

Possible Implications of Two Management Types in Olive Groves on Plant Diversity

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Summary

To evaluate the impact of two predominant management types (mowing vs. tilling) in olive groves on plant diversity, we have surveyed olive groves at ten localities in the surroundings of Šibenik (Dalmatia, Croatia). Among the surveyed groves, 12 were managed by tilling and 11 were managed by mowing. Altogether 323 taxa from 207 genera and 58 families were recorded. The families with the highest numbers of taxa were *Fabaceae*, *Poaceae*, *Cichoriaceae* and *Asteraceae*. Mowed olive groves were significantly richer in flora (280 taxa) in relation to the tilled ones (181 taxa), with 138 taxa in common to the both management types. An analysis of the life forms showed the domination of therophytes (54.18%) and the phytogeographical analysis showed that the most frequent floral element was Mediterranean (46.13%). Mowed olive groves almost exclusively contained endemic and endangered species while the invasive alien plant taxa were recorded mostly in the tilled olive groves. Mowing seems as much better management practice from the standpoint of the nature conservation. Based on its floristic composition and richness, tillage seems to completely remove the nursing effect that olive groves can provide for the dry grasslands listed in the Annex I of the Habitat Directive, which are otherwise, in open spaces without grazing exposed to disappearing through the process of secondary succession.

Key words

Mediterranean habitats, mowing, tillage, conservation, Croatia

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Introduction

Olive (*Olea europaea* L.) is one of the main crops in the Mediterranean area, with great economic importance particularly in Greece, Italy and Spain (Orlandi et al., 2004; Allen et al., 2006; Davy et al., 2007) as well as in Croatia (Šimunović, 2005). Row crops and grassland vegetation that develops in the olive groves contributes significantly to the overall biological and landscape diversity of the Mediterranean area (Siebert, 2005; Allen et al., 2006; Cardenas et al., 2006; Davy et al., 2007; Duarte et al., 2008; Maccherini et al., 2013). The vegetation in the ecosystem of the olive groves ensures stable conditions for the development of diverse animal habitats (Siebert, 2005; Allen et al., 2006; Stroosnijder et al., 2008). Unfortunately, in recent times, many small producers have abandoned the traditional way of cultivating olives, while olive groves are raised under more intensive management making systematic use of artificial fertilizers and pesticides and with more intensive weed control and soil management. This leads to a number of negative consequences: reduction of biodiversity, soil pollution with pesticides, erosion etc. (Duarte et al., 2008; Stroosnijder et al., 2008). All this has endangered biodiversity of Mediterranean basin known as one of the World's biodiversity hotspots (Mayers et al., 2000). A recent analysis made by Nikolić et al. (2008) and Jelaska et al. (2010) has confirmed Croatian coastal part as integral part of Mediterranean basin with its high biodiversity value. Olive groves have been very important constituent of that biodiversity in the past, when they were maintained by grazing or mowing. That way, olive groves actually provided nursing effect to the Mediterranean grasslands that are today listed on the Annex I of the Habitat Directive (e.g. Eastern sub-Mediterranean dry grasslands (*Scorzonero villosae-Chrysopogonetalia grylli* Horvatić et Horvat in Horvatić 1963) – NATURA2000 code 62A0, Council of Europe, 1992), as a consequence of overall abandonment of raising livestock.

On the Croatian coast, including the Šibenik-Knin County olive growing and vine growing have an exceptionally long tradition (Friganović, 1976; Šimunović, 2005). The meanings of olive growing and area under olive trees have changed throughout history, and in the last fifteen years, there was an upward trend in the number of fruit trees and the portion of olive groves in the total cultivated land (Tomić and Vranješ, 2006). Unfortunately, there is an increase in the share of new plantations with a more intensive way of farming, and a reduction in the share of small olive groves with a traditional method of cultivation. As a result of their particular plantation characteristics and farming practices, traditional plantations have potentially the highest biodiversity and landscape value, and the least negative effects on the environment. But in the whole Mediterranean area these plantations are also the least viable in economic terms and hence most vulnerable to abandonment (Duarte et al., 2006).

In Croatia there has been paid no special attention to the research of the flora of olive groves so far. Single data can be found in the works of authors who have explored the flora and vegetation of the localities in the Croatian coastal area. In the analysis of vegetation surrounding the Dubrovnik, Birač (1973) records a grassland community *Gastridio-Brachypodietum ramosi* Horvatić (1962) 1963 in olive groves, and in the review of the grassland vegetation on the island of Šipan, Hećimović

(1984) noted olive groves as habitats of several communities of the order *Thero-Brachypodietalia* Braun-Blanquet 1931 (1936): *Oryzopsetum miliaceae* Horvatić (1956) 1958 ex Birač 1973, *Brachypodio ramosi-Cymbopogonetum hirti* Horvatić 1961, *Gastridio ventricosi-Brachypodietum ramosi* Horvatić 1963 and *Trifolio cherleri-Brachypodietum rupestris* Hodak 1975. In the survey of the vegetation of the island of Murter, Pandža (2003) lists olive groves, among others, as habitats in which occurs a weed vegetation on moderately humid and moderately nitrified soils with root crops ass. *Tribulo-Amarantheum* Hodak 1962 ex Pandža et al. 2005 (class. *Stellarietea mediae* R. Tx. Lohm et Preising in R. Tx. 1950).

In a small number of floristic works, along with plant species in the lists of flora, "olive groves" are listed as a separate type of habitat (Regula-Bevilacqua and Jurković Bevilacqua, 1980; Hećimović and Hećimović, 1986, 1987). In remaining, majority of papers, olive groves are included within the widely accepted types of habitats such as "vineyards and olive groves" (Milović, 2002; Pandža, 1998; Pandža and Milović, 2008); "olive groves and orchards" (Hećimović, 1981), "cultivated surfaces" (Milović and Pandža, 2010), "fields" and "cultures" (Domac, 1955). Therefore, from the above works, it is not possible to extract the number of taxa and species composition of the flora of olive groves as a specific type of habitat. In presenting the flora of the island of Rava, Pandža and Milović (2008) specifically set aside olive groves as important habitats for endangered plants from the orchid family (*Orchidaceae*).

The principle aim of our study was to investigate the floristic composition of olive groves in the Šibenik area, with special emphasis on comparing two predominant management types (i.e. mowing vs. tilling) and their influence on plant diversity. Additional aim was to estimate importance of olive groves as habitat types for conservation of plant diversity across the coastal area of Croatia.

Researched area

The survey of the flora of olive groves was conducted in the wider area of Tribunj, Dazlina, Donje polje and Grebaštica, in the coastal area of the Šibenik-Knin county, South Croatia (Figure 1).

The relief of this area is characterized by a plateau developed on Paleogenic and Cretaceous limestone, whose continuity is broken by limestone hills and dolomite-flysh valleys (Mamužić et al., 1966). Soils suitable for agricultural production are scarce: the limestone plateau is represented by shallow and skeletal red soil ("terra rossa"), while deeper soils with a greater capacity for water are found in the valleys, where they were made by the deteriorating of softer rock, marl and dolomite (Friganović, 1976; Kranjec, 1958).

