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Research

Spiritual values shape taxonomic diversity, vegetation composition, and conservation status in woodlands of the Northern Zagros, Iran

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ABSTRACT. Sacred groves are under-researched in Muslim countries so that their overall contribution to biodiversity conservation remains unknown. We studied 22 sacred groves and 45 surrounding woodlands in Northern Zagros, Iran, to compare taxonomic diversity, vegetation composition, and the conservation status of plant species. Sacred groves had higher taxonomic diversity and a more valuable species pool by sheltering numerous endangered plant species. Multivariate analysis indicated a substantial difference in the vegetation composition of sacred groves and surrounding woodlands. Traditional deliberate protection (because of religious values) plus some environmental variables were the main drivers of the distinct vegetation composition of sacred groves. Sacred groves are the only remains of old-growth forests in the border regions of Iran and Iraq and they are important refuges of biocultural diversity. To better link the conservation of nature and culture, we recommend encouraging local people to preserve spiritual values, myths, and taboos around sacred groves.

Key Words: *endangered species; in situ conservation; religious beliefs; sacred groves; silvopastoral practices*

INTRODUCTION

Many protected areas in developing countries have experienced conflicts and lack local community support because of often missing consideration of local people's demands and interests in protected area management (Bhagwat and Rutte 2006). However, there is plenty of evidence that people have actively protected parts of their local landscapes for generations for cultural or spiritual reasons (Wild et al. 2008). Such sacred natural sites include mountains, water sources, trees, groves, and forests and are found all over the world (Dafni 2007). Many sacred natural sites have been recognized as hotspots of biocultural diversity in which spiritual/religious, cultural, and biological values are interlinked (Frascaroli and Verschuuren 2016). Because of their wide spatial distribution, their location in agricultural landscapes where formal protected areas are underrepresented, and their preservation status, sacred natural sites have the potential to be integrated as important stepping stones into formal conservation plans (Wild et al. 2008, Deil et al. 2014).

The relationships between faith and nature conservation values are deeply rooted and have been well recognized by conservation institutions, e.g., UNESCO, IUCN, and WWF (Bhagwat et al. 2011). Among 11 mainstream faiths, eight of them (Baha'i, Buddhism, Daoism, Hinduism, Jainism, Shinto, Sikhism, and Zoroastrianism) regard nature as divine or sacred (Dudley et al. 2009). Christian, Jewish, and Muslim theology see the environment as "God's creation to serve humankind" (White 1967), realizing that this could hardly be interpreted as wasteful use but rather implies conservation and careful treatment of its resources. The deep human-nature relationships underlying these faiths are materialized in a high number of sacred natural sites in central, east, and south Asia (Dudley et al. 2009), most notably in India (Ormsby and Bhagwat 2010), China, Thailand, and Japan (Verschuuren and Furuta 2016). Different social-ecological aspects of sacred natural sites have been studied in many parts of the world (Dudley et al. 2010, Cardelús et al. 2013, Frascaroli and Verschuuren 2016). Hardly any social or ecological studies have been carried out on sacred natural sites in Muslim countries, with very few exceptions, e.g., sacred groves in Morocco (Jäckle et al. 2013) and graveyards in Turkey (Löki et al. 2015).

Sacred natural sites have persisted via veneration of saints from pre-Christian to Christian, pre-Jewish to Jewish, and pre-Muslim to Muslim societies (Dafni 2007). For instance, in the Kurdish territory of Iran, sacred natural sites are rooted in ancient religions like Mithraism and Zoroastrianism. Until recently, almost every village maintained its own sacred place, e.g., a part of the forest, a valley, a mountain summit, or a spring with its surroundings (Shakeri and Mostafa 2018), despite the Arab conquest of the Persian Empire in AD 7th–8th centuries (Morony 2019) and the subsequent conversion of Kurdish people to Islam in AD 16th–17th centuries (Roohi 2014). Most sacred natural sites in Kurdistan served as burial grounds to the villages and they are seen as an abode of their ancestors' body and soul; therefore, they have been strictly protected by local people as "sacred groves" (Shakeri 2006). Generally, one or several people endow part of their woodland to serve as a new cemetery to the village (i.e., new sacred grove) when there is no more burial place in the old sacred grove. Thereafter, the new sacred grove will be under the same maintenance and protection as the old ones by local communities. Sacred groves are protected through taboos and strict rules, including the prohibition of livestock grazing, hunting, and collection of fodder, edible plants for commercial use, lumber, and fuel-wood (Plieninger et al. 2020). Additionally, local people protect sacred groves from land encroachment and wildfires by light pollarding (approximately every 10 years) and collecting dead branches to establish a hedge around the sacred grove.

Sacred groves are embedded in a mosaic landscape of oak wood-pastures and traditional farmlands (Figure A1.1a) that developed through a long history of civilization in the Zagros Mountains of

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Iran (Izady 1994). Local peoples' livelihoods are heavily dependent on natural resources, expressed in a traditional land-use system called "Galazani" (Figure A1.1b). In this system, each family manages part of the woodland by applying traditional silvopastoral techniques (Valipour et al. 2014). Goats and sheep are the dominant livestock in the region. They feed on ground vegetation during the growing season and depend on dried oak leaves (leaf hay) as winter fodder. Local people pollard oak trees in specific three- to four-year rotations to sustain leaf fodder for their livestock (Ghazanfari et al. 2004).

The Zagros Mountains are part of the Irano-Anatolian vegetation region. They occupy about 10% of Iran but harbor more than 25% of the country's total number of plant species and are an important biocultural refugium; however, less than 1% of the total land is designated as protected area (Darvishsefat 2006). In this context, sacred groves gain considerable importance as biodiversity-rich islands within a matrix of increasingly intensified land uses. Sacred groves are patchy and cover small areas in the Zagros region (from 0.3 to 7.0 ha), but are of considerable conservation importance as they harbor the only remaining old-growth remnants of climax forests (Shakeri and Mostafa 2018). First studies have described the structure and diversity of woody species in sacred groves of Kurdistan (Shakeri et al. 2009, Ghahramany et al. 2017), but the composition and diversity of ground vegetation and the contribution of sacred groves to biodiversity conservation remained unknown. To better understand the contribution of sacred groves to "in situ conservation", we need comparative data from sacred groves and their surrounding silvopastoral woodlands. To fill this gap, the present study aimed to compare the taxonomic diversity, vegetation composition, and conservation status of plants between sacred groves and surrounding woodlands. We formulated the following research questions:

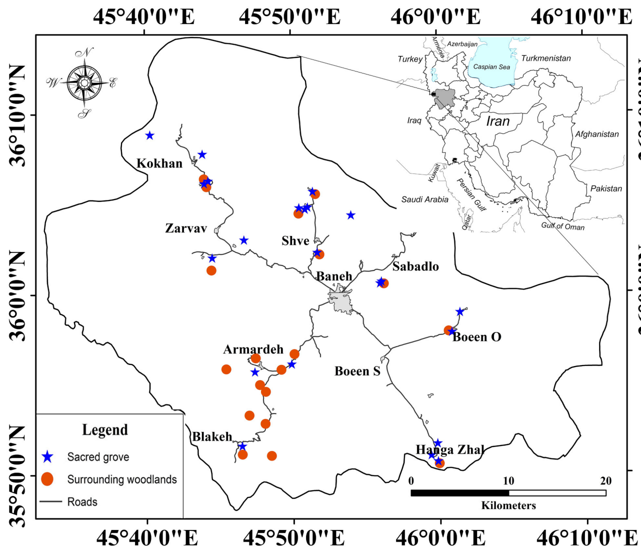
1. How does taxonomic diversity of sacred groves differ from that of surrounding woodlands?
2. How distinct is the vegetation composition of sacred groves from surrounding woodlands?
3. Which are the most important environmental variables affecting vegetation composition?
4. What is the conservation status of plants in sacred groves and surrounding woodlands?

