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Characterization of *Thymus vulgaris* subsp. *vulgaris* Community by Using a Multidisciplinary Approach: A Case Study from Central Italy

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Abstract: *Thymus vulgaris* L. is an emblematic species of the Mediterranean tradition. As a crop, this species has been spread wherever possible by man around the World. Often escaped from cultivations, defining its natural environment and the limits of its natural range is very much complicated as these have been greatly altered and influenced by human presence, in a positive or in a negative way. In addition to ecology and biogeography studies, we carried out human ecology research to understand whether, in a multidisciplinary (pan-ecological) approach, the case study of the *Th. vulgaris* subsp. *vulgaris* community can be considered of natural or of naturalised origin. An ecological, bio-geographical, and floristic review on this species is reported to help the discussion. Our study could be a good way to improve scientific discussions and applications even for other places and other situations. Some outlook and proposals are reported to improve management and conservation measures, in order to foster our "green-sphere" protection strategies through plants.

Keywords: alien/native; biological succession; garrigue/garriga; human impact; plant community; potential habitat; *thymus* sect. *thymus*; traditional knowledge; Valle Subequana; vegetation dynamics

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1. Background

In areas that have been inhabited for a long time, albeit in alternating phases, human influence/impact is not a negligible variable, especially when we focus on the distribution and assembly of species and biological communities. For this reason, it can be very difficult to understand whether the presence of a species is due to human influences or not. Similarly, it is difficult to understand how much the distribution of a species may have been altered by the human presence, as well as how much a plant population is more or less close to a head series vegetation, or how much a plant community could have shifted from its original point following the human impact.

In areas that have been influenced for a long time by human presence, the differences between what is considered natural, sub-natural, or artificial (alien) could be difficult to assess. In any case, the answer being nonsensical is a risk because it might influence management strategies, decisions, and results. On the other hand, the answer risks being not suggestive but inaccurate or erroneous, which is especially unacceptable for rare and worthy of conservation taxa. The native/non-native chorology exercise can be specious in case it is purely ideological and it may prevent the conservation of important species. Nevertheless, these chorological considerations can be of some interest if applicable to the vegetation potential studies, to ecological dynamics trajectories surveys, in order to test the conservation policies hypotheses and to establish management activities (e.g., active,

non-active, or mixed management strategies). This, according to the precaution principle, if the goal is to improve these species' conservation and to comply with natural dynamics, to ensure a better quality of the environment and more sustainability of land uses. For these reasons, in similar cases, historical, archival, and human ecology surveys could be relevant for ecological and biogeography research to better understand the trends and trajectories. Such a study with this perspective, conducted in a multidisciplinary manner, can be useful to understand the current situation of the environment, of biodiversity, and of species distribution and their status (native or non-native), in particular for those taxa that can be more associated with man and his culture, such as *Thymus vulgaris*.

2. Introduction

In the study area, and to a broader extent in Central Adriatic Italy, the native or non-native status for *Thymus vulgaris* has always been uncertain. Our thyme study stations could be considered as:

- Non-Native (more or less naturalised, or occasional presence), from old crops, that found desirable habitat through the degradation of the natural vegetation and soils, to the extent of creating more arid and opened conditions, suitable for this species;
- Native, consisting of residual communities deriving from older populations deleted or reduced by clearing, grazing, excessive soil erosion, and related vegetation degradation (degeneration and regression phenomena) that could have removed or reduced natural primary populations. In this case, *Th. vulgaris* may have found refuge in secondary areas due to the disappearance of the primary ones, thanks to the widespread anthropogenic pressure linked to the past strong use of the land.

In fact, the study stations were reported for the first time by Cianfaglione [1] and considered a natural species presence, then confirmed as a presence by Bartolucci et al. [2] but considering *Th. vulgaris* naturalised species; later, the native/non-native status was reconsidered by Conti et al. [3] as a natural native presence. Because of these doubts, we have decided to carry out this work, with the hope of being able to better clarify this status, especially for the consequences that could be applied to the land management and biodiversity conservation strategies. This, especially because in Italy *Th. vulgaris* is relatively rare in nature and because the area where the studied populations have been reported falls in an Abruzzo regional natural park (namely: Parco naturale regionale del Sirente Velino), threatened by the frequent boundaries re-shaping/surface reductions that are continuously proposed or carried out over time; and menaced by the current environment and development policies and by the related excessive human impact concerns.

For the study area, we analysed *Th. vulgaris* community originality, dynamics, potential vegetation, environment characteristics, threats, conservation outlooks, and links with local culture. About Human ecology issues, we conducted interviews, asking questions to local people to get local traditional knowledge (presence, uses, and perceptions) about thyme in order to complete the environmental analysis of soil, vegetation, and plant dynamics.

Our work was carried out to try to answer the following research questions:

- Is it possible to understand if *Th. vulgaris* is a native or alien species related to the study area?
- Are *Th. vulgaris* study communities primary or secondary? How much could man have influenced the expression of these communities?
- What is the traditional local knowledge regarding this species?
- What are the dynamics and the potential of this vegetation?
- Are there other spots nearby, in which this vegetation could have potential, and where it could be possible to make other conservation sites for this local genotype?

The results of our study aimed at contributing to formulating new ideas about species and habitat management measures (i.e., active or not conservation) that could be tested implying the due ethics and the precaution principle, looking for improving the conserva-

tion of these species and improving the sustainability of local human activities: both for ensuring a better quality of the environment and of people's lives.

3. Materials and Methods

3.1. Study Area Description

3.1.1. Geography

The study area is located in Central Adriatic Italy, in the "Appennino abruzzese" portion of the "Appennino Centrale" (Central Apennines; see Figure 1), in the L'Aquila province, Abruzzo administrative region. It belongs to the "Valle Subequana" valley, which is situated between the "Monte Sirente" mountain chain and the southern offshoots of the "Gran Sasso d'Italia" mountain chain (i.e., Mandra Murata and Piazza Clementina Mts.), along with the "Fiume Aterno-Pescara" river basin (Media valle dell'Aterno sector). We noticed two *Th. vulgaris* populations: Survey Station No.1 (Colle di More Mt., a small punctual area in Molina Aterno municipality) GPS Coordinates 42°9′35.68″ N–13°43′5.99″ E and; survey station No.2 (Colle Putano Mt., a large area in Castelvecchio Subequo municipality) GPS Coordinates (datum WGS84) e.g.,: (a) 42°8′11.89″ N–13°44′8.94″ E; (b) 42°8′5.25″ N–13°43′49.87″ E [1,2] (Figure 2).

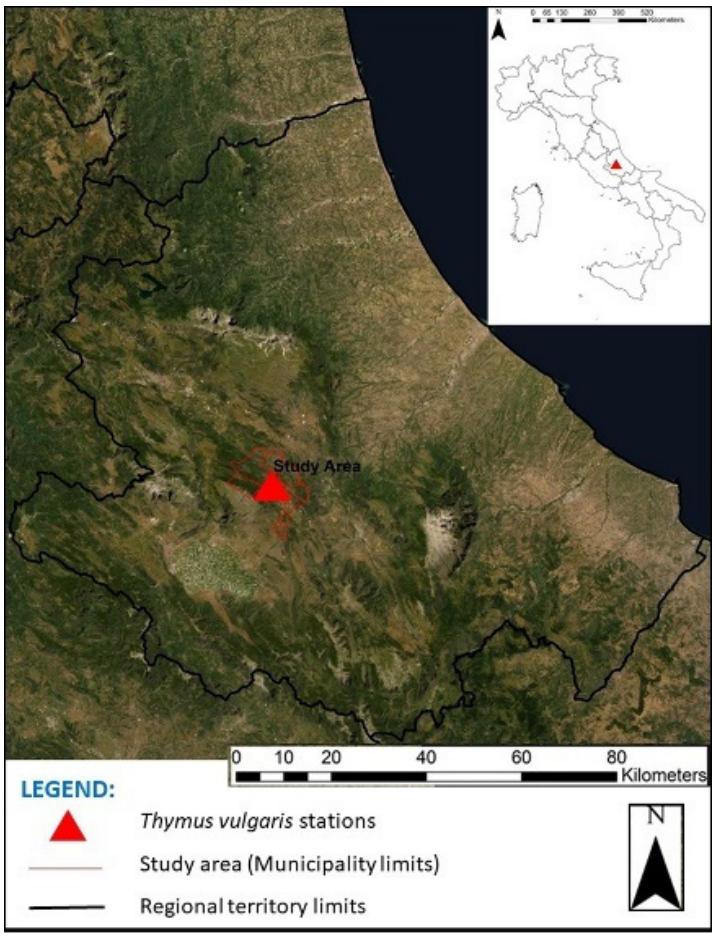

Figure 1. Study area Location within the central Italy; the Apennines mountain chain; and the Abruzzo administrative region.

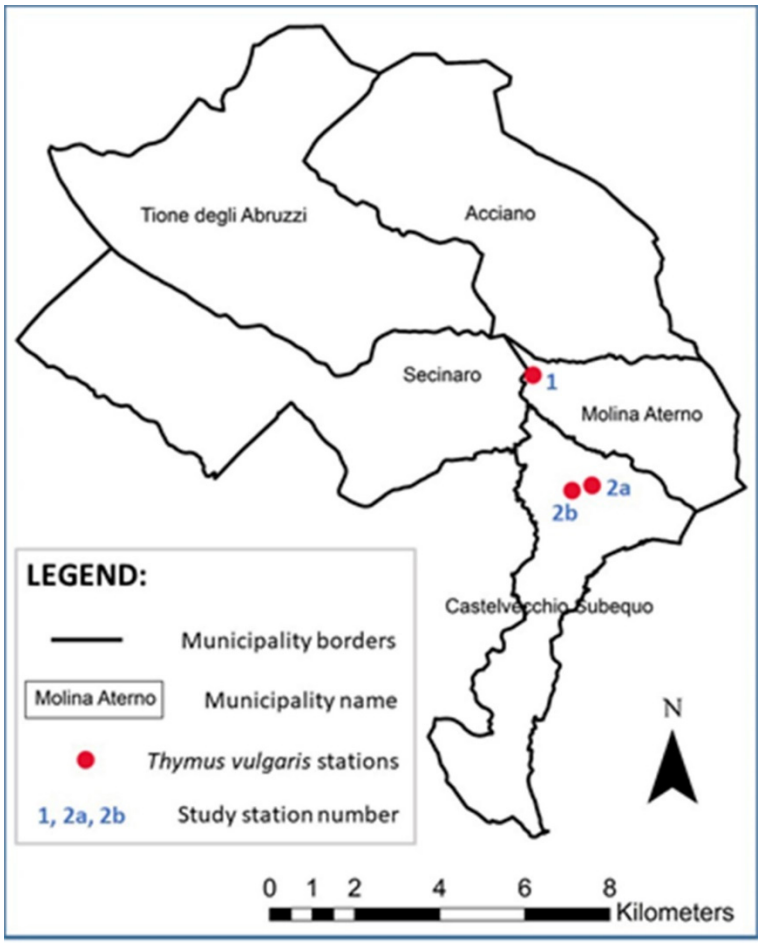

Figure 2. Study stations (red points) placed within the municipalities of the study area. Station No.1 belongs to the Molina Aterno Municipality and, the Station No.2(a, b) belongs to the Castelvecchio Subequo Municipality.

