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Effects of some woody nurse plants on preservation composition and biodiversity of understory herbaceous in southern Zagros forests (Case study: Vezg region, Yasouj, Iran)

Mohammad Amin Sadat[1], Sohrab Alvaninejad[1,*], Parviz Gholami[2], Alireza Salehi[1]

[1]*Department of Forestry, Faculty of Agriculture and Natural Resources, Yasouj University, Yasouj, Iran.*
[2]*Department of Rangeland and Watershed Management, Faculty of Natural Resources, Sari University of Agricultural Science and Natural Resources, Sari, Iran.*

[*]**Corresponding author:** salvaninejad@yu.ac.ir

Original Research

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Abstract:

Studying the effects of woody nurse plants on the composition and biodiversity of herbaceous understory plants, especially in arid and semi-arid areas, is essential for managing the ecosystems optimally. This research was conducted to investigate the role of canopy cover of nurse plants in preserving the composition and biodiversity of herbaceous understory plants in the Vezg region located in Southern Zagros forests in Kohgiluye and Boyerahmad province, Iran. Three woody nurse species of *Amygdalus lycioides* Spach., *Pyrus glabra* Boiss., and *Daphne mucronata* Royle., which have been recognized as the indicator species to support natural regeneration and their relative importance in the composition of upper-story plants were selected. Canopy cover percentages were recorded for understory plants for nurse species and adjacent open space (control) in 1 m^2 plots. Also, biodiversity and richness indices of understory plants were computed along with their vegetation cover percentage using Past software. Vegetation data between three woody nurse species was analyzed using the ANOVA, and the means were compared using the Duncan test. Eighty-one species in open space and the understory of nurse species were identified. The highest cover percentages of understory plants was related to annual plants such as *Taeniatherum crinitum* and *Bromus tectorum*. Also, the highest cover percentages in open spaces were related to annual species involving *Heteranthelium piliferum*, *Scariola orientalis*, and *Alyssum marginatum*. Results showed higher values of biodiversity indices for woody nurse species *A. lycioides* and *D. mucronata* than those for *P. glabra*. Generally, results demonstrated that the nurse species, especially *A. lycioides*, could be used as a shelter to increase the growth of annual herbaceous species and could preserve high-quality species for livestock grazing.

Keywords: Biodiversity indices; Understory plants; Nurse plants; Zagros forests

Introduction

One of the critical issues in managing natural resources is preserving and maintaining of plant biodiversity. Many studies have pointed out the importance of biodiversity in ecosystems' stability, preservation, and firmness (Kumar et al., 2018). Diversity is the main issue of ecological research and is applied to manage natural ecosystems in many cases (Hamilton, 2005). In a study of diversity, first, its components should be recognized, since biodiversity includes a combination of various forms and diverse shapes of plant and animal communities and addresses the structural studies of plant populations, frequency, and distribution patterns; on the other hand, it is utilized as an index to compare the ecological status. Diversity is a combination of two concrete components: species richness and evenness. These indices are regarded as important criteria for the health of ecological and environmental systems. Understory vegetation is an important component in forest ecosystems, providing a high

contribution to stand development and canopy succession (Yazdani et al., 2020). In forest and rangeland ecosystems, the effects and interactions between species, as well as between the environment and species, play an influential role in plant distribution, richness, growth, plant community survival, and ecosystem yield (Callaway et al., 2002). The relationships between plants primarily consist of competition (negative impact), neutrality (no impact), and facilitation (positive impact), in which the facilitation element is considered to be a significant driving force in sequences of plant communities and revival of vegetation (GomezAparicio et al., 2005; Ren et al., 2008). In forest ecosystems under livestock grazing, the balanced interactions between facilitation and competition among plants move towards decreased competition and increased facilitation relationships. Facilitation is a crucial structural process in preserving diversity and a combination of plant communities, usually defined as a positive impact of plants on the growth and establishment of other species (Bruno et al., 2003). The presence of range bushes and shrubs in arid and semi-arid ecosystems can be introduced as nurse plants, which are more likely to facilitate the establishment and survival of other plants (Vandenberghe et al., 2009). Nurse plants facilitate the establishment of plant species under their canopy cover by providing specific microclimate conditions, increasing the soil humidity and nutrients, and reducing sunlight and temperature, followed by decreased evaporation and perspiration and decreased erosion (Padilla and Pugnaire, 2006; Foronda et al., 2020). Since the nurse plants are equipped with defense systems such as thorns, blades, dense vegetation canopy, and low palatability, the target plants can be protected against livestock grazing (Bruno et al., 2003), leading to the protection of plant species and an increase of species diversity (Cavieres et al., 2002).