METHODS

Study area

The study area, Baneh, is located in the northern Zagros mountain range of Kurdistan province, western Iran (35°45′ to 36°10′ N and 45°40′ to 46°10′ E; Fig. 1). The Baneh area ranges from 1000 to 3200 m in altitude, with an average elevation of 1550 m above sea level. Baneh receives 675 mm of annual precipitation, most of it as snow in winter. It experiences warm, dry summers and cold winters typical of a sub-Mediterranean subcontinental climate with an average annual temperature of 13.7 °C (Mohammadi Samani et al. 2020). The soil depths depend on physiographic conditions (shallow on steep slopes and degraded lands, deep in depressions and flat areas), generally with sandy or clay-loam texture that overlay calcareous, shale, or schist bedrocks (Mohammadi Samani et al. 2020).

Fig. 1. Location of selected sacred groves (blue stars) and surrounding woodlands (red circles) in Baneh, northwest Iran.



Oak-dominated woodlands (Lebanon oak, *Quercus libani* and Aleppo oak, *Quercus infectoria*) are the most widespread vegetation of the northern Zagros range and they mainly serve as grazing areas for local herds. Sacred groves, the only patches of old-growth forests, are wooded areas surrounding cemeteries, sanctuaries, or tombs without grazing and human disturbances, such as pollarding. Their spatial distribution is imposed by the distribution of villages and their surface area range from 2000 to 80,000 m². There are a total of 190 villages in the Baneh region and each one has between one and three sacred groves.

Data collection

We identified sacred groves and the surrounding woodlands in the region by using topographic maps and satellite imagery. The sacred groves were located between 50 m and 1 km from the villages. In total, we visited 58 villages and 120 sacred groves. From these, we focused on sacred groves larger than 0.5 ha with little or no soil disturbance (caused by ongoing burial practices or treasure hunting excavations). We then selected surrounding woodlands with trees that had been regularly pollarded during the last three decades and where the understory had not been cultivated. We obtained permission from the village councils to sample sacred groves and from local owners to sample their woodlands. In cases in which a sacred grove was not surrounded by eligible woodland or in which the owners did not permit access, we searched for slightly more distant woodlands in a similar physiographic, soil, and vegetation condition. Finally, we selected 22 sacred groves and 45 surrounding woodlands and sampled 122 vegetation relevés. We took only one relevé in homogenous and several relevés in sacred groves and surrounding woodlands with heterogeneous physiography and vegetation, leading to a total of 32 relevés in sacred groves and 90 relevés in surrounding woodlands. The minimal area approach suggested by Müller-Dombois and Ellenberg (2002) indicated a minimal plot size of 280 m² and 225 m² for sacred groves and surrounding woodlands, respectively. We consistently used a plot size of 300 m² in both types.

We carried out vegetation sampling from May to June in 2016 and 2017. We recorded all vascular plant species and collected one voucher per species for further determination and analysis in the lab. Plant species and subspecies were determined in the herbarium of the Forest and Rangelands Research Institute, Sanandaj, Kurdistan Province, using the Floras of Iran and Iraq (Townsend and Guest 1974, Assadi et al. 1989). These floras are also the taxonomic reference works of this paper. Voucher specimens were stored in the herbarium HKS of the Kurdistan Agricultural and Natural Resources Research and Education Center. We used the Londo decimal scale to estimate the cover-abundance of each species per plot (Londo 1976). We also measured geographical position and environmental variables, including altitude (m a.s.l.), inclination (%), aspect, crown canopy percentage, bare soil (%), and litter depth (cm). We collected five mixed representative soil samples at a depth of 0–10 cm in the four corners and center of each relevé. Soil texture, pH, EC (µS/cm), total nitrogen (%), phosphorus (mg/kg), potassium (mg/kg), and organic carbon (%) were measured in the lab.

Data analyses

To evaluate taxonomic diversity, we calculated the Shannon (H), Simpson (D_1), and Pielou (J) indices by using the *vegan* package in R. We then compared the differences between diversity indices of sacred groves and surrounding woodlands by a student t-test after checking that assumptions of normality ($p > 0.05$) and homogeneity of variances ($p > 0.05$) were fulfilled. We estimated beta diversity by the Bray-Curtis dissimilarity index in the *betapart* package (Baselga and Orme 2012) and then performed an analysis of variance (ANOVA) to test for significant differences between sacred groves and surrounding woodlands. The species pool size and numbers of overlooked species were estimated by the Chao estimator (f_0) in the *vegan* package (Oksanen et al. 2010).

To compare and illustrate the vegetation composition of sacred groves and surrounding woodlands, we applied nonmetric multidimensional scaling (NMDS) with the Bray distance and number of axes fixed to three. We assessed goodness-of-fit of this analysis with the stress value and Shepard diagram (Young 2013). PERMANOVA was used to test the significance of NMDS with 999 permutations. Then, 15 environmental and soil variables on NMDS were fitted to relate the environmental factors to vegetation composition (Legendre and Legendre 2012). A tri-plot of species, samples, and environmental variables (with only significant variables) was constructed to illustrate their correlations in the ordination space. All analyses were carried out in R 3.6.1 (R Core Team 2019). We assessed the national conservation status of plant species by using the Red Data Book of Iran and other published literature (Jalili and Jamzad 1999, Willis 2001).

RESULTS

Taxonomic diversity

We identified a total of 254 vascular plant species belonging to 163 genera of 45 families; among them, 114 species were found uniquely in sacred groves, 46 species uniquely in surrounding woodlands, and 94 species occurred in both (Table A2.1). The highest species numbers were recorded from the families of Asteraceae (47), Fabaceae (32), Poaceae (16), Apiaceae (16), and Caryophyllaceae (12). Four species of Orchidaceae were only found in sacred groves. Hemicryptophytes, therophytes, and cryptophytes with 39, 35, and 20%, respectively, were the most abundant plant life forms. We found 208 and 140 plant species in sacred groves and surrounding woodlands, respectively, and the nonparametric Chao estimator predicted total species numbers of 250 ± 15 (SE) and 153 ± 7 (SE), respectively.

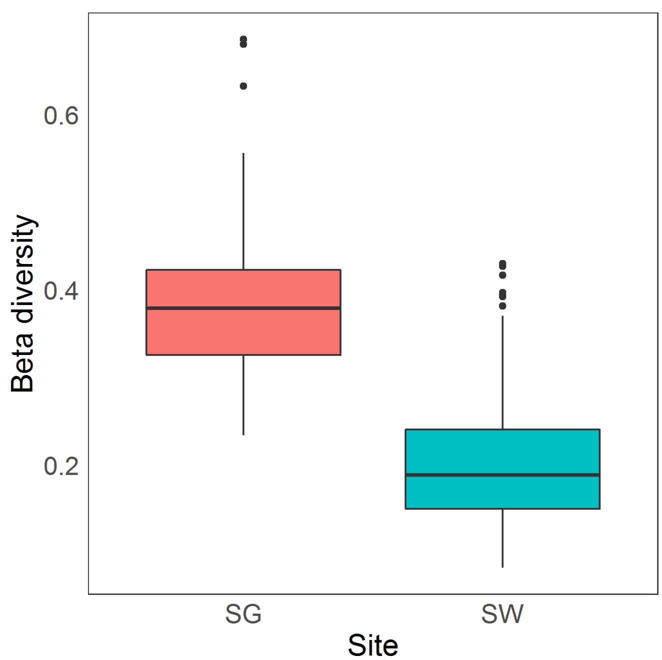
Significant differences in all diversity indices were found between sacred groves and the surrounding woodlands ($p < 0.001$). Species richness, species evenness, and species diversity were significantly higher in sacred groves (Table 1). Beta diversity of sacred groves was also significantly higher (0.402 ± 0.117) than that of surrounding woodlands (0.209 ± 0.084) (Fig. 2).

Table 1. Student t-test results for species richness, Shannon, Simpson, and Pielou indices of sacred groves (32 relevés) and the surrounding woodlands (90 relevés).