According to data from weather stations in Šibenik for the period 1976-2006, mean annual temperature is 15.4°C and mean annual precipitation 773.8 mm. The area is characterized with a Mediterranean climate with warm, dry summers, and moderately cold, wet winters. According to the Köppen Climate classification applied on the area of Croatia (Bertović, 1975), the Šibenik area has a Csax" Mediterranean climate type usually referred to as the "olive tree climate".

Regarding the phytogeographical position (Trinajstić, 1998), the researched area completely belongs to the Eumediterranean zone characterized by the zonal evergreen forest association *Fraxino orni-Quercetum ilicis* Horvatić (1956) 1958.

Material and methods

Field researches of the floristic composition of olive groves have begun in the fall of 2007 and were completed in the summer of 2009. The study was conducted on 23 olive groves situated on ten localities in the wider area of Šibenik (Figure 1, Table 1). The investigated olive groves are privately owned, they have small surfaces (an average of 2000 m²), with no irrigation system and low use of fertilizers and pesticides. Most of the olive groves are either in direct contact or in close proximity to the surrounding natural vegetation, which facilitates the immigration of plants from their natural habitats. According to these characteristics these are olive groves with a predominantly traditional way of cultivation, with the main difference in the treatment of soil and ground vegetation: in 11 olive groves the ground layer vegetation between the trees is periodically mowed, while 12 olive groves are periodically tilled by a mini rotary tillers. Management types were designated based on visual inspection and information from the groves owners where available. Physiognomy of the developed ground layer vegetation among the two designated types was so striking different, that we are sure that a-priori classification was correct even for groves where we couldn't contact the owners. Eight groves were surveyed throughout complete vegetation season from March till October (marked with asterisk in Table 1), while the rest were visited two or three times in March and June.

The taxa were identified by the following keys and books: Horvatić and Trinajstić (1967), Tutin et al. (1968–1980, 1993); Trinajstić (1975–1986), Pignatti (1982), Domac (1994). Nomenclature follows Nikolić (2014). The taxa are listed in an alphabetical order of families, genera and species. For each taxon a numeric mark that indicates whether it was found in tilled (1) and / or in a mowed olive grove (2) are given.

Raunkier's life forms were assigned to taxa based on Pignatti (1982) and marked with the standard abbreviations in the flora list before the name of the species: Ch (Chamaephyta), G (Geophyta), H (Hemicryptophyta), P (Phanerophyta) and T (Therophyta). If more than one life form was quoted for a single taxon, the most appropriate one was chosen considering field observations in the studied area.

The classification of taxa according to chorological types was adjusted according to Horvatić (1963) and Horvatić et al. (1967/1968). For species that are not listed in these two sources, data from Pignatti (1982) and Fournier (1961) was used and adjusted to basic groups. The belonging of a species to a certain floral element in the flora list has been indicated by the respective abbreviation: Mediterranean plants (MED), South-European plants (SEU), European plants (EU), Eurasian plants (EUS), Circum-Holarctic plants (CIHO), Widespread plants (WSP) and Cultivated and Adventitious plants (CUAD).

Species considered to be endemic according to NIKOLIĆ (2013) are denoted with the abbreviation "end" in the flora list. The endangered status of species was used as categorized

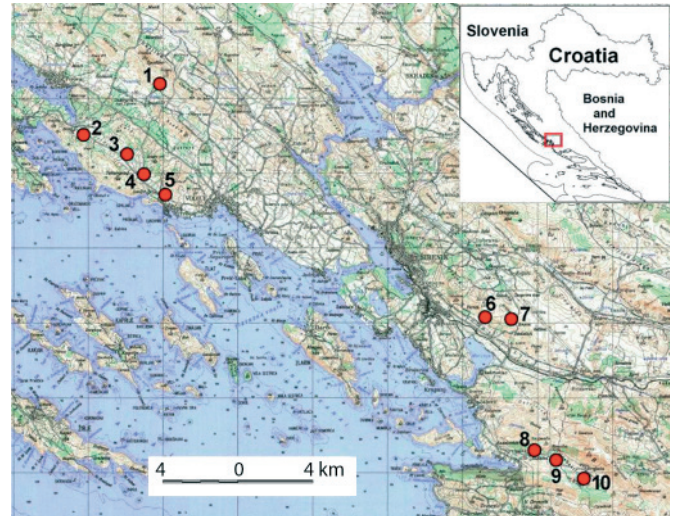


Figure 1. The area of Šibenik with the position of localities of surveyed olive groves: 1-Dazlina, 2-Ivinj, 3-Ivinj draga, 4-Sovje, 5-Tribunj, 6-Donje polje, 7-Bikarac, 8-Grebaštica, 9-Konoba, 10-Brnjača

Table 1. List of the researched olive groves with their size, management practice and name of locality (shown in Figure 1). Groves marked with asterisk (*) were surveyed throughout complete vegetation season. Coordinates corresponds to Bessel ellipsoid, Gauss-Krüger projection (Transverse Mercator), 5th zone

No.	Coordinates of the olive groves	Surface (m ²)	Managed practice	Locality
1	x=5555568; y=4850145	2500	mowing	Ivinj
2	x=5555620; y=4850354	5000	tilling	Ivinj
3	x=5558103; y=4849112	2200	mowing	Ivinj draga
*4	x=5558581; y=4848831	1400	mowing	Ivinj draga
*5	x=5558039; y=4849082	1500	tilling	Ivinj draga
*6	x=5558682; y=4848701	1100	tilling	Ivinj draga
7	x=5556600; y=4849628	2500	tilling	Ivinj draga
*8	x=5559094; y=4847462	1400	mowing	Sovje
9	x=5558928; y=4848794	2000	mowing	Sovje
10	x=5558984; y=4848763	3000	tilling	Sovje
11	x=5560270; y=4846697	2500	mowing	Tribunj
*12	x=5560053; y=4846721	1000	tilling	Tribunj
*13	x=5561760; y=4852533	1400	mowing	Dazlina
*14	x=5561420; y=4652824	2000	tilling	Dazlina
15	x=5577579; y=4838995	1500	tilling	Donje polje
16	x=5578757; y=4840174	3000	mowing	Bikarac
17	x=5578911; y=4840150	1500	tilling	Bikarac
18	x=5579531; y=4833006	2500	tilling	Grebaštica
19	x=5580695; y=4832836	2000	tilling	Konoba
20	x=5581650; y=4832342	2500	tilling	Konoba
21	x=5582043; y=4831650	2000	mowing	Brnjača
22	x=5582793; y=4831893	2200	mowing	Brnjača
23	x=5582767; y=4831839	1800	mowing	Brnjača

in Nikolić and Topić (2005) and Nikolić (2013) and marked by standard abbreviations, pointing out their degree of threat: CR-Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened. The lower categories of endangerment like LC-Low

Concern and *DD-Data Deficient* have not been analyzed in this paper. Taxa protected by the Nature Protection Act (Anonymus, 2013a) and listed in the Ordinance on Designating Wild Taxa Protected (Anonymus, 2013b) are denoted as “spr^c”-strictly protected. Species considered to be invasive alien species according to Boršić et al. (2008) are denoted with the abbreviation “IAS”.

