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Ecological Parameters Affecting the Distribution of *Vaccinium arctostaphylos* L. in Ecotone Rangelands of Namin County, Iran

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ABSTRACT

Aim: This study aimed to investigate the ecological factors affecting the distribution of the rare, endangered, and medicinal species of *Vaccinium arctostaphylos* L. in ecotone rangelands of Namin County in 2019.

Materials & Methods: Sampling was performed from the presence and absence locations of *V. arctostaphylos* in eight habitats. Soil samples were taken from 0-30 cm depth, and physiographic variables were recorded. Moreover, a digital elevation model, slope, and aspect map were derived. Rainfall and temperature gradient maps were derived using gradient equations, and the values for sampling points were extracted. Data analysis was performed by independent t-test and discriminant analysis test.

Findings: Results showed the Stream Power Index (SPI) ($p<0.05$), pH, EC, lime, soluble sodium, organic carbon, soil texture, and species density ($p<0.01$) are significantly different between the presence and absence of the species. Results of the discriminant analysis showed that the three functions explained 86.4, 10.7, and 2.8% of the total data variance, respectively. Generally, 19 variables including elevation, slope, aspect, precipitation, Topographic Wetness Index (TWI), plan curvature index (PC), SPI, pH, EC, lime, phosphorus, soluble potassium, soluble sodium, magnesium, organic carbon, bicarbonate solution, saturation percentage (SP), sand percentage and species density were identified as the essential factors affecting the distribution of *V. arctostaphylos*. SP was the most crucial factor in the presence and absence of species.

Conclusion: Generally, by identifying the most influential ecological factors on the distribution of *V. arctostaphylos*, practical steps have been taken to improve the habitat of the rare species.

Keywords: Discriminant analysis, Environmental factors, Ardabil province, Soil characteristics, Endangered species.

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Introduction

Environmental factors always affect plant species, and the combination of these elements affects any species at every stage of growth and development. In order to correctly understand the environmental factors affecting the establishment of species and manage, exploit, improve, restore, and prevent the extinction of essential plants in rangelands, it is necessary to identify and determine the ecological factors affecting plant species distribution. Plant growth in natural habitats results from various biological factors such as elevation, climate, and soil [1]. The relationships between environmental factors and vegetation are very complex, and in order to achieve proper rangeland management, these complex relationships must be studied with skill and accuracy [2]. Environmental factors influence habitat characteristics and have a significant role in plant distribution patterns. Therefore, analyzing the relationship between environmental factors and vegetation is a fundamental issue in ecology [3]. The importance of determining a set of variables that influence plant distribution may be observed in their impact on species biology and adaptation to growth-limiting conditions [4,5]. Predicting potential habitats and identifying factors affecting the distribution of native plants is a good way to protect biodiversity and restore rangeland ecosystems [6, 7]. Many studies have been performed in various regions of the world, including Iran, to investigate the relationship between environmental factors and the distribution of plant species. For example, Samadi et al. [8], in a study of influential ecological factors on *Leucanthemum vulgare* Lam. distribution in Ardabil Province rangelands, concluded that the most critical factors in the distribution of *L. vulgare* are a total of 15 components (slope, aspect, precipitation, temperature, pH, EC, calcium, potassium, soluble potassium, soluble sodium phosphorus, lime, organic carbon, silt percentage, and soil volumetric moisture). In addition, Asaadi and Khoshnod Yazdi [9] noted *that Hymenocrater calycinus* Boiss is compatible with a semi-arid climate and is distributed at an elevation of 1400-2500 meters above sea level (masl). Ghorbani and Molaei [10] at the southeastern rangelands of Sabalan, concluded that the distribution of *Artemisia* species is more affected by aspect, temperature, pH, particulate organic carbon, organic carbon, silt, sand, phosphorus, slope, litter, total canopy, bare soil, stone and gravel, elevation, EC. Elbalola et al. [11] in wetlands of Central Sudan related that soil parameters such as sodium, nitrogen, clay, water holding capacity, EC, organic carbon, organic carbon, and silt are all positively associated with vegetation properties. Moreover, pH, calcium, and sand are negatively associated with vegetation features.

