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PLANT COMMUNITIES IN URBAN HABITATS OF ISTANBUL-TURKEY

VOLKAN ALTAY[1*], İBRAHİM İLKER ÖZYİĞİT[2] AND CELAL YARCI[2]

[1]*Department of Biology, Science and Arts Faculty, Mustafa Kemal University, 31040, Antakya, Hatay, Turkey*
[2]*Department of Biology, Science and Arts Faculty, Marmara University, 34722, Göztepe, Istanbul, Turkey*
**Corresponding author E-mail: valtay@mku.edu.tr; Phone: +90 326 245 58 66; Fax: + 90 326 245 58 67*

Abstract

This study aims to analyze and classify distribution of urban vegetation as plant communities in Anatolian Side of Istanbul Turkey. The study was carried out in all districts of the Anatolian side excluding Şile and in total, 223 quadrates were recorded during 2004-2009 vegetation periods. Braun-Blanquet method was used for classification. As a result of the study, a total of 13 plant communities distributed in the study area was found. The plant groups were; *Sarcopoterium spinosum*, *Erica manipuliflora*, *Tordylium apulum*, *Sinapis arvensis*, *Rapistrum rugosum*, *Carduus pycnocephalus*, *Carduus nutan*s, *Centaurea iberica*, *Centaurea solstitialis* subsp. *solstitialis*, *Rumex crispus*, *Ammi visnaga*, *Cichorium intybus* and *Parietaria judaica*. The floristic, ecologic and syntaxonomic analyses of these plant groups were realized and their distributions in the study area were given. Additionally, some soil properties such as maximum water holding capacity, pH**,** electrical conductivity, organic matter, $CaCO_3$, P_2O_5, K_2O and texture (sand, silt and clay) were analyzed. The formation and development conditions of them were described and discussed at the end of the paper. Protection against damage of this vegetation or at least protection of the existent situation was presented as suggestions.

Introduction

Cities represent amazing range of habitats such as remnant natural, semi natural, modified or newly created habitats with their associated plants and animals (Gilbert, 1989; Jim & Chen, 2008). The destruction of natural ecosystems resulted in urbanization, followed by conversion of the land into built up structures and man made new habitats such as lawns, gardens, parks, meadows, small woodlands, ponds, hedges and ditches (Honu *et al*., 2009). However, floristic species composition in cities is closely related with human activities (Hope *et al*., 2003). Population increase and demand of land for infrastructure has resulted in destruction of existing vegetation and inadequate planting sites and lower quality of ecological environment and human health (Jim, 2000; Jackson, 2003).

Urban habitats occur with the presence of large numbers of people and infrastructure of urban areas that is associated with climate, hydrology, substrate, disturbance regime and management practices (Pickett *et al*., 2001; Turner *et al*., 2005). Trampling, vehicular movement, building activities (residential and industrial); transport links (roads, pavements, railways, canals); and open land required for parking vehicles and disposal of wastes recurrently affect vegetation, hence, only those species capable of regenerating after repeated disturbance become residents of urban habitats (Gilbert, 1989; Benvenuti, 2004). The cultivation of alien species of trees, shrubs and herbs imported from distant regions of the world has been recognized as important component of urban vegetation (Honu *et al*., 2009). Such practices, however, have affected indigenous vegetation and have negative impact on floristic diversity of native plant species (Ali & Malik, 2010).

In urban areas, demolition of buildings and subsequent leveling produces bare substrates composed of building rubble (usually brick or concrete) mixed with finer material (often containing a large amount of mortar) and in those areas plant communities, which are definitively urban in character are formed (Gilbert, 1989; 1992). The conditions are often not uniform across in those types of sites, but are usually low in organic material, reasonably fertile (though often lacking nitrogen), rapidly draining and alkaline (Gilbert, 1989). Limited nutrient and water availability, together with disturbance caused by rock fall and grazing, restricts the establishment of vigorous species and promotes early successional species rich plant communities similar to semi-natural grasslands (Davis, 1982; Gilbert, 1989).

The ecological surveys are necessary for an adequate characterization of a plant community. The vegetation in the disturbed areas does not reflect a naturally evolved species composition, but rather a mixture of small remnant native plants patches dominated by patches of largely invasive weedy alien plants, and areas of mixed native and non native plants. There are few undisturbed habitats left in some parts of the world. Plant ecologists have placed increasing emphasis on a functional understanding of vegetation (Lehsten & Kleyer, 2007). The response of plant communities to environmental change is generally studied by analyzing the composition of plant traits across communities. A lot of work has been done in ordinating the tropical, temperate, deciduous, desert and calcareous types of vegetation, whereas lesser work has been reported from disturbed vegetation. The ecological surveys of such disturbed areas were conducted by few researchers, in order to understand the damage made to ecology of the area and also to understand the diversity and dispersion status of species in the area (Muhammad *et al*., 2008; Shah *et al*., 2010).

Materials and Methods

Study area: Istanbul is located in the northwest part of Turkey (41^o 01.2' N, 28^o 58.2' E) and extends both on European (Thrace) and Asian (Anatolia) sides of the Bosphorus. The study area (Asian side) is located on east side of Istanbul 40^o 48' and 41^o 16' in latitude and 29^o 04' and 29^o 58' in longitude (Altay *et al*., 2010a; Yasar *et al*., 2010; Municipality, 2011). Its neighbors are the Black Sea in the north, Marmara Sea in the south, Kocaeli City in the east and Bosphorus in the west (Fig. 1).

