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Investigating Plant Diversity Indices, Soil Characteristics, and Floristic Quality in Three Different Forest Types in Zagros

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ABSTRACT

Aims: This study investigated the variation in plant diversity, floristic quality indices, and the forest integrity of various broadleaf forest types.
Materials & Methods: In this study, we used 288 plots of 1m^2 in the middle Zagros forest to investigate the role of three forest types including *Quercus infectoria*, *Quercus brantii*, and *Pyrus glabra* on forest diversity indices and floristic quality
Findings: results revealed significant differences in Shannon wiener, Margalef, and Menhinic indices, as well as some soil properties, between forest types, but no significant differences in evenness and Simpson indices. Diversity indices mean coefficient of conservatism and floristic quality index (FQI) were significantly greater in the protected forest dominated by *Quercus infectoria* than in other protected forests.
Conclusion: This study demonstrates that tree species and certain topographical and edaphic factors have distinct effects on the distribution of understory plants, plant diversity, and floristic quality in different forest types. The results of this research, while confirming the use of plant diversity indices, also introduce the conservatism coefficient and species fidelity as additional tools in evaluating forest integrity, because by using them, more and better information can be obtained about the conditions of the forest.

Keywords: Conservation; Diversity indices; Floristic quality; Herbaceous plants; Soil properties; Tree species.

CITATION LINKS

[1] Dehghan Rahimabadi P., Azarnivand H., Malekian A. Hydrogeological ... [2] Sakizadeh M. Performance of ... [3] Bahar Gogani M., Douzbakhshan M., Shayesteh K., Ildoromi A.R. New formulation ... [4] Ghazavi R., Ebrahimi H. Estimation of Artificial Groundwater Recharge by Flood Water Spreading System in ... [5] Ravikumar P., Somashekar R.K. Principal component analysis ... [6] Su Z., Wu J., He X., Elumalai V. Temporal changes of ... [7] Priyanka M., Venkata M., Ratnakar D. Groundwater Quality ... [8] Abdalazem, A.H., Gamee M.A., Hamdan A., Awad A.A.M., Mohamed A.G. Groundwater ... [9] Ravikumar P., Somashekar R., Angami M. Hydrochemistry and evaluation of ... [10] Elsayed, S., Hussein H., Moghanm F.S., Khedher K.M., Eid E.M., Gad M. Application of Irrigation Water Quality Indices and Multivariate Statistical Techniques for Surface Water Quality Assessments in the Northern Nile Delta, Egypt. Water. 2020; 12(1): e3300. ... [11] Taheri M., Gharaie M.H.M., Mehrzad J., Afshari R., Datta S. Hydrogeochemical. ... [12] Banda, T.D., Kumarasamy M. Application of multivariate statistical. ... [13] Horton R.K. An index number ... [14] Ram A., Tiwari S., Pandey H., Chaurasia A.K., Singh S., Singh Y. Groundwater ... [15] Khalaf R.M., Hassan W.H. Evaluation of irrigation water quality index IWQI for Al-Dammam ... [16] Tarawneh M.S.M., Janardhana M.R., Ahmed M.M. Hydrochemical ... [17] Abbasnia A., Yousefi N., Mahvi A.H., Nabizadeh R., Radfard M., Yousefi M., Alimohammadi M. Evaluation ... [18] Jehan S., Ullah I., Khan S., Muhammad S., Khattak S.A., Khan T. Evaluation of ... [19] Subba Rao N., Srihari C., ... [20] Ramachandran Muthulakshmi Y. Geo-spatial analysis of ... [21] Yıldız S., Karakuş C.B. Estimation of ... [22] Sadat-Noori S., Ebrahimi K., Liaghat A. Groundwater quality ... [23] Soleimani H., Nasri O., Ojaghi B., Pasalari H., Hosseini M., Hashemzadeh B., Kavosi A., Masoumi S., Radfard M., Adibzadeh A. Data on drinking water quality using water quality index (WQI) and assessment of groundwater quality for irrigation purposes in Qorveh & ... [24] Hojjati, M.H., Boustani F. An assessment of groundwater crisis in Iran, case study: Fars Province. World. Acad. ... [25] Nafarzadegan A., Zadeh M.R., Kherad M., Ahani H., Gharehkhani A., Karampoor M., Kousari M. Drought area monitoring during the past three decades in Fars ... [26] Choubin B., Malekian A., Golshan M. Application of several data-driven techniques to predict a standardized ... [27] Brown R.M., McClelland N.I., Deininger R.A., Tozer R.G. Water quality index-Do ... [28] Ayers R.S., Westcot D.W. Water quality for agriculture: Food and Agriculture Organization of the. ... [29] Meireles, A.C.M., Andrade E.M.D., Chaves L.C.G., Frischkorn H., Crisostomo L.A. A new proposal of the classification of irrigation water. Rev. Cienc...