Namin rangelands are among Iran's most important rangelands in terms of environmental factors such as high-quality forage plants, genetic and economic resources, forage production, and livestock and apiculture [8]. *Vaccinium arctostaphylos* L. from the Ericaceae family commonly grows in the understory of Fagus trees in the forests of the north of Iran, and the ecotone of these forests and grasslands is one of the rare and valuable medicinal plants. Due to its effective therapeutic effects, such as decreasing blood sugar and blood pressure and its antioxidant properties, this species has long been recommended and consumed in the form of infused fruits and leaves in Iranian medicine. Moreover, *V. arctostaphylos* has several adverse effects and risks in addition to its many health advantages. It has a lot of oxalates. Thus, it is not suitable for folks who have kidney stones. It is a shrub plant or semi-shrub up to 3 m tall [12,13]. In Iran, there is only one species of *Vaccinium*, which grows mainly in the Guilan Province's elevations (ecotone habitats of forests and grass-

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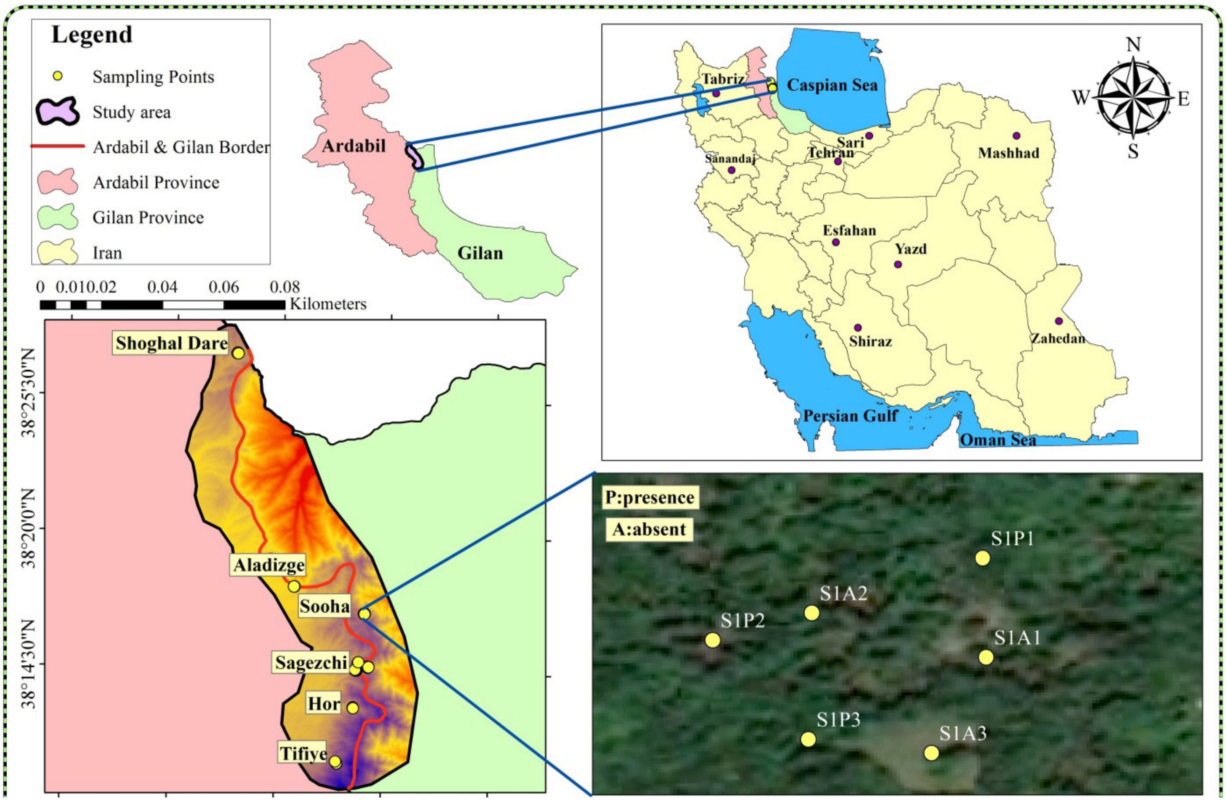

Figure 1) Location of the study area in Namin region, Ardabil province of Iran (S1P1: Site1 and presence point 1; S1A1: Site 1 and absent point 1 and … .)

lands between Ardabil and Guilan), and is endangered due to its inability to reproduce in nature through seeds. *V. arctostaphylos* are found in most forested areas of Anatolia, the Caucasus, Siberia, North America, and especially Europe [14-16].