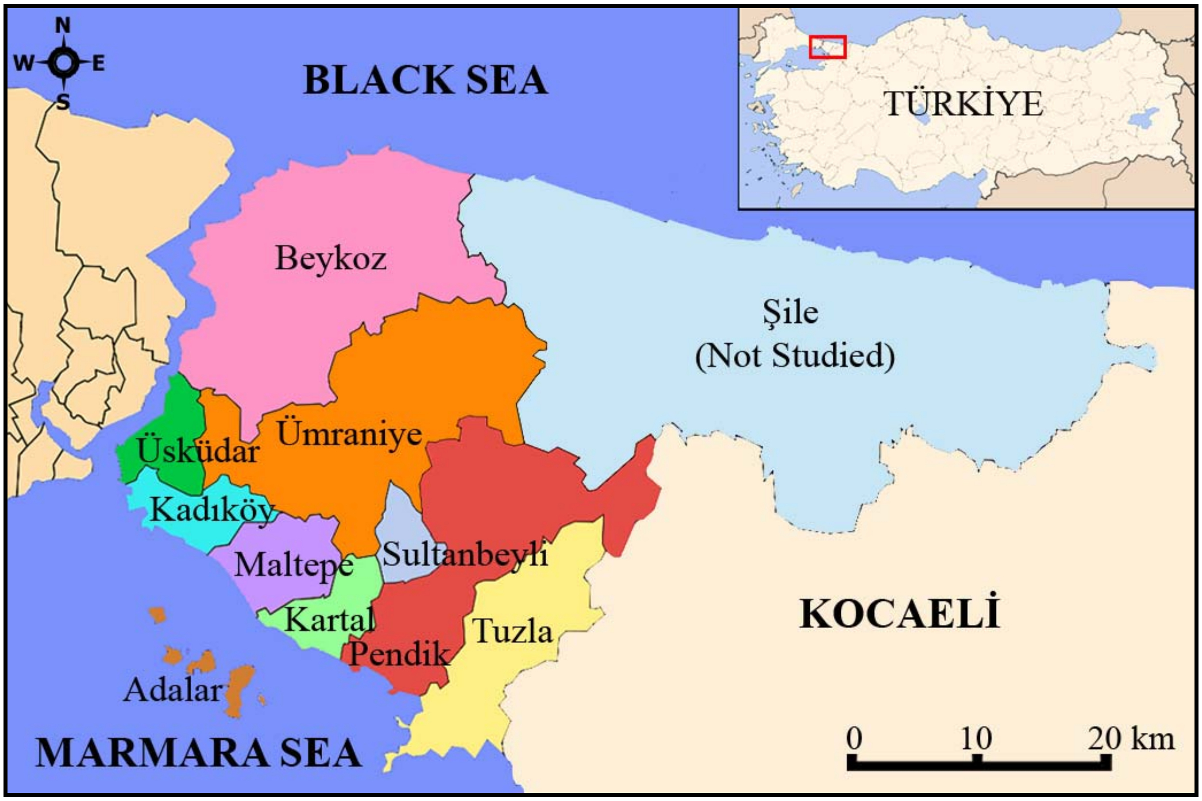

Fig. 1. Districts studied in Istanbul during 2004-2009 (Adalar, Beykoz, Kadıköy, Kartal, Maltepe, Pendik, Sultanbeyli Tuzla, Ümraniye, and Üsküdar).

Study sites: The study was realized in 10 different districts of Asian side, which follows as Adalar, Beykoz, Kadıköy, Kartal, Maltepe, Pendik, Sultanbeyli Tuzla, Ümraniye and Üsküdar during 2004-2009 vegetation periods. For this purpose, the study area was extensively surveyed, and the available species at selected sites were enlisted based on 223 quadrates. The details of plant community structure with dominant species were reported.

Climate: The climate of the research area is typical four-season continental climate of the Mediterranean Region. In the summer, less precipitation and high temperature are characteristic and the annual mean temperature is 14.5^{o}C for the last two decades. Between May and September the temperature is generally above 30^{o}C and between November and April it is rarely below 0^{o}C. In the vegetation period, the daily mean temperature is approximately 8^{o}C, which lasts for about 280 days (between 15 March and 20 December). January and February are the coldest months (mean low -3.2^{o}C) while July and August are the warmest (mean high 28.5^{o}C). Annual precipitation is about 690.7 mm; the highest precipitation occurs in winter (Anon., 2009; Altay *et al.*, 2010a, b; Osma *et al*., 2010; Yasar *et al*., 2010).

Geology: Geological age of the research area consists of a sedimentary sequence from Ordovician to Carboniferous, which reaches several thousand meters. In the research area, structural features of arkose and quartzite are seen (Tuysuz, 2003; Yasar *et al*., 2010).

