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Coexistence of herbal forest flora with phanerophyte up-story on Chahartagh forest reserve site in Cheharmahal va Bakhtiari province

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Abstract

Phytosociology and forest ecosystem typology results have not been always matched. This inconsistency is greater in highly diverse forests. The current study demonstrates this concept that phanerophyte composition of up stratum in a well-protected central Zagros forest can determine the pattern and composition of herbal plants on the forest floor. More than two hundred micro plots were launched on a thirty hectare of the Chahartagh forest reserve site. The species survey consisted of herbal cover of the micro plot and a number of trees located inside the diameter of ten meters around the micro-plots. The phanerophyte distribution was considered as the actual factors and herbal cover was considered as the natural responds and the relationships were analyzed by a canonical correspondence analysis. The Monte Carlo test showed a highly directed co-distribution of the under and upper stories in the forest.

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Introduction

Zagros forests cover a vast area of the Zagros mountain ranges stretching from Piranshahr (Western Azerbaijan province) in the northwest of Iran near Firoozabad (Fars province) having an average length and width of 1300 and 200 km, respectively. Classified as semi-arid, Zagros forests covers 5 million hectares and consist 40% of Iran's forests. The forest components reached to the climax about 5,500 years ago (Sagheb-Talebi *et al.,* 2005). Unfortunately, despite the richness in fauna and flora, the area of this habitat has reduced over the past century and, there are signs of disturbance in forest structure of remaining stands. The causes of these destructive changes are mainly natural and human factors such as land-use changes, the influence of dust storm pollution concentration, pest and disease infections, successive drought and, over harvest of the forests and pastures. Extinction of valuable plant and animal species, pollution of vital water ecosystems, wetlands and other cases are the result of the (Ghahremaninejad and Agheli, 2010). Undoubtedly, rehabilitation programs in partnership with native people are in the top priorities of strategic management to improve forest conditions and exit of the present unsuitable situation. Usually the result of such programs evaluates the natural situation of habitat restoring. Most studies measured multiple response variables. Each response variable was separated into one of three categories: ecosystem function, animal community, or plant community. Ecosystem variables included nutrient cycling, decomposition rates, and abiotic measurements. Animal and plant community variables included estimates of density, diversity, evenness, and species composition (Jones and Schmitz, 2009). Therefore, selection of appropriate methods to estimate coverage and diversity of the plant community is always interesting. Trees and shrubs play a major role in the forest ecosystem and forest existence roughly equivalent to the presence or absence of these components. However, remember the fact that other components of the biological community also contribute to the formation of this complex system and complementary relations in the community are due to their presence. (Volkov *et al.,* 2005).

Therefore, there are two questions: can predict the forest floor species composition by recognizing the forest tree species and composition? In addition, are there any relationships between the diversity of forest trees and shrubs and herbaceous plants? This study aims to find a possible relationship between tree and shrub species diversity and herbaceous plant species diversity to answer this question.

Materials and methods

The study area

The study area was the part of the Chahartagh forest reserve site, located about 100 km southeast Shahrekord and 40 km from the Ardal city and adjacent to Chahartagh villages. The reserve site covers an area of 400 hectares, between 31°, 49' and 21" and 31°, 49' and 55" northern latitudes and 50°, 51' and 14" and 50°, 51' and 26" eastern longitude. The habitat front is eastern and general slope (especially in the study area) is 27 percent. Elevation in the habitat is variable, at least 2100 m to 3100 m respectively in the bank of the Sabzkooh River along Kallar Mountains.

Forest type of this habitat is; "juniper-oak-ash" and its main species are; Mahaleb cherry (*Cerasus mahaleb*), Montpellier Maple (*Acer monspessulanum*), Hawthorn (*Crataegus aronia*) and *Lonicera nummulariifolia*.

Methods

In this study was done at 33 hectares of the Chahartagh forest reserve site. The exact location of all trees and shrubs (Phanerophytes) with a crown diameter more than 25.0 cm of each species recorded using mapping method. In this study, azimuth and distance of all trees and shrubs was complete measured using a compass and meter. Because of the mountainous topography of habitat to have a precious record of each interval, the gradient was recorded with an inclinometer then distances were converted to the horizontal. Finally, using geometric relationships and consider the random starting point as the zero point, first Cartesian coordinates for each tree was calculated and then using the coordinates of the specified reference point all locations was converted to Universal Transverse Mercator. The obtained data as a point layer was entered into the GIS environment (using Arc GIS 9.3 software).

To estimate herbaceous plant cover, first optimized micro plot size was calculated by change the areas including 50 × 50, 75 × 75, 100 × 100 and 150 × 150 centimeters. After selecting the optimized micro plots size, 200 micro plots were randomly placed on the map of the study area.