The first study station (called: Colle di More) is at the south mouth of "La Stretta" Canyon, also known as "Goletta di Acciano e Molina". The station is South-East exposed, in a place called "Carlealle", at the foot of the "Colle Bufame" Mt. (locally also known as "Colle di More" Mt.), around 509 to 511 m asl, counting an average of 14% of slope inclination. This station is 1.9 km far from Molina Aterno, 1.7 km from Acciano, 3.23 Km from Secinaro and 4.9 Km from Goriano Valli village centres. Goriano Valli is now a hamlet of Tione degli Abruzzi municipality, but before 1951 it was afferent to the same municipality of Molina Aterno [4].

The second station (called: Colle Putano) could be divided into two populations situated at average 440 m away from each other as the crow flies, as example: (2a) 42°8′11.89″ N–13°44′8.94″ E; and (2b) 42° 8′5.25″ N–13°43′49.87″ E, up to the top of the Colle Putano Mountain (42°8′8.75″ N–13°43′50.32″ E).

The two stations (2a and 2b) are geomorphologically separated by a wooded small valley gully that goes up to the mountain ridge, in contact with the paleo terrace at the top and with the river bottom of the Riaccio stream below.

Station 2a is placed at the northern mouth of the "Gole di San Venanzio" Gorges, close to the confluence of the lateral branch "Vallone del Riaccio" Canyon, sited respectively at the orographic right side of the "Fiume Aterno" River and to the left side of the "Riaccio" Torrent, which is also known as "Rio Grande". This station is South-East exposed, placed at the mid-slope of "Colle Putano" Mt. (locally also known as Colle Butano Mt.), up to the "S.S. 5 Tiburtina-Valeria" National roads. The altitudinal range of the station is between 485 to 526 m asl, counting an average of 30% of slope inclination. This station is respectively 1.2

and 0.78 Km far from Molina Aterno and Castelvecchio Subequo village centres. Station 2b station is placed closer to the village of Castelvecchio Subequo. This station develops more or less discontinuously from the village edge up to the top of the Colle Putano Mountain (the average is between 544 and 607 m asl.). This station is 1.4 Km far from Molina Aterno, and 0.45 Km far from Castelvecchio Subequo villages centre. Over here, the slope is more fluctuating and characterised by a double inclination: one of them faces the south-west and the other one faces the south-east, counting an average of almost 30% of inclination.

Distances were measured from a bird's eye view on the IGM (Italian Military Geographic Institute) map 1:25,000, considering the study station distance to the village centre.

3.1.2. Substrate and Soil

The study area substrate is calcareous (mainly composed of limestone characterised by variable clasts such as calcirudite, and possible punctual marls outcrops).

According to what is reported on the WRB (World Reference Base for Soil Resources) [5], the study stations area soils are not developed (Leptosols and Lithic Leptosols); usually, they are well-drained due to their thinness and stoniness (Rendzina type) and, because of the slope inclination that can reach up to 40 degrees. They can be interspersed by crags, cliffs, and gully/dejection fans (locally respectively called "Balze", "Paritë", "Rava", and "Ravine"). These soils are found in places where erosion plays a strong role (due to natural or artificial causes); that is the reason why substratum and bedrock can easily emerge. Consequently, the Topsoil layer (O Horizon) is thin or absent, often characterised by recent deposits. In the study stations area, the soil ranges between 0 to 25 cm of deepness. The soil tends to be thinner by passing from the bottom to the top of the slope. It becomes even incrementally thinner close to the rocky outcrops and when the slope inclination increases. Under the same conditions, the more the slope increases, the more the soil tends to be thinner.

The litter can sometimes be absent or positioned directly on the substrate; its presence is not constant, generally assuming secondary importance or playing a decisive but punctual role.

The mineral part originates from the bedrock levels, but small siliceous particles mostly come from the downward erosion of the old upper fluvial-lacustrine deposits (i.e., paleo-terraces). Clasts of various sizes can be found with a certain variability, resulting in more stony, or more sandy areas, etc.

Sometimes it is possible to find a thin layer (max 2 cm) of humus (topsoil) directly deposited on the substrate (without finding any layer of soil).

Topsoil tends to slide downwards along the slope, because of accumulation and erosion dynamics. The more the areas are exposed and steep, the more they are subject to effects of erosion, while the flatter or sheltered surfaces are those where material could be more subject to accumulation.

Soils tend to be sandier and stony at their most superficial portion. Similarly, the soil pH can be from alkaline (especially on the top), to weakly alkaline/neutral (especially in a deeper, less calcareous, and more developed soil): generally, it is between around 7 to 8. Typically, the skeleton is quite abundant, consisting of calcareous coarse fragments. These soils are strongly subject to eluviation/illuviation dynamics and therefore to possible rubefaction phenomena as well. In these cases, soils are reddish or brownish-red, characterised by a fersiallitic component (mainly deriving from the paleo-terraces above) mixed with the skeleton and the substrate, which derive from the mother rock. In any case, the soil thickness depends on the erosion/accumulation balance existing along the slope. In case the substrate or the soil is richer in clay or in residual components, they both can be saturated by water during the wettest periods and they can be very dry during the driest periods. They are unattractive soils for rainfed agriculture because of their difficulty in holding water, but they may have a huge potential for trees (forests) or livestock grazing (especially for sheep and goats' pastures). Nevertheless, at the mountains foot, the soils become thicker, more developed, and richer.

3.1.3. Climate and Bioclimatic Data

About climate and bioclimate of the study area (see Section 3.1), referring to the Global Bioclimatic Classification [6] we can place the study area in the Submediterranean variant of the Temperate oceanic bioclimate, characterised by a mesotemperate thermotype and an ombrotype positioned between the lower sub-humid and the upper dry levels. The continentality level is rather relevant because of the effect of the surrounding mountains.

3.1.4. Human Presence

In the area, human presence almost dates from prehistoric times. The oldest settlements found date almost back to the Neolithic age (e.g., rock paintings located at the "Gole di San Venanzio" Gorges, "Rava Tagliata" locality. The human impact and inhabitants strongly fluctuated during different ages [7–10], implying alternating phases of strong presence and human impact versus low population and less anthropic pressure. Actually, a low human population density characterises the "Valle Subequana" Valley (see Section 4.5 Soil and Land Uses) but an inverse impact phenomenon occurs despite the decrease of the demographic impact, due to mechanisation and current economic-environmental policies on agriculture and forestry management [11–14].

3.2. Fieldworks

From 2013 to 2021, in-depth open and semi-structured interviews were conducted asking questions to inhabitants (425 respondents being between 40 and 99 years old), which were selected by using snowball sampling techniques. Participants were asked about their traditional knowledge and about the existence of thyme in the area (according to their experience and memories from their ancestors) via open interviews. Informants were selected at the villages surrounding the two *Th. vulgaris* study localities, in the Valle Subequana Valley (Acciano, Castelvecchio Subequo, Goriano Valli, Molina Aterno and Secinaro villages, see Figure 2). Consequently, the biogeographical, ecological, and soil fieldworks were concentrated in the two study stations.

All the respondents were questioned during oral interviews about thyme presence, perceptions, and traditional knowledge (see annexes). We did identification sessions as well to look for which taxa were recognised as thyme by local peoples. This session consisted of in situ and ex situ experiences. In addition, we collected anecdotes and stories freely shared by the interviewees. The in-situ experiences consisted of two trials:

- Walking in search of the thyme used and cited by the interviewees (in situ experience). In this regard, we acted in two ways: firstly, the interviewees guided us to the places where they generally know thyme exists and where they generally harvest it. Secondly, we proceeded by accompanying the interviewees to our *Th. vulgaris* study localities in order to check whether they recognised this species as thyme and if they had any knowledge about the uses of this species.
- In case of the unavailability of interviewees to travel to gathering locations, or when they could not move around easily, it was decided to show the different samples of the various local "thyme" cognitive label specimens (ex situ experience) to the informants (see the Section 4.3).

Local name(s) of each quoted taxon was specifically recorded beside scientific names. Interviews were conducted in Italian and in local dialects. Researchers adhered to the ethical guidelines of the International Society of Ethnobiology (ISE) [15], and the American Anthropological Association (AAA) [16]. Informed consent was always obtained verbally before conducting the interviews, ensuring privacy and anonymity of data.

Regarding the first thyme station (Colle di More), we interviewed the inhabitants of the neighbouring villages (Molina Aterno, Acciano, Secinaro, and Goriano Valli). The inhabitants of Secinaro and Goriano Valli villages were interweaved despite being much farther from the studied station (respectively 3.23 and 4.9 Km), as they lived in the study station surrounding area, and because the boundaries of their municipal territories meet while lapping the territory of the study station No.1. This is the reason why it is conceivable

that their inhabitants could have frequented that zone or that they could have some knowledge about the study station zone.

At the second station (Colle Putano) we interviewed the inhabitants of the neighbouring villages (Castelvecchio Subequo and Molina Aterno).

Human's pressure dynamics were evaluated through the population density trends and by land-use changes. Referring to the ISTAT (Italian Statistics National Institute) data [17], the average actual population density of Molina Aterno, Acciano, Castelvecchio Subequo, Secinaro and Tione degli Abruzzi municipalities territories resident community is of 21,33 inhab/m^2. This value is halftime that of the estimated world population density (48 inhab/m^2), six times less than the Abruzzo region density (119 inhab/m^2), and 10 times less than the average Italian national density (197 inhab/m^2). Currently, the study area population density of the municipalities is at a minimum level (Acciano: 9.7 inhab/m^2; Castelvecchio Subequo: 46.2 inhab/m^2; Molina Aterno 31 inhab/m^2; Secinaro: 11.5 inhab/m^2; Tione degli Abruzzi: 8.2 inhab/m^2). From 1860 to 2021, human density peaked during 1911 in Molina Aterno (85.83 inhab/m^2), Castelvecchio Subequo (129.45 inhab/m^2) and Secinaro (60 inhab/m^2); and in 1901 in Tione degli Abruzzi (52.57 inhab/m^2).

Land-use dynamics changes were evaluated by aerial photos, by available historical pictures and by soil uses taken from cadastral archives and by local people testimonials. We used the "Archivio Tradizioni Subequane" archive, in order to consult the bibliographic material, photos, maps, manuscripts, and other data concerning local tradition, history, and culture related to our research, to look for evidence of land-use changes, thyme uses, and related possible local traditional knowledge.

Plant taxa nomenclature is in line with the updated checklists of the vascular flora native to Italy [18] and subsequent updates [19–23] summarised in the Portale della Flora d'Italia/Portal to the Flora of Italy 2020 [24,25]. The phytosociological investigation was based on the classical phytosociological method of Zurich–Montpellier Sigmatist school [26], and the syntaxonomic nomenclature follows the Italian Prodrome of Vegetation [27]. The soil and the substrate were analysed referring to Giordano [28], Flügel [29], the geological map of Italy [30], the soil map of Abruzzo [31], and the Thematic map of the Soil Quality Index [32]. Soil pH characteristics were analysed by an XS PC70 field multimetre. In order to understand the environmental context, we studied the potential vegetation and the contact vegetation. The study area land and soil uses were provided by consulting local archives, by interrogating local people, and by observing the aerial photos, the old photos, and the cadastral maps.

