EFFECT OF ASPECTS, ELEVATION, AND SLOPE GRADIENT ON ZAWITA FOREST UNDERSTORY VEGETATION COMPOSITION

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ABSTRACT:

Vegetation diversity patterns are necessary to identify species of plants in the Zawita mountains area, Duhok Governorate, Iraq, to investigate the influence of topographical elements (aspects - north and south, elevations and slope gradients) on diagnosis, density, frequency, and species richness and diversity of species in the Zawita forest understory vegetation. Sampling vegetation was surveyed at (1 * 1 m^{-2}), for 8 quadrats per each zigzag transect. The data were designed with a strip-strip block design, with four replicates for each transect. The results revealed significant differences in frequency, density, and Shannon index due to aspects, elevations, and slope gradient. While other measured traits, species richness, and Simpson index were not affected significantly. The highest density was recorded for the north-facing aspect at high altitude while the Shannon index diversity has existed in the south aspect at low elevation and low slope gradient.

Keywords: aspects, elevations, slope angle, botanical vegetation, diversity.

تاثير الواجهات، الارتفاعات ودرجة ميل الارض على تركيب الغطاء النباتي في غابات زاويته

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المستخلص:

أجريت الدراسة في منطقة جبل زاويته بمحافظة دهوك ، إقليم كردستان العراق ، للتحقق من أنماط التنوع النباتي الضروري للتعرف على أنواع النباتات في هذه المنطقة ، حيث تأثرت بالعناصر الطبوغرافية (الواجهات – الشمال والجنوب ، والارتفاعات عن مستوى سطح البحر, masl ودرجة ميل الارض) على كثافة وتكرار الافراد النبات وغزارة الانواع مع دراسة صفات التنوع الحيوي للانواع الموجودة تحت غطاء غابات زاويته. مسحت عينات الغطاء النباتي ب (1*1 م^{2})، وذلك باخذ ثمانية مربعات خشبية لكل صفة بطريقة متعرجة. صممت التجربة بتصميم الشرائط المنشقة للقطاعات الكاملة مع اخذ اربع مكررات لكل معاملة. اظهرت النتائج بان هناك اختلافات في التكرار والكثافة مع دليل شانيون لكل من الواجهات والارتفاعات ودرجة الميل بينما قياسات لكل من وفرة الانواع و دليل سمبسون لم تختلف معنويا مع العوامل المدروسة. اذ ان اعلى كثافة للنباتات سجلت في الواجهات الشماليةمع الارتفاعات العالية بينما التنوع الحيوي لدليل شانيون سجلت في الواجهات الجنوبية مع الارتفاعات المنخفضة وكذلك درجة الميل.

الكلمات المفتاحية: الواجهات، الارتفاعات، درجة الميل، الغطاء النباتي، التنوع النباتي.

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INTRODUCTION

The study of the natural plant density, its distribution and the changes that occur in mountains and nature reserves due to various biotic or abiotic factors has long been a topic of interest to specialists. The botanical diversity and distribution in a mountain are also affected by the elevation scales (48). In study by (42) at Zawita area observed (28 families, 77 genera and 86 species) of vegetation cover. In some countries, south-facing slopes receive much more solar radiation than north-facing slopes (24). (7) surveyed seven samples of forest plots in New South Wales, Australia, found significant differences in canopy height as a function of aspect. Quantifying the characteristics of forests on different slope aspects on a regional or national scale can provide a scientific basis for assessing the vegetation pattern and determining management options for vegetated forests in mountainous regions (6, 44). Ecological choices are used to describe the distribution patterns of species as well as species richness. Changes in species distribution along the aspects and elevations have been known to result in the emergence of new geographic mountains (11). Recent analyses of forest inventory data from north-facing slopes support a higher tree growing stocks, variety and a vertical distribution of vegetation cover than on other facing slopes (57). (9) also showed that south-facing slopes have vegetation that is more resistant to stress or drought, while northern slopes usually consist of vulnerable vegetation species that are more susceptible to drought. Altitude is associated with a wide range of factors that influence plant establishment, including precipitation, climate change, and soil properties (16). However, both aspects and altitudes alone cannot demonstrate that all causal biological factors are a proxy for microclimate variables such as temperature, water availability, and wind direction (18). Change along elevation, slope gradation, topography, and geographic elements such as aspects and slope degree play a role in the distribution of plant species in a natural ecosystem (35). In the Kurdistan Region of Iraq, Duhok Governorate, Zawita mountain is a natural reserve area that contains a high biodiversity of endemic plants and wild animals (17). Recent studies by (27); included in the floral composition and species abundance of vegetation carried out in different locations of the mountains of the Kurdistan Region, and their results indicated that the highest vegetation of species richness was recorded in the northern aspect of the high elevations. The present work aims to survey the diversity of plant species as it is affected by topographical variables such as aspects, elevation and slope level, and to search for answers to the following questions:

1. To what extent do the number of plants and the division of their diversity depend on topographic indicators?
2. What is the topographical element that contributes to the index of species richness and diversity at Zawita Mountain?

MATERIALS AND METHODS

Survey Site: The study was conducted at Zawita mountain (36°54’27.72” N, 43°09’49.05” E) (composite SZA image 36 – 43; 14-11-2016; DEM N36 E42, N36 E43 (USGS Global. Gov.), which is located at the North-East of Duhok city, from different altitude, it was measured according to the GPS (Global Positioning System (eTrex Vista TM) GARMIN Ltd. 2001-2002 (Figure 1). This area recorded under management of the Forestry Directorate for Zawita center. The mountain is of low population density. The botanical plants of the Zawita area contain a diversity of trees, shrubs, and herbaceous (17). The climatological elements on Zawita location are continental type. Minimum temperature from winter to summer through study is (1.4 – 20.8 ˚C) and maximum from (7.9 – 39.8 ˚C) respectively, and rainfall was (1000 mm), with a dry season from Jun to September and wet rainfall season from November to April (Agriculture Directorate for Duhok District Center at Zawita, 2021).

