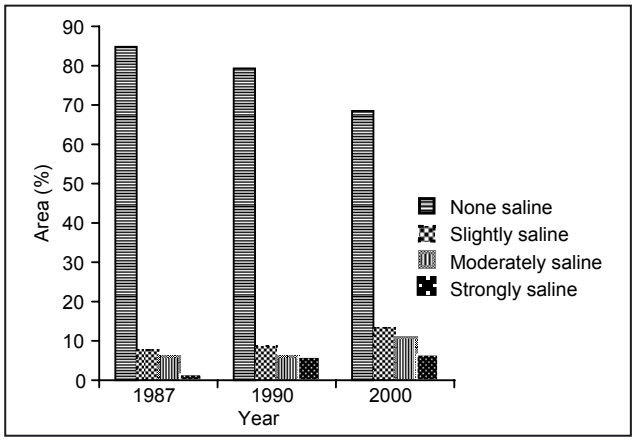

Fig. 5. Variation of salinity in the Harran Plain between 1987 and 2000.

sinthium, *Festuca callieri* subsp. *callieri*, *Poa bulbosa*, *Teucrium polium*, *Astragalus microcephalus*, *Phlomis pungens* var. *pungens*, *Bromus japonicus* subsp. *japonicus*, *Thymbra spicata* var. *spicata*, *Eryngium campestre* var. *virens,* etc., have left it owing to salinization. Furthermore, young seedlings of salinity-tolerant taxa, such as *Tamarix smyrnensis,* were detected. Due to anthropogenic factors, the associations in the area have been changing to halophytic and many adventive species have emerged, such as *Amaranthus retroflexus*., *A. albus, Xanthium strumarium* subsp. *strumarium, X. spinosum, Chenopodium album* subsp. *album* var. *album*, *Polygonum arenastrum*, *P. aviculare*, *Rumex pulcher*, *Hyoscyamus reticulatus*, *Tribulus terrestris*, *Urtica dioica*, *U. pilulifera*, *Parietaria judaica*, *Salsola tragus*, *Portulaca oleracea*, *Heliotropium circinatum,* and *H. europaeum*. After salinization some plant species got extinct in the area, while the habitat of others has shrunk. The main reason is the increasing salt levels in the soil. The vegetation cover in the studied area is about 40–50 %. Generally, this is one-storey vegetation and the height of the grass is around 10–20 cm. Only the association *Phragmitetum australisae* reaches the height of 2 m. This association grows particularly in or along the wet areas and around the irrigation canals and has a simple structure with domination of one species (*Phragmites australis*). The following species occasionally show presence in the association: *Typha domingensis*, *T. minima* var. *minima*, *T. minima* var. *gracilis*, *Juncus gerardi* subsp. *gerardi*, *J. gerardi* subsp. *libanoticus*, *Carex divisa*, *Alopecurus arundinaceus*, and *A. myosuroides* var. *myosuroides*. The associa-

Table 5. ***Aeluropuseto lagopoidesae-Chenopodietum vulvariae*** **ass. nova. Type Relevés no. 23 (In Akçakale-Harran Plain).**