The field operations were performed in May 2012 (in accordance with the peak of herbal plant activities) by finding places of micro plots that located before and take images with high quality as well record altitude for every micro plot.

Sociological records at any micro plot introduced as a report including herbaceous cover and species. In addition, herbaceous plants were categorized based on life form (Raunkiaer life form classification), corotypes and families. Then each micro plot was assumed as the center of circular of 10 meters radius and the trees in this circular were counted according to their species.

Canonical Correlation Analysis wad used to analyze correlations between herbal cover and micro plot adjacent tree counts matrices. The Monte Carlo test was used to determine significant Eigenvalues.

Canonical Correlation Analysis was calculated using the Pcord4 software.

Results and discussion

Canonical Correlation Analysis was showed relatively high Eigen values obtained for the first component from converging of the herbal cover data matrix and adjacent trees, and shrubs matrix (0.752). The Eigenvalue obtained for the second axis is relatively low, however, the test results for both of the axis represents a significant correlation between the distribution of trees and forest floor plants by the Monte Carlo test (table 1). The correlation between the distribution of trees and shrubs, and forest floor plants was confirmed by Monte Carlo method (table 2). Therefore, the Monte Carlo tests showed that there was no significant difference between the presence (cover) herbal plant and distribution of trees and shrubs. The two-dimensional figure that provided by the test was interpretable (table 1). Figure 1 shows the distribution of scoring points of the herbaceous species along with vector values of trees and shrubs. Since the Monte Carlo results were not significant for the second axis of Canonical Correlation Analysis, a rectangular form was used in Fig 1 to facilitate the conclusions. Accordingly, just under stories species (forest floor) will be considered that changing along the axis of the first component. Table 3 shows the codes of herbaceous species in Fig 1.

Table 1. Monte Carlo test results – Eigenvalues.

	Real data	Randomized data 100 runs			
Axis	Eigenvalue	Mean	Minimum	Maximum	p
1	0.725	0.324	0.236	0.599	0.0060
2	0.429	0.243	0.221	0.298	0.0400
3	0.218	0.219	0.167	0.250	0.1000

Pearson and Kendall correlation coefficient between herbal cover and the trees and shrubs presence were 86% and 68% respectively for the first axis, 84% and 52% respectively for the second axis that suggests the high Eigenvalue of Canonical Correlation Analysis (Table 2).

Table 2. Monte Carlo test results – trees and shrubs-herbal species Correlations.

	Real data	Randomized data 100 runs			
Axis	Herbal - phanerophyte Corr	Mean	Minimum	Maximum	p
1	0.860	0.791	0.638	0.940	0.0100
2	0.745	0.741	0.660	0.840	0.0900
3	0.688	0.718	0.622	0.743	0.4000

Acer monospessulanum L. (=*A.cinerascens* Boiss), *Cerasus mahaleb* (L.) Mill, *Populus alba* L. and *Malus orientalis* species in the Canonical Correlation Analysis graph (Fig 1) have been together in the first quarter with herbal species frequently from the three families: Umbelliferae, Compositae and Cruciferae. There is a strong positive correlation.

Table 3. Species code of herbal plant used in Canonical correlation analysis graph.

Code	Species	Code	Species	Code	Species
75	*Plantago lanceolata*	38	*Euphorbia Boissieriana*	1	*Agropyron trichophorum*
76	*Poa bulbosa*	39	*Falcaria vulgaris*	2	*Alcea aucheri*
77	*Polygonum pyum*	40	*Fibigia macrocarpa*	3	*Allium atroviolaceum*
78	*Prangos ferulacea*	41	*Ficaria ranunculoides*	4	*Allium hirtifolium*
79	*Pterocephalus canus*	42	*Fumaria asepala*	5	*Alyssum linifolium*
80	*Ranunculus arvensis*	43	*Gagea gageoides*	6	*Alyssum longistylum*
81	*Roemeria hybrid*	44	*Galium verum*	7	*Alyssum marginatum*
82	*Roemeria refracta*	45	*Gentiana olivieri*	8	*Asperugo procumbens*
83	*Salvia multicaulis*	46	*Geranium ibericum*	9	*Asperula molluginoides*
84	*Sanguisorba minor*	47	*Geranium montanum*	10	*Astragalus susianus*
85	*Scandix ibericum*	48	*Geranium tuberosum*	11	*Astragalus aegobromus*
86	*Scariola orientalis*	49	*Gladiolus atroviolaceus*	12	*Astragalus cephalanthus*
87	*Scorzonera buphthalmoides*	50	*Glycyrrhiza glabra*	13	*Astragalus myriacanthus*
88	*Scorzonera calyculata*	51	*Graellsia saxifragifolia*	14	*Bellevalia longistyla*
89	*Scorzonera phaeopappa*	52	*Grammosciadium scabridum*	15	*Boissiera squarrosa*
90	*Stachys acerosa*	53	*Heteranthelium piliferum*	16	*Bongardia chrysogonum*
91	*Stachys lavandulifolia*	54	*Hordeum bulbusum*	17	*Brassica elongata*
92	*Stipa hohenackeriana*	55	*Hypericum scabrum*	18	*Bromus tectorum*
93	*Taeniatherum crinitum*	56	*Ixiolirion tataricum*	19	*Bromus tomentellus*
94	*Tanacetum polycephalum*	57	*Lamium amplexicaule*	20	*Bunium persicum*
95	*Taraxacum syriacum*	58	*Lappula microcarpa*	21	*callipeltis eueullaria*
96	*Thlaspi arvensis*	59	*Lasiopogon muscoides*	22	*Capsella bursa*
97	*Tragopogon longirostris*	60	*Leontice armeniaca*	23	*Cardaria draba*
98	*Trifolium arvense*	61	*Linum album*	24	*Carex stenophylla*
99	*Trifolium repens*	62	*Linum usitatissimum*	25	*Centaurea depressa*
100	*Tulipa stapfii*	63	*Lotus corniculatus*	26	*Centaurea virgata*
101	*Turgenia latifolia*	64	*Medicago sativa*	27	*Cerastium inflatum*