Fig 1. The selected topographic site of the study area at Zawita mountain (Pin pointer).

Vegetation sampling and Data collection:

The study was conducted by selecting two aspects included south and north-facing. Within each aspect, three elevation gradients were marked by GPS (Global Positioning System (eTrex Vista TM) GARMIN Ltd. 2001-2002, and within each elevation two slopes % were selected (10% and 20%), for each elevation gradient (Figure 2), according to engineering land surveying (4).

$$\boldsymbol{Slope}\ \% = \frac{\boldsymbol{Rise}}{\boldsymbol{Horizontal\ distance}} \times 100$$

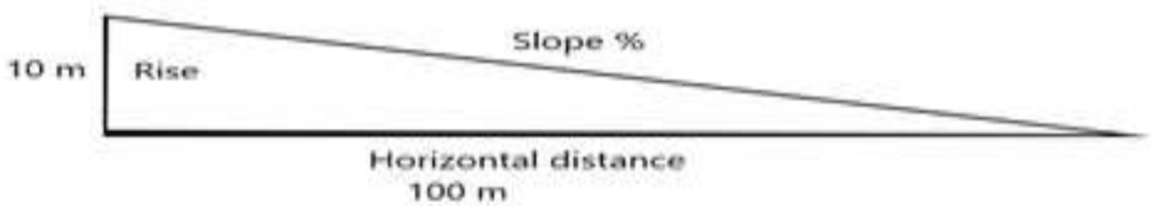


Figure 2. Illustrate the slope % measuring method (4)

$$\boldsymbol{Slope}\ \% = \frac{10}{100} \times 100 = 0.1 \times 100 = 10\%$$

Along the elevation gradient for distance separating between each elevation was 100 m ± 10 m (Figure 2) (58). Sample's collection survey of all botanical plants was started from May to September in 2020. Starting at 900 m above sea level for each aspect, which is settled transect every 100 m along the elevation gradient, up to 1200 m for each topographical aspect. Each slope site was applied zig-zag transect method (23), which is divided equally into 10 main plots (20 * 20 m). In each plot, all of the trees and shrubs of species were recorded with four main samples plot. For each main plot of trees and shrubs, the vegetation of herbaceous plants survey was conducted by zig-zag method reference sampling occurring every 10 m and staggered to the left and the right of the transect. Sampling herbaceous carried out by surveying a 1 m^{-2} quadrat and all vegetation in the quadrat was recorded (13) for a total of 8 quadrats per transect. The botanical plants were identified according to the flora of Iraq (19), and also depending on online flora as a guide (27) and deposited in the Herbarium, Department of Forestry, College of Agricultural Engineering Sciences, University of Duhok, Iraq.

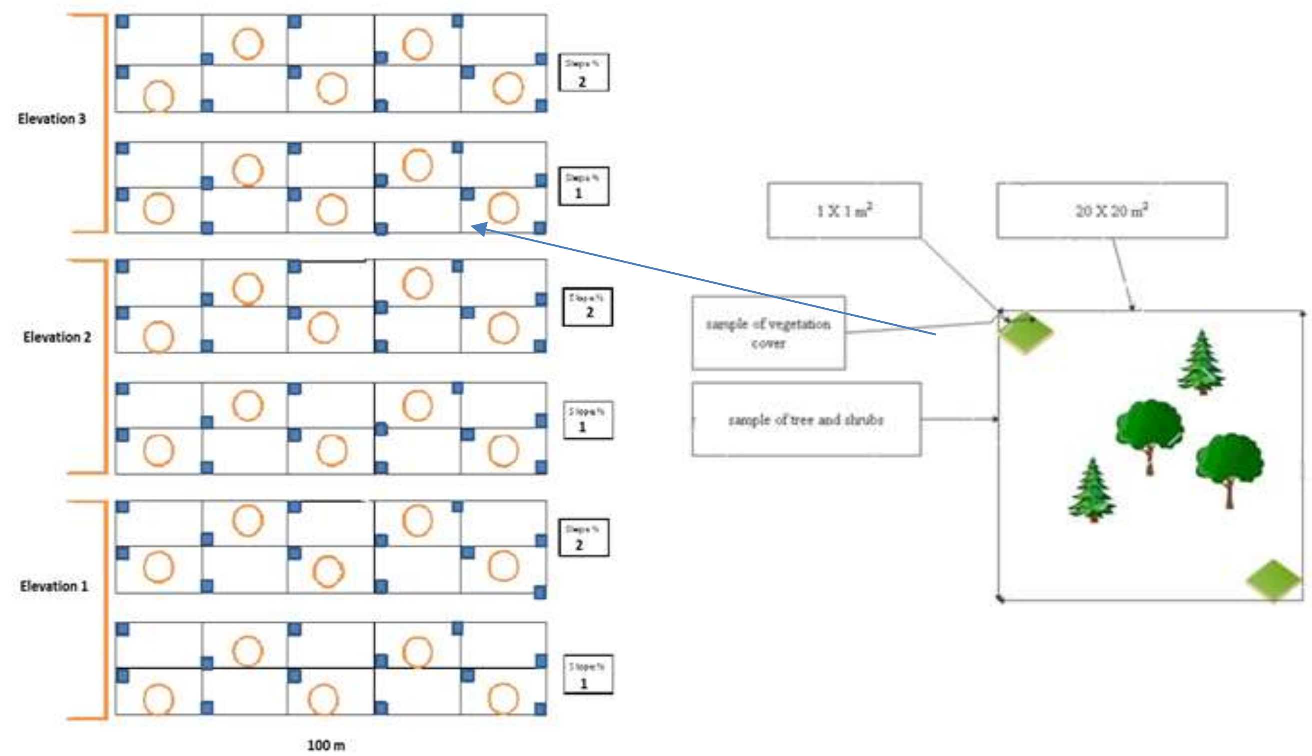


Fig 3. Diagram of sampling plot design of the study of botanical plants characteristics per quadrate using zig-zag method (23) for one facing-aspect with elevations and slope gradients at Zawita mountain.