As a result of the research gap and lack of knowledge about the ecological factors affecting the distribution of this rare and endangered species, this study aimed to determine environmental variables affecting the distribution of *V. arctostaphylos* such as soil, climate factors, and topography in the Namin region. Understanding the environmental components that influence plant distribution can aid familiarity with native species adaption, preference orientation, and application in rangeland improvement projects.

Materials & Methods

Study area

The study area is located in the geographical coordinates of 38°10′30″N to 48°34′00″E and 38°27′30″N to 48°42′00″E in the Namin region of Ardabil Province (Figure 1). The mean rainfall of the region using data from the nearest station (Namin, at an elevation of 1345 masl) is 378 mm, and the average temperature is 8.9°C [17,18]. Different geographic characteristics, considerable elevation differences, and closeness to the Caspian Sea have created optimal growth conditions for various species and the establishment of several plant communities in this ecotone area [18]. The climate of this region is influenced by the climate of the Caspian Sea and the mountainous wall of the western Alborz, as well as humid air entering the region.

Sampling Method

To conduct the present study using land use map and several stages of initial field visits to wooded rangelands and grasslands of elevations between Ardabil and Guilan Province, where the medicinal species of *V. arctostaphylos* (Figure 2) is distributed, and eight habitats were selected based on the diverse topography of the area and the purpose of the study. Because this is rare, finding it in the area was challenging; therefore, the species' location in each habitat was determined first, and then longitude and latitude data and physiographic factors were recorded using GPS. Then, from a depth of 0-30 cm (active rooting depth), 40 soil samples were taken from the presence and absence areas of species [1]. Then, in the University of Mohaghegh Ardabili's soil science laboratory, some physical and chemical properties of soil including pH, EC, texture, lime, soluble potassium, magnesium, saturation percentage of soil (SP%), soluble sodium, organic carbon, absorbable phosphorus, soluble bicarbonate, total neutralizing value (TNV) and the percentage of clay, silt, and sand were measured using physical and chemical analysis methods [19].

Figure 2) Pictures of *V. arctostaphylos* in the study area.

A DEM map with 20×20 pixel dimensions was created using 1:25000 maps and $\text{ArcGIS}_{ver.10.8}$ software, and it was used to create maps of elevation, slope, geographical directions, and topographic indices, including Topographic Wetness Index or Compound Topographic Index (TWI or CTI) (Eq. 1), Stream Power Index (SPI) (Eq. 2), and land plan curvature index (PC) [20-22]. The plan curvature tool in $\text{ArcGIS}_{ver.10.8}$ software was used to create these indices, and the numerical value of these maps was extracted.

In the next step, using Eq. (3), the aspect data were quantified [23]. Then, using the Eq. of rainfall gradient and temperature of the region, rainfall and temperature maps were prepared using $\text{ArcGIS}_{ver.10.8}$ software. The rainfall map was extracted and controlled using Eq. (4) and the temperature map using Eqs. (5) and (6); based on the DEM and 25-year rainfall calibration relationship in the Namin region for sampling sites.

$$\text{CTI or TWI} = \ln(\alpha/\tan\beta) \quad \text{Eq. (1)}$$

$$\text{SPI} = As \times \tan(b) \quad \text{Eq. (2)}$$

$$A' = \cos(45-A) + 1 \quad \text{Eq. (3)}$$

$$P = 0.1908H + 79.95 \quad \text{Eq. (4)}$$

$$T_{max} = 23.0428 - 0.0051286H \quad \text{Eq. (5)}$$

$$T_{mean} = -4.36532 + 0.917135Tmax \quad \text{Eq. (6)}$$

where α was the amount of accumulation of upstream flow, β was the slope angle, As was the target region's area, b was the slope's degree, A' was the converted value of aspect, A was the azimuth value of aspect, P was the rainfall, H was the elevation, T_{max} was the maximum temperature, and T_{mean} was the mean temperature.

The mean of the examined characteristics in these two groups of sites was compared using data collected from all locations (presence and absence of species) and an independent t-test. Discriminant Analysis (DA) was used to determine the degree of importance of the measured variables (physiographic, climate, and soil variables). A discriminant function is constructed by creating a function from a collection of functions for a K group, where the number of K-1 groups or independent variables is smaller each time. The first function gives the best linear composition for predicting group membership [24-26]. Then, the collinearity of the between variables was investigated.

