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ASSESSING THE CONSERVATION STATUS OF *CRAMBE TATARIA* SEBEÓK IN ROMANIA: DISTRIBUTION PATTERNS AND POPULATION EVALUATION METHODS

Marilena ONETE[1], Luiza-Silvia MIHAI[1], Simona MIHĂILESCU[1], John Owen MOUNTFORD[2], Minodora MANU[1], Roxana-Georgiana NICOARĂ[1]

[1]Institute of Biology Bucharest, 296 Splaiul Independentei, District 6, Bucharest, Romania
[2]Centre for Ecology & Hydrology, MacLean Building, Benson Lane, Crowmarsh, Wallingford, United Kingdom

Corresponding author email: luizaschiriac@gmail.com

Abstract

Crambe tataria Sebeók (Brassicaceae family) is a rare and vulnerable perennial steppe species with a fragmented distribution in Central and Eastern Europe. It is listed as vulnerable on the IUCN Red List, protected under national legislation, and included in Annex II of the Habitats Directive (92/43/EEC). Our field studies and literature review indicate that the species occurs mainly in steppe and forest-steppe regions in southern and eastern Romania. Population assessments in Romania show a favorable conservation status over three reporting periods to the European Commission. However, our field observations and monitoring reveal considerable variability in monitoring methods among experts, underscoring the need for standardized protocols to ensure accurate population evaluation and more effective conservation of the species. We can specify that, due to the fragility of habitats integrating Crambe and their multiple threats, the over-dimensioned population assessment does not take into account the growing strategies of the species. Therefore, the species remains at risk at the national level, and its conservation status requires urgent clarification to guide effective management measures.

Key words*: Crambe tataria, Brassicaceae, conservation status, distribution pattern, population evaluation methods.*

INTRODUCTION

The overall objective of sustainable development includes maintaining biodiversity while continuing or even encouraging human activities, taking into account economic, social, cultural, and regional aspects. The conservation of wild plant species (as part of the natural heritage of the European Community) is an essential and specific Community objective of preserving, protecting, and improving the quality of the environment, as more and more wild species are endangered. At European level, many species are threatened with extinction (species of Community importance) in the environment described by specific abiotic and biotic factors in which those species are found at any stage of their biological cycle (the habitat of a species) (H.D. 1992). Plant species are influenced by a set of factors that can affect the natural long-term expansion of the species and the abundance of their populations (Crawley, 2009; Silvertown & Charlesworth, 2009). According to the Habitats Directive (1992), the conservation status of the plant species is good if: the species remains a viable element of its natural habitats based on population dynamics data for the species concerned species; the area of natural distribution of the species is not reduced or threatens to diminish in the near future; the species has and is highly likely to continue to have a habitat sufficiently extensive to maintain its population in the long term.

The conservation status of a species it is revealed by species monitoring (IUCN SSC, 2026) that requires the systematic collection and analysis of recurring observations or measurements to assess variations in condition and progress toward achieving the management goals. Clearly formulated objectives are fundamental to effective monitoring, as they determine what is measured, how accurately, and at what frequency (Elzinga et al., 2001).

Monitoring can be conducted directly, through counts or measures of species performance (cover or reproductive output), or indirectly, by observing habitat conditions, associated species,

or potential threats to the focal species (Marsh & Trenham, 2008).

Monitoring programs are crucial for identifying threatened species, assessing management interventions, and tracking invasive/pest species. Nevertheless, their decentralized nature often limits researchers' ability to obtain a comprehensive understanding of existing monitoring practices (Marsh & Trenham, 2008). Recent research highlights that there is a wide range of methodologies, indicators, and databases currently available to address diverse monitoring requirements. However, there are still significant challenges in both data collection and its application to monitoring and decision-making. These include inconsistent or insufficient methods, tools, and technologies; limited institutional capacity and financial resources; poorly defined indicators and monitoring frameworks; data gaps in existing databases; and restricted access to or exchange of information (IUCN SSC, 2026).

In Romania, there are 56 plant species listed in Annexes II and V of the Habitats Directive (1992) requiring monitoring for establishing the best conservation strategies, and *Crambe tataria* Sebeók (Brassicaceae family) is one of them.

Based on the historical use of *C. tataria* species (and other species from the Brassicaceae family) (source of biofuel applied in agriculture, the food and technical industry, soil bioremediation, etc.), *research* aimed at: the oil composition and some morphological characters (Comlekcioglu et al., 2008), chemical composition and morphological properties, as well as pulping potential (Tutus et al., 2010), seed and fruit fatty acid compositions (Barut et al., 2022) of *C. tataria* stalks growing in Turkey; mass consumption of the underground parts by Hungarian ethnic groups living in the Carpathian Basin (Dénes et al., 2012) and the traditional utilization of the species in the Crapathians from Eastern Europe (including its ecological and conservation status) (Paniagua-Zambrana & Bussmann, 2024).