In recent years, the discussion about the nurse plants and their role in protecting understory plants in the destroyed habitats involving Mediterranean regions, Alpine habitats, deserts, semi-dry scrublands, Savanna, ecotones among abandoned and grazed agricultural lands, and tropical semi-humid forests have been addressed (Callaway et al., 2002; Gholami et al., 2016; Badano et al., 2016; Yazdani et al., 2020; MadrigalGonzalez et al., 2020). In most studies, the nurse plants play a significant role in preserving the vegetation of understory herbaceous plants. In Zagros forests, human destruction cutting and branching of trees, agriculture under tree canopies, human fires, land use change, seed collecting, overgrazing, and off-season grazing have affected plant species diversity. The conditions mentioned above, along with climatic changes and disturbances, lead to the removal of dominant species and the presence of invasive species. So far, studies have been conducted mainly in rangeland ecosystems to investigate the effects of bushes on plant composition and diversity, and less research has been done concerning the impact of woody plants such as trees and shrubs on the understory plants (Khazani et al., 2022). The studies performed in the forests located in Vezg region, Kohgiluye and Boyerahmad province, Iran have presented woody species such as *A. lycioides*, *D. mucronata*, and *P. glabra* as the most critical nurse plants in preserving natural regeneration (Sadat et al., 2022). A vast area of desired forests at high altitudes has been allocated to these species. So far, studies on the role of these mentioned species of nurse plants in preserving the herbaceous plant's composition and diversity have not been reported. One of the crucial questions concerning such habitats is how the different nurse plants (shrubs and trees) affect the composition and diversity of herbaceous plants. Thus, this research was conducted to study the role of nurse plants and the facilitation of three mentioned species (*A. lycioides*, *D. mucronata*, and *P. glabra*) in the composition and diversity of herbaceous understory plants.

Materials and methods

Study area

This research was conducted in the forests in the Vezg region of Kohgiluye and Boyerahmad province, Iran. This area is located 15 km southeast of Yasouj city (figure 1). Its altitude is $2130-2150$ m above sea level and in the northwest geographical direction. The dominant tree and shrub vegetation includes *Amygdalus lycioides* Spach., *Pyrus glabra* Boiss., *Daphne mucronata* Royle, *Crataegus azarolus* L., *Acer monspesuulanum* L. *Subsp. Cinerascens* (Boiss), *Fraxinus rotundifolia* Miller, *Pistacia atlantica* Desf., *Lonicera nummulariifolia* Jaub & Spach and *Quercus brantii* Lindl., (Sadat et al., 2022). The rainfall is Mediterranean climate, such as other parts of Zagros, and consequently, it has a $5-8$ month drought period, from early May to late November and, sometimes up to December. The mean annual precipitation is 796.5 mm using the 38-year data from the synoptic station, Yasouj, and the mean annual temperature is 14.5 °C.

Vegetation data and sampling method

This research first determined the case study situation based on aerial images. After visiting the forest, a piece with an area of 6 ha was selected as the sample plot of the target region. The dominant tree and shrub vegetation were *Amygdalus lycioides* Spach., *Pyrus glabra* Boiss., and *Daphne mucronata* Royle, that accounted almost 60% of different forms of nurse species (Sadat et al., 2022). *A. lycioides* (Rosaceae) is a thorny shrub with many branches at a height of 2 m which is distributed in Zagros forests (Sabeti, 2006). *P. glabra* (Rosaceae) is a small tree with a height of about $5-7$ m, and has thorny branches distributed in Zagros forests. *D. mucronata* (Thymelaeaceae) is a shrub with a height of 1 m, growing in steppe areas up to the altitude of 3000 m above sea level in Zagros forests. Sampling was done from vegetation understory and in open spaces at the beginning of the growing season in May 2020. In the desired region, four 100 m transects (two along the slope and two perpendicular to the slope) with an interval of 50 m were used randomly in the same topographical conditions. Along each transect, 10 trees of *Amygdalus*, *Daphne*, and *Pyrus* were considered as one sampling unit. The adjacent presence of three desired species led to the removal of such destructive elements as soil and topographical changes in data collection (figure 1). Below each tree, the 1 m^2 plots were randomly established (Abedi and Arzani, 2015). Plots

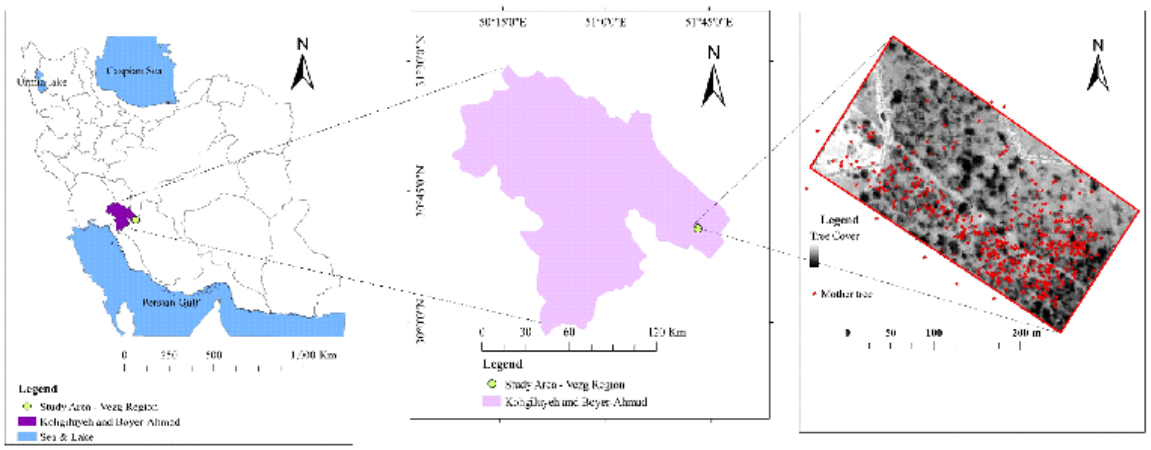

Figure 1. The location of the study area, Kohgiluyeh and Boyer-Ahmad, Iran.

were located precisely below the crown of nurse species to remove the impact of other trees and shrubs. Close to the selected tree in open spaces, a 1 m^2 plot was specified, and then crown and percentage of herbaceous species were estimated. Also, vegetation groups, including life form, biological form, and life span of all the species close to each nurse species understory and in open spaces were recorded.