	Degree of freedom	T	P-value	Sacred groves (Mean±SD)	Surrounding woodlands (Mean±SD)
Species richness	49.4	7.164	0.001***	33.4±6.6	23.9±5.8
Shannon-Weaver index	46.9	5.358	0.001***	2.798±0.351	2.427±0.290
Simpson index	60.4	4.248	0.007**	0.901±0.052	0.854±0.058
Pielou index	46.3	2.067	0.044*	0.799±0.072	0.770±0.058

* P < 0.05; ** P < 0.01; *** P < 0.001

Fig. 2. Box-plot of the measure of beta diversity for sacred groves (SG, red) and surrounding woodlands (SW, blue; ANOVA, p < 0.001).



Vegetation composition

The stress value for NMDS analysis was equal to 0.119 and the Shepard plot showed that original dissimilarities were well preserved in the analysis (Fig. A1.2). Vegetation composition between sacred groves and surrounding woodlands was significantly different based on PERMANOVA analysis (Table 2). These two groups were differentiated along the first axis of the NMDS ordination space (Fig. 3).

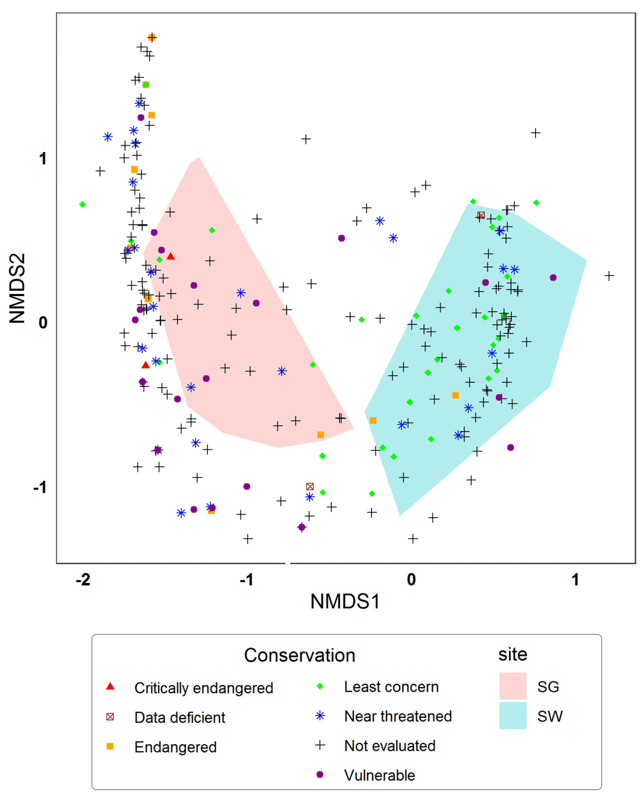
The following species were found much more commonly in sacred groves than in surrounding woodlands: *Malabaila sekakul, Prangos ferulacea, Bellevalia olivieri, Muscari comosum, Alliaria petiolata, Lonicera nummulariifolia, Silene latifolia, Salvia bracteata, Cerasus microcarpa, Crataegus pontica,* and *Rosa canina.* Most are species of shrubby undergrowth or other palatable plants of deep soil, plus a few exceptions, such as *Bromus sterilis* and *Galium aparine*. Conversely, the surrounding woodlands showed much higher frequencies of *Achillea wilhelmsii, Arenaria serpyllifolia, Velezia rigida, Trifolium purpureum, Aegilops triuncialis, Bromus danthoniae, Bromus tectorum, Heteranthelium piliferum,* and *Ziziphora capitata,* which are mostly annual plants of disturbed ground or perennial grazing indicators, e.g., *Poa bulbosa.*

Table 2. PERMANOVA results for the vegetation composition of sacred groves and surrounding woodlands.

	Degree of freedom	Sums of Sqs	Mean Sqs	F. Model	R^2	P (> F)
Site	1	5.393	5.393	21.889	0.154	0.001 ***
Residuals	120	29.565	0.246		0.845	
Total	121	34.958			1.000	

*** P < 0.001

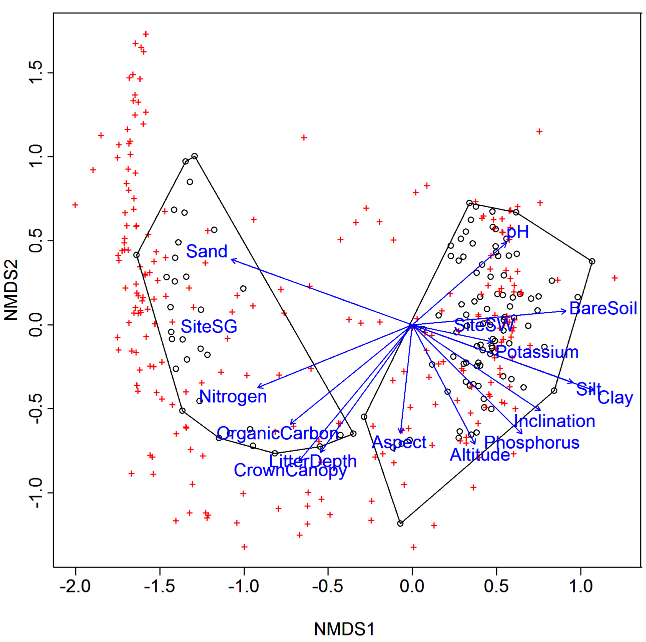
Fig. 3. Nonmetric multidimensional scaling (NMDS) convex hull of relevés between sacred groves (SG) and surrounding silvopastoral woodlands (SW). Only species scores are depicted and to prevent overcrowding of the diagram, species names are not displayed.



Environmental drivers of vegetation composition

Fitting environmental variables on the NMDS ordination space resulted in 14 significant variables. Litter depth (cm), crown canopy (%), organic carbon (%), nitrogen (%), and sand (%) positively pointed out toward sacred groves while other variables including aspect, altitude (a.s.l.), inclination (%), potassium (mg/kg), phosphorus (mg/kg), bare soil (%), pH, silt (%), and clay (%) were toward the surrounding woodlands (Fig. 4).

Fig. 4. Tri-plot of species, relevés, and environmental variables resulting from fitting significant-environmental variables on nonmetric multidimensional scaling (NMDS) analysis of sacred groves (SG) and surrounding silvopastoral woodlands (SW). To prevent overcrowding in the diagram, species names and relevé numbers are not shown.



Conservation status

Out of the 254 species identified, 161 (63.4%) could not be evaluated according to their national conservation status (Jalili and Jamzad 1999, Willis 2001). Two species (0.8%) were data deficient, 31 (12.2%) were of least concern, 29 (11.4%) near threatened, 20 (7.9%) vulnerable, 11 (4.3%) endangered, and two (0.8%) were in critically endangered categories (Table A2.1). All

11 endangered species (woodland couch, *Elymus panormitanus*; a Southwest Asian species of spurge, *Euphorbia macrocarpa*; the imperial fritillaries *Fritillaria imperialis* and *Fritillaria straussii*; the bee orchids *Ophrys reinholdii* subsp. *straussii* and *Ophrys sphegodes* subsp. *transhyrcana*; the recently described regional endemic star-of-Bethlehem, *Ornithogalum sanandajense*; some near-eastern species of skullcap, *Scutellaria condensata* subsp. *pycnotricha;* saw-wort, *Serratula grandifolia*; and the goat's-beards *Tragopogon latifolius* and *Tragopogon buphthalmoides*) and two critically endangered narrowly endemic garlic species (*Allium hooshidaryae* and *Allium saralicum*), with a further 15 of the vulnerable, 27 of the near-threatened, and 25 of the least concern species were located in sacred groves. Whereas in the surrounding woodlands, 25 species were of least concern, 14 near threatened, 12 vulnerable, and three endangered (*Elymus panormitanus* and two *Tragopogon* species; see also Table A2.1).