Experimental Design:

The design was factorial of three factors in a strip-split plot complete block arrangement with four replications. Within each block, the two aspect levels in vertical strips, and the three elevations in horizontal strips and the two slope levels within every intersection of aspect and elevation as subplots factor.Transect will lay out with 100m x50m at interval (Figure 3). The total number of sampling during the study was 96 of quadrat vegetation (2 aspects X 3 elevations X two slopes, with 8 samples).

Analysis of Data

Vegetation parameters were used to calculate density (D), frequency (F), species richness (20).

$$\textbf{Density} = \frac{\textbf{Number of individual plants}}{\textbf{quadrats area m}-\textbf{2}}$$

$$\textbf{Frequency} = \frac{\textbf{Number of quadrat in which the species occurs}}{\textbf{Total number of quadrats studied}}$$

Richness = number of species per specified number of individual plants

To measuring of vegetation species diversity using different characters, such as Simpson's Index (32), Shannon Wiener Index (38), which is the sum of all plant species in the quadrat fields of the experimental plots. Shannon-Wiener Index (H')

$$= -\sum\left(\left(\frac{ni}{N}\right) X \ ln \left(\frac{ni}{N}\right)\right)$$

Where ni = number of individuals of each species and N = total number of individuals for the quadrate, and ln = the natural log of the number

$$\textbf{Simpson's Index} = \sum \frac{ni\,(ni-1)}{N\,(N-1)}$$

Where ni = number of individuals of each species and N = total number of individuals for the quadrate

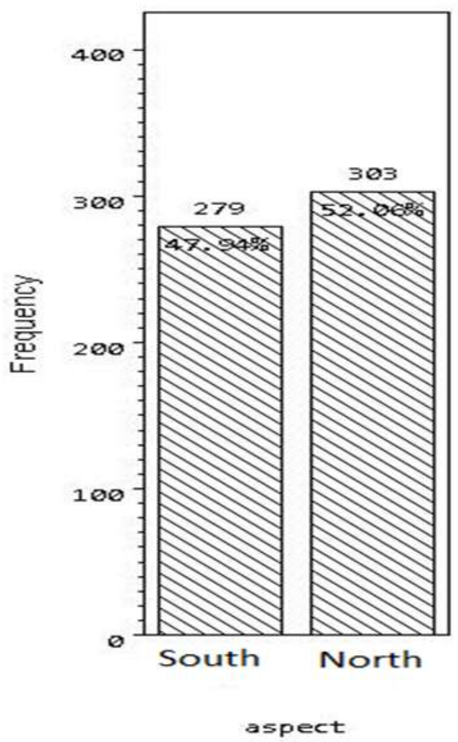
SAS software 9.4 (25) was used to conduct significance test for different aspects, altitudes, and slope gradients and DMRT test (15) for means comparison.

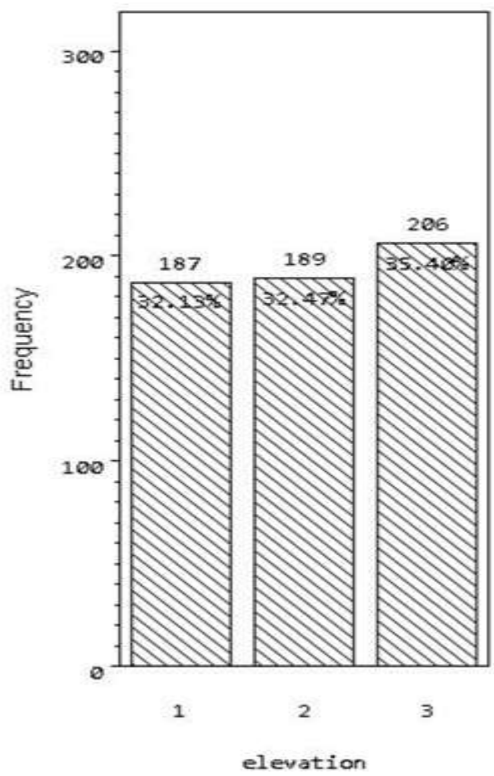
RESULTS AND DISCUSSION

Vegetation cover: Vegetation covers composition revealed to existence of (118) species belonging to (27) families from all sample study (appendix 1 and 2), 77 species interplay between south and north facing slope. The dominant family observed was *Fabaceae* which is contributing (22.9%), *Asteraceae* (19.5%) and *Poaceae* (15.3%) of the total families. In previous studies at Zawita area; (42) found (28 families, 77 genera and 86 species) of vegetation cover. The strong variation noticed the vegetation structure between south and north is possibly due to the different ecological modification of the plant species to these opposing aspects (1, 3, 26, 28, 49, 51, 52). The northern aspects were inhabited by drought-avoiding species, while the rough southern aspects were dominated by drought-tolerant species and nutrient deficient species. It's worth noting that the harshest growing environment that is characterized by moisture and nutrient starvation. This strong separation of species composition between opposing aspects corroborates the vegetation category of (28), who diagnosed different vegetation formations associated with different slope aspects. For example, Fabaceae represented the largest family in these arid aspects as thy are dominant species with their distinctive drought tolerance, nitrogen fixation, and water and soil conservation properties (30, 46).

Frequency % of plants

Frequency distribution of plants was showed that the south aspect (47.94%) while the north aspect is (52.06%) (Figure 4). Since the data depend on different outcomes of aspects, the frequency on the north side is more specific than on the south side due to different temperature and humidity distribution between them which is a key determinant of vegetation pattern and species distribution (5, 9). The occurrence of species at altitude (1100 – 1200 masl) was compared (35.40%) in (1000 – 1100 masl) and (900 – 1000 masl) is an indication that the species are (32.47% and 32.13%) respectively. The presence of the species frequency distribution allows us to build the semi-rare score of percentage for different altitudes, which can bring in about a tiny spacing between altitudes. The altitudinal difference between them and data recorded at the field site was relatively small (100 m); nevertheless, the accuracy of the temperature was low at the base of the valley, apparently due to the formation of a persistent temperature inversion at night and during low solar elevation in winter (8, 9). Based on the percentage of the slope, it was found (52.75%) with a slope of 10%. Only (47.25%) occurred on 20% of the slopes. The pattern in this factor may arise erosion of structure of soil moisture for a shallow soil over chalk, where rapid drainage of water predominates, and accumulate to valley area (9, 36). which is directly affect the regeneration of species and therefore the frequency decrease.