Data analysis

First, the normality of vegetation data was examined using Kolmogorov-Smirnov test. Since some data followed no normal distribution, logarithmic conversion was applied to normalize these data before conducting a statistical test. Considering the canopy cover type and percentage of every herbaceous understory species, Simpson and Shannon-Wiener diversity indices, Margalef and Menhenik species richness, and uniformity indices were estimated using Past software. For means comparison of species diversity indices and functional vegetation groups understory of nurse species, one-way ANOVA and Duncan test were used by SPSS22 software. A multivariate analysis was conducted to investigate the species group response, or species changes in the understory of nurse species. First, Detrended Correspondence analysis (DCA) was implemented on data to measure gradient length, and as the gradient length of axes was less than 3, the redundancy analysis (RDA) was used. Results was presented in a biplot diagram.

Results

Plant species composition

In this research, 81 plant species were identified in nurse species' understory and open spaces (Table 1).

For *A. lycioides*, 60 and 27 species were identified in the understory and open spaces, respectively, with 27 common species. 39 and 6 species were exclusively observed in understory and open spaces, respectively. For this species, *Taeniatherum crinitum* and *Bromus tectorum* were considerably dominant understory and had the highest canopy cover percentage. In the open space, the highest canopy cover percentage was observed in *Heteranthelium piliferum*.

For *P. glabra*, 46 and 25 species were identified in the understory and the open space, respectively, with 22 common species. 24 and 3 species were exclusively observed understory and in open space, respectively. For this species, *Taeniatherum crinitum* and *Bromus tectorum* were dominant, and they had the highest canopy cover percentage in the understory. In the open space the species of *Scariola orientalis* and *Alyssum marginatum* had the highest canopy cover.

For *D. mucronata*, 53 species in the understory and 24 species in open space were identified, with 20 common species. 33 and 4 species were exclusively observed understory and in open space, respectively. For this species, *Taeniatherum crinitum*, *Bromus tectorum*, and *Heteranthelium piliferum* were dominance and had the highest canopy cover percentage in understory. In open space *Scariola orientalis* and *Alyssum marginatum*, had the highest canopy cover percentage (Table 1).

Means of biodiversity indices

For mean comparisons, one way ANOVA was conducted for biodiversity indices between woody nurse plants understory. The results indicated that there was significant differences between the understory of the three mentioned species in terms of biodiversity indices as Simpson diversity, Shannon-Wiener diversity and Pielou uniformity indices ($p < 0.05$) (Table 2). However, considering Margalef and Menhenik richness indices, the three species had no significant differences. Means comparison results indicated that most herbage species were related to the understory of *A. lycioides*, and the least number was attributed to *P. glabra*. Margalef richness index had the most value understory of *A. lycioides*, whereas the difference between nurse plants understory was not statistically significant. The most values in terms of Simpson and Shannon-Weiner diversity and Pielou uniformity indices were observed for the species *D. mucronata*.

Means of functional groups

One way ANOVA was conducted between three nurse species for mean comparison of functional groups in understory. Result showed that the canopy cover percentage of functional groups in annual grass, annual forbs ones, and plant families of Poaceae, Boraginaceae, and Geraniaceae

Table 1. Herbaceous vegetation composition (%) understory and in open space of nurse species.