The resistance of the *C. tataria* species under extreme environmental conditions has been studied by investigating the biological features of the species: the anatomical structure of the vegetative organs (root, stem, leaf) revealing its anatomical adaptations to arid climatic conditions from Western Kazakhstan (Aktobe region) (presence of a thick cuticle, a developed sclerenchymatic structure, and a robust root system that allows the plant to withstand water scarcity and extreme temperatures) (Turalin et al., 2019); morpho-physiological adaptations (deep roots, reserve organs, vegetative rest) increasing the species' resistance to low temperatures, thus allowing it to survive cold winters from the Ukrainian steppes (Gritsenko, 2025).

Studies developed in the western Kazakhstan/Aktobe region have suggested an active reproductive capacity of the *C. tataria* species but high vulnerability to ecological disruption. Analyses have been conducted on the characteristics of the age stages (juvenile, immature, generative mature, etc.) in the populations, describing the demographic structure and showing the predominance of generatively mature individuals (Kupriianov et al., 2020a). The individuals of the species are mosaically distributed, and both their natural density and regeneration are influenced by edaphic factors; thus, the researchers emphasise the importance of preserving natural habitats for maintaining their viability (Kuprijanov et al., 2020b).

Other studies applied to *C. tataria* have made important contributions in the field of genetics and biotechnology, highlighting essential aspects of regeneration, genetic variability, and the genetic structure of natural populations. Pushkarova et al. (2018) analysed the regeneration capacity and genetic variability of *C. tataria* in *in vitro* cultures, highlighting that the species can be effectively regenerated through tissue cultures using different types of explant; micropropagation processes do not significantly affect genetic stability, although minor somaclonal variations may occur; in vitro techniques may support ex situ conservation and controlled multiplication of this rare species. Chokheli et al. (2022) assessed genetic diversity and produced DNA fingerprinting showing moderate genetic variability in the populations of *C. tataria*, indicating a sufficient genetic basis for adaptation but a vulnerability to geographical isolation; the potential use of molecular markers (RAPD, ISSR, SSR) to identify and monitor genotypes; and the importance of maintaining genetic diversity for long-term preservation. Thus, for conserving

natural populations of *C. tataria:* the researchers developed *in vitro* propagation methods for creating more plant material, providing genetically homogeneous regenerated plants, and reintroducing them into its natural habitats.
Studies for identifying potential habitats for the restoration of populations of *C. tataria*, and characterizing areas with favourable ecological conditions for reintroduction (steppe, piedmont soils, sunny slopes) have been developed in the Republic of Moldova (Izverscaia & Ghendov, 2020). Here, the first controlled reintroduction of the species nationwide documenting the steps of reintroduction (collection of biological material, cultivation, transplantation, and monitoring of the establishment success) (Izverscaia et al., 2021).
In Crimea, the phytocoenological characteristics of *Crambe* populations, and the structure of plant communities, the composition of accompanying species, and edaphic conditions (Mykhailova, 2013).
Recently reports about the presence of new populations of the species in the Ulytau region (Kazakhstan) (Kubentayev et al., 2024) and the North Dnieper Steppe (Ukraine) (Kyiak, 2025) have determined extending the knowledge regarding the natural distribution area of the species, signalling the need to protect it in the Asian-central steppe ecosystems.
In Romania, *C. tataria* had been included in an assessment and monitoring programme at the national level (Mihăilescu et al., 2015; M.O. 3351, 2023), describing standard monitoring methods, population status assessment criteria, and habitat parameters. At the local level, concrete data on the local distribution and conservation status of the species have been highlighted through the inventory and mapping of *C. tataria* in small protected areas (Bădărău, 2019). Over the years, on Romanian *C. tataria* populations had been realised through a more comprehensive study regarding detailed ecological and chorological research, analysing morphological variation, demographic structure, geographical dispersion, and the influence of environmental factors on density and regeneration (Chirilă, 2021, 2022); the habitat preferences of the species, identifying the optimal conditions for development (southern slopes, limestone soils, xerophilic steppe vegetation) and the causes of population decline (Chirilă et al., 2022). Farther more, Chirilă et al. (2025) developed the first detailed study on the genetic structure of the populations of *C. tataria* in Romania, using ISSR markers. The results showed: moderate levels of genetic diversity among the analysed populations; significant genetic differentiation between geographic groups, suggesting habitat fragmentation and a possible restriction of genetic flow; and the need for in situ and ex situ conservation to maintain genetic diversity at the species level.
Our paper aims to develop population assessments in Romania over three reporting periods for the European Commission; the standardization in monitoring methods among experts to ensure accurate population evaluation and more effective conservation of the species.