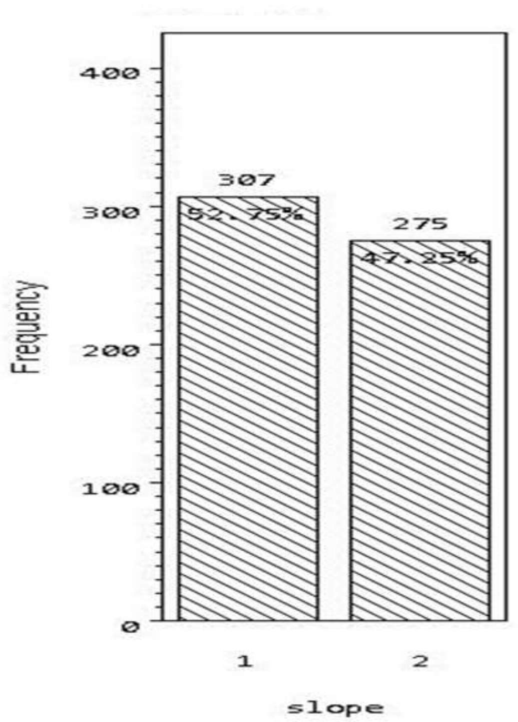


Figure 4. Shows the frequency of the vegetation of individual species between aspects, elevations and slope percentage (elevation 1=900-1000; 2=1000-1100; 3=1100-1200 mas.l.; slope 1= 10%; 2= 20%).

Density, species richness, and diversity of vegetation along with aspects

Individual botanical plants per sample ranged (138.17 – 214.92), with the highest value was recorded in the north-facing aspect while the lowest was recorded in the south-facing aspect (Table 1). While, the value of Shannon diversity index (H) was significantly (P-value = 0.0191) differences between aspect categories, with the highest value was recorded in the south-facing aspect. This result could be due to competition for sunlight. Previous studies on aspects of the Ashawa resort - Duhok Provence (2). limitation of water resources and light could strong competition between aspects (41, 54) in natural habitat depending in rainwater for mountain, causing increasing of plants in north-facing compared with south-facing (5, 27, 40). On the other hand, the southern aspect of mountains is higher exposure to radiation of sunlight than the northern aspect, which is causes higher temperature, low humidity, and higher soil moisture losses by evaporation (17, 33). There were no significant differences (p-value = 0.163) in species richness among the facing aspects class. Similarly, there was no significant (P-value = 0.4115) difference in Simpson diversity index (D) between south and north-facing categories aspect, though a higher number of Simpson index was recorded in the northern aspect (Table 1). These results concurred with those of (37), who suggested that the richest species number on north-facing of Iberian Pyrenees forest mountains. As well as with the results of (49), who referred that species richness differed between north-facing compared with south-facing aspects due to higher resources availability, particularly through soil moisture. Differences in species understory vegetation were different with south and northern aspects due to differential of water and nutrient availability on the aspects (33). On the other hand, the south-facing was a fewer species richness of vegetation understory forest, which is maintained a more stress-tolerant and light-demanding flora composition (8).

Table 1. Mean value for traits of plant species and diversity across aspects within significant difference (P> 0.05) according to DMRT test (15).

Characters	South	North	P – value
Density (m^{-2})	138.17 b	214.92 a	0.0296
Species richness	17.88 a	20.79 a	0.1630
Shannon index (H)	1.94 a	1.36 b	0.0191
Simpson index (D)	0.83 a	0.86 a	0.4115

Density, species richness, and diversity of vegetation along with altitude (elevations)

A total of individual plants for each quadrate sample among elevations recorded (142.69, 140.22, and 246.72) respectively, with low elevation to high altitude. The highest significant value was recorded in (1100 – 1200 m) and the lowest value was in (1000 – 1100m) which was not significantly different with low altitude (900 – 1000 m). While a diversity of Shannon Wiener index (H) was significantly higher at the low elevation (900 – 1000 m) compared to the high altitude (1100 – 1200 m) and moderate elevation (1000 – 1100 m), and the diversity was varied from (1.86 to 1.1.50) respectively (Table 2). These results are consistent with those of (22), who reported that the number of individuals per quadrate sample was relatively high but the biodiversity of the Shannon index is low. Species richness and Simpson diversity index (D) with increasing elevation recorded in each quadrate sample increased linearly, but non-significantly between them (Table 2). The higher value of both richness and Simpson diversity was recorded with high altitude (19.94, 0.86) while decreased these values (18.81, 0.83) were recorded at low elevation (900 – 1000 m) respectively. This result was founded with (34), which is increasing altitude in semi-arid mountains to increase species richness. However, these differences were not reflected in changes in Simpson's diversity index. Differences in rich species may be to differential water levels and availability of soil nutrients on different elevations (33). Differences in diversity between the elevational range, which resulted in higher species richness (14). The climate of the high altitude, forests with low anthropogenic effects (such as forest management and air pollution) encourage a rich species of flora (43, 50). The higher species richness coincides well with high altitude which is phorophyte species (29, 31), were explained the increase of altitude gradient is a significant difference in species richness in the forests of Mount Duro, Nagelle Arsi, Ethiopia. Which are causes to strongly affect the length of the growing season followed by moisture and temperature (55).

Table 2. Mean value for traits of plant species and diversity across elevations within significant difference (P> 0.05) according to the DMRT test (15).