Row	Scientific Name	*Abbre.*	*A. lycioides*		*P. glabra*		*D. mucronata*	
			under	open	under	open	under	open
1	*Heteranthelium piliferum*	*He.pi*	99.2	37.2	85.5	63.1	8.2	15.2
2	*Taeniatherum crinitum*	*Ta.cr*	3.3	93.0	74.2	58.0	45.2	2.1
3	*Crepis kotschyana*	*Cr.ko*	2.1	47.0	39.0	76.0	11.1	28.0
4	*Poa bulbosa*	*Po.bu*	6.0	2.0	89.0	12.0	64.0	7.0
5	*Alyssum marginatum*	*Al.ma*	29.1	81.0	39.1	12.2	63.3	65.2
6	*Silene conoidea*	*Si.co*	71.0	34.0	39.0	7.0	7.0	12.0
7	*Bunium caroides*	*Bu.ca*	76.2	-	82.3	23.0	74.3	32.0
8	*Bromus tectorum*	*Br.te*	52.1	46.1	6.1	26.1	3.9	44.2
9	*Acinus graveolens*	*Ac.gr*	32.0	37.0	7.0	12.0	37.0	37.0
10	*Galium tricornutum*	*Ga.tr*	42.1	-	23.0	-	86.0	-
11	*Asyneuma sp.*	*As.*	2.0	12.0	64.0	7.0	38.1	32.0
12	*Tragopogon buphthalmoides*	*Tr.bu*	43.0	31.0	5.1	6.0	7.0	-
13	*Serratula bakhtiaricca*	*Se.ba*	31.0	7.0	-	-	17.0	-
14	*Valerianella oxyrrhyncha*	*Va.ox*	-	2.0	-	-	7.0	51.0
15	*Arenaria leptoclados*	*Ar.le*	28.0	15.0	47.0	91.0	5.0	53.0
16	*Centaurea solstitialis*	*Ce.so*	15.0	28.0	12.0	15.0	-	-
17	*Melica persica*	*Me.pe*	45.0	23.0	41.0	15.0	58.0	-
18	*Lasiopogon muscoides*	*La.mu*	-	68.1	7.0	5.0	7.0	49.0
19	*Muscari neglectum*	*Mu.ne*	2.0	-	26.0	-	17.0	-
20	*Anchus italica*	*An.it*	47.0	-	-	-	-	-
21	*Alyssum dasycarpum*	*Al.da*	55.0	-	-	-	-	-
22	*Gundelia tournefortii*	*Gu.to*	35.0	-	-	-	32.0	-
23	*Scorzonera sp.*	*Sc.*	7.0	2.0	77.0	12.0	51.0	2.0
24	*Tulipa sp.*	*Tu.*	2.0	7.0	-	-	-	-
25	*Torilis arvensis*	*To.ar*	-	22.1	-	28.0	-	6.0
26	*Ceratocephalus falcata*	*Ce.fa*	-	76.0	-	47.0	-	64.0
27	*Vicia sativa*	*Vi.sa*	41.0	-	28.0	-	17.0	-
28	*Tanacetum polycephalum*	*Ta.po*	17.0	-	-	-	32.0	12.0
29	*Astragalus ovinus*	*As.ov*	37.0	-	-	-	-	-
30	*Garhadiolus angulosus*	*Ga.an*	-	12.0	-	-	-	-
31	*Anthriscus nemorosa*	*An.ne*	28.0	-	-	-	-	-
32	*Bellevalia glauca*	*Be.gl*	34.0	-	34.0	7.0	31.0	-
33	*Arrhenatherum kotchyi*	*Ar.ko*	41.0	-	77.0	12.0	28.0	-
34	*Tragopogon graminifolius*	*Tr.gr*	12.0	-	7.0	-	-	-
35	*Ficaria kochii*	*Fi.ko*	12.0	-	-	-	7.0	-
36	*Falcaria vulgaris*	*Fa.vu*	12.0	-	35.0	-	31.0	-
37	*Ranunculus oxyspermus*	*Ra.ox*	2.0	-	-	-	53.0	-
38	*Senecio vernalis*	*Se.ve*	7.0	-	25.0	-	-	-
39	*Trigonella monantha*	*Tr.mo*	2.0	-	23.0	-	-	-
40	*Geranium tuberosum*	*Ge.tu*	47.0	-	23.0	23.0	68.1	25.0
41	*Astragalus effusus*	*As.ef*	49.0	7.0	2.0	-	26.0	-

Continued of Table 1.

Row	Scientific Name	*Abbre.*	*A. lycioides*		*P. glabra*		*D. mucronata*	
			under	open	under	open	under	open
42	*Scariola orientalis*	*Sc.or*	12.0	47.0	64.0	31.2	97.0	65.2
43	*Phlomis olivieri*	*Ph.ol*	12.0	7.0	12.0	-	-	-
44	*Cerastium dichotomum*	*Ce.di*	43.0	-	71.0	41.0	11.1	41.0
45	*Erysimum repandum*	*Er.re*	12.0	-	-	-	-	-
46	*Lamium amplexicaule*	*La.am*	43.0	-	-	-	-	-
47	*Onosma bulbotrichum*	*On.bu*	41.0	-	-	-	-	-
48	*Astragalus curvirostris*	*As.cu*	35.0	7.0	-	-	-	-
49	*Picnomon acarna*	*Pi.ac*	-	-	7.0	-	7.0	-
50	*Roemeria refracta*	*Ro.re*	-	15.0	-	15.0	-	25.0
51	*Bupleurum gerardii*	*Bu.ge*	7.0	-	-	-	-	-
52	*Bromus tomentellus*	*Br.to*	32.0	7.0	2.0	7.0	38.0	-
53	*Gagea gageoides*	*Ga.ga*	12.0	-	-	-	-	-
54	*Scandix aucheri*	*Sc.au*	32.0	-	-	-	31.0	-
55	*Scabiosa persica*	*Sc.pe*	-	-	2.0	-	2.0	-
56	*Thesium kotschyanum*	*Th.ko*	-	-	15.0	-	12.0	-
57	*Bunium cylindricum*	*Bu.cy*	17.0	-	12.0	-	15.0	-
58	*Corydalis verticillaris*	*Co.ve*	-	-	43.0	-	25.0	-
59	*Erodium cicutarium*	*Er.ci*	-	-	7.0	-	7.0	-
60	*Chaerophyllum macropodum*	*Ch.ma*	-	-	12.0	-	-	-
61	*Koelpinia linearis*	*Ko.li*	-	-	7.0	-	12.0	-
62	*Cardaria draba*	*Ca.dr*	-	-	7.0	-	-	-
63	*Lactuca serriola*	*La.se*	-	-	-	-	2.0	-
64	*Taraxacum montanum*	*Ta.mo*	-	-	-	-	28.0	7.0
65	*Taraxacum syriacum*	*Ta.sy*	-	-	-	-	7.0	-
66	*Eryngium billardieri*	*Er.bi*	-	-	-	-	7.0	-
67	*Chardinia orientalis*	*Ch.or*	31.0	-	-	-	34.0	-
68	*Papaver argemone*	*Pa.ar*	-	-	-	-	7.0	-
69	*Adonis aestivialis*	*Ad.ae*	-	-	-	-	-	12.0
70	*Salvia syriaca*	*Sa.sy*	-	-	-	-	2.0	7.0
71	*Nepeta macrosiphon*	*Ne.ma*	28.0	-	-	-	-	-
72	*Allium ampeloparsum*	*Al.am*	12.0	-	-	-	-	-
73	*Malva neglecta*	*Ma.ne*	0.1	-	-	-	-	-
74	*Fumaria parviflora*	*Fu.pa*	0.2	-	-	-	-	-
75	*Lotus corniculatus*	*Lo.co*	0.3	-	0.3	-	0.5	-
76	*Aegilops triuncialis*	*Ae.tr*	0.3	-	0.2	-	0.3	-
77	*Hordeum bulbosum*	*Ho.bu*	0.3	-	0.3	-	0.2	-
78	*Boissiera squarrosa*	*Bo.sq*	0.4	-	-	-	-	-
79	*Sanguisorba minor*	*Sa.mi*	0.3	-	0.3	-	0.2	-
80	*Ixiolirion tataricum*	*Ix.ta*	0.2	-	0.1	-	0.1	-
81	*Marrubium vulgare*	*Ma.vu*	0.1	-	0.1	-	0.3	-