A synoptic table (Table 1) was built to compare our vegetation surveys with the phytosociological table's data available in the European literature related to the vegetation with dominant or co-dominant *Th. vulgaris* subsp. *vulgaris*. In this table, only the species that are present in more than half of the surveys of at least one original table (symbol X) are reported. The symbol "O" indicates the presence of a species in an original table where it appears in less than half of the surveys.

Life forms and chorological types of spectra were calculated for the plant community investigated in the study area. Both of them were calculated in three different ways: simple (presence/absence of every species); on the basis of the frequency of every species; weighted (coverage degrees of every species). For a clearer interpretation, the chorological types, taken from Flora d'Italia [33] have been grouped into broader categories: Stenomediterranean type (Stenomedit., W-Stenomedit., E-Stenomedit.); Eurimediterranean (Eurimedit., N-Eurimedit., W-Eurimedit.); Orophytes (Med.-Mont., N-Medit.-Mont., NE-Medit.-Mont., W-Medit.-Mont., Orophyte S-Europ.); Turanian (Eurimedit.-Turan., Stenomedit.-Turan.); Eurasian (Eurasiat., S-Europ.-Sudsib., Europ., Europ.-Caucas., W- and C-Europ., SE-Europ.); Pontic (Eurimedit.-Pontic, SE-Europ.-Pontic); Atlantic (W-Europ. (Atl.), Eurimedit.-Subatl.); Paleotemperate and Endemic. The phytosociological classification corresponds to the Prodrome of Italian vegetation [27].

Table 1. Synoptic table. Progressive No. corresponds to: 1 = our surveys; 2 = *Thymo vulgaris-Hyparrhenietum hirtae*; 3 = *Teucrio polii-Thymetum vulgaris*; 4 = *Helianthemo oelandici-Thymetum vulgaris*; 5 = *Hyperico coris-Lavanduletum angustifoliae thymetosum vulgaris*; 6 = *Thymo vulgaris-Globularietum cordifoliae*; 7 = *Thymo vulgaris-Euphorbietum spinosae*.

Progressive No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Number of Relevés	**2**	**9**	**16**	**16**	**6**	**3**	**10**
Thymus vulgaris subsp. *vulgaris*	X	X	X	X	X	X	X
Cytiso-Satureion montanae							
Thymus sect. *Serpyllum*	X			O	O		
Cephalaria leucantha	X				O		O
Hyssopus officinalis subsp. *aristatus*	X						
Cisto ericetalia/Cisto-Micromerietea							
Satureja montana subsp. *montana*	X			O	X		X
Micromeria graeca	X	X					
Aethionema saxatile	X						O
Ononis pusilla subsp. *pusilla*	X			O	X		
Argyrolobium zanonii subsp. *zanonii*	X		O	O	O	O	X
Petrosedum rupestre	X		O	X	O		
Fumana procumbens	O		X	X			O
Teucrium capitatum subsp. *capitatum*	O		X			X	
Coronilla minima subsp. *minima*			O	X		X	O
Helianthemum apenninum subsp. *apenninum*				X	O		O
Thliphthisa purpurea			X	O			O
Fumana ericifolia			O		O	X	O
Artemisia alba			O	X	X		
Hyssopus officinalis subsp. *officinalis*				O	O		
Euphorbia spinosa					O		X
Rosmarinetea officinalis							
Helianthemum oelandicum subsp. *italicum*				X		X	O
Aphyllanthes monspeliensis			O			X	O
Staehelina dubia				O		X	
Coris monspeliensis						X	
Lavandula latifolia						X	
Rhaponticum coniferum						X	
Festuco-Brometea							
Bromopsis erect	X		X	X	X		X
Globularia bisnagarica	X		X	O	O	X	O
Teucrium chamaedrys	O		X	O	X	O	X
Poterium sanguisorba	X		O			O	O
Galium corrudifolium	X			X	O		O
Eryngium campestre	X			O		X	X
Crupina vulgaris	X		X	O			O
Cynanchica aristata	X				X		

Table 1. *Cont.*

Progressive No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Number of Relevés	**2**	**9**	**16**	**16**	**6**	**3**	**10**
Odontites luteus	X			O			O
Stipa capillata	X				O		
Seseli montanum subsp. *montanum*	X						O
Leontodon crispus	X						O
Dianthus ciliatus subsp. *ciliatus*	X						
Petrorhagia saxifraga	X						
Eryngium amethystinum	X						
Allium moschatum	X						
Pentanema montanum	X						
Carex humilis					X	X	
Festuca ovina					X	O	X
Seseli tommasinii					X		
Dianthus gr. sylvestris				O	X		O
Festuca robustifolia				X			
Globularia cordifolia					O	X	
Koeleria vallesiana					O	X	O
Cynanchica pyrenaica subsp. *cynanchica*						X	O
Potentilla verna							X
Lygeo-Stipetea							
Dactylis glomerata subsp. *hispanica*	X	O					
Hyparrhenia hirta subsp. *hirta*		X				O	
Bituminaria bituminosa		X					O
Ampelodesmos mauritanicus		X					
Helictochloa bromoides subsp. *bromoides*						X	
Tuberarietea guttatae							
Medicago minima	X	X					X
Coronilla scorpioides	X	X					O
Trifolium scabrum	X	X					O
Bupleurum baldense	X	O					O
Trifolium stellatum	X	O					
Helianthemum salicifolium	X						O
Vicia peregrina	X						
Linum strictum	O	X					O
Trifolium campestre	O	X					O
Brachypodium distachyon		X					O
Hypochaeris achyrophorus		X					O
Catapodium rigidum		X					O
Briza maxima		X					
Scorpiurus muricatus		X					
Alyssum alyssoides	O						X

Table 1. *Cont.*

Progressive No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Number of Relevés	**2**	**9**	**16**	**16**	**6**	**3**	**10**
Bombycilaena discolor							X
Cerastium pumilum							X
Others Species							
Reichardia picroides	X	X					X
Avena barbata	X	X					
Convolvulus cantabrica	X	O	X	O		O	O
Potentilla pedata	X			O	O		
Urospermum dalechampii	X	O					O
Carlina corymbosa	X	O					
Convolvulus elegantissimus	X	O					
Helichrysum italicum subsp. *italicum*	X				O		
Polygala nicaeensis subsp. *mediterranea*	X						
Carduus pycnocephalus subsp. *pycnocephalus*	X						
Orlaya grandiflora	X						
Centaurium erythraea subsp. *erythraea*		X					
Galactites tomentosus		X					
Lysimachia arvensis		X					
Asparagus acutifolius		X					
Sonchus tenerrimus		X					
Blackstonia perfoliata subsp. *perfoliata*		X					
Bothriochloa ischaemum			X	O			
Achnatherum calamagrostis			X		O		
Lavandula angustifolia					X		O
Sempervivum tectorum					X		
Juniperus oxycedrus						X	O
Linum suffruticosum subsp. *appressum*						X	
Onobrychis supina						X	
Trinia glauca subsp. *glauca*						X	
Lotus dorycnium						X	
Sedum album					O		X
Poa bulbosa subsp. *bulbosa*							X
Crucianella angustifolia							X

With the word "Garriga" we mean a (suf)frutex low and open arid formation typical for Mediterranean areas. It is other times known under the French name Garrigue. Macchia is used in the sense of "Macchia Mediterrana", often thorny it consists of a shrub-land or thicket type that sometimes is identifiable by the French word Maquis or the Spanish Matorral and Cardonal in some ways. In our case, all the listed formations are differentiated since they are impoverished of the most thermophilic species, because of Sub-Mediterranean conditions and due to the orography characteristic of the study zone, and because the evergreen woody species (trees and shrubs) are reduced at few species, mostly of conifers.

4. Data Analysis and Results

4.1. Climate and Bioclimate Data Extrapolation for the Study Area

Regarding the climate and the bioclimate of the study area, no measuring station is present nearby. The closest thermometric stations are placed in Goriano Sicoli and Popoli, both 7 km far from the study area, and placed at different elevations (respectively 785 and 260 m asl). The closest pluviometric stations are placed in Beffi (640 m asl; 8 km far) and Roccacasale (500 m asl, 11 km far) placed at similar elevations above the sea level, but at different mesoclimatic contexts. After the extrapolation of data from these stations and according to the bioclimatic characterisation (see Section 3.1), we can place the study site in the Submediterranean variant of the Temperate oceanic bioclimate, characterised by a mesotemperate thermotype and an ombrotype positioned between the lower sub-humid and the upper dry levels; with marked continentality characteristics, deriving from the effect of the surrounding mountains. Winters are rather cold (min. temp. can reach almost −15 °C); and characterised by hot summers (max. temp. can attempt 40 °C). Rains are not frequent; the average annual precipitation range is between 600 to 800 mm, reaching a maximum peak between autumn and winter. Examined climatic data were from 1920 to 2020.

4.2. Ecological, Biogeographical, and Taxonomic Review on Thymus Vulgaris

Thymus L. (Lamiaceae) belongs to the monophyletic subfamily Nepetoideae Kostel. [34]. It can be considered one of the most critical genera of the Euro-Mediterranean flora. It includes about 220 accepted species distributed in the Old World (Europe, northwest Africa and Ethiopia, Asia) and in Greenland [24,35–44]. According to the morphological classification proposed by Jalas [45] *Thymus* is subdivided into eight sections: *Th.* sect. *Micantes* Velen., *Th.* sect. *Mastichina* (Mill.) Benth., *Th.* sect. *Piperella* Willk., *Th.* sect. *Teucrioides* Jalas, *Th.* sect. *Pseudothymbra* Benth., *Th.* sect. *Thymus*, *Th.* sect. *Hyphodromi* (A.Kern.) Halácsy and *Th.* sect. *Serpyllum* (Mill.) Benth. *Thymus vulgaris* belongs to *Th.* sect. *Thymus*, a section distributed in the western Mediterranean [35,46] and characterised by plants that are usually erect, rarely creeping, providing holotrichous stems, leaves with revolute margin, usually hairy, with spiciform or capituliform inflorescences. Currently, three subspecies are recognised within *Th. vulgaris*. The subsp. *vulgaris* occurs in Spain, France, and Italy, subsp. *aestivus* (Reut. ex Willk.) A.Bolòs and O.Bolòs from Spain and Baleares and subsp. *mansanetianus* P.P.Ferrer, A.Navarro, E.Laguna and Mateo endemic of E Spain [18,47–49]. A fourth taxon is *Th. vulgaris* subsp. *palearensis* (O.Bolòs and Vigo) O.Bolòs and Vigo that is considered by Morales [46] as an altitude morph-type without taxonomic value.