MATERIALS AND METHODS

This Pontic-Pannonian relict species was first published in Tataria Hung.: 7 (1799) is primarily distributed across steppes and meso-xerophilic grasslands in Central and Eastern Europe, extending into Western Asia (Marhold, 2011). The Eur-Asian distribution comprises: Austria, Bulgaria, Central European Russia, Czechia-Slovakia, East European Russia, Hungary, Italy, Kazakhstan, Krym, North Caucasus, NW Balkan Peninsula, Romania, South European Russia, Transcaucasus, Türkiye, Ukraine, West Siberia (RBGK, 2026) (Figure 1).



Figure 1: Distribution of *Crambe tataria* in Eur-Asia (after Euro+Med PlantBase and RBGK, 2026)

In Romania, the species is treated as vulnerable (Dihoru & Dihoru, 1994; Oltean et al., 1994; Witkowski et al., 2003) and rare (Oltean et al., 1994). From a legal perspective, it is present in Appendix I of the Bern Convention (1982), Annex IIb of the Habitat Directives (1992) and Romanian Low 49 (2011) in the Continental (Figure 2a) and Steppe bioregions. Nyárády (1955) publishes one of the first morphological and taxonomic descriptions of the genus Crambe in the flora of Romania, establishing the basis of the botanical classification of the *C. tataria* species. He describes *C. tataria* as honey/nectar source plant (very large inflorescence) (Figure 2b), with a very long root (about 20 cm), "thick as an arm", black-brown, with white, fleshy and sweet (containing starch and sugar), with a multicapitate root collar (Figure 2c) consumed alone as salad and together with leaves as vegetables.

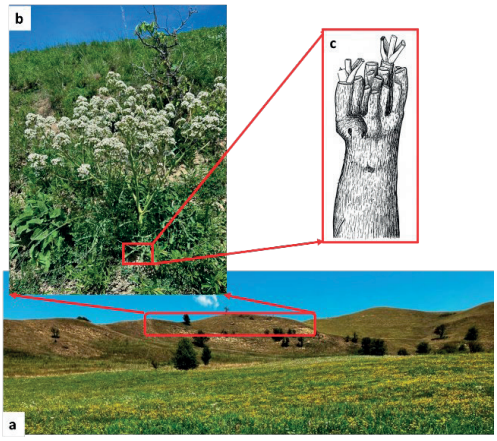

Figure 2: Transylvanian *Crambe tataria* habitat (a) (photo: Onete M.), habitus (b) (photo: Mehedin B.) and morphology of the upper part of the root (c) (after Nyárády, 1955)

For better establishment of the monitoring program, we needed to know more about plant species biology (life history and expectancy, flowering period, annual variability in flowering, etc.). The ontogeny of *Crambe tataria* Sebeók was studied in western Kazakhstan, revealing that the species is a slow-developing perennial (12-30 years to maturity), with age-related stages defined by shifts in root structure and flowering capacity: juvenile (a rosette of 3-4 large leaves, lacking the hard pubescence typical of adults; often die with the early May heat); immature (prior to the development of the shoot, the thin root system reaching 40 cm deep); virginal (the root system reaches depths of 100-150 cm); generative (young - forming vegetative buds on the shortened shoot (Figure 2c), habits - shortened rosettes produce 1-2 terminal buds from which generative shoots develop; middle/old - vegetative buds are not formed; the underground rhizome often branches into two, rarely three). In arid conditions, the root system might reach 4 m in depth, with branching densities decreasing, and individuals may never bloom (remaining in virginal/non-flowering state indefinitely). In less severe areas, individuals matured (became generative) in 5-7 years, showing high plasticity to resist extreme arid environments. The „tumbleweed" (running) dry former inflorescence bearing seeds is instrumental in ensuring dissemination by wind (anemochory) of the seeds over long distances, a vital adaptation for survival in open steppe habitats (Kupriianov et al., 2020a).

We analysed the publications concerning the *C. tataria* species from Romania (scientific articles, reports, standard data forms, and management plans) to obtain a good estimation of the species distribution and for the evaluation of the methods used by different authors for the species.

According to the Habitats Directive (92/43/EEC), Articles 11 and 17 stipulate that species listed in Annexes II and IV must be regularly monitored, with their conservation status reported to the European Commission every six years. The field assessment and monitoring of the conservation status of the *C. tataria* species of community interest (2007-2023) involved the estimation of the conservation status of the species for three reporting periods (every six years) to the European Commission (2007-2012, 2013-2018 and 2019-2023). We collected the data from the field using data forms that comprised: the location of the individuals (registered with GPS Garmin eTrex Summit), population parameters, habitat characteristics, pressures and threats (P.O.S. project, 2011; Mihăilescu et al., 2015a; 2015b; P.O.I.M., 2023; Annex 1 from M.O. 3351, 2023; Mihăilescu et al., 2024).

