

Anthyllis hermanniae L. subsp. *brutia* Brullo & Giusso (Fabaceae): population survey and conservation tasks

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Abstract: *Anthyllis hermanniae* subsp. *brutia*, is an Italian endemic shrub occurring just in one locality by the Calabrian Ionian coast in southern Italy. Objective of this study is to provide data on population numbers, demography and ecology, as well as to identify the main threats on the long term conservation of the target taxon. The survey has been carried out through field census work, sampling biometric and dendrometric data, and applying simple statistics. The population, counting totally 962 individuals, is divided in two stands concentrated in the central part of the distribution area. It is restricted to a narrow belt on the inland part of the dune slope encompassed between an artificial pine forest at the dune top, and the dune-specialized vegetation on the slope. Some biometric insights, such as stem diameter, plant height and number of annual rings, suggest the role of micro-ecology in individual shaping. The most relevant threatening factor for the long term conservation of this rare taxon is the rapidly spreading *Pinus halepensis* subsp. *halepensis*. Local population of this invasive alien species, deriving from planted individuals, is now invading the *A. hermanniae* subsp. *brutia* habitat. Chorological and ecological data here provided should hopefully steer further population dynamics investigation as well as any urgent environment management actions.

Keywords: *Anthyllis hermanniae* subsp. *brutia*; Calabria; chorology; conservation; demography; endemics; population; Rete Natura 2000; Sovereto

How to cite this paper:

Caruso, G. (2022). *Anthyllis hermanniae* L. subsp. *brutia* Brullo & Giusso (Fabaceae): population survey and conservation tasks. *Research Journal of Ecology and Environmental Sciences*, 2(4), 92–102. Retrieved from <https://www.scipublications.com/journal/index.php/rjees/article/view/339>

Received: June 18, 2022

Accepted: September 28, 2022

Published: September 29, 2022



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1. Introduction

Calabria is the region occupying the southern part of the Italian Peninsula that preserves the largest number of endemic species [30]. Despite a long history of scientific investigation, still today new botanical knowledge is fairly regularly added. This new information covers several aspects of botanical knowledge, such as taxonomy [10,25], flora [12, 17,18,25], vegetation [3,19,44], ethnobotany [20,21,22], phytotoponyms [35,36], geographic distribution with focus on rare native [39,11] or endemic [4,28,29,38,43] plant species. Even the knowledge about alien and invasive plant species is rapidly increasing for this territory [16,24,25,33,37,40]. In spite of the abundance of new botanical knowledge studies regarding rare and endemic populations and their demographic composition are still rare, exactly while that kind of information is increasingly essential to scientifically based monitoring, management and conservation of biodiversity.

Anthyllis hermanniae L. (Fabaceae) is a species complex with an E-Mediterranean distribution. As part of this taxonomic group seven different taxa of subspecific rank have been described on the base of morphological and ecological features [5,6]. One of these subspecies, *Anthyllis hermanniae* L. subsp. *brutia* Brullo & Giusso (Figure 1), is known to occur in only one locality representing the taxon's *locus classicus et unicus* [9]. The area, named "Bosco Sovereto" or "Bosco Soverito" or "Dune di Sovereto" depending on the

source of the toponym, is located in the Isola di Capo Rizzuto municipality (Crotone province) by the Ionian Sea (Figure 2A-B-C). The area partially overlaps the Site of Community Importance IT9320102 “Dune di Sovereto” belonging to Natura 2000 Network [10]. The climate of the area, as shown by thermo-pluviometric diagram (Figure 3), is typically Mediterranean, characterized by long summer drought and moderately rainy winters. According to [26], the bioclimatic features of the study area are the following: Macrobioclimate Mediterranean, Bioclimate Pluviseasonal Oceanic, Continentality Weak Euoceanic, Thermotype Upper Thermomediterranean, Ombrotype Upper Dry [8]. The area is geologically dominated by a thick basement of a complex sedimentary rock mostly represented by calcarenite, locally interbedded with sand and/or conglomerate, often covered by stabilized sandy dunes [19] (Figure 4). The geological features of the substrates, mainly porous and permeable, enhance the dryness of the area during the dry season.

According to different authors [9,14,41], *A. hermanniae* subsp. *brutia* is adapted to the driest part of this environment, markedly the open clearings where rocky basement is naked or covered by a thin sandy layer.