The presence and absence of *V. arctostaphylos*

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were used as dependent variables, with soil, climatic, and topographic parameters used as independent variables in the analysis. The stepwise method was used to identify the entry of variables into the model while doing this analysis. Simultaneously, the F test was used to choose the best discriminant variables, which resulted in significant differences. Wilks Lambda's statistic was used to test the discriminant function's efficiency in creating significant differences between groups, the significance of which was determined using the Chi-square statistic [27]. After examining the assumptions of DA, the main variables of the model were chosen based on the standard discriminant coefficients. $SPSS_{Ver.26}$ software was used to perform analysis.

Findings

Table (1) shows the results of a t-test comparing the presence of *V. arctostaphylos* to the absence of this species in terms of ecological parameters. The variables of SPI at the 5% level and pH, EC, lime, soluble sodium, organic carbon, soil texture, and species density at the 1% level were significantly different in the presence and absence locations of species. The distribution rate of the studied species is directly affected by decreasing SPI, pH, EC, lime, organic carbon, soil texture and density, and increasing dissolved sodium.

According to the discriminant analysis results, functions 1, 2, and 3 explained 86.4, 10.7, and 2.8% of the variance of the whole data, respectively (Table 2). The eigenvalue and canonical correlation coefficient of the first function are higher than those of the other functions, indicating that this function is a better discriminant function and can identify groups well.

The Wilks Lambda values for the audit functions are shown in table (3). The value of this index increases from the first to the third function. The closer this index gets to zero, the more appropriate the estimation function is in separating the groups. Therefore, since the value of Wilks Lambda in function one is closer to zero, this function has a better estimate in the separation of groups. According to the results of the Chi-square test, the value of the Wilks Lambda statistic is significant ($p<0.01$), indicating a difference between the mean of the presence and absence groups.

In each of these three functions, the studied parameters had different coefficients. Using these coefficients, the influential factors in the grouping of the studied areas and the distribution of *V. arctostaphylos* can be determined (Table 4). Accordingly, primarily soluble potassium, pH, phosphorus, magnesium, organic carbon, lime, slope, soluble sodium, soil texture, elevation, TWI, temperature, and rainfall; in the second priority, species density, silt percentage, sand, and soluble bicarbonate percentage and in the third priority, PC, aspect, EC, SPI, and clay percentage, were effective in differentiating locations and distribution species, respectively.

The classification results of the studied sites by discriminant analysis method are shown in Table (5). The percentages in this table demonstrate how well the observed and estimated items match. When each location's information is incorporated in the discriminant function, the function correctly detects membership to the same site in 100% of cases. The function accurately recognizes membership in 100% of cases where information on the presence and absence of *V. arctostaphylos* is included. In general, all of the prominent grouped cases (100%) have been correctly categorized.

To distinguish the presence or absence of the studied species, 19 factors including elevation, slope, aspect, precipitation, TWI, PC, SPI, pH, EC, lime, phosphorus, soluble potassium, soluble sodium, magnesium, organic carbon, soluble bicarbonate, soil

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Table 1) Comparison of the studied parameters at locations with the presence and absence of *V. arctostaphylos* with t-test.

Variables	Presence locations Mean ± SD	Absence locations Mean ± SD	t
Elevation (m)	104.031692.95±	107.381698.8±	0.17^{ns}
Slope (%)	7.3624.06±	7.0222.65±	-0.62^{ns}
Aspect	0.690.65±	0.660.37±	-0.13^{ns}
Precipitation (mm)	20.53403.54±	20.82404.06±	0.08^{ns}
Temperature (˚C)	0.519.21±	0.519.20±	-0.08^{ns}
TWI	1.355.55±	1.335.46±	-0.21^{ns}
PC	1.770.12±	1.270.61±	0.99^{ns}
SPI	4140.831609.63±	743.22388.41±	-1.30*
pH	0.56.16±	0.095.39±	-6.77**
EC (ds.m^{-1})	0.20.63±	0.060.43±	-4.20**
Lime (%)	1.486.02±	0.464.82±	-3.46**
Mg (ppm)	12.838.09±	8.9121.60±	-4.73^{ns}
K (mg.kg^{-1})	98.15642.08±	74.73383.91±	-9.36^{ns}
Na (ppm)	7.4139.51±	3.4242.68±	1.74**
P (mg.kg^{-1})	2.3611.27±	1.597.07±	-6.59^{ns}
OC (%)	5.138.68±	1.063.18±	-4.69**
HCo_3^- (meq.l^{-1})	3.5513.72±	2.6111.52±	-2.23^{ns}
SP (%)	3.7312.77±	2.8312.46±	-1.63**
Clay (%)	2.588.64±	5.7310.27±	1.16^{ns}
Silt (%)	7.3727.23±	7.3632.30±	2.17^{ns}
Sand (%)	8.4364.12±	10.7757.43±	-2.19^{ns}
The density of *V. arctostaphylos* (No. ha^{-1})	18.3715.95±	0.000.00±	-3.88**