Relevés no.	23	24	25	26	27	28	29	30	Classis of location
Wideness of area (m^2)	50	50	50	50	50	50	50	50	
Altitude (m)	351	350	350	351	350	351	350	350	
Inclination (°)	1	2	2	1	2	2	2	2	
Length of plant (cm)	40	40	35	45	35	40	40	45	
Number of plant (1 m^2)	4	5	3	4	4	4	5	3	
Plant cover (%)	60	60	40	65	80	40	60	70	
Characteristic species of association									
Chenopodium vulvaria	13	23	33	33	33	33	23	23	V
Aeluropus lagopoides var. *lagopoides*	44	24	24	24	+4	14	24	44	V
Tamarix smyrnensis	24	14	–	–	–	–	+4	–	II
Factorovskya aschersoniana	+1	+1	–	–	–	+1	–	–	I
Characteristic species of *Aeluropion lagopoidesae*									
Chenopodium foliosum	+3	+3	13	13	23	13	+3	+3	V
Salsola soda	33	13	13	+3	+3	13	23	13	V
Cressa cretica	12	+2	+2	12	+2	–	12	22	IV
Frankenia pulverulenta	–	+1	11	+1	–	+1	+1	–	III
Characteristic species of *Salsolo-Aeluropetalia*									
Atriplex nitens	13	13	13	–	–	13	+3	+3	IV
Polygonum equisetiforme	+2	–	+2	+2	12	–	12	–	III
Gypsophila antari	–	+1	–	+1	–	+1	11	11	III
Characteristic species of *Salicornietea*									
Peganum harmala	22	+2	22	22	12	12	22	+2	V
Prosopis farcta	+2	–	+2	+2	–	12	+2	+2	IV
Polygonum aviculare	12	–	–	12	12	–	+2	–	III
Participants									
Hymenolobus procumbens	41	31	42	41	41	31	31	31	V
Hordeum murinum subsp. *glaucum*	21	11	–	11	+1	–	21	+1	IV
Bupleurum croceum	–	+1	+1	+1	+1	+1	–	+1	IV
Xanthium spinosum	+2	–	+2	–	+2	–	+2	+2	III
Hordeum spontaneum	–	+1	–	+1	–	–	11	–	II
Factorovskya aschersoniana	–	–	–	–	+1	–	+1	–	I
Centaurea solstitialis subsp. *solstitialis*	–	–	–	–	–	–	+1	+1	I
Cuscuta palaestina subsp. *balansae*	+1	–	–	–	–	–	+1	–	I

Table 6. ***Frankenieto pulverulentae-Salsoletum sodae*** **ass. nova. Type Relevés no. 13 (In Akçakale-Harran Plain).**

Relevés no.	13	14	15	16	17	18	19	20	Classis of location
Wideness of area (m^2)	50	50	50	50	50	50	50	50	
Altitude (m)	350	350	350	350	350	351	350	351	
Inclination (°)	1	2	2	1	2	1	2	1	
Length of plant (cm)	40	40	45	45	35	40	40	50	
Number of plants (1 m^2)	4	5	3	4	4	4	5	3	
Plant cover (%)	65	55	60	40	65	70	50	60	
Characteristic species of association									
Salsola soda	34	34	44	44	34	44	44	44	V
Frankenia pulverulenta	11	–	–	–	–	+1	21	21	III
Characteristic species of *Aeluropion lagopoidesae*									
Aeluropus lagopoides var. *lagopoides*	14	24	14	34	24	14	14	34	V
Chenopodium vulvaria	23	13	13	13	33	23	13	+3	V
Cressa cretica	22	+2	22	22	–	32	–	22	IV
Salsola incanescens	+2	–	–	–	+2	+2	–	–	II
Characteristic species of *Salsolo-Aeluropetalia*									
Salsola crassa	+2	+2	12	12	12	+2	+2	12	V
Polygonum aviculare	22	12	22	12	12	22	12	12	V
Atriplex nitens	+3	–	23	13	–	–	+3	+3	III
Chenopodium sosnowskyi	+2	–	+2	–	+2	+2	–	–	III
Characteristic species of *Salicornietea*									
Peganum harmala	22	22	22	12	22	22	22	+2	V
Polygonum equisetiforme	11	+1	11	11	21	11	+1	+1	V
Alhagi pseudalhagi	+2	+2	12	–	–	+2	+2	+2	IV
Participants									
Hymenolobus procumbens	31	41	31	41	31	31	31	31	V
Alhagi mannifera	–	33	23	23	23	23	33	33	IV
Xanthium spinosum	+1	–	+1	–	+1	+1	+1	+1	IV
Cuscuta palaestina subsp. *balansae*	–	–	–	+1	+1	–	+1	–	II
Hypecoum pendulum	–	–	+1	–	–	+1	+1	–	II
Prosopis farcta	+1	–	+1	–	–	+1	–	–	II
Hordeum murinum subsp. *glaucum*	+1	+1	–	–	–	–	+1	21	II
Centaurea solstitialis subsp. *solstitialis*	+1	+1	+1	–	+1	–	–	–	II
Ceratocephalus falcatus	+1	+1	–	–	+1	+1	–	–	II
Epilobium hirsutum	–	–	+1	–	–	–	+1	+1	II
Adonis aestivalis subsp. *aestivalis*	–	+1	+1	+1	–	–	–	–	II
Echinaria capitata	–	––	+1	+1	–	–	–	–	I
Factorovskya aschersoniana	+	–	–	–	–	–	+1	–	I
Oligochaeta divaricata	–	–	–	+1	–	–	+1	–	I
Eremopyrum bonaepartis subsp. *bonaepartis*	–	–	–	+1	–	–	+1	–	I

