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RESEARCH ARTICLE

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Global and Regional IUCN Red List Assessments: 16

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Abstract

In this contribution, the conservation status assessment of three vascular plants according to IUCN categories and criteria are presented. It includes the assessment of *Aubrieta columnae* subsp. *sicula*, *Calligonum zakirovii* and *Santolina decumbens* subsp. *tisoniana* at global level.

Keywords

conservation, extinction risk, IUCN protocol, threats

How to contribute

The text of the global and regional assessments should be submitted electronically to Simone Orsenigo (simone.orsenigo@unipv.it) or to Giuseppe Fenu (gfenu@unica.it); the text, up to 8000 characters in length (spaces included), must include a distribution map and a picture of the assessed species.

Red List Assessments

Aubrieta columnae Guss. subsp. *sicula* (Strobl) M.A.Koch, D.A. German & R.Karl

Global assessment

Taxonomy and nomenclature

Order: Brassicales *Family*: Brassicaceae

Aubrieta deltoidea (L.) DC. subsp. *sicula* (Strobl) Phitos, Candollea 25: 76 (1970) = *Aubrieta deltoidea* (L.) DC. var. *sicula* Strobl, Verh. Zool.-Bot. Ges. Wien 53: 458 (1903).

Common name: Aubrezia sicula (It), Sicilian Aubrieta (En).

Geographic distribution range: *Aubrieta columnae* subsp. *sicula* (Fig. 1) is endemic to the limestone cliffs of Sicily (Italy). This subspecies is mainly distributed in the Madonie massif (north-west Sicily), and only one population in the Peloritani Mounts (north-east Sicily). Both areas hosting several narrow endemic plants (Brullo et al. 1995; Sciandrello et al. 2015). In particular, this subspecies occurs in the Madonie massif in the following localities: Pizzo Carbonara (1979 m a.s.l.), Cozzo Piombino (1620 m a.s.l.), Mufara Mount (1865 m a.s.l.), Quacella Mount (1869 m a.s.l.), Rocca di Mele (1620 m a.s.l.), Piano della Noce, and Piano della Principessa (Domina et al. 2016 onwards; Cambria 2020). The only site in the Peloritani Mountains, named Rocca Salvatesta (Novara di Sicilia municipality), was first reported by Nicotra (1880) (Fig. 2).

Figure 1. *Aubrieta columnae* Guss. subsp. *sicula* (Strobl) M.A.Koch, D.A.German & R.Karl (Rocca Salvatesta, Sicily). Photograph by Gianmarco Tavilla.

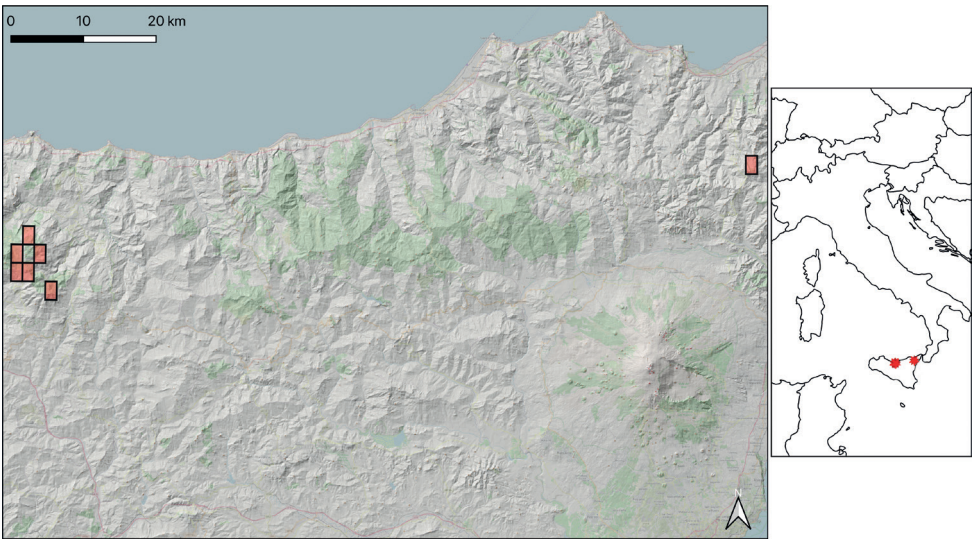

Figure 2. Geographic range and distribution map of *Aubrieta columnae* Guss. subsp. *sicula* (Strobl) M.A.Koch, D.A.German & R.Karl.