For comparison of plant assemblage between surveyed groves with presence/absence data, we have employed PCoA (Principal Coordinate Analyses) analyses based on square complement of Jaccard index of similarity as a distance measure using PrCoord and CANOCO 4.5 software (ter Braak and Šmilauer, 2002; Lepš and Šmilauer, 2003) on complete sample, and cluster analyses with “complete linkage” as agglomerative method with City-block (Manhattan) distances, for building dendrogram in Statistica 8.0 software (StatSoft) for eight groves (four mowed and four tilled) for which we had data collected throughout complete vegetation season.

Results

Flora analysis

On the 23 studied olive groves 323 taxa of higher plants originating in 207 genera and 60 families were observed (Table 2), with dominance of Magnoliopsida (83% of taxa) in comparison to Liliopsida (17% of taxa). On 11 mowed olive groves 280 taxa were found, while flora on the 12 tilled olive groves consisted of 181 taxa (Appendix 1). Two management types shared 138 taxa (42.73% of all taxa), while flora unique to mowed groves was much richer (142 taxa; 43.96%) than that found only in tilled groves (43 taxa; 13.31%).

Table 2. Taxonomical analysis of the olive groves flora of the Šibenik area

Taxa	Magnoliopsida	Liliopsida	Total
Families	50	10	60
Genera	174	33	207
Species	235	49	284
Subspecies	33	6	39
Species & subspecies	268	55	323

Table 3. The most represented families in the flora of the researched olive groves

Families	Flora of all olive groves (N=23)		Flora of tilled groves (N=12)		Flora of mowed groves (N=11)	
	No. of taxa	%	No. of taxa	%	No. of taxa	%
<i>Fabaceae</i>	40	12.38	21	11.60	36	12.86
<i>Poaceae</i>	34	10.53	22	12.15	32	11.43
<i>Cichoriaceae</i>	26	8.05	11	6.08	23	8.21
<i>Asteraceae</i>	22	6.81	13	7.18	20	7.14
<i>Brassicaceae</i>	17	5.26	11	6.08	15	5.36
<i>Caryophyllaceae</i>	17	5.26	13	7.18	15	5.36
<i>Lamiaceae</i>	17	5.26	5	2.76	16	5.71
<i>Scrophulariaceae</i>	12	3.72	7	3.87	10	3.57
<i>Apiaceae</i>	11	3.41	6	3.31	10	3.57
<i>Geraniaceae</i>	10	3.10	7	3.87	7	2.50
<i>Rosaceae</i>	10	3.10	5	2.76	9	3.21
<i>Euphorbiaceae</i>	8	2.48	6	3.31	4	1.43
<i>Chenopodiaceae</i>	6	1.86	6	3.31	1	0.36
Other families	93	28.79	48	26.52	82	29.29
Total	323	100.00	181	100.00	280	100.00

The most abundant families in the flora of the olive groves (Table 3) were *Fabaceae* (12.38%), *Poaceae* (10.53%), *Cichoriaceae* (8.05%) and *Asteraceae* (6.81%), without significant differences in percentages when compared between management types, while absolute number of observed taxa was much higher in mowed groves in all four most abundant families. The families *Chenopodiaceae* and *Amaranthaceae* are almost exclusively represented in the flora of the tilled olive groves, which is expected because these families contain weed and ruderal species. On the other hand, *Cichoriaceae* and *Lamiaceae* are somewhat more frequent in the flora of the mowed olive groves, while *Caryophyllaceae*, *Euphorbiaceae* and *Geraniaceae* are slightly more frequent in the flora of the tilled olive groves (Table 3).

Life form spectra (Table 4), with the highest share of therophytes (54.18%) and hemicryptophytes (25.70%), confirmed their affiliation to the Mediterranean area. However, distinct differences can be observed between two management types, where in tilled groves there is higher share of therophytes (67.96% vs. 51.79% in mowed) and lower share of hemicryptophytes (19.89% vs. 26.79% in mowed).

Mediterranean floral element as most frequent (46.13%), followed by South-European (20.43%) was expected (Table 5). Floral elements in the flora of the mowed and tilled olive groves showed significant differences between mowed and tilled olive groves as a consequence of a stronger anthropogenic influence on the tilled olive groves. Therefore, in tilled olive groves there is a reduced share of Mediterranean plants (33.15% vs 50.36% in mowed), and an increased share of widespread plants (30.39% vs 15.36% in mowed) as well as cultivated and adventitious plants (4.42% vs 0.71% in mowed).

Five plant species having status of invasive ones were recorded (1.55% of all taxa), with just two of them being recorded also in the mowed groves (Table 6). Endemic taxa (7) were found only in the mowed olive groves: *Aurinia sinuata*, *Carduus microp-terus* ssp. *micropterus*, *Centaurea spinosociliata* ssp. *crystata*, *Chaerophyllum coloratum*, *Ophrys x flavicans*, *Tanacetum cin-erariifolium* and *Trifolium dalmaticum*.

Out of eight threatened taxa i.e. *Delphinium peregrinum* (EN); *Ophrys bertolonii*, *O. sphegodes* ssp. *atrata* and *Trifolium*

Table 4. The life forms spectra of the flora of the surveyed olive groves

Life form	Flora of all olive groves		Mowed groves (N=11)		Tilled groves (N=12)	
	No. of taxa	%	No. of taxa	%	No. of taxa	%
Chamaephyta	19	5.88	18	6.43	4	2.21
Geophyta	26	8.05	24	8.57	10	5.52
Hemicryptophyta	83	25.70	75	26.79	36	19.89
Phanerophyta	20	6.19	18	6.43	8	4.42
Therophyta	175	54.18	145	51.79	123	67.96
Total	323	100.00	280	100.00	181	100.00

Table 5. The share of floral elements in the flora of the surveyed olive groves

Floral elements	Flora of all olive groves (N=23)		Mowed groves (N=11)		Tilled groves (N=12)	
	No. of taxa	%	No. of taxa	%	No. of taxa	%
Cult. & Adventitious	9	2.79	2	0.71	8	4.42
Circum-Holarctic	1	0.31	1	0.36	0	0.00
European	7	2.17	7	2.50	3	1.66
Eurasian	29	8.98	26	9.29	20	11.05
Mediterranean	149	46.13	141	50.36	60	33.15
South-European	66	20.43	60	21.43	35	19.34
Widespread	62	19.20	43	15.36	55	30.39
Total	323	100.00	280	100.00	181	100.00