DISCUSSION

Taxonomic diversity

Diversity and understory plant composition across Zagros forests have remained unknown in the literature because of inaccessibility (poor road connection) and difficulties in identifying plants to the species level. This study is, to our knowledge, the first comparative investigation of ground vegetation of sacred groves and surrounding woodlands in this global biodiversity hotspot. We found that 22 sacred groves in Baneh area comprised 20% of the flora in the whole northern Zagros region (208 out of approximately 1000 species; Assadi et al. 1989). Sacred groves have preserved ecological and cultural values around the world for many centuries (Bhagwat and Rutte 2006, Frascaroli et al. 2016), but their importance is higher in countries with longer civilization history and more exploitative land use. In such areas, they often form near-natural islands that are surrounded by degraded lands (Dudley et al. 2010). Approximately 250 sacred groves exist in Baneh county alone, with a density of 16 sacred groves per 100 km^2 (Shakeri 2006). Because of the endowment of new woodlands by local people to serve as sacred groves, their number is growing continuously. Our research highlights that, in relation to their small area, they harbor a disproportionally high number of unique and valuable species.

Sacred groves had significantly higher species richness, Shannon, Simpson, Pielou diversity indices, and beta diversity than the surrounding woodlands, confirming findings on the importance of sacred groves from other parts of the world for conserving biodiversity (Mgumia and Oba 2003, Frascaroli et al. 2016). Globally, sacred groves have low rates of anthropo-zoogenic disturbance because of local long-term protection (Allendorf et al. 2014); in northern Zagros, this protection seems highly effective thus far, as local people strongly embrace conservation values, taboos, and practices for sacred groves (Plieninger et al 2020). For example, local rules strictly interdict collecting firewood, hunting, livestock grazing, and commercial collection of fruits and plants in sacred groves, despite the high dependence of local people on natural resources. Although the surrounding woodlands are almost depleted of deadwood, litter, and plant debris, high stocks of deadwood and litter can increase soil nitrogen in sacred groves (Shakeri 2006), which adds to the overall habitat diversity of the landscape and supports species that are not otherwise found.

Silvopastoral activities, such as overly high grazing pressure and frequent pollarding, can cause lower woodland indicator species diversity; heavy grazing reduces the diversity of palatable plants and changes the abundance and dominance of species (Papanikolaou et al. 2011). Pollarding of oak trees reduces the tree canopy up to 20% and results in leaf area index reduction (from 1.92 in sacred groves to 0.33 in pollarded stands; Abbasi et al. 2017). Increased insolation, together with heavy grazing in woodlands, alter soil physical and chemical properties (Sharrow 2007, Mohammadi Samani et al. 2020), which may subsequently level habitat variation and reduce taxonomic diversity (Orefice et al. 2017). Because of higher canopy cover and habitat heterogeneity and lower soil disturbance, sacred groves support shade-tolerant species. They contribute to beta and landscape-scale diversity (Mgumia and Oba 2003, Frascaroli et al. 2016), shelter hidden diversity (Pärtel 2014), and may even harbor unrecognized plant and/or fauna taxa new to science, e.g., two newly identified mite species from sacred groves of Kurdistan (Babaeian et al. 2019, Paktinat-Saeij et al. 2020).

Vegetation composition

Despite the fact that both sacred groves and the surrounding woodlands are likely to originate from the same class of zonal vegetation, i.e. *Quercetea persicae* (Zohary 1963), sacred groves are now islands of old-growth forests surrounded by silvopastoral woodlands with significantly distinct vegetation composition and structure. Other studies also addressed the dissimilarity in species composition between sacred groves and the surrounding managed lands and typically found much greater microhabitat heterogeneity in sacred groves (Deil et al. 2005, Bhagwat and Rutte 2006). Strict social taboos play an important role in providing ecological niches for shade-tolerant, nutrient-demanding, and sensitive species (Mgumia and Oba 2003).

Shrubs are key elements for many animal populations (Watson et al. 2011), but they are absent from overused silvopastoral woodlands. The Maraz goat, the main kind of livestock browsing in silvopastoral woodlands in northern Zagros, yields mohair, a valuable product. Therefore, people frequently clear oak sprouts and shrubs to prevent them from trapping the valuable Maraz goats' mohair (Shakeri 2006). Overgrazing can reduce the abundance of palatable and rare species and homogenize vegetation by shifting the community composition toward unpalatable forbs and annual grasses and herbs, such as *Aegilops triuncialis, Bromus tectorum, Filago arvensis, Taeniatherum crinitum, Picnomon acarna,* and *Echinops orientalis* (Bouahim et al. 2010). Spiritual values and traditional silvopastoral practices resulted in complementary vegetation in sacred groves and the surrounding woodlands. Sacred groves are thus unique in their combination of cryptophytes, nutrient-demanding, and woodland-specialist species, while the surrounding silvopastoral woodlands are rich in therophytes, ruderals, and light-demanding species.

Environmental drivers of vegetation composition

Five out of the 14 significant environmental variables driving the vegetation composition of sacred groves and surrounding woodlands (litter depth, crown canopy cover, soil organic carbon, nitrogen, and sand %) were positively correlated to sacred groves. These environmental variables are a direct or indirect outcome of deliberate protection of sacred groves. Taboos that prevent livestock grazing, litter and deadwood collection, and pollarding have an important role in retaining tree canopy cover and increasing soil fertility. Plant litter is an important factor for the successful regeneration of oak trees, as resource for soil nutrient cycling (Córdova et al. 2018), and essential for soil faunal and fungal diversity (Wardle et al. 2006). Litter depth is negatively correlated with soil pH because accumulation of oak litter can increase soil acidity, due to the production of CO_2 by microbial respiration (Singh and Gupta 1977), thus supporting rare acidophilic geophytes of Near East woodlands in sacred groves, such as *Ornithogalum brachystachys* and *Allium macrochaetum*, and a rare species of saw-wort, *Serratula grandifolia* (Gaderzadeh et al. 2015).

The positive correlation of tree canopy (%) with soil organic carbon and nitrogen indicates the importance of canopy coverage for soil fertility in these forests (Isichei and Muoghalu 1992). Canopy coverage of sacred groves ranges from 40 to 90% (on average 70%), while in the surrounding woodlands, it ranges between 10 and 40% (on average 20%; Shakeri 2006). To maintain a balance in fodder production between trees and ground vegetation in silvopastoral systems, it is essential to keep the tree canopy cover around 20–30% (Hartel and Plieninger 2014, Valipour et al. 2014). More light availability shifts the species pool toward light-demanding species. Accordingly, it is generally hard to find shade-tolerant species in the surrounding woodlands. In sacred groves, however, Southwest Asian chervil, *Chaerophyllum macropodum*; bellflower, *Campanula involucrata*; buttercup, *Ranunculus constantinopolitanus;* and broad-leaved helleborine, *Epipactis helleborine* are among the shade-tolerant plants that colonize beneath the closed canopy.

In the surrounding woodlands, livestock grazing can both directly and indirectly, i.e., by influencing chemical and physical soil variables, affect vegetation composition. High grazing rates can destroy soil texture, cause soil compaction and erosion (Daniel et al. 2002, Mohammadi Samani et al. 2020), and increase soil potassium and phosphorus content, owing to fecal deposition by livestock (James et al. 2007). Coarse-textured soils have higher infiltration rates (Schulz et al. 2016) and provide more suitable microhabitats for geophytes and nutrient-demanding species, such as *Allium atroviolaceum, Chaerophyllum macropodum, Chaerophyllum aureum, Fritillaria straussii, Epipactis helleborine,* and *Symphytum kurdicum*.

Conservation status

We found that sacred groves in Kurdistan shelter many plants of high conservation value. The fact that 60% of the studied plant species have not been evaluated based on IUCN conservation criteria suggests that this world region needs closer attention by conservation science. Still, of the evaluated plant species in the sacred groves, at the national level, 6% were endangered and critically endangered, 13% were near threatened, and 7% were in vulnerable categories. Considering that most of these plants are endemic and restricted to the region, these sacred groves are particularly important for protecting threatened plant species on national and global levels. Specifically, two critically endangered garlic species *Allium hooshidaryae* and *Allium saralicum* have only recently been identified and have limited distribution in northern Zagros (Fritsch and Friesen 2002, Mashayekhi et al. 2005). We found these two species in three and four sacred groves, respectively. Ten out of 11 endangered species in sacred groves are medicinal and edible plants that have an important role in Kurdish cuisine and medicinal culture (Khezri 2002). In the surrounding woodlands, only 2% of the plants were in the threat category of endangered, 10% near threatened, and 9% vulnerable. The Mediterranean-Southwest Asian woodland grass, *Elymus panormitanus* and the Near East goat's-beards *Tragopogon latifolius* and *Tragopogon buphthalmoides* are endangered species shared between sacred groves and the surrounding woodlands. Both *Tragopogon* species are edible and of medicinal value, and *Elymus panormitanus* is appreciated for its forage value for livestock (Asri 2011).