Table 7. ***Cresso creticae-Aeluropusetum lagopoidesae*** **ass. nova. Type Relevés no. 1 (In Akçakale-Harran Plain).**

Relevés no.	1	2	3	4	5	6	7	8	9	10	Classis of location
Wideness of area (m^2)	50	50	50	50	50	50	50	50	50	50	
Altitude (m)	350	349	350	349	349	348	350	350	348	349	
Inclination (°)	1	2	2	3	2	1	2	2	2	2	
Length of plant (cm)	20	20	25	25	25	20	20	20	25	20	
Number of plant (1 m^2)	4	3	3	4	4	4	2	3	3	3	
Plant cover (%)	70	60	70	45	60	60	50	70	70	60	
Characteristic species of association											
Aeluropus lagopoides var. *lagopoides*	24	24	24	24	34	44	34	34	44	34	V
Cressa cretica	22	12	22	–	12	+2	+2	12	12	22	V
Aeluropus littoralis	14	–	14	+4	14	+4	–	+4	14	–	IV
Characteristic species of *Aeluropion lagopoidesae*											
Salsola soda	13	13	23	23	23	+3	23	23	13	33	V
Gypsophila antari	–	+1	11	+1	11	11	11	–	11	11	IV
Frankenia pulverulenta	–	+1	11	+1	–	–	–	21	21	21	III
Petrosimonia brachiata	+1	–	+1	–	+1	–	–	+1	–	–	II
Chenopodium album subsp. *album* var. *album*	–	+1	–	+1	–	–	–	–	+1	–	II
Characteristic species of *Salsolo-Aeluropetalia*											
Polygonum aviculare	12	12	12	12	+2	12	12	22	12	22	V
Salsola crassa	–	+2	+2	+2	+2	–	+2	12	12	12	IV
Cynodon dactylon var. dactylon	33	–	+3	–	–	13	+3	+3	–	–	III
Characteristic species of *Salicornietea*											
Alhagi mannifera	+3	33	43	43	23	13	–	–	+3	23	IV
Salicornia europaea	+2	+3			+3			+3			II
Prosopis farcta	–	–	12	12	12	12	–	+2	–	–	III
Polypogon maritimus subsp. *maritimus*	+1	–	–	+1	–	+1	–	–	+1	–	II
Participants											
Hymenolobus procumbens	11	11	+1	+1	+	+1	11	11	11	+1	III
Factorovskya aschersoniana	+1	–	+1	+1	+1	–	+	–	+	+1	II
Phleum exaratum subsp. *exaratum*	+1	+1	+1	–	11	–	+1	11	–	+1	II
Avena eriantha	+1	–	–	+1	–	–	+1	+1	–	+1	II
Centaurea solstitialis subsp. *solstitialis*	–	+1	–	+1	–	–	+1	–	+1	–	II
Epilobium hirsutum	–	+1	+1	–	–	+1	–	–	–	–	II
Phalaris paradoxa	–	–	–	–	+1	–	–	–	+1	–	I
Lathyrus sativus	+1	–	–	–	–	–	+1	–	–	–	I
Ornithogalum umbellatum	–	–	–	–	+1	–	–	–	+1	–	I

Table 8. ***Cresso creticae-Hordetum murinumae*** **ass. nova.Type Relevés no. 34 (In Selam-Amik Plain).**