Distribution: *Countries of occurrence*: Italy (Sicily).

Biology: *Plant growth form*: perennial (chamaephyte).

Chromosome number: 2*n* = 16 (Romano et al. 1987).

Flowering and fruiting time: flowering from May to June, fruiting from July to August.

Reproduction: No detailed information is available.

Habitat and ecology: *Aubrieta columnae* subsp. *sicula* is a perennial plant belonging to orophilous carbonate communities referable to *Saxifragion australis* Biondi & Ballelli ex Brullo 1984 alliance [*Asplenietea trichomanis* (Br.-Bl. in Meier & Br.-Bl. 1934) Oberd. 1977 class]. This vegetation grows on limestone rocks with a maximum altitude of 1,900 m a.s.l. This subspecies is characteristic of this alliance together with *Cynanchica gussonei* (Boiss.) P.Caputo & Del Guacchio, *Draba turgida* É.Huet & A.Huet ex Ces., Pass. & Gibelli, *Helichrysum nebrodense* Heldr., *Hieracium symphytifolium* Froel., *Saxifraga callosa* subsp. *australis* (Moric.) Pignatti ex Tavilla & Del Guacchio, *Silene saxifraga* L. subsp. *rupicola* (É.Huet ex Nyman) C.Brullo & Brullo (Cambria 2020; Tavilla and Del Guacchio 2023).

Population information: The Madonie massif hosts the highest number of individuals, found in seven sites. Moreover, in almost all sites in which the species occurs, it is limited to single isolated stands. The Peloritani population is represented by over 100 mature individuals. This taxon occurs in rock crevices and occupies outcrops with limited growth surfaces. These rocky outcrops do not allow an accurate count of the individuals; in particular, this stand is located on a steep slope that makes the plants difficult to monitor, especially in the Madonie area.

Threats:

2.3 Livestock farming and ranching (nomadic grazing): grazing by goats poses a significant threat as they consume wild plants on outcrops at lower elevations, reaching even the most remote areas.

6.3 Work and other activities: the construction of the FlyEye astronomical observatory on Mt. Mufara will cause a significant disturbance to this population and nearby areas, such as Mt. Quacella and P. Carbonara (ESA 2018). Additionally, it is expected to attract more tourists to the area.

11.1 Habitat shifting and alteration: climate change alters environmental niches, causing species to shift their habitat range. Moreover, a shift in the flowering period was observed, probably due to changes in temperature and rainfall trends in Sicily (Cannarozzo et al. 2008; Viola et al. 2014) that may increase or decrease individual fertility.

CRITERIA APPLIED

Criterion B: **AOO:** 28 km^2 calculated with GeoCAT (Geospatial Conservation Assessment Tool) software (Bachman et al. 2011).

a) Severely fragmented.
b) Continuing decline observed and projected in: (iii) area extent and quality of habitat, and (iv) number of subpopulations or location.

Red List category and Criteria (Global Assessment)

EN	**Endangered**	**B2ab(iii,iv)**

Rationale for the assessment: Thanks to detailed fieldwork in Sicily, literature surveys, and confirmation of occurrences, the assessment of *Aubrieta columnae* subsp. *sicula* must be reevaluated. Due to the grazing that affected the species habitats and the ongoing climate change, a reduction in population size can be expected. In the investigations carried out, it was observed that most individuals flowered in May, while, until recent years, flowering peaks were observed in late June. This observation suggests a future threat to individual fertility, particularly in high Mediterranean mountain zones that are most vulnerable to climate change (Kazakis 2021). The future construction of the astronomical observatory on the top of Mt. Mufara is a concrete threat to the Madonie population. The construction of the observatory will attract more people to the area, leading to potential risks for this population. Furthermore, it should be highlighted that Mt. Mufara represents a connection point between the Mt. Quacella and Pizzo Carbonara sites. Hence, according to criterion B, *Aubrieta columnae* subsp. *sicula* can be assessed as Endangered (EN) based on its AOO of 28 km^2.

Previous assessment: This subspecies has been previously classified as vulnerable (VU) at a global level according to criterion D2 (Orsenigo et al. 2018; Rossi et al. 2020).