Soil analysis: Soil samples were collected with a soil borer at a depth of 30 cm. from each quadrate and fed through a 2-mm sieve. Soil texture was determined by using hygrometer method (Bouyoucos, 1962). Percentage values of the three textural fractions, clay (0-2 μm), silt (2-50 μm) and sand (50-2000 μm), were characterized according to a soil texture triangle. Electrical conductivity was determined according to USDA (1954). Soil pH was measured with an electronic pH-meter in a 1:2.5 soil/water suspension. $CaCO_3$ were determined with volumetric methods by using a calcimeter. Organic matters were measured according to Smith & Weldon (1941). Plant-available soil phosphorus was determined spectrophotometrically with Olsen method (Black, 1965).

Ecological analysis of the plant communities: The plants were identified according to "Flora of Turkey and the East Aegean Islands" (Davis, 1965-1985) and preserved in MUFE Herbarium (Marmara University, Science and Arts). Ecological data were recorded using random quadrate sampling method. Totally, 223 fixed quadrates, which ranged from 9 to 25 m^2 were used at each site and all individual plants in the quadrates were counted. For the classification of vegetation the Braun-Blanquet approach (Braun-Blanquet, 1932), which is recognized world-wide (Westhoff & Van der Maarel, 1980; Pignatti, 1995), was used. Life forms of all identified communities were mentioned according to Raunkiaer (1934). For syntaxonomic nomenclature and synonyms of the higher levels of classification Mucina (1997) and Rivas-Martinez *et al*., (1999) were followed.

Results and Discussion

In this study, 13 different plant communities were observed in 223 quadrates. The observed communities were named with dominant species names, which are *Sarcopoterium spinosum*, *Erica manipuliflora*, *Tordylium apulum*, *Sinapis arvensis*, *Rapistrum rugosum*, *Carduus pycnocephalus*, *Carduus nutans*, *Centaurea iberica*, *Centaurea solstitialis* subsp. *solstitialis*, *Rumex crispus*, *Ammi visnaga*, *Cichorium intybus* and *Parietaria judaica*. The most remarkable taxa in the community and their observed months were given in Table 1.

In the study area, while *Erica manipuliflora* communities were observed in non-destroyed open lands, which are near forests or natural areas near the edge of the city, the remaining communities were observed in urban lands. *Rapistrum rugosum* and *Sinapis arvensis* communities are not only widespread, but also the communities with the highest number of taxa (Table 2). Unlike other communities, *Parietaria judaica* community is represented with less quadrate and taxa numbers because of its distribution on walls (Altay *et al*., 2010b). Additionally, it was observed that *Erica manipuliflora* community preferred higher altitudes (Table 2).

Table 1. Plant community names, the most remarkable taxa in the community and their observed months.

Plant community	The most remarkable taxa in the community	Observed months
Sarcopoterium spinosum	*Dactylis glomerata* subsp. *hispanica, Scabiosa columbaria* subsp. *columbaria*, *Avena sterilis* subsp. *sterilis*	May-July
Erica manipuliflora	*Cistus salviifolius, Lavandula stoechas* subsp. *stoechas, Dactylis glomerata* subsp. *hispanica, Bellis perennis*, *Brachpodium sylvaticum*	October-November
Tordylium apulum	*Carduus pycnocephalus*, *Euphorbia helioscopia*, *Calendula arvensis, Avena sterilis* subsp. *sterilis*, *Hordeum murinum* subsp. *leporinum*.	April-May
Sinapis arvensis	*Carduus pycnocephalus*, *Sonchus asper* subsp. *glaucescens*, *Sinapis arvensis*	April-June
Rapistrum rugosum	*Carduus pycnocephalus*, *Sonchus asper* subsp. *glaucescens, Avena sterilis* subsp. *sterilis*, *Bromus sterilis*	April-June
Carduus pycnocephalus	*Sonchus asper* subsp. *glaucescens*, *Galium aparine*, *Sinapis arvensis*	April-May
Carduus nutans	*Carduus pycnocephalus*, *Sonchus asper* subsp. *glaucescens, Avena sterilis* subsp. *sterilis*, *Malva sylvestris*	May-June
Centaurea iberica	*Plantago lanceolata, Echium vulgare, Cynodon dactylon* var. *dactylon*, *Plantago coronopus* subsp. *coronopus*	May-July
Centaurea solstitialis subsp. *solstitialis*	*Plantago lanceolata, Cichorium intybus*, *Centaurea diffusa*	June-August
Rumex crispus	*Carduus pycnocephalus*, *Sonchus asper* subsp. *glaucescens, Bromus sterilis*, *Malva sylvestris*	April-July
Ammi visnaga	*Carduus pycnocephalus*, *Agrostis capillaris* var. *capillaris*, *Scabiosa columbaria* subsp. *columbaria*	June-August
Cichorium intybus	*Plantago lanceolata, Sonchus asper* subsp. *glaucescens*, *Bromus sterilis*	June-October
Parietaria judaica	*Sonchus asper* subsp. *glaucescens, Galium aparine, Mercurialis annua, Euphorbia helioscopia, Stellaria media* subsp. *media*, *Cymbalaria muralis* subsp. *muralis*	April-May

Table 2. Some ecological parameters of plant communities.