Characters	900 – 1000m	1000 – 1100 m	1100 – 1200 m	P – value
Density (m^{-2})	142.69 b	140.22 b	246.72 a	0.0001
Species richness	18.81 a	19.250 a	19.940 a	0.7550
Shannon index (H)	1.860 a	1.5000 b	1.5900 b	0.0230
Simpson index (D)	0.830 a	0.8400 a	0.8600 a	0.1936

Density, species richness, and diversity of vegetation along with slope %

Number of plants per square quadrate sample was varied from 174.21 to 178.88, with the higher value recorded in steep slope percent and the lowest value in minimum slope (Table 3). While the highest species richness was recorded in the low slope gradient compared with the steep slope, which was not significantly different. The Shannon Wiener diversity (H) was significantly affected (P = 0.0146) by the slope. The higher diversity was recorded in the low area slope compared with the lowest value diversity which was found in the steep slope (Table 3). Simpson index (D) of species was not significantly affected by slope, though the highest value was recorded in narrow slope area. These results accord with (47, 58), whom reported that slope angle strongly influenced species richness and diversity of forest under vegetation through an effect on soil characters, especially soils on steeper slopes, were affected by bedrock and tended to be less moist and more acidic. The tendency of cofactor topography like the slope, and soil structure with chemical and physical kind affected the distribution manner of vegetation communities (10, 45). The direct action of rainfall in steep slope areas was exposed to erosion of water to the valley which is causes loss controlling soil properties and runoff of water (12, 56). The importance of slope angle towards dispersal species richness was that in creating microclimate distribution through a topographic range (9), concluded that the plant community structure and species diversity were significantly affected by fluctuating topographical microclimate. Species diversity maybe restricts the distribution from the steep slope to narrow slope area (21, 39). The migration and dispersal of species maybe important changes in the distribution and indicate of change in population in the slope area (53).

Table 3. Mean value for traits of plant species and diversity across slope gradient within significant difference (P> 0.05) according to DMRT test (15).

Characters	10 %	20 %	P – value
Density (m^{-2})	174.21 a	178.88 a	0.6623
Species richness	20.04 a	18.63 a	0.4165
Shannon index (H)	1.85 a	1.46 b	0.0146
Simpson index (D)	0.86 a	0.83 a	0.2212

Conclusion

Zawita forest is one of the important naturally nearby the Duhok city from ecological, economically, socially, touristically, and culturally. This study was designed to investigate the significance of aspects, elevation, and slope gradient on vegetation cover at Zawita mountains. The data obtained from results concluded that the north-facing aspects was more rich vegetation and species due to more abundance of soil moisture and lower in mean temperature particularly during the summer season compared with south-facing aspects. Shannon biodiversity was higher at the south-facing aspect because most species are tolerant of light and open space among trees and shrubs. The increasing of elevation resulted in increasing vegetation and rich species; this was attributed to lower activity of humans at high elevation, while the steep slope caused declination of the plants and species due to erosion by rainfall to the valley area.

Appendix 1. Plant's species distribution from the environmental impacts in South aspect

No.	Families	Botanical name	South aspect					
			900 - 1000 msl		1000 - 1100 msl		1100 - 1200 msl	
			Slope 10%	Slope 20%	Slope 10%	Slope 20%	Slope 10%	Slope 20%
1	Poaceae	*Aegilops triuncialis* L.	+	+	-	+	-	-
2	Poaceae	*Aegilops umbellulata* Zhur.	+	+	-	+	+	+
3	Malvaceae	*Alcea kurdica*	-	-	-	-	-	+
4	Amaryllidaceae	*Allium stamineum* Boiss	+	-	-	-	+	+
5	Primulaceae	*Anagallis arvensis* L.	+	+	+	+	+	+
6	Boraginaceae	*Anchusa strigosa* Banks and Sol.	+	-	-	-	-	-
7	Fabaceae	*Astragalus spinosus* (Forssk.) Muschl.	+	-	-	-	-	-
8	Fabaceae	*Astragalus oocephalus* Boiss.	-	+	-	-	-	-
9	Poaceae	*Avena fatua* L.	+	+	-	-	+	+
10	Poaceae	*Avena ludoviciana* Dur.	-	-	-	-	-	+
11	Poaceae	*Bromus danthoniae* Trin in Mey.	+	+	+	+	+	+
12	Poaceae	*Bromus danthoniae* var. danthoniae	+	+	-	+	+	+
13	Poaceae	*Bromus madritensis* L.	+	+	-	-	+	-
14	Asteraceae	*Centaurea rigida*	+	-	-	-	-	-
15	Asteraceae	*Centaurea virgate* Lam.	+	-	-	+	+	-
16	Asteraceae	*Chardinia orientalis* (L.) Kuntze.	+	-	-	+	-	-
17	Asteraceae	*Crepis foetida* L.	+	-	-	+	-	+
18	Fabaceae	*Coronilla scorpioides* (L.) Koch.	-	-	-	-	+	-
19	Asteraceae	*Crupina crupinastrum* (Moris) Vis.	+	+	-	-	+	+
20	Poaceae	*Cynosurus elegans* Desf.	-	-	-	-	-	+
21	Poaceae	*Echinaria capitata* (L.) Desf.	-	+	-	-	+	-
22	Asteraceae	*Echinops ritro* L.	+	-	+	+	-	-
23	Euphorbiaceae	*Euphorbia helioscopia* L.	+	-	-	-	-	-
24	Asteraceae	*Filago anatolica* (Boiss. et. Heldr.)	+	-	-	+	+	-
25	Asteraceae	*Garhadiolus hedypnois* (Fisch. Et. Mey.) Jaub. et Spach.	+	-	+	+	+	-
26	Asteraceae	*Geropogon hybridus* (L.) Sch. Bip.	+	+	-	-	-	-
27	Iridaceae	*Gladiolus kotschyanus* Boiss.	+	-	+	-	-	+
28	Fabaceae	*Glycyrrhiza glabra* L. var. glabra	+	-	-	-	-	-
29	Asteraceae	*Gundelia tournefortii* L.	+	-	+	-	+	-
30	Fabaceae	*Hippocrepis unisiliquosa* L.	-	-	-	+	-	-
31	Poaceae	*Hordeum bulbosum* L.	-	-	+	-	+	-
32	Poaceae	*Hordeum spontaneum* Koch.	+	+	+	+	+	-
33	Hypericaceae	*Hypericum retusum* auch ex Jaub.	+	-	-	-	-	-
34	Apiaceae	*Lagoecia cuminoides*	+	+	-	-	-	-
35	Fabaceae	*Lathyrus aphaca* L.	+	-	-	-	-	-
36	Campanulaceae	*Legousia speculum-veneris* (L.) Chaix.	+	+	+	+	+	-
37	Brassicaceae	*Lepidium latifolium* L.	-	+	+	-	-	+
38	Linaceae	*Linum nodiflorum* L.	-	-	-	-	+	+
39	Linaceae	*Linum strictum* L.	+	+	+	+	+	+
40	Poaceae	*Lolium rigidum* Gaud.	+	+	+	-	+	-
41	Poaceae	*Lophochloa phleoides* (Vill) Rchb.	-	-	+	+	-	-
42	Fabaceae	*Medicago polymorpha* L.	-	-	-	-	-	+
43	Fabaceae	*Medicago radiate* L.	+	+	+	+	+	+
44	Fabaceae	*Medicago rigidula* (L.) Desre.	+	-	-	-	-	+
45	Asparagaceae	*Muscari comosum* (L.) Mill.	-	-	+	-	-	-
46	Asparagaceae	*Muscari inconstrictum* Rech. f.	-	-	+	-	-	-