Conservation actions: Currently, *Aubrieta columnae* subsp. *sicula* grows only within Natura 2000 areas. In the Madonie massif, it is found in the SPA "Parco delle Madonie" (code ITA02050), and two SACs, viz. "Monte Quacella, Monte dei Cervi,

Pizzo Carbonara, Monte Ferro, Pizzo Otiero" (code ITA020016) and "Monte S. Salvatore, Monte Catarineci, Vallone Mandarini, Ambienti Umidi" (code ITA020004). All these sites are also located within the boundaries of the Madonie Regional Natural Park. In the Peloritani mountains, the species grows exclusively in the SAC "Rocca di Novara" (code ITA030006). Although it thrives in these nature reserves, *Aubrieta columnae* subsp. *sicula* is not protected by international, national, or regional laws.

Conservation actions needed: Further research is necessary to understand the reproductive biology, phenology, and population trends. Conducting research activities and establishing a monitoring program is recommended. Populations that are vulnerable to climate change should be regularly monitored through dedicated management actions. Additionally, in-situ and ex-situ conservation measures are suggested for potential plant translocation programmes to increase the number of individuals in the population.

Gianmarco Tavilla, Manuela Porrovecchio, Salvatore Cambria

Calligonum zakirovii (Khalk.) Czerep.

Global assessment
Taxonomy and nomenclature
Order: Polygonales *Family*: Polygonaceae

Calligonum zakirovii (Khalk.) Czerep., Vasc. Pl. Russia & Adj. States: 407 (1995).

Common name: Kandym zakirov (En).

Geographic distribution range: *Calligonum zakirovii* (Fig. 3) is a narrow endemic and locally rare shrub growing in the remnant lowlands of Kyzylkum desert in Uzbekistan (Khasanov et al. 2019). It occurs on the territory of Bukhara and Navoi regions (Fig. 4). This species was described by Khalkuziev (1966) as *Calliphysa zakirovii* from southwestern Kyzylkum on the southern part of Kuldzhuktau mountains, near the village of Churuk. Later, when dealing with the vascular plants of Russia and neighboring countries, Cherepanov (1995) renamed it as *Calligonum zakirovii*. In recent years, the subpopulations of Ayakguzhumdy and Chontabay, located in Navoi region, have been reported (Tojibaev et al. 2020). To date, only one population of this species is known, divided into three subpopulations (Fig. 4).

Distribution: *Countries of occurrence*: Uzbekistan.

Biology: *Plant growth form*: shrub (nanophanerophyte).

Flowering and fruiting time: flowering from April to May and fruiting from May to June.

Reproduction: Literature sources do not provide enough information about reproduction.

Habitat and Ecology: *Calligonum zakirovii* is a shrub 70–150 cm high, with slightly curved branches, white flowers and spherical fruits (Khasanov et al. 2019). It occurs in fixed gypsum sands of the foothills at an altitude of 304–363 m a.s.l.

Figure 3. *Calligonum zakirovii* (Khalk.) Czerep. from Kyzylkum desert (Bukhara region Uzbekistan). Photograph by Khabibullo F. Shomurodov.