Plant community	Quadrate number	Taxa number	Plant cover %	Average plant high cm.	Altitude m.	Slope %
Sarcopoterium spinosum	15	92	80-100	60-80	2-209	5-45
Erica manipuliflora	10	35	75-100	60-80	160-236	5-30
Tordylium apulum	9	44	90-100	40-80	0-200	5-45
Sinapis arvensis	31	102	75-100	100-150	0-155	5-45
Rapistrum rugosum	58	116	60-100	100-150	0-232	5-45
Carduus pycnocephalus	18	74	85-100	100-150	0-111	5-45
Carduus nutans	11	72	75-100	140-180	0-213	5-30
Centaurea iberica	14	50	80-100	60-80	35-161	5-10
Centaurea solstitialis subsp. *solstitialis*	9	60	85-100	80-120	16-164	5-20
Rumex crispus	13	75	95-100	120-140	0-201	5-30
Ammi visnaga	13	71	80-100	80-120	3-158	5-45
Cichorium intybus	17	71	65-100	80-120	1-104	5-45
Parietaria judaica	5	7	75-90	30-50	-	-

Soil characteristics such as saturation, pH, electrical conductivity (EC), $CaCO_3$, organic matter, P_2O_5, K_2O, % values of sand, clay and silt, and soil texture of the areas where plant communities distributed were given in Table 3. As seen in the table, while soil pH values of the areas where *Erica manipuliflora* community distributed were acidic (5.63), pH values of the areas that other communities distributed were close to the neutral values. This situation suggests that *Erica manipuliflora* community was present only in open lands as mentioned above and the pH values in those areas are acidic. *Sinapis arvensis* and *Rapistrum rugosum* communities were observed in areas with higher EC values. The lowest soil EC values were measured in the areas where *Erica manipuliflora* community was distributed. It was observed that *Rumex crispus*, *Ammi visnaga*, and *Cichorium intybus* communities prefer soils with higher $CaCO_3$ like some urban areas where their soils are include rubble from construction activities. Additionally, the soils where *Erica manipuliflora* community was distributed did not contain $CaCO_3$. *Tordylium apulum* community preferred soils with higher organic composition, while *Centaurea solstitialis* subsp. *solstitialis* community soils with higher organic composition. The highest P_2O_5 values were measured in the areas where *Carduus pycnocephalus* community was distributed. *Sarcopoterium spinosum* and *Erica manipuliflora* communities were distributed in soils with the lowest P_2O_5. In the study area, while *Carduus pycnocephalus* community was distributed in soils with higher K_2O, *Centaurea solstitialis* subsp. *solstitialis* community preferred lower K_2O concentrations. It was observed that *Sarcopoterium spinosum* and *Cichorium intybus* communities preferred sandy clay loamy (SCL) soils, while the remaining preferred sandy and loamy soils in the study area. Additionally, the soil values were not studied for *Parietaria judaica* community since it is a member of wall flora (Altay *et al*., 2010a, b).

Table 3. Soil characteristics of areas where plant communities distributed.

Plant community	Saturation %	pH	EC mmhos /cm	$CaCO_3$ %	Organic matter %	P_2O_5 Kg/da	K_2O Kg/da	Sand %	Clay %	Silt %	Texture
Sarcopoterium spinosum	43	7.09	0.53	3.52	1.69	2.88	17.55	58	20	22	SCL
Erica manipuliflora	44	5.63	0.25	0.00	3.63	2.88	21.06	64	15	21	SL
Tordylium apulum	59	7.52	0.58	8.00	4.60	11.22	64.35	57	17	26	SL
Sinapis arvensis	40	7.50	1.12	6.96	1.51	12.45	35.10	67	14	19	SL
Rapistrum rugosum	44	7.53	1.09	10.42	1.51	11.83	35.10	60	18	22	SL
Carduus pycnocephalus	55	7.35	0.64	6.00	3.15	39.16	56.16	61	18	21	SL
Carduus nutans	46	7.45	0.53	8.40	3.87	19.11	69.03	65	15	20	SL
Centaurea iberica	49	7.29	0.93	6.24	2.72	14.36	38.61	61	17	22	SL
Centaurea solstitialis subsp. *solstitialis*	45	7.41	0.65	9.76	1.09	5.51	19.31	60	19	21	SL
Rumex crispus	46	7.22	0.79	15.20	1.63	11.83	56.16	58	18	24	SL
Ammi visnaga	45	7.43	0.65	15.20	2.60	10.02	46.80	60	18	22	SL
Cichorium intybus	47	7.49	0.66	13.76	2.54	10.02	43.29	58	20	22	SCL
Parietaria judaica					Not studied						

EC: electrical conductivity SCL: sandy clay loamy, SL sandy and loamy

In this study, the largest groups were therophytes and hemicryptophytes when floristic compositions of plant communities examined (Table 4). As it is known, therophytes and hemicryptophytes are widespread in areas under influence of Mediterranean climate (Akman & Ketenoglu, 1987; Altay *et al*., 2010 a, b; Osma *et al*., 2010).

The most common phytogeographical elements were Mediterranean and Euro-Siberian elements (Table 5). This is because Istanbul's climate is predominantly Mediterranean. However, the northern side of Istanbul is partly affected by the oceanic climate (Aksoy, 1994; Altay *et al*., 2010a, b; Osma *et al*., 2010). Additionally, % values of widespread and cosmopolitan taxa in the communities were given in Table 5.