Table 2. Results of ANOVA and mean comparison between nurse plants for biodiversity indices (Mean ± standard deviation) understory of three nurse species.

Indices	*A. lycioides*	*P. glabra*	*D. mucronata*	F value	P value
Number of Species	17.40 ± 4.58 a	13.50 ± 2.72 b	16.01 ± 3.7 ab	2.82	0.05*
Simpson Indices	0.68 ± 0.14 ab	0.69 ± 0.12 b	0.82 ± 0.03 a	5.45	0.01*
Shannon-Weiner Indices	1.85 ± 0.43 ab	1.72 ± 0.36 b	2.16 ± 0.24 a	4.28	0.02*
Pielou Indices	0.39 ± 0.10 b	0.43 ± 0.08 b	0.56 ± 0.07 a	11.35	0.000**
Menhinick Indices	1.69 ± 0.41a	1.37 ± 0.25 a	1.63 ± 0.35 a	2.5	0.11
Margalef Indices	3.52 ± 0.95 a	2.73 ± 0.57 ab	3.30 ± 0.79 ab	2.7	0.09

**, * and = significance at 1%, and 5% probability levels, respectively.
The means of rows with the same letter are not significantly different ($\rho < 0.01$).

had a significant difference understory of three species (Table 3) ($p < 0.05$). Means comparison results of vegetation functional groups indicated that the most and least vegetation values in annual grass were related to the understory of *Amygdalus* and *Daphne*, respectively. In addition, the most vegetation value in annual forbs was related to *Daphne*, *Amygdalus*, and *Pyrus*. Most canopy covers of the family Poaceae belonged to the understory of *Amygdalus*, which

Table 3. Result of ANOVA and means comparison of functional groups (Mean ± standard deviation) in vegetation understory of three desired species.

Plant functional groups		*A. lycioides*	*P. glabra*	*D. mucronata*	F value	P value
Longevity	Annual Plants	82.04 ± 0.04 a	76.7 ± 0.05 a	72.19 ± 0.05 ab	3.20	0.05 ns
	Perennial Plants	20.98 ± 0.20 a	18.44 ± 0.19 a	22.84 ± 0.17 a	0.57	0.57 ns
Vegetative form	Annual Graminea	70.97 ± 0.56 a	69.37 ± 0.06 a	58.97 ± 0.07 b	4.63	0.019 *
	Perennial graminea	2.63 ± 0.35 a	3.85 ± 0.22 a	2.69 ± 0.31 a	0.56	0.57 ns
	Annual forbs	9.71 ± 0.21 ab	5.74 ± 0.31 b	12.7 ± 0.09 a	5.00	0.014 *
	Perennial forbs	17.22 ± 0.22 a	13.47 ± 0.16 a	17.79 ± 0.17 a	1.11	0.34 ns
Biological form	Hemicryptophyte	9.34 ± 0.41 a	5.24 ± 0.37 a	7.87 ± 0.35 a	0.89	0.42 ns
	Trophite	82.04 ± 0.37 a	76.7 ± 0.05 ab	72.19 ± 0.05 b	3.20	0.57 ns
	Geophyte	9.33 ± 0.16 a	11.06 ± 0.15 a	11.48 ± 0.17 a	0.75	0.48 ns
Palatable classes	Palatable	19.37 ± 0.16 a	17.9 ± 0.17 a	18.72 ± 0.18 a	0.10	0.90 ns
	Palatable 1	43.2 ± 0.39 a	43.6 ± 0.17 a	49.9 ± 0.10 a	0.15	0.86 ns
	Palatable 2	24.22 ± 0.30 a	20.15 ± 0.17 a	21.84 ± 0.27 a	0.13	0.88 ns
Plants family	Poaceae	74.7 ± 0.05 a	73.7 ± 0.06 a	62.61 ± 0.07 b	4.97	0.015 *
	Asteraceae	5.67 ± 0.20 a	4.3 ± 0.35 a	6.27 ± 0.38 a	0.50	0.62 ns
	Brassicaceae	2.21 ± 0.36 a	1.56 ± 0.35 a	3.62 ± 0.26 a	1.58	0.22 ns
	Caryophyllaceae	1.70 ± 0.26 a	1.74 ± 0.27 a	2.03 ± 0.32 a	0.10	0.90 ns
	Apiaceae	3.96 ± 0.32 a	5.05 ± 0.15 a	5.02 ± 0.23 a	0.40	0.67 ns
	Lamiaceae	1.35 ± 0.35 a	0.28 ± 0.18 b	1.08 ± 0.21 ab	2.92	0.07 ns
	Alliaceae	1.09 ± 0.29 a	0.61 ± 0.34 a	0.43 ± 0.33 a	0.72	0.49 ns
	Boraginaceae	0.83 ± 0.37	-	-	5.16	0.013 *
	Ranunculaceae	0.28 ± 0.23 a	-	0.57 ± 0.27 a	2.30	0.12 ns
	Fabaceae	2.36 ± 0.43 a	1.22 ± 0.32 a	0.12 ± 0.38 a	1.41	0.26 ns
	Geraniaceae	0.47 ± 0.18 b	0.32 ± 0.21 b	1.73 ± 0.33 a	4.69	0.018 *
	Papaveraceae	-	-	0.07 ± 0.09	1.00	0.38 ns
	Fumariaceae	0.2 ± 0.17 a	0.43 ± 0.28 a	0.25 ± 0.2 a	0.35	0.71 ns