Aim of this work is to improve the lacking knowledge about the chorology of *A. hermanniae* subsp. *brutia*, its population size and demographic composition. Some aspects of this rare taxon’s ecology are also discussed in order to contribute to environmental management decision making in a long term conservation perspective.



Figure 1. A blooming branch of *Anthyllis hermanniae* subsp. *brutia*.

2. Materials and Methods

The botanical observations on the study area started on spring 2004. The field work about *Anthyllis hermanniae* subsp. *brutia* has been mostly carried out during the spring-summer 2007 and 2008. The observations about the invasive behavior of *Pinus halepensis* subsp. *halepensis* in the investigated area continued until 2019 (and will be part of a further specific paper). The whole population of *A. hermanniae* subsp. *brutia* has been censused. In order to facilitate the census operation the area has been divided in 15 sectors on the

base of pre-existent roads (Figure 5). The inland part of the investigated area, rather flat, has been planted with exotic woody species such as *Pinus halepensis* Miller subsp. *halepensis* [9]. This artificially forested area is crossed, normally to the coast line, by many unsealed roads.

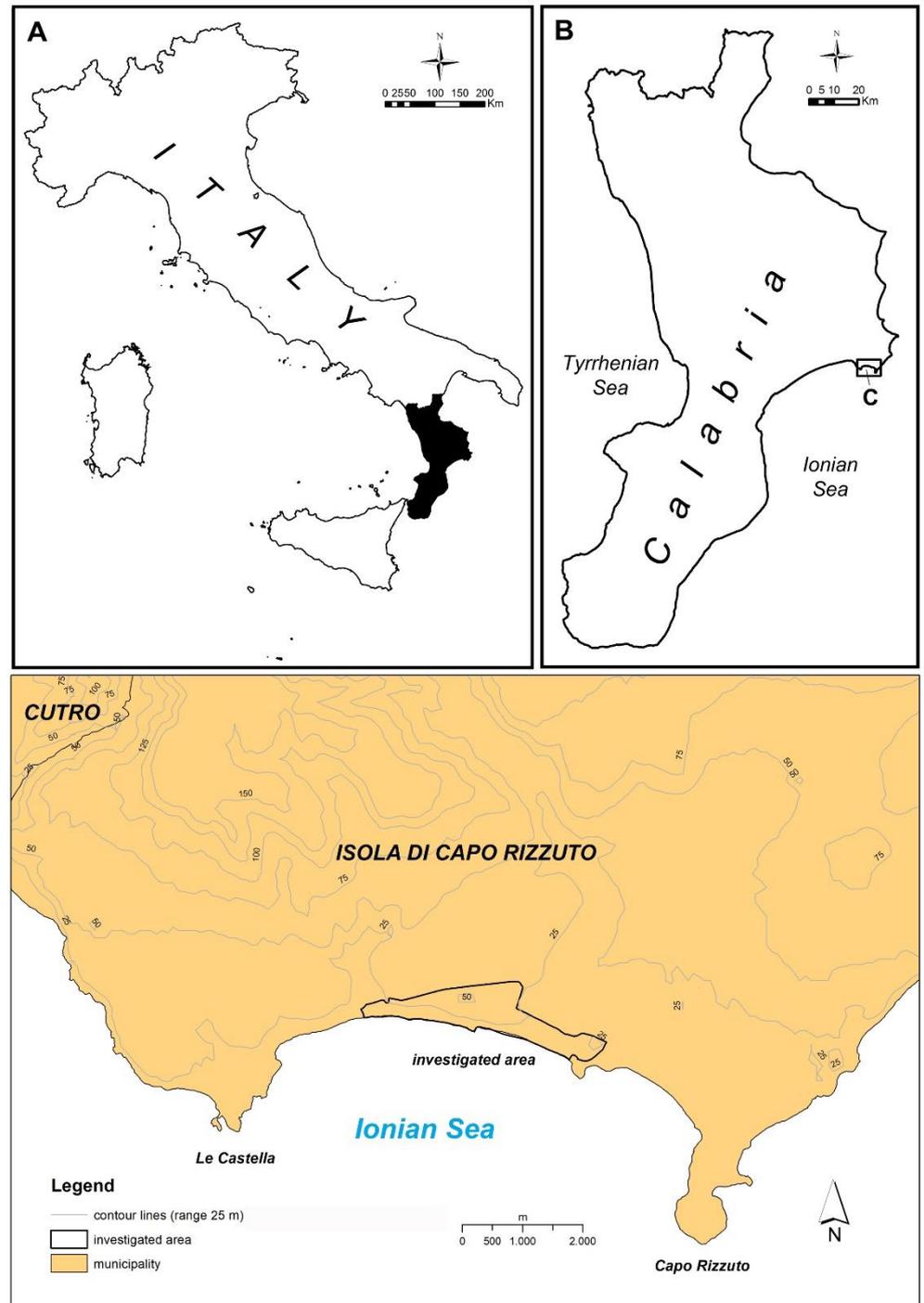


