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Development dynamics of coenopopulations of the species *Caragana grandıflora* (M. Bieb.) DC. (Fabales Fabaceae) in the Republic of Azerbaijan

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ABSTRACT During the study, the coenopopulations of the species *Caragana grandiflora* (M. Bieb.) DC. (Fabales Fabaceae) found in the flora of Azerbaijan were evaluated in *Caraganetum* and *Caraganeta-Pistacetum-Juniperusosum* formations. As a result of observations, it was noted that no young type of coenopopulation was found in the coenopopulations, and the viability and dynamics were at a low level. During the study, an evaluation was carried out according to IUCN criteria, and species *C. Grandiflora* was determined to be in danger of extinction, and it was classified as "Critically Endangered" (CR).

KEY WORDS Flora; culture; formation; virginile; immature.

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INTRODUCTION

Of the 80 species of the *Caragana* Fabr. genus, (Fabales Fabaceae) one wild species and one cultivated species are found in Azerbaijan (Asgarov, 2016; Churyulina et al., 2020; Mammadova, 2022). Among them, the species *Caragana grandiflora* (M. Bieb.) DC. distributed in the Lesser Caucasus, Nakhchivan AR, Gobustan and steppe plateau, on arid clayey-stony slopes, xerophilous bushwood and sparse forests is a low shrub. It is characterized by the stipulas turned into thorns, the butterfly-shaped yellow small flowers located in bunches of 2–5 pieces and the beans elongated with a short stalk. The species in culture has a strong root system, soil protection and other properties, so it is planted and cultivated for meliorative purposes. It is mostly used in regions with semi-desert and steppe vegetation. It is a melliferous, vitamin-rich, technically important and valuable wood plant (Ahmedova, 2013).

Although plants belonging to the leguminous family are widely spread all over the Earth, but in recent times, due to the influence of environmental factors, their occurrence has decreased relatively (Ibadulllayeva et al., 2021; The Red Book of the Republic of Azerbaijan, 2013). Environmental factors also affect the species *C. grandiflora* found in the wild. Preserving, increasing the number and protection of this one species found wild in the flora of Azerbaijan is one of the important issues. Since it is impossible to prepare practical measures such as the preparation of plant protection measures and the efficient use of biological resources without conducting work at the coenopopulation level, for the first time, we set the goal of evaluating the coenopopulations of the species *C. grandiflora*, and some morphological signs of the coenopopulation, the structure of its ontogeny, development dynamics, as well as the assessment of its vitality were carried out.

MATERIAL AND METHODS

In 2014–2017, the territories of Ordubad and Gabala districts were selected as the object of the research. Evaluation of coenopopulations of the *Caragana grandiflora* was the main goal of the research.

While the structure of the coenopopulation of the species *C. grandiflora* was carried out on the basis of generally accepted methods, some demographic indicators such as recovery index, replacement and age index, coenopopulation types, the structure of vitality were also determined (Kudryavsev, 2008; Ilina, 2017). The demographic structure was determined by the relationship of different ontogenetic age groups, and the morphometric indicators of individuals were taken as the basis for the evaluation of the vitality of the studied species (Iskander, 2011; Mammadova, 2016). The methods developed by Rabotnov (1960), Uranov (1975) and Loskutov (2012) were used to study the assessment of ontogeny, development dynamics, and vitality of the coenopopulations of the studied species.

The main indicators of the vitality of the coenopopulation were evaluated according to the classification of Zoblin (1993) and Ishbirdin et al. (2006). The vitality of coenopopulation (Q-vitality) is classified according to Zoblin (1993) as follows:

1. Coenopopulation in developing - $Q=1/2(a+b)>c$;
2. Coenopopulation in equilibrium - $Q=1/2(a+b)=c$;
3. Coenopopulation in crisis - $Q=1/2(a+b)<c$.

Sample plots of 500 m^2 were established in the study areas. In total, 550 individuals of the species *C. grandiflora* were studied. In the bushes, shoots in different age states were observed. The width and length, the maximum and minimum height of the bush, the maximum diameter of the shoot, the amount of vegetative and generative shoots in the bush were taken as biometric signs. Based on the mentioned biometric traits, the development cycle of the species *C. grandiflora* was studied.

The development of partial bushes in the ontogeny of the species *C. grandiflora* was observed as follows: immature (im), virginile (v), young generative and virginile (g_1 and g_1v), middle-aged generative and virginile (g_2 and g_2v), aged generative and virginile (g_3 and g_3v), subsenile (ss), senile (s) and corpse (sc).