Wild edible plants have important cultural and economic roles in rural areas of Iran. In fact, they are an important part of Kurdish cuisine; people use these plants in almost every dish (Khezri 2002). People are free to collect plant roots, bulbs, leaves, flowers, and fruits in the rural environment from grasslands and woodlands as low-cost food and also as traditional medicine. The food habits of the locals change during the year reflecting the plants' seasonality. During springtime, searching for wild edible plants and mushrooms is an important income source for some people and a popular hobby for many. The high demand for edible and medicinal plants has resulted in the extinction of some of these plants in specific localities and subsequent loss of local traditional knowledge (Khajoei Nasab and Khosravi 2014).

Many studies have emphasized the significance of sacred groves for the protection of endangered species (Bhagwat and Rutte 2006, Ray and Ramachandra 2010). This protection is mainly provided by general taboos that prevent people from hunting and collecting plants, fruits, or fuelwood and that prohibit livestock grazing (Allendorf et al. 2014); some taboos target specific plants or animal species (Dafni 2007). Although the main motivation of local people to preserve sacred groves is for their spiritual and cultural significance, still biodiversity and habitat conservation are a significant by-product of sacred groves, essential for many plant species. Among the endangered species, only the imperial fritillaries, *Fritillaria imperialis* and *Fritillaria straussii*, have high spiritual and cultural value for local people and generally people protect them no matter where they grow, because they are considered symbols of resurrection and love. Sacred groves in Kurdistan may harbor as yet unrecognized plants new to science (Maroufi 2010) and they are also important for protecting faunal diversity by providing suitable ecological niches for arthropods (Babaeian et al. 2019, Paktinat-Saeij et al. 2020) and vertebrates such as the Caucasian squirrel (*Sciurus anomalus* Gmelin) whose population has dramatically declined in Zagros because of habitat loss and overhunting (Sadeghi et al. 2017). Local people in Kurdistan have a deep connection to nature and they obtain most of their traditional food and medicine from local plants; nevertheless, they do not only abstain from collecting medicinal and edible plants from sacred groves but they also protect them from other disturbances, such as fire and livestock grazing. This traditional deliberate protection resulted in protecting the endangered species, unique biodiversity, and vegetation composition of sacred groves.

CONCLUSION

Our results showed that the values, taboos, and practices of sacred groves are expressed in significantly different conservation status, plant diversity, vegetation composition, and environmental conditions compared to more intensively used surrounding woodlands. Most notably, sacred groves hold higher taxonomic diversity and harbor many vulnerable and endangered plant species. The vegetation diversity and composition of sacred groves are an outcome of abiotic factors and active protection by local people. In the surrounding woodlands, heavy grazing and pollarding of oak trees supports light-demanding, ruderal, and unpalatable plants, whereas sacred groves are colonized by shade-tolerant woodland specialists, including several endangered species.

Despite the small extent of sacred groves, our findings indicate that they can serve as an important complement to formal protected areas. Also, the vegetation composition and structure of sacred groves provides necessary baselines to reconstruct degraded areas. Given that sacred groves are globally endangered through resource-use pressures, poor governance, socioeconomic inequity, war, and corruption, the conservation status of the sacred groves studied here is remarkable. We recommend that this traditional protection be encouraged to conserve both nature and culture at one of the hotspots of biodiversity and civilization in the Middle East.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/12290

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Data Availability:

The vegetation and environmental data that support the findings of this study are available on request from the corresponding author (shakeri.zahed@gmail.com). None of the data are publicly available because of their containing information that could compromise endangered plant species. Our research did not target human subjects, and therefore formal approval was not required from our institution.

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Appendix 1

Title: Spiritual values shape taxonomic diversity, vegetation composition, and conservation status in woodlands of the Northern Zagros, Iran

Figure A1.1: (a) A sacred grove surrounded by traditional farmland and woodland and (b) Silvopastoral woodland of traditionally pollarded oaks.

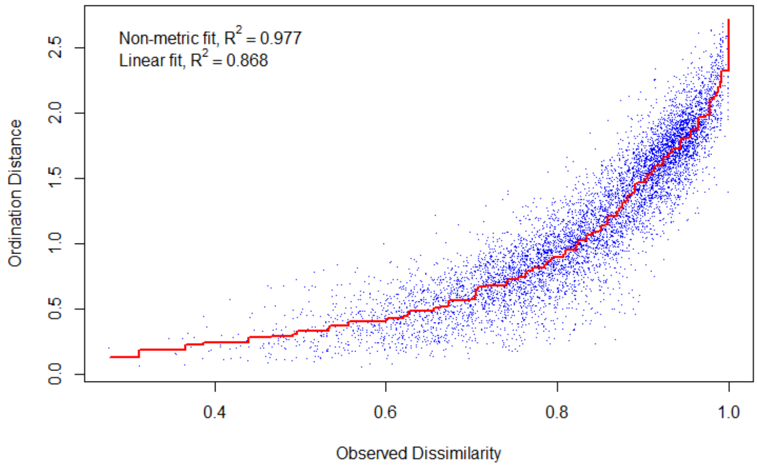

Figure A1.2: Shepard diagram resulted from non-metric multidimensional scaling analysis to plot the ordination distance and linear fit line of vegetation data against the original dissimilarities.

Appendix 2

Title: Spiritual values shape taxonomic diversity, vegetation composition, and conservation status in woodlands of the Northern Zagros, Iran

Table A2.1: Plant species found in sacred groves (SG) and surrounding woodlands (SW) of Baneh area. Scientific names follow the International Plant Name Index (https://www.ipni.org/). Common plant names in English are given, if appropriate, at species or genus level. Abbreviations for life form: Ch, Chamaephyte; Cr, cryptophyte; He, hemicryptophyte; Ph, phanerophyte; and Th, therophyte. Conservation status of species evaluated based on IUCN categories at national level (Jalili and Jamzad 1999). Abbreviations for IUCN plant categories: CR, critically endangered; DD, data deficient; EN, endangered; LC, least concern; NE, not evaluated; NT, near threatened; and VU, vulnerable. Constancy classes (I: 0-20%, II: 21-40%, III: 41-60%, IV: 61-80%, and V: 81-100%) provided for each species at all sites (All), sacred groves (SG), and surrounding woodlands (SW) respectively.

Family	Scientific name	Common English name	Life form	Conservation status	Constancy classes		
					All	SG	SW
Acanthaceae	*Acanthus dioscoridis* L.	Dioscorides' Bear's-breech	He	NT	I	I	I
Aceraceae	*Acer monspessulanum* L.	Montpellier maple	Ph	VU	I	I	I
Amaryllidaceae	*Allium atroviolaceum* Boiss.	Broadleaved wild leek	Cr	VU	I	I	I
	Allium eriophyllum Boiss.	Wild garlic	Cr	NE	I	I	0
	Allium hooshidaryae Mashayekhi, Zarre & R.M.Fritsch	Wild garlic	Cr	CR	I	I	0
	Allium jesdianum Boiss.& Buhse	Wild garlic	Cr	VU	I	I	0
	Allium macrochaetum Boiss. & Hausskn. ex Boiss.	Wild garlic	Cr	NT	I	II	I
	Allium saralicum R.M. Fritsch	Wild garlic	Cr	CR	I	I	0
	Allium stamineum Boiss.	Wild garlic	Cr	VU	I	0	I
Anacardiaceae	*Pistacia atlantica* Desf.	Persian turpentine tree	Ph	NT	I	I	I
Apiaceae	*Bunium elegans* (Fenzl) Freyn	Pignut	He	NE	III	III	III
	Chaerophyllum aureum L.	Golden chervil	He	NT	I	III	I
	Chaerophyllum macropodum Boiss.	Chervil	He	NT	I	I	I
	Chaerophyllum macrospermum (Willd. ex Schult.) Fisch. & C.A.Mey.	Chervil	Cr	NT	I	I	0
	Falcaria vulgaris Bernh.	Longleaf	He	NT	I	I	0
	Grammosciadium scabridum Boiss.	-	Th	NE	I	I	I
	Grammosciadium platycarpum Boiss. & Hausskn. ex Boiss.	-	He	NE	I	I	0
	Heptaptera anatolica (Boiss.) Tutin	-	He	NE	I	III	0
	Heracleum persicum Desf. ex Fisch.,	Persian	He	NT	I	I	0