Figure 2. Calabria as part of the Italian peninsula (A) and study area inside Calabrian territory (B-C).

The adjoining area seaward hosts a mosaic of different vegetation types. This belt, following the direction of the unsealed roads crossing the artificial forest, was divided in 15 sectors using white ropes. Inside each sector bushes belonging to the investigated

species and having the appearance of a single individual has been censused. Although a study carried out on a small sample of randomly chosen individuals has shown that many of the *A. hermanniae* subsp. *brutia* bushes are made of more than one single individual (unclearly at the moment if clonal or not) for this work each bush has been censused as a single individual. In order to avoid lacking or multiple counts at the time of the registration each individual has been marked with a white biodegradable plastic strip. Each single patch formed by *A. hermanniae* subsp. *brutia* plants has been georeferenced by GPS and mapped by Quantum GIS software. Patches closer each other less than 100 m have been represented as a single formation (Figure 5). Besides, 4 transects have been drawn (Figure 6) in order to show the location of the studied species along the dune slope.

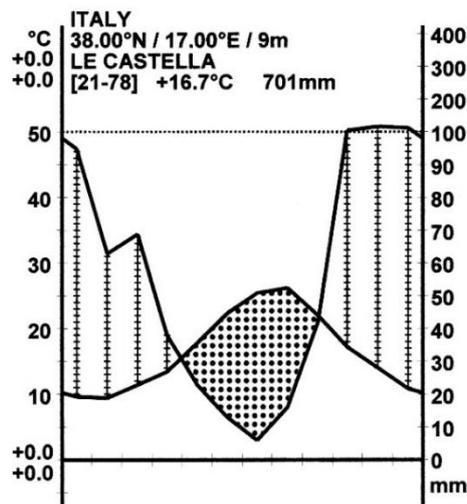


Figure 3. Thermo-pluviometric diagram according to [44] of Le Castella station, the nearest to the study area.