Relevés no.	31	32	33	34	35	36	37	38	Classis of location
Wideness of area (m^2)	50	50	50	50	50	50	50	50	
Altitude (m)	85	83	85	85	85	86	84	85	
Inclination (°)	1	2	2	1	2	2	2	2	
Length of plant (cm)	35	40	35	45	35	30	30	25	
Number of plant (1 m^2)	4	5	3	4	4	4	5	3	
Plant cover (%)	55	50	45	45	65	45	55	70	
Characteristic species of association									
Hordeum murinum subsp. *glaucum*	13	23	33	33	33	33	23	23	V
Cressa cretica	22	24	24	24	+4	11	23	34	V
Alhagi mannifera	24	14	–	–	–	–	+4	–	II
Characteristic species of *Hordetion murinumae*									
Chenopodium foliosum	+3	+3	13	13	23	13	+3	+3	V
Prosopis farcta	33	13	13	+3	+3	13	23	13	V
Petrosimonia brachiata	12	+2	+2	12	+2	–	12	22	IV
Euphorbia macroclada	–	+1	11	+1	–	+1	+1	–	III
Characteristic species of *Salsolo-Aeluropetalia*									
Atriplex nitens	13	13	13	–	–	13	+3	+3	IV
Polygonum equisetiforme	+2	–	+2	+2	12	–	12	–	III
Gypsophila antari	–	+1	–	+1	–	+1	11	11	III
Characteristic species of *Salicornietea*									
Peganum harmala	22	+2	22	22	12	12	22	+2	V
Adonis annua	+2	–	+2	+2	–	12	+2	+2	IV
Salicornia europaea	12	–	–	12	12	–	+2	–	III
Participants									
Geranium dissectum	11	21	+1	21	11	11	–	–	IV
Raphanus raphanustrum	21	11	–	11	+1	–	21	+1	IV
Ranunculus chius	–	+1	+1	–	+1	+1	–	+1	II
Ranunculus cornutus	+2	–	+2	–	+2	–	+2	+2	III
Cichorium intybus	–	+1	–	+1	–	–	11	–	II
Cerastium anomalum	–	–	–	–	+1	–	+1	–	I
Ornithogalum umbellatum	+1	–	–	–	+1	–	–	–	I
Consolida orientalis	–	–	–	+1	–	–	–	+1	I
Lactuca serriola	–	–	–	–	–	–	+1	–	I
Rumex tuberosus subsp.*tuberosus*	–	–	+1	–	+1	–	–	–	I
Allium scorodoprasum subsp. *rotundum*	–	–	–	–	–	+1	–	–	I
Melilotus indica	–	+1	–	+1	–	–	–	+1	I
Cuscuta palaestina subsp. *balansae*	+1	–	–	–	–	–	+1	–	I
Centaurea solstitialis subsp. *solstitialis*	–	–	–	–	–	–	+1	+1	I

tion *Glycyrrhizetum glabrae,* dominated by *Glycyrrhiza glabra,* is also wide-spread along the roads and on the edge of the fields. This association grows in low-level halophytic areas, occasionally mixed with *Prosopis farcta* and *Alhagi pseudoalhagi* and may form the associations *Glycyrrhizeto glabra-Prosopetum farctae* and *Glycyrrhizeto glabra-Alhagetum pseudoalhagae*. The number of these associations increases with the level of salt in the soil, as well as that of *G. glabra*.

Classification of vegetation in the investigated area:

Type: Halophytic steppe
Classis: *Salicornietea*
Ordo: *Salsolo-Aeluropetalia*
Alliance: *Aeluropion lagopoidesae*
Associations:
Aeluropuseto lagopoidesae – Chenopodietum vulvariae ass. nova
Frankenieto pulverulentae – Salsoletum sodae ass. nova
Cresso creticae – Aeluropusetum lagopoidesae ass. nova
Alliance: *Hordetion murinumae*
Associations:
Prosopo farctae – Hordetum murinumae ass. nova
Cresso creticae – Hordetum murinumae ass. nova
Alhago manniferae – Hordetum murinumae ass. nova
Ammio visnagae – Hordetum murinumae ass. nova

Type: Meadow and water-marsh
Classis: *Phragmitetea*
Ordo: *Phragmitetalia*
Alliance: *Phragmition australisae*
Association: *Phragmitetum australisae*

A list of widespread plant associations in the area is given in Table 5–10 and a vegetation map of the investigated area is given in. After spring, very few plant species with a short vegetation period survive until autumn. Most halophytic species are as follows: *Cressa cretica*, *Alhagi mannifera*, *Petrosimonia brachiata*, *Salicornia europaea*, and *Ammi visnaga.*

The high summer temperatures cause floor water to sink to lower layers. Therefore, plants with roots that can reach these lower levels can survive as phytosenoses. With the autumn rains, seeds which have fallen between soil layers during summer germinate and grow into new green plants. Consequently, the soil surface turns completely green in February. The young shoots, which have emerged during these periods, reach 5–6 cm in height at the end of May. When ephemerous plants mature, most of them bloom and develop seeds at the beginning of June, and shed these seeds in July and August. The seeds of *Petrosimonia brachiata*, however, mature and are shed in early autumn.