	C.A.Mey. & Avé-Lall.	hogweed					
	Johreniopsis scoparia (Boiss.) Pimenov	-	He	DD	I	I	I
	Malabaila sekakul Boiss.	-	He	NT	I	IV	0
	Physocaulis nodosus W.D.J.Koch	-	Th	NE	I	I	0
	Prangos ferulacea Lindl.	-	He	LC	II	IV	I
	Scandix iberica Heldr. ex Boiss.	Shepherd's-needle	Th	NE	I	I	I
	Scandix stellata Banks & Sol.	Shepherd's-needle	Th	NE	I	I	0
	Torilis leptophylla Rchb.f.	Hedge-parsley	He	NE	IV		
	Turgenia latifolia Hoffm.	Greater bur-parsley	Th	NE	I	I	I
Araceae	*Arum conophalloides* Kotschy ex Schott	Lords-and-ladies	Cr	NT	I	I	0
	Arum virescens Stapf	Lords-and-ladies	Cr	NT	I	II	0
Aristolochiaceae	*Aristolochia bottae* Jaub. & Spach	Birthwort	Cr	NE	I	I	0
Asparagaceae	*Bellevalia olivieri* (Baker) Wendelbo	Hyacinth	Cr	NT	I	III	0
	Muscari comosum Mill.	Tassel hyacinth	Cr	NE	II	IV	I
	Muscari longipes Boiss.	Grape hyacinth	Cr	NE	I	I	0
	Ornithogalum brachystachys K.Koch	Star-of-Bethlehem	Cr	VU	I	I	0
	Ornithogalum cuspidatum Betrol.	Star-of-Bethlehem	Cr	VU	I	I	I
	Ornithogalum sanandajense Maroofi	Star-of-Bethlehem	Cr	EN	I	I	0
	Puschkinia scilloides Adams	Striped squill	Cr	NT	I	I	0
Asteraceae	*Achillea biebersteinii* Afan.	Yarrow	He	VU	I	I	0
	Achillea wilhelmsii K. Koch	Yarrow	He	LC	III	I	IV
	Anthemis altissima L.	Chamomile	Th	NE	I	I	0
	Anthemis haussknechtii var. *haussknechtii* Boiss. & Reut.	Chamomile	Th	NE	I	0	I
	Anthemis tinctoria L.	Yellow chamomile	He	NE	I	I	0
	Carduus arabicus Jacq.	Arabian thistle	Th	NE	I	I	0
	Centaurea aggregata Fisch. & C.A.Mey.	Knapweed	He	NE	I	I	0
	Centaurea behen L.	Knapweed	He	VU	I	II	I
	Centaurea iberica Trevir. ex Spreng.	Knapweed	Th	NE	I	0	I
	Centaurea solstitialis L.	Yellow Starthistle	He	NE	I	I	I
	Centaurea virgata subsp. *squarrosa* (Willd.) Gugler	Knapweed	Th	NE	I	I	I
	Cephalorrhynchus rechingerianus Tuisl	-	Cr	VU	I	II	0
	Chardinia orientalis (L.) Kuntze	Eastern shardeni	Th	NE	III	I	III
	Chondrilla juncea L.	Rush skeletonweed	Th	NE	I	0	I
	Cousinia fursei Rech.f.	-	He	LC	I	I	I
	Cousinia i-lata Boiss. & Hausskn. ex Boiss.	-	He	VU	I	0	I
	Crepis alpina L.	Alpine hawksbeard	Th	NE	I	0	I

	Crepis sancta (L.) Bornm.	Holy hawksbeard	Th	NE	I	0	I
	Crupina crupinastrum (Moris) Vis.	Southern Crupina	He	NE	I	I	I
	Echinops inermis Boiss. & Hausskn.	Globe thistle	He	VU	I	I	0
	Echinops orientalis Trautv	Eastern globe thistle	He	NE	II	I	II
	Eryngium billardierei F.Delaroche	Eryngo	He	NE	I	II	I
	Filago arvensis L.	Field cottonrose	Th	NE	III	I	III
	Garhadiolus angulosus Jaub. & Spach	-	Th	NE	II	I	III
	Gundelia tournefortii L.	Tumble thistle	Cr	NT	I	I	I
	Helichrysum armenium DC.	Armenian everlasting	He	NE	I	I	I
	Hieracium echioides Lumn.	Adderhead hawkweed	He	NE	I	I	0
	Hieracium procerum Fr.	Tall hawkweed	He	NE	I	0	I
	Lactuca serriola L.	Prickly lettuce	Th	LC	I	I	0
	Lapsana communis L.	Nipplewort	Th	NE	I	III	0
	Onopordum carduchorum Bornm. & Beauverd	Donkey thistle	He	NE	I	I	I
	Picnomon acarna (L.) Cass.	Thistle	Th	NE	II	I	III
	Pimpinella aurea DC.	Burnet-saxifrage	He	NE	I	I	I
	Rhaponticum insigne (Boiss.) Wagenitz	Knapweed	He	NE	I	I	0
	Scariola orientalis (Boiss.) Soják	Oriental lettuce	He	NE	II	I	III
	Scorzonera laciniata Vahl ex DC.	Scorzonera	Cr	NE	I	III	0
	Scorzonera mucida Rech.f., Aellen & Esfand.	Scorzonera	Cr	LC	I	I	I
	Scorzonera phaeopappa Boiss.	Scorzonera	Cr	NE	I	I	0
	Senecio orientalis Friv. ex Griseb.	Ragwort	He	NE	I	I	0
	Senecio vernalis Franch.	Eastern groundsel	He	NE	I	I	I
	Serratula grandifolia P.H.Davis	Saw-wort	He	EN	I	I	0
	Taraxacum montanum H.Koidz.	Mountain dandelion	He	NE	I	I	I
	Tragopogon latifolius Boiss.	Goat's-beard	He	EN	I	I	I
	Tragopogon buphthalmoides Boiss.	Goat's-beard	Cr	EN	I	I	I
	Tragopogon graminifolius DC.	Goat's-beard	He	NE	I	I	0
	Xeranthemum squarrosum Boiss.	Immortelle	He	NE	I	I	0
Boraginaceae	*Anchusa italica* Retz. var. italica	Italian bugloss	He	NE	I	0	I
	Buglossoides arvensis L. I.M.Johnst.	Corn gromwell	Th	NE	I	I	0
	Myosotis lithospermifolia Hornem.	Forget-me-not	He	NE	I	I	0
	Myosotis ramosissima Rochel	Forget-me-not	He	NE	I	0	I
	Onosma subsericea Freyn	Onosma	He	NE	I	I	0
	Rochelia disperma Hochr.	-	Th	NE	I	0	I
	Symphytum kurdicum Boiss. & Hausskn. ex Boiss.	Kurdish comfrey	He	VU	I	III	I
Brassicaceae	*Alliaria petiolata* (M. Bieb.) Cavara & Grande	Garlic mustard	He	NE	I	IV	I
	Alyssum stapfii Vierh.	Stapf's alison	Th	NE	I	0	I