Thymus vulgaris is a perennial evergreen (suf)frutex chamaephyte, erect, up to 30 cm, rarely decumbent (Figure 3). In some cases, the basal part could be not very developed and the apical part rather transient in winter, giving rise to rather herbaceous formations; while on the contrary, in other cases, the basal part can be very developed, the stem can be relatively thick, and the apical parts can be more durable: originating a subshrub that looks like a small shrub. Plants tend to become overly woody and loose after several years, developing through more stems made of desquamating bark (in longitudinal) stripes, particularly observable in adult and large specimens (Cianfaglione pers. obs.) (Figure 4). Leaves are ovate-lanceolate, more or less revolute at the margin, without basal cilia but pubescent on both sides, and covered by numerous sessile glands. Inflorescences are capitate, more or less elongated, and they are characterised by bracts, which are similar to the leaves, rarely wider. Flowers are pink, rarely whitish; the calyx is campanulate, richly covered by reddish glands [50] (Figure 5). This species is rich in essential oils glands, presenting an important variety of forms [51,52] and a high diversity of chemotypes [53–56], giving it a wide variety of medicinal constituents [57,58]. For that reason, it is considered as an officinal and aromatic plant, largely known and used for several purposes (e.g., in gastronomy, perfumery, medicine, and as a ritual plant) (viz. [59–63]. As a consequence of its chemotype variability, the smell and the taste can be very different [64,65], even resembling a lemony or a verbena scent; offering shades that depend on the terroir and on the balsamic period [66].

Figure 3. An example of a secondary garriga (station 2a) with open and stony patches, in winter habitus. We have observed *Th. vulgaris* subsp. *vulgaris* specimens with greener leaves and others with more silver leaves, but these differences are clearly remarkable only in the winter habitus. Photo: Kevin Cianfaglione, 10 January 2022.

Figure 4. A detail of the desquamating bark in most adult specimens. Photo: Kevin Cianfaglione, 10 January 2022.

Figure 5. A flowering individual of *Th. vulgaris* subsp. *vulgaris*. Photo: Bruno Santucci, 1 May 2017.

Thymus. vulgaris is considered a Stenomediterranean corotype, distributed in the western Mediterranean, between Spain, France, and Italy see: [19,47,49]. It could be considered a naturalised alien species in North Africa, Caribbean, New Zealand, Central and Northern Europe (see [46]). In the wild, this species is typical of arid soils (dry at least in summer) and of open formations (i.e., scrublands, dunes, rocky/stony slopes, garriga, Mediterranean Macchia, para-steppes, and other open or arid grasslands). It could also be comprised in pastures, especially when its herbaceous habit is dominant and even in after wildfires formations or in formerly cultivated fields and other ruderal areas. It grows from sea level up to 2000 (2450) m as reported at the Pyrenees Mountains. Depending on the altitude, the exposition [67], on the substrate and on soil uses (i.e., pastures or former cultivations), up to the mountain belt [51], the thyme growth can be favoured to the extent of creating formations that can be even very thick and dominant (i.e., [68,69], thanks to its possible allelopathic effects as well [70–72]. For its characteristics, *Th. vulgaris* is a typical plant species of the Mediterranean culture [73–75]. Besides that, it represents one of the most popular and known aromatic plants and a worldwide cultivated essence. It is popularly called "Common Thyme", "Garden Thyme", "Cultivated Thyme", or just "Thyme", thus embodying the stereotyped representation of the whole genus and similar species. *Thymus vulgaris* is one of the species that has been closely linked to the human presence, to the point that its distribution has been positively or negatively influenced, depending on the situation. Moreover, its habitats are often secondary and linked, in some way, to man's crippling, to previous practices of deforestation, grazing, and fire that may have eroded and impoverished the soils. These are the reasons why it has become difficult to assess when *Th. vulgaris* is of spontaneous or artificial origin and therefore it is often considered a sub-spontaneous species.

Thymus vulgaris secondary populations cannot be stable, depending on the anthropic factor, and thus they tend to degenerate (rarefying) more as the human pressure increases, or in the case of secondary succession. In such environments, due to the degree of aridity and to the intensity of the erosive phenomena, these dynamics can be more or less relatively long over time.

Due to the species' biological characteristics, the effects of decay due to inbreeding also could represent another threat for the *Th. vulgaris* populations perpetuation (i.e., [76,77]. The presence of *Th. vulgaris* is or it could be considered natural, not only in strictly Mediterranean

environments but even in mountainous ones and others less characteristic Mediterranean conditions (i.e., [78–80]. Normally, regarding the status of this species in their stations (i.e., [81]) and the characterisation and the possible differentiation between the more Mediterranean and the more mountainous communities, many questions remain unanswered.

In Italy, *Th. vulgaris* subsp. *vulgaris* is considered a relatively rare or remarkable taxon. Although it may seem quite widespread at the regional level, it occurs more infrequently as native species. It is reported to be a native species in the western side of the Italian Peninsula, from the north to the centre (*viz.* Valle d'Aosta, Piemonte, Lombardia, Liguria, Emilia Romagna, Toscana, and Lazio administrative regions) and in Abruzzo at the eastern side [2,18,19]. It is reported as alien in the rest of Italy (*viz.* Friuli-Venezia Giulia, Marche, Umbria and Puglia administrative regions) [18]. This taxon has previously been reported several times for Abruzzo localities [82–85], but the more recent field studies have always given negative results about them, not possible to confirm today [2]. This led to the idea that this species was considered a casual alien for the region until it was reported in our study area.

From a phytosociological point of view, in the prodrome of Italian vegetation [27] *Th. vulgaris* is never considered as having a diagnostic value, even when it is considered as abundant and frequent in garriga formations. In another hand, *Thymus vulgaris* subsp. *vulgaris* is considered, by Mucina et al. [86], a diagnostic species of the classes *Festuco hystricis-Ononidetea striatae* Rivas-Mart. et al., 2002 and *Ononido-Rosmarinetea* Br.-Bl. in A. Bolòs and Vayreda 1950. Several plant formations are described considering *Th. vulgaris* as a dominant or as a co-dominant species. For example, the *Hyperico coris-Lavanduletum angustifoliae* Vagge and Biondi 2008 *thymetosum vulgaris* Vagge and Biondi 2008 sub-association, related to the most xerophilic aspect of the Lavanduleti (wild lavender formations) of the "Alpi Marittime e Occidentali" and of Haute Provence; the association was framed in the alliance *Artemisio albae-Satureion montanae* Allegrezza et al., 1997 [87]. Castelli [88] referred the *Teucrio polii-Thymetum vulgaris* and the *Helianthemo oelandici-Thymetum vulgaris* (described for the Northern Apennines) to the *Xerobromion* Br.-Bl. and Moor 1938; subsequently both of them were relocated to the sub-alliance *Astragalenion monspessulani* Biondi, Allegrezza and Zuccarello 2005, now elevated to the alliance rank [89]. The phytoassociation *Thymo vulgaris-Hyparrhenietum hirtae* (Di Pietro and Blasi, 2002) was proposed in abandoned olive-grove grasslands, as part of the *Hyparrhenion hirtae* Br.-Bl., P. Silva and Rozeira 1956 alliance for the communities found in the "Monti Ausoni" Mts. (Tyrrhenian pre-Apennines) [90]. In the Alpi Marittime, two different associations have been described: the *Thymo vulgaris-Euphorbietum spinosae* Guinochet 1975, and the and the *Thymo vulgaris-Globularietum cordifoliae* O. Bolós 1954. The first one was generically framed by the author in the class *Thero-Brachypodietea* Br.-Bl. in Br.-Bl. et al., 1947 [91], and now considered a synonym of *Lygeo sparti-Stipetea tenacissimae* Rivas-Mart Class. 1978 *nom. conserv. propos*. The second association was included in the *Aphyllantion* Br.-Bl. 1931 alliance, which, by some authors, is considered to be a synonym of *Helianthemo italici-Aphyllanthion monspeliensis* Díez-Garretas, Fernández-González and Asensi 1998 [92], while other authors consider it a synonym of the *Deschampsion mediae* Br.-Bl. et al., 1952 *nom. conserv. propos*. [86].

4.3. Study Area Local Traditional Knowledge and Perception

Thymus taxa that grow spontaneously in the "Valle Subequana" valley, are known in the traditional knowledge in the same cognitive label (locally called Tumë, Tume, or Timë) according to the different local dialectal variations. Taxonomically, it also includes species from other genera (*viz*. *Satureja montana*, *Helichrysum italicum*, and *Micromeria graeca*), as follow:

- *Satureja montana* L. subsp. *montana* embodies the stereotype of the local cognitive label of Thyme. This species represents the symbolic species of thyme according to the local knowledge and perception, as it is a species that, par excellence, represents the thyme cognitive label. It is locally known as "Tume", "Timë", or "Tumë". It represents the best thyme type to be used, the most sought, and the most properly said. It is

harvested in nature, rarely cultivated at home garden, used as an aromatic plant to flavour meats and cheeses in particular, but to a lesser extent, also tomato sauces, salads, bakery, oils and animal fats used for cooking purposes.

- The creeping *Thymus* species (i.e., *Th. striatus* Vahl subsp. *acicularis* (Waldst. & Kit.) Ronniger, *Th. longicaulis* C.Presl, and *Th. moesiacus* Velen.) and other similar taxa possibly occurring (in wild or cultivated) in the Valle Subequana are always considered as thyme (and called "Tume", "Timë", or "Tumë"), but they are considered of lesser importance, of lower quality and of lesser consideration (if compared to *Satureja montana*). There is no real differentiation between these various creeping *Thymus* taxa. The only distinction concerns the intensity (quality and quantity) of perfume and hairiness. It is considered preferable to use specimens that are as less hairy as possible. Sometimes creeping thyme taxa are locally called adding to the noun, the adjective: "pazzë", or "stupëdë" where "pazzë" and "stupëdë" are local dialect adjectives respectively meaning wild/crazy and stupid, in both cases used traditionally to indicate wild specimens or taxa that are useless or of secondary importance in the local people perception. This confirms the secondary importance of these taxa, in local culture, when compared to the *Satureja montana*. Despite everything, even creeping thyme species could sometimes be grown at home or in gardens (7,2% of interviewed people do it or have seen others doing it in the valley); this is considered as a "modern" (post-war period) phenomenon.
- *Thymus vulgaris* represents an exception since, by local people's perception, this species does not belong to the same thyme cognitive label. Rather, it is considered as another plant. This species results to be totally unknown by the local traditional knowledge (respondents do not know this species), pointing out no possible traditional use. Nobody recognises it as thyme (neither for the appearance, nor for the taste, nor for the smell) and nobody identifies possible uses of it. Only the 3.8% of interviewed people (some of the respondents between 40 and 50 years old) recognised this species as thyme, but just because they read about it, or they have seen it lately, as a cultivated novelty (at home, in stores, in gardens, or in flowerpots). They concluded by adding that it was not used in traditional issues but, in recent years, it could be cultivated at home as a novelty, by purchased seeds or seedlings.
- *Micromeria graeca* (L.) Benth. ex Rchb., at times could be considered within the thyme local cognitive label. In those cases, this species is considered as a very low thyme quality (a sort of "pazzë", or "stupëdë" more than the creeping *Thymus* taxa). It was mainly used in the past (approximately until the 1940–1970s), in case of scarcity of other species. It was generally used in mixture with other thyme species for food or others uses. It has never been observed as being grown in gardens, although it can grow spontaneously around houses, where it could be tolerated.
- *Helichrysum italicum* (Roth) G.Don subsp. *italicum* is considered as thyme but of another type, to be used in another way. This species is locally known as "Tumacchië", "Tumacchio", "Tumacchijë", meaning "Timaccio" in Italian, a pejorative form often indicating bad or shoddy, somehow in the sense of a worse thyme. This happens because, despite being pleasantly scented, this species confers a strong bittering effect. It is traditionally used to flavour meat, but moderately, due to its bittering properties. It was widely used to create special torches as well, specifically used to burn pig's hairs and to flame their skin, once killed, in preparation for slaughtering and rind treatments. This practice left much-appreciated aromas to them. In case of necessity/scarcity, *Satureja montana* and *Micromeria graeca* or other scented suffrutex (i.e., *Teucrium capitatum* L. subsp. *capitatum* and *Artemisia alba* Turra) could also have been used, mixed to make torches. Nevertheless, people preferred to make pig torches only by using *H. italicum*. At the same level, this species was even preferred and used as fuel in substitution of wood. Plants were harvested (cut at the base or eradicated) to be used as fuel for cooking (even in ovens). Other chamaephytes were also used in this way but *H. italicum* was preferred. This happened because in the valley, during the Second World