**, * and ns = significance at 1 and 5% levels and non-significant, respectively.
The means of rows with the same letter are not significantly different ($\rho < 0.01$).

had no significant difference from *Pyrus*. Most canopy covers for the family of Geraniceae belonged to the understory of *Daphne*. Concerning the vegetation value of the family Boraginacese, the plants were present in the understory of *Amygdalus* (Table 3).

Multivariate analysis (RDA analysis)

Group response of plant species understory of three nurse plants were examined using RDA analysis. Result indicated that the canopy cover of three species significantly affected vegetation composition ($F = 1.36$ & $P = 0.03$). According to figure 2, the canopy cover of three species along two axes affected the plant species. Common species were mainly observed in the understory of *Amygdalus* and *Daphne*. Such species as *Allium ampeloparsum*, *Gagea gageoides*, *Nepeta macrosiphon*, and *Alyssum dasycarpum* were affected by the understory of *Amygdalus* on the positive side of the first axis and negative side of the second axis. Such species as *Poa bulbosa*, *Chaerophyllum macropodum*, *Cardaria draba*, and *Arenaris leptoclados* were more correlated with the understory of *Pyrus* on the negative side of the first axis and the positive side of the second axis. Also, species including *Papaver argemone*, *Valerianella oxyrrhyncha*, *Salvia syriaca*, and *Taraxacum syriacum* had more tendency towards the presence understory of *Daphne* on the negative sides of the first and second axes (figure 2).

Discussion

In arid and semi-arid areas, nurse woody species can play a considerable role in the frequency and diversity of understory species (Yazdani et al., 2020; Erfanzadeh et al., 2020). Nurse species can provide suitable environmental conditions for understory plants by decreasing temperature, evaporation, perspiration, and sunlight, maintaining soil humidity, increasing soil nutrients, organic matter, and shading by piles of leaves. Most studies conducted on the effects of bushes and shrubs on herbaceous plant composition, biological diversity, and production rate and the comparison between those understory and open spaces have demonstrated significant positive effects on the desired indices (Badano et al., 2016; Gholami et al., 2016; Bruno et al., 2003), but concerning their comparisons in terms of composition and biological diversity, less research has been done particularly in Zagros forests. This study, 81 herbaceous species were identified in open spaces and understory of woody species. Research results indicated that values of diversity and richness indices for the understory of *Daphne* and *Amygdalus* were higher than that for *Pyrus*. Therefore, the impact of canopy cover on composition and diversity does not follow a uniform pattern because of the life form and more thorns in *Amygdalus*, thick branches and leaves, and more shading in *Pyrus* as well as non-palatability and allelopathic effect of *Daphne* while maintaining humidity, reducing sunlight and protecting plants from livestock grazing have led to the increased vegetation diversity and richness as compared to the species *Pyrus*. Generally, these two species enhanced plant diversity by stabilizing the environmental conditions and supplying decomposed elements of humus (Erfanzadeh et al., 2020). *Pyrus glabra* is a tree with a height of almost $5-7$ m (Jazirehi and Ebrahimi Rostaghi, 2003), with more sexual regeneration in this region (Sadat et al., 2022). Maternal trees are present in the life form of standard trees, so their role in protecting the herbaceous plants' understory is less than *Amygdalus* and *Daphne*. However, it has lots of thorny branches and dense canopy cover. In a similar research, (Yazdani et al., 2020) compared the impact of three species, including *Daphne Mezerum*, *Amygdalus scoparia*, and *Ebenus sellata*, on the