Table 4. Percentage values of the life forms (H= hemicryptophytes; Ph= phanerophytes; G= geophytes; Ch= chaemaphytes; Th= therophytes).

Plant community	Th	H	Ph	G	Ch
Sarcopoterium spinosum	46	31	8	8	7
Erica manipuliflora	3	34	33	18	12
Tordylium apulum	78	20	-	-	2
Sinapis arvensis	67	30	-	1	2
Rapistrum rugosum	58	35	1	3	3
Carduus pycnocephalus	76	22	-	1	1
Carduus nutans	40	54	-	3	3
Centaurea iberica	64	32	-	2	2
Centaurea solstitialis subsp. *solstitialis*	52	45	-	-	3
Rumex crispus	51	43	3	-	3
Ammi visnaga	42	51	-	4	3
Cichorium intybus	52	42	-	3	3
Parietaria judaica	57	43	-	-	-

Table 5. Percentage values of phytogeographical elements of plant communities and their % distributions.

Plant community	Medit. El.	Euro-Sib. El.	Ir.-Tur. El	Widespread	Cosmopolitan
Sarcopoterium spinosum	23	7	-	18.48	1.08
Erica manipuliflora	34	17	-	14.29	-
Tordylium apulum	14	5	-	18.18	2.27
Sinapis arvensis	11	3	-	22.55	2.94
Rapistrum rugosum	13	4	-	21.55	3.45
Carduus pycnocephalus	11	4	-	14.87	5.41
Carduus nutans	14	4	1	20.83	2.78
Centaurea iberica	10	4	-	28	6
Centaurea solstitialis subsp. *solstitialis*	15	5	2	15	1.67
Rumex crispus	19	4	1	16	-
Ammi visnaga	17	4	-	19.72	1.41
Cichorium intybus	11	6	-	23.94	4.23
Parietaria judaica	-	-	-	-	-

Species within the floristic composition of plant communities and their syntaxonomy (alliance, order and class) were given at the end of the paper (Appendix-1). The most widespread plant taxa in the communities were *Hordeum murinum* subsp. *leporinum*, *Cichorium intybus*, *Bromus sterilis*, *Dactylis glomerata* subsp. *hispanica*, *Plantago lanceolata*, *Cynodon dactylon* var. *dactylon*, *Rapistrum rugosum*, *Sonchus asper* subsp. *glaucescens*.

In this study, some members of *Liliaceae, Iridaceae* ve *Orchidaceae* families were not observed or rarely observed within plant communities although they are members of rural habitats. Additionally, only *Cymbalaria muralis* was observed in *Parietaria judaica* community as a rare plant, and no other rare plant was found in the research area. Endemic taxa in plant groups were *Cirsium polycephalum* and *Ballota nigra* subsp. *anatolica*. Most of the plant communities were within *Stellarietea mediae* class, when the syntaxonomic structure is searched. This class is the most represented class in ruderals and agricultural areas where anthropogenic pressure is present. Furthermore, this class shows therophytic properties and prefers soils rich in nitrate (Tüxen, 1950; Knapp, 1959; Böttcher, 1971; Dorogostajskaja, 1972).

In this study, for the first time in Turkey, communities, which were distributed in urban lands, were studied. 13 different plant communities were found in Anatolian Side of Istanbul. Therophytes were the best represented life forms due to their greater tolerance to disturbance. As mentioned in many previous papers, we observed that determinants of plant growth and distribution are some environmental factors such as soil moisture, mineral nutrient composition and topography (Sharma *et al*., 1983; Skarpe, 1990; Ahmad *et al*., 2010). These factors were also found as important components for the determination of plant communities during different seasons and sites. It is assumed that there are various locations yet to be discovered in many urban lands and therefore we suggest that detailed study should be undertaken to find new plant communities in those lands.

Appendix 1. Syntaxonomy and floristic composition of communities. 1. *Sarcopoterium spinosum*, 2. *Erica manipuliflora*, 3. *Tordylium apulum*, 4. *Sinapis arvensis*, 5. *Rapistrum rugosum*, 6. *Carduus pycnocephalus*, 7. *Carduus nutans*, 8. *Centaurea iberica*, 9. *Centaurea solstitialis* subsp. *solstitialis*, 10. *Rumex crispus*, 11. *Ammi visnaga*, 12. *Cichorium intybus*, 13. *Parietaria judaica*.

		1	2	3	4	5	6	7	8	9	10	11	12	13
	***Hordeion leporini* Alliance**													
G	*Asphodelus fistulosus*							x				x		
Th	*Carduus pycnocephalus*			x	x	x	x	x			x	x		
Th	*Crepis foetida* subsp. *foetida*			x			x					x	x	
Th	*Hordeum murinum* subsp. *leporinum*	x		x	x	x	x	x	x	x	x	x	x	
Th	*Plantago lagopus*	x		x	x	x			x	x		x	x	
Th	*Rostraria cristata*				x	x			x					
H	*Rumex pulcher*	x			x	x	x	x	x	x	x	x	x	
Th	*Trifolium nigrescens* subsp. *petrisavi*				x	x								
	***Fumario-Euphorbion* Alliance**													
Th	*Euphorbia helioscopia*	x		x	x	x	x	x	x		x	x		x
Th	*Euphorbia peplus* var. *minima*	x		x	x		x							
Th	*Mercurialis annua*			x	x	x	x	x	x					x
Th	*Senecio vulgaris*	x		x	x	x	x							
H	*Sonchus oleraceus*				x						x			
	***Dauco-Melilotion* Alliance**													
Ch	*Cichorium intybus*	x	x		x	x		x	x	x	x	x	x	
Th	*Echium vulgare*	x			x	x	x	x	x	x	x	x	x	
Th	*Medicago lupulina*								x					

Appendix 1. (Cont'd.).