War and in the post-war period (until the 1960s), there was the greatest shortage of wood and herbaceous cover ever. This period corresponds to the lowest peak in the extent of plant cover (forests, garriga, shrublands, and pastures) that has ever been reached in Valle Subequana Valley history; to the point that there was a great lack of fuel for daily use and of fodder. The fuel scarcity, in the municipality of Castelvecchio Subequo concerned even the availability of the chamaephytes; consequently, there was no other choice to use cobs and corn sticks as fuel. The inhabitants were necessarily forced to move to neighbouring municipalities in order to look for corn sticks and cobs to even steal them, favoured by the darkness of the night. For these reasons, even today the inhabitants of this village are known as Turzari (translatable as "Cobarians", meaning "cob people") by the neighbouring villages [93]. In the past, *Helichrysum italicum* was not cultivated at home or in gardens, although it can grow spontaneously around houses and gardens, where it could be tolerated. A recent (rare) phenomenon, however, is that of growing it at home as an ornamental/aromatic plant.

- There is another similar species, *Satureja hortensis* L., which is commonly known and traditionally cultivated, or it can rarely be found as an unstable presence in ruderal areas or more generally, in undoubted synanthropic conditions. This species could be considered a sort of "Thyme", but more often, it is considered in another and autonomous cognitive label. It is locally known as "Sautraija" (and similar variants such as Sautrajja, Sautraijja, Sautrajje, Sautrajjä or Sautrajjë—according to the different local dialectal declinations), but more rarely it could be also called "Sauzarena", "Sauzarenë", or "Sauzarenä". It is typically cultivated as an aromatic plant. Unlike other thyme taxa, it is mainly used for the condiment of tomato sauces, salads, bakery, oils, and other fats for cooking; and to a lesser extent, it is also used for flavouring meats and cheeses.

Traditional knowledge related to the "Thyme", intended as a broad cognitive and multi-taxa group (the set of species listed up to here), was found to be identical for the rest of the Agro Peligno and other neighbouring areas where traditional uses of *Th. vulgaris* have not been recorded and there is no reported presence of this species.

According to the different local dialectal variations, the character "ë"and "ä" are to be considered unspoken or half-fallen "e" and "a" in pronunciation, following Italian phonetics.

4.4. Studied Community Characteristics

The plant communities of our study area (Table 2) show a clear predominance of chamaephytes, hemicryptophytes, and therophytes (according to the Raunkiær system of biological forms), as evidenced by the biological spectrum analysis (Figure 6). If we consider the weighted spectrum values, the first two Raunkiær categories (chamaephytes and hemicryptophytes) are co-dominant. However, the high value of hemicryptophytes presence seems to be determined by the low cover values and by the presence of numerous species, rather than by a constant dominance. Only *Cephalaria leucantha* (L.) Roem. and Schult., in fact, reaches the value 2 in both relevées (phytosociological surveys). Further occasional species, found later, are *Anacamptis pyramidalis* (L.) Rich., *Arenaria leptoclados* (Rchb.) Guss., *Draba verna* L., *Ophrys bertolonii* Moretti, *Ophrys classica* Devillers-Tersch. and Devillers, *Ophrys funerea* Viv., *Ophrys insectifera* L., *Orobanche gracilis* Sm., *Plantago sempervirens* Crantz, *Saxifraga tridactylites* L., *Silene italica* (L.) Pers., *Valerianella locusta* (L.) Laterr. These species have been found to be composed of very ephemeral or very rare covers, despite being very much widespread in Italy.

Table 2. Proposed new association table. Rel No.2 is the holotypus of the new proposed plant association.

		Progressive Rel.No.	**1**	**2**
		Elevation.	**520**	**530**
		Exposition	**SSE**	**SSE**
		Slope. (°)	**20**	**18**
		Vegetation Cover (%)	**60**	**70**
		Stones (%)	**60**	**50**
		Rocks (%)	**0**	**0**
		Mosses (%)	**30**	**40**
		Lichens (%)	**5**	**-**
		Surface of Rel. (m^2)	**25**	**20**
		Date of Rel.	**22 June 2018**	
Biological Form	**Chorlogical Type**		**Plant Cover**	
		Aethionemo saxatilis-Thymetum vulgaris* Ciaschetti, Cianfaglione and Pirone *ass. nova hoc loco		
Ch Frut	W-Stenomedit.	*Thymus vulgaris* L. subsp. *vulgaris*	2	3
H Scap	Ne-Medit.-Mont.	*Dianthus ciliatus* Guss. subsp. *ciliatus*	1	1
Ch Suffr	Medit.-Mont.	*Aethionema saxatile* (L.) W.T.Aiton	1	+
G Bulb	Ne-Medit.-Mont.	*Allium moschatum* L.	1	+
H Scap	Eurimedit.	*Polygala nicaeensis* Risso *ex* W.D.J.Koch subsp. *mediterranea* Chodat	+	+
		Cytiso-Saturejon montanae/Artemisio albae-Saturejetalia/Cisto-Micromerietea		
H Scap	Orof. S-Europ.	*Cephalaria leucantha* (L.) Roem. and Schult.	2	2
Ch Suffr	Stenomedit.	*Micromeria graeca* (L.) Benth. *ex* Rchb.	2	2
Ch Suffr	W-Stenomedit.	*Argyrolobium zanonii* (Turra) P.W.Ball subsp. *zanonii*	1	1
Ch Suffr	Eurasiat.	*Hyssopus officinalis* L. subsp. *aristatus* (Godr.) Nyman	+	1
Ch Rept	Se-Europ.	*Thymus longicaulis* C.Presl subsp. *longicaulis*	+	+
H Scap	Eurimedit.	*Ononis pusilla* L. subsp. *pusilla*	+	1
Ch Succ	W- E C-Europ.	*Petrosedum rupestre* (L.) P.V.Heath	+	1
Ch Suffr	W-Medit.-Mont.	*Satureja montana* L. subsp. *montana*	(+)	1
Ch Suffr	Eurimedit.-Pontic	*Fumana procumbens* (Dunal) Gren. and Godr.	1	-
Ch Suffr	Se-Europ.	*Onosma echioides* (L.) L. subsp. *echioides*	1	-
Ch Suffr	SE-Europ	*Cytisus spinescens* Sieber *ex* Spreng.	+	-
Ch Suffr	Stenomedit.	*Teucrium capitatum* L. subsp. *capitatum*	-	1
Ch Suffr	S-Europ.-Sudsib.	*Ruta graveolens* L.	-	1
		Others Species		
Ch Suffr	N-Eurimedit.	*Helichrysum italicum* (Roth) G.Don subsp. *italicum*	2	1
T Scap	Eurimedit.	*Odontites luteus* (L.) Clairv. subsp. *luteus*	1	1
H Scand	E-Stenomedit.	*Convolvulus elegantissimus* Mill.	1	1
T Scap	S-Europ.-Sudsib.	*Crupina vulgaris* Cass.	2	+
H Scap	SE-Europ.-Pontic	*Eryngium amethystinum* L.	2	1
H Scap	W-Medit.-Mont.	*Pentanema montanum* (L.) D.Gut.Larr., Santos-Vicente, Anderb., E.Rico & M.M.Mart.Ort.	1	1

Table 2. *Cont.*

		Progressive Rel.No.	1	2
H Caesp	Stenomedit.	*Dactylis glomerata* L. subsp. *hispanica* (Roth) Nyman	1	1
H Scap	Stenomedit.	*Galium corrudifolium* Vill.	1	1
H Scap	S-Europ.-Sudsib.	*Globularia bisnagarica* L.	1	1
T Scap	Eurimedit.	*Helianthemum salicifolium* (L.) Mill.	1	1
H Ros	S-Europ.-Sudsib.	*Leontodon crispus* Vill.	1	1
H Caesp	Eurimedit.	*Petrorhagia saxifraga* (L.) Link	1	1
H Scap	Paleotemp.	*Poterium sanguisorba* L.	1	1
H Caesp	Eurasiat.	*Stipa capillata* L.	1	1
T Rept	Eurimedit.	*Trifolium scabrum* L.	1	1
H Scap	Eurimedit.	*Cynanchica aristata* (L.f.) P.Caputo and Del Guacchio subsp. *aristata*	1	+
H Scap	Stenomedit.	*Carlina corymbosa* L.	1	+
H Caesp	Paleotemp.	*Bromopsis erecta* (Huds.) Fourr.	+	1
T Scap	Eurimedit.	*Bupleurum baldense* Turra	+	1
T Scap	S-Europ.-Sudsib.	*Orlaya grandiflora* (L.) Hoffm.	+	1
H Scap	W-Medit.-Mont.	*Seseli montanum* L. subsp. *montanum*	+	1
T Scap	Eurimedit.	*Avena barbata* Pott *ex* Link	+	+
H Bienne	Eurimedit.-Turan.	*Carduus pycnocephalus* L. subsp. *pycnocephalus*	+	+
H Scap	Eurimedit.	*Convolvulus cantabrica* L.	+	+
T Scap	Eurimedit.	*Coronilla scorpioides* (L.) W.D.J.Koch	+	+
H Bienne	Europ.	*Echium vulgare* L.	+	+
H Scap	Eurimedit.	*Eryngium campestre* L.	+	+
T Scap	Eurimedit.	*Medicago minima* (L.) L.	+	+
H Scap	W-Eurimedit.	*Potentilla pedata* Willd. *ex* Hornem.	+	+
H Scap	Stenomedit.	*Reichardia picroides* (L.) Roth	+	+
H Scap	Eurimedit.	*Urospermum dalechampii* (L.) F.W.Schmidt	+	+
T Scap	Eurimedit.-Turan.	*Vicia peregrina* L.	+	+
T Scap	Eurimedit.	*Ajuga chamaepitys* (L.) Schreb.	1	-
T Scap	Stenomedit.	*Stachys romana* (L.) E.H.L.Krause	1	-
H Caesp	Endem.	*Stipa dasyvaginata* Martinovský subsp. *apenninicola* Martinovský and Moraldo	1	-
T Scap	Paleotemp.	*Trifolium campestre* Schreb.	1	-
T Scap	Eurimedit.	*Alyssum alyssoides* (L.) L.	+	-
T Scap	Eurimedit.	*Buglossoides arvensis* (L.) I.M.Johnst. subsp. *arvensis*	+	-
T Scap	Eurimedit.-Subatl.	*Crepis vesicaria* L.	+	-
T Scap	Eurimedit.	*Filago pyramidata* L.	+	-
T Scap	Eurimedit.	*Helminthotheca echioides* (L.) Holub	+	-
T Scap	Stenomedit.	*Hippocrepis ciliata* Willd.	+	-
H Scap	Paleotemp.	*Hypericum perforatum* L. subsp. *veronense* (Schrank) Ces.	+	-
H Scap	Endem.	*Linaria purpurea* (L.) Mill.	+	-
H Caesp	Eurimedit.	*Melica ciliata* L. subsp. *ciliata*	+	-