Introduction

Because ecosystem integrity (EI) is an important indicator for determining the relationship between biodiversity loss and ecosystem services, the concept of ecosystem integrity emphasizes that the ecosystem should have an exceptional capacity for maintaining biodiversity and quality [1]. In other words, EI focuses on maintaining the capacity of systems to sustain wildlife and ecosystem services, especially in the presence of disturbances [2], consequently, forest management has adopted a more ecological approach and strives for greater diversity and naturalness in forests in recent decades. Trees as dominant components of the forest can influence the composition of vegetation, diversity, and soil [3]. Examining the effects of overstory tree species on soil properties, ground flora, and forest integrity, is essential for ensuring sustainable forest management.

Tree species are directly linked to soil properties, Litter production and decomposition and nutrients return to the soil pool [4,5]; indeed, trees have the potential to impact soil nutrient mineralization, availability via soil microorganisms, and the current soil fertility [5]. Beyond species diversity, environmental factors such as local climate and topography can also directly or indirectly influence forest stability via their effects on species richness and stand structural characteristics [6].

For measuring ecosystem integrity, numerous conventional diversity indices, such as species richness, the Simpson index, the Shannon- Weiner index, the Simpson's Dominance index, and the Pielou evenness index, have been proposed [7,8]. Further, an understanding of the diversity and stand structure of species is can be effective in evaluating the integrity of the forest ecosystem [8]. For instance, Jafari *et al.* (2019) demonstrated that collecting information about plant composition could help biodiversity conservation agencies and natural resources managers develop a useful tool to protect endemic and endangered plant species [9]. However, selecting and developing indicators to measure a complex concept like ecological integrity and track its changes over time presents a formidable challenge. An adequate index should incorporate several essential characteristics, such as an ecosystem's structure, composition, function [10], and conservatism value [11]. In other words, we require methods that refer to a metric value derived from qualitative or quantitative data on a specific group of organisms, such as the floristic quality index (FQI). The FQI is an evaluation technique for inferring ecosystem integrity [12] that combines qualitative (e.g., life history or biological information) and quantitative (i.e., species richness) data into a single measure for plants [13]. FQI incorporates two measures of a site's integrity: biodiversity and "species conservatism" coefficient of conservatism (CC), a score between 0 and 10 assigned to each plant species in a local flora by local plant experts, reflects disturbance tolerance and habitat integrity fidelity [14].

The "Zagros forests" are located in western Iran. The region features a Mediterranean climate with deciduous oak-dominated forests. Increasing human disturbances and pressures (such as economic development, urban expansions, and human population density) and hot winds have caused widespread fragmentation and degradation of forests [11]. Consequently, it is necessary to investigate the effects of tree species on plant diversity, floristic quality, and ecosystem integrity. In this study, we sought to present a methodology for evaluating the ecological integrity of protection forests at regional scales in the Zagros forests. The primary objectives of the study are outlined below:

- To determine the influence of tree species on species diversity, specialist species, floristic quality, and soil properties;
- To examine the correlation between understory diversity, floristic quality, and dominant species, as well as how they manifest under the conservation effects;
- To assess how floristic quality indices may be applied to evaluate forest integrity and future natural forest and identify successfully conserved areas.

Materials & Methods

Study area

We selected three protected study sites with diverse dominant tree species (Shineh Ghelaee, Ghalegol, and Chamhesar) in the Province of Lorestan, located in the middle Zagros forests; the predominant broad-leaved deciduous species of these forests are *Quercus infectoria* Oliv., *Quercus brantii* Lindl., and *Pyrus glabra* Buhs, respectively. These areas are protected from anthropogenic disturbances, including grazing and farming.

The Chamhesar forest (is approximately 90 km north of the city of Khorramabad. The Ghalegol forest (is situated about 35 km southwest of Khorramabad. Shineh Ghelaee forest () is situated approximately 50 km to the northwest of Khorramabad. All three forests are located at similar altitudes (1500–2500 m), and the soil is generally shallow, reddish-brown, infertile, and frequently mixed with gravel and boulders. Black soils are uncommon in these forests.

Vegetation sampling and analyses

In this study, based on floristic composition and previous experiences in the Zagros forest, we used multi-scale sampling methods; in addition, eight tree sampling plots of 500 m^2 were created, as well as 72 plots of 4 m^2 for shrubs and 288 plots of 1-m^2 were sampled to capture the cover of all vascular plants. The plot size was chosen to be appropriate for the scale and structure of the vegetation [15]. In the survey, plant species names of all trees, shrubs, and herb layers in the plots and tree sizes and community traits of the forests were recorded in detail. Tree diameters at breast height (DBH) were measured with a diameter tape, as was tree height (Th) with a Suunto device, canopy cover, and tree density (Td).

In addition, we identified the type and density of shrubs. To accurately identify plant samples, sampling was done from late April to early July 2016 at the peak of the growing season [16], and herb coverage was calculated as the percentage of the surveyed species' area to the total surveyed area [17]. We used different books such as Flora Iranica [18], Color Flora of Iran (1991–2000), Dictionary of Iranian Plant Names [19], and Flora of Iraq [20] to identify plant species, habitat descriptions, nativity, and rarity of species. Each sampling plot's ancillary data included its altitude, slope aspect, slope position, and slope gradient in degrees, latitude, and longitude. Moreover, physiographic factors (i.e., slope, direction, and height) were measured in each area.