Note: **: p<0.01; *: p<0.05; ^{ns}: indicates lack of significant difference.

texture, sand percentage, and species density were identified as the important factors. According to the findings, functions 1, 2, and 3 can predict 86.40, 97.20, and 100% of the independent variables, respectively, with canonical correlation values of 0.697, 0.884, and 0.985 and distinguish between the presence and absence of the *V. arctostaphylos* species (Eqs. 7, 8 and 9). The findings of discriminant analysis models revealed that the saturation percentage of soil (SP) was the most important factor in the presence and absence of V. arctostaphylos species in all equations.

Discussion

Results of comparison of selected ecological factors using independent t-test showed that SPI (p<0.05) and variables of pH, EC, lime, soluble sodium, organic carbon, soil texture, and species density (p<0.01) all had significant differences in presence and absence locations of *V. arctostaphylos*. Moreover, the SPI, pH, EC, lime, organic carbon, soil texture, and density had the opposite effect, and dissolved sodium directly affected the distribution of the species. Because there are no comparable references for the factors affecting the distribution of *V. arctostaphylos*, similar environmental factors impacting the

Table 2) Results of discriminant analysis (DA) for environmental factors of *V. arctostaphylos.*

Function	Eigenvalue	Percent of Variance	Cumulative Percent	Canonical Correlation (R^2)
1	28.801[a]	86.40	86.40	0.983
2	3.583[a]	10.70	97.20	0.884
3	0.943[a]	2.80	100	0.697

The first three canonical discriminant functions were used in the analysis.

Table 3) Wilks Lambda values of audit functions obtained from *V. arctostaphylos* species discriminant analysis.

Test of Function(s)	Wilks Lambda	Chi-square	df	Sig.
1 toward 2	0.004	153.475	57	0.000
2 toward 3	0.112	60.125	36	0.007
3	0.515	18.263	17	0.372

Table 4) Discriminant coefficients of the measured variables in the studied areas obtained from the Discriminant Analysis.

Variables	Function		
	1	2	3
K (mg.kg^{-1})	**-0.282***	-0.076	-0.046
pH	**-0.205***	-0.021	-0.007
P (mg.kg^{-1})	**-0.200***	-0.059	-0.129
Mg (ppm)	**-0.142***	-0.052	0.066
OC (%)	**-0.142***	-0.025	0.000
Lime (%)	**-0.105***	-0.030	0.104
Slope (%)	**0.069***	-0.041	-0.046
Na (ppm)	**0.052***	0.010	0.032
SP (%)	**-0.049***	-0.020	0.019
Elevation (m)	**0.036***	0.026	0.005
TWI	**-0.031***	-0.021	-0.022
Temperature [b] (°C)	**-0.015***	-0.008	-0.010
Precipitation (mm)	**0.015***	0.008	0.010
The density of *V. arctostaphylos* (No. ha^{-1})	0.099	**-0.437***	-0.194
Silt [b] (%)	0.064	**0.113***	0.066
Sand (%)	-0.065	**-0.091***	-0.023
HCo_3^- (meq.l^{-1})	-0.066	**-0.074***	0.044
PC	0.010	0.004	**-0.231***
Aspect	0.028	0.103	**-0.228***
EC (ds.m^{-1})	-0.127	-0.058	**0.149***
SPI	-0.040	0.005	**-0.108***
Clay [b] (%)	0.034	0.013	**-0.059***

*. Most considerable absolute correlation between each variable and any discriminant function
b. This variable not used in the analysis.