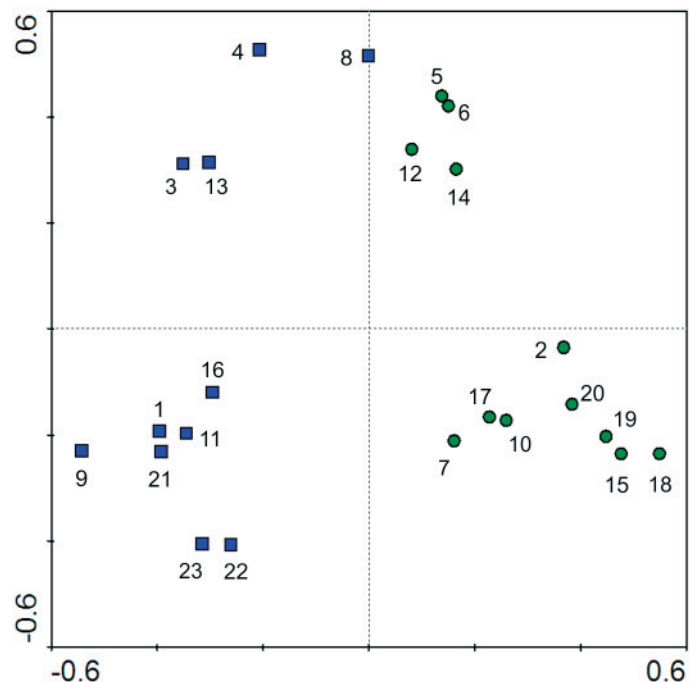
Table 6. Comparison of flora between two types of olive grove managements

Category	Flora of all olive groves		Flora of mowed groves		Flora of tilled groves	
	No. of taxa	% of total flora (323)	No. of taxa	% of total flora (280)	No. of taxa	% of total flora (181)
Endemic	7	2.17	7	2.50	0	0.00
Threatened	8	2.48	8	2.86	2	1.10
Strictly protected	12	3.72	12	4.29	1	0.55
Invasive Alien Sp	5	1.55	2	0.71	5	2.76

resupinatum (VU); *Aegilops neglecta*, *Centaurea spinosociliata* ssp. *cristata*, *Chaerophyllum coloratum* and *Scandix pecten-veneris* (NT) found in mowed groves, only two (*T. resupinatum*, *S. pecten-veneris*) were found also in tilled groves. Out of twelve strictly protected taxa, just one (*Trifolium resupinatum*) were found both in mowed and tilled groves, while remaining eleven were found exclusively in mowed olive groves.

Results of the PCoA analyses (Figure 2) has shown that olive groves with different management practices are differentiated from each other. Four mowed and four tilled groves that are positioned to the upper part of the biplot are those which were sampled throughout whole vegetation season (March – October). Those remained grouped within same management practice after cluster analyses (Figure 3) showing significant differences in species assemblages.

Figure 2. PCoA biplot of all sampled olive groves (with square complement of Jaccard index of similarity as a distance measure) on first two ordinal axes (1st axis explaining 9.6% and 2nd axis further 8.2% of variation). Squares – mowed olive groves; circles – tilled olive groves (numerical labels of groves corresponds to those in Table 1).



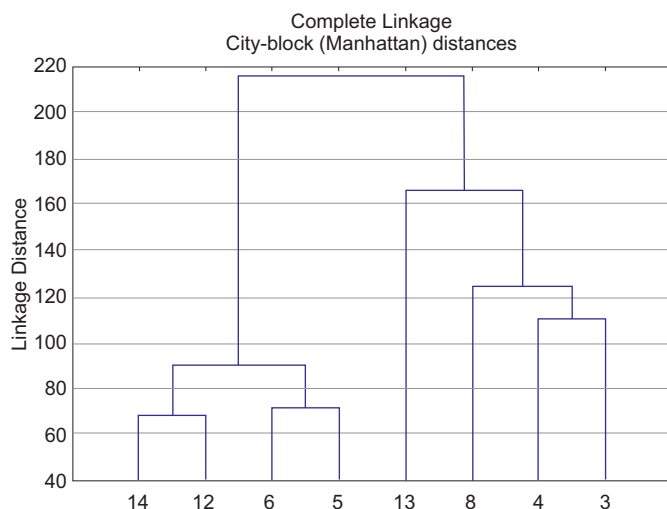


Figure 3. Dendrogram of cluster analyses of presence/absence data on vascular plant species in eight olive groves (numerical labels of groves corresponds to those in Table 1). Left cluster consisted of tilled, and right one of mowed groves.

Discussion and conclusion

Flora of the studied olive groves is very rich (323 of taxa) and represents a share of as much as 30% of the total flora of the wider Šibenik area (1075 of taxa; Milović, 2002). High richness of the vascular flora in olive groves have been recorded in other parts of the Mediterranean (Huqu et al., 2009; Maccherini et al., 2013; Perrini et al., 2014), confirming importance of olive groves as habitats important for plant diversity conservation (and hence the overall diversity).

As expected, by the number of taxa, the mowed olive groves (280) were considerably richer than the tilled olive groves (181). Periodic mowing of the ground layer in olive groves, prevents their overgrowth, and favors the development of different types of dry Mediterranean grasslands that are rich in species (Hećimović, 1984; Pandža, 2003). On the other hand, in the tilled olive groves the ground layer vegetation is periodically completely removed, which reduces the total number of taxa. Nevertheless, this research shows that even in tilled olive groves, without the use of herbicides or with their limited use, a rich weed flora can develop. In contrast, Uremis (2005) lists only 92 taxa for olive groves with an intensive form of treatment and the systemic use of pesticides, in the area of the Province of Hatay in Turkey.

The most abundant families in the flora of the olive groves (Table 3) are almost identical to the percentages of these families in the total flora of the Šibenik area (Milović, 2002). These families are also most prevalent in the flora of ancient olive groves of Apulia in Southern Italy (Perrino et al., 2014), weed flora of the olive groves in the province of Hatay in Turkey (Uremis, 2005) and weed flora of olive groves in Albania (Huqi et al., 2009) as well as in the agrestal and ruderal flora of the southern Spain (Pujadas Salva and Hernandez Bermejo, 1988). These families are rich in thermophilous species whose dispersal is significantly

facilitated by the humans. As it is, their presence indicates the Mediterranean character of the climate, as well as the strong and long-lasting anthropogenic impact. In general, there are no significant differences in the prevalence of certain families in the flora of the tilled olive groves in comparison with the mowed olive groves flora (Table 3).

As expected, therophytes are the dominant life form in the flora of the olive groves (54.18%; Table 4), which is a general characteristic of the flora in areas with a Mediterranean climate (Horvat, 1949). On the other hand, therophytes are a reliable indicator of anthropogenic impact. Therefore, researchers of the urban flora note a correlation between an increased share of therophytes in the flora of habitats and parts of the city with higher anthropogenic impacts (Chronopoulos and Christodoulakis, 2003; Hruska, 1993/1994). For weed flora in the olive groves with an intensive form of treatment Uremis (2005) states that the share of therophytes is over 70%. Therophytes, as reliable indicators of anthropogenic influence, are also confirmed by this study, according to which their share in flora of tilled olive groves (stronger anthropogenic influence) is significantly higher than in mowed olive groves (67.96% vs 51.79%). On the other hand, in the flora of the tilled olive groves, compared to mowed, there is a reduced share of all other life forms, particularly hemicryptophytes (19.89% vs 26.79%).