Table 2. *Cont.*

Progressive Rel.No.			1	2
T Scap	Paleotemp.	*Sabulina tenuifolia* (L.) Rchb. subsp. *tenuifolia*	+	-
G Rhiz	SE-Europ.	*Phleum hirsutum* Honck. subsp. *ambiguum* (Ten.) Cif. and Giacom.	+	-
T Scap	S-Europ.-Sudsib.	*Scabiosa triandra* L.	+	-
H Scap	N-Medit.-Mont.	*Stachys recta* L.	+	-
H Ros	Eurasiat.	*Silene otites* (L.) Wibel	+	-
T Scap	Stenomedit.-Turan.	*Triticum vagans* (Jord. and Fourr.) Greuter	+	-
G Bulb	Paleotemp.	*Allium sphaerocephalon* L. subsp. *sphaerocephalon*	-	1
T Scap	Stenomedit.	*Linum strictum* L.	-	1
H Scap	Paleotemp.	*Silene vulgaris* (Moench) Garcke subsp. *vulgaris*	-	1
Ch Suffr	Eurimedit.	*Teucrium chamaedrys* L. subsp. *chamaedrys*	-	1
P Lian	Europ.-Caucas.	*Clematis vitalba* L.	-	+
G Bulb	W-Europ. (Atl.)	*Bunium bulbocastanum* L.	-	+
H Scap	Endem.	*Erysimum pseudorhaeticum* Polatschek	-	+
T Scap	Eurimedit.	*Lathyrus sphaericus* Retz.	-	+
H Scap	Paleotemp.	*Lotus corniculatus* L. subsp. *corniculatus*	-	+
T Scap	Eurimedit.	*Nigella damascena* L.	-	+
T Scap	Stenomedit.	*Tordylium apulum* L.	-	+
T Scap	Eurimedit.	*Trifolium stellatum* L.	-	+
T Scap	S-Europ.-Sudsib.	*Xeranthemum inapertum* (L.) Mill.	-	+

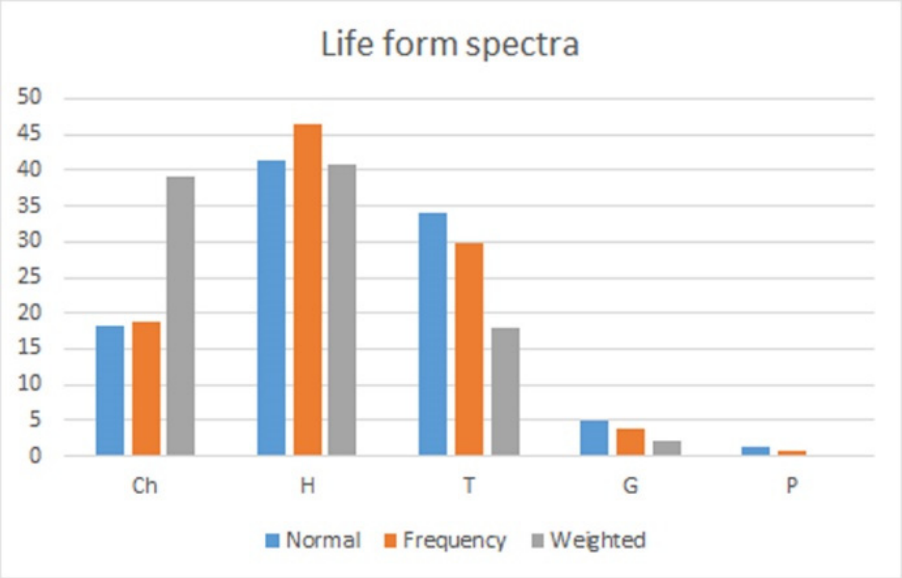

Figure 6. Life Forms spectra analysis chart of the newly proposed association *Aethionemo saxatilis-Thymetum vulgaris* in the Abruzzo region: Ch = Chamaephytes; H = Hemicryptophytes; T = Therophytes; G = Geophytes; P = Phanerophytes.

The populations we studied are characterised by an important presence of mosses and terrestrial lichens layer, as it is typical for Central Adriatic Apennines arid areas vegetation. Old *Th. vulgaris* specimens often show notable epiphytic encrustations of lichens. Sometimes

cyanobacteria blooms (such as *Nostoc* species) can be observed in the study station garriga beyond the hottest and driest period of the year.

The Sigmeta shrub formations are characterised by *Crataegus laevigata* (Poir.) DC., *Paliurus spina-christi* Mill., *Rosa canina* L., *Asparagus acutifolius* L., *Fraxinus ornus* L. subsp. *ornus*, *Juniperus deltoides* R.P.Adams. The Sigmeta forest's actual vegetation consists of *Quercus pubescens* Willd. subsp. *pubescens* dominated forest, completed mainly by sporadic *Fraxinus ornus* L. subsp. *ornus*. The first station (Colle di More) forest and shrublands formations are differentiated by the presence of *Pyrus spinosa* Forssk., *Spartium junceum* L., and *Sorbus domestica* L.; while in the second station (Colle Putano) the forest and shrublands formations are differentiated by the presence of *Rhamnus saxatilis* Jacq., *Buxus sempervirens* L., *Pinus nigra* J.F.Arnold subsp. *nigra cfr* var. *italica* Hochst [94], *Pinus halepensis* Mill. subsp. *halepensis*, *Quercus ilex* L. subsp. *ilex* and *Prunus dulcis* (Mill.) D.A. Webb. The Sigmeta forests of the second station are completed by patches of *Pinus nigra* J.F. Arnold subsp. *nigra cfr* var. *italica* Hochst or *Pinus halepensis* Mill. subsp. *halepensis* reforestation (Figures 7–9).

In the study area, as happens frequently, small patches of therophytes coenoses form a vegetation mosaic with the dynamically connected garriga, secondary pastures/grasslands/meadows, and forests (incl. edges/mantles). We carefully excluded patches of other vegetation types from our phytosociological relevées. Species that are characteristic of other plant formations were taken into account only when they were isolated and scattered in our thyme garriga.

The presence of woodland species and of forest precursor species that are beginning to develop in our study communities (where the secondary succession is more advanced), and in the surroundings (where there are similar ecological characteristics) demonstrates a forestry potential and consequently how the study communities are placed in a secondary seral situation.

Figure 7. A winter overview of the secondary study garriga (station No.2a), related Sigmeta shrubs, young trees, and rests of sparse cultivated almond trees (a snag in the background, near small pines, junipers, and oaks; and an old remnant almond tree base after wood harvesting, in the foreground). Photo: Kevin Cianfaglione, 10 January 2022.

Figure 8. An example of *Th. vulgaris* subsp. *vulgaris* secondary garriga in flower (late spring/early summer habitus), in the station 2b, with a more ruderal/nitrophilic facies. Photo: Bruno Santucci, 1 May 2017.

Figure 9. An example of *Th. vulgaris* subsp. *vulgaris* secondary garriga in flower, in the station 2b, in an undisturbed secondary succession, interspersed with a grassland. Photo: Marinella Miglio, 1 May 2017.

From a chorological point of view, a clear prevalence of Mediterranean species is remarkable (Figure 10), among which the Eurimediterranean chorotype is the most represented in quantity and frequency, while the Stenomediterranean one shows the largest cover, thanks to *Th. vulgaris* subsp. *vulgaris*. European and Eurasian species are the next for

relevance; however, concerning the coverage values, they are placed just after the typical mountain species, consisting almost entirely of the Mediterranean-Mountain chorotype. The paleotemperate species show appreciable values, especially relative to the normal spectrum and the contribution of the Turanian and Pontic species is not insignificant, especially the latter if we consider the weighted spectrum (6.0%). The comparison of our study community with other communities dominated by *Th. vulgaris* subsp. *vulgaris* described in Europe shows a certain floristic autonomy of our investigated community (Table 1).

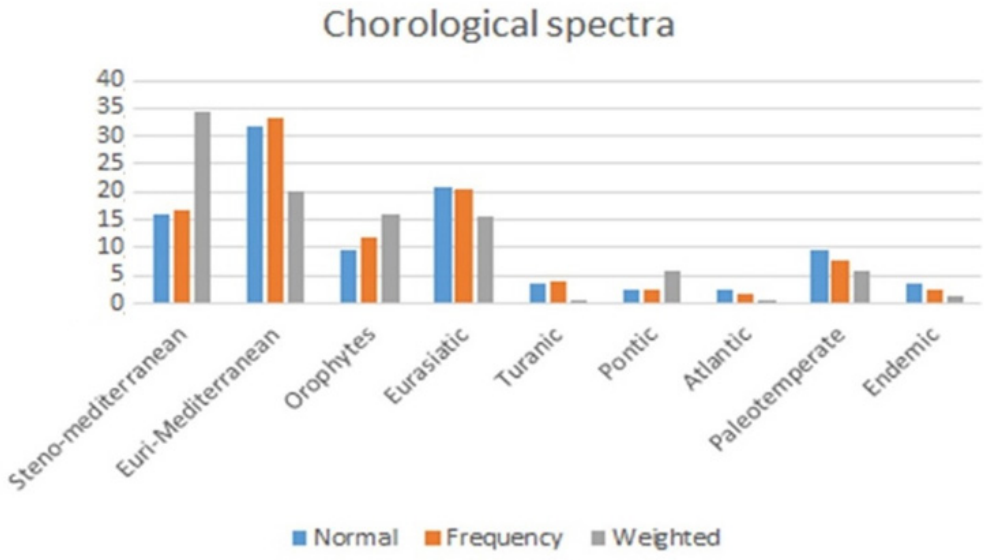

Figure 10. Chorological spectra analysis chart of the newly proposed association *Aethionemo saxatilis-Thymetum vulgaris* in the Abruzzo region.