Plant diversity indices

Diversity indices were calculated using presence/absence and cover data. We characterized each quadrat's species richness, diversity, and evenness to determine their variation among the three forest types. Species number, Menhinick's and Margalef's richness indices (S), Shannon-Wiener (H), Simpson's diversity indices, and Simpson's evenness index [21] were calculated for various forest types.

Soil sampling

Using a soil auger, four individual 0–10 cm and 10–30 cm soil samples were collected randomly from the corners and center of the main plots in each plot and combined to yield five soil samples. In total, 48 composite soil samples were collected (three forests two soil

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Table1) Coefficient of conservatism ranking criteria.

CC values	Criteria
0	Nonnative species that obligate to ruderal areas
1-3	Native taxa that are seen in many ecosystems and disturbed habitats, Varying affinity to ruderal areas
4-6	Native taxa that are typically related to a specific plant community and obligate to natural areas, however, tolerate moderate disturbance
7-8	these Native taxa have tolerated only minor disturbances and have fidelity to high-quality natural areas
9-10	Native taxa obligate to high-quality natural areas with a low tolerance for disturbances

Table 2) Total amounts of diversity indices (mean values ± s.d) and ANOVA results of comparison biodiversity indices among different forest-protected types.

Heterogeneity Index	Shineh Ghelaee	Ghalegol	Chamhesar	F
Richness	32.2(1.04)^{a}	22.04(1.3)^{b}	29.76(1.11)^{b}	20.96**
Margalef	6.16(0.28)^{b}	4.4(0.27)a	5.48(0.2)^{b}	12.01**
Menhinic	2.57(0.17)^{b}	2.02(0.13)^{a}	2.16(0.08)^{ab}	4.45*
Evenness	0.47(0.03)^{a}	0.48(0.03)^{a}	0.4(0.01)^{a}	2.25^{ns}
Simpson	0.842(0.02)^{a}	0.802(0.02)^{a}	0.836(0.01)^{a}	0.86^{ns}
Shannon wiener	2.62(0.11)^{b}	2.25(0.09)^{a}	2.43(0.05)^{ab}	3.69*

Different letters in a row are statistically significant at a 5% level probability

depths, and eight plots or replicates). Roots, organic residues, and rock fragments were removed manually, and soil samples were air-dried, crushed, and sieved to a sample size of 2 mm. The Bouyoucos-hydrometer method was utilized to calculate the proportion of small particles (silt, clay, and sand). The pH of the soil was determined using a pH meter (1:5 soil/water), and the total soil organic carbon content was calculated through the Walkley–Black dichromate oxidation method [22]. Total nitrogen (N) was determined using the Kjeldahl method, and total phosphorus (P) was calculated via the Olsen and Sommers method [23].

Conservatism Coefficient and Floristic Quality Index assignment

The Conservatism Coefficient (CC) for each taxon was determined by assigning each an integer from 0 to 10 based on the species' tolerance to disturbance and its fidelity to habitat integrity. Species that are not found in specific habitat types or that are common in disturbed areas received a low CC score, while species that are adapted to a habitat with a specific combination of environmental parameters received higher CC scores. All non-native species were assigned values of 0 [13] (Table 1).

A list of CC scores for plant species occurring in Kakareza and Shine Ghelaee forests was compiled from previous work by Mirazadi *et al.* (2017), and we used it, to exploit the CC scores of plants identified in this article. The Floristic Quality Index (FQI) is based on the calculation of the mean CC [13, 14]. The mean

Table 3) Number of native species, mean CC, and FQI of different protected forests.

Types	Native Species	Mean CC	FQI
Shineh Ghelaee	124	3.49	38.86
Ghalegol	113	3.49	37.09
Chamhesar	99	3.21	31.93

Table4) Comparison of ecological properties and silvicultural characteristics (mean values ± s.d) among different forest-protected types.