As expected, in the flora of all surveyed olive groves, the most frequent floral elements were Mediterranean (46.3%) followed by South-European (20.43%) and widespread plants (19.2%, Table 3). These three floral elements are also the most frequent in the total flora of the wider Šibenik area (Milović, 2002). The dominant presence of plants of Mediterranean floral element is recorded in the flora of olive groves in Albania (Huqi et al., 2009) and Italy (Perrino et al., 2014) as well. There is a surprisingly low proportion of cultivated and adventitious plants, whose share, even in the flora of the tilled olive groves, is about half (4.42%) the share in the flora of the wider Šibenik area (8.09%; Milović, 2002). It can be assumed that this group of plants, in the Šibenik area, is more related to agricultural fields with other cultures and/or ruderal habitats.

Only five plant species (1.55% of total number of taxa) with invasive status according to Boršić et al. (2008) were recorded. As expected, invasive alien species are more prevalent in tilled than in mowed olive groves (2.76% vs 0.71%). Tilled groves have higher level of disturbance that facilitate the presence of invasive species (Walter et al., 2005; Vilá et al., 2007; Nikolić et al., 2013), while in the mowed groves there is a significantly greater competition from native grassland species. *Conyza sumatrensis* and *Diploaxis eruroides* are frequent on tilled olive groves, but they are quite rare on mowed olive groves. Both species are common throughout the Šibenik area, in arable land (vineyards) and in ruderal habitats by the settlements and along the roads. Invasive species *Amaranthus albus* and *A. retroflexus* were found only in the tilled olive groves where they come within the weed community *Tribulo-Amaranthetum*. Neophyte *Bidens subalternans* is rare in the flora of the researched olive groves (found in two of the twelve plowed olive groves), but is observed as very widespread in ruderal habitats throughout the Šibenik area. This research indicates that the flora of small olive groves with a traditional form of treatment shows a certain degree of

resistance to the penetration of new invasive species. Although the number of invasive alien species in the olive groves of the Šibenik area is not worrisome, the possible immigration of new species should be monitored in order to promptly take steps to suppress their spread. All above observed and discussed differences in olive groves were supported with the multivariate analyses (Figure 2 and 3).

Because of the abandonment of traditional farming and the lack of mowing and grazing, once large areas under dry Mediterranean grasslands gradually disappear and are overrun by thickets and forests (Ljubičić et al., 2008; Maccherini et al., 2013), so these types of habitats, with many grassland species, are among the most vulnerable in the Croatian area. It is therefore an even greater importance of small family olive groves which are maintained by mowing or grazing as refuges for the preservation of endangered habitat types and species. In recent years, because of the increased use of herbicides in arable land, as well as in tilled olive groves, some weed species are becoming increasingly rare (e.g. *Scandix pecten-veneris*, *Calendula arvensis*, *Chenopodium album*, *C. strictum*, *Papaver rhoeas*, *Trigonella esculenta*, *Urtica urens*).

Complete lack of endemic plants, and just two endangered plant found in tilled groves, compared to seven endemic and eight endangered plants in mowed ones, further confirmed that mowing is much better management practice from the standpoint of nature conservation. Tillage completely removes nursing effect that olive groves can provide for the dry grasslands listed in the Annex I of the Habitat Directive, which are otherwise, in open spaces without grazing exposed to disappearing through the process of secondary succession.

In the Šibenik area and throughout the Croatian coast a traditional way of growing olives, which yield less crops than those in intensively managed groves, but contributes to the maintenance of biological and landscape diversity and has the least adverse effect on the environment (including less erosion), should be encouraged.

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Appendix 1. Floristic list of the surveyed olive groves.

(management practice: 1-tilling, 2-mowing; life form: Ch (Chamaephyta), G (Geophyta), H (Hemicryptophyta), P (Phanerophyta) and T (Therophyta); chorological types (floral element): Mediterranean plants (MED), South-European plants (SEU), European plants (EU), Eurasian plants (EUAS), Circum-Holarctic plants (CIHO), Widespread plants (WSP) and Cultivated and Adventitious plants (CUAD); endemic – “end”; endangered status: CR (Critically Endangered), EN (Endangered), VU (Vulnerable), NT (Near Threatened); “spr”- strictly protected; invasive alien species – “IAS”).

Magnoliophytina *Magnoliopsida*

Amaranthaceae

- T *Amaranthus albus* L.; 1; CUAD; IAS
T *Amaranthus graecizans* L.; 1; WSP
T *Amaranthus retroflexus* L.; 1; CUAD; IAS

Anacardiaceae

- P *Pistacia lentiscus* L.; 2; MED
P *Pistacia terebinthus* L.; 2; MED

Apiaceae

- H *Chaerophyllum coloratum* L.; 2; MED; end; NT; spr
H *Daucus carota* L. ssp. *carota*; 1, 2; SEU
H *Eryngium amethystinum* L.; 1, 2; MED
H *Eryngium campestre* L.; 1; MED
H *Foeniculum vulgare* Mill.; 1, 2; MED
T *Orlaya grandiflora* (L.) Hoffm.; 2; SEU
T *Scandix pecten-veneris* L.; 1, 2; WSP; NT
T *Tordylium apulum* L.; 1, 2; MED
T *Tordylium maximum* L.; 2; EUAS
T *Tordylium officinale* L.; 2; MED
T *Torilis nodosa* (L.) Gaertn.; 2; MED

Araliaceae

- P *Hedera helix* L.; 2; EU

Aristolochiaceae

- G *Aristolochia clematitis* L.; 2; SEU

Asteraceae

- H *Achillea millefolium* L.; 1; WSP
 T *Anthemis arvensis* L.; 1, 2; WSP
 T *Anthemis segetalis* Ten.; 1, 2; MED
 H *Aster linosyris* (L.) Bernh.; 2; SEU
 T *Bidens subalternans* DC.; 1; CUAD; IAS
 T *Calendula arvensis* L.; 1, 2; SEU
 H *Carduus micropterus* (Borbás) Teyber ssp. *micropterus*; 2; MED; end; spr
 H *Carduus pycnocephalus* L.; 1, 2; MED
 H *Carlina corymbosa* L. ssp. *corymbosa*; 2; MED
 H *Centaurea spinosociliata* Seenus ssp. *cristata* (Bertol.) Dostál; 2; MED; end; NT; spr
 T *Conyza sumatrensis* (Retz.) E.Walker; 1, 2; CUAD; IAS
 T *Crupina crupinastrum* (Moris) Vis.; 1, 2; SEU
 H *Dittrichia viscosa* (L.) Greuter; 1, 2; MED
 T *Filago pyramidata* L.; 1, 2; SEU
 Ch *Helichrysum italicum* (Roth) G. Don ssp. *italicum*; 2; MED
 H *Inula conyza* DC.; 2; SEU
 T *Pallenis spinosa* (L.) Cass.; 1, 2; MED
 H *Picnomon acarna* (L.) Cass.; 2; MED
 T *Senecio vulgaris* L.; 1, 2; WSP
 Ch *Tanacetum cinerariifolium* (Trevir.) Sch.Bip.; 2; MED; end; spr
 T *Tyrimnus leucographus* (L.) Cass.; 2; MED