	Alyssum szovitsianum Fisch. & C.A.Mey.	Szovits' alison	Th	NE	I	I	I
	Arabis nova Vill.	Ear rock-cress	Th	NE	I	I	0
	Cardaria draba Desv.	Hoary cress	He	NE	I	I	I
	Erysimum collinum Andrz.	Wallflower	Th	NE	I	I	0
	Fibigia clypeata (L.) Medik.	-	He	NE	I	I	0
	Neslia apiculata Fisch., C.A.Mey. & Avé-Lall.	Ball mustard	Th	NE	I	0	I
	Parlatoria rostrata Boiss. & Hohen.	-	Th	LC	I	I	0
	Thlaspi perfoliatum L.	Perfoliate penny-cress	Th	NE	I	I	I
Campanulaceae	*Asyneuma amplexicaule* (Willd.) Hand.-Mazz.	-	Cr	NE	I	I	0
	Campanula involucrata Aucher ex A.DC.	Bellflower	He	NT	I	I	I
	Legousia speculum-veneris (L.) Chaix	Venus's-looking-glass	Th	NE	I	I	0
Caprifoliaceae	*Cephalaria syriaca* Schrad.	Syrian cephalaria	Th	NE	I	I	0
	Lonicera nummulariifolia Jaub. & Spach	Dwarf honneysuckle	Ph	NE	I	IV	0
	Pterocephalus plumosus Coult.	-	He	NE	I	0	I
	Valerianella dactylophylla Boiss. & Hohen.	Corn salad	Th	NE	I	I	I
Caryophyllaceae	*Agrostemma githago* L.	Corncockle	Th	NE	I	I	0
	Arenaria serpyllifolia L. var. *serpyllifolia*	Thyme-leaved sandwort	Th	NE	III	0	III
	Cerastium dichotomum L.	Forked chickweed	Th	NE	II	I	II
	Dianthus strictus Sm.	Pink	He	NE	I	0	I
	Herniaria glabra L. var. *glaberrima* Fenzl	Smooth rupturewort	He	NE	I	0	I
	Petrorhagia cretica (L.) P.W.Ball & Heywood	Cretan pink	Th	NE	I	0	I
	Silene ampullata Boiss.	Catchfly	He	NE	I	I	I
	Silene latifolia Britten & Rendle	White campion	He	NE	I	III	0
	Silene *prilipkoana* Schischk.	Catchfly	He	NE	I	I	0
	Stellaria media (L.) Vill.	Common chickweed	Th	NE	I	I	I
	Vaccaria grandiflora Jaub. & Spach	Cowherb	Th	NE	I	I	I
	Velezia rigida L.	Stiff velezia	Th	NE	II	0	III
Cistaceae	*Helianthemum ledifolium* (L.) Mill.	Rock-rose	Th	LC	I	0	I
Crassulaceae	*Sedum rubens* Jacq. ex Nyman	Red Stonecrop	Th	NE	I	0	I
Cucurbitaceae	*Bryonia multiflora* Boiss. & Heldr.	Bryony	Cr	NT	I	I	0
Dioscoreaceae	*Tamus communis* Link	Black bryony	Cr	NE	I	I	0
Euphorbiaceae	*Euphorbia cheiradenia* Boiss. & Hohen.	Spurge	He	NE	I	I	0
	Euphorbia condylocarpa M. Bieb.	Spurge	He	NE	I	I	0
	Euphorbia helioscopia L.	Sun spurge	Th	NE	I	I	0
	Euphorbia macrocarpa Boiss. & Buhse	Spurge	He	NE	I	I	0
	Euphorbia phymatosperma Boiss. & Gaill.	Spurge	Th	EN	I	II	0

Fabaceae	*Astragalus caryolobus* Bunge	Milkvetch	He	NT	I	I	0
	Astragalus curvirostris Boiss.	Milkvetch	He	LC	I	I	I
	Astragalus echinops Boiss.	Milkvetch	He	LC	I	I	0
	Astragalus gossypinus Fisch.	Milkvetch	He	LC	II	II	II
	Astragalus michauxianus Boiss.	Milkvetch	He	LC	II	I	II
	Astragalus ovinus Boiss.	Milkvetch	He	LC	I	I	I
	Astragalus piranshahricus Maassoumi & Podlech	Milkvetch	Ch	VU	I	I	0
	Astragalus sp.	Milkvetch	He	NE	I	I	I
	Astragalus tortuosus DC.	Milkvetch	He	LC	I	I	I
	Astragalus verus Olivier	Milkvetch	He	LC	I	0	I
	Cicer oxyodon Boiss. & Hohen.	Wild chickpea	Th	VU	I	I	0
	Coronilla varia L.	Crown vetch	He	NE	I	I	0
	Lathyrus aphaca L.	Yellow vetchling	Th	NT	I	I	0
	Lathyrus inconspicuus L. var. inconspicuus	Inconspicuous vetchling	Th	NT	I	0	II
	Lathyrus rotundifolius Willd.	Persian everlasting pea	Th	VU	I	I	0
	Lens orientalis subsp. orientalis (Boiss.) Ponert	Eastern lentil	Th	NE	I	0	I
	Lotus corniculatus var. *corniculatus* L.	Common bird's-foot-trefoil	Th	NE	I	I	I
	Lotus gebelia Var. gebelia Vent.	Bird's-foot-trefoil	He	NE	I	I	I
	Medicago sativa L.	Alfalfa, Lucerne	He	NE	I	I	0
	Pisum sativum L.	Garden pea	Th	NE	I	I	0
	Trifolium campestre C.C.Gmel.	Hop trefoil	Th	NE	I	I	I
	Trifolium dasyurum C.Presl	Eastern starry clover	Th	NE	I	I	0
	Trifolium pilulare Boiss.	Ball cotton clover	Th	LC	I	0	I
	Trifolium pratense L.	Red clover	He	NE	I	I	0
	Trifolium purpureum Gueldenst. ex Ledeb.	Purple clover	Th	NE	II	0	III
	Trifolium repens Walter	White clover	He	NE	I	II	0
	Trifolium spumosum L.	Mediterranean clover	Th	DD	I	I	I
	Vicia michauxii Schrank ex Steud.	Michaux' tare	Th	NE	I	I	I
	Vicia narbonensis L.	Narbonne vetch	Th	NE	I	II	I
	Vicia sativa subsp. *sativa* L.	Common vetch	Th	NE	I	II	0
	Vicia sericocarpa Fenzl	Vetch	Th	LC	I	I	I
	Vicia variabilis Freyn & Sint. ex Freyn	Vetch	Th	NE	II	III	I
Fagaceae	*Quercus brantii* Lindl.	Brant's oak	Ph	NT	III	IV	II
	Quercus i-ectoria Oliv.	Aleppo oak	Ph	LC	V	V	V
	Quercus libani Oliv.	Lebanon oak	Ph	LC	IV	IV	IV
Gentianaceae	*Gentiana olivieri* Griseb.	Olivier's gentian	Cr	NE	I	I	I
Geraniaceae	*Geranium* sp.	Crane's-bill	Cr	NE	I	I	I
	Geranium tuberosum L.	Tuberous crane's-bill	Cr	NE	I	III	I