Ecological Properties	Shineh Ghelaee	Ghalegol	Chamhesar	F
First depth				
Clay	26.8(5.92)[b]	18.4(3.89)[a]	28.4(6.77)[b]	7.17[**]
Silt	29.5(3.47)[b]	7.8(2.29)[a]	30.5(5.06)[b]	91.94[**]
Sand	43.6(7.04)[b]	73.7(5.2)[a]	41(8.5)[b]	52.79[**]
K	411.5(100.2)[b]	187.7(43.2)[a]	174.6(71.8)[b]	22.8[**]
P	9.26(10.5)[a]	20.9(15.17)[a]	22.3(23.2)[a]	1.48[ns]
N	0.03(0.007)[b]	0.45(0.13)[a]	0.03(0.02)[b]	71.8[**]
OC	0.32(0.05)[a]	0.57(0.07)[a]	0.25(0.06)[a]	51.17[**]
pH	7.7(0.08)[b]	7.38(0.19)[a]	7.63(0.16)[b]	8.97*
EC	0.74(0.21)[a]	0.79(0.14)[a]	0.82(0.29)[a]	0.26[ns]
Ca	5.9(2.65)[a]	4.42(2.53)[a]	4.7(1.28)[a]	0.94[ns]
Bulk Density	1.35(0.17)[a]	1.29(0.21)[a]	1.34(0.25)[a]	0.2[ns]
second depth				
Clay	36.02(3.2)[b]	25.18(5.3)[a]	36(6)[b]	12..45[**]
Silt	35.25(5.37)[b]	10.8(4.45)[a]	30.18(5.5)[b]	51.47[**]
Sand	28.68(7.04)[b]	64.31(5.2)[a]	33.8(7.64)b	44.48[**]
K	146.35(71.79)[b]	377.7(84.01)[a]	152.75(34.43)[b]	31.14[**]
P	6.35(15.26)[a]	7.83(7.07)[a]	13.02(23.2)[a]	0.71[ns]
N	0.02(0.007)[b]	0.27(0.08)[a]	0.02(0.005)[b]	65.95[**]
OC	0.24(0.09)[a]	0.47(0.09)[a]	0.19(0.05)[a]	26.35[**]
pH	7.88(0.29)[b]	7.38(0.19)[a]	7.65(0.28)[b]	7.45[**]
EC	0.82(0.34)[a]	0.66(0.1)[a]	0.78(0.44)[a]	0.46[ns]
Ca	5.9(2.65)[a]	4.42(2.53)[a]	4.7(1.28)[a]	0.96[ns]
Bulk Density	1.44(0.25)[a]	1.29(0.21)[a]	1.39(0.21)[a]	0.8[ns]
physiographic properties				
Altitude	1790.25(34.69)[a]	1897.87(41.23)[a]	1384(12.85)[a]	2.86[ns]
Slope	37.75(4.05)[a]	36.25(3.73)[a]	31.12(3.47)[a]	0.85[ns]
Exposure	1.83(0.05)[a]	1.86(0.07)[a]	1.82(0.06)[a]	0.13[ns]
silvicultural characteristics				
Canopy	56.84(3.66)[a]	58.81(5.19)[a]	69.06(4.57)[a]	2.1[ns]
Tree Height	3.84(0.18)[a]	6.02(0.31)[b]	3.48(0.19)[a]	33.4[**]
Tree Density	70.12(9.62)[b]	78(10.86)[b]	142.15(9.85)[a]	15.2[**]

Different letters in a row are statistically significant at a 5% level probability

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Table 5) Correlation matrix for linear relationships between selected soil parameters and biodiversity indices.

	Environmental Factors	Fisher	Shannon Wiener	Margalef	Menhinic	Richness
First Depth	Clay	0.24*	0.2^{ns}	0.32**	0.17^{ns}	0.41**
	Silt	0.34**	0.28*	0.49**	0.28*	0.6**
	Sand	-0.33**	-0.28*	-0.47**	-0.27**	-0.58**
	K	-0.35**	-0.26*	-0.49**	-0.31*	-0.59**
	P	-0.23*	-0.11^{ns}	-0.23*	-0.2^{ns}	-0.22^{ns}
	N	-0.32**	-0.22^{ns}	-0.49**	-0.27*	-0.61**
	OC	-0.33**	-0.23^{ns}	-0.5**	-0.28*	-0.61**
	pH	0.19^{ns}	0.18^{ns}	0.31**	0.15^{ns}	0.4**
	EC	-0.00^{ns}	0.17^{ns}	0.04^{ns}	0.03^{ns}	0.05^{ns}
	Ca	0.44**	0.14^{ns}	0.45**	0.42**	0.43**
	Bulk Density	0.26*	0.35**	0.29*	0.27*	0.27*
Second Depth	Clay	0.24**	0.21^{ns}	0.34**	0.22^{ns}	0.4**
	Silt	0.38**	0.33**	0.48**	0.33**	0.55**
	Sand	-0.35**	-0.3**	-0.46**	-0.31**	-0.53**
	K	-0.32**	-0.17^{ns}	-0.44**	-0.27*	-0.35**
	P	-0.09^{ns}	0.13^{ns}	-0.01^{ns}	-0.07^{ns}	0.02^{ns}
	N	-0.37**	-0.27*	-0.54**	-0.33**	-0.64**
	OC	-0.30**	-0.21^{ns}	-0.45**	-0.24*	-0.62**
	pH	0.32**	0.27*	0.38**	0.28*	0.41**
	EC	0.05^{ns}	0.1^{ns}	0.07^{ns}	0.00^{ns}	0.12^{ns}
	Ca	0.28*	-0.05^{ns}	0.26*	0.22^{ns}	0.26*
	Bulk density	0.06^{ns}	0.1ns	0.15^{ns}	0.08^{ns}	0.18^{ns}
	Altitude	-0.4**	-0.27*	-0.45**	-0.35**	-0.48**
	Canopy	0.03^{ns}	0.04^{ns}	0.08^{ns}	-0.08^{ns}	0.14^{ns}

** and * show statistical significance at 1% and 5% levels, respectively. ^{ns} shows no significant differences.

CC value was calculated by applying Eq. (1).

$$\text{Mean CC} = \frac{\sqrt{CC}}{N} \qquad \text{Eq. (1)}$$

In which CC is the CC value of all native species, and N is the total number of species (species richness).