		1	2	3	4	5	6	7	8	9	10	11	12	13
H	*Melilotus officinalis*				x	x	x	x	x				x	
H	*Reseda lutea* var. *lutea*					x							x	
	***Onopordion acanthii* Alliance**													
H	*Carduus nutans*				x	x		x			x	x		
	***Onopordion illyrici* Alliance**													
Th	*Centaurea diffusa*	x	x					x		x	x	x	x	
H	*Scolymus hispanicus*					x	x	x	x	x	x	x	x	
	***Arction lappae* Alliance**													
H	*Conium maculatum*				x	x	x	x			x			
	***Chenopodion muralis* Alliance**													
H	*Ecballium elaterium*				x	x	x	x			x			
Th	*Urtica pilulifera*						x							
	***Caucalidion platycarpae* Alliance**													
Th	*Sherardia arvensis*	x		x		x								
	***Papaveretalia rhoeadis* Order**													
Th	*Papaver rhoeas*			x	x	x	x	x			x			
Th	*Sinapis arvensis*	x		x	x	x	x	x	x		x	x	x	
Th	*Veronica persica*	x			x	x	x	x			x			
	***Sisymbrietalia officinalis* Order**													
Th	*Avena barbata*				x	x					x			
Th	*Avena sterilis*	x		x	x	x	x	x			x	x	x	
Th	*Bromus hordeaceus*				x	x	x	x	x		x		x	
Th	*Bromus sterilis*	x		x	x	x	x	x	x	x	x	x	x	
Th	*Catapadium rigidum*	x			x	x	x					x	x	
H	*Malva sterilis*			x	x	x			x					
Th	*Matricaria chamomilla* var. *recutita*				x	x	x	x	x		x		x	
Th	*Medicago polymorpha* var. *vulgaris*	x		x	x	x	x	x	x		x			
Th	*Sisymbrium officinale*						x			x				
Th	*Trifolium resupinatum* var. *resupinatum*				x	x	x		x		x			
	***Thero-Brometalia* Order**													
Th	*Cynosurus echinatus*	x			x	x					x	x		
Th	*Daspyrum villosum*			x	x	x					x	x	x	
Th	*Medicago rigidula*				x									
Th	*Onobrychis caput-galli*							x						
Th	*Pallenis spinosa*	x				x		x			x	x	x	
Th	*Torilis leptophylla*											x		
Th	*Tordylium apulum*	x		x	x	x	x	x			x			
Th	*Trifolium campestre*	x		x	x	x	x		x			x		
Th	*Trifolium stellatum* var. *stellatum*	x			x	x		x					x	
	***Onopordetalia acanthii* Order**													
H	*Cardaria draba* subsp. *draba*				x	x		x			x		x	
H	*Cirsium vulgare*									x		x		
H	*Convolvulus arvensis*				x	x		x	x	x	x	x	x	
H	*Malva sylvestris*						x	x		x	x	x	x	
Th	*Picris hieracioides*							x		x		x	x	
H	*Silybum marianum*				x	x	x	x	x	x	x			
	***Eragrostietalia* Order**													
Th	*Chenopodium botyris*									x				
Th	*Portulaca oleracea*									x				
Th	*Xanthium spinosum*									x				
	***Polygono-Poetea* Class**													
H	*Plantago major* subsp. *intermedia*					x			x				x	
Th	*Poa annua*				x	x	x		x				x	
Th	*Polygonum arenastrum*				x					x			x	
Th	*Polygonum aviculare*						x			x				
	***Artemisetea vulgaris* Class**													
Th	*Centaurea solstitialis* subsp. *solstitialis*				x	x			x	x	x	x	x	
H	*Eryngium campestre* var. *virens*	x			x	x			x	x		x	x	
H	*Foeniculum vulgare*				x	x		x		x		x	x	
H	*Galium aparine*	x		x	x	x	x	x			x	x		x
Th	*Malva neglecta*					x							x	

Appendix 1. (Cont'd.).