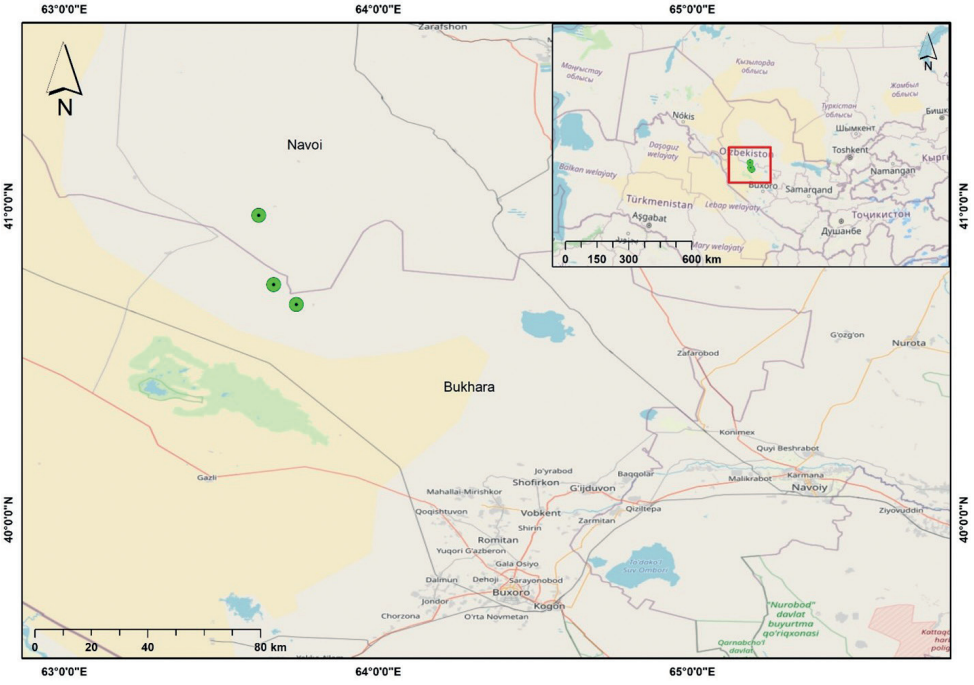

Figure 4. Geographic range and distribution map of *Calligonum zakirovii* in Kyzylkum desert (Uzbekistan).

According to Saribaeva (2009), the average annual temperature in the arid regions of the southern Kyzylkum, where it grows, is 17 °C, and the amount of precipitation is < 80 mm (Djangeldi weather station, 2007). It is recorded that all subpopulations, including the main one (Churuk), occur in phytocoenoses dominated by *Artemisia diffusa* Krasch. ex Poljakov and *Salsola arbuscula* Pall.

Population information: In 2019–2020 we observed the existence of two subpopulations of this species showing a total number of around 500 individuals (Tojibaev et al. 2020). Another small subpopulation was identified during field research in 2021–2023. Currently, there are 394 individuals in the Churuk subpopulation, and 103 and 11 in the Ayakguzhumdy and Chontabay subpopulations, for a total of 508 plants. Reproductive individuals are the majority (90.3%), senescent plants 5.8%, while juveniles represented only 3.9% of the total. The lack of historical data on the demographic structure of this population does not allow us to draw unambiguous conclusions about its dynamics, but the indicators of the demographic structure in all subpopulations revealed that the global population is in a regressive state.

Threats:

2.3 Livestock farming & ranching (*2.3.1 Nomadic grazing* and *2.3.2 Small-holder grazing, ranching or farming*): the Kyzylkum desert is used as a pasture for fattening small and large cattle in all seasons of the year (Shomurodov, Khasanov 2014) and continuous livestock grazing is one of the most destructive effects on the population (Shomurodov, Khabibullaev 2022). The use of the territory as an active pasture is responsible, in particular, for a sharp decline in young individuals of *C. zakirovii*.

4.1 Transportation & Service corridors (Roads & railroads): all subpopulations are crossed by roads that are actively used. A bush base is used to rescue cars that have become bogged down in the mud in winter. Roadside individuals are the most heavily damaged by this practice.

5.2 Gathering terrestrial plants (5.2.2 Unintentional effects [species is not the target]): branches of *C. zakirovii* are harvested and used as firewood by locals (Tojibaev et al. 2020).

11 Climate change & severe weather (Storms & flooding): due to climate change, frequent frosts observed during flowering and at the beginning of fruiting negatively affect rejuvenation of the population.

CRITERIA APPLIED:

Criterion B: **EOO:** 72 km^2 calculated with a GeoCAT (Geospatial Conservation Assessment Tool) software (Bachman et al. 2011).

AOO: 12 km^2 calculated with GeoCAT software and based on user defined cell width (2 km) (Bachman et al. 2011).

a) No more than three locations based on the main threat (*2.3 Livestock farming & ranching*).

b) Continuous decline observed in extent of occurrence: (i), area of occupancy (ii), extent and quality of habitat (iii), number of locations or subpopulations (iv), and number of mature individuals (v).

Red List category and Criteria (Global Assessment)

EN	**Endangered**	**B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v)**

Rationale for the assessment: *Calligonum zakirovii* is endemic to the Kyzylkum desert where this plant has a very narrow range, consisting of a single population divided in three subpopulations. The northern subpopulation, located near Chontabay, is especially at risk of extinction being composed by only 11 individuals. The analysis of the demographic structure of subpopulations shows that the elimination of seedlings occurs for various reasons (livestock grazing, frosts, water erosion); the low proportion of juvenile plants suggested that the population has regressed in its recovery, while the high percentage of senescent individuals is an indication of a continuous decline in mature plants. Summarizing, *C. zakirovii*, considering the restricted EOO and AOO, the number of locations (three based on the main threat) and the continuous decline in extent of occurrence, area of occupancy, quality of habitat, number of subpopulations, and number of mature individuals, must be considered as Endangered (EN) at a global level.