The FQI among different protected forest types was objectively compared. The FQI can be calculated by Eq. (2).

$$\text{FQI} = \frac{R}{\sqrt{N}} \qquad \text{Eq. (2)}$$

In which FQI is the floristic quality index, R is the sum of the coefficients of conservatism for all plants recorded in the area, and N is the number of native species recorded.

Statistical Analysis

The one-way analysis of variance (ANOVA) was used for finding the differences among three forest types of biodiversity indices and soil properties. Before the ANOVA procedure, a test of normality for indices and parameters was conducted with the Kolmogorov–Smirnov test, and data were checked for their homogeneity of variance using Levene's test. The Pearson correlations between measured soil variables and diversity indices were determined across the forest types. A post hoc Duncan test was used to detect significant differences between the three forest types. Statistical analyses were performed using SPSS, version 19. Diversity indices were measured by PAST software. All tests were performed at the 0.05 level of significance.

Findings

The results of the floristic survey, including Life forms of taxa, predominant plant families, and Chronological types of plants in Shineh Ghelaee, Chamhesar, and Ghalegol forest types are presented in the figures 1, 2, 3.

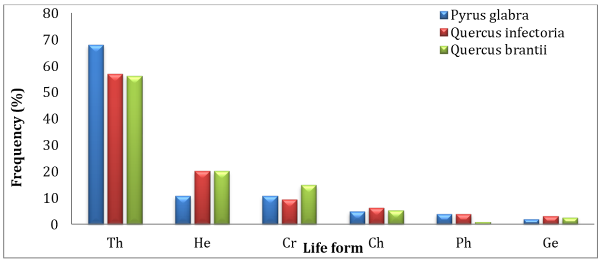

Figure 1) Life forms of taxa sampled in the floristic survey.

In this study Th, He, Cr, Ch, Ph, and Ge indicated Therophytes, Hemicryptophite, Cryptophites, Chamephites, Phanerophyte, and Geophite respectively.

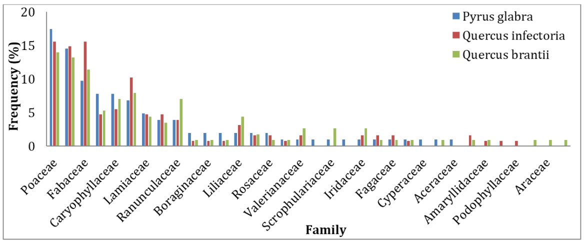

Figure 2) The percentage of plant families sampled in the floristic survey.

The Chorology of each species was determined by using distribution data in floras (Figure3).

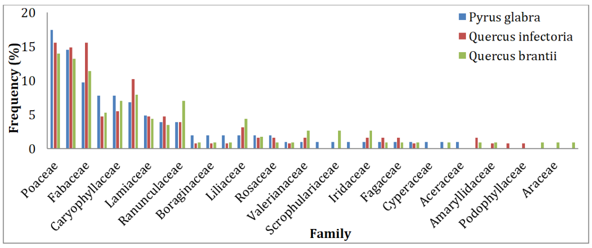

Figure 3) Chronological types of plants sampled in the floristic survey.

A comparison of average values of diversity indices among forest types shows that the lowest values are found in the Ghalegol protected forest dominated by *Quercus brantii* and the highest diversity indices values occurred in the Shine Ghelaee forest (except the evenness index, which was higher in the Ghalegol forest), whereas *Quercus infectoria* is the major tree species. So, results of the analysis of variance showed diversity indices such as Menhinic and Margalef indices as well as the Shannon-Wiener diversity index varied greatly among forest types, While, no difference was found in these types in terms of Simpson dominance and evenness indices (Table 2). Based on the results, the first category of CC values had the greatest abundance in three forest types and the fourth category is the lowest. Most of the species identified in the Chamhesar forest (*Pyrus glabra* type) were generalist species (CC: 1-3), whereas this forest had the lowest number of specialist and low tolerance species (CC: 7-8 and 9-10).

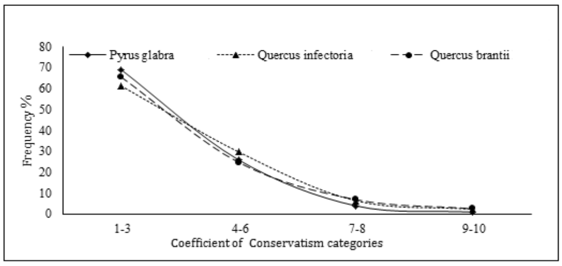

Figure 4) Percent of taxa within each CC category for *Quercus infectoria, Quercus brantii, and Pyrus glabra* types.