RESULTS AND DISCUSSIONS

Our assessments of *Crambe tataria* populations at national level started during the first reporting period (2007-2012) and continue even in the present. Knowledge about the biology, ecology, distribution, population density, and sozology has been highlighted in comprehensive publications over the years (Mihăilescu et al., 2015a, 2015b).

C. tataria found in the ecological (mesoxerophilic-mesophilic species on sunny, dry, and eroded or grassy hills and bushes) (Gafta & Mountford, 2008; Bădărău, 2019; Chirilă, 2021; Chirilă et al., 2022) and developmental optimum in steppe and forest-steppe regions from Romania (Chirilă, 2022; 2023; Chirilă et al., 2022; 2025) (Figure 3).

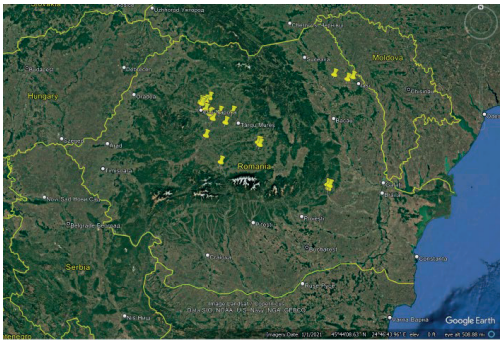

Figure 3: The distribution of *Crambe tataria* in Romania

Chirilă (2021) and our assessment at the national level highlighted that the distribution sites of *C. tataria* populations mentioned in the old Romanian literature are far from being confirmed. The species is presented as being hosted in many Natura 2000 protected areas in Romania (F.C., 2011) (Table 1), showing small populations integrated in different conservation categories (sozology) thus being rare (R), vulnerable (V) or endangered (EN) in all of the protected areas due mainly to anthropic impact (overgrazing, burning the vegetation, etc.).

If the factors affecting narrowly distributed populations continue to operate, the species might become: endangered/threatened (its survival is improbable); vulnerable (it almost passes into endangered/threatened); rare (the population of the species is very small and under risk) (Oltean et al., 1994).

The integrative habitat 6240* Sub-pannonic steppic grasslands is largely distributed in Transylvania (Cluj, Mureș, Alba, Sibiu, Brașov) and 62C0* Ponto-Sarmatic steppes is mainly distributed in N-W Romania (Iași, Vaslui, Suceava, Botoșani) since toward Central-South (Galați, Buzău) the habitats change (Table 1).

Table 1. The presence and conservation category (sozology) of *Crambe tataria* in protected area from Romania (according to S.F., 2011)

Protected areas		County	Sozology
Natura 2000 Code	Name		
6240* Sub-pannonic steppic grasslands			
ROSCI0333	Pajiștile Sărmășel - Milaș - Urmeniș	Bistrița Năsăud, Cluj, Mureș	P
ROSCI0238	Suatu -Cojocna - Crairât	Cluj	R
ROSCI0099	Lacul Știucilor - Sic - Puini - Bonșida	Cluj	R
ROSCI0295	Dealurile Clujului Est	Cluj	P
ROSCI0040	Coasta Lunii	Cluj, Mureș	R
ROSCI0331	Pajiștile Balda - Frata - Mihești de Câmpie	Cluj, Mureș	R
ROSCI0408	Zau de Campie	Mureș	R
ROSCI0079	Fânațele de pe Dealul Corhan - Săbed	Mureș	R
ROSCI0187	Pajiștile lui Suciu	Alba	R
ROSCI0211	Podișul Secașelor	Alba, Sibiu	V
ROSCI0093	Insulele Stepice Șura Mică - Slimnic	Sibiu	R
ROSCI0227	Sighișoara - Târnava Mare	Mureș, Sibiu, Brașov	R
62C0* Ponto-Sarmatic steppes			
ROSCI0171	Pădurea și pajiștile de la Mârzești	Iași	EN
ROSCI0080	Fânațurile de la Glodeni	Vaslui	R
ROSCI0286	Colinele Elanului	Vaslui	R
ROSCI0081	Fânețele seculare Frumoasa	Suceava	R
ROSCI0082	Fânețele seculare Ponoare	Suceava	R
ROSCI0399	Suharau - Darabani	Botoșani	R
40C0* Ponto-Sarmatic deciduous thickets			
ROSCI0151	Pădurea Gârboavele	Galati	V
1530* Pannonic salt-steppes and salt-marshes			
ROSCI0272	Vulcanii Noroioși de la Pâclele Mari și Pâclele Mici	Buzau	R

Legend: R – rare; V -Vulnerable, EN – endangered/ threatened.