In seasonal dynamics, the herbaceous association *Hordetum murinumae* (formed by dominating *Hordeum murinum*) is one of the most widespread associations in the investigated area (Table 11). The dry-matter output of the association in its steppe habitats changes according to season. This variability is at its minimum in early spring and at its maximum in autumn. In winter, it decreases again and minimizes (Table 11). The role of geophytes in phytomass formation is important. However, in summer and autumn the role of perennial plants is important too. In spring, grasses (*Poaceae*) also form a signiifcant part of the phytomass.

In summer and autumn, the herbs output depends on the development of ephemerous plants and the values change between 122.5–411.0 gr/m^2. On the contrary, in winter it amounts to 10.1–21.5gr/m^2 and there is a clear downslide. Seasonal changes in phytomass depend on the amount of different groups, such as fodder crops in the region.

Three important agrobotanical groups of *Hordeum murinum* and other *Poaceae,* participating in the composition of the plant groups, exist in each group. Their amount changes according to the associations (Table 12). This variability can be observed in the amount of each agrobotanical group. While *Hordeum murinum* and other *Poaceae* and *Alhagi mannifera+Prosopis farcta* and other *Poaceae* can be observed mainly in spring, other herbs prevail in summer and autumn. This depends on the various perennial plants and the long vegetation periods. These results play an important role in the phytomass structure in autumn. Among various herbs, the most widespread dominant species is *Ammi visnaga,* which is not eaten by animals because of the essential oil in its composition. When it is dominant, it suppresses the other plants because of its height of over 1 m. This species spreads out as a secondary plant flora in the region.

The productivity of the widespread plant associations in the studied area is illustrated in Table 13. The productivity of dry herbs varies between 310–1200 gr/m^2 (Table 13).

Table 9. ***Ammio visnagae-Hordetum murinumae*** **ass. nova. Type Relevés no. 45 (In Selam-Amik Plain)**

Rrelevés no.	39	40	41	42	43	44	45	46	Classis of location
Wideness of area (m^2)	50	50	50	50	50	50	50	50	
Altitude (m)	82	85	85	85	85	86	84	85	
Inclination (°)	1	2	1	1	2	1	2	1	
Length of plant (cm)	60	55	65	45	75	70	65	55	
Number of plant (1 m^2)	4	5	6	4	7	4	5	5	
Plant cover (%)	65	65	60	55	65	70	55	60	
Characteristic species of *Ammi visnagae-Hordetum murinumae*									
Ammi visnaga	34	34	44	44	34	44	44	44	V
Hordeum murinum subsp. *glaucum*	44	33	23	33	44	44	45	33	V
Aegilops biuncialis	–	+2	+1	+1	–	–	11	+1	II
Avena sterilis subsp. *ludoviciana*	+1	+2	–	–	+1	+1	+2	+2	III
Lolium rigidum var. *rigidum*	–	–	+1	+1	+2	+2	–	+1	II
Characteristic species of *Hordetion murinumae*									
Alhagi mannifera	14	24	14	34	24	14	14	34	V
Chenopodium vulvaria	23	13	13	13	33	23	13	+3	V
Cressa cretica	22	+2	22	22	–	32	–	22	IV
Petrosimonia brachiata	+2	–	+2	–	+2	+2	–	–	II
Hordeum bulbosum	11	–	–	11	–	+1	21	21	III
Characteristic species of *Salsolo-Aeluropetalia*									
Euphorbia macroclada	+2	+2	12	12	12	+2	+2	12	V
Polygonum aviculare	11	12	11	–	12	–	12	+2	V
Atriplex nitens	+3	–	23	13	–	–	+3	+3	III
Cirsium lappaceum	+2	–	+2	–	–	+2	–	–	III
Characteristic species of *Salicornietea*									
Aegilops biuncialis	22	22	22	12	22	22	22	+2	IV
Bromus tectorum	11	+1	11	11	21	11	+1	+1	III
Eremopoa capillaris	+2	+2	12	–	–	+2	+2	+2	II
Salicornia europaea	+2	–	–	–	+2	+1	–	–	I
Participants									
Anthemis tinctoria var. *tinctoria*	31	21	11	21	31	31	31	31	IV
Aegilops biuncialis	–	33	23	23	23	23	33	33	IV
Xanthium spinosum	+1	–	+1	–	+1	+1	+1	+1	III
Cuscuta palaestina subsp. *balansae*	–	–	–	+1	+1	–	+1	–	II
Hypecoum pendulum	–	–	+1	–	–	+1	+1	–	II
Crypsis aculeata	+1	–	+1	–	–	+1	–	–	II
Lagurus ovatus	+1	+1	–	–	–	–	+1	21	II
Centaurea solstitialis subsp. *solstitialis*	+1	+1	+1	–	+1	–	–	–	II
Ceratocephalus falcatus	+1	+1	–	–	+1	+1	–	–	II
Epilobium hirsutum	–	–	+1	–	–	–	+1	+1	II
Adonis aestivalis subsp. *aestivalis*	–	+1	+1	+1	–	–	–	–	II
Echinaria capitata	–	––	+1	+1	–	–	–	–	I
Oligochaeta divaricata	–	–	–	+1	–	–	+1	–	I
Eremopyrum bonaepartis subsp. *bonaepartis*	+1	–	–	–	–	–	+1	–	I