		1	2	3	4	5	6	7	8	9	10	11	12	13
H	*Medicago sativa* subsp. *sativa*											x		
H	*Silene vulgaris* var. *vulgaris*					x								
	***Molinio-Arrhenatheretea* Class**													
G	*Agrostis stolonifera*												x	
H	*Dactylis glomerata* subsp. *hispanica*	x	x	x	x	x		x		x	x	x	x	
H	*Holcus lanatus*					x	x		x					
Th	*Lolium perenne*	x			x	x	x	x	x	x	x	x	x	
H	*Lotus corniculatus* var. *corniculatus*	x		x	x	x	x	x		x	x	x	x	
H	*Plantago lanceolata*	x		x	x	x	x	x	x	x	x	x	x	
H	*Poa trivialis*				x									
H	*Prunella vulgaris*	x												
G	*Rumex acetosella*					x						x		
H	*Rumex crispus*				x	x	x	x	x	x	x	x	x	
Ch	*Taraxacum officinale*						x							
H	*Trifolium pratense* var. *pratense*							x						
H	*Trifolium repens* var. *repens*								x					
H	*Vicia cracca* subsp. *stenophylla*				x	x								
	***Stellarietea mediae* Class**													
Th	*Anagallis arvensis* var. *arvensis*	x		x	x	x	x	x	x	x			x	
H	*Anchusa officinalis*												x	
Th	*Borago officinalis*										x			
Th	*Bromus diandrus*			x			x							
Th	*Bromus japonicus* subsp. *japonicus*	x				x								
Th	*Calendula arvensis*			x	x	x	x	x			x			
Th	*Capsella bursa-pastoris*			x	x	x	x	x	x				x	
Th	*Cerastium glomeratum*	x		x	x	x	x	x	x				x	
Th	*Chenopodium album*				x	x		x	x	x	x	x	x	
Th	*Conyza canadensis*									x				
H	*Cynodon dactylon* var. *dactylon*	x	x		x	x	x	x	x	x	x	x	x	
H	*Diplotaxis tenuifolia*			x	x	x	x	x	x			x		
Th	*Erodium cicutarium* subsp. *cicutarium*			x	x	x	x	x	x	x	x		x	
Th	*Erodium malacoides*				x	x		x	x		x	x	x	
Th	*Geranium dissectum*			x	x	x		x	x		x			
Th	*Geranium molle* subsp. *molle*			x	x	x	x	x			x			
Th	*Geranium pusillum*						x							
Th	*Geranium rotundifolium*			x	x	x	x							
Th	*Lamium amplexicaule*					x								
Th	*Lamium purpureum* var. *purpureum*			x	x	x	x				x			
Th	*Lolium multiflorum*					x								
Th	*Medicago orbicularis*				x	x	x	x		x	x	x	x	
Th	*Ranunculus muricatus*				x		x				x			
Th	*Raphanus raphanistrum*				x	x	x	x	x	x	x	x	x	
Th	*Rapistrum rugosum*	x		x	x	x	x	x	x	x	x	x	x	
Th	*Setaria viridis*				x					x				
Th	*Silene nocturna*				x	x	x							
H	*Sonchus asper* subsp. *glaucescens*	x			x	x	x	x	x	x	x	x	x	x
Th	*Stellaria media* var. *media*			x	x	x	x				x			x
Th	*Torilis nodosa*				x	x	x	x			x			
Th	*Urospermum picroides*	x		x	x	x	x	x					x	
Th	*Vicia sativa*	x		x		x	x				x		x	
	***Thero-Brachypodietea* Class**													
H	*Carlina corymbosa*	x								x	x	x	x	
Th	*Trifolium arvense* var. *arvense*	x											x	
	***Festuca-Brometea* Class**													
H	*Centaurea virgata*		x											
G	*Hordeum bulbosum*	x			x	x	x	x	x			x	x	
Th	*Phleum exaratum* subsp. *exaratum*				x			x						
H	*Sanguisorba minor*	x	x			x					x	x		
	***Cisto-Micromerietea* Class**													
H	*Anthoxanthum odoratum* subsp. *odoratum*	x												
Ph	*Calicotome villosa*		x											

Appendix 1. (Cont'd.).