Boraginaceae

- T *Anchusa cretica* Mill.; 2; MED
 T *Echium plantagineum* L.; 1, 2; MED
 T *Heliotropium europaeum* L.; 1; MED
 T *Lithospermum arvense* L.; 1, 2; EUAS
 T *Myosotis ramosissima* Rochel; 2; EUAS

Brassicaceae

- Ch *Aethionema saxatile* (L.) R. Br.; 2; SEU
 T *Alyssum alyssoides* (L.) L.; 1, 2; SEU
 T *Alyssum campestre* (L.) L.; 1, 2; MED
 H *Arabis hirsuta* (L.) Scop.; 2; WSP
 H *Aurinia sinuata* (L.) Griseb.; 2; MED; end; spr
 Ch *Brassica oleracea* L.; 1; CUAD
 T *Capsella rubella* Reut.; 1, 2; MED
 T *Cardamine hirsuta* L.; 1, 2; WSP
 T *Clypeola jonthlaspi* L.; 2; MED
 T *Diplotaxis erucoides* (L.) DC.; 1, 2; MED; IAS
 T *Diplotaxis muralis* (L.) DC.; 1, 2; WSP
 H *Diplotaxis tenuifolia* (L.) DC.; 1, 2; WSP
 T *Erophila verna* (L.) Chevall. ssp. *praecox* (Steven) Walters; 1, 2; WSP
 T *Hornungia petraea* (L.) Rchb.; 2; WSP
 H *Lepidium graminifolium* L.; 2; SEU
 T *Raphanus sativus* L.; 1; CUAD
 T *Thlaspi perfoliatum* L.; 1, 2; EUAS

Campanulaceae

- H *Campanula rapunculus* L.; 2; EUAS
 T *Legousia hybrida* (L.) Delarbre; 1, 2; SEU

Caprifoliaceae

- P *Lonicera etrusca* Santi; 2; MED

Caryophyllaceae

- T *Arenaria serpyllifolia* L. ssp. *leptoclados* (Reichenb.) Guss.; 1, 2; EUAS
 T *Arenaria serpyllifolia* L. ssp. *serpyllifolia*; 1, 2; WSP

- T *Cerastium brachypetalum* Pers. ssp. *roeseri* (Bois. et Heldr.) Nyman; 1; SEU
 T *Cerastium glomeratum* Thuill.; 1; WSP
 T *Cerastium pumilum* Curtis ssp. *glutinosum* (Fries) Jalas; 1, 2; WSP
 T *Cerastium semidecandrum* L.; 1, 2; SEU
 H *Herniaria incana* Lam.; 2; SEU
 T *Holosteum umbellatum* L. ssp. *umbellatum*; 1, 2; EUAS
 T *Minuartia hybrida* (Vill.) Schischkin in Komarov; 1, 2; EUAS
 T *Minuartia mediterranea* (Link.) K. Maly; 1, 2; MED
 T *Petrorhagia prolifera* (L.) P. W. Ball et Heywood; 1, 2; EUAS
 H *Petrorhagia saxifraga* (L.) Link; 2; SEU
 H *Silene latifolia* Poir.; 2; MED
 H *Silene vulgaris* (Moench) Garcke ssp. *angustifolia* Hayek; 1, 2; MED
 T *Stellaria media* (L.) Vill.; 1, 2; WSP
 T *Stellaria pallida* (Dumort) Piré; 1, 2; EUAS
 T *Velezia rigida* L.; 2; MED

Chenopodiaceae

- T *Atriplex patula* L.; 1; WSP
 H *Beta vulgaris* L. ssp. *vulgaris*; 1; MED
 T *Chenopodium album* L.; 1, 2; WSP
 T *Chenopodium strictum* Roth; 1; WSP
 T *Chenopodium vulvaria* L.; 1; SEU
 T *Polycnemum majus* A. Braun; 1; SEU

Cichoriaceae

- H *Chondrilla juncea* L.; 1, 2; EUAS
 T *Crepis foetida* L. ssp. *foetida*; 1, 2; SEU
 T *Crepis neglecta* L.; 1, 2; MED
 T *Crepis sancta* (L.) Babç.; 1, 2; MED
 T *Crepis vesicaria* L. ssp. *taraxacifolia* (Thuill.) Thell.; 2; SEU
 T *Crepis vesicaria* L. ssp. *vesicaria*; 2; SEU
 T *Crepis zacintha* (L.) Babç.; 2; MED
 T *Hedypnois cretica* (L.) Dum.Cours.; 2; MED
 H *Hieracium praealtum* Vill. ex Gochnat ssp. *bauhini* (Besser) Petunn.; 2; EUAS
 H *Hypochoeris cretensis* (L.) Bory et Chaub.; 2; MED
 H *Hypochoeris radicata* L.; 2; SEU
 H *Lactuca serriola* L.; 1; WSP
 H *Lactuca viminea* (L.) J. et C.Presl; 2; SEU
 H *Leontodon crispus* L.; 2; SEU
 H *Leontodon tuberosus* L.; 2; MED
 H *Picris hieracioides* L.; 1, 2; EUAS
 H *Reichardia picroides* (L.) Roth; 1, 2; MED
 T *Rhagadiolus stellatus* (L.) Gaertn.; 1; MED
 H *Scolymus hispanicus* L.; 1, 2; MED
 H *Scorzonera laciniata* L.; 2; WSP
 T *Sonchus asper* (L.) Hill ssp. *glaucescens* (Jord.) Ball; 1; MED
 T *Sonchus oleraceus* L.; 1; WSP
 T *Sonchus tenerrimus* L.; 1, 2; MED
 T *Taraxacum laevigatum* auct. croat.; 2; SEU
 H *Tragopogon porrifolius* L.; 2; MED
 H *Urospermum dalechampii* (L.) Scop. ex F.W.Schmidt; 2; MED
 T *Urospermum picroides* (L.) Scop. ex F.W.Schmidt; 2; MED

Cistaceae

- Ch *Fumana ericifolia* Wallr.; 2; MED

Clusiaceae

- H *Hypericum perforatum* L.; 1, 2; SEU

Convolvulaceae

H *Convolvulus althaeoides* L. ssp. *tenuissimus* (Sibth. et Sm.) Stace; 1, 2; MED