The synoptic table (Table 1) shows several taxa that are exclusive (or almost) to our study community. Among the typical garriga taxa for which we have assigned a greater differential significance we found *Cephalaria leucantha*, *Hyssopus officinalis* subsp. *aristatus* (and *Aethionema saxatile*. Among the taxa that are most closely related to perennial arid pastures, we found *Stipa capillata*, *Seseli montanum* subsp. *montanum*, *Leontodon crispus*, and some taxa that are exclusively linked to our study communities, like: *Dianthus ciliatus* subsp. *ciliatus*, *Petrorhagia saxifraga*, *Eryngium amethystinum*, *Allium moschatum*, and *Pentanema montanum*. The typical taxa of annual semi-natural communities (*Tuberarietea guttatae* class) are relatively well represented in our community, as it is also the case described for the Lazio administrative region [95]. However, in that case, they are clearly differentiated by the remarkable presence of species from the *Lygeo-Stipetea* class. Even though some annual species (therophytes) are present in our surveys, they do not have a key role in characterising the investigated vegetation, because they represent opportunistic plants showing a faster fluctuating presence. In our opinion, some taxa among "other species" in Table 1, instead, are useful for differentiation purposes as: *Helicrhysum italicum* susbp. *italicum* and *Polygala nicaeensis* subsp. *mediterranea*. Both the taxa are quite common and typical in the Central Apennines for chamaephytes and hemicryptophyte herbaceous formations (e.g., [89,90,96–101]. On the basis of the floristic autonomy of the investigated vegetation, we propose a new plant association called *Aethionemo saxatilis-Thymetum vulgaris* Ciaschetti, Pirone, and Cianfaglione *ass. Nova* (typus Rel. 2 of Table 2), relating to the garriga formations, dominated by *Th. vulgaris* subsp. *vulgaris* of inland areas of central Italy, characterised by the prevalence of Mediterranean species, including several mountain species, and by a significant presence of European and Eurasian species, on the calcareous substrate in Submediterranean Temperate climates characterised by a Mesotemperate thermotype and a Sub-humid ombrotype. The association is framed in the *Cytiso spinescentis-Satureion montanae* Pirone and Tammaro 1997 alliance; *Artemisio albae-Saturejetalia montanae* (Allegrezza, Biondi, Formica, and Ballelli 1997) Biondi and Allegrezza *in* Biondi, Allegrezza, Casavec-

chia, Galdenzi, Gasparri, Pesaresi, Vagge and Blasi 2014 Ordo; *Cisto cretici-Micromerietea julianae* Oberdorfer *ex* Horvatić 1958 Class.

In the two studied stations, the *Thymus vulgaris* plants were found to be very old; the oldest ones can date up to about 40 years. These two study stations populations have different population dynamics from the fluctuation (mature populations with senescent or dead portions/samples), characterised by adult (woody and loose) specimens, and by regressing patches that are mostly related to human disturbance; while other patches are stable, others are in full development or in renovation.

4.5. Soil and Land Uses

The first station zone (Colle di More) is characterised by a wide soil use patches history, prevalently of arborated pastures, simple pastures interspersed by coppices, simple arable lands, and arborated arable land parcels. Afterword, in more recent times (from the 10s to the 70s of the XXth Century), the soil use was mostly transformed into non-irrigated arable lands or dry pastures (mostly consisting in rainfed rotating crops/pastures or, generally, in unstable meadows) also through hydraulic arrangements and light terracing works. The presence of trees has drastically decreased at times, if not completely disappeared. Subsequently, these lands were all left to secondary successions and mostly transformed into woodlands dominated by downy oak (*Quercus pubescens* subsp. *pubescens*) and in a small part in shrubby pastures or non-used grasslands (slower secondary successions). A strong wildfire affected the first station, and the remains have been uprooted during vegetation "cleanings" activities and agronomic "tillage". At the moment, no other presence has been found in the surroundings of this station.

The second station appears healthy, even if it has decreased in surface in recent years at the lowest portions of 2a and 2b study sites, where *Th. vulgaris* continues to renew itself but to assemble in looser communities often. This seems to be caused mainly by phenomena of nitrophilisation (and therefore of competition) and by trampling (especially referring to the 2b site), as well as by possible natural phenomena of fluctuation or decay. The second study station appears more arid and poorer in soil; this corresponds to the soil use history that is mostly identifiable in simple arid pastures, interspersed with parcels of wooded arid pastures, almond orchards, arborated arable lands, and barren or productive uncultivated parcels. Afterwards (from the 10s to the 70s of the XXth Century) when possible, the soil use was transformed into rainfed arable lands (mainly of mixed purposes), almond orchards, and arid pastures (for mixed use or as unstable rotational meadows). To limit soil erosion and desertification, reforestation through conifers (mainly *Pinus nigra cfr* var. *italica* and *P. halepensis* subsp. *halepensis*) was carried out on some surfaces. The soil of this station is relatively arid and poor, to the extent that even the reforested trees have developed slowly, very little, producing relatively few renewal seedlings.

The point 2b has a more discontinuous slope and two ecological conditions (upside and low side). Fewer emerging stones, of smaller clasts (pebbles), characterise the lower side and the substrate tends to be richer in silicates. The forest potential is more remarkable. Over here, we can also find a remarkable nitrophilic/ruderal effect attributable to recent human and grazing activities. In some points, the secondary succession is characterised by the presence of few young and slender shoots of *Ulmus minor* Mill. subsp. *minor*, *Prunus domestica* L., *Acer campreste* L. and of *Ailanthus altissima* (Mill.) Swingle, at the moment not threatening our studied thyme population. At times, the grasses can be taller, thicker, more florid, and richer in nitrophilic/ruderal species. In the surroundings, there are also scattered specimens of almond trees (mostly snag), scattered specimens (or small forest patches) of *Quercus pubescens* subsp. *pubescens* and a small reforested particle of *Pinus nigra* subsp. *nigra cfr* var. *italica*. Reforested particles are sited below the station, at the edge of the SS 5 road, not impacting nor threatening the *Th. vulgaris* population. Moreover, being on the edge of the inhabited centre, this population suffers in a more significant way (if compared to 2a) because of the human influence (urbanisation, vegetation trampling, and widespread wild and irregular excavations for the truffles harvesting). The upper side, close to the

top of the Colle Putano Mountain, is stonier (and rich in cobbles) characterised by some boulders and rocky outcrops, where *Th. vulgaris* could find primary habitat conditions in an open rocky garriga or under a thin arid forest. Over here, we can find few and not excessive impacting traces of recent pasture/grazing activities. The soil conditions are decisive during the years with particularly dry and hot climatic prolongated extreme events when even large or the most drought-tolerant species can be damaged by the extreme event stress. In those conditions, after almost four decades of agriculture/pasture abandonment, a certain soil and certain hydrogeological stability have been regained in undisturbed conifer reforestation and in other surfaces left in secondary succession, which have regained a certain soil quality and more structured wild vegetation patches, consisting of woodlands, shrub-lands, and even unused arid grasslands (slower succession). In the period during/after the Second World War, the changes in land uses caused the lowest forest coverage for the zone, with no more woods in the surroundings, and very rare and scattered trees and shrubs among pastures and crops [93].

The vegetational signs of the study localities and the evidence related to the observation of plant formations in similar conditions, in the surroundings, indicate that the potential vegetation is given by woody communities dominated by *Quercus pubescens*, characterised by a rather arid parasteppic nuance, by undergrowth garriga species, and by the relatively slow and scarce growth of the forest components.

In the first study station (Colle di More), due to the more evolved and piedmont soil, a more structured and developed forest is to be expected, albeit always accompanied by thermoxerophilic species such as *Pyrus spinosa*, *Spartium junceum*, and *Sorbus domestica*. These three species have been detected only in the first station and in the close surroundings related sigmeta. Regarding the second station (Colle Putano), the more marked characteristics of aridity and soil thinness make the termoxeric vegetation's characteristics more accentuated. In fact, it could be conceivable that *Pinus nigra* and *P. halepensis* could find a natural place at these conditions, together with *Celtis australis* L. subsp. *australis*, *Quercus ilex*, and *Acer monspessulanum* L. subsp. *monspessulanum*, as it can be considered for what happens to these species in the nearby stations [102], accompanied by the sporadic presence of *Prunus dulcis* of uncertain origin at the moment.

In impluvia or in areas characterised by thicker soils (greater loose substrate or richer in clayey), the expression (transgression) of mesophilic species such as *Cornus sanguinea* L. subsp. *hungarica* (Kárpáti) Soó and *Ulmus minor* subsp. *minor*, and *Prunus spinosa* L. is possible, thus indicating a moister condition gradient up to a mesic plant community (Figures 11–13). Around the second study site, some specimens of *Buxus sempervirens* L. were also scattered found, but they have recently been killed (or almost) by the infestation of the Box tree Moth [*Cydalima perspectalis* (Walker, 1859)], which is strongly spreading in the area (Figure 14). Regarding the second study case (Colle Putano), the characteristics of aridity and of poor tree development (growth and canopy cover) are confirmed by a nearby cadastral parcel occupied by a very small area of reforestation consisting of Mediterranean conifers (*Pinus halepensis* subsp. *halepensis*), which shows a remarkably reduced development and a little renewal unlike normal conditions (if compared to the average of other surrounding formations). This pines parcel, together with black pine (*Pinus nigra* subsp. *nigra cfr* var. *italica*) closer parcels, can be useful to be kept as a reference point for future monitoring activities. Around the second thyme studied population, we find specimens (or even cut bases, or snags) of almond trees. This surface consisted of an arborated (almond trees) arid pasture, and the soil was previously cultivated (at least partially), as a result of the cadastral archive consultation. The first study station was previously cultivated and then left as pastures following the typical rainfed agriculture rotation, consequently, it was left in secondary succession by agriculture abandon and then re-cultivated or disturbed by wildfires and vegetation removal (land cleaning), deleting consequently this thyme station.

Figure 11. An aspect of "Macerine" (right side) and, of the rocky environments with dejection fans which could provide primary habitats for *Th. vulgaris*; next to the station No.2a. Photo: Kevin Cianfaglione, 10 January 2022.

Figure 12. An aspect of the *Thymus vulgaris* subsp. *vulgaris* on rocky environments, accompanied by *Buxus sempervirens* (where more sand and debris are accumulated between rocks); station No.2b topside. Photo: Marinella Miglio, 1 May 2017.

Figure 13. An aspect of rocky environments with dejection fans where *Th. vulgaris* subsp. *vulgaris* find rocky primary habitats and, where in future it could find place even in the thin arid forest understory; station No.2b topside. Photo: Marinella Miglio, 1 May 2017.

Figure 14. An example of how *Buxus sempervirens* shrubs are generally looking recently in the study area (station 2a), killed or nearly, after the disease caused by the lepidoptera attack. In the best cases, as in the photo, it is possible to notice some small regrowth at the base. Photo: Kevin Cianfaglione, 10 January 2022.

Surrounding garriga and macchia are characterised by the presence of a lot of Orchidaceae, and other remarkable species such as *Salvia officinalis* L., by one of the largest known spots of *Ephedra major* Host. that was characterised by the biggest known specimens, which were destroyed due to an involuntary fire [103] caused by cigarette butts thrown on the roadside, and by rare and haggard specimens of *Cercis siliquastrum* L. and *Cotinus coggygria* Scop. The presence of the last species adds a biogeographical interest to the local vegetation because it belongs to the Italian peninsula southern distribution limit for this species [104]. A remarkable specimen of *Cotinus coggygria* and another one of *Buxus sempervirens* growing in the surroundings were recently eliminated, as they were ignored during some works [103]. A remarkable specimen of *Cercis siliquastrum* was destroyed for the same reasons near the SS5 national road.

