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Using vegetation characteristics and biomass of earthworms to estimate fire damages in different elevation classes (case study: Zagros forests in Iran)

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Key words: GIS, Earthworm's biomass, fire, earthworms, vegetation.

Abstract

T Forest fire is the major disturbance that can severely change forest areas. The 1250 *800 m inventory networks using GIS with scale 1/25000 of digital maps were applied for this research. Thirty 30*25 m sample plots had been recorded and then some properties including the spices frequency, the spices type, canopy area, sample plot area, the quantity and biomass of earthworms in one squire meter in the center of sample plots were measured. Canopy area was recorded using two perpendicular diameters and canopy percent for each sample plot was obtained with the total canopy area of trees and shrubs divided by its sample plot area. The results of analysis of variance indicated vegetation, quantity, and biomass had significant relationship between their frequency and canopy percent of trees and shrubs, quantity and vegetation percent, quantity and length, dry and wet weight as well as diameter of earthworms, and also had no significant relationship for moisture percent. Class 1000-1500 of non-fire had maximum canopy percent and a significant difference with burned area. When the elevation increased, the quantity and canopy of trees and shrubs would increase. Results showed the studied properties in control area had more value than those in burned area.

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Introduction

Biodiversity is a several-million-year heritage that can't be obtained easily and also has a high potential for making welfare, peace, and comfort. Biodiversity term refers to comprehensive quantity and diversity of life raging from plants, animals to microbes. This diversity occurs in all level of ecological organizations. It is clear that destructing ecosystems threats the essential net in the world. Forests are the natural ecosystems which can adjust the disorders made by nature and human, but if the pressure of the human activities on forests increased, the forests couldn't reform themselves appropriately (Barnes *et al.*, 1998). Forest dynamics are affected by factors and processes including site conditions, spices combination, regeneration, and disturbances. Forest fire is the main and important disturbance that can severely change the area of forests. As a consequent, increasing the knowledge about forest fires for managing these natural ecosystems should be considered by experts and they will inform it to local people. Firing cause to destruct genetic stocks, delay reaching climax, and impose high expense on society (Jazirie, 1990). 3063 fire events had occurred from 1991 to 1997 that omitted 13700 ha of natural resources in Iran and also the maximum of this issue belonged to 1998 with 998 fire events which covered an area of 206713ha (Hematboland, 1988). FAO in 2005 reported about 6500 ha of Iran's forests are destructed each year. Hence, the less amount of forest and more utilizations than other countries cause to get more consideration about short and long time consequences of this destructive environment phenomenon (Sohailiesfehani, 2009). Fire is one of the most dangerous events that threat forests and rangelands especially in arid and semiarid areas and causes to make a significant reduction in woody and herbal supplies (Laughlin *et al.*, 2004) and also can affect site quality and fauna as well as other sections of ecosystem as a strong environmental factor (Feller, 1982). Fire events have various effects on vegetation so that they increase spices richness and diversity in dormant season and decrease diversity in growing season (Dal, *et al.*, 2002). As regards, bio reserves are the main component for supporting the life in the world (Mohammadifazel *et al.*, 2000) so identifying economic problems, sustainability, and application of ecosystems are the essential factors in this field (Ammer, 2005). Although the fire effect on soil fauna and their relationship with plant societies is unclear in long time, it is supposed that there is a tangled relation among soil organisms (e.g., earthworms) and vegetation (Hart *et al.*, 2005). Therefore, earthworms are the main microorganisms in the soil that have significant quantity and weight (Hajizadeh, 1990). Hence, earthworms were selected to study the fire effects on biodiversity of soil organisms.