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Y (Function 1)= 1.795- Elevation + 0.538 Slope + 1.36 Precipitation + 0.138 TWI –1.992 pH + 3.615 TNV – 1.486 P + 0.93 K + 3.275 Na + 0.924 Mg – 2.868 OC + 6.341 SP (R^2:0.697)	Eq. (7)
Y (Function 2)= 0.065- Elevation – 0.611 Slope + 0.186 Precipitation – 0.617 TWI –10.114 pH + 4.612 TNV – 5.686 P + 12.594 K + 2.131 Na + 2.639 Mg – 2.337 OC + 2.243 HCO_3^- + 17.052 SP – 8.17 Sand – 1.424 Density (R^2:0.884)	Eq. (8)
Y (Function 3)= 1.111- Elevation + 0.186 Slope - 0.351 Aspect + 2.593 Precipitation + 0.032 TWI – 0.375 PC – 0.484 SPI –5.045 pH + 4.310 EC -0.557 TNV – 0.335 P + 1.534 K - 0.391 Na + 2.874 Mg – 0.848 OC - 3.767 HCO_3^- + 5.041 SP – 1.950 Sand - 0.128 Density (R^2:0.985)	Eq. (9)

Table 5) Classification results with the discriminant analysis method for *V. arctostaphylos*.

Groups			Predicted group membership		Total
			Presence of V. arctostaphylos	**Absence of V. arctostaphylos**	
Original	Value	Presence of *V. arctostaphylos*	20	0	40
		Absence of *V. arctostaphylos*	0	20	
	%	Presence of *V. arctostaphylos*	100	0	100
		Absence of *V. arctostaphylos*	0	100	

distribution of different species were used to compare the current study with previous studies. According to the results of Mosayebi et al. [28] on the ecological factors affecting the distribution of *Agropyron libanoticum* Hack. The variables of elevation, rainfall, and temperature ($p<0.01$) and stone and gravel and organic carbon ($p<0.05$) were significantly different. According to the results of Samadi et al. [8] also found that the variables of aspect, EC, magnesium, soluble sodium, phosphorus, lime, volumetric soil moisture ($p<0.01$), and the factors of potassium and particulate organic carbon ($p<0.05$) had significant differences between the locations of presence and absence of *Leucanthemum vulgare*.

To determine the factors affecting the presence and absence of the *V. arctostaphylos* using discriminant analysis, 19 factors were identified as the important factors. Accordingly, primarily soluble potassium, pH, phosphorus, magnesium, particulate organic carbon, lime, slope, soluble sodium, soil texture, elevation, TWI, temperature, and rainfall; in the second priority, species density, silt percentage, sand, and soluble bicarbonate percentage and in the third priority, PC, aspect, EC, SPI, and clay percentage, were influential in differentiating locations and spreading species. Based on the results of discriminant analysis, three models were extracted to investigate the factors affecting the distribution of *V. arctostaphylos* species. In the first model, 12 factors (R^2:0.697), in the second model, 15 factors (R^2:0.884), and in the third model, 19 factors (R^2:0.985) were identified. In addition, function three was identified as the best separator of presence and absence of *V. arctostaphylos*. The findings of discriminant analysis models revealed that the saturation percentage of soil (SP) was the most crucial factor in the presence and absence of *V. arctostaphylos* species in all equations. This shows that *V. arctostaphylos* is highly dependent on soil moisture. This

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has caused it to grow understory trees. Ghorbani et al. [29] stated that the variables of EC, litter, rainfall, temperature, elevation and soil properties such as potassium, silt, and bare soil were the most critical factors in the distribution of *Dactylis glomerata* and *Thymus kotschyanus*. In addition, Mosayebi et al. [28] showed that rainfall, elevation, temperature, slope, loam percent, aspect, stone and gravel, phosphorus, clay, soil depth, total canopy cover, organic carbon, and sand were the most important affecting the distribution of *Agropyron libanoticum* in Alborz Province. The current study results showed that elevation parameters and related factors such as rainfall and temperature are the most important determinants in *V. arctostaphylos* distribution. Rainfall and temperature are the two most important climate characteristics in each region, and both are affected by elevation. Elevation has a direct relationship with rainfall and an inverse relationship with temperature. According to the current study results, the maximum presence of *V. arctostaphylos* can be found at elevations of 1500 to 1900 meters, at temperatures of 7-10 °C, and with precipitation ranging from 350 to 450 mm. This is consistent with Fathi et al. [13] found that this species grows best in the shade and low light and that it is distributed in the elevation range of 1300-1800 meters, with an average annual temperature of 8-16 °C, rainfall of 200-300 mm, loamy soil, and an acidic pH. Ghorbani et al. [30] found comparable results in studying the distribution of *Thymus kotschyanus*. According to Mohtashamnia [31], elevation is an essential factor in the distribution of *Artemisia aucheri*. In addition, the effect of elevation on vegetation has been emphasized in studies conducted by many researchers [31-33]. Rainfall and temperature are critical climatic variables influenced by elevation and affect soil moisture, the start of the growing season, the length of the growing season, and the vegetation type. Also, according to the results of DA, the percentage of the slope is an influential factor in the differentiation of places of the presence and absence and the distribution of *V. arctostaphylos* species. The slope is one of the most important factors of topographical and its changes during a gradient can affect the type of vegetation cover [34, 35]. Due to high water flow, the soil dries up quickly on steep slopes, and severe soil erosion inhibits plant growth. Ghorbani et al. [1] consider slope as one of the factors influencing changes in canopy cover percentage and density of *Artemisia fragrans* Willd. and *Artemisia austriaca* Jacq.