G *Convolvulus arvensis* L.; 1, 2; WSP

H *Convolvulus cantabrica* L.; 2; SEU

Crassulaceae

Ch *Sedum ochroleucum* Chaix; 2; SEU

Ch *Sedum sexangulare* L.; 2; SEU

Dipsacaceae

H *Cephalaria leucantha* (L.) Roem. et Schult.; 2; MED

T *Lomelosia brachiata* (Sm.) Greuter et Burdet; 2; MED

Euphorbiaceae

T *Chrozophora tinctoria* (L.) A. Juss.; 1; MED

T *Euphorbia chamaesyce* L.; 1; SEU

T *Euphorbia falcata* L.; 1, 2; SEU

Ch *Euphorbia fragifera* Jan; 2; MED

T *Euphorbia helioscopia* L.; 1, 2; WSP

T *Euphorbia peplus* L.; 1; WSP

Ch *Euphorbia spinosa* L.; 2; MED

T *Mercurialis annua* L.; 1; WSP

Fabaceae

H *Anthyllis vulneraria* L. ssp. *praepropera* (A. Kerner) Bornm.; 2; MED

Ch *Argyrolobium zanonii* (Turra) P. W. Ball; 2; MED

H *Bituminaria bituminosa* (L.) Stirton; 1, 2; MED

P *Coronilla emerus* L. ssp. *emeroides* Boiss. et Spruner; 2; MED

T *Coronilla scorpioides* (L.) Koch; 1, 2; MED

H *Coronilla varia* L.; 1, 2; EU

Ch *Dorycnium hirsutum* (L.) Ser.; 2; MED

T *Hippocrepis biflora* Spreng.; 2; MED

T *Hippocrepis ciliata* Willd.; 1; MED

T *Lathyrus cicera* L.; 1, 2; MED

H *Lathyrus latifolius* L.; 1, 2; SEU

T *Lens nigricans* (M. Bieb.) Godr.; 2; MED

T *Medicago coronata* (L.) Bartal.; 1, 2; MED

T *Medicago littoralis* Rohde ex Loisel.; 2; MED

T *Medicago lupulina* L.; 2; WSP

T *Medicago minima* (L.) Bartal.; 1, 2; WSP

T *Medicago orbicularis* (L.) Bartal.; 1, 2; MED

T *Medicago rigidula* (L.) All.; 2; MED

H *Medicago sativa* L.; 1, 2; WSP

T *Onobrychis caput-galli* (L.) Lam.; 2; MED

H *Ononis pusilla* L.; 1; SEU

T *Ononis reclinata* L.; 2; MED

T *Scorpiurus muricatus* L.; 1; MED

T *Securigera securidaca* (L.) Degen et Dörf.; 1, 2; MED

P *Spartium junceum* L.; 2; MED

T *Trifolium angustifolium* L.; 2; MED

T *Trifolium campestre* Schreber; 1, 2; WSP

T *Trifolium dalmaticum* Vis.; 2; MED; end; spr

T *Trifolium resupinatum* L.; 1, 2; MED; VU; spr

T *Trifolium scabrum* L.; 2; MED

T *Trifolium stellatum* L.; 2; MED

T *Trifolium tomentosum* L.; 2; MED

T *Trigonella esculenta* Willd.; 1, 2; MED

T *Trigonella monspeliaca* L.; 1, 2; MED

T *Vicia angustifolia* L. ssp. *angustifolia*; 1, 2; EU

T *Vicia faba* L.; 1; CUAD

T *Vicia hybrida* L.; 1, 2; MED

T *Vicia narbonensis* L.; 1, 2; MED

T *Vicia peregrina* L.; 2; SEU

T *Vicia villosa* Roth ssp. *varia* (Host) Corb.; 2; MED

Fumariaceae

T *Fumaria officinalis* L.; 1, 2; WSP

T *Fumaria parviflora* Lam.; 1; WSP

Geraniaceae

T *Erodium ciconium* (L.) L. Hér.; 1, 2; MED

T *Erodium cicutarium* (L.) L. Hér.; 1, 2; WSP

T *Erodium malacoides* (L.) L. Hér.; 1; MED

T *Geranium columbinum* L.; 2; EUAS

T *Geranium dissectum* L.; 2; WSP

T *Geranium molle* L. ssp. *brutium* (Gasparr.) Graebn.; 1, 2; MED

T *Geranium molle* L. ssp. *molle*; 1; WSP

T *Geranium purpureum* Vill.; 2; SEU

T *Geranium rotundifolium* L.; 2; EUAS

G *Geranium tuberosum* L. ssp. *tuberosum*; 1; EUAS

Lamiaceae

T *Acinos arvensis* (Lam.) Dandy; 2; EU

T *Ajuga chamaepitys* (L.) Schreb.; 1, 2; MED

H *Calamintha nepetoides* Jord.; 2; SEU

H *Clinopodium vulgare* L.; 2; WSP

T *Lamium amplexicaule* L.; 1, 2; EUAS

H *Marrubium incanum* Desr.; 2; MED

H *Mentha longifolia* (L.) Huds.; 1; WSP

Ch *Micromeria juliana* (L.) Benth. ex Rchb.; 2; MED

H *Origanum heracleoticum* L.; 2; MED

H *Origanum vulgare* L.; 2; EUAS

H *Salvia bertolonii* Vis.; 2; MED

H *Salvia verbenaca* L.; 2;

Ch *Satureja montana* L. ssp. *variegata* (Host) P. W. Ball; 1, 2; MED

H *Stachys thirkei* K.Koch; 2; MED

Ch *Teucrium chamaedrys* L.; 2; SEU

Ch *Teucrium polium* L. ssp. *capitatum* (L.) Arcang.; 2; MED

H *Thymus longicaulis* C.Presl; 2

Linaceae

H *Linum bienne* Mill.; 2; MED

Ch *Linum tenuifolium* L.; 2; SEU

Malvaceae

T *Althaea hirsuta* L.; 1, 2; SEU

H *Malva sylvestris* L.; 1; WSP

Oleaceae

P *Phillyrea latifolia* L.; 2; MED

Papaveraceae

T *Papaver rhoeas* L.; 1, 2; WSP

T *Papaver strigosum* (Boenn.) Schur; 1, 2; MED

Plantaginaceae

H *Plantago lanceolata* L.; 1, 2; WSP

Plumbaginaceae

Ch *Plumbago europaea* L.; 1, 2; MED

Polygalaceae

H *Polygala nicaeensis* Risso ex Koch ssp. *mediterranea* Chodat; 2; MED

Polygonaceae

T *Fallopia convolvulus* (L.) Á.Löve; 1; WSP

T *Polygonum aviculare* L.; 1, 2; WSP

H *Rumex pulcher* L. ssp. *pulcher*; 1, 2; SEU

Portulacaceae

T *Portulaca oleracea* L.; 1; WSP

Primulaceae

- T *Anagallis arvensis* L.; 1, 2; WSP
 T *Anagallis coerulea* Schreb.; 1, 2; WSP
 T *Asterolinon linum-stellatum* (L.) Duby; 2; MED
 G *Cyclamen hederifolium* Aiton; 2; SEU

Ranunculaceae

- G *Anemone hortensis* L.; 2; MED
 P *Clematis flammula* L.; 1, 2; MED
 T *Delphinium peregrinum* L.; 2; SEU; EN; spr
 T *Nigella damascena* L.; 2; MED
 G *Ranunculus ficaria* L. ssp. *calthifolius* (Rchb.) Arcang.; 2; EU