47	**Boraginaceae**	***Myosotis arvensis***	+	+	+	+	+	+
48	**Fabaceae**	***Onobrychis cardachorum* Townsend.**	+	+	+	+	+	+
49	**Fabaceae**	***Onobrychis crista-galli* (L.) Lam.**	-	-	-	+	-	-
50	**Boraginaceae**	***Onosma alborosea* Fisch. and C.A. Mey.**	+	-	-	-	-	-
51	**Asparagaceae**	***Ornithogalum kurdicum* Bornm.**	-	-	+	+	-	-
52	**Orobanchaceae**	***Parentucellia latifolia subsp. flaviflora* (Boiss.) Hand**	+	-	-	+	+	-
53	**Poaceae**	***Phalaris brachystachys* Link in Schrad.**	-	-	-	+	-	-
54	**Asteraceae**	***Picris pauciflora* Willd.**	+	+	+	+	-	+
55	**Apiaceae**	***Pimpinella eriocarpa* Banks and Sol.**	+	-	-	-	+	-
56	**Plantaginaceae**	***Plantago lanceolata* L.**	+	-	-	-	+	-
57	**Poaceae**	***Poa bulbosa* L.**	-	+	-	-	-	+
58	**Rosaceae**	***Poterium lasiocarpum* Bioss. et Haussken.**	-	-	+	-	-	-
59	**Poaceae**	***Polypogon monspeliensis* (L.) Desf.**	-	-	-	-	+	-
60	**Asteraceae**	***Rhagadiolus stellatus* (L.) Gaertn.**	+	-	-	+	+	-
61	**Lamiaceae**	***Salvia acetabolosa* L.**	+	+	-	+	-	+
62	**Lamiaceae**	***Salvia bracteata Banks* et Sol.**	-	+	-	+	-	-
63	**Apiaceae**	***Scandix pectin-veneris* L.**	+	-	-	-	-	-
64	**Scrophulariaceae**	***Scrophularia xenoglossa***	-	-	-	-	-	+
65	**Scrophulariaceae**	***Scorpiurus muricatus* L.**	+	-	+	+	+	-
66	**Asteraceae**	***Serratula cerinthifolia* (Sm.) Boiss.**	-	+	+	-	+	+
67	**Rubiaceae**	***Sherardia arvensis* L.**	+	+	-	-	+	-
68	**Lamiaceae**	***Teucrium polium* L.**	+	-	-	-	-	+
69	**Lamiaceae**	***Thymus kotschyanus* Boiss. et Hohen.**	+	-	-	+	-	+
70	**Apiaceae**	***Tordylium cordatum* (Jacq.) Poir.**	-	-	+	+	-	-
71	**Apiaceae**	***Torilis nodosa* (L.) Gaertn.**	+	+	+	-	-	+
72	**Asteraceae**	***Tragopogon porrifolius* L.**	-	-	-	+	-	+
73	**Fabaceae**	***Trifolium campestre* Schreb.**	+	+	+	+	+	+
74	**Fabaceae**	***Trifolium dasyurum* Presl.**	+	+	-	-	-	-
75	**Fabaceae**	***Trifolium pilulare* Boiss.**	+	+	+	+	-	+
76	**Fabaceae**	***Trifolium purpureum* Lois.**	+	+	+	+	+	+
77	**Fabaceae**	***Trifolium stellatum* L.**	+	-	+	+	+	+
78	**Fabaceae**	***Trifolium resupinatum* L.**	-	+	+	+	+	-
79	**Fabaceae**	***Trigonella monspeliaca* L.**	+	-	-	+	-	-
80	**Fabaceae**	***Trigonella spicata* Sm.**	+	-	-	-	-	-
81	**Asteraceae**	***Urospermum picroides* (L.) Scop. ex. Schmidt.**	+	+	+	+	+	+
82	**Fabaceae**	***Vicia hybrid* L.**	+	-	+	+	-	-
83	**Lamiaceae**	***Ziziphora capitata***	+	-	-	-	-	-
84	**Asteraceae**	***Zoegea leptaurea* L.**	+	+	+	+	+	+

Appendix 2. Plant's species distribution from the environmental impacts in North aspect.