5. Discussion

5.1. General Considerations

In wild conditions, *Thymus vulgaris* could be considered a remarkable species and worthy of attention. This species is considered a relatively rare plant especially at the local level, in Adriatic Central Italy.

We used our case study as an example through a multidisciplinary study to understand the native or non-native nature of *Th. vulgaris* in the study area. We have taken as an example and examined the two population localities from "Valle Subequana" Valley (Central Italy) since the only confirmed thyme community in the Adriatic central Italy (east-central Italian side) sector is here described with doubts about its indigenous status. Therefore, the opportunity was taken to make a literature analysis of the floristic, ecological, taxonomical, and biogeographical characteristics of *Th. vulgaris*, also making an overview on the phytosociological characteristics to resume the state of the art of knowledge about this species, to make comparisons applied to our case study.

What can be seen from literature is that *Th. vulgaris* is a species closely linked to human culture, in particular to the Mediterranean one; the consequence is that its natural presence can always be questioned, assuming a possible introduction or facilitation by man. This is even more likely in territories that have been inhabited or used for many centuries.

About the two thyme study localities, we can consider this species as a natural presence, both for the environmental context and for their population's characteristics, even though they may have been unintentionally favoured by a historical anthropic influence (disturbance and land-use history in the study area). Since the potential vegetation of the two studied stations corresponds to forest vegetation (thermoxeric woods dominated by *Quercus pubescens* subsp. *pubescens*), it is assumed that, in the original situation, these communities were displaced towards positions more exposed to natural erosion or on thinner soils (for example, on steep slopes, on screes at the edges of cliffs or rocky outcrops) that is where there are naturally more marked aridity conditions, which are consequently more unfavourable to tree species covers. The original (primaeval) *Th. vulgaris* position could consist of three cases: open rocky communities; thin forests characterised by an undergrowth rich in garriga species; or scattered specimens in various communities (as often happens in its native range, and that is the reason for which, often, is not considered to have a phytosiociologic diagnostic value).

Punctual and rare traces of possible residual primary habitats can be identified on the rocky outcrops and in more arid and thin soils (even under a potential cover of mature thin/arid forests). In other cases, *Th. vulgaris* could have transgressed from its primary locations to the surroundings, where it has found suitable conditions taking advantage of the human activities impact. The human activities pressure, at the same time, could have caused an equal degradation/regression of the primary environments to the extent of degenerating them, shifting them, or making them disappear. In this way, a shift in the species' presence and in the related communities was caused. At the plant landscape scale, in geobotanical terms [105], it means that *Th. vulgaris* transgressed towards the contact sigmeta disappearing from its original minorisigmeta. In the most arid conditions, it is

possible to imagine that *Th. vulgaris* has not shifted away, but it was reassembled in other communities (in more open conditions), following the disappearance of the thin forests where it was used to be part of the herbaceous layer.

In the first study station, *Th. vulgaris* was only in secondary conditions, up to now, after its disappearance due to human impact, no regeneration of this station has been noted, and no nearby stations have been found.

In the second study station, we found some portions that are of secondary type. Nevertheless, in some points, the general conditions of aridity, rocky, slope, and soil characteristics could allow some primary patches. Here, even a coexistence of *Th. vulgaris* subsp. *vulgaris* among the trees (thin forests undergrowth with garriga species) is conceivable, and this can be confirmed by the scarce growth and the low canopy coverage that even the conifers have shown, lesser than the norm. In the first and in the second station the soil often was artificially ameliorated (stone removal and terraced) to make it more suitable for agricultural and pastoral practices. Piles of stones (locally known as Macerine and Murziate) are present as evidence of this fact (see Figure 11). The consequence is that the soil has become thicker and less stony, this may have a negative impact on *Th. vulgaris* because the soil may have become more favorable for those species competing with the *Th. vulgaris* along the secondary succession.

Due to the anthropic pressure in the environment, *Thymus vulgaris* can have found displaced to a possible original condition, as it is known for other garriga and shrubs such as *Juniperus* species in similar environmental conditions, due to anthropic activities (i.e., in [106]), shifted from the original place to a secondary habitat, towards temporarily favourable conditions, following the human impact pressure dynamics. Long-term monitoring should be conducted to study the local stations' plant community dynamics in deeper detail. To look for where these species can persist on their own (primary conditions), where the forest is unable to develop to the point to prevent the permanence of the garriga species such as *Thymus vulgaris* (*viz*. where the soil/topsoil remains very arid, poor, or underdeveloped).

The disappearance of the *Th. vulgaris* population occurring in the first study station (Colle di More) is certainly due to recent human factors consequences, and this could lead to the hypothesis that also the other no longer found stations, reported in the past in central Adriatic Italy, may have disappeared in the same way. Consequently, those past presences can be re-evaluated, considering them as not necessarily naturalised.

Thymus vulgaris is a well-known species, strictly linked to the Mediterranean culture, the fact that this species is not known and is not used in the local popular tradition leads us to think that this plant could improbably have been voluntarily introduced or escaped to crops, even in the past.

The second study of thyme population disappearances makes us understand how much the residual stations (in particular those of central Adriatic Italy) of *Th. vulgaris* are very fragile and therefore strongly threatened. If on one hand, man may have favoured and spread this species (possible positive influence), these disappearing examples represent the possible negative influence of man on this species distribution. In line with the arguments laid by this work, if after the practicable targeted activities it is not possible to guarantee the perpetuation of *Th. vulgaris* in the zone in the long period and in primary conditions, only then plausible casual naturalisation could be hypothesised.

Lastly, a reflection should be made on the chorology of the taxon we studied. In fact, a particular feature of the studied *Th. vulgaris* populations is that they are located at the Italian central Adriatic (East) side, unlike the other populations of central Italy which are from the Tyrrhenian (West) side, and consequently placed in hotter conditions.

A conclusive observation about our *Th. vulgaris* stations vegetation, which arises from the human ecology research, is that *Th. vulgaris* is not known in the traditions of the study area (the species was not recognised as thyme while even other thyme-like species were recognised and used). This datum, complete and confirm the environmental characteristics and land-use history observations, excluding a possible ancient voluntary introduction of

Th. vulgaris in the study area. For all these reasons, following the precautionary principle, until proven otherwise the *Th. vulgaris* cannot be considered alien to the study area.

Only long-time monitoring with reintroduction tests in environments where this species could develop in a primary way could be able to dispel any further doubts.

These monitoring actions will also be useful if aimed to try to understand if these communities tend to be characterised by a dominant or by a sporadic presence of *Th. vulgaris* in primary conditions, and to observe the other possible community characteristics of primary habitats. At the same time, it is interesting to consider the influence of human activities in that long-time monitoring program to test how anthropogenic influence could advantage or not the secondary communities and their assembly.

5.2. Management Perspectives

In addition to the protection of primary environments and to the reconstitution of primary communities in other surrounding places, it could be interesting to think on actions for the protection or restoration of *Thymus vulgaris* secondary formations. This should be thought in secondary pastures (i.e., of grasslands, garriga, and arborated types), but also in other productive areas (such as olive, almond, and other orchards and groves), to save the traditional landscape elements or to rebuild/restore these typical formations. In both cases, in a multipurpose synergic way, by reasoned and rational choices, facing the heritage loss, the socio-economic changes, and the land degradation (i.e., crop changes, pollution, and urbanisation) could be managed.

These actions on secondary habitats must be designed with the aim of enhancing the land mosaic diversity of secondary habitats and preserving the heritage of the related traditional landscape elements rather than counteract the spontaneous land renaturalisation.

Mixed and synergic uses could be privileged such as arborated pastures, studied in order to maintain trees and at the same time to provide an adequate place for secondary formations that are suitable for the conservation of interesting/rare species, like *Th. vulgaris*. This spirit would combine, for example, the interests of the protection/reconstitution of almond orchards, with the need to conserve/restore secondary open formations by using non-forest spaces or spaces not yet recolonised by the secondary succession (respecting as much as possible the spaces now renaturalised or in the phase of renaturalisation).

These efforts should be conceived in relatively limited areas, preferring already used surfaces or where the human influence is stronger (i.e., closest areas to the villages or along the roads . . .). Arborated pastures could host some types of woody species (wild trees, fruit trees, shrubs, decorative/landscaping species, or other useful plants).

This type of management can contribute to preventing arsons, accidental fires, and wildlife damages, making a natural buffer zone to keep selected wildlife species away from agricultural and urban activities. This natural barrier could also help to avoid the propagation of diseases from the wild and vice versa. Wild or domestic trees and shrubs could find a place as emergency resources for the most endangered wildlife species, especially during the years of fodder scarcity.

These suggestions must be considered in targeted actions and programs carried out for biodiversity conservation and land management. They should be considered even to make human activities more sustainable, durable, and useful (in case they are applied in active pastures, and active woody crops and groves).

In that way, on one hand, it will be possible to restore or preserve the remnants of the ancient typical landscape uses, while on other hand, it will also be possible to leave other surfaces for other uses, even for renaturalisation purposes: through careful choices, scrupulous analysis, and correct territorial planning.

6. Conclusions

Thymus vulgaris is a species extremely linked to the human culture, in particular to the Mediterranean one; the consequence is that its natural presence can always be questioned, assuming possible positive or negative influences of man related to the species distribution

and to the plant community assembly characteristics. These doubts are always possible and legitimate for every species living in long inhabited territories or in areas influenced by the human presence for many centuries, also including the species for which this problem does not normally arise. Therefore, given the results of our study and the circumstances, we can consider *Th. vulgaris* presence in the study areas a native species. The species presence is to be considered as native, while the study communities are mostly secondary (semi-natural). The analysis of our two study stations shows that in disturbed communities the human impact can be the reason for species decay/extinction. On the other hand, often the fluctuations of the most undisturbed thyme communities can be linked to natural dynamics of senescence and to secondary succession trajectories.

The considerations we made and the discussions of our paper should be contemplated for future conservation, monitoring, and management programs aimed to foster sustainability, landscape, conservation, biodiversity, and environmental issues. Actions are recommended for monitoring this species dynamics and population trends in the end, in order to promote and adjust protection measures in the study area. This should be done to try to understand how to manage secondary habitats, in order to preserve them under human activities (to avoid conflicts between conservation measures and land uses) and, on the other hand, to identify and manage the closest point suitable to this species as primary habitats (to avoid conflicts between natural dynamics linked to biological successions). All this should be done in order to seek the best possible solutions for the species worthy of more attention, in favour of biodiversity and nature conservation.

Finally, in a more generic way, what is recommended to the local authorities, related to the vegetation and plants biodiversity, is to pay more attention in terms of giving more information to the inhabitants, and in terms of actions planning and works authorisations which may affect the vegetation in some way, in order to avoid risks for relevant specimens, species or communities.

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