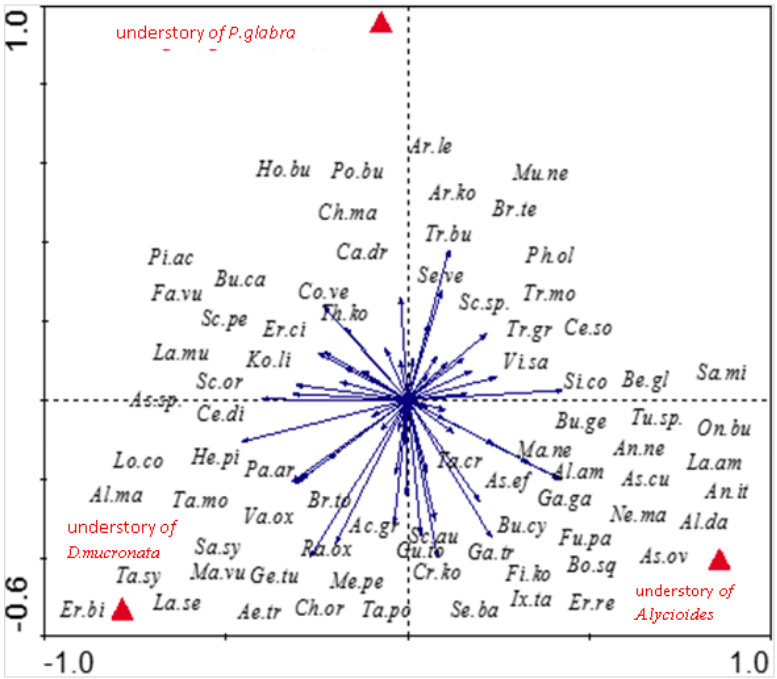

Figure 2. Biplot of RDA for relationships between group response of understory species and nurse species. The nurse plants are shown by a triangle. The full name of understory species is shown in Table 1.

production, diversity, and richness of herbaceous plants understory in the rangelands in Chenarnaz, Yazd, Iran. Their research results indicated that the species of *Daphne* and *Amygdalus*, compared to *E. sellata*, played more effective roles in increasing diversity indices. In contrast, the role of *Ebenus sellata* was more in increasing the production of understory herbaceous plants. However, in another research on the impact of canopy cover of such species, as *Pistacia atlantica*, *Acer monspessulanum* and *Craraegus azarolus* on species diversity in Nejdareh, Urmia, Iran, it has been reported that the increased tree height and consequently, the decreased shading resulted in the significant increase of understory species diversity (Khazani et al., 2022); it is contrary to other results. This difference may be due to climate, habitat conditions, nurse species type, and livestock grazing pressure in the two regions. In another study conducted by Gholami et al. (2016) on the impact of *Astragalus microcephalus* on understory vegetation indices in the protected rangelands, Tang-e-Sayad, in Chaharmahal and Bakhtiari province, Iran, it was reported that although the vegetation indices (diversity, richness, and functional groups) understory were less affected by the mechanical facilitation conditions of *Astragalus* due to balanced livestock grazing in the region, the facilitation role of this species in preserving the valuable plant species was obvious in this regard. Assessing the group response of plant species in functional groups indicated that the cover percentage understory of three nurse species was related to annual plants, annual grass, and trophies in terms of longevity, life form, and biological form, respectively. So, the highest cover percentage understory of the three mentioned species was related to annual plants such as *Taeniatherum crinitum* and *Bromus tectorum*. Also, the most cover percentage in open space was given to annual herbaceous species, including *Heteranthelium piliferum*, *Scariola orientalis*, and *Alyssum marginatum*. Generally, annual plants and trophites are resistant to destruction due to high growth speed. Meanwhile, perennial plants had less resistance to destruction because of slow growth and a long time to reach reproductive maturity (Grime, 1974).

Regarding palatability rate, an abundance of palatable class 1 (semi-palatable) species is a completely obvious understory of three species, indicating the impact of intense livestock grazing in the region. Therefore, in addition to palatable species, semi-palatable ones in open spaces were unsafe for livestock damage. In addition, based on the research results, production of palatable range species understory of trees has been reduced (Tashakori-Zadeh and Matinkhah, 2009).

Investigating the group response of vegetation understory of mentioned species and biplot diagram of RDA demonstrated that such species as *Allium ampeloparsum*, *Gagea gageoides*, *Nepeta macrosiphon* and *Alyssum dasycarpum* were present understory of *Amygdalus* and such species as *Poa bulbosa*, *Chaerophyllum macropodum*, *Cardaria draba* and *Arenaria leptoclados* were observed understory of *Pyrus*. The species, including *Papaver argemone*, *Valerianella oxyrrhyncha*, *Salvia syriaca*, and *Taraxacum syriacum*, tended to be present understory of *Daphne*. An understory of the three desired species was helpful for the above species, while the above ones do not exist or were intensely grazed. Gholami et al. (2016) pointed out that the species *Astragalus microcephalus* harmed the canopy cover of permanent species including *Scariola orientalis*, *Geranium tuberosum*, and *Cousinia calcitrapa*, and annual species such as *Alyssum limifolium*, *Eremopyrum bonaepartis* and *Ceratocephalus falcata* but for other species in the region, it acted as a good shelter and provided suitable conditions for growth, germination and revitalization. Therefore, the interaction between plants significantly affects the composition and structure of plant communities. Accordingly, the best coexistence mode between nurse plants and understory ones is established when the nurse plants have high resistance to environmental stresses, and the plants are strong competitors.

Conclusion

Comprehensive protection of forest and rangeland ecosystems requires management based on preserving and maintaining species diversity. According to the research findings, it can be mentioned that in arid and semi-arid ecosystems such as Zagros forests, under the effect of limiting environmental factors such as decrease or lack of rainfall during vegetative season, livestock overgrazing and other destruction elements, composition and diversity of herbaceous plants are considerably affected by canopy cover of trees and shrubs. Generally, woody plants (trees and shrubs) proportional to forestry structure and phenological stage have different performances in diversity and biological factors, so each woody species has more growth capacity and scope and more ability to preserve and grow plant species. Therefore, selecting the best nurse species is essential in forest revival and enrichment projects because they are more likely related to the project's success. In these regions, the most suitable nurse species are the local ones, improving environmental conditions for natural regeneration and vegetation preservation so that *Amygdalus* and *Daphne* play considerable roles in increasing diversity indices. So, it was suggested that such species as *Amygdalus* should be used as leading species in forest revival and enrichment plans in open spaces and regions without forests, and then, such species as oak, pistachio, and *Pyrus* can be planted after improving soil conditions and increasing canopy cover percentage.