			North aspect					
			900 - 1000 msl		1000 - 1100 msl		1100 - 1200 msl	
No.	**Families**	**Botanical name**	**Slope 10%**	**Slope 20%**	**Slope 10%**	**Slope 20%**	**Slope 10%**	**Slope 20%**
1	**Poaceae**	***Aegilops ovate*** **L.**	-	-	-	-	-	+
2	**Poaceae**	***Aegilops triuncialis*** **L.**	+	+	+	+	+	+
3	**Poaceae**	***Aegilops umbellulata*** **Zhur.**	+	+	+	+	+	+
4	**Malvaceae**	***Alcea kurdica***	-	-	+	-	+	-
5	**Boraginaceae**	***Alkanna kotschyana*** **DC.**	-	-	-	+	-	-
6	**Amaryllidaceae**	***Allium stamineum*** **Boiss**	-	-	+	-	-	-
7	**Primulaceae**	***Anagallis arvensis*** **L.**	+	+	-	+	-	-
8	**Boraginaceae**	***Anchusa azurea*** **Mill.**	-	-	+	+	-	-
9	**Boraginaceae**	***Anchusa strigosa*** **Banks and Sol.**	+	-	-	+	-	-
10	**Aristolochiaceae**	***Aristolochia bottae*** **Jaub. et. Spach.**	-	-	+	+	-	-
11	**Fabaceae**	***Astragalus spinosus*** **(Forssk.) Muschl.**	+	+	-	-	-	-
12	**Fabaceae**	***Astragalus oocephalus*** **Boiss.**	-	-	+	-	-	-
13	**Poaceae**	***Avena fatua*** **L.**	-	-	+	+	+	+
14	**Poaceae**	***Avena ludoviciana*** **Dur.**	-	-	-	+	-	+
15	**Poaceae**	***Bromus danthoniae*** **Trin in Mey.**	-	+	+	+	+	+
16	**Poaceae**	***Bromus danthoniae var. danthoniae***	+	+	+	-	+	+
17	**Poaceae**	***Bromus madritensis*** **L.**	-	-	+	-	-	+
18	**Asteraceae**	***Calendula arvensis*** **L.**	-	-	-	-	+	-
19	**Brassicaceae**	***Cardaria draba***	-	+	-	-	-	-
20	**Asteraceae**	***Carduus pycnocephalus*** **L.**	-	-	-	-	+	-
21	**Apiaceae**	***Carum carvi*** **L.**	-	+	-	+	+	-
22	**Caprifoliaceae**	***Cephalaria cetosa***	-	+	+	+	-	-
23	**Asteraceae**	***Centaurea rigida***	-	-	-	-	-	+
24	**Asteraceae**	***Centaurea virgate*** **Lam.**	-	+	-	-	-	-
25	**Asteraceae**	***Chardinia orientalis*** **(L.) Kuntze.**	-	+	+	+	-	+
26	**Asteraceae**	***Crepis foetida*** **L.**	-	-	+	-	+	+
27	**Fabaceae**	***Coronilla scorpioides*** **(L.) Koch.**	+	+	-	+	+	-
28	**Asteraceae**	***Crupina crupinastrum*** **(Moris) Vis.**	+	+	-	+	-	+
29	**Poaceae**	***Cynosurus elegans*** **Desf.**	-	-	-	-	+	-
30	**Poaceae**	***Dactylis glomerata*** **L.**	-	-	-	-	+	-
31	**Asteraceae**	***Echinops ritro*** **L.**	-	-	+	+	+	-
32	**Geraniaceae**	***Erodium cicutarium*** **(L.) L 'Her'**	-	+	-	-	-	-
33	**Euphorbiaceae**	***Euphorbia macroclada*** **Boiss.**	-	-	-	+	-	-
34	**Asteraceae**	***Filago anatolica*** **(Boiss. et. Heldr.)**	-	-	-	-	-	+
35	**Asteraceae**	***Garhadiolus hedypnois*** **(Fisch. Et. Mey.) Jaub. et Spach.**	-	-	-	-	+	-
36	**Asteraceae**	***Geropogon hybridus*** **(L.) Sch. Bip.**	+	-	+	+	-	-
37	**Iridaceae**	***Gladiolus kotschyanus*** **Boiss.**	+	+	+	+	+	+
38	**Asteraceae**	***Gundelia tournefortii*** **L.**	-	+	-	-	-	-
39	**Fabaceae**	***Hippocrepis unisiliquosa*** **L.**	+	+	-	+	+	-
40	**Poaceae**	***Hordeum bulbosum*** **L.**	+	-	+	+	+	+
41	**Poaceae**	***Hordeum spontaneum*** **Koch.**	-	-	+	+	+	+
42	**Hypericaceae**	***Hypericum lydium*** **Boiss.**	-	+	-	-	-	-
43	**Apiaceae**	***Lagoecia cuminoides***	-	-	+	+	+	+
44	**Campanulaceae**	***Legousia speculum-veneris*** **(L.) Chaix.**	+	+	-	+	-	-
45	**Brassicaceae**	***Lepidium latifolium*** **L.**	-	-	-	+	+	+
46	**Fabaceae**	***Lens orientalis*** **(Boiss.) Schmalh.**	-	-	-	+	+	+
47	**Linaceae**	***Linum nodiflorum*** **L.**	-	-	-	+	-	+
48	**Linaceae**	***Linum strictum*** **L.**	+	+	+	+	+	+
49	**Poaceae**	***Lolium rigidum*** **Gaud.**	-	-	-	-	+	+
50	**Poaceae**	***Lophochloa phleoides*** **(Vill) Rchb.**	-	+	-	-	+	-
51	**Fabaceae**	***Medicago polymorpha*** **L.**	+	+	-	-	-	+
52	**Fabaceae**	***Medicago radiate*** **L.**	+	+	+	-	-	+
53	**Fabaceae**	***Medicago rigidula*** **(L.) Desre.**	-	-	+	+	+	-
54	**Asparagaceae**	***Muscari comosum*** **(L.) Mill.**	-	-	-	+	-	-
55	**Asparagaceae**	***Muscari inconstrictum*** **Rech. f.**	+	-	-	+	-	-
56	**Boraginaceae**	***Myosotis arvensis***	+	-	+	+	+	+
57	**Fabaceae**	***Onobrychis cardachorum*** **Townsend.**	+	+	-	-	-	-
58	**Fabaceae**	***Onobrychis crista-galli*** **(L.) Lam.**	-	-	-	-	-	+
59	**Fabaceae**	***Onobrychis ptolemaica*** **(Delile) DC. subsp. macroptera.**	+	+	-	+	-	-
60	**Fabaceae**	***Onobrychis kotschyana*** **Fenzl.**	-	-	+	-	-	+
61	**Fabaceae**	***Ononis sicula*** **Guss. Spiny.**	-	-	+	-	-	-
62	**Boraginaceae**	***Onosma alborosea*** **Fisch. and C.A.**	-	-	+	+	+	+