In early spring, sprouting was observed only in the *Caraganetum* formation group of Ordubad district. It was not observed in the *Caraganeta-Pistacetum-Juniperusosum* formation group of Gabala district. The sprout consists of one shoot, two cotyledon leaves, a radicle growing deep into the soil, and 2–3 leaves have already developed in juvenile individuals. Hardness was not observed in the leaves. The height of the plant reaches 10–12 cm. In the immature age state, the number of vegetative shoots in the ramet increases. In the virginile age state, the height reaches 1 m, and the diameter of the cover reaches 2.2 m. The virginile age state ends its ontogenesis by 5 years. Flowering and fruiting of the plant are observed during the generative age period.

The study of the *C. grandiflora* species at the coenopopulation level, the study of its development dynamics, and the determination of the possibilities of adaptation to environmental conditions are relevant in terms of the protection of Azerbaijan's endangered species (Mamedova, 2014).

RESULTS AND DISCUSSION

The *C. grandiflora* species found in the wild in Azerbaijan is a short shrub with a height of up to 2 m. The bark is grayish. The young branch is angular. False shoots are thorny and very tough. Some of the feathery leaves hardened and turned into thorns. Small leaves are 5–12 mm long and 2-3 mm wide. The tip of the reverse lanceolate or wedge-shaped leaves is thin, pointed at the tip, and glabrous or covered with hairs. The flowers are single. The flower stalk is shorter than the calyx, equal to or larger than it. The calyx is green or reddish-brown in color. 12–16 mm long, tubular, usually saccular from the base, swollen, hairy. The crown is large, 2.5–3 cm long, golden in color at first, and then turns red. The bean is slightly sessile, 2.5–4 cm long. The surface is linear, glabrous or hairy. The flower base is small, elongated. Flowering occurs in May-June or July. In Azerbaijan, it is mainly distributed in the territory of Nakhchivan AR, in the lower mountain belt. It is also found in dry and gravelly areas (Ganbarli, 2006; Gurbanov, 2018).

Coenopopulation studies of the species *C. grandiflora* was carried out in *Caraganetum* formation group (CP I, in 2014–2015), in leguminous phytocoenoses (common in mountain-brown soils come out from under the forest of shrub vegetation type of Ordubad district), in *Caraganeta-Pistacetum-Juniperusosum* formation group (CP II, in 2016–2017 years) or in sparse forest with the dominance of leguminous bushes of the xerophytic sparse forest type of Gabala district.

Sample plots of 500 m^2 were established in the study areas. In total, 550 individuals of the species *C. grandiflora* were studied. In the bushes, shoots in different age states were observed. As biometric traits, the width and length, the maximum and minimum height of the bush, the maximum diameter of the shoot, the amount of vegetative and generative shoots in the bush were taken as the basis. Based on the mentioned biometric traits, the development cycle of the species *C. grandiflora* was studied (Table 1).

Sizes	v	g_1	g_2	g_3	S
Width of leaf, mm	2	2	3	3	2
Length of leaves, mm	5	6	12	13	10
Number of generative shoots	-	15	15	11	-
Length of of generative shoots, cm	-	80	90	90	-

Table 1. Some morphological traits of the coenopopulation of the *Caragana grandiflora* species.

The development of partial bushes in the ontogeny of the species *C. grandiflora* was observed as follows: virginile (v), young generative and virginile (g_1 and g_1v), middle-aged generative and virginile (g_2 and g_2v), aged generative and virginile (g_3 and g_3v), subsenile (ss), senile (s) and corpse (sc) (Table 2).

In early spring, sprouting was observed only in the *Caraganetum* formation group found in Ordubad district. It was not observed in the *Caraganeta-Pistacetum-Juniperusosum* formation group found in Gabala district. The absence of juvenile and immature individuals in the formation groups proves that regeneration with seed does not occur. The sprout consists of one shoot, two cotyledon leaves, a radicle growing deep into the soil, and 2–3 leaves have already developed in juvenile individuals. Stiffness was not observed in the leaves. The height of the plant has reached 10-12 cm. In the virginile age state, the height reached 1 m, and the diameter of the cover reached 2.2 m. The virginile age state ends its ontogenesis by 5 years. Flowering and fruiting of the plant are observed during the generative age period.