The distribution of *C. tataria* in these habitats shows its preferences for dry, oligotrophic, and alkaline or saline substrates, sunny slopes. There are major ecological differences between locations, ranging from the xerophilous habitat (Buzău) to the mesophilous conditions (Sibiu), which directly affect plant vigor. Population survival is threatened by the impact of human activities in the surrounding areas, such as the use of pesticides in adjacent crops or habitat fragmentation caused by land-use changes.

Factors such as fires (which destroyed over 90% of the Insulele Stepice Șura Mică - Slimnic site in 2011 in Sibiu County), grazing, and mowing have an immediate and severe impact on population viability.

Repeated and standardized surveys of plant (and animal) populations are essential for evaluating changes in abundance, distribution, and environmental factors, thus supporting conservation and management strategies. Methods such as transect and plot sampling are typically used to quantify population dynamics and overall health (Gibbs et al., 1998). The protocol and methodology for monitoring the conservation status of plant species of community interest have been published as guides (Mihăilescu, et al., 2015 a, b, c; M.O. 3351 - Annex 1, 2023). The description of the field methods is essential for detecting the two key population parameters: population size and the size of the one or more habitats of the species (Higgins et al., 1996). Regarding population size, the following information should be provided: the minimum proportion of the population that must be monitored, the number and size of monitoring plots, as well as the criteria for selecting their locations, the specific parameters (counted or estimated), such as the number of individuals (genets and/or ramets – terms that are not always easy to distinguish). In the case of populations with a limited distribution range and a small number of individuals, it is recommended to count all individuals and measure the entire distribution area (Davy & Jefferies, 1981; Gauthier et al., 2017; Bernardo et al., 2019; McDonald & Thompson, 2004). For populations with a large number of individuals, methodologies usually involve surveying a representative number of plots, so that a significant portion of the population (at least 10%) can be estimated in total (Gibbs et al., 1998; Elzinga et al., 2001; IUCN SSC, 2026). The species fact sheet also includes several practical details for planning field activities: the monitoring frequency within one year or over a six-year reporting cycle; the optimal period for inventorying (months of flowering, fruiting, etc.); the minimum number of people required for conducting the field survey; the number of days per year necessary for the inventory work. Following CSM (2014), we grouped the species in groups accordingly with their integrative habitats (where they have their ecological optimum for survival and reproduction). The direct and indirect attributes (quantitative features or characteristics) are mandatory. If the attributes are not observed, it indicates unfavourable environmental conditions for the species' existence (Table 2). This group of species grows in habitats with relatively large areas, often grazed or at least occasionally trampled by sheep.

The optimal monitoring period depends on each species' phenology, ideally during the flowering period. The number and placement of monitoring plots depend on the continuity or fragmentation of the habitat within the studied area. The fixed-point photographic method may also be used as a complementary monitoring tool.

Table 2: The attributes, objectives, and evaluation method for *C. tataria* populations (after M.O. 3351, 2023)

Attribute	Objective	Evaluation method
Direct attributes		
Presence / absence (P)	The species must be present	Identification / recording of the species
Population size – number of individuals	At least the minimum size of a viable population; no decline >10% of the total number	Counting of functional individuals
Population size – distribution area	No more than 10% loss from the total distribution area of the population/ species	Mapping
Regeneration success	The number of fruits should not decrease compared to the normal number; at least 10% of the total population should produce fruits, spores, or seeds	Counting fruits or estimating fruit/spore/seed production
Indirect attributes		
Availability of suitable niche	Sufficient area of suitable habitats for maintaining populations; no loss of habitat area or linear extent (rock surfaces, slopes, etc.)	Mapping (area or length)
Negative indicator: physical disturbance / grazing	Grazing or trampling only by wild animals, occasionally	Visual assessment
Negative indicator: shading	Tree / shrub cover should be <10%	Visual assessment
Negative indicator: competition	Accompanying species should not be numerous or overlapping with the target species	Visual assessment
Negative indicator: alien species (plants or animals)	Alien plants and animals have minimal or no presence	Visual assessment (e.g. Braun-Blanquet, DAFOR, etc.)