102	*Valerianella carinata*	*65*	*Melica jacquemontii*	28	*Cerastium umbelat*
103	*Valerianella cymbicarpa*	*66*	*Melica eligulata Boiss*	29	*Ceratocephalus falcatus*
104	*Valerianella sysimbriifolia*	*67*	*Muscari neglectum*	30	*Chaerophyllum umbelic*
105	*Verbascum agrimoniifolium*	*68*	*Nonea persica*	31	*Cirsium bracteosum*
106	*Veronica orientalis*	*69*	*Onopordun acanthium*	32	*Clypeola aspera*
107	*Vicia michauxii*	*70*	*Ornithogalum persicum*	33	*Colchicum haussknechtii*
108	*Vicia villosa*	*71*	*Papaver argemona*	34	*Conringia perfoliata*
109	*Ziziphora tenuir*	*72*	*Papaver dubium*	35	*Corydalis rupestris*
		73	*Papaver fugax Poir*	36	*Crepis foetida*
		74	*Phlomis olivieri*	37	*Crucianella gilanica*

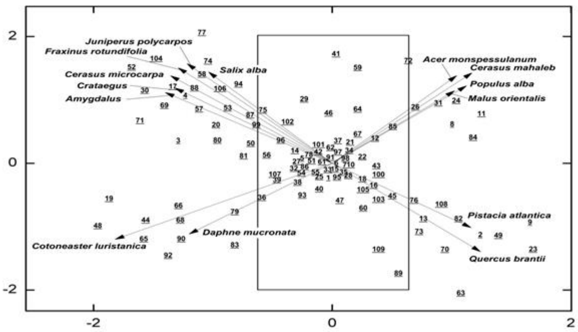

Fig. 1. The most important herbal species in relation to the tree and shrub species.

The tree and shrubs of *Juniperus polycarpos* C.Koch., *Fraxinus rotundifolia* Mill., *Cerasus microcarpa* (C.A.M) Boiss., *Cratagus aronia* (L.) Bosc. and *Amygdalus* sp showed a positively correlated relationship along with seven herbaceous species belonging to the Asteraceae family in the second quarter.

Cotoneaster luristanica G. Klotz. and *Daphne angustifolia* C.Koch (=*D.mucronata*) shrubs indicated a strong negative correlation along with three herbal species altogether with one frequency, of Liliaceae, Umbelliferae and Labiatae family in the third quarter.

Quercus brantii Lindl. and *Pistacia mutica* F.&M. (=*P.atlantica*) trees had most accompanied by herbaceous species, frequently from four families including Malvaceae, Rubiaceae, Papaverraceae and Labiatae, in the fourth quarter.

Monte Carlo results in Table 2 indicated that to interpret the correlation between the presence of trees and shrubs and herbal species, the first component of the Canonical Correlation Analysis table should be considered, since the results of these tests indicated no significant difference in the second component axis. Therefore, although with considering to the second component axis (y-axis), the 23th species (*Cardaria draba*) located near *Cerasus mahaleb*, but due to denial of interpretation of this axis, these two species in widely separated and overlooked their correlations.