Hypericaceae	*Hypericum asperulum* Jaub. & Spach	St John's-wort	Cr	LC	I	I	I
	Hypericum lysimachioides Boiss. & Noë	St John's-wort	Ch	LC	I	I	0
	Hypericum scabrum L.	Scabrous St John's-wort	He	LC	I	0	I
Iridaceae	*Iris reticulata* M.Bieb.	Netted iris	Cr	LC	I	I	I
Ixioliriaceae	*Ixiolirion tataricum* (Pall.) Herb. & Traub	Lavender mountain-lily	Cr	LC	I	I	I
Lamiaceae	*Lallemantia iberica* Fisch. & C.A.Mey.	Dragon's head	Th	NE	I	I	0
	Lamium album subsp. *Album* L.	White dead-nettle	He	NE	II	II	II
	Lamium *amplexicaule* var. *amplexicaule* L.	Henbit dead-nettle	Th	NE	I	I	I
	Marrubium astracanicum Jacq.	Astrakhan horehound	He	NE	I	0	I
	Marrubium cuneatum Banks & Sol.	Cuneate horehound	Cr	NE	I	0	I
	Nepeta sintenisii Bornm.	Catnip	He	NE	I	I	0
	Phlomis persica Boiss.	Persian Jerusalem sage	He	LC	II	I	II
	Salvia atropatana Bunge	Atropatene sage	He	NE	I	I	0
	Salvia bracteata Sims	Bracteate sage	He	NE	I	IV	0
	Scutellaria condensata subsp. *pycnotricha* Rech.f.	Skullcap	He	EN	I	I	0
	Teucrium polium Decne. ex C.Presl	Felty germander	Ch	NE	I	I	I
	Ziziphora capitata L.	Ziziphora	Th	NE	IV	I	V
Liliaceae	*Fritillaria imperialis* L.	Crown imperial fritillary	Cr	NT	I	I	0
	Fritillaria straussii Bornm.	Strauss' fritillary	Cr	EN	I	I	0
	Tulipa systola Stapf	Desert tulip	Cr	NT	I	I	I
Malvaceae	*Alcea hohenackeri* Boiss.	Hollyhock	He	NE	I	0	I
	Alcea kurdica (Schltdl.) Alef.	Kurdish hollyhock	He	NT	I	I	0
Orchidaceae	*Cephalanthera kurdica* subsp. *kurdica* (Bornm.) H.Sundermann.	Kurdish helleborine	Cr	NT	I	I	0
	Comperia comperiana (Steven) Asch. & Graebn.	Comperia	Cr	NE	I	II	0
	Epipactis helleborine (L.) Crantz	Broadleaved helleborine	Cr	EN	I	II	I
	Ophrys reinholdii subspec. *straussii* (H.Fleischm.) E.Nelson	Reinhold's bee-orchid	Cr	EN	I	I	0
	Ophrys sphegodes var. *transhyrcana* (Czerniak.) P.J.Cribb	Transhyrcanian bee-orchid	Cr	EN	I	I	0
Orobanchaceae	*Orobanche coelestis* Boiss. & Reut. ex Reut.	Broomrape	Th	NE	I	I	0
	Orobanche kochii F.W.Schultz	Broomrape	Th	NE	I	I	0
	Rhynchocorys elephas (L.) Griseb.	-	Th	NE	I	I	0
Papaveraceae	*Fumaria vaillantii* Loisel.	Few-flowered fumitory	Th	EN	I	I	0
	Papaver bracteatum Lindl.	Poppy	He	NE	I	I	0
	Papaver macrostomum subsp.	Poppy	Th	VU	I	I	0

	macrostomum Boiss. & A.Huet						
Plantaginaceae	*Plantago lanceolata* L.	Ribwort plantain	He	NE	I	I	I
	Veronica bozakmanii M.A.Fisch.	Speedwell	Th	NE	I	0	II
	Veronica campylopoda Boiss.	Bent-stalked speedwell	He	NE	II	I	II
	Veronica orientalis Mill.	Eastern speedwell	He	NE	I	I	0
Poaceae	*Aegilops triuncialis* L.	Barbed goatgrass	Th	NE	II	0	III
	Alopecurus pratensis L.	Meadow foxtail	He	NE	I	0	I
	Avena sterilis L.	Winter wild oat	Th	NE	I	I	0
	Bromus danthoniae var. *danthoniae* Trin. ex C.A.Mey.	Oat brome	Th	LC	IV	I	V
	Bromus sterilis L.	Barren brome	Th	LC	I	IV	I
	Bromus tectorum L.	Drooping brome	Th	LC	III	0	IV
	Dactylis glomerata L.	Orchard grass	He	NE	I	III	I
	Elymus panormitanus (Bertol.) Tzvelev	Woodland couch grass	Th	NT	I	II	I
	Eremopoa persica var. *persica* (Trin.) Roshev.	Persian hermitage	Th	VU	II	0	II
	Heteranthelium piliferum Hochst. ex Jaub. & Spach	-	Th	NE	III	I	IV
	Hordeum bulbosum L.	Bulbous barley	Cr	LC	III	IV	III
	Hordeum vulgare L.	Common barley	He	LC	I	0	I
	Milium pedicellare (Bornm.) Roshev. ex Melderis	Milletgrass	Th	NE	I	I	0
	Poa bulbosa L.	Bulbous bluegrass	Cr	LC	IV	II	V
	Taeniatherum crinitum (Schreb.) Nevski	Medus-head	Th	NE	II	I	III
	Trisetum flavescens (L.) P.Beauv.	Yellow oatgrass	He	NE	I	I	0
Polygonaceae	*Polygonum aviculare* L.	Prostrate knotweed	He	NE	I	0	I
	Rumex angustifolius Engelm. ex Meisn.	Narrow-leaved dock	He	NE	I	II	0
Ranunculaceae	*Ceratocephalus testiculatus* (Crantz) Roth	Curveseed butterwort	Th	NE	II	0	II
	Delphinium pallidiflorum Freyn	Pale-flower larkspur	He	NE	I	I	0
	Ranunculus arvensis L.	Corn buttercup	Th	NE	I	I	I
	Ranunculus aucheri Clem. ex Boiss.	Buttercup	Cr	NE	II	II	III
	Ranunculus constantinopolitanus var. *villosus* (DC.) Mobayen & Z.Maleki	Constantinople buttercup	He	VU	I	I	0
	Ranunculus demissus Orphan. ex Nyman	Buttercup	Cr	NE	I	I	0
	Ranunculus oxyspermus Willd.	Buttercup	Cr	NE	I	I	0
	Ranunculus pinardi Boiss.	Buttercup	Th	NE	I	I	I
	Ranunculus sericeus Willd.	Illyrian buttercup	Th	NE	I	I	0
Rhamnaceae	*Paliurus spina-christi* Mill.	Jerusalem thorn	Ph	LC	I	I	0
Rosaceae	*Amygdalus communis* L.	Sweet almond	Ph	NE	I	I	0

	Cerasus microcarpa Boiss.	Small-fruited cherry	Ph	NE	I	IV	0
	Cotoneaster morulus Pojark.	Cotoneaster	Ph	NE	I	I	0
	Crataegus pontica K.Koch	Pontic hawthorn	Ph	NE	II	IV	I
	Prunus communis subsp. *divaricata* (Ledeb.) Brandis	Plum	Ph	NE	I	I	0
	Pyrus syriaca Boiss.	Syrian pear	Ph	NE	I	III	I
	Rosa canina Sol. ex Bab.	Common dog-rose	Ph	NE	I	III	0
Rubiaceae	*Asperula arvensis* L.	Blue woodruff	Th	NT	II	I	II
	Callipeltis cucullaris Stev.	-	Th	NE	I	0	I
	Crucianella exasperata Fisch. & C.A.Mey.	Crosswort	Th	VU	I	0	I
	Crucianella gilanica subsp. *carduchorum* Ehrend. & Schönb.-Tem.	Crosswort	He	VU	I	I	0
	Galium aparine L.	Cleavers	Th	NE	I	IV	0
	Galium haussknechtii Ehrend.	Bedstraw	Th	NT	I	I	0
	Galium humifusum M.Bieb.	Bedstraw	He	NE	I	I	0
	Galium kurdicum Boiss. & Hohen.	Bedstraw	He	NT	I	0	I
	Galium setaceum Lam.	Bedstraw	He	NT	I	0	I
	Galium tricornutum Dandy	Corn cleavers	He	NE	II	0	II
	Galium verum L.	Yellow bedstraw	He	NE	I	II	0
Scrophulariaceae	*Parentucellia latifolia* subsp. *flaviflora* (Boiss.) Hand.-Mazz.	Red bartsia	Th	NE	I	0	I
Thymelaeaceae	*Daphne mucronata* Royle	Kashmir daphne	Ph	NE	I	I	0
Urticaceae	*Parietaria lusitanica* subsp. *chersonensis* (Láng) Chrtek	Mediterranean pellitory-of-the-wall	Th	NE	I	0	I
Violaceae	*Viola modesta* Ball	Modest violet	Th	NE	I	I	0