Among all forest types, native species richness ranged from 99 to 124 species. The mean CC (Eq. 1) and FQI (Eq. 2) were calculated for each forest type. Based on the results, the mean CC and FQI values calculated for Shineh and Ghalegol protected forests are consistently greater than Mean CC and FQI scores calculated for Chamhesar protected forests. The greatest difference in FQI was between Shineh and Chamhesar forests, due to the expansion of widespread species in the Chamhesar forest and excluding them for calculation of mean CC

and FQI. The results showed in table 3.
The cover of trees was highest for *Pyrus glabra* (69.06) m^2 than for oak spp (*Quercus brantii* with 58.81and *Quercus infectoria* with 56.48 m^2), however, the height of the average trees was significantly highest in the *Quercus brantii* type (6.02 m).
Significant changes in mean concentrations were observed for most soil variables (except EC, calcium, and bulk density) ($P < 0.05$) among forest-protected types (Table 4).
The correlation analysis result revealed that there was a significant correlation between some of the soil properties and biodiversity indices.

Discussion

This study recorded 128, 114, and 103 taxa in Shine Ghelaee, Chamhesar, and Ghalegol, respectively. The predominant plant life forms were Therophytes, Hemichryptophytes, and Chryptophytes, and the most common plant families are Poaceae, Asteraceae, and Fabaceae. The results also revealed that plants with a geographical distribution in the Irano-Turanian, Mediterranean, Irano-Turanian, and Euro-Siberian, Mediterranean, and Irano-Turanian regions were the most significant group in the three forests.
In the present study, Shine Ghelaee and Chamhesar had higher diversity indices than the Ghalegol forest (Table 2). This variation may also be attributable to differences among dominant tree species in three forests; thus, we can assume that tree species may influence understory diversity and floristic quality [24].
In the majority of instances, it demonstrated that the changing in the quantity and quality of floristic and biodiversity patterns is due to the microclimate created under the tree canopy [25, 26].
Bunium luristanicum Rech, *Astragalus longirostratus* Pau, and *Astragalus leonardii* Maassoumi exhibited the highest CC class in the plant herbaceous species categories (CC: 9-10), while *Bunium rectangulum* Boiss. & Hausskn, *Cousinia khorramabadensis* Bornm, *Cousinia disfulensis* Bornm, *Astragalus kirrindicus* Boiss, *Astragalus rhodosemius* Boiss. & Hausskn, *Astragalus brachycalyx* Fischer, *Astragalus curvirostris* Boiss, *Arum rupicola* Boiss, *Ranunculus pinardi* (Stev.) Boiss, *Asyneuma persicum* (A.DC.) Bornm, *Ficaria kochii* (Ledeb.) Iranshahr & Rech.f., and *Epipactis persica* (Soo) Nannfeldt demonstrated a CC of between 7 and 8. *Carduus arabicus* Jacq. ex Morray, *Carthamus lanatus* (L), *Picnomon acarna* (L.) Cass., *Cerastium dichotomum* L., *Ceratocephala falcata* (L.) Pers., *Bromus tectorum* L. *Hordeum spontaneum* C. Koch, and others are among the most prevalent species identified in the three forests and are considered disturbance species in the Lorestan Province forest.
In contrast to diversity indices, we observed the lowest floristic quality index and mean CC values in the forest of Chamhesar (Table 3). It seems that the presence and distribution of generalist and disturbance-tolerant species can be effective in preserving and rise in ground flora diversity in the Chamhesar forest; however, these species significantly affect the decline in mean CC and FQI in the Chamhesar forest. In this regard, natural areas with an FQI of 35 or higher (such as Ghalegl and Shineh Ghelaee) are deemed high quality [13]. It is believed that FQI values do not imply that one type of forest is "better" than another; rather, they merely provide a method for measuring the degree of naturalness of the species present.
We focused on soil properties and interactions with the forest understory and tree species. Information about changing patterns of forest soils revealed that soil nutrients, such as K and N, were higher in the Ghalegol forest (Table 4). The soil macro elements amount is directly linked to nutrients released by

trees and nutrient cycling through litter [27]; however, no differences in SOC among forest types were found. Based on our results, the highest and the lowest SOC contents belonged to Ghalegol and Chamhesar forests, respectively (Table 4); this probably happens for the aggregation of more litter on the forest floor of the Ghalegol forest.

Different tree species play a significant role in the biogeochemical regulation of ecosystems by stabilizing soil organic carbon [28]. In this regard, Ghasemi Aghbash revealed that various tree species have distinct carbon sequestration capacities [29]. The EC of soil samples collected from three forests ranges from 0.74 to 0.81dS m-1. EC is determined by the composition and nature of humus in forest soils, which includes high calcium content. In this regard, the variation in leaf traits and litter quality may have caused a change in the soil EC among forest types [30]. Since soil fertility has always been strongly related to the accumulation and turnover of soil organic carbon and nitrogen [31], these findings support the hypothesis that the fertile soil (Ghalegol forest), due to increased competition among herbaceous species (Table 4), some of them (especially species with a higher competitive power) can outcompete others and dominate at the forest herbaceous layer, resulting in a decrease in plant diversity and richness [32]. Soil parameters, especially texture and fertility, have been regarded as the key factors that cause structural and floristic variation in vegetation [33]. Bond (1983) determined that under the desired conditions, few species can increase the prevalence and distribution of forest understory. Roem and Berendse (2000) reported a negative relation between soil nitrogen and plant diversity in grassland and heathland communities, consistent with our findings [34]. Conversely, some scholars contend that invasive exotic plant species may be more likely to invade regions with nutrient-rich soils [27; 35]. Jimenez *et al.* (2007) demonstrated that organic carbon could improve soil conditions and increase species diversity and richness [36].