		Mey.						
63	**Boraginaceae**	***Onosma sericeum* Willd.**	-	-	-	+	-	-
64	**Asteraceae**	***Onopordum carduchorm* Born. et Beau.**	-	+	-	-	-	-
65	**Asparagaceae**	***Ornithogalum kurdicum* Bornm.**	-	+	-	+	-	-
66	**Papaveraceae**	***Papaver macrostomum* Boiss. et. Huet.**	-	+	+	-	-	-
67	**Orobanchaceae**	***Parentucellia latifolia subsp. flaviflora* (Boiss.) Hand**	+	+	-	+	-	+
68	**Asteraceae**	***Phagnalon rupestre* (L.) DC.**	-	-	+	-	-	-
69	**Poaceae**	***Phalaris brachystachys* Link in Schrad.**	-	-	-	-	+	-
70	**Asteraceae**	***Picris pauciflora* Willd.**	+	+	-	+	+	+
71	**Apiaceae**	***Pimpinella eriocarpa* Banks and Sol.**	+	-	-	+	+	-
72	**Plantaginaceae**	***Plantago lanceolata* L.**	-	+	+	-	+	-
73	**Plantaginaceae**	***Plantago psyllium* L.**	-	-	-	-	-	+
74	**Poaceae**	***Poa bulbosa* L.**	-	+	-	-	+	-
75	**Rosaceae**	***Poterium lasiocarpum* Bioss. et Haussken.**	+	+	+	+	+	-
76	**Polygalaceae**	***Polygala monspeliaca* L.**	-	+	-	-	-	-
77	**Poaceae**	***Polypogon monspeliensis* (L.) Desf.**	+	-	-	-	-	-
78	**Ranunculaceae**	***Ranunculus asiaticus* L.**	-	+	-	-	-	+
79	**Asteraceae**	***Rhagadiolus stellatus* (L.) Gaertn.**	-	-	+	-	-	+
80	**Lamiaceae**	***Salvia acetabolosa* L.**	+	+	-	+	+	+
81	**Lamiaceae**	***Salvia bracteata* Banks et Sol.**	-	-	-	-	+	+
82	**Lamiaceae**	***Salvia syriaca* L.**	-	-	-	-	-	+
83	**Scrophulariaceae**	***Scorpiurus muricatus* L.**	-	+	-	-	-	-
84	**Asteraceae**	***Senecio vulgaris* L.**	-	-	-	-	-	+
85	**Asteraceae**	***Serratula cerinthifolia* (Sm.) Boiss.**	-	+	-	+	+	+
86	**Rubiaceae**	***Sherardia arvensis* L.**	+	-	+	+	+	+
87	**Brassicaceae**	***Sinapis alba* L.**	-	+	-	-	-	-
88	**Asteraceae**	***Sonchus oleraceous* L.**	-	-	-	-	+	-
89	**Asteraceae**	***Taraxacum officinale* (L.) Web. ex Wigg.**	-	-	-	+	-	-
90	**Lamiaceae**	***Teucrium polium* L.**	+	+	-	-	-	-
91	**Lamiaceae**	***Thymus kotschyanus* Boiss. et Hohen.**	+	+	-	-	-	-
92	**Apiaceae**	***Tordylium cordatum* (Jacq.) Poir.**	-	-	-	-	-	+
93	**Apiaceae**	***Torilis nodosa* (L.) Gaertn.**	-	+	+	+	+	+
94	**Asteraceae**	***Tragopogon porrifolius* L.**	+	-	+	-	+	+
95	**Fabaceae**	***Trifolium campestre* Schreb.**	+	+	+	+	+	+
96	**Fabaceae**	***Trifolium dasyurum* Presl.**	-	-	+	-	-	-
97	**Fabaceae**	***Trifolium pilulare* Boiss.**	+	+	+	+	+	-
98	**Fabaceae**	***Trifolium purpureum* Lois.**	-	-	+	+	+	+
99	**Fabaceae**	***Trifolium stellatum* L.**	+	-	+	-	+	+
100	**Fabaceae**	***Trifolium repens* L.**	-	-	-	+	-	-
101	**Fabaceae**	***Trifolium resupinatum* L.**	-	-	-	-	+	+
102	**Fabaceae**	***Trigonella monspeliaca* L.**	+	-	+	+	-	-
103	**Fabaceae**	***Trigonella spicata* Sm.**	+	-	+	-	-	-
104	**Asteraceae**	***Urospermum picroides* (L.) Scop. ex. Schmidt.**	+	+	+	+	-	+
105	**Scrophulariaceae**	***Verbascum speciosum* Schrad.**	-	-	-	-	-	+
106	**Scrophulariaceae**	***Verbascum Thapsus* L.**	-	+	-	-	-	+
107	**Fabaceae**	***Vicia hybrid* L.**	-	-	+	-	+	+
108	**Fabaceae**	***Vicia narbonensis* L.**	-	-	-	-	-	+
109	**Fabaceae**	***Vicia sativa* L.**	-	-	-	+	+	-
110	**Lamiaceae**	***Ziziphora capitata***	-	-	-	-	-	+
111	**Asteraceae**	***Zoegea leptaurea* L.**	+	+	+	+	+	+

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