Previous assessment: The taxon was not evaluated at the global level (IUCN 2023).

Conservation actions: As a rare and endemic species, since 2019, *C. zakirovii* has been included in the national Red Book of the Republic of Uzbekistan with category 1 (on the brink of extinction; Khasanov et al. 2019). The area where its population is distributed is not included in any reserve or protected area.

Conservation actions needed: Territories where *C. zakirovii* populations grow spontaneously should be included in protected areas; in fact, when protecting this species, first of all, necessary focus on subpopulations that are more prone to extirpation. In-situ and ex-situ conservation studies of this species are required. To protect juvenile plants from being trampled by livestock, translocation should be planned and carried out. Through joint projects and/or articles, it is necessary to make the international community aware of the actual situation of rare species in Uzbekistan (Orsenigo et al. 2022; Fenu et al. 2022) and thereby search for ways to solve the problem.

Khabibullo F. Shomurodov, Bekhruz Sh. Khabibullaev, Giuseppe Fenu

Santolina decumbens Mill. subsp. *tisoniana* Giacò & Peruzzi

Global assessment

Taxonomy and nomenclature

Order: Asterales *Family*: Asteraceae, Tribe: Anthemideae

Santolina decumbens Mill. subsp. *tisoniana* Giacò & Peruzzi J. Syst. Bot. 61: 13 of 16 (12 Dec 2022) [epublished]

Common name: This subspecies has no common name. The common names of *S. decumbens* are creeping hoary lavender-cotton (En), and santoline couchée (Fr).

Geographic distribution range: *Santolina decumbens* subsp. *tisoniana* (Fig. 5) was recently described by Giacò et al. (2023), and is endemic to a restricted area at Bouches-du-Rhône (southern France), approximately between Berre-L'Ėtang and Lançon-Provence (Fig. 6).

Distribution: *Countries of occurrence*: France.

Biology: *Plant growth form*: perennial (chamaephyte).

Flowering and fruiting time: flowering from May to June and fruiting in July.

Reproduction: The pollination strategy is entomophily, and the most probable dispersal strategy is barochory (i.e., the seeds are dispersed just through gravity). There is no data concerning the germination rate of this subspecies.

Habitat and ecology: *Santolina decumbens* subsp. *tisoniana* is an evergreen aromatic shrub occurring in garrigues from 5 to 160 m a.s.l., on poor calcareous soils. It is associated with other Mediterranean thermophilous plants, such as *Cistus albidus* L., *Rhaponticum coniferum* (L.) Greuter, *Staehelina dubia* L., and *Thymus vulgaris* L.

Population information: The distribution of *S. decumbens* subsp. *tisoniana* covers less than 25 km^2. In this small area, the single extant population is severely fragmented in nine small sites that are located at least 1 km apart; five fall within a strongly anthropized area, whereas four fall in the ZPS ("Zone de Protection Spéciale" of the network Natura 2000) "Garrigues de Lançon et Chaînes alentour". However, according to our field observations, this taxon is rarer in the latter zone. In the ZPS, a natural recolonization, resulting in reconnection of the isolated sites, is improbable due to the scarce dispersal capability of the diaspores. In the anthropized area, a natural recolonization is probably impossible due to the high percentage of land used for human activities.

Figure 5. *Santolina decumbens* Mill. subsp. *tisoniana* Giacò & Peruzzi. Photograph by Lorenzo Peruzzi.