It should be noted that changes in the environment through shading, wind speed, rainfall interception, interference with light penetration, the quantity and quality of litter, and finally, change in soil characteristics due to differences in tree species types may also contribute to these differences [37]. Litter decomposition rates can be affected by the plant species effects on the physical environment or soil community [38]. Given that Shineh Ghelaee and Chamhesar types were found on similar soil–site types, it is likely that a substantial proportion of the differences in diversity and productivity between these forest types were caused by the influence of the dominant species.

Some environmental characteristics, such as altitude, soil texture, and organic carbon, among others, are associated with the primary factors influencing floristic differentiation in forest types. Richness and diversity indices were found to be significantly negatively correlated with altitude (Table 5). Although there was no significant difference in altitude between regions, the altitude was higher in the Ghalegol forest type than in other sites; this suggests that altitude may play an even larger role in the low heterogeneity of the *Quercus brantii* type. Furthermore, the lower altitude of the Shineh Ghelaei forest type has increased the richness and diversity of herbaceous species in this forest type. Because it alters the availability of resources such as heat and water, altitude is one of the most important factors influencing habitat differentiation [39]. This result is consistent with the findings of Corner (2012), who observed that short-distance altitudinal gradients exhibit complex variation in abiotic conditions [39].

In most cases, researchers investigated plant altitudinal biodiversity patterns

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and observed that altitude plays a role in regulating species richness patterns [40]. The results presented here revealed differences in assessing the ecosystem integrity of different forest types using diversity and floristic quality indices; however, many studies have used diversity indices to estimate forest integrity. According to the findings of this study, CC and FQIs are more auxiliary methods of assessing forest quality. For example, we found higher diversity indices in Chamhesar, while lower mean CC and FQI values were also observed in this forest. We could estimate that the Chamhesar forest had lower integrity than others because the CC score of each plant reflects its fidelity to specific habitat integrity [14]. We found that FQI provides a relatively rapid, reliable, and repeatable method of assessing forest quality and integrity.

Conclusion

According to the findings of this study, differences in diversity, soil properties, and floristic quality among forest types are partly attributable to the feedback effects of dominant tree species on ecosystem processes, and the presence of trees has significantly varying effects on vegetation diversity and soil properties. In addition, there is widespread agreement that using individual diversity and ecosystem quality indices as indicators of forest integrity has significant limitations. This study revealed differences between the results of plant diversity indices and the mean CC and FQI for assessing ecosystem integrity in various forest types. Biological indicators and floristic quality indices can provide important information for prioritizing conservation areas and be used to advocate for more effective ecosystem management plans.

References

1. Dehghan Rahimabadi P., Azarnivand H., Malekian A. Hydrogeological Drought and Groundwater Quality Changes Using GRI and GQI in Semnan and Damghan Plains, Iran. ECOPERSIA 2022; 10(2): 95-108.
2. Sakizadeh M. Performance of Classification Methods to Evaluate Groundwater (Case Study: Shoosh Aquifer). ECOPERSIA 2014; 2(2): 597-612.
3. Bahar Gogani M., Douzbakhshan M., Shayesteh K., Ildoromi A.R. New formulation of fuzzy comprehensive evaluation model in groundwater resources carrying capacity analysis. ECOPERSIA 2018; 6(2): 79-89.
4. Ghazavi R., Ebrahimi H. Estimation of Artificial Groundwater Recharge by Flood Water Spreading System in an Arid Region Using Inverse Modeling and SCS Method; A case Study of Mosian Plain. ECOPERSIA 2018; 6(3): 187-194.
5. Ravikumar P., Somashekar R.K. Principal component analysis and hydrochemical facies characterization to evaluate groundwater quality in Varahi river basin, Karnataka state, India. Appl. Water Sci. 2017; 7(2): 745-755.
6. Su Z., Wu J., He X., Elumalai V. Temporal changes of groundwater quality within the groundwater depression cone and prediction of confined groundwater salinity using Grey Markov model in Yinchuan area of northwest China. Expo. Health. 2020; 12(1): 447–468.
7. Priyanka M., Venkata M., Ratnakar D. Groundwater Quality Appraisal and Its Hydrochemical Characterization in and around Iron Ore Mine, Chitradurga, Karnataka. Int. j. hydrol. 2017; 1(5): 151-161.
8. Abdalazem, A.H., Gamee M.A., Hamdan A., Awad A.A.M., Mohamed A.G. Groundwater Quality Assessment for Irrigation in West Edfu Region, Aswan, Egypt. Assiut. J. Agric. Sci. 2020. 51(1): 125–149.
9. Ravikumar P., Somashekar R., Angami M. Hydrochemistry and evaluation of groundwater suitability for irrigation and drinking purposes in the Markandeya River basin, Belgaum District, Karnataka State, India. Environ. Monit. Assess. 2011; 173(1): 459-487.
10. Elsayed, S., Hussein H., Moghanm F.S., Khedher K.M., Eid E.M., Gad M. Application of Irrigation Water Quality Indices and Multivariate Statistical Techniques for Surface Water Quality Assessments in the Northern Nile Delta, Egypt. Water. 2020; 12(1): e3300.
11. Taheri M., Gharaie M.H.M., Mehrzad J., Afshari R., Datta S. Hydrogeochemical and isotopic evaluation of arsenic contaminated waters in an argillic alteration zone. J. Geochem. Explor. 2017; 175(1): 1-10.
12. Banda, T.D., Kumarasamy M. Application of multivariate statistical analysis in the development of a surrogate water quality index (WQI) for South