Moreover, the present study results showed that among soil properties, potassium, pH, phosphorus, magnesium, organic carbon, lime, sodium, and soil texture are the most important factors affecting the distribution of *V. arctostaphylos*. Exchangeable potassium has been effective in the distribution of *V. arctostaphylos*. It plays an active role in regulating photosynthesis, carbohydrate transport, protein synthesis, facilitating soil nutrients transfer, and is considered a soil fertilizer. Potassium in the soil also aids water absorption and increases drought and frost resistance in plants [36]. Darvishi et al. [37] also reported that the amount of potassium salts played a significant role in the distribution of *Astragalus gossypinus*. After nitrogen, phosphorus is the most important nutrient in plant nutrition, and it is essential for reproductive growth. In plants, phosphorus is required for photosynthesis, protein metabolism, respiration, and enzyme synthesis [6,32]. Magnesium and potassium are more easily absorbed in the soil and have a higher transfer coefficient. Magnesium is a vital and required element in plant biological responses [38]. In their experiments, Asaadi and Khoshnod Yazdi and Samadi et al. [9,8] used discriminant analysis to demonstrate

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the effects of potassium, phosphorus, magnesium, and sodium variables on plants distribution.

There was a significant difference in pH and EC between locations with and without *V. arctostaphylos*, indicating that the species prefers acidic soils with low salinity. Ghorbani et al. [1] found that pH and EC of soil affect the distribution of *Artemisia fragrans* Willd. and *Artemisia austriaca* Jacq. Moreover, Jafari et al. [38] reported that EC, pH, organic carbon, potassium, phosphorus, percentage of sand and silt, soil gravel and slope, aspect, elevation, rainfall, and temperature were impacted on the presence and absence of *Ferula gummosa* (Boiss.). *V. arctostaphylos* is more widespread on the soil, with 4.82 to 6.02% lime. Having adequate lime in the soil helps create a good soil structure; but, if the soil lime level rises too high, it creates a hard layer in the soil and raises the pH, providing unfavorable conditions for the plant to absorb some elements [39, 40]. Gavili Kilaneh and Vahabi [41] introduce the percentage of soil lime as one of the factors affecting the distribution of plant species in the studied region. The presence of substances that hinder seed germination in the fruit is the leading cause of this species' decline and rarity [15]. Plant species were classified into four categories proposed by IUCN as exposed, extinction species, low risk, vulnerable, and lacking data [42].

Conclusion

Results showed 19 variables including elevation, slope, aspect, precipitation, Topographic Wetness Index (TWI), land plan curvature index (PC), SPI, pH, EC, lime, phosphorus, soluble potassium, soluble sodium, magnesium, organic carbon, bicarbonate solution, sand percentage, and species density were identified as the important factors affecting the distribution of *V. Arctostaphylos*. The discriminant variables entered into the functions were of all the studied factors, namely topography, climate, and soil, indicating that these factors were chosen correctly. According to the findings of this study, by identifying the habitat of *V. arctostaphylos* and the impacts of environmental factors on species distribution, practical steps have been taken to improve and restore the habitat of *V. arctostaphylos* and areas with similar conditions. In particular, the findings of this study can be used in the Namin rangelands, which between Ardabil and Gilan Province, for management objectives to conserve this medicinal and rare plant. These can be very useful in rangeland regeneration projects for recommending species compatible with various ecological conditions. These can also be used to determine the areas with the potential to emerge the rare, endangered, and medicinal species *V. arctostaphylos*. Future research should focus on mapping the habitats of *V. arctostaphylos* and distribution patterns concerning climate change.

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