Table 10. ***Prosopo farctae-Hordetum murinumae*** **ass. nova. Type Relevés no. 54 (In Selam-Amik Plain).**

Relevés no.	47	48	49	50	51	52	53	54	55	56	Classis of location
Wideness of area (m^2)	50	50	50	50	50	50	50	50	50	50	
Altitude (m)	85	85	84	85	85	86	84	85	83	86	
Inclination (°)	1	2	2	3	2	1	2	2	2	2	
Length of plant (cm)	20	20	25	25	25	20	20	20	25	20	
Number of plant (1 m^2)	5	3	4	5	4	6	2	3	4	5	
Plant cover (%)	50	65	75	55	60	65	50	65	70	60	
Characteristic species of *Prosopo farctae-Hordetum murinumae*											
Hordeum murinum subsp. *glaucum*	24	34	24	24	34	44	34	34	44	34	V
Prosopis farcta	22	+2	22	–	12	+2	+2	22	12	22	V
Avena sterilis subsp. *ludoviciana*	12	–	11	+4	12	+4	–	+4	12	–	IV
Characteristic species of *Alhago manniferae-Hordetum murinumae*											
Alhagi mannifera	13	13	23	23	23	+3	23	23	13	33	V
Characteristic species of *Hordetion murinumae*											
Chenopodium album	–	+1	11	+1	11	11	11	–	11	11	IV
Hordeum bulbosum	–	+1	11	+1	–	–	–	21	21	21	III
Petrosimonia brachiata	+1	–	+1	–	+1	–	–	+1	–	–	II
Melilotus indica	–	+1	–	+1	–	–	–	–	+1	–	II
Characteristic species of *Salsolo-Aeluropetalia*											
Polygonum aviculare	12	12	12	12	+2	12	12	22	12	22	V
Euphorbia falcata	–	+2	+2	+2	+2	–	+2	12	12	12	IV
Cynodon dactylon var. *dactylon*	33	–	+3	–	–	13	+3	+3	–	–	III
Characteristic species of *Salicornietea*											
Alhagi mannifera	+3	33	43	43	23	13	–	–	+3	23	IV
Petrosimonia brachiata	+2	+3			+3			+3			II
Aegilops biuncialis	–	–	12	12	12	12	–	+2	–	–	III
Polypogon maritimus subsp. *maritimus*	+1	–	–	+1	–	+1	–	–	+1	–	II
Salicornia europaea		+2	–	–	–	+2		–	–	–	I
Participants											
Bromus japonicus subsp. *japonicus*	41	31	31	41	31	41	41	31	31	31	V
Lagurus ovatus	11	–	–	11	11	–	–	11	+1	11	IV
Phleum exaratum subsp. *exaratum*	+1	+1	+1	–	11	–	+1		–	+1	III
Avena eriantha	+1	–	–	+1	–	–	+1	+1	–	+1	III
Centaurea solstitialis subsp. *solstitialis*	–	+1	–	+1	–	–	+1	–	+1	–	II
Epilobium hirsutum	–	+1	+1	–	–	+1	–	–	–	–	II
Phalaris paradoxa	–	–	–	–	+1	–	–	–	+1	–	I
Crypsis aculeata	–	11	–	–	–	–	+1	–		–	I

Table 11. Seasonal dynamic of the associations (Amik Plain, during 1999–2000).