As a result of the conducted studies, it was clarified that in the *Caraganetum* formation group (CP I) found in the Ordubad district, the ontogenesis of the *C. grandiflora* species was observed to develop at a normal level (Table 3). The number of

CP		Ontogenetic age states								Σ
		j	im	V	g_1	g_2	g_3	ss	s	
CP I	2014	1	-	12	10	9	8	15	12	67
	2015	-	-	16	10	7	5	13	10	61
CP II	2016	-	-	10	9	8	6	12	9	54
	2017	-	-	10	8	7	5	11	11	52
	Σ	1	-	48	37	31	24	51	42	234
	%	0.43	-	20.5	15.8	13.2	10.2	21.8	17.9	99.8

Table 2. The structure of the ontogeny of the coenopopulation in which the species *Caragana grandiflora* is distributed.

generative individuals was maximum (g_1=16.7%) in CP II (*Caraganeta-Pistacetum-Juniperusosum* formation group) only in 2016 during flowering stage. In general, the presence of a low level of coenopopulation in the partial bushes of the *C. grandiflora* species is related to the decrease in the number composition.

The diversity of individuals in this species is observed between the ages of 8 and 18. This coincides with the middle-aged generative age state. In the case of young generative age state, according to the development cycle, the succession process takes place in 5 stages:

The presence of individuals in different age states in the composition of bush is observed in the age range of 1 to 15.

Young individuals go through a full development period up to 5 years;

Degradation of mature coenopopulations occurs between 6 and 10 ages. 2/3 of the bush is destroyed. But healthy, developing individuals remain.

Stabilization of aged individuals can last up to 10 years. At this time, the density decreases slightly. At the same time, the formation of individual young shoots is also observed.

Degradation and destruction of aged individuals is observed between 18 and 20 ages.

During the assessment of coenopopulations of the *C. grandiflora* species, transitional and aged-type coenopopulation types were determined (Table 3).

During the assessment of the coenopopulations of the species *C. grandiflora*, the coenopopulation was transitional (Δ–ω=0.53–0.58) only in the CP I (*Caraganetum* formation group) in 2015. Other coenopopulation types were aged: in CP I Δ-ω=0.60–0.54 in 2014, in CP II Δ- ω=0.58–0.57 in 2016, Δ-ω=0.59–0.54 in 2017. The absence of a young type of coenopopulation in the coenopopulations, the low level of vitality and dynamics, showed that the species *C.grandiflora* is in danger of extinction. This species is classified as "Critically Endangered" (CR) according to the IUCN threat category. As a result of the conducted research, it should be noted that it is considered appropriate to conduct continuous observations on the coenopopulation of the *C. grandiflora* species.

With the beginning of a new invasion cycle in the *Caraganetum* of large-flowered *C. grandiflora*, formation of new individuals of the coenopopulation was observed. In that formation group, the development of individuals with young age states was observed. The maximum recovery index of this species (I_b = 0.76) was found in CP I in 2015. At the same time, with the increase in density, extinction in the coenopopulation also increased. Mature populations were formed as a result of dynamic development of young individuals. At this time, the ability of vegetative reproduction weakens. The capacity for intensive growth is also maintained. The dynamics and strategy of the young plant reflect the ecological adaptation of the species to the formation. In *C. grandiflora* species, it is characterized by an increase in density at the early stage of development, and then a sharp decrease (Fig. 1).

During the conducted research, it was determined that the vitality of each individual of the *C. grandiflora* species is characterized by one ascending curve in ontogeny and is directed to the

CP	CP type	Years	Ontogenetic age state in %								Indexes			
			j	im	v	g_1	g_2	g_3	ss	s	I_b	$I_ə$	Δ	ω
CP I	Aged	2014	1.5	-	17.9	14.9	13.4	11.9	22.4	17.9	0.48	0.24	0.60	0.54
	Transitional	2015	-	-	26.2	14.9	11.5	8.2	21.3	14.9	0.76	0.37	0.53	0.58
CP I I	Aged	2016	-	-	18.5	16.7	14.8	11.1	22.2	16.7	0.43	0.23	0.58	0.57
	Aged	2017	-	-	19.2	15.4	13.5	9.6	21.1	21.1	0.49	0.24	0.59	0.54

Table 3. Assessment of coenopopulations of the species *Caragana grandiflora*.