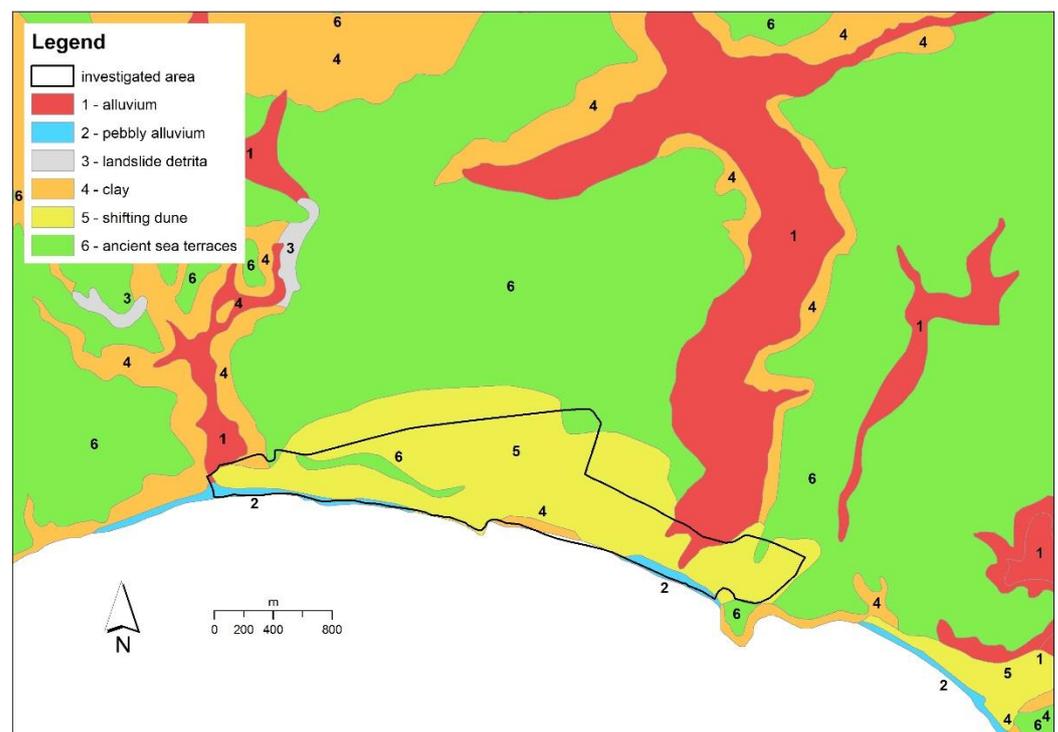


Figure 4. Geologic map of the investigated area (from [19] modified).

A small amount of censused plants (3% of individuals, randomly selected) has been involved in a biometric study. Plant's age has been determined sampling wood at the base of the main stem axis by a Pressler gimlet and later counting annual rings. Stem's diameter (by means of a calibre) and plant's height (tape measure) have been measured as well. To the collected database a simple statistical analysis has been applied, including average (μ), variance (σ^2), standard deviation (σ), correlation coefficient (ρ).

3. Results

The total amount of censused population counts 962 plants, divided in 21 patches. The highest number of plants has been found inside the sector 7 (258 plants; 26.8% of the whole population), followed by sector 8 (180; 18.7%) and sector 6 (142; 14.8%). This core area, represented by sectors 6, 7 and 8, contains a total of 580 plant, corresponding to more than 60% of the taxon. The other sectors, as shown in Table 1, host fewer plants while sectors 1 and 15 host no plants. Patches are relatively close each other forming only two clearly separated stands (> 100 m) first of which, westward, encompasses sectors 2, 3, 4, 5, 6, 7, 8 and the other eastward, encompasses sectors 10, 11, 12, 13, 14.

Table 1. *Anthyllis hermanniae* subsp. *brutia* population census.

stand	sector	patch nr	plants	plants/sector	% sector
	1	0	0	0	0
1 West	2	1	9	11	1.1
		2	2		
	3	3	65	65	6.8
	4	4	15	60	6.2
		5	45		
	5	6	20	73	7,6
		7	53		
	6	8	40	142	14.8
		9	57		
		10	45		
7	11	258	258	26.8	
8	12	180	180	18.7	
9	13	25	25	2.6	
2 East	10	14	7	7	0.7
	11	15	20	20	2.1
	12	16	15	40	4.2
		17	8		
		18	17		
	13	19	15	51	5.3
20		36			
14	21	30	30	3.1	
	15	0	0	0	0
		total	962	962	100

Although statistically not completely significant due to the reduced sample size, the biometric study offered interesting information about the investigated taxon. As shown in Table 2, the average diameter of the measured stems is 1.4 (0.7-4.1) cm, the average height 89.7 (35-220) cm.

Table 2. Biometric features of a 3% sample of *A. hermanniae* subsp. *brutia* population: d = main stem diameter (cm); h = plant height (cm); r = number of rings; μ = average; σ^2 = variance; σ = standard deviation; ρ = correlation coefficient.