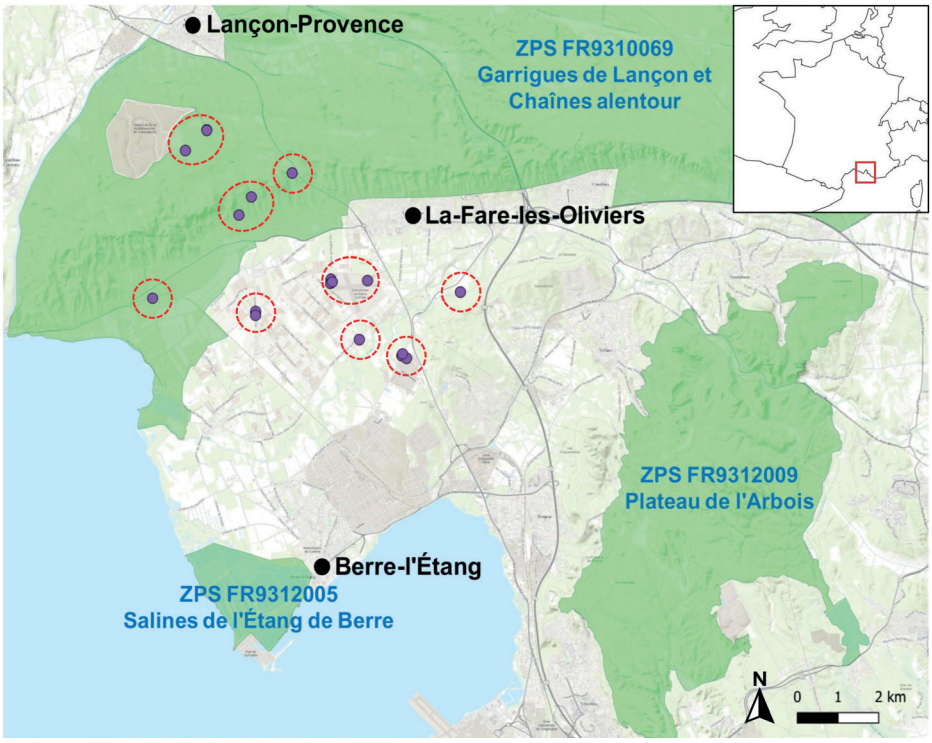

Figure 6. Distribution map of *Santolina decumbens* Mill. subsp. *tisoniana* Giacò & Peruzzi. The nine isolated sites are circled in red.

Threats:

1.1 Housing & Urban Areas and *1.2 Commercial & Industrial Areas*: most of the population grows in a strongly anthropized area potentially affected by the expansion of both suburbs and industrial activities. Since the taxon was just recently described (Giacò et al. 2023), there is no previous demographic information, but it can be hypothesized that this subspecies was more abundant in its small range before the urbanization and the expansion of human activities.

7.1.1 Increase in Fire Frequency/Intensity: the south-eastern portion of France is strongly affected by wildfires, especially during the summer period (San-Miguel-Ayanz et al. 2022). A wildfire in the ZPS "Garrigues de Lançon et Chaînes alentour", a typical Mediterranean scrubland, can be a huge threat for that portion of the population growing in semi-natural environments.

11.2 Habitat Shifting & Alteration and *11.3 Droughts*: *Santolina decumbens* subsp. *tisoniana* grows in Mediterranean environments with long periods of summer drought. Climate change could exacerbate these conditions, leading to a highly inhospitable environment.

CRITERIA APPLIED:

Criterion B: **EOO:** 40 km^2 calculated with GeoCAT (Geospatial Conservation Assessment Tool) software (Bachman et al. 2011).

AOO: 40 km^{2}calculated with GeoCAT software (Bachman et al. 2011).

a) Severely fragmented.
b) Continuing decline projected in: (iii) area extent and quality of habitat.

Red List category and Criteria (Global Assessment)

CR	**Critically Endangered**	**B1ab(iii)**

Rationale for the assessment: Giacò et al. (2023) pointed out the need for an extinction risk assessment. Indeed, *S. decumbens* subsp. *tisoniana* is endemic to a very restricted area at Bouches-du-Rhône. Here, it can be found in the protected area (ZPS) "Garrigues de Lançon et Chaînes alentour", but it is more common in the southernmost anthropized area potentially affected by further expansion of urbanization and industrial activities. During fieldworks in 2020 and 2023, a strong fragmentation was observed both in the ZPS and in the anthropized area. By applying the criterion B, considering the EOO of 40 km^2, the low quality of the habitat and the strong fragmentation, this taxon has to be considered as critically endangered at a global level.

Previous assessment: This subspecies was not previously evaluated (IUCN 2023).

Conservation actions: A portion of the single extant population falls in the ZPS "Garrigues de Lançon et Chaînes alentour". During summer 2023, seeds were collected and stored in the seed bank of the PLANTSEED Lab, Department of Biology, University of Pisa (Italy). In addition, plants will be cultivated in the Botanic Garden of Pisa.

Conservation actions needed: Periodical monitoring would be helpful to understand demographic trends.

Antonio Giacò, Lorenzo Peruzzi

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