Our data (location of the individuals, population parameters/attributes, habitat characteristics, pressures and threats) for characterizing the conservation status of *C. tataria* at the national level have been reported to the European Comision at the end of every reporting period (2007-2012, 2013-2018 and 2019-2023). Thus, the European database (EIONET, 2025) allows the comparative analysis of the three reporting cycles (2001-2006, 2007-2013, and 2013-2018) for *Crambe tataria* Sebeók (Brassicaceae) under the Habitats Directive (92/43/EEC, Art. 17) and provides a coherent picture of the species' conservation status evolution in Central and Eastern Europe, highlighting both ecological trends and the effectiveness of the implemented protection measures (Table 2) (EIONET, 2026). The 2001-2006 period represented a baseline stage, characterized by insufficient information and limited geographic coverage. Only small populations were reported in a few countries (Italy, Czech Republic, Hungary, and Slovakia), showing declining trends and degraded habitats. The overall species status was assessed as "U1 – Unfavourable-Inadequate" or "Poor."

During 2007-2013, the reporting range expanded through the inclusion of Eastern European countries (Romania, Bulgaria), where viable populations still existed. More accurate data were collected on population structure and habitat quality, based on standardized monitoring. The species' condition was transitioning between "U1" and "FV", showing initial signs of improvement in the East.

In 2013-2018, the reporting range remained extensive. Populations were stable or increasing in Romania, Bulgaria, and Slovakia, being evaluated as "FV - Favourable" for Romania and Bulgaria. Steppe habitats were well preserved in Eastern Europe, largely due to reintroduction measures (e.g., in the Republic of Moldova) (Izverscaia & Ghendov, 2020; Izverscaia et al., 2021) and improved management of protected areas, contributed significantly to the recovery of the species' conservation status.

The database created by our research team comprises all the necessary characteristics (attributes) for characterizing the conservation status of a species as stipulated in Table 3 (EIONET, 2026a).

Table 3: Evaluation of the conservation status of *C. tataria* at European level (After EIONET, 2026)

ETC/BD treated member states' data Period 2001-2006

MS	Reg	Range (km²)				Population				Habitat for the species (km²)				Future prosp.	Overall Assess.	Areas from gridded maps(km²)				Quality		
		Area	% MS	Trend	Ref.	Size&Unit	% MS	Trend	Ref.	Area	% MS	Trend	Suitable			Range	% MS	Distrib.	% MS	Range	Population	Habitat
IT	CON	110	100	-	>110	7 - 7 loc.	100	=	>7	N/A	N/A	N/A	N/A	Good	U1	600	100	300	100	G (12/2006)	M (12/2006)	()
CZ	PAN	873	64.4	=	873	10000 - 15000 indiv.	77.2	-	15000	0.94	62.3	X	0.94	Poor	U1	2400	55.10	600	23.50	G (12/2006)	M (2005-2006)	M (12/2006)
HU	PAN	478	35.3	-	478	2500 - 3000 indiv.	17	-	3000	0.40	26.4	-	0.50	Poor	U1	1753	40.30	1753	68.70	G (2006)	G (2006)	G (2006)
SK	PAN	5	0.4	=	5	500 - 1400 indiv.	5.9	=	1400	0.17	11.2	=	N/A	Good	FV	200	4.60	200	7.80	G (12/2006)	G (12/2006)	G (12/2006)

Treated data from Member States reports Period 2007-2012

MS	Reg	Range (km²)				Population				Habitat for the species (km²)					Future prosp.	Overall assessment				Areas from gridded maps(km²)			
		Area	% MS	Trend	Ref.	Size&Unit	% MS	Trend	Ref.	Area	% MS	Qual.	Trend	Suitable		Curr. CS	Qualifier	Prev. CS	Nat. of ch.	Range	% MS	Distrib.	% MS
BG	BLS	800	100	x	800	10 - 10 indiv.	100	x	>10	0.90	100	m	x	0.90	N/A	U2	-	N/A		800	100	700	100
AT	CON	100	1.7	0	≈100	725 - 725 indiv.	0.4	+	>725	0.03	N/A	m	+	0.12	N/A	U1	+	N/A	nc	100	8.30	100	10
BG	CON	600	10	x	600	8 - 8 indiv.	N/A	x	>8	0.20	N/A	g	x	0.20	N/A	U1	-	N/A		600	50	400	40
IT	CON	500	8.3	0	≈500	3000 - 3500 indiv.	1.8	-	≈3000	N/A	N/A	m	-	N/A	N/A	U1	-	U1	d	500	41.70	500	50
RO	CON	4800	80	0	≈4800	50000 - 300000 indiv.	97.8	0	≈50000	1000	100	m	0	1000	N/A	FV		N/A		N/A	N/A	N/A	N/A
CZ	PAN	1200	64.9	0	≈1200	3708 - 6788 indiv.	62.7	-	>3708	0.94	64.5	m	0	N/A	N/A	U1	=	U1	nc	1200	70.60	800	53.30
HU	PAN	500	27.1	-	>500	2500 - 2700 indiv.	31.1	0	>2500	0.40	27.3	m	0	0.40	N/A	U1	=	U1	nc	500	29.40	500	33.30
SK	PAN	148.25	8	0	≈148.25	200 - 850 indiv.	6.3	0	≈200	0.12	8.2	m	0	N/A	N/A	FV		FV		N/A	N/A	200	13.30
RO	STE	100	100	0	≈100	10 - 100 indiv.	100	0	≈10	100	100	g	0	100	N/A	FV		N/A		N/A	100	N/A	100