Resedaceae

- H *Reseda lutea* L.; 1, 2; WSP
 H *Reseda phyteuma* L.; 1, 2; SEU

Rhamnaceae

- P *Paliurus spina-christi* Mill.; 1, 2; MED

Rosaceae

- H *Agrimonia eupatoria* L.; 2; CIHO
 H *Potentilla australis* Krašan; 2; MED
 G *Potentilla recta* L.; 1, 2; EUAS
 P *Prunus cerasifera* Ehrh.; 1; CUAD
 P *Prunus dulcis* (Mill.) D. A. Webb; 2; CUAD
 P *Prunus mahaleb* L.; 2; SEU
 P *Rosa canina* L.; 1, 2; WSP
 P *Rubus caesius* L.; 2; EUAS
 P *Rubus heteromorphus* Ripart ex Genev.; 1, 2; MED
 H *Sanguisorba minor* Scop. ssp. *muricata* Briq.; 1, 2; SEU

Rubiaceae

- T *Galium aparine* L.; 1, 2; WSP
 P *Rubia peregrina* L.; 2; MED
 T *Sherardia arvensis* L.; 1, 2; WSP
 T *Valantia muralis* L.; 2; MED

Santalaceae

- P *Osyris alba* L.; 1, 2; MED

Saxifragaceae

- T *Saxifraga tridactylites* L.; 1, 2; MED

Scrophulariaceae

- T *Euphrasia rostkoviana* Hayne; 2; EU
 T *Kickxia spuria* (L.) Dumort.; 1; EUAS
 H *Linaria angustissima* (Loisel.) Borbás; 1, 2; SEU
 T *Linaria simplex* (Willd.) DC.; 1; MED
 T *Misopates orontium* (L.) Raf.; 1, 2; EUAS
 T *Odontites lutea* (L.) Clairv.; 2; SEU
 T *Verbascum orientale* (L.) All.; 2; MED
 H *Verbascum pulverulentum* Vill.; 2; SEU
 H *Verbascum sinuatum* L.; 2; MED
 T *Veronica cymbalaria* Bodard; 1, 2; SEU
 T *Veronica hederifolia* L.; 1, 2; EUAS
 T *Veronica polita* Fr.; 1, 2; EUAS

Solanaceae

- T *Solanum villosum* Mill.; 1, 2; SEU

Theligonaceae

- T *Theligonum cynocrambe* L.; 1, 2; SEU

Ulmaceae

- P *Ulmus minor* Miller; 1; WSP

Urticaceae

- T *Urtica urens* L.; 1; WSP

Valerinaceae

- T *Valerianella discoidea* (L.) Loisel.; 2; MED

- T *Valerianella echinata* (L.) DC.; 2; MED
 T *Valerianella locusta* (L.) Laterrade; 2; MED
 T *Valerianella muricata* (Stiven ex M. Bieb.) J.W.Loudon; 1, 2; MED
 T *Valerianella pumila* (L.) DC.; 2; MED

Verbenaceae

- H *Verbena officinalis* L.; 1; WSP

Violaceae

- T *Viola arvensis* Murray; 1, 2; WSP
 T *Viola kitaibeliana* Schultes; 1, 2; MED

Vitaceae

- P *Vitis vinifera* L.; 1, 2; WSP

Zygophyllaceae

- T *Tribulus terrestris* L.; 1, 2; SEU

LILIOPSIDA**Amaryllidaceae**

- G *Allium ampeloprasum* L.; 1, 2; MED
 G *Allium carinatum* L.; 1, 2; EU
 G *Allium roseum* L.; 1, 2; MED
 G *Allium subhirsutum* L.; 2; MED

Araceae

- G *Arum italicum* Mill.; 2; MED
 H *Biarum tenuifolium* (L.) Schott; 2; MED

Asparagaceae

- G *Asparagus acutifolius* L.; 1, 2; MED

Colchicaceae

- G *Colchicum hungaricum* Janka; 2; MED

Cyperaceae

- H *Carex distachya* Desf.; 2; MED
 G *Carex flacca* Schreb. ssp. *serrulata* (Biv.) Greuter; 2; MED

Iridaceae

- G *Hermodactylus tuberosus* (L.) Mill.; 2; MED

Liliaceae

- G *Muscari comosum* (L.) Mill.; 1, 2; SEU
 G *Muscari neglectum* Guss. ex Ten.; 1, 2; MED
 G *Ornithogalum collinum* Guss.; 2; SEU
 G *Ornithogalum refractum* Kit. ex Schltr.; 2; SEU
 Ch *Ruscus aculeatus* L.; 2; MED

Orchidaceae

- G *Ophrys bertolonii* Moretti; 2; SEU; VU; spr
 G *Ophrys scolopax* Cav. ssp. *cornuta* (Steven) E.G.Camus; 2; MED; spr
 G *Ophrys sphegodes* Miller ssp. *atrata* (Lindley) E. Mayer; 2; MED; VU; spr
 G *Ophrys x flavicans* Vis.; 2; MED; end; spr

Poaceae

- T *Aegilops geniculata* Roth; 2; MED
 T *Aegilops neglecta* Req. ex Bertol.; 2; MED; NT
 T *Aegilops triuncialis* L.; 1, 2; MED
 T *Avena barbata* Pott ex Link; 1, 2; WSP
 T *Avena sterilis* L.; 1, 2; SEU
 T *Brachypodium distachyon* (L.) P.Beauv.; 2; MED
 H *Brachypodium retusum* (Pers.) P.Beauv.; 2; MED
 H *Bromus erectus* Huds.; 2; WSP
 T *Bromus hordeaceus* L.; 1, 2; WSP
 T *Bromus madritensis* L.; 1, 2; MED
 T *Bromus rigidus* Roth; 1, 2; SEU
 T *Bromus sterilis* L.; 1, 2; WSP
 T *Bromus tectorum* L.; 2; EUAS

- H *Cleistogenes serotina* (L.) Keng; 2; SEU
 G *Cynodon dactylon* (L.) Pers.; 1; WSP
 T *Cynosurus echinatus* L.; 1, 2; SEU
 H *Dactylis glomerata* L. ssp. *glomerata*; 1, 2; EUAS
 H *Dactylis glomerata* L. ssp. *hispanica* (Roth) Nyman; 1, 2; MED
 T *Dasypyrum villosum* (L.) P.Candargy; 1, 2; SEU
 T *Desmazeria rigida* (L.) Tutin; 2; MED
 H *Dichanthium ischaemum* (L.) Roberty; 2; SEU
 G *Elymus repens* (L.) Gould; 1, 2; WSP
 T *Hordeum murinum* L. ssp. *leporinum* (Link) Arcang.; 1, 2; MED
 H *Lolium perenne* L.; 1, 2; EU
 T *Lolium rigidum* Gaudin ssp. *rigidum*; 1, 2; SEU
 T *Lophochloa cristata* (L.) Hyl.; 1, 2; WSP
 H *Melica ciliata* L.; 2; EUAS
 T *Phleum echinatum* Host; 2; MED
 T *Phleum subulatum* (Savi) Asch. et Graebn.; 1, 2; MED
 T *Poa annua* L.; 1, 2; WSP
 H *Poa bulbosa* L.; 1, 2; EUAS
 T *Setaria viridis* (L.) P.Beauv.; 1; EUAS
 H *Stipa bromoides* (L.) Dörf.; 2; MED
 T *Vulpia ciliata* Dumort.; 1, 2; SEU
Smilacaceae
 P *Smilax aspera* L.; 2; MED

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