Authors Contributions
All authors have contributed equally to prepare the paper.

Availability of Data and Materials
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abedi M., Arzani H. (2015) Rangeland Assessment: Vegetation Measurement. *Publication of Tehran University* (Tehran, Iran), 306. In Persian

Badano E. I., Samour-Nieva O. R., Flores J., Flores-Flores J. L., Flores-Cano J. A., Rodas-Ortiz J. P. (2016) Facilitation by nurse plants contributes to vegetation recovery in human-disturbed desert ecosystems. *Journal of plant ecology* 9 (5): 485–497.

Bruno J. F., Stachowicz J. J., Bertness M. D. (2003) Inclusion of facilitation into ecological theory. *Trends in ecology and evolution* 18 (3): 119–125.

Callaway R. M., Brooker R. W., Choler P., Kikvidze Z., Lortie C. J., Michalet R., Armas C. (2002) Positive interactions among alpine plants increase with stress. *Nature* 417 (6891): 844–848.

Cavieres L., Arroyo M. T., Penaloza A., Molina-Montenegro M., Torres C. (2002) Nurse effect of Bolax gummifera cushion plants in the alpine vegetation of the Chilean Patagonian Andes. *Journal of Vegetation Science* 13 (4): 547–554.

Erfanzadeh R., Hazhir Sh., Jafari M. (2020) Effect of cushion plants on the soil seed bank in overgrazed semiarid regions. *Land Degradation and Development* 31 (8): 990–1000.

Foronda A., Pueyo Y., Castillejo J. M., Luz Giner M. de la, Alados C. L. (2020) Substrate-specialist plants for restoring vegetation in post-mining gypsum substrates. *Catena* 186:104308.

Gholami P., Shirmardi H. A., Amuzgar L. (2016) The effect of mechanical facilitation of Astragalus microcephalus Willd. species on vegetation indicators in semi-steppe grasslands of Central Zagros. *Journal of Plant Ecosystem Conservation* 4 (8): 77–87. In Persian

GomezAparicio L., Valladares F., Zamora R., Luis Quero J. (2005) Response of tree seedlings to the abiotic heterogeneity generated by nurse shrubs: an experimental approach at different scales. *Ecography* 28 (6): 757–768.

Grime J. P. (1974) Vegetation classification by reference to strategies *Nature* 250 (5461): 26–31.

Hamilton A. J. (2005) Species Diversity or Biodiversity. *Journal of Environmental Management* 75:89–92.

Jazirehi M. H., Ebrahimi Rostaghi M. (2003) Silviculture in Zagros. *University of Tehran Press* (Tehran, Iran), 560. In Persian

Khazani M. A., Alijanpour A., Motamedi J., Sheidai Karkaj E. (2022) The effect of forest canopy on the diversity of understory vegetation (Case study: Nejadreh Reservoir, Urmia, West Azerbaijan). *Journal of Plant Research (Iranian Journal of Biology)* 35 (2): 418–433. In Persian

Kumar P., Chen H. Y., Searle E. B., Shahi C. (2018) Dynamics of understory biomass, production and turnover associated with long-term over story succession in boreal forest of Canada. *Forest Ecology and Management* 427:152–161.

MadrigalGonzalez J., Cano-Barbacil C., Kigel J., Ferrandis P., Luzuriaga A. L. (2020) Nurse plants promote taxonomic and functional diversity in an arid Mediterranean annual plant community. *Journal of Vegetation Science* 31 (4): 658–666.

Padilla F. M., Pugnaire F. I. (2006) The role of nurse plants in the restoration of degraded environments. *Frontiers in Ecology and Environment* 4 (4): 196–202.

Ren H., Yang L., Liu N. (2008) Nurse plant theory and its application in ecological restoration in lower subtropics of China. *Progress in Natural Science* 18 (2): 137–142.

Sabeti H. (2006) Forests, Trees and Shrubs of Iran. *Pub. Ministry of Agriculture and Natural Resources* (Tehran, Iran), 874. In Persian

Sadat M. A., Alvaninezhad S., Salehi A., Askari Y., Gholami P. (2022) The importance of nurse species in establishing natural regeneration in forests of South Zagros (Vezg forest, Yasouj). *Journal of Forest Research and Development* 8 (1): 27–41. In Persian

Tashakori-Zadeh M., Matinkhah S. H. (2009) Investigation on the effects of crown canopy of trees on pasture yield and quality of understory vegetation in central Zagros. *Iranian Journal of Forest* 1 (4): 321–331. In Persian

Vandenberghe C., Smit C., Pohl M., Buttler A., Frelechoux F. (2009) Does the strength of facilitation by nurse shrubs depend on the grazing resistance of tree saplings? *Basic and Applied Ecology* 10 (5): 427–436.

Yazdani M., Erfanzadeh R., Mosleh Arani A. (2020) Comparison of the effect of three wood species *Daphne mezerum*, *Amygdalus scopaia* and *Ebenus stellata* on the production, diversity and richness of the understory herbaceous plants. *Journal of Range and Watershed Management* 73 (3): 663–673. In Persian