plant	habitat	sector	d	h	r
A001	Shrubland	3	0.8	100	5
A002	Garrigue	3	1.2	80	8
A003	Shrubland	3	1.2	90	9
A004	Mantle	3	1.3	115	8
A005	Shrubland	3	1.2	100	10
A006	Shrubland	3	1.2	80	9
A007	Garrigue	4	0.9	52	8
A008	Garrigue	4	0.6	35	6
A009	Garrigue	4	0.7	60	5
A010	Garrigue	4	0.7	55	5
A011	Mantle	3	2.6	120	10
A012	Mantle	3	4.1	150	13
A013	Mantle	4	3.5	220	23
A014	Shrubland	14	1.2	100	10
A015	Shrubland	13	1.7	90	17
A016	Garrigue	13	1	80	12
A017	Shrubland	13	1.8	90	20
A018	Shrubland	13	1.6	100	25
A019	Mantle	13	2.3	150	22
A020	Garrigue	7	1	50	8
A021	Shrubland	7	1.1	100	8
A022	Garrigue	7	1	60	6
A023	Garrigue	7	1	70	9
A024	Garrigue	7	0.9	40	18
A025	Garrigue	7	0.8	65	14
A026	Mantle	7	2.2	120	10
A027	Shrubland	8	1.2	70	8
A028	Shrubland	8	0.7	80	13
A029	Shrubland	8	1.2	80	11
		μ	1.4	89.7	11.4
		σ^2	0.69	1,447	31
		σ	0.83	38	5,6
		ρ	d-h	h-r	d-r
			0.84	0.5	0.5

The average age of plants (number of rings) is 11.4 (5-25). The high value (1,447) of variance of plant height (h) suggests a big variation of this parameter. However, as demonstrated by a relatively low value (38) of standard deviation, this effect is mainly due to the square values used in calculating variance that tends to amplify the effect of data far from average.

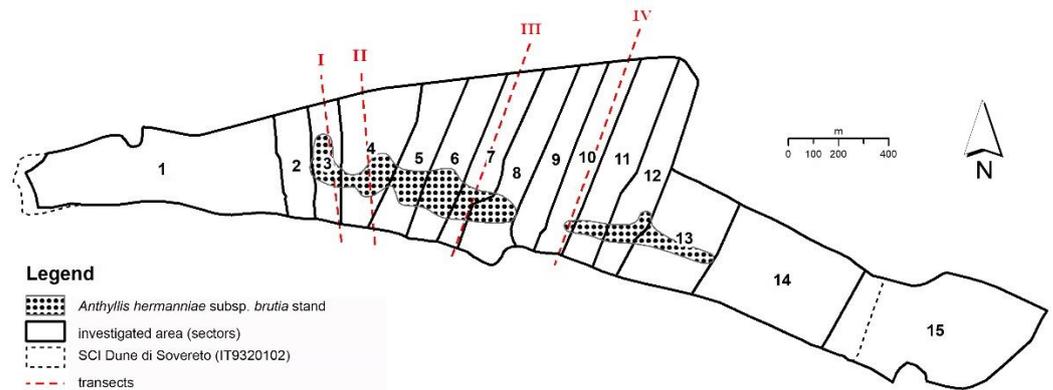


Figure 5. Study area, its division in 15 sectors following the existing unsealed roads, 4 transects normal to the coast line and areas of *Anthyllis hermanniae* subsp. *brutia* occurrence.

The coefficient of correlation among the measured biometric features (d , h , r) is different. Not surprisingly the correlation coefficient is quite high (0.84) between the diameter (d) and the height of the plant (h), but it is unexpectedly lower between height (h) and number of rings (r) (0.5) as well as for diameter (d) and number of rings (r) (0.5). This suggests, how also noticed during the field work, that the biometry of this taxon is strongly influenced by micro-ecological features. Taller individuals are usually concentrated close to trees and/or tall shrubs belonging to competitor species (habitats indicated as “shrubland” and “mantle” in Table 2). This is probably due to the higher water supply guaranteed by shading and to light competition. In such ecological niches, higher individuals grown fast (thus showing few annual wood rings) are common, while in arid ecological niches (habitat indicated as “garrigue” in Table 2), given less competition and water supply, short individuals grown slowly (showing many annual rings) are the rule.

Transects crossing in N-S direction the dune slope belonging to the study area (Figure 6) provide further information. First, the studied plant never occurs under the trees. It seems totally unfit to live as an understory species. Moreover, it shows the tendency to set back from the coastline. Not being a specialized psammophyte, according to reference [10], it fails to colonize the sea side of the dune, evidently more suitable for genuine dune-specialized taxa. Due to the occurrence of the *Pinus halepensis* subsp. *halepensis* artificial forest on the continental side of the dune system, representing a biological barrier to the backward expansion of the *A. hermanniae* subsp. *brutia* population, at the moment it's impossible to say how far from coastline it could have established. Given the current ecological situation, the investigated taxon is restricted inside a relatively narrow belt encompassed between the pine forest and the specialized dune vegetation. Across this belt *A. hermanniae* subsp. *brutia*, as well as other native shrub species, faces the invasion of *P. halepensis* subsp. *halepensis*, progressively increasing in number, size, seed dispersing capacity. First generation of pines, directly deriving from planted individuals, has now reached sexual maturity thus actively contributing to seed-dispersion and colonization process. Without a rapid, drastic appropriate management intervention, addressed to contain the invasion in the short term, the risk for the survival of the species, whose conservation status, according to IUCN criteria [15] is today Critically Endangered CR B2ab(iii) [9], is undoubtedly high.