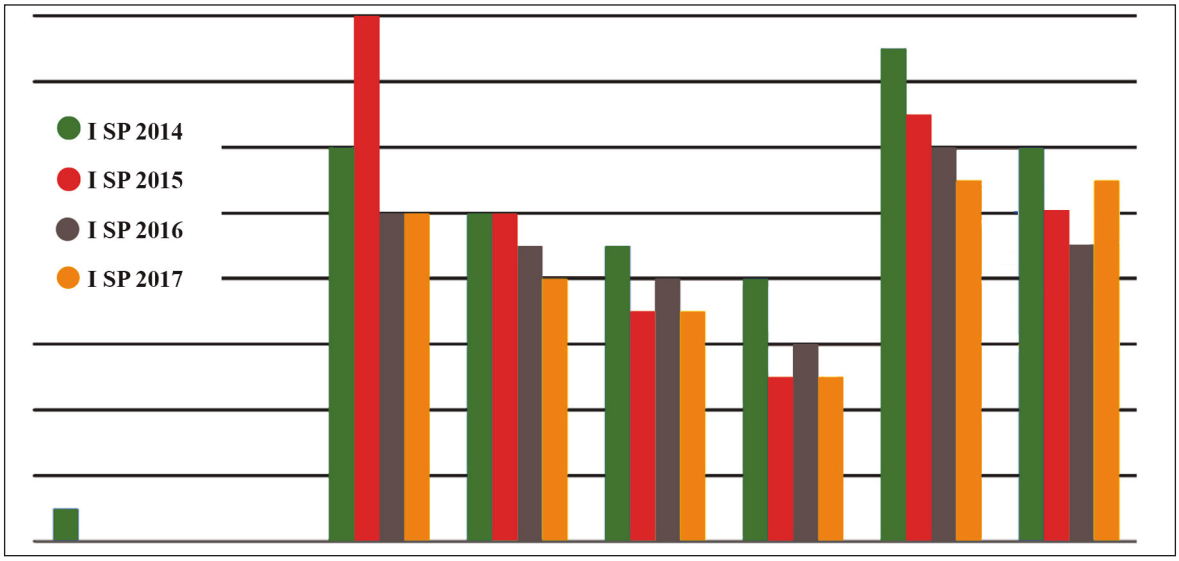

Figure 1. Development dynamics of the coenopopulation in which the *Caragana grandiflora* species is distributed.

CP	Years	Amount of individuals in CP in %			I_Q	Q	Vitality of CP
		a	b	c			
CP I	2014	40	19	41	0.72	29.5	Crisis state
	2015	35	27	36	0.86	31	Crisis state
CP II	2016	43	19	39	0.79	31	Crisis state
	2017	38	19	42	0.68	28.5	Crisis state

Table 4. Assessment of the viability of *Caragana grandiflora* species.

rising branch of ontogeny, while the non-conforming one decreases. Many individuals of this species at the same age state have different viability in a coenopopulation. As a result, seeds of different quality can be formed, which are also unstable to germination time and competition. The coenopopulation of the species is dominated by individuals with a medium level of vitality. One group of them goes through ontogeny completely, and the other does not go through a certain part of the age state. As a result, when they reach the level of destruction, they have low vitality. Plants with a low level of vitality quickly pass into the senile state in ontogeny.

The process of destruction accelerated with the beginning of the second dormancy period in the *Caraganeta-Pistacetum-Juniperusosum* formation group found in the *C. grandiflora* species in Gabala district. In general, the environmental conditions increase the ontogenetic adaptation of the species and increase its ecological sustainability. The development of individuals of the *C. grandiflora* species was low in CP I and II, and was evaluated by the vitality in the crisis state (Table 4).

As a result of the research, it was found that the reason for the destruction process of the species is the rapid aging of the population during the drought years (2016–2017). It should also be noted that negative observation of fluctuation changes in a wide range will cause the species to be unable to take a firm position among other populations in the future. Therefore, it is important to carry out constant control and monitoring of the species *C. grandiflora* in the territory of Gabala district.

CONCLUSIONS

The observations have shown that the protection strategy of a part of the ranges
of woody plant species that are in danger of extinction in the flora of Azerbaijan has not been fully developed. In this regard, one of the most important issues of the modern era is the identification of woody plant species that are in danger of extinction, and the clarification of the reasons for their classification as rare plant categories.

During the assessment of the coenopopulations of the *C. grandiflora* species, the absence of a young type of coenopopulation in the coenopopulations, the low level of vitality and dynamics, showed that the species *C. grandiflora* is in danger of extinction. Therefore, this species is classified as "Critically Endangered" (CR) according to the IUCN threat category. As a result of the conducted research, it should be noted that it is considered appropriate to conduct continuous observations on the coenopopulation of the *C. grandiflora* species, and the preservation of such species should be one of the most urgent issues today.

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