Canonical correlation analysis results confirmed the high correlation between the trees and shrubs and plants of the forest floor along of the axis first component. The results of this analysis indicate that the high association between trees. Regardless of the tree ecological needs, the relative density of trees regulates the different species together. This means that the four species with the highest density of trees and shrubs (*Cratagus aronia*, *Cerasus microcarpa*, *Fraxinus rotundifolia* and *Juniperus polycarpos*) appeared in the second quarter. Similarly, two species of *Cotoneaster luristanica* and *Daphne angustifolia* (with a higher density than seven individual per hectares) are located in the left of the main axis. Only two species of *Quercus brantii* and *Pistacia mutica* (with a higher density than seven individual per hectare) located in the right of the first component axis. Except the density factor, it seems that most tree species located in the right of the first axis are including the high demand species and appears in the final stages of evolution. *Cratagus aronia* species can take maximum advantage of the rich soils by the coexistence with mycorrhizal fungi (Wright and Upadhyaya 1998) and this demonstrated that the *Fraxinus rotundifolia* similar species in Iran northern forests (*Fraxinus excelsior* L.) is in need of rich soils too (Espahbodi *et al.,* 2003, Tabari *et al.,* 2002). So after the high density factor, soil richness factor can be considered. Unlike trees and shrubs, most of the forest floor species that along with them are low frequent plants such as *Cardaria draba*, *Alcea aucheri*, *Leontice armeniaca* and *Stachys lavandulifolia* that each one had minimum distance to the tree species in the same quarters. All species appeared with the cover less than 0.2 near trees except in the case of *Leontice armeniaca* in lowland and *Stachys* lavandulifolia in midland that allocated cover more than 0.5. However, the most abundant species at all altitudes (lowland, midland and upland) are *Stipa hohenackeriana*, *Trifolium repens* and *Hordeum bulbusum*. Canonical Correlation Analysis graph indicated that these species are almost the furthest from all the trees. So this can be concluded that there is a dominant and recessive forms of relationship between species of further distances from trees and just one species dominant over other herbal plants and extent its cover. Whereas there is a light competitive condition in the understory, (due to the existence of a desirable microclimate) more species with less coverage was appeared. At the higher altitudes, there was more species with less coverage and only two species covered by more than 0.4 in the habitat. These results are true as well for the midland unless the cover of one of the two species is very high and is even more than 0.8. At low altitude, many species had more than 0.4 coverage, so the results of this analysis showed accompaniment of associated herbal plant with the uplands trees and shrubs.

Almost all herbaceous plants located in the region with the highest density of trees are allocated to the hydrophilic plants. *Polygonum patulum* (Davis *et al.,* 1988, Georgoudis *et al.,* 2005) and *Veronica orientalis* (Batooli, 2003) and *Lappula microcarpa* (Gholami *et al.,* 2006) are the most hydrophilic ones. Despite favorable precipitation, it did not seem to meet the water needs of such species in the Chahartagh sparse forest, so the high correlation between such herbal species and the presences of trees in high density may be related to appear more water in the a high density of trees (more shade). The other trees such as *Fraxinus rotundifolia* (the most frequent tree), has grown at the bank of the seasonal stream that confirmed needs of soil moisture. *Brassica elongate* species appear in juniper habitat in the north of America (Laursen and Seppelt 2009), then likely it settle on the Chahartagh Reserve site along with juniper trees.

The presence of the high density of trees on the left of the first component axis along with herbaceous species such as *Tanacetum polycephalum* and *Allium hirtifolium* which requires high soil organic matter (Jones and Willett, 2006; Šourková *et al.,* 2005), could be interpreted as high levels of litter and soil organic matter content.

Three species of *Valerianella sysimbriifolia*, *Grammosciadium scabridum* and *Phlomis olivieri* have high aromatic material, On the one hand escape from herbivores, Sue wild, On the other hand have not been associated with main range species and due to its special chemical composition is distributed in particular areas of the forest (Mirza and Nik, 2003; Sonboli *et al.,* 2005; Violon *et al.,* 1983).

Forest floor herbaceous species that are associated with *Quercus brantii* and *Pistacia mutica* species (right opposite of the high density trees), had different ecological characteristics. *Cardaria draba* is resistant to soil moisture changing and grows abundantly in all regions, but *Asperula molluginoides* species is sensitive to soil moisture changing and only grows in rich soils. Since unlike most of the Zagros forests, *Quercus brantii* and *Pistacia mutica* had a low density (for *Pistacia mutica* less than the 7 individuals per hectare) in this habitat, the association of herbal plant with various demands could take local conditions into account, such as topography. For example, both of these trees have heavy seeds that limited their distribution areas to the same particular herbal species areas. Totally the results showed that when a relatively small area of the forest were studied, at the conclusion of the final multivariate analysis should consider the only areas with higher density and the trees.

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