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Comparison Study of Natural Vegetation Structure Between Ajlun and Tafileh Woodlands in Jordan

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ABSTRACT

Woodland vegetation in the Ajlun Mountains of northern Jordan and Tafileh mountains of southern Jordan were investigated and quantitatively surveyed to determine the patterns of vegetation dynamics associated with altitude and topography. Three tree species (*Quercus coccifera* L., *Q. infectoria* Oliver and *Q. Aegilps* and seven shrubs (*Styrax officinalis* L., *Cistus creticus* L., *Cistus salviifolius* L., *Atriplex halimus* L., *Calycotome villosa* (Poir.)Link, *Retema raetam* L.and *Sarcopoterium spinosum* (L.) Spach) dominate the woody vegetation in Ajlun woodlands, while three tree species (*Juniperus phoenicea* L., *Pistacia atlantica* Desf, and *Quercus aegilps* L.and five shrubs (*Colutea istria* Miller, *Gomphocarpus sinaicus* (R.)Br., *Thymelaea hirsute* (L.) Endl., *Crataegus aronia* (L.)Bosc.ex DC, and *Daphne linearifolia* Hart.) dominate the woody vegetation in Tafileh woodlands. Lower altitudes of south-west facing slopes demonstrate generally the higher plant densities than the higher altitudes of north-east facing slopes in both sites. Species segregation in both woodland regions occurs on the basis of three main investigated factors: (1) Community ecological importance value complex of the species which combines the relative density, the relative coverage, and the relative frequency of the species). (2) Altitudes above sea level. (3) Slopes (north-east and south-west facing sides).

Keywords: Woodland; Vegetation dynamics; Phyto-geography; Mountain slopes.

INTRODUCTION

Jordan lies between longitudes 35^0 40' and 39^0 E and between latitudes 29^0 30' and 34^0 N in the transition region between the arid and the semi-arid bioclimates. Jordan is of great interest in vegetation ecology because it is the meeting place of the Mediterranean, Irano-turanian and Saharo-arabian regions or the Holarctic kingdom and the Nubo-sindian region of the palaeotropic kingdom (Mueller-Dombois and Ellenberg, 1974). For this reason there are conspicuous changes in the vegetation and in the composition of the flora over relatively short distances (within 30 km on the western slopes of the Border Mountains). Ajlun and Tafileh mountains are good representatives of northern and southern parts of Jordan and considered among the highest highlands which support forests and woodland vegetation due to unique climate and topography (Boulos, 1978; Al-Eisawi, 1982; Karim and Al-Qura'n, 1986 and 1988).

This is because these mountains are dominated by a mosaic form of phytogeographical elements extending from mediterranean, passing through irano-terranian and saharo-arabian, and ending with nubo-sindian one, and even this presence of a mixture of phytogeographical elements is recorded within certain narrow slope strips which often extended to the west towards the Jordan rift valley reflects the complexity of topography; since the diversification of bioclimate is highly related to the fluctuations in topographic factors(Zohary and Feinbrun-Dothan,1966-1986; Wong and Lertzman, 2001).

During the tertiary period, upheaval of mountains in the middle east brought about not only the physiographical segregation, but gave rise as well to climatic differentiation which serves to stimulate the diversity of plant species in highland areas. In the investigated areas, *Quercus* and *Juniperus* trees dominate the woodland vegetation where festooned or sculptured with lichen species, while different fungus species are distributed on the ground below. It is speculated that Ajlun and Tafileh mountains may have been the center of origin for *Quercus* and *Juniperus* species from which they migrated to the lower peripheral regions south or west or even to the north through many ways especially via cap fruits and pollen grains (Burdon, 1959; Zohary, 1973; Bender, 1974; Brooks and Mandit, 1983; Manos et al., 1999; Manos and Standford, 2001).

The first study area is located 10 km west of Ajlun city near Rabad castle within Ajlun Mountains at an elevation from 1000-1400 m above the sea level, while the second one is 20 km south of Tafileh city in Al Ata'ta Mountain near Dana within Tafileh highlands at an elevation from 1000-1400 m above the sea level. These areas are dominated by subhumid conditions since they are influenced by the westerly fronts' currents associated with winter precipitation, so the cold snowy winter is the general climate. The mean annual precipitation in the first study area is of 660 mm in winter, the spring months tend to be wetter with average precipitation about 200mm, the mean summer temperature is about 30^0C, from 39^0C is the average winter temperature, transpiration rates are 300 mm/year. While the mean annual precipitation in the second study area is less than 400 mm in winter, the spring months tend to be wetter with average precipitation about 120 mm, the mean summer temperature is about 34^0C, from 5-13^0C is the average winter temperature, transpiration rates are about 150 mm / year. The ridges in the highlands of both sites are remnants limestone mixed with metamorphosed intrusive rock. Massive undifferentiated sandstones (so-called Nubian sand-stones of the Cambrian formation are dominant. Limestones and dolomites, chalky marls and clays of the cenomanian and santonian-turonian. The soil parent material consists of metamorphic rocks with 6.5-7.0 pH in both sites, the soil texture ranges from loamy silt to silt clay to gravel clay. The first 15 cm often produces an average of 2.2% organic matter in the first site, and less than 2.0 in the second one, but indicating the favorable climatic conditions for plant growth and development (Burdon, 1959; A.R.M.D., 1990-2003).

Inhabitants and residents have largely impacted this area and adjacent woodlands by different ways and methods to get pasture, timber for fuels and building materials and implements since these forests are not protected, they are free opened for public and grazing animals which gives a real evidence that these pressures influenced by the human activities and have helped to bring about a shift of middle eastern woodland to the north and west, so these high impact pressure forces make the regeneration also been seriously curtailed (Risser and Zelder,1968; Pollard, 1971; Mueller-Dombois and Ellenberg, 1974; Manos et al., 1999; Landers et al., 1999; Manos and Standford, 2001).

These study areas need to be framed fully in terms of the following concrete research questions: (1) how has the importance value altered the contemporary forest stand structure and species composition? (2) How does vegetation structure and composition vary in relation to elevation and aspect effects? (3) How does the vegetation density vary in relation to the habitat type?

These three research questions are the vital ones to draw a clear image about the essentiality of this investigated subject of Oak and Juniper forests in Jordan (Risser and Zelder, 1968; Pollard, 1971; Lorimer, 1985; Manos et al., 1999; Manos and Standford, 2001).

It is wrathful to say that this comparison survey in Ajlun and Tafileh woodlands inform of concrete representative data is very important and still be the comprehensive purpose of this study which might be helpful in characterizing the vegetation structure types dominated within the investigated area for the benefits of human who's the center of the ecosystem.

MATERIALS AND METHODS

Two sampling methods were used to quantify the major habitat types represented within the study areas including lower and higher elevations, slope aspects (north-east and south-west facing slopes), and plateau sites (Brower et al., 1990).

The point-center quarter sampling method is the first and was used to collect tree data. Points were chosen randomly by 20 meters and the first point was chosen to begin sampling, between every two successive points and a compass bearing was used to establish a line of direction for each transect, 40 m. between every two parallel transects. In each stand from four transects, each transect 10m x 10m as a total of 40 trees per habitat type were evaluated. A grand total of 200 trees were recorded for density while measured for diameter 43 cm above the ground surface to the breast level as the standard height for trees' trunks (Canfield, 1941; Dileou, 1977; Dix, 1961; Greig-Smith, 1963; Heltshe and Forrester, 1983).

The line-intercept sampling method (belt transects) was the second method and used in collecting shrub data (Lorimer, 1985; Krebs, 1989; Landers et al., 1999; Manos et al., 1999; Manos and Standford, 2001). Twenty five line-strips were established per stand for a grand total of 100 line strips, each $50m^2$ in area. 40 meters separated the parallel transects. Data collected included plant density, frequency and coverage for all shrub species. These data were in turn converted into relative values and summed to calculate the community ecological importance value indices (IV), which were calculated simply as sum of the relative density (RD), the relative frequency (RF), and the relative coverage (RC), and It's sum to 300(for a maximum value of 300). Behavior indices (BI) were also used to provide an indication of the extent to which a species may increase or decrease in dominance and simply calculated as **Relative Coverage** X **Relative Frequency**. RD can be calculated by **dividing the number of the individuals of the species** by the **total number of the individuals of all species**. RF can be calculated by **dividing the frequency of the species** by the **total frequencies of all species**. RC can be calculated by **multiplying the area covered by the species depending on its diameter** presented in the tables (5, 6) by the absolute density (**RD** X **Total Density**), the result then divided on the number of the individuals of the species

(Catan, 1963; Risser and Zelder, 1968; Mueller-Dombois and Ellenberg, 1974; Lorimer, 1985; Brooks and Mandit, 1983; Brower et al., 1990).

RESULTS

Ajlun woodlands were dominated by three tree and seven shrub species (Table 1). *Quercus aegilops* L. is the most dominant tree species while *Sarcopoterium spinosum* (L.) Spach, is the most dominant dwarf shrub species within the investigated woodland strata. While Tafileh woodlands were dominated by three tree and five shrubs' species (Table 2). *Juniperus phoenicea* L, is the most dominant tree species while *Thymelaea hirsuta* (L.) Endl, is the most dominant shrub species within the investigated woodland strata.

During the ecological investigation, the most herbal composition of the plant vegetation cover observed in Ajlun woodlands was consist of: *Aegilops kotschi* Boiss, *Lotus creticus* L., *Crucianella maritima* L., *Lecokia cretica*(Lam.)DC., and *Poa bulbosa* L., *Anthemis cotula* L., *Bellis perennis* L., *Calendula arvensis* L., *Centaurea iberica* Trev., and *Stipa capensis* Thrunb, while the most herbal composition of the plant vegetation cover observed in Tafileh woodland was consist of: *Reichardia tingitana* (L.)Roth., *Aegilops kotschi* Boiss, *Centaurea iberica* Trev., *Plantago afra* L., *Euphorbia hierosolymitana* Boiss, *Lecokia cretica* (Lam.)DC., *Poa bulbosa* L., and *Gagea reticulata* (Pall.) Schult. This result obtained is different from what has obtained by Brooks and Mandit (1983) during their investigation in Asir woodland of south western Saudi Arabia. The vegetation structure in Asir woodland is highly differentiated from what was present in Ajlun because of difference in the phytogeographical elements dominated there.

By looking to the data collected from the ecological survey (Tables 3 and 4) of the investigated community, plant species segregate by elevation and slope aspect. The ecological importance values vary within Ajlun and Tafileh woodlands accordingly; plant densities of the investigated north-east slopes differ from that of the south-west slopes (slopes involved range from 10-30^0 in angle), also the elevations above the sea level within the slope facing destinations reflected distinctive kind of variations(elevations involved range from 1000-1400m). In general, the plant density decreases on high elevated north-east slopes on plateau sites, while the lower elevations of the south-west facing slopes have the highest plant densities (Tables 2 and 3). Stacked frequency distributions of tree size-classes by species would help demonstrate that a lot of trees examined were of small trees and not many big ones, perhaps because of pasture clearing and fuel collecting by people and cattle.

Plant density and coverage increases on the lower elevation slopes compared with higher elevation slopes, while the species composition and the importance values are more similar in higher elevation slopes than the lower elevation slopes. In general, the tendency of behavior index in Ajlun woodland species show variation; *Quercus infectoria* Oliver, *Q. coccifera* L., *Q.aegilops* L., *Cistus creticus* L., *Retema raetam* L., *Atriplex halimus* L., and *Sarcopoterium spinosum* (L.)Spach, to increase on lower elevation slopes, while *Styrax officinalis* L., *Cistus salviifolius* L., and *Calycotome villosa* (Poir) Link, have the tendency of behavior index to increase on higher elevation slopes (Table 3).

While the tendency of behavior index in Tafileh woodland species examined show some kind of variation: *Juniperus phoenicea* L., *Pistacia atlantica* Desf, *Quercus aegilops* L., *Gomphocarpus sinaicus* R.Br, *Thymelaea hirsute* (L.) Endl, and *Daphne linearifolia* Hart. have the tendency to increase on lower elevation slopes, while *Colutea* *istria* Miller and *Crataegus aronia* (L.)Bosc.ex DC have the tendency of behavior index to increase on higher elevation slopes.

These results obtained were similar to that obtained by Brooks and Mandit (1983) in their general headlines, but differ naturally in their vegetation composition

The presence of certain species in the Ajlun woodlands was more impacted in specific habitats, *Quercus* trees and *Cistus* shrubs' species are increasing in dominance on north-east slopes, while *Styrax officinalis* L., *Retema taetam* L., and *Calycotome villosa* (Poir)Link are increasing in dominance on south-east facing slopes, which support scattered densities of some vegetation cover species not included within the study, these species are representing mainly labiatae(mint family) such as: *Teucrium polium* L., *Phlomis viscosa* Poirt, *Salvia dominica* L., and *Ballota undulata* (Sieb.ex Fresen)Benthem. The absence of *Styrax officinalis* L.and *Calycotome villosa* (Poir) Link is the major distinctive character of the plateau vegetation, although these two species are considered from the most important members of Ajlun woodland vegetation (Table 3).

It is worthy to recognize after the analysis of the data obtained in table 4, the presence of certain species in Tafileh woodland was more important in specific habitats, *Pistacia atlantica* Desf, *Quercus aegilops* L., *Thymeleae hirsuta* (L.)Endl, and *Daphne linearifolia* Hart. species were increasing in dominance on north-east facing slopes, while the major increasing in dominance on south-west facing slopes occur to *Juniperus phoenicea* L., south-west facing slopes also support some scattered densities of some vegetation cover species not included within the study, these species are representing mainly: *Diplotaxis hara* (Forsk.)Boiss, *Astragalus spinosus* (Forsk) Muschl., *Teucrium polium* L., *Phlomis viscosa* Poirt, and *Ballota undulata* (Sieb.ex Fresen.) Benthem. The absence of *Pistacia atlantica* Desf and *Colutes istria* Miller was the major distinctive character of the plateau vegetation, although these two species are considered from the most important members of Tafileh woodland vegetation.

These findings obtained in tables 3 and 4 were ultimately incompatable by findings of Brooks and Mandit (1983).

By analysis of the data obtained in tables 7 and 8 concerning the diameter measurements collected from *Quercus* and *Juniperus* trees (200 from each) in the study as indicated previously in materials and methods' section, the results show that most of trees and shrubs' boles fall within 24-55 cm category of percent distribution % domains (66-82%), even the diameter measurements collected by different investigators for the same woodland species may vary among them because it depends how the investigator did take the measurements, either collected at the ground level, or above the ground surface as collected here in this study at 43 cm height above the ground surface (at breast level) as the minimum, and therefore the results obtained do not completely looks like each others.

Generally, the higher elevation in all habitat types and facing slopes show a wider range of diameter classes than the lower elevation, although in most cases, their densities are extremely lesser than what exist in the lower elevation (Table 7 and 8), while south-west facing slopes show an increase in *Quercus* and *Juniperus* densities over the north-east facing slopes, and over the plateau stands too, so doubtless, most of this increase is occurring in the lower elevation (1000-1200m). Consequently, I think the regeneration negatively affected due to continuous reduction in species diversity and tree size distribution.

DISCUSSION

Because these forests are opened for public, the human intervention through wood gathering and livestock grazing, may play the major role which influences the vegetation structure types in the Ajlun and Tafileh woodlands, and these factors are similar to those influencing any vegetation dynamics in the middle east area, since the stacked frequency distributions of tree size-classes by species have a lot of small trees, and not many big ones, consequently; the understory is dominated by unpalatable and toxic species which have increased especially under the grazing pressure particularly from the goat herds, this natural phenomenon can be seen especially in opened forests and non protected areas (Greig-Smith, 1963; Zohary, 1973; Brooks and Mandit, 1983; Manos et al., 1999; Manos and Standford, 2001).

The utilization of seedlings by grazing animals, and the collection of *Quercus* and *Juniperus* fruits to be used in tanning industry of animal skins are influencing the tree densities negatively. So under the climatic conditions exist in Ajlun and Tafileh mountains, one could expect densities at least of 400-600 trees per hectare in Ajlun woodland, while 300-500 trees per hectare in Tafileh woodland, which was not occur although *Quercus aegilops* and *Juniperus Phoenicea* are usually considered from the most prolific producers of viable seeds, this means that Ajlun and Tafileh woodland forests were from the main hot spots in Jordan need to be focus on to increase its productivity and to lay an illegible bases of sustainable development.

CONCLUSION

Doubtless, according to the above results and discussion obtained, we concluded that the vegetation stand structure and species composition of the ecological community are influenced by the topography and elevation, which increase in the south-western highlands of Ajlun and Tafileh mountains, and supports the segregation of woodland vegetation components. The intervention of human activities play a major role in influencing the vegetation structure types through wood gathering and livestock grazing resulting most often in increasing the dominance percentage of understudy species of unpalatable or toxic ones, which consequently reduces the densities of woodland species under investigation; the investigated tree species demonstrated a relatively low measurements in diameter which were reflected later on the values of relative coverage and importance values.

At the end, under these pressure conditions, regeneration force will stay at small value and has not the ability to substitute the loss in vegetation structure, therefore; the vegetation structure measurements related to the importance value complex will stay unable to increase the vegetation density in relation to habitat types, and unable to increase the contemporary forest stand structure and species composition in relation to human activities, and finally unable to increase the vegetation structure and composition to the maximum in relation to elevation and aspect effects unless the gettingrid of suppressing factors pointed at before.

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Table -1: Values of ecological survey of major perennial species in Ajlun woodland related to RD*, RF*, RCi*, IV*, and BI*.

Plant species (i)	Habit	RD	RF	RC	IV	BI
Quercus infectoria Oliver	Tree	2	3	7	12	21
Quercus coccifera L.	Tree	4	10	8	22	80
Quercus aegilops L.	Tree	7	8	13	28	104
Styrax officinalis L.	Shrub	4	5	4	13	20
Cistus creticus L.	Shrub	17	12	10	39	120
Cistus salviifolius L.	Shrub	15	10	9	34	90
Retema raetam L.	Shrub	8	11	5	24	55
Calycotome villosa (Poir) Link	Shrub	9	6	6	21	36
Atriplex halimus L.	Shrub	8	8	11	27	88
Sarcopoterium spinosum (L.)Spach	Shrub	15	15	14	44	210
Others	Tree, shrub	11	12	13	36	156

* RD : relative density of the plant species investigated
* RF : relative frequency of the plant species investigated
* RC : relative coverage of the plant species investigated
* IV : ecological importance value of the plant species investigated
* BI : behavior index of the plant species investigated

Table-2: Values of ecological survey of major perennial species in Tafileh woodland related to RD, RF, RC, IV, and BI.

Plant species (i)	Habit	RD	RF	RC	IV	BI
Juniperus phoenicea L.	Tree	16	12	20	48	240
Pistacia atlantica Desf	Tree	9	10	8	27	80
Quercus aegilops L.	Tree	12	9	13	34	117
Colutea istria Miller	Shrub	10	9	8	27	72
Gomphocarpus sinaicus R.Br.	Shrub	13	12	5	30	60
Thymelaea hirsute (L.)Endl.	Shrub	15	13	18	46	234
Crataegus aronia (L.)Bosc.ex DC.	Shrub	8	12	8	28	96
Daphne linearifolia Hart	Shrub	10	11	10	31	110
Others	Tree, shrub	07	12	10	29	120

- Details are same as in Table-1.

Table-3: Distribution of the ecological importance values related to the elevation and slope aspects in Ajlun woodlands.

Plant species	North-East slopes		South-West slopes		Plateau 1400 m
	1000-1200 m	1200-1400 m	1000-1200 m	1200-1400 m	
Quercus infectoria Oliver	22	16	20	13	10
Quercus coccifera L.	20	15	19	10	12
Quercus aegilops L.	28	20	27	25	12
Styrax officinalis L.	15	12	13	15	-
Cistus creticus L.	50	39	49	17	22
Cistus salviifolius L.	42	32	41	12	18
Retema raetam L.	30	22	28	26	30
Calycotome villosa (Poir) Link	32	21	30	18	40
Atriplex halimus L.	8	6	7	19	-
Sarcopoterium spinosum (L.)Spach	55	47	53	38	65

Table- 4: Distribution of the ecological importance values related to the elevation and slope aspects in Tafileh woodlands.

Plant species	North-east slopes		South-west slopes		Plateau 1500 m
	900-1200 m	1200-1500 m	900-1200 m	1200-1500 m	
Juniperus phoenicea L.	28	18	65	13	10
Pistacia atlantica Desf	24	13	20	8	-
Quercus aegilops L.	30	14	18	11	8
Colutea istria Miller	13	10	11	13	-
Gomphocarpus sinaicus R.Br.	40	20	39	10	20
Thymelaea hirsuta (L.)Endl.	48	37	27	15	16
Crataegus aronia (L.)Bosc.ex DC	20	28	24	20	28
Daphne linearifolia Hart	30	19	18	16	38

Table- 5: Estimated tree and shrub densities (per/ha) by habitat types of Ajlun woodland.

Habitat type	Estimated density (per/ha)
North-east slopes	5512
South-east slopes	6280
Plateau sites	4892
Lower elevation slopes	7410
Higher elevation slopes	4895

Table-6: Estimated tree and shrub densities (per/ha) by habitat types of Tafileh woodland.

Habitat type	Estimated density (per/ha)
North-east slopes	6622
South-east slopes	7390
Plateau sites	6010
Lower elevation slopes	8520
Higher elevation slopes	6018

Table-7: Distribution of mean density (per/ha) and percent distribution % of *Quercus aegilops* L. boles surveyed in the Ajlun woodland near Rabad castle.

Habitat type	Mean density (per/ha)	Percent distribution %				
		8-23 cm	24-39 cm	40-55 cm	56-71 cm	72-87 cm
North-east slopes	105	12	35	32	17	03
South-west slopes	210	30	40	30	00	00
Plateau	80	15	40	30	13	02
Lower elevation	215	18	42	40	00	00
Higher elevation	101	14	30	46	10	00
General woodland	130	16	40	30	12	02

Table-8: Distribution of diameter measurements of *Juniperus phoenicea* L.boles surveyed in the Tafileh woodland in Al-ata'ta Mountain near Dana.

Habitat type	Mean density (per/ha)	Percent distribution %				
		8-23 cm	24-39cm	40-55cm	56-71cm	72-87cm
North-east slopes	120	10	37	34	15	04
South-west slopes	225	28	42	30	00	00
Plateau	95	13	42	32	11	02
Lower elevation	230	16	44	40	00	00
Higher elevation	115	12	32	48	12	00
General woodland	145	14	42	32	10	02