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ORIGINAL PAPER

Diversity indices or floristic quality index: Which one is more appropriate for comparison of forest integrity in different land uses?

Z. Mirazadi[1] · B. Pilehvar[1] · K. Abrari Vajari[1]

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Abstract Zagros forest in Iran has been heavily altered by anthropogenic disturbances such as farming, grazing and other activities. In this study, we first estimated the herbaceous plants coefficient of conservatism within this region. Forest integrity of different land uses was then assessed by common measures of plant diversity and the indices were specifically developed to estimate vegetation integrity (conservatism coefficient, floristic quality index and modified floristic quality index). As complementary approaches, some soil physiochemical properties were applied to judge forest integrity. A total of 81, 82, 88, native species were recorded in understory grazing (UG), abandoned fields (AF), and protected area (PA) land uses, respectively. Common species had higher abundance in AF land use, whereas specialized species were found in PA land use. Diversity indices and modified floristic quality index values were higher in AF land use compared to UG and PA land uses, and fisher alpha diversity index highlighted the significant differences in the plant diversity among land uses, while PA land use had high species richness with greater number of sensitive species and floristic quality index. Soils under PA land use showed the highest organic carbon, nitrogen and pH. Based on results, floristic quality index and mean coefficient of conservatism can be more informative than species-diversity measures in assessing floristic integrity and in contradiction to diversity indices, are accurate tools to determine differences in the integrity of land uses. Results indicate that PA land use have indeed progressed ecologically toward a vigorous ecosystem as observed by the development of its vegetation community.

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✉ B. Pilehvar
pilehvar.b@lu.ac.ir; babakpilehvar@yahoo.com

[1] Forestry Department, Faculty of Agriculture and Natural Resources, Lorestan University, Khorramabad, Iran

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Introduction

Land use change is the primary cause and key processes of disturbances in forest ecosystem dynamics (Ewers and Didham 2006; Kobayashi and Koike 2010; Rhemtulla et al. 2009). The expansion and intensification of human uses such as anthropogenic habitat modification have strong effects on biodiversity and land cover (Sala et al. 2000). Ecological integrity has been defined as a measure of the composition, structure, and function of an ecosystem in relation to the system's natural or historical range of variation, as well as perturbations caused by natural or anthropogenic agents of change (Parrish et al. 2003). Assessing the integrity of an ecosystem requires developing measures of the structure, composition, and function of an ecosystem as compared to reference or benchmark ecosystems (Lindenmayer and Franklin 2002; Young and Sanzone 2002).

Plant diversity indices are useful tools in quantifying vegetation properties in various habitats. Species richness is one of the most direct and simple measures (Colwell and Coddington 1994; Krebs 1999). Other measures, such as Shannon index, Simpson's diversity and Simpson's evenness have been also used to quantify biological diversity (Vance-Chalcraft et al. 2010; Botta-Dukat 2005). Although traditional diversity indices are relatively easy to calculate, understand and communicate and they have been applied to provide tools for long-term monitoring forest ecosystems (Lamb et al. 2009), they may give little indication of site quality. Quality is an important consideration for natural resource managers because it provides critical information for identifying unique habitats, setting conservation priorities, evaluating the efficacy of restoration measures, and monitoring trends.

Among the measures that have been developed to assess the habitat quality and conservation values of plant assemblages, Swink and Wilhelm (1979) introduced the floristic quality index (FQI). Floristic quality assessment (FQI) is a recognized technique for assessing habitat quality or condition using aspects of the plant community (Chamberlain and Ingram 2012). Especially FQI has been proposed as a tool that can: compare different sites regardless of plant community type, monitor sites over time, assess the anthropogenic impacts on an area, and ultimately, measure the ecological condition of an area (Swink and Wilhelm 1994; Lopez and Fennessy 2002). Higher values of FQI indicate greater floristic quality and ecosystem integrity. FQI is increasingly used in basic ecological and conservation research (e.g. Panzer and Schwartz 1998; Spyreas and Matthews 2006; McNicoll and Augspurger 2010).

In FQI, the quality of a plant assemblage is assessed as the ecological fidelity of its species to natural or intact habitats. This index is created to evaluate site quality based on the mean coefficient of conservatism values and the number of native species. Coefficient of conservatism or CoC values represent an index (scaled from 0 to 10) assigned to native species based on their likelihood to be found in undisturbed, remnant lands (Swink and Wilhelm 1994).

Zagros Mountains of northwestern Iran, which harbor approximately 40% of the country's forests, are covered by open park-like forests that are mainly dominated by deciduous oak trees and subject to traditional pollarding practices to produce fodder and firewood. Conditions in this region, such as topography, shortage of rangelands and animal fodder, and lack of modernization have maintained a situation of particularly intense interaction between its people and natural resources. In Zagros forest, management practices vary locally and have been found to be unsustainable (Ghazanfari et al. 2004) in many locations. Cattle grazing in forest can have negative impacts on both overstory and understory vegetation (Brown and Boutin 2009; Mabry 2002) and farming may have several impacts on plant communities at multiple scales from habitat conversion to the introduction of invasive and non-native species. Maintaining natural diversity and species composition in habitats, which are affected by anthropogenic activities, are the main goals of ecosystem management (Roberts and Gilliam 1995), thus there is a need for well-defined measures assessing these anthropogenic effects.

In Zagros region, several studies were conducted by various methods to estimate forest integrity. Many studies have been conducted using diversity indices to investigate forest integrity. Several studies have evaluated the impacts of disturbances such as grazing, windstorms and floods on the shrub density, plant diversity and forest structure (Abasi et al. 2006; Abrari Vajari and Veis Karami 2005) and some others measured biodiversity in relation to physiographic and edaphic factors (Mirzaei et al. 2008; Pilehvar et al. 2010; Heidari et al. 2010; Haidari et al. 2012). Taft et al. (2006) performed a study at Nachusa Grasslands to assess progress in tallgrass prairie by standard diversity measures (e.g., Shannon–Weiner Index, Evenness, Species Richness) and indices developed specifically to estimate vegetation integrity (Taft et al. 2006) but in the present study assignment of CoC and FQI and comparing them to diversity indices were performed for the first time in Iran. The objectives of this study are: (1) to assign conservatism coefficient to some herbal plant species of the middle Zagros as a pilot project (2) to compare mean CoC and FQI among different land uses and with other indices such as Shannon Wiener (H′) and species richness to examine the impacts of land use on plant community composition and forest integrity. The current study was guided by three hypotheses:(1) We expected that FQI and mean CoC have a strong ability in differentiating forest integrity among three land use types, understory grazing (UG), abandoned fields (AF), and protected area (PA) (2). We expected that understory vegetation communities in disturbed (grazed and abandoned fields) forests to have more non-native and weedy generalist species than preserved forests and, (3) we expected to find a link between plant community qualities, soil physiochemical properties and floristic quality index.

Study area

We conducted this study in Kakareza forest Watershed in Lorestan Province at Zagros forest of Iran. The study area elevation ranged from 1200 to 2400 m above sea-level. This region has a semiarid Mediterranean climate with a mean annual precipitation of 450 mm and monthly mean temperatures in January and July of −10 and 36 °C, respectively. The soil type is loam. The natural vegetation of the area consists of the relatively pure oak stands dominated by Persian oak (i.e. *Quercus brantii*), other companion tree species are *Acer monspessulanum*, *Cerasus microcarpa*, and *Crataegus meyeri*.

Kakareza forest is an ideal setting to study herbaceous layer response to human disturbance because both natural and anthropogenic disturbances have altered forest composition. Farming and grazing are the most important land uses in this region, where the majority of forest cover has been removed. The selection of the study sites was based on actual data, representing different classes and intensities of human-induced disturbance regimes. For the purposes of this study, vegetation surveys were performed in three lands uses: natural forest with Understory Grazing (UG), natural forest with Abandoned Fields (AF), and Protected Area (PA).

Sites description

UG land use has been grazed by cattle's (mostly sheep) within the past 30 years, with no other recent forest management. Grazing in remnant forests can cause soil compaction, resulting in drier conditions, which also shifts species composition towards exotic and weedy native species.

AF land use abandoned for almost 20 years. During 1972–2009 about 353,000 ha (69%) of Zagros Forests (western Iran) are declined mainly due to converting to agricultural lands (Henareh Khalyani et al. 2012) and subsequently subjected to inappropriate tillage practices, soil disturbance and permeability.

Among these, PA forest with known and/or documented history of minimal human disturbance is characterized by an herbaceous layer with a diverse suite of native perennials, many of which are forest specialists. Preserved forests were owned by government conservation organizations, and were not actively managed for timber harvest or subject to grazing within the most recent 15 years. Vegetation types and floristic composition of all land uses were the same and only management practices were significantly different among them.

Vegetation sampling

Sampling was performed during late April to early of July 2015 to ensure that in the peak annual growth, the highest number of vascular plant species could be identified (DeKeyser et al. 2009). Of course some plant species may miss during this period and some may appear, so we surveyed plots twice to find new species to species composition. A random sampling design was used to determine the location of the plots. A total of 19 plots (7 from UG, 6 from AF and 6 from PA) were surveyed. Species presence/absence was recorded within plots of 250 m^2 (Fig. 1). In each quadrat, all vascular plant species were identified to the lowest taxonomic division possible. Presence and canopy foliar cover of all species were visually estimated within each ten subplots of 0.25 m^2 (Abrams and Hulbert 1987). If a plant species could not be identified in the field, it was collected, pressed, and identified in the laboratory. Presence/absence and cover data were used to calculate diversity indices.

Vegetation metrics

Species richness (S), (Magurran 1988), species diversity indices including Menhinick, Margalef, Shannon Wiener (H′), Simpson's diversity index (Simpson 1949) and Fisher α index and mean species percent cover were calculated for different land uses.

Soil sampling

Within each plot, we collected a composed sample of soil consisting of five systematically distributed subsamples from the upper layer of soil (0–10 cm depth) since major alterations have occurred in this horizon after the land use change (Sims 2000). Large roots and pieces of organic material, such as twigs and leaves, were removed by hand in the field. After collection, each composed sample was placed in a labeled ziploc bag that was immediately

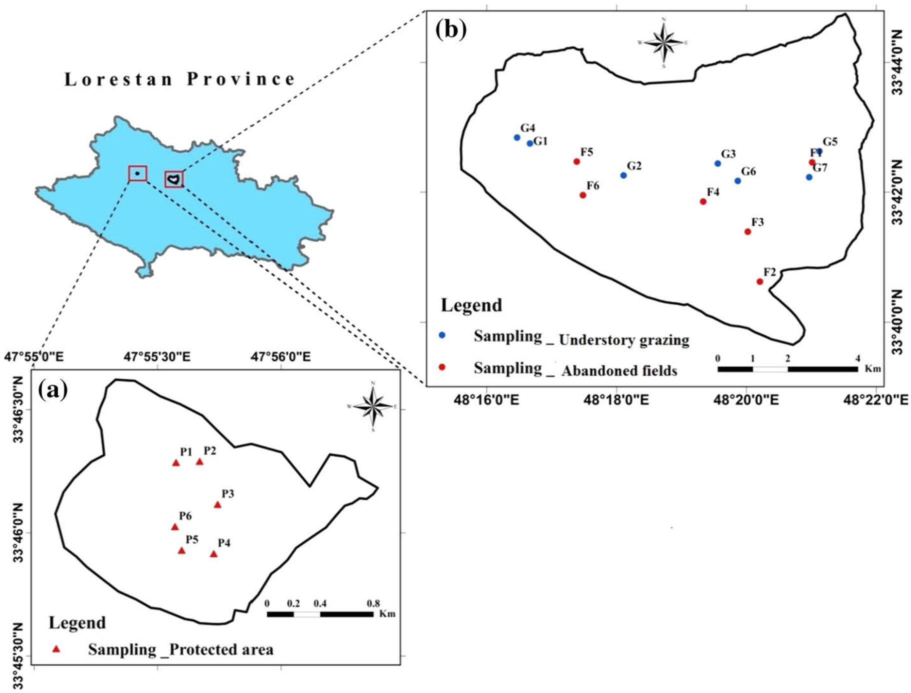

Fig. 1 Locations of the sampling point on the different land uses, Lorestan. Iran

sealed, then air-dried for subsequent analyses. A sub-sample of the air-dried soil was passed through a 2 mm sieve to remove large rocks and organic debris and used for chemical analysis. pH was measured in a soil/water ratio 1:1 (McLean 1982). Soil organic carbon was determined by the Walkley–Black dichromate oxidation procedure (Nelson and Sommers 1982). Total N was measured by the Kjeldahl procedure and total phosphorus (P) was determined according to Olsen and Sommers (1982).

Assignment of CoC values

Upon identification of all collected species, a Coefficient of Conservatism (CoC) was assigned to each species. The CoC values are determined as follows in Table 1 (Taft et al. 2006; Bernthal et al. 2003; Andreas et al. 2004; Fennessy et al. 2001). We convened a committee of the most experienced botanists of Iran. Regional coefficient values were assigned a rank on a scale of 0–10. A core team of botanists met to assign a CoC value for each native species using the above-mentioned criteria. Non-natives were assigned a zero (Spyreas et al. 2012). The team consisted of Valiolah Mozaffarian, Ali Akbar Maassoumi, Mostafa Assadi, Younes Asri, Farideh Attar and Gholam Hassan Veiskarami. Supplementary data were used to verify the field experience. Flora Iranica (Rechinger 1967–1998), Color Flora of Iran (1991–2000), Dictionary of Iranian Plant Names (Mozaffarian 2004), Flora of Iraq (Townsend et al. 1985), and Biodiversity of plant species in Iran (Ghahraman and Attar 1999) provided information on range occurrences, habitat descriptions, and species nativity and rarity.

Table 1 Assignment of Coefficient of Conservatism (CoC) scores to the vascular flora of middle Zagros forest (Kakareza forest)

CoC categories	Criteria
0	Non native species the species is obligate to ruderal areas
1–3	Native taxa that found in a wide variety of plant communities and very tolerant of disturbance, and found in disturbed sites
4–6	Native taxa that typically associated with a specific plant community, but tolerate moderate disturbance
7–8	Native taxa that is typical of well-established communities, which have sustained only minor disturbances. These plants have a fidelity to native lands of high quality
9–10	Native taxa with high degrees of fidelity to a narrow range of synecological parameters and restricted to narrow ecological conditions, with low tolerance of disturbance, rater 95% confident these plants were growing in an undisturbed or native land of high quality

Mean coefficient of conservatism

The mean CoC value was calculated by summing the CoC values of all native species and dividing by the total number of species (species richness = N): Mean CoC = ΣCoC/N.

Floristic quality index

The FQI represents a weighted estimate of species richness (N), obtained by multiplying the mean coefficient of conservatism by the square root of species richness:

$$FQI_{std} : mean\, CC \times \sqrt{\mathrm{N}_{native}}.$$

where CoC_i is the coefficient of conservatism for species i and N_{native} species is the total number of native species within the area of interest (sampling site).

Modified floristic quality index

The modified FQI (FQI_{mod}) is calculated for different land uses, using the following equations:

$$\mathrm{FQI_{mod}}: \left(\sum(\mathrm{cover}_i \times \mathrm{CoC}_i)/100\right) \times 10$$

where $cover_i$ is the percent cover for species i at a sample unit within a sample site and CoC_i is coefficient of conservatism for species (Cretini et al. 2012).

The multiscale modified Whittaker plots (Stohlgren et al. 1995; Barnett et al. 2003) were used, which have been shown to record greater species richness than some alternative sampling designs. According to Stohlgren et al. (1997a, b) and previous study in this region Pilehvar et al. (2010) the dimensions of the modified multi-scale Whittaker plots and subplots are shrunken to half, therefore, our sampling plots consist of a 10 m × 25 m plot (250 m^2) that contains 10, 0.25 m^2 subplots, 6 of them located inside plot perimeter and four of them outside the perimeter of 25 m^2 subplot, 2, 2.5 m^2 subplots (in opposite corners), and 1, 25 m^2 subplot (in plot center), (Barnett et al. 2003).

Statistical analyses

The mean values of species cover and calculated indices were compared by means of an analysis of variance (ANOVA). Before performing the ANOVA, we tested the normality and homoscedasticity assumptions with Kolmogorof-Smirnov and Levene's tests, respectively. The LSD procedure was used to separate the means of the plant diversity indices that differed at $p \leq 0.05$. Statistical processing was performed using SPSS 16 Software.

Results

A total of 194 vascular plant species were recorded in 19 plots, which belonged to Papilionaceae (36 species), Composita (24 species), Poaceae (19 species), Brassicaceae (16 species), Apiaceae (15 species), and other families (78 species).

Common diversity indices (Margalef, Menhinic, Shannon, Simpson and Fisher α) were higher in AF land use. Shannon's diversity and Simpson diversity index for all species showed no significant difference among different land uses. Fisher α diversity index, Margalef and Menhinic showed significant difference among three land uses (Table 2; Fig. 3).

Coefficient of conservatism and floristic quality index

We assigned coefficients of conservatism to 128 native taxa identified in three land uses. Non-native species were all assigned a CoC score of 0. Results showed that the second category of CoC (CoC 4–6) had the greatest abundance in three land uses (Fig. 2).

There were 88 native plant species in PA, while 81 native plants were found in two other land use types (i.e. AF and UG). PA land use had greater richness of native, mean CoC value and higher FQI than UG and AF land uses.

The difference of the mean CoC-values between AF and PA may not be great (0.58), but it does appear that mean CoC scores calculated using PA CoC values are consistently greater than Mean CoC scores calculated using AF CoC values. The greatest difference of FQI was between PA and AF (6.95) while AF and UG showed the lowest difference (2.0). For the AF land use, FQI_{mod} score was higher than FQI score (Table 3), due to the mean sum of species cover was higher (49.86) in AF land use. Totally, in the AF land use, the cover of species belonging to the first and second CoC categories was 93.86% of the total

Table 2 Mean values of plant diversity and ANOVA results (F), in middle Zagros forest (Kakareza forest)

Land uses	Evenness	Menhinic	Simpson's diversity	Margalef	Shannon–Weaver diversity	Fisher (α)
UG	0.4835	3.68	0.86	7.03	2.52	23.74
AF	0.496	5.12	0.88	9.63	2.94	61.17
PA	0.352	3.96	0.78	7.57	2.38	28.09
F	1.83^{ns}	4.01*	2.95^{ns}	3.96*	2.93^{ns}	4.43*

* Significant at $p < 0.05$

ns No significant

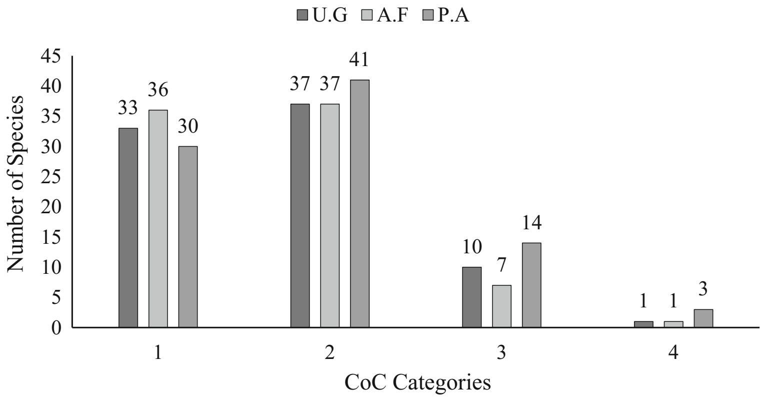

Fig. 2 Number of taxa within each CoC category 1 (CoC 1–3), 2 (CoC 4–6), 3 (CoC 7–8), 4 (CoC 9–10) for UG, AF and PA land uses. Most taxa were assigned coefficients in the mid- to high-portion of the ranking scale for Kakareza native taxa

Table 3 Summary of floristic quality variables for UG, AF and PA land uses

Land uses	Species richness	Number of native species	Number of non native species	Cover (%)	Mean cover	Mean CoC	FQI	FQImod
UG	121	81	40	39.88	0.49 (0.84)	4.27	38.44	101.51
AF	120	82	38	49.86	0.59 (0.96)	4.07	36.44	112.69
PA	127	88	39	35.27	0.4 (0.89)	4.62	43.39	92.41

area, while, in the UG and PA land uses, this species cover was 91.77 and 90.44%, respectively.

Soil chemical and physical analyses

Results indicated that there were differences in soil physiochemical traits associated with the different land uses (Table 4; Fig. 4). Soils under different land uses differed markedly in some of their properties. Soils under PA showed the highest organic carbon, nitrogen and pH. Available phosphorus and clay content were the highest in UG, which decreased in AF and PA. Soil C:N ratios for the top 10 cm were not significantly different among land

Table 4 Result of soil physiochemical traits in sites under different land uses in middle Zagros, Iran

Land uses	OC (%)	AN (mg kg^{-1})	C:N ratio	AP (mg kg^{-1})	EC (ds m^{-1})	pH	AK (mg kg^{-1})	Clay content (%)	Silt content (%)
UG	2.38	0.22	10.78	3.56	0.49	7.74	3.85	25.83	36.66
AF	2.35	0.2	11.49	3.85	0.46	7.72	4.08	23.58	42
PA	4.42	0.39	11.18	3.29	0.59	7.78	3.77	22.75	35.91
F	10.83**	8.89**	0.815^{ns}	0.23^{ns}	1^{ns}	0.2^{ns}	0.33^{ns}	0.35^{ns}	5.61**

** Significant at $p < 0.01$

ns No significant

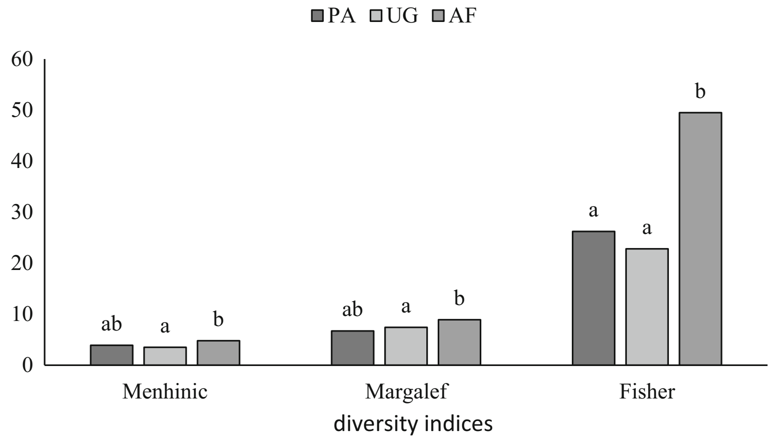

Fig. 3 Mean of Menhinic, Margalef and Fisher indices at three land uses, significant differences denote at α 0.05 using LSD post hoc test

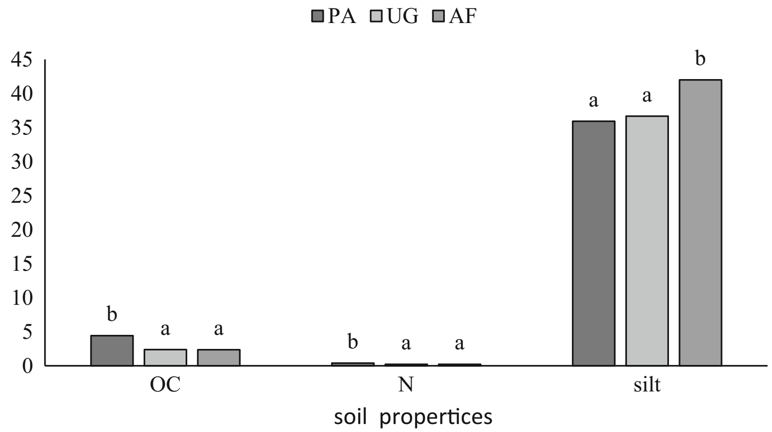

Fig. 4 Mean of organic carbon, Nitrogen and Silt content at three land uses, significant differences denote at α 0.05 using LSD post hoc test

uses, whereas, the C:N ratio and available potassium were the highest in the AF land use (Table 4).

Discussion

The most important aspect of this study is assigning Coefficient of Conservatism (CoC) score to the middle Zagros forest of Iran for the first time. Although the concept of conservatism coefficient was introduced for the first time in Iran, botanical experts welcomed this idea and after numerous meetings, conservatism coefficient was assigned to the plant species in the middle Zagros forest. The study results highlighted the differences between the application of common diversity indices and mean CoC and FQI in ecosystem integrity in different land uses. In general, human disturbance in grazing and abandoned fields had great impacts on herbaceous species community quality.

We expected that excluding anthropogenic disturbances from PA by protection management leads to different vegetation compositions and enhanced ecosystem stability, and observed that biodiversity indices had the highest values in AF land use. We observed a decrease in total diversity and total richness in the PA land use, but there was corresponding increase in mean CoC value and FQI in this land use. We observed high floristic quality and high mean CoC, at a site with minimal human disturbance (PA) and low floristic quality or low mean CoC at a site with a high degree of human disturbance (AF). Our results were in agreement with the study of Gerken Golay (2013) that showed that mean CoC was the highest for preserved area and lowest for secondary forest sites in Iowa forests.

Researchers have argued that one of the problems with diversity measures is the equal weighting of every species regardless of its tolerance to disturbance or its fidelity to a specific habitat (Wilhelm and Masters 1995). Despite differences among the land uses, the fail of Shannon and Simpson diversity indices to demonstrate the differences in the different land uses is one of the weaknesses of diversity indices so that these indices could not identify subtle compositional shifts that are important for conservationists (Rooney and Rogers 2002; Cohen et al. 2004; Hooper et al. 2005; Filippi-Codaccioni et al. 2010; Cretini et al. 2012) and do not indicate whether inherent characteristics of a species lead to greater vulnerability to disturbance. Finally, these measures provide little information on site quality. The high values of richness indices in the AF land uses were also unexpected and it is another weakness of diversity indices.

The results indicated that FQI can be helpful to compare the floristic quality among different land uses and can identify the best land use with high floristic composition. Mean CoC and FQI aggregate more qualitative information on individual species and overall community composition could be useful to assess factors such as conditions of natural areas, their conservation value and impact of human disturbance better (Noss 1990; Lavorel and Garnier 2002). The higher values of diversity indices in the AF land use have been addressed to a short-term response of the system to disturbance, as emphasized by Pitkänen (2000), Peltzer et al. (2000) and Roberts and Zhu (2002). This result is also in agreement with other studies by Odum (1985), as well as Sheil and Burslem (2003) who expressed that species diversity often increases in response to disturbances. However, these results are in contrast with the studies by Findlay and Houlahan (1997), Mensing et al. (1998), Smith and Haukos (2002) who declared that the vegetation diversity has been found to be negatively correlated with increased agriculture and urban land use in wetland.

Clearly, the significant decrease in mean CoC and FQI in the AF land use can be explained by the presence of low conservative species, loss of high quality indicator species, and/or a reduction or loss of native species. Decrease in tree layer density and configuring open area in coppice Zagros oak forest, is an opportunity for exotic species invasion; since exotic species compete with native species for resources (Olff and Ritchie 1998). *Bromus. dantonieh* in *Bromus tectorom* , *Trifolium stellatum*, *Trifolium arvense*, *Trifolium campestre*, *Euphorbia sororia* are widespread species that are known to be disturbance tolerant and abundant in the AF land use. These plants have low CoC values (first CoC category) and are considered as good indicators of habitat conditions. The least conservative species (CoC values < 3) are adapted to extreme anthropogenic or natural degradation that eliminates both high and mid conservatives (Freyman et al. 2015).

In turn, *Astragalus leonardii*, *Astragalus longirostratus*, *Ranunculus pinardi*, *Vaccaria grandiflora*, *Gypsophila persica*, *Bongardia chrysogonum*, *Nigella oxypetala* and *Dactylis glomerata* are not tolerant of disturbances and they were observed in only the PA land use. Thus, these species appear to be good indicators of high ecological integrity in Zagros forest. Since these are sensitive species and might become absent quickly after disturbances and they can be a good predictor of the health of the system as they are either present or absent when management changes (Cousins et al. 2004).

Pietrzykowski (2014) expresses that many plant species are good indicators of habitat conditions. The more endemic and narrowly distributed species that exist in an area, the higher the floristic quality of the area should be. On the other hand, if widely distributed species constitute the main body of a flora, the floristic quality will be obviously low (Tu et al. 2009). These results highlight the subjective nature of CoC-value assignment and emphasize on the fact that plants in PA are more "conservative".

In contrast to FQI, that was a reliable indicator to assess protection practices, FQI_{mod} lacks the ability for proper judgment on vegetation integrity in the PA land use. As the result of Zagros degradation and increases in the distance between trees, the absorbed irradiance by ground flora has been increased and this condition leads to the dominance and expansion of less conservative taxa and disturbance tolerant species (i.e., CoC scores of 1–6). Therefore, in AF land use, percent cover was the highest value. These species are often opportunist, invasive and weedy plants. More disturbance tolerant species with greater percent cover increased the modified floristic quality index in AF over PA, which had more conservative species and lower percent cover. Some studies in Central Europe also have shown that the reduction of the cover of dominant species is due to disturbance (Wohlgemuth et al. 2002). PA land use has higher floristic quality and it is a healthy land use compared to UG and AF land uses. Among the indices tested in this study, the Mean CoC and FQI would be the most sensitive ones in detecting changes in the forest integrity result of Zagros forest. We realized that the modified FQI alone will not describe forest integrity and it must be complemented by indices such as FQI and mean CoC.

Forest integrity and soil physiochemical properties linkage

There were differences in physiochemical soil properties in three land uses. Vegetation cover has fundamental effects on soil properties (Rutigliano et al. 2004), mainly due to its contribution of organic matter to soil.

Our study showed that soil organic C, available N, and available K generally decreased with increases in disturbances, whereas, available phosphorus and pH tended to increase. These results may be attributed to the frequent disturbance of these soils by occasionally removing rock fragments. The impacts of farming on soil organic carbon are well documented, with a significant reduction in soil organic carbon (Collins et al. 2000; Post and Kwon 2000). Cultivation in Zagros forests, which is mainly located on steep slopes leads to surface soil erosion and nutrient loss. Soil recovery after cultivation abandonment occurs slowly and pioneer plant species that are mainly invasive species occupy these fields. The primary stages of secondary succession involve similar conditions, but are not sustained. Organic matter has key influence on physical, chemical and biological soil attributes. Thus, soil physiochemical properties can be a good indicator of soil health and forest integrity. This result was consistent with the study by Wu et al. (2010) who reported that the accumulation of SOC was greater in natural grassland than in arable land in the southern Loess Plateau. Wang et al. (2007) concluded that SOC content in woodlands and grasslands decreased after cultivation in the central Loess Plateau. In contrast, Schiffman and

Johnson (1988) found no difference in total soil C among converted plantations, old field afforested sites, native forests and control fields.

The cessation of cultivation and conversion to perennial vegetation will increase total soil carbon (Degryze et al. 2004). AF land use had higher amounts of K as compared to the UG and PA land uses, which may be due to the addition of K-fertilizers. This result is in accordance with Kosmas et al. (2000) in Greece forests. Similar trends for potassium were found for exchangeable sodium. Due to soil quality would appear to be an ideal indicator of sustainable land management (Herrick 2000), we can state that the increases in Floristic quality values and soil organic carbon in the protected site revealed that protection management is likely successful during a fifteen-year period and the conservation of vegetation on PA land use led to the sequestration of soil organic carbon.

Conclusion

The results of the study indicated that CoC and FQIs could better discriminate land use integrity than species diversity indices such as Simpsons or Shannon. The ability of the CoC and FQI to detect differences helps ecologists and managers to assess the protection practices. Land managers could identify areas that support a large proportion of native and high conservative flora. The integration of the diversity indices with the FQI could be considered as a valid methodology to assess forest integrity better and more research should be conducted using the FQI and related metrics on natural and disturbed ecosystems to determine whether restoration and mitigation projects can attain the goals of achieving natural ecosystem functions.

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References

Abasi S, Hosseini SM, Pilevar B, Zare H (2006) Effects of conservation on woody species diversity in Oshtorankooh region, Lorestan. Iran J For 1(1):1–10

Abrams M, Hulbert LC (1987) Effect of topographic position and fire of species composition in tall grass prairie in northeast Kansas. Am Midl Nat 117:442–445

Abrari Vajari K, Veis Karami GH (2005) Floristic study of Hashtad- Pahlu region in Khorramabad (Lorestan). J Pajouhesh Sazandegi 67:58–64

Andreas BK, Mack JJ, Mccormac JS (2004) Floristic quality assessment index (FQAI) for vascular plants and mosses for the state of Ohio. Environmental Protection Agency, Columbus

Barnett DT, Stohlgren TJ, Kartesz JT (2003) The rich get richer: patterns of plant invasions in the United States. Front Ecol Environ. doi:10.1890/1540-295(2003)001[0011:TRGRPO]2.0.CO;2

Bernthal TW, Watermolen DJ, Cchrane TS (2003) Development of a floristic quality assessment methodology for Wisconsin: Final Report to USEPA-Region V. Wisconsin Department of Natural Resources

Botta-Dukat Z (2005) Rao's quadratic entropy as a measure of functional diversity based on multiple traits. J Veg Sci. doi:10.1111/j.1654-1103.2005.tb02393.x

Brown CD, Boutin C (2009) Linking past land use, recent disturbance, and dispersal mechanism to forest composition. Biol Cons. doi:10.1016/j.biocon.2009.02.035

Chamberlain SJ, Ingram HM (2012) Developing coefficients of conservatism to advance floristic quality assessment in the Mid-Atlantic region. J Torrey Bot Soc. doi:10.3159/TORREY-D-12-00007.1

Cohen MJ, Cartsenn S, Lane CR (2004) Floristic quality indices for biotic assessment of depressional marsh condition in Florida. Ecol Appl. doi:10.1890/02-5378

Collins HP, Elliott ET, Paustian K, Bundy LG, Dick WA, Hugins DR, Smuker AJM, Paul EA (2000) Soil carbon pools in long-term corn belt agro ecosystems. Soil Biol Biochem. doi:10.1016/S0038-0717(99)00136-4

Colwell RK, Coddington JA (1994) Estimating the extent of terrestrial biodiversity through extrapolation. Philos Trans R Soc Lond. doi:10.1098/rstb.1994.0091

Cousins R, Mackay CJ, Clarke SD, Kelly C, Kelly PJ, Mccaig RH (2004) Management Standards and work-related stress in the UK: practical development. Work Stress. doi:10.1080/02678370410001734322

Cretini KF, Visser JM, Krauss KW, Steyer GD (2012) Development and use of a floristic quality index for coastal Louisiana marshes. Environ Monit Assess. doi:10.1007/s10661-011-2125-4

Degryze S, Johan Six W, Keithpaustin Z, Sherrij W, Eldor M, Paul W, Merckx R (2004) Soil organic carbon pool changes following land-use conversions. Glob Chang Biol 10:1120–1132

DeKeyser ES, Biondini M, Kirby D, Hargiss C (2009) Low prairie plant communities of wetlands as a function of disturbance: physical parameters. Ecol Indic. doi:10.1111/j.1529-8817.2003.00786.x

Ewers RM, Didham RK (2006) Confounding factors in the detection of species response to habitat fragmentation. Biol Rev. doi:10.1017/S1464793105006949

Fennessy S, Gernes M, Mack J, Wardrop DH (2001) Methods for evaluating wetland condition: using vegetation to assess environmental conditions in wetlands. Environmental Protection Agency, Washington

Filippi-Codaccioni O, Devictor V, Bas Y, Julliard B (2010) Toward more concern for specialization and less for species diversity in conserving farmland biodiversity. Biol Cons 143:1493–1500

Findlay CS, Houlahan J (1997) Anthropogenic correlates of species richness in Southeastern Ontario Wetlands. Conserv Biol. doi:10.1046/j.1523-1739.1997.96144.x

Freyman WA, Masters LA, Packard S (2015) The universal floristic quality assessment (FQA) calculator: an online tool for ecological assessment and monitoring. Methods Ecol Evol. doi:10.1111/2041-210X.12491

Gerken Golay ME (2013) Assessing the composition and function of hardwood forest herbaceous flora: implications and applications for forest restoration. Dissertation, Iowa State University

Ghahraman A, Attar F (1999) Biodiversity of plant species in Iran. University of Tehran, Thran

Ghazanfari H, Namiranian M, Sobhani H, Mohajer RM (2004) Traditional forest management and its application to encourage public participation for sustainable forest management in the northern Zagros Mountains of Kurdistan Province, Iran. Scand J Forest Cand Res. doi:10.1080/14004080410034074

Haidari M, Jalilvand H, Haidari RH, Shabanian N (2012) Study of plant biodiversity in grazed and non-grazed areas in the Iran-o-Turanian ecological zones (case study: Yazd Province, Iran). Ann Biol Res 3(11):5019–5027

Heidari M, Attar Roshan S, Hatami Kh (2010) The evaluation of herb layer biodiversity in relation to physiographical factors in south of Zagros forest ecosystem (case study: Dalab protected area). RNRRC 1(2):28–42

Henareh Khalyani A, Mayer ANL, Falkowski MJ, Muralidharan D (2012) Deforestation and landscape structure changes related to socioeconomic dynamics and climate change in Zagros forests. J Land Use Sci 8(3):321–340

Herrick JE (2000) Soil quality: an indicator of sustainable land management? Appl Soil Ecol 15:75–83

Hooper DU, Chapin FS, Ewel JJ, Hector A, Inchausti AP, Lavorel S et al (2005) Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecol Monogr. doi:10.1890/04-0922

Kobayashi Y, Koike F (2010) Separating the effects of land-use history and topography on the distribution of woody plant populations in a traditional rural landscape in Japan. Landsc Urban Plan. doi:10.1016/j.landurbplan.2009.11.003

Kosmas C, Gerontidis ST, Marathianou M (2000) The effect of land use change on soils and vegetation over various lithological formations on Lesvos (Greece). Catena. doi:10.1016/S0341-162(99)00064-8

Krebs CJ (1999) Ecological methodology, 2nd edn. Addison-Welsey Educational, Vancouver

Lamb EG, Bayne E, Holloway G, Schieck J, Boutin S, Herbers J, Haughland DL (2009) Indices for monitoring biodiversity change: are some more effective than others? Ecol Indic. doi:10.1016/j.ecolind.2008.06.001

Lavorel S, Garnier E (2002) Predicting changes in community composition and ecosystem functioning from plant traits: revisiting the Holy Grail. Funct Ecol 16:545–556

Lindenmayer DB, Franklin JF (2002) Conserving forest biodiversity: A comprehensive multiscaled approach. Island, Washington

Lopez RD, Fennessy MS (2002) Testing the floristic quality assessment index as an indicator of wetland condition. Ecol Appl. doi:10.2307/3060957

Mabry C (2002) Effects of cattle grazing on woodlands in central Iowa. J Iowa Acad Sci 109:53–60
Magurran AE (1988) Ecological diversity and its measurement. Springer, Netherlands
McLean E (1982) Soil pH and lime requirement. In: Page AL (ed) Methods of soil analysis. Part 2. Chemical and microbiological properties. Springer, Madison, pp 199–223
McNicoll M, Augspurger C (2010) A comparison of vegetation and seed bank community structure in a sand prairie in Illinois, USA. Am Midl Nat 164:136–150
Mensing DM, Galatowitsch SM, Tester JR (1998) Anthropogenic effects on the biodiversity of riparian wetlands of a northern temperate landscape. J Environ Manage. doi:10.1006/jema.1998.0215
Mirzaei J, Akbarnia M, Hosseini SM, Sohrabi H, Hossein zadeh J (2008) Biodiversity of herbaceous species in related to physiographic factors in forest ecosystems in central Zagros. Iran J Biol 20(4):375–382
Mozaffarian V (2004) Dictionary of Iranian plant names. Institute of Farhang-e Mo'aser, Tehran
Nelson DW, Sommers LE (1982) Total carbon, organic carbon and organic matter. American Society of Agronomy, Madison
Noss RF (1990) Indicators for monitoring biodiversity a hierarchical approach. Conserv Biol 4:355–364
Odum EP (1985) Trends expected in stressed ecosystems. Bioscience 35:419–422
Olff H, Ritchie ME (1998) Effects of herbivores on grassland plant diversity. Trends Ecol Evol. doi:10.1016/S0169-5347(98)01364-0
Olsen SR, Sommers LE (1982) Phosphorus. In: Miller AL, Keeney RH (eds) Methods of soil analysis. Part 2. Chemical and microbiological properties. Springer, Madison, pp 403–430
Panzer R, Schwartz MW (1998) Effectiveness of a vegetation-based approach to insect conservation. Conserv Biol 12:693–702
Parrish JD, Braun DP, Unnasch RS (2003) Are we conserving what we say we are? Measuring ecological integrity within protected areas. Bioscience 53:851–860
Peltzer DA, Bast ML, Wilson SD, Gerry AK (2000) Plant diversity and tree responses following contrasting disturbances in boreal forest. For Ecol Manage. doi:10.1016/S0378-1127(99)00130-9
Pietrzykowski M (2014) Soil quality index as a tool for Scots pine (Pinus sylvestris) monoculture conversion planning on afforested reclaimed mine land. J For Res 25(1):63–74
Pilehvar B, Veiskarami GH, Taheri Abkenar K, Soosani J (2010) Relative contribution of vegetation types to regional biodiversity in Central Zagross forests of Iran. Biodivers conserve. doi:10.1007/s10531-010-9899-5
Pitkänen S (2000) Classification of vegetation diversity in managed boreal forests in eastern Finland. Plant Ecol. doi:10.1023/A:1009877403926
Post WH, Kwon KC (2000) Soil carbon sequestration and land use change: processes and potential. Glob Chang Biol 6:317–327
Rechinger K H (1967–1998) Flora Iranica. Gruz, Austria
Rhemtulla JM, Mladenoff DJ, Clayton MK (2009) Legacies of historical land use on regional forest composition and structure in Wisconsin, USA (mid-1800s–1930s–2000s). Ecol Appl 19:1061–1078
Roberts MR, Gilliam FS (1995) Patterns and mechanisms of plant diversity in forested ecosystems: implications for forest management. Ecol Appl 5:969–977
Roberts MR, Zhu L (2002) Early response of the herbaceous layer to harvesting in a mixed coniferous–deciduous forest in New Brunswick. For Ecol Manage, Canada. doi:10.1016/S0378-1127(01)00544-8
Rooney TP, Rogers DA (2002) The modified floristic quality index. Nat Area J 22:340–344
Rutigliano FA, Ascoli RD, De Santo AV (2004) Soil microbial metabolism and nutrient status in a Mediterranean area as affected by plant cover. Soil Biol Biochem. doi:10.1016/j.soilbio.2004.04.029
Sala OE, Chapin FS III, Armesto JJ, Berlow E, Bloomfield J et al (2000) Global biodiversity scenarios for the year 2100. Science 287:1770–1774
Schiffman PM, Johnson WC (1988) Phytomass and detrital carbon storage during forest regrowth in the southeastern United States Piedmont. Can J For Res 19:69–76
Sheil D, Burslem DFRP (2003) Disturbing hypotheses in tropical forests. Trends Ecol Evol. doi:10.1016/S0169-5347(02)00005-8
Simpson EH (1949) Measurement of diversity. Nature. doi:10.1038/163688a0
Sims JT (2000) Soil fertility evaluation. In: Sumner ME (ed) Handbook of soil science. CRC Press, Boca Raton, pp D-113–D-127
Smith LM, Haukos DA (2002) Floral diversity in relation to playa wetland area and watershed sturbance. Conserv Biol 16:964–974
Spyreas G, Matthews JW (2006) Floristic conservation value, nested understory floras, and the development of second-growth forest. Ecol Appl 16:1351–1366
Spyreas G, Meiners SG, Matthews GW, Molano-Flores B (2012) Successional trends in Floristic Quality. J Appl Ecol. doi:10.1111/j.1365-2664.2011.02100.x

Stohlgren TJ, Falkner MB, Schell LD (1995) A Modified–Whittaker nested vegetation sampling method. Plant Ecol. doi:10.1007/BF00045503
Stohlgren TJ, Chong GW, Kalkhan MA, Schell LD (1997a) Rapid assessment of plant diversity patterns: a methodology for landscapes. Environ Monit Assess. doi:10.1023/A:1005796618823
Stohlgren TJ, Coughenour MB, Chong GW, Binkley D, Kalkhan MA, Schell LD, Buckley DJ, Berry JK (1997b) Analysis of plant diversity. J Landsc Ecol. doi:10.1023/A:1007986502230
Swink F, Wilhelm G (1979) Plants of the Chicago region. Morton Arboretum, Lisle
Swink F, Wilhelm G (1994) Plants of the Chicago region, 4th edn. Indiana Academy of Science, Lisle
Taft JB, Hauser C, Robertson KR (2006) Estimating floristic integrity in tallgrass prairie. Biolo Cons. doi:10.1016/j.biocon.2006.02.006
Townsend CC, Guest E, Omar SA, Al-kayat AH (1985) Flora of Iraq. Ministry of Agriculture & Agrarian Reform, Republic of Iraq
Tu WG, Gao XF, Wu N, Liu SH (2009) A novel method for floristic quality assessment using the vegetation of the Jiuding Mountain. Nord J Bot, Sichuan. doi:10.1111/j.1756-1051.2009.00203.x
Vance-Chalcraft HD, Willig MR, Cox SB, Lugo AE, Scatena FN (2010) Relationship between aboveground biomass and multiple measures of biodiversity in subtropical forest of Puerto Rico. Biotropica. doi:10.1111/j.1744-7429.2009.00600.x
Wang XL, Guo SL, Ma YH, Wu JS (2007) Effects of land use type on soil organic C and total N in a small watershed in loess hilly-gully region. Chin J Appl Ecol 18(6):1281–1285
Wilhelm GS, Masters LA (1995) Floristic quality assessment in the Chicago region and application computer programs. Morton Arboretum
Wohlgemuth T, Bürgi M, Scheidegger CH, Schütz M (2002) Dominance reduction of species through disturbance a proposed management principle for central European forests. For Ecol Manage. doi:10.1016/S0378-1127(01)00662-4
Wu GL, Liu ZH, Zhang L, Hu TM, Chen JM (2010) Effects of artificial grassland establishment on soil nutrients and carbon properties in a black-soil-type degreded grassland. Plant Soil. doi:10.1007/s11104-010-0363-9
Young TF, Sanzone S (2002) A framework for assessing and reporting on ecological condition. Ecological Processes and Effects Committee, Washington