African watersheds. Water. 2020; 12(6): e1584.
13. Horton R.K. An index number system for rating water quality. J. Water Pollut. Control Fed. 1965; 37(3): 300-306
14. Ram A., Tiwari S., Pandey H., Chaurasia A.K., Singh S., Singh Y. Groundwater quality assessment using water quality index (WQI) under GIS framework. Appl. Water Sci. 2021; 11(2): 1-20.
15. Khalaf R.M., Hassan W.H. Evaluation of irrigation water quality index IWQI for Al-Dammam confined aquifer in the west and southwest of Karbala city, Iraq. Int. J. Civ. Eng. 2013; 2(3): 21-34.
16. Tarawneh M.S.M., Janardhana M.R., Ahmed M.M. Hydrochemical processes and groundwater quality assessment in North eastern region of Jordan valley, Jordan. HydroResearch. 2019; 2(1): 129-145.
17. Abbasnia A., Yousefi N., Mahvi A.H., Nabizadeh R., Radfard M., Yousefi M., Alimohammadi M. Evaluation of groundwater quality using water quality index and its suitability for assessing water for drinking and irrigation purposes: Case study of Sistan and Baluchistan Province (Iran). Hum. Ecol. Risk. Assess. 2019; 25(4): 988-1005.
18. Jehan S., Ullah I., Khan S., Muhammad S., Khattak S.A., Khan T. Evaluation of the Swat River, Northern Pakistan, water quality using multivariate statistical techniques and water quality index (WQI) model. Environ. Sci. Pollut. Res. 2020; 27(31): 38545-38558.
19. Subba Rao N., Srihari C., Deepthi Spandana B., Sravanthi M., Kamalesh T., Abraham Jayadeep V. Comprehensive understanding of groundwater quality and hydrogeochemistry for the sustainable development of suburban area of Visakhapatnam, Andhra Pradesh, India. Hum Ecol. Risk. Assess. 2019; 25(1-2): 52-80.
20. Ramachandran Muthulakshmi Y. Geo-spatial analysis of irrigation water quality of Pudukkottai district. Appl. Water Sci. 2020; 10(3): 1-14.
21. Yıldız S., Karakuş C.B. Estimation of irrigation water quality index with development of an optimum model: a case study. Environ. Dev. Sustain. 2020; 22(5): 4771-4786.
22. Sadat-Noori S., Ebrahimi K., Liaghat A. Groundwater quality assessment using the Water Quality Index and GIS in Saveh-Nobaran aquifer, Iran. Environ. Earth. Sci. 2014; 71(9): 3827-3843.
23. Soleimani H., Nasri O., Ojaghi B., Pasalari H., Hosseini M., Hashemzadeh B., Kavosi A., Masoumi S., Radfard M., Adibzadeh A. Data on drinking water quality using water quality index (WQI) and assessment of groundwater quality for irrigation purposes in Qorveh & Dehgolan, Kurdistan, Iran. Data Brief 2018; 20(1): 375-386.
24. Hojjati, M.H., Boustani F. An assessment of groundwater crisis in Iran, case study: Fars Province. World. Acad. Eng. Tech. 2010; 4(10): 2066-2070.
25. Nafarzadegan A., Zadeh M.R., Kherad M., Ahani H., Gharehkhani A., Karampoor M., Kousari M. Drought area monitoring during the past three decades in Fars Province, Iran. Quat. Int. 2012; 250(1): 27-36.
26. Choubin B., Malekian A., Golshan M. Application of several data-driven techniques to predict a standardized precipitation index. Atmósfera. 2016; 29(2): 121-128.
27. Brown R.M., McClelland N.I., Deininger R.A., Tozer R.G. Water quality index-Do we dare?. Water. Sew. Works. 1970; 117(10): 339–343.
28. Ayers R.S., Westcot D.W. Water quality for agriculture: Food and Agriculture Organization of the United Nations Rome. 1985; 29(1): 1-174.
29. Meireles, A.C.M., Andrade E.M.D., Chaves L.C.G., Frischkorn H., Crisostomo L.A. A new proposal of the classification of irrigation water. Rev. Cienc. Agron. 2010; 41(3): 349-357.