Member States reports Period 2013-2018

MS	Region	Range (km²)				Population										Habitat for the species				Future prospects				Overall assessment						Distribution area (km²)		
		Surface	Status (% MS)	Trend	FRR	Min	Max	Best value	Unit	Type est.	Method	Status (% MS)	Trend	FRP	Unit	Occupied suff.	Unoccupied suff.	Status	Trend	Range prosp.	Population prosp.	Hab. for sp. prosp.	Status	Curr. CS	Curr. CS trend	Prev. CS	Prev. CS trend	Status Nat. of ch.	CS trend Nat. of ch.	Distrib.	Method	% MS
BG	BLS	1900	100	=	1900	3	3	N/A	i	minimum	b	100	=	7	i	N	Y	FV	-	unk	poor	poor	U1	U1	-	U2	-	noChange	noChange	600	b	100
AT	CON	100	3.57	=	≈	N/A	N/A	725	i	estimate	a	3.02	x	>		N	N	U1	=	good	poor	poor	U1	U1	=	U1	+	noChange	genuine	100	a	5.56
BG	CON	1200	42.86	=	1200	4	4	N/A	i	minimum	b	0.02	=	5	i	Y		FV	=	unk	unk	unk	XX	FV	=	U1	-	noChange	noChange	600	b	33.33
IT	CON	500	17.86	=	≈	5500	6000	N/A	i	estimate	a	23.98	=	≈		Y		U1	=	poor	poor	good	U1	U1	=	U1	-	knowledge	noChange	500	a	27.78
RO	CON	1000	35.71	=	>	5000	30000	N/A	i	estimate	a	72.98	=	35000	i	Y		FV	=	good	good	good	FV	FV	=	FV		noChange	noChange	600	a	33.33
CZ	PAN	1200	61.59	=	1200	3900	5000	N/A	i	interval	a	67.97	-	6000	i	Y		U1	-	good	poor	poor	U1	U1	-	U1	=	noChange	noChange	800	a	50
HU	PAN	600	30.80	=	>	1150	1800	N/A	i	estimate	a	22.53	-	>>		N	Y	U1	u	poor	bad	poor	U2	U2	x	U1	=	genuine	genuine	600	a	37.50
SK	PAN	148.26	7.61	=	≈	159	1085	N/A	i	estimate	a	9.50	=	≈		Y		U1	=	good	poor	poor	U1	U1	=	FV		knowledge	knowledge	200	b	12.50
RO	STE	300	100	=	>	100	1000	N/A	i	estimate	a	100	=	1000	i	Y		FV	=	good	good	good	FV	FV	=	FV		noChange	noChange	200	a	100

Legend: FV Favourable XX Unknown U1 Unfavourable-Inadequate U2 Unfavourable-Bad

The EU-level biogeographical conservation status of species within each region was determined through an integration of information provided by Member States, or by applying a weighting system to their national assessments. When comprehensive data (i.e. population attributes) were available, they were combined and evaluated using the same criteria employed at the national level. In cases where data were incomplete or inconsistent, the assessment relied on a weighted aggregation of national evaluations, reflecting both the condition and proportion of the species or habitat represented in each country. As with Member State evaluations, the biogeographical status at the EU scale was categorized as favourable, unfavourable–inadequate, or unfavourable–bad (EIONET, 2026b).

The data recorded for the period 2007-2012 (following Romania's accession of Romania at the European Union) were scarce and more descriptive; observations regarding the species' ecology, phenology, and growth strategies were made (P.O.S. project, 2011; Mihăilescu et al., 2015a; 2015b). For the reporting period 2007–2013, and 2013-2018 the database improved mainly to the standard database required by the European Commission (P.O.I.M., 2023; Annex 1 from M.O. 3351, 2023; Mihăilescu et al., 2024). The Comision realized that there are inconsistencies in the database due to the monitoring methodology adopted by every reporting country and decided to uniformize the national databases for a better integration in the European database. For the upcoming report (due by 31 July 2025), the European Commission approved in 2023 a standardized reporting format for species types (DG Environment, 2023), that we used for *C. tataria* standard conservation evaluation.