4. Discussion

The study area is increasingly threatened by tourists who usually reach the beach trampling the dune native vegetation. Also fire occurs quite often here, but it is not clear how this factor influences the dynamics alien-native species. According to [1,31] *Pinus*

halepensis subsp. *halepensis* doesn't naturally occur in Calabria, and doubtfully occurs as a native species even in other administrative regions of Italy [34] where local populations of this taxon have a long history of occurrence. Other authors [13] consider the species native to Calabria only on rocky soils, while on sandy dunes they considered it an apophyte, a native synanthropic species that benefits and spreads in anthropized environments. Other authors [37] does not consider this taxon alien to Calabria, while they consider alien *Pinus halepensis* Mill. subsp. *brutia* (Ten.) Holmboe. Even not considering the invasive behavior of *Pinus halepensis* subsp. *halepensis* in other environments [1], the observations confirming the taxon in the study area as an undoubtedly introduced and invasive species, are the following: 1) the coetaneity of pine trees forming the artificial forest at the top of the dune; 2) the regularity of square planting scheme (3 x 3 m) of the pine forest on the dune top; 3) the almost totally absence of understorey under the artificial pine canopy on the dune top; 4) the total absence of evergreen Mediterranean tree species which are expected to form a forest in this kind of environment (e.g. *Quercus ilex*); 5) the absence/rarity of pine plants along the dune slope before the start of the invasion process (first survey carried out on spring 2004), probably due to seeds from the mature individuals planted at the dune top; 6) the increasing occurrence of young pines of different ages on the dune slope, as a possible result of multiple seeds release from mature plants planted at the dune top; 7) the toponym "Bosco Sovereto" is a phytotoponym, due to the word "bosco" meaning "wood, forest", and the word "sovereto" meaning "made by cork trees", so the complete meaning is "forest made by cork trees", maybe being a forest of *Quercus suber* L., the natural forest covering, at least partially, the study area and the surroundings in the past, well before the planting of the alien pines.

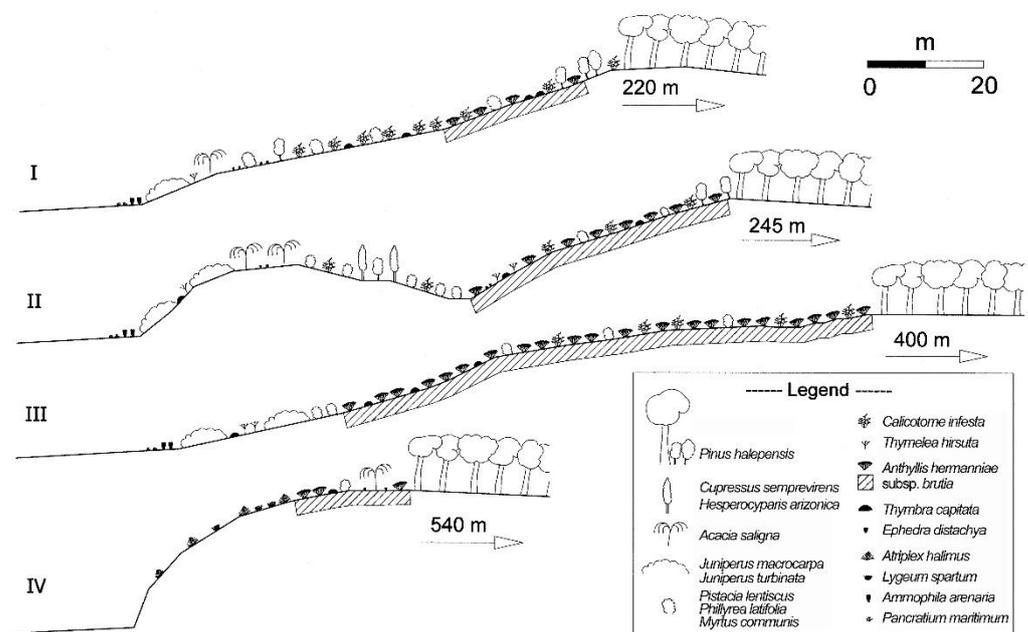


Figure 6. Dominant species distribution along transects (I-IV) crossing the study area (see also Figure 5).