Associations	Output (gr/m^2) and seasons			
	Spring	Summer	Autumn	Winter
Alhago manniferae-Hordetum murinumae	146.0	182.0	281.4	12.4
Prosopo farctae-Hordetum murinumae	213.0	195.2	263.7	–
Ammio visnagae-Hordetum murinumae	122.5	413.0	411.0	21.5
Cresso creticae-Hordetum murinumae	104.1	120.1	238.7	15.7

Table 12. The structure of above-ground phytomass in the associations according to agrobotanical groups (Amik Plain).

Associations	Total gr/m^2	Fractions (gr/m^2)		
		Hordeum murinum and other *Poaceae*	*Alhagi mannifera+Prosopsis farcta* and other *Poaceae*	*Ammi visnaga+Cressa cretica* and other *Poaceae*
Alhago manniferae-Hordetum murinumae	413.0	120.0	17.7	276.2
Prosopo farctae-Hordetum murinumae	195.7	105.7	90.0	–
Ammio visnagae-Hordetum murinumae	106.9	60.9	–	46.0
Cresso creticae-Hordetum murinumae	229.0	79.0	–	150.0

Table 13. Productivity of prevalent plants in the studied area (Akçakale).

Species	Fresh weight (gr/m^2)	Dry weight (gr/m2)	Rate of damp (%)
Aeluropus lagapoides var. *lagapoides*	1620	1200	25.9
Salsola soda	2050	860	58.1
Cressa cretica	670	290	56.7
Alhagi mannifera	1140	310	72.8
Average	**1370**	**665**	**53.3**

Conclucions

1. Halophytic areas in the Harran plain were studied in the following districts: Gürgelen, Toytepe and İmambakır villages, places at altitude of 330–350 m in Akçakale county towards the border with Syria.
2. In this region, halophytic areas have increased steadily due to irrigation. These halophytic areas have increased by 394 % from 1987 to 2000.
3. The following species grow in the areas (Harran and Amik): *Prosopis farcta*, *Alhagi pseudoalhagi*, *A. mannifera*, *Polygonum arenastrum*, *Xanthium spinosum*, *X. strumarium*, *Chenopodium album*, *Rumex pulcher*, *Peganum harmala*, *Amaranthus retroflexus*, *A. albus*, *Cressa cretica*, *Petrosimonia brachiata*, *Salicornia europaea*, *Salsola soda*, *S. dendroides*, *Frankenia pulverilenta*, *Phragmites australis*, *Tamarix smyrnensis*, *Glycyrrhiza glabra* var. *glabra*, *G. glabra* var. *glandulifera*, *Aeluropus lagopoides* var. *lagopoides*, *A. littoralis*, *Cynodon dactylon*.
4. Due to increasing salinization, the following species have migrated into the areas: *Salsola dendroides*, *Cressa cretica*, *Tamarix smyrnensis*.
5. Due to anthropogenic factors, the vegetation has changed to a succession containing halophytic plants, such as *Amaranthus retroflexus*, *A. albus*, *Xanthium strumarium*, *X. spinosum*, *Chenopodium album* subsp. *album* var. *album*, *Polygonum arenastrum*, *P. aviculare*, *Rumex pulcher*, *Hyoscyamus reticulatus*, *Tribulus terrestris*, *Urtica dioica*, *U. pilulifera*, *Parietaria judaica*, *Physalis alkekengi*, *Salsola tragus*, *Portulaca oleracea*, *Heliotropium circinatum*, *H. europaeum*.
6. Vegetation of the investigated Harran and Amik plains has been classified, and two types, two classes, two orders, three alliances, and eight associations have been determined.

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