Together with numerical population trends, researchers need to integrate abiotic factors (soil, microclimate) and biotic interactions (pollination or competition with invasive species like for instance black locust shoots). Analysing the structure and dynamics of its habitat determine a better understanding of the persistence of the species (Higgins et al., 1996; Gauthier et al., 2017).

According to the Habitats Directive (1992), Favourable Conservation Status (FCS) implies long-term population viability and a stable natural range. In Table 3, the European evaluation for the species is marked as Inadequate (U1), reflecting the failure to meet these criteria due to combined anthropogenic and natural pressures. In Romania, the viability of the species' in both bioregions where it is present (Continental and Steppe) is Favourable (FV) due to management measures taken for the protected areas comprising *C. tataria* populations, especially because the integrative habitat are priority (*) meaning that there are natural habitat types in danger of disappearance; thus,, the Community has particular responsibility for their conservation.

CONCLUSIONS

Crambe tataria is a multifunctional species valued for its agricultural, industrial, and ecological applications, including biofuel production and soil restoration. Studies reveal significant biochemical and morphological diversity, as well as strong anatomical and physiological adaptations that enable survival in arid steppe environments. Despite its reproductive potential, populations remain vulnerable to habitat disturbance and soil degradation. Moderate genetic variability and successful in vitro regeneration support both in situ and ex situ conservation approaches. Overall, integrating ecological, anatomical, and genetic insights is essential for effective management and long-term preservation of this rare steppe relict.

This perennial species has a slow developmental cycle, requiring between 12 and 30 years to reach maturity. Its longevity, coupled with the fact that, in arid conditions, plants may remain vegetative and never flower, makes populations extremely vulnerable to ecological disturbances. In Romania, calcareous steppe habitats remain essential yet fragile, requiring continued protection from agricultural intensification and land-use pressures. There are major ecological differences between sites that directly affect plant vigour. Due to its rarity, fragmented, relict distribution, and habitat destruction, *C. tataria* is protected by national and international laws applied in Romania.

The habitats supporting *Crambe tataria* are priority habitats: fragile and facing multiple threats, mainly anthropogenic (overgrazing,

vegetation burning, pesticide use, and habitat fragmentation) that affect *C. tataria*'s survival. Although official reports to the European Commission indicate a favourable conservation status for this species, field observations suggest that these evaluations may be overstated, as they often overlook the species' specific growth strategies. The favourable status reported in Romania is largely due to management measures implemented in protected areas (Natura 2000 sites), where the species' habitats are considered priorities. However, many sites cited in older literature have not been recently reconfirmed. A proper conservation assessment must integrate not only numerical data but also elements such as soil structure, microclimate, and biotic interactions (e.g. pollination or competition with invasive species like *Robinia pseudoacacia*). Although the situation appears stable on paper, the species' biological fragility and the lack of a unified data collection methodology call for an urgent reassessment of its conservation status to guide truly effective management actions. The species remains at risk at the national level.

There is considerable variation in the methods used by different experts, highlighting the need for standardized protocols to ensure accurate population assessments and effective conservation measures.

At European level, between 2001 and 2018, *C. tataria* transitioned from being a "vulnerable and poorly known species" to one with locally favourable status, stable populations, and partially restored habitats in Eastern Europe, while still remaining threatened in the western part of its natural range. This evolution reflects the effectiveness of regional coordination in conservation policies and the continuous monitoring framework established by the Habitats Directive.

The number of reporting countries increased over time. The overall population trend shifted from decline in the first period to growth in Eastern Europe later on. The conservation status evolved from "U1" (Unfavourable) through a transitional phase to "FV" (Favourable) at both local and regional levels.

The general trend indicates slow but steady improvement, supported by greater awareness and better integration of conservation measures into European biodiversity policies.

Monitoring programs play an essential role in identifying and assessing the conservation status of species, as well as in evaluating the effectiveness of management actions. But their different structure makes it difficult for researchers to gain a comprehensive overview of current monitoring efforts. There are varied methods, indicators, and databases to support most species and ecosystem monitoring needs, and the collection and use of data in conservation planning are still constrained by major obstacles such as inconsistent methodologies, insufficient institutional and financial resources, weak or poorly harmonized indicators, incomplete datasets, and restricted access to or exchange of information. To overcome these barriers, it is vital to strengthen institutional and technical capacity within national agencies/institutions, expand data acquisition through coordinated research and conservation projects, align indicators and methodologies, and promote open data sharing in formats accessible to scientists, practitioners, and decision-makers.

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USE OF GENERATIVE ARTIFICIAL INTELLIGENCE (GenAI)

The authors declare the use of Generative Artificial Intelligence (GenAI) tools in the preparation of this manuscript. GenAI was used exclusively for language editing and text refinement and for image clearance (Figure 2c). All scientific content, data analysis, and

interpretations were developed and verified by the authors.

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