		1	2	3	4	5	6	7	8	9	10	11	12	13
Ph	*Cistus creticus*	x	x								x			
Ph	*Cistus salviifolius*	x	x								x			
Ph	*Erica arborea*		x											
Ph	*Erica manipuliflora*	x	x											
Ch	*Lavandula stoechas* subsp. *stoechas*	x	x											
H	*Melica ciliata*	x												
Ch	*Micromeria graeca* subsp. *graeca*	x												
H	*Psoralea bituminosa*	x										x		
H	*Sarcopoterium spinosum*	x	x			x					x			
Ph	*Spartium junceum*	x				x								
	***Quercetea ilicis* Class**													
Ph	*Arbutus unedo*		x											
G	*Asparagus acutifolius*	x	x									x		
Ph	*Juniperus oxycedrus* subsp. *oxycedrus*		x											
H	*Osyris alba*	x	x											
Ph	*Phillyrea latifolia*	x	x											
Ph	*Pistacia terebinthus* subsp. *terebinthus*	x												
	***Quercetea pubescentis* Class**													
G	*Brachypodium sylvaticum*		x											
H	*Dorycnium pentaphyllum* subsp. *herbaceum*	x	x									x		
Th	*Geranium purpureum*				x						x			
H	*Hypericum perforatum*	x				x				x	x	x	x	
Ph	*Quercus infectoria* subsp. *infectoria*		x											
Ph	*Quercus pubescens*	x	x											
Ch	*Teucrium chamaedrys* subsp. *chamaedrys*	x	x											
	Companions													
Th	*Aegilops geniculata*	x												
H	*Agrostis capillaris* var. *capillaris*	x	x		x	x	x	x		x	x	x	x	
H	*Alcea pallida*							x		x	x	x	x	
G	*Allium paniculatum* subsp. *paniculatum*	x												
Th	*Ammi visnaga*									x	x	x	x	
H	*Anthemis cretica* subsp. *tenuiloba*	x		x	x	x		x			x	x	x	
Th	*Arenaria leptoclados*						x							
H	*Asperula tenella*	x												
G	*Asphodelus aestivus*		x											
H	*Ballota nigra* subsp. *anatolica*							x		x	x			
H	*Bellis perennis*		x											
H	*Berula erecta*	x				x					x	x		
Th	*Bleckstonia perfoliata* subsp. *perfoliata*	x												
Th	*Briza maxima*	x					x					x		
G	*Briza media*		x											
H	*Calamintha nepeta* subsp. *glandulosa*											x		
Th	*Calepina irregularis*						x							
G	*Carex flacca* subsp. *serulata*	x	x											
Th	*Centaurea iberica*				x	x		x	x	x			x	
H	*Centaurium erythraea* subsp. *erythraea*	x												
H	*Cirsium polycephalum*									x				
H	*Convolvulus cantabrica*				x	x						x		
Th	*Crepis sancta*	x		x	x	x	x	x	x					
Th	*Cymbalaria muralis* subsp. *muralis*													x
Th	*Daucus guttatus*	x			x	x				x			x	
H	*Dianthus leptopetalus*					x								
H	*Echinops ritro*	x												
H	*Echium italicum*							x		x		x	x	
Th	*Filago vulgaris*						x							
Th	*Helminthotheca echioides*				x	x	x	x	x	x	x	x	x	
Th	*Hypocrepis unisiliguosa* subsp. *unisiliguosa*	x												
Th	*Gastridium phleoides*				x	x								
Th	*Geranium robertianum*				x									
H	*Glaucium flavum*					x								
G	*Inula oculus-christi*		x											

Appendix 1. (Cont'd.).

		1	2	3	4	5	6	7	8	9	10	11	12	13
H	*Inula viscosa*	x	x			x		x		x	x	x	x	
Th	*Kickxia commutata* subsp. *commutata*									x				
Th	*Lavatera punctata*				x									
G	*Leontodon tuberosus*		x											
H	*Lepidium graminifolium*					x				x	x		x	
H	*Lepidium spinosum*				x									
H	*Linum bienne*	x		x		x						x		
Th	*Linum trigynum*	x												
Th	*Malva nicaeensis*				x	x	x	x	x			x	x	
Ch	*Mentha longifolia* subsp. *typhoides*					x				x				
G	*Mentha pulegium*												x	
Th	*Moenchia mantica* subsp. *mantica*	x												
G	*Muscari neglectum*	x				x								
Th	*Nigella damascena*	x												
H	*Ononis spinosa* subsp. *glandulosa*	x										x		
Th	*Ononis viscosa* subsp. *breviflora*									x				
G	*Ornithogalum umbellatum*	x												
Th	*Papaver dubium*				x		x							
H	*Parietaria judaica*													x
Th	*Petrorhagia prolifera*								x					
H	*Phalaris aquatica*				x	x				x	x		x	
H	*Plantago coronopus* subsp. *coronopus*					x	x	x	x	x	x	x	x	
G	*Poa bulbosa*					x								
H	*Potentilla inclinata*	x												
H	*Prunella laciniata*	x												
Th	*Ranunculus marginatus* var. *marginatus*				x	x								
Ph	*Rubus canescens* var. *canescens*		x											
H	*Rumex conglomeratus*					x								
H	*Ruta montana*	x												
Ch	*Salvia verbenaca*	x		x	x	x		x			x	x	x	
H	*Scabiosa columbaria* subsp. *columbaria*	x			x	x		x		x	x	x	x	
H	*Scabiosa columbaria* subsp. *ochlera*									x				
Th	*Scorpius muricatus* var. *subvillosus*				x									
H	*Scrophularia scopolii* var. *scopolii*					x								
G	*Serapias cordigera*		x											
Th	*Silene dichotoma* subsp. *dichotoma*											x		
Th	*Sinapis alba*						x							
Th	*Spergularia bocconii*				x	x			x	x	x			
H	*Stachys byzantinum*	x	x											
H	*Stachys officinalis* subsp. *balcanica*			x										
H	*Symphytum orientale*				x									
H	*Telephium imperati* subsp. *orientalis*				x									
Ch	*Thymus longicaulis* subsp. *longicaulis*	x	x											
Th	*Torilis nodosa*	x												
H	*Tragopogon longirostris* var. *longirostris*				x	x								
Th	*Trifolium angustifolium* var. *angustifolium*	x				x				x		x		
Th	*Trifolium glomeratum*	x												
Th	*Trifolium lappaceum*	x												
Th	*Trifolium scabrum*				x									
Th	*Trifolium tomentosum*							x		x				
Th	*Valerianella turgida*	x												
H	*Verbascum lasianthum*				x						x	x	x	
Th	*Veronica cymbalaria*			x		x	x							
Th	*Vicia hybrida*			x		x								

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