At ecological level (including vegetation, vegetation series, habitat, conservation priorities), the massive occurrence of an alien species, moreover with a clear invasive tendency, configures a different situation than those described in areas where *Pinus halepensis* subsp. *halepensis* naturally occurs [7] or is a long term established entity [34]. Due to the relatively recent introduction of pines on this dune system, and the co-occurrence of a so extremely rare endemic entity, the conservation priority must be

focused on the last one. Besides, pine forests on Mediterranean coasts are fire-prone environment [1]. In case of wildfires, the natural recover of vegetation would probably benefit pines, that are fast growing plants and, above all, trees. When young, this plants grow using shrubs as a nursery, but after a few years these young individuals grow quickly surmounting and shading the shrub species, *Anthyllis* included. That's why it was crucial surveying the target taxon and draw a clear picture of the population situation at the moment of the survey. Futher investigation would be necessary in the next years, in order to better understand the competitive dynamics between the endemic *Anthyllis hermanniae* subsp. *brutia* and the alien pines on this dune slope, to assess the *Anthyllis* population trend, and to best address the conservation efforts.

5. Conclusions

Recent surveys across the study area (last one dated back to spring 2019), unfortunately confirms the dramatic and seemingly unstoppable increasing of mature *Pinus halepensis* subsp. *halepensis* individuals, actively reproducing at an alarming rate, and thus seriously affecting the long term conservation of *Anthyllis hermanniae* subsp. *brutia*. Although many aspects of the *A. hermanniae* subsp. *brutia* biology and ecology still remain uninvestigated, this study presents a detailed chorology of this rare, endemic taxon. The studied population, divided in two main stands, is concentrated in part of the western stand (corresponding to sectors 6, 7 and 8) where more than 60% occurs. At the periphery of the distribution area the concentration of plants sharply decrease to zero in sectors 1 and 15. Along the dune slope, the only habitat suitable to this plant, it fights against pine invasion and imminent risk of extinction. Some biometric insights, such as stem diameter, plant height and number of annual rings, seem suggest the role of micro-ecology in shaping individuals, subject however deserving further investigation.

The dune system today hosting the artificial pine wood occurring in the study area belongs to *Pistacio-Rhamnetalia alterni* Riv.-Mart. 1975 phytosociological order [*Quercetea ilicis* Br.-Bl. (1936) 1974 phytosociological class]. According to 92/43/EEC Habitat Directive, despite artificial and potentially able to threat the long-term conservation of the extremely rare and endemic *A. hermanniae* subsp. *brutia*, this forested area should be considered a priority habitat (2270*: Wooded dunes with *Pinus pinea* and/or *Pinus pinaster*) [2]. This means that if this pine forest will be assessed as a priority habitat, every management effort would be concentrated in maintaining the pine forest, even at the expense of *A. hermanniae* subsp. *brutia*. This would lead to a rapid extinction of the endemic taxon and would represent a terrible lost for biodiversity. A solution to this conflict could be to maintain the pine forest at the top of the dune system, where it has been originally planted, while the new pine individuals developing along the dune slope and threatening the natural shrub formation where *A. hermanniae* subsp. *brutia* occurs, would be removed. Maybe, also considering how fire-prone are the Aleppo's pine plantations, could be wise to progressively restore the natural vegetation in the area, even thank to a gradual removing of alien pines.

Anyway, considering the persisting and increasing occurrence of threatening factors [8,9] the chorological information here presented should represent the base for any further future study on population dynamics, as well as leading any environmental management decision.

Author Contributions: Conceptualization, methodology, validation, formal analysis, field investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision: G.C.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Acknowledgments: The author is very grateful to the anonymous reviewers who helped improve the manuscript.

Conflicts of Interest: The author declares no conflict of interest.

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