The aim of this study is an estimate fire damages in different elevation classes by using vegetation characteristics and biomass of earthworms to in Zagros forests (west of Iran)

Material and methods

Site description

Kohgiloieh-va-Boierahmad province with an area of 16249 km² covers one per cent of total area of Iran. The existence of various climates among its cities cause to make an especial view in this region and it is known as four season province (i.e., the differences among four seasons is significant). Dill Protected Region with the longitude ranging from 50 ° 46 ' E to 36 ° 45 W which has differences of soil characteristics, physiography, and fauna and flora diversity was selected for this research. This conserved area with an area of 10374 ha and the minimum and maximum elevation ranging from 500 to 2020 m above sea level (a. s. l.) is the most beautiful place for tourism that it due to high diversity of plant spices such as *Querqus branti, Ulmus carpinifolia, Crataegus aronia, Pistacia atlantica, and Amygdalus communis*. Fire events are usually happened in summer season due to dry vegetation of forest floor that the main event was happed in 1998 (fig.1). Most studies about fire have considered the forest soil characteristics. However, there hasn't been done an appropriate study about the effects of fire on biodiversity of soil microorganisms yet. Hence, studying the effects of most dangerous event, fire, on biodiversity is the goal of this research.

Methods

Determining the area of plots and the condition of burned area had been done precisely. As regards, physiographical parameters (i.e., slope, direction, and elevation) have significant effects on soil features such as its moisture and chemistry (Enright, 2005) and they are known as the most important factor in separating ecosystem units(Sohrabi, *et al*., 2007). Every biodiversity researcher should consider all physiographical parameters for their studying, because they have interaction with themselves (Barnes, *et al*., 1998). The appropriate spice according to its location on the land was selected for this study. The 1250 *800 m inventory networks using GIS with scale 1/25000 of digital maps were applied for this research (fig.2.). Accordingly, thirty 30*25 m sample plots had been recorded and then some properties including the spices quantity, the spices type, canopy area, sample plot area, earthworm's quantity and biomass in one squire meter in the center of sample plots were measured. After that, Canopy area was recorded using two perpendicular diameters and finally canopy percent for each sample plot was obtained with the total canopy area of trees and shrubs divided by sample plot area (Pourhashemi, 2000; Mohammadi *et al.,* 2006; Salehi *et al.,* 2010). Direction was equal for all samples so slope and above sea level just were measured in this study. Four 1.5 *1.5 micro plots were randomly selected for vegetation in each plot (Cain, 19388) and the spices type and canopy percent according to quadratic network system were measured (Mesdaghi, 2001). Metallically cubic box was used for studying earthworm's quantity and biomass (Koch *et al*, 2009). For identifying the type of earthworms using Boch's dentification key and it was determined that the earthworms belonged to *lumbricidae* family, *lumbricus* genus, and *terrestris spices*. After five times compacting metallic box in soil, their quantity and wet weight were recorded. Finally, the earthworms were sent to laboratory and were maintained in 60 º c for 48 hours (Jalilvand *et al*, 2007). Data analysis was done with SAS (Statistical Analysis System) and Duncan method. T-test was used for difference between fire and non-fire area.

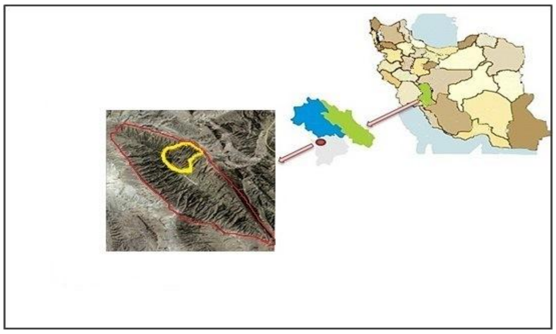

Fig. 1. The location of burned area in Dill protected region.

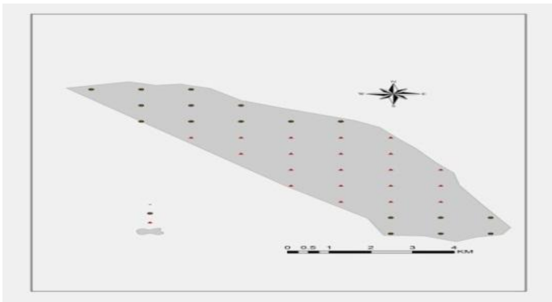

Fig. 2. The inventory network and location of plots.

