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The effect of exclosure on cultural services of semi-arid shrublands of Kerman province, Iran

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Abstract

Biodiversity conservation and ecosystem services provision are of the main ecosystem management objectives. Despite the enormous importance of cultural services, they are often ignored in ecosystem management plans due to the difficulty in quantifying. This study was done to investigate the impact of exclosure on cultural services in semi-arid shrublands. Flowering plants were considered as a proxy for cultural services. The canopy cover and the number of plant species inside and outside the exclosure were recorded in two vegetation types *Artemisia aucheri* and *Artemisia aucheri-Zygophyllum eurypterum*. The results showed that exclosure significantly increased diversity, abundance and richness of plant species. The exclosure also significantly increased the diversity, richness and abundance of flowering species in both vegetation types. A positive relationship was found between diversity indices and flowering species diversity. The results also showed that perennial forbs had a greater role in providing cultural services. It can be concluded that exclosure can promote both plant species diversity and cultural services in semi-arid shrublands.

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Introduction

Natural ecosystems support human life through providing multiple ecosystem services (Brück et al., 2022). These ecosystem services can be maintained by sustainable management of ecosystems (Schröter et al., 2017). One of the greatest challenges that ecosystem management faces to is the loss of biodiversity and ecosystem services (Sun et al., 2022). Conservation plans should be focused on biodiversity and ecosystem services protection (Graves et al., 2017). Plant species diversity contributes in supplying ecosystem services (Bagella et al., 2020). Therefore, biodiversity conservation is essential to supply ecosystem services (Souza et al., 2021).

There are numerous studies dealing with conservation of provisioning and regulating ecosystem services under management changes to ensure food and water security (Rosenfield et al., 2022; MA, 2005). However, cultural services are rarely included in such studies. Cultural ecosystem services defined as “the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience” (MA, 2005). These services sometime are called informational services and are comprised esthetic, spiritual and religious, historic (heritage value), scientific and educational information (Kosanic and Petzold, 2020). Chan et al. (2016) believed that cultural services are services that are everywhere and yet nowhere. Cultural services are composed both art and human (Church et al., 2014) and they are essential for cultural identity and even survival (Kosanic and Petzold, 2020). Demand for cultural ecosystem services is expected to increase due to world population growth (Hegetschweiler et al., 2017).

Ecosystem services are defined mainly based on the natural science paradigms that are difficult to apply for cultural services (Tengberg et al., 2012). Understanding of the cultural services is difficult for their intangible essence (Nahuelhual et al., 2014). Hence, cultural services are rarely quantified in ecological studies (Zhao et al., 2022). As cultural services are related to condition and shape of ecosystems, a number of proxies are commonly used for their quantifying such as the amount of green space (Barthel et al., 2005), the pathways for recreation activities (Lovell and Taylor 2013), or some land covers (van Berkel and Verburg, 2014). Abundance of flowers can be a proper indicator to study cultural services through their aesthetic appreciation (Graves et al., 2016, 2017). Variation of flora plays an important role in ecosystem management (Sakurai et al., 2011).

Studies evaluating the relationship between biodiversity conservation and the protection of cultural ecosystem services are limited (Junge et al., 2009). Biodiversity is related to cultural services such as recreation, aesthetic, nature conservation (Mace et al., 2012). Aesthetic is one of the cultural services which is often assumed to be positively correlated with biodiversity (Wallace, 2007). Flowering plant species can be used to relate biodiversity to cultural services (Graves et al., 2017).

Cultural services are of enormous importance in the human well-being and their assessment and acknowledgement lead to more sustainable ecosystem management (Raymond et al., 2013). However, there is a paucity of information on cultural services in shrublands which are the predominant land cover of arid and semi-arid regions. Therefore, it is necessary to know whether management practices can improve both the environmental quality and cultural services (e.g., recreation, aesthetic, sense of place) and subsequently can benefit to human well-being (Krasny et al., 2014). Hence, impact of exclosure on cultural services was assessed in semi-arid shrubland in this study.

Materials and Methods

Study area

The study area is located in Khabr National Park (28º47′ to 29º1′N and 56º18′ to 56º33′E) in Kerman province. Exclosure area is surrounded by fences and ditches excluding grazing livestock for more than 25 years. The region is characterized by 340 mm mean annual precipitation, which mostly occurs in winter. *Artemisia aucheri* is dominant species in the studied region.

Collect data

After preliminary studies and visiting the area, two vegetation types *Artemisia aucheri* and *Artemisia aucheri-Zygophyllum eurypterum* were identified by physiognomic methods. Random-systematic sampling was performed to collect data in each vegetation type. Hence, five 100-m transects with 100 m intervals were laid out in the region and six quadrats were randomly placed along each transect. The canopy cover and number of plant species were recorded in each quadrat.

Diversity indices

Simpson's Diversity Index (D) was determined by calculating the relative cover of each plant species as following:

$$D=1-\sum P_i^2$$

where p_i= relative cover of species i in each plot.

Margalef's richness index (R) was calculated for species richness as following:

$$R = \frac{S-1}{\ln n}$$

where S is number of taxa and n is number of individuals.

Data analysis

The data were checked for normality by Kolmogorov-Smirnov test which was performed by SPSS 20.0. Student t-test was used to compare two vegetation types in terms of diversity indices and life forms. The relationship between diversity indices and flowering species was assessed using Pearson's correlation coefficient.

Results

In the vegetation types *Artemisia aucheri* and *Artemisia aucheri* - *Zygophyllum eurypterum*, species richness increased significantly from 1.5± 0.77 and 1.02± 0.21 outside the exclosure to 2.22 ± 0.73 and 1.85±0.43 inside the exclosure respectively (Figure 1). The species abundance, in the vegetation type *Artemisia aucheri*, increased significantly from 4.1±1.2 outside the exclosure to 8.7±1.9 inside the exclosure (Figure 1c). The species abundance, in the vegetation type *Artemisia aucheri* - *Zygophyllum eurypterum*, increased significantly from 1.6±3.6 outside the exclosure to 7± 1.9 inside the exclosure (Figure 1d). Species diversity increased significantly from 0.35 ± 0.19 outside the exclosure to 0.74± 0.08 inside the exclosure in the vegetation type *Artemisia aucheri* (Figure 1e). For the vegetation type *Artemisia aucheri* - *Zygophyllum eurypterum*, species diversity increased significantly from 0.41±0.21 outside the exclosure to 0.64 ±0.21 inside the exclosure (Figure 1f).

The results showed that the flowering species richness in the vegetation type *Artemisia aucheri* increased significantly from 1.4±0.34 outside the exclosure to 1.81± 0.49 inside the exclosure (Figure 2a) and in the vegetation type *Artemisia aucheri* - *Zygophyllum eurypterum* increased significantly from 0.90±0.20 outside the exclosure to 1.57±0.21 inside the exclosure (Figure 2b). The flowering sspecies diversity in the vegetation type *Artemisia aucheri* increased significantly from 0.31±0.12 outside the exclosure to 0.61±0.19 inside the exclosure (Figure 2c). The flowering species diversity in the vegetation type *Artemisia aucheri* - *Zygophyllum eurypterum* increased significantly from 0.30± 0.25 outside the exclosure to 0.57± 0.19 inside the exclosure (Figure 2d). The flowering species abundance in the vegetation type *Artemisia aucheri* increased significantly from the average of 3.9±1.1 outside the exclosure to 7.1±1.9 inside the exclosure (Figure 2e). The flowering species abundance in the vegetation type *Artemisia aucheri* - *Zygophyllum eurypterum* increased significantly from the average of 2.3 ± 1.8 outside the exclosure to 5.8±1.6 inside the exclosure (Figure 2f).

Pearson's correlation analysis showed that diversity indices for flowering plant species is significantly correlated to species indices (Table 1). There was a positive significant relationship between the flowering species diversity and richness (R^2=0.985, $p<0.01$). A positive significant relationship was observed between flowering species diversity and species richness (R^2=0.923, $p<0.01$). There was a positive significant correlation between flowering species diversity and species diversity (R^2=0.627, $p<0.01$). A positive significant relationship was observed between flowering species richness and species richness (R^2=0.902, $p<0.01$). There was a positive significant relationship between flowering species richness and species diversity (R^2=0.951, $p<0.01$).

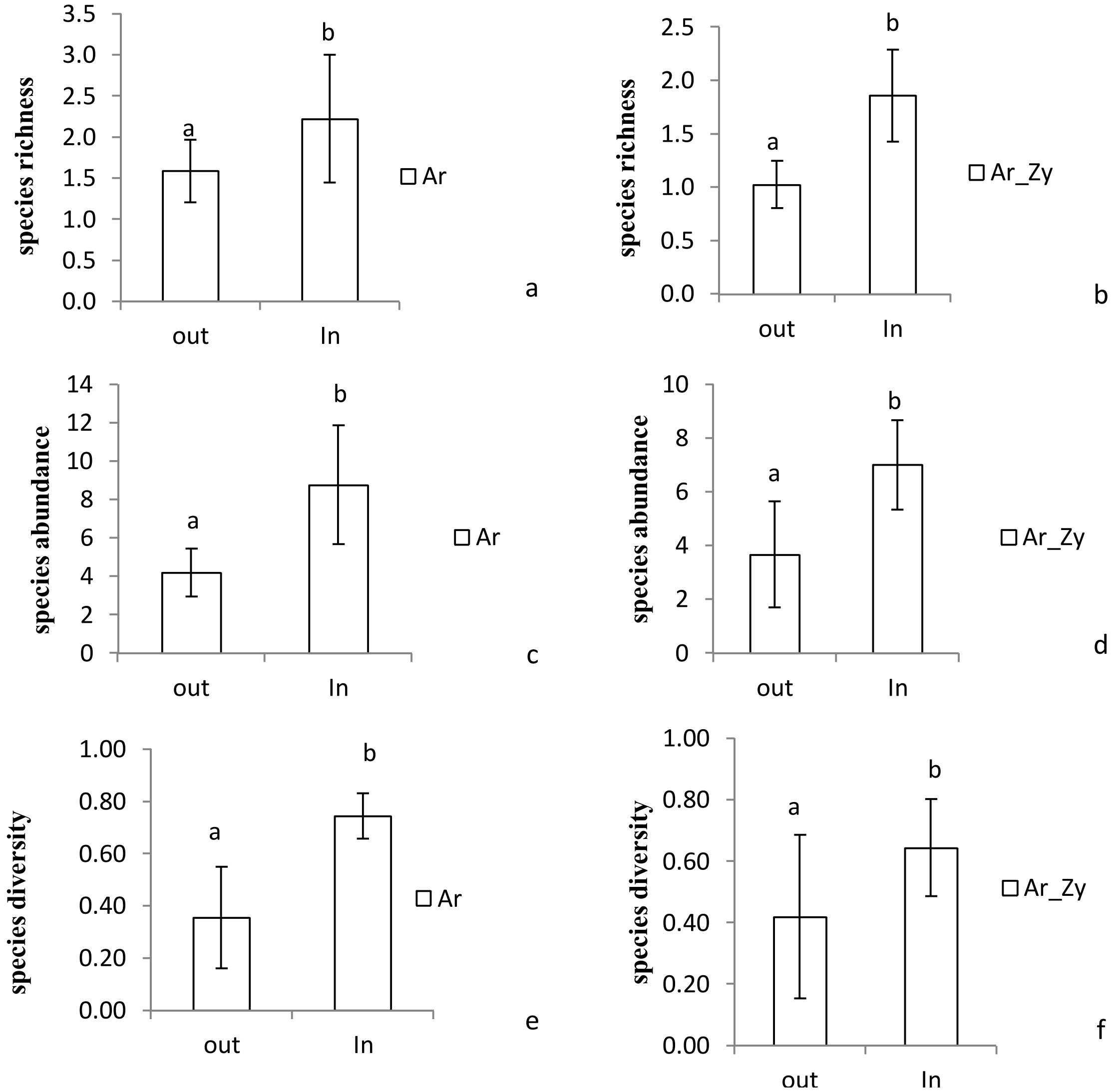
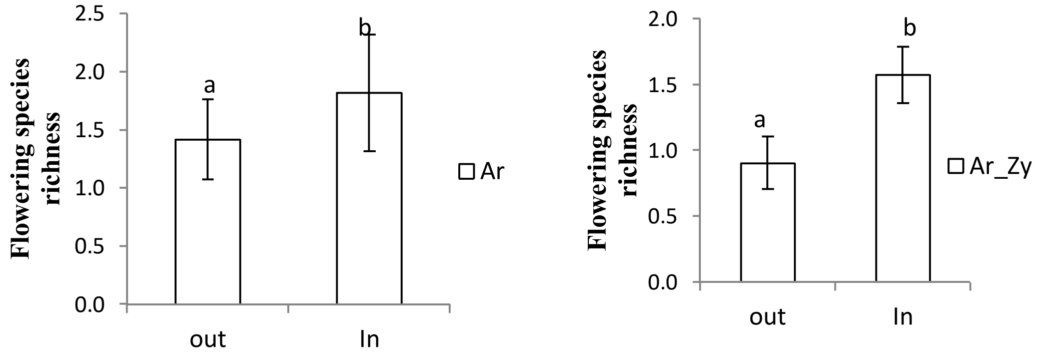


Figure 1. The differences between outside and inside of exclosure based on species diversity indices. Values are mean ± SD. Significant differences are showed by the superscripts a and b the same letter indicates no significant difference.



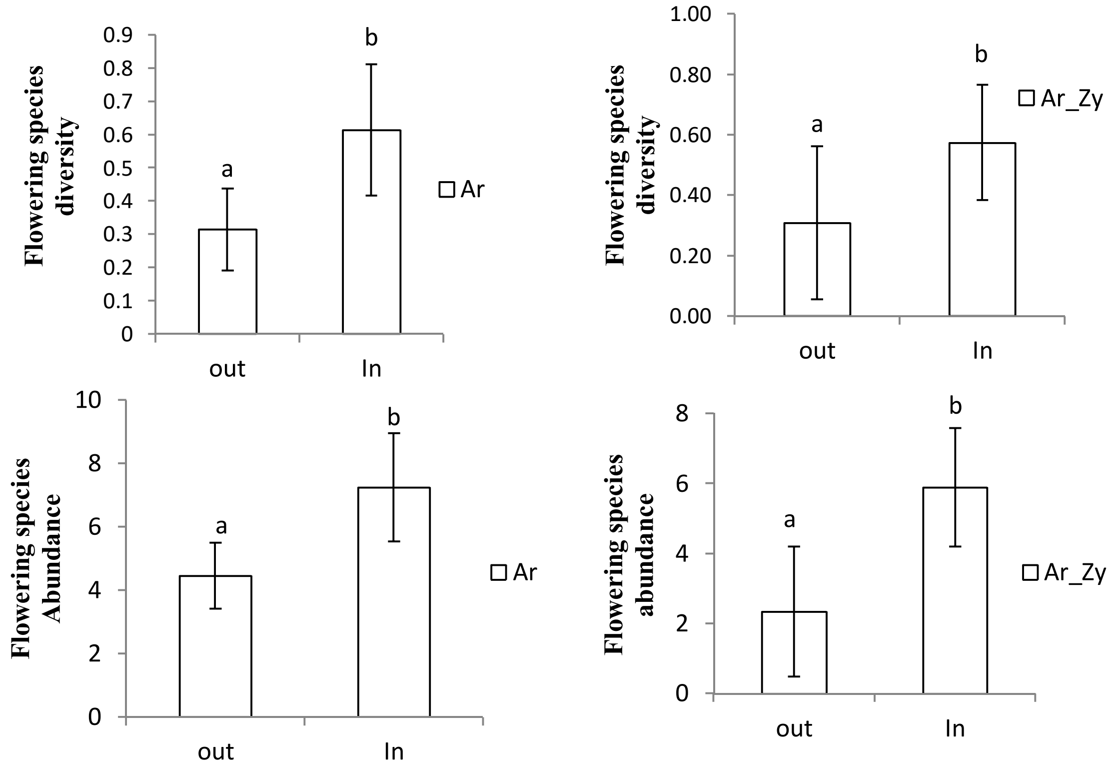


Figure 2. The differences between outside and inside of exclosure based on flowering species diversity indices. Values are mean ± SD. Significant differences are showed by the superscripts a and b the same letter indicates no significant difference.

Table 1. Pearson's correlation coefficient between flowering species diversity indices and species diversity indices. Significant correlation are shown by: **p = 0.01

	Flowering species diversity	Flowering species richness	Species richness	Species diversity
Flowering species diversity	1	0.985**	0.923**	0.627**
Flowering species richness		1	0.902**	0.951**
species richness			1	0.758**
Species diversity				1

Table 2. The differences between outside and inside of exclosure based on life form of flowering species. Values are mean ± SD. Significant differences are showed by the superscripts a and b the same letter indicates no significant difference.

	Ar		Ar-Zy	
	In	Out	In	Out
Annual flowering forbs	4.23±0.56a	2.53±0.35b	3.12±0.98a	1.2±0.89b
Perennial flowering forbs	6.08±1.23a	1.89±0.68b	4.23±1.23a	1.31±0.74b
Flowering semi-shrub	15.14±4.32a	9.21±1.23b	10.23±2.32a	8.23±1.32a
Flowering shrub	2±2.1a	1.15±0.68a	6.12±1.2a	5.23±1.32a

The results also showed that the exclosure significantly affects different life forms of flowering species (Table 2). In the vegetation type *Artemisia aucheri*, annual flowering forbs were significantly increased from 2.53±0.35 outside the exclosure to 4.23± 0.56 inside the exclosure ($p<0.05$). Perennial flowering forbs were significantly increased from 1.89±0.68 outside the exclosure to 6.08±1.23 inside the exclosure

($p<0.05$). Flowering semi-shrubs were significantly increased from 9.21±1.23 outside the exclosure to 15.14±4.32 inside the exclosure ($p<0.05$). There was no significant difference between inside and outside the exclosure in terms of flowering shrubs, but they were increased from 9.21±1.23 outside the exclosure to 15.14±4.32 inside the exclosure ($p>0.05$). In the vegetation type *Artemisia aucheri - Zygophyllum eurypterum*, annual flowering forbs were significantly increased from 1.2±0.89 outside the exclosure to 3.12±0.98 inside the exclosure ($p<0.05$). Perennial flowering forbs were significantly increased from 1.31±0.74 outside the exclosure to 4.23±1.23 inside the exclosure ($p<0.05$). There was no significant difference between inside and outside the exclosure in terms of flowering semi-shrubs, but they were increased from 8.23±1.32 outside the exclosure to 10.23±2.32 inside the exclosure ($p<0.05$). Flowering shrubs were significantly increased from 5.23±1.32 outside the exclosure to 6.12±1.2 inside the exclosure ($p<0.05$).

Discussion

The results of this study showed that exclosure has increased species diversity and richness in two vegetation types of the region, indicating the positive effects of exclosure on diversity conservation. This is in accord with the results of Fikadu and Argaw (2021) stating that reducing the intensity of livestock grazing provided suitable conditions for species growth and biodiversity increase. However, a number of studies have shown that livestock grazing is necessary to maintain species diversity (e.g. Karamiet al., 2021). Mahmoudi et al. (2011) also showed that the species diversity and richness had increased in the protected area and concluded that proper management practices can cause ecosystem stability and increase biodiversity by reducing or eliminating livestock from the ecosystem. Kiani Sadr et al. (2016) concluded that exclosure had a significant effect on species density, diversity and richness.

The results also showed that the exclosure improved the diversity of flowering plants in the studied region. The promotion of flowering plant diversity was different in different vegetation types. Forrest et al. (2010) also showed that plant communities that are different in terms of plant composition, are different in providing flowering plants and cultural services. *Artemisia aucheri* vegetation type, which includes more flowering forb plants, is more successful in providing cultural services. Hence, flowering forbs are valuable species for providing cultural services in semi-arid shrublands which should be given more attention in protection plans.

The diversity of flowering plants as an indicator of cultural services had a positive significant relationship with species diversity. Marshall and Moonen (2002) also showed that rich ecosystems in plant species usually provide beautiful landscapes. Color diversity in flowering plant can enhance the value of cultural services in the natural ecosystems (Lindemann-Matthies et al., 2010). People are very interested in seeing wild flowering plants (Satz et al., 2013). The results Cordell (2012) showed that flowering plants photography is one of the dominant activities of tourists. Flowering plants as a component of biodiversity are important to promote cultural services (Kremen et al., 2007). People's motivation to conserve biodiversity and native species is also increasing by promoting flowering plants and thus increasing the value of cultural services such as tourism and aesthetic value (Schirpke et al., 2016; De Lacy and Shackleton, 2017). Enhancing flowering plants also has a significant effect on promoting pollinator activity and pollination service (Kremen et al., 2007; Williams and Winfree, 2013). The flowering plant conservation program and cultural services pursue other ecosystem conservation goals and are a good way to prevent biodiversity loss (MA, 2005).

Knowing of flowering plants diversity and cultural services is very low (Daniel et al., 2012) .In addition to anthropogenic activities, flowering species diversity is influenced by environmental factors such as soil and landscape and topography (Gornish and Tylianakis, 2013). Hence, it is necessary to study the spatial variations of flowering plants in different landscapes under new studies. In this study, flowering plants have been studied just in spring. Examining the temporal changes of flowering plants and the potential of ecosystems in providing cultural services throughout the year can provide proper information for management planners. In general, exclosure as one of the best methods of rangeland improvement in arid and semi-arid regions (Wang et al., 2019) is able to improve both biodiversity and cultural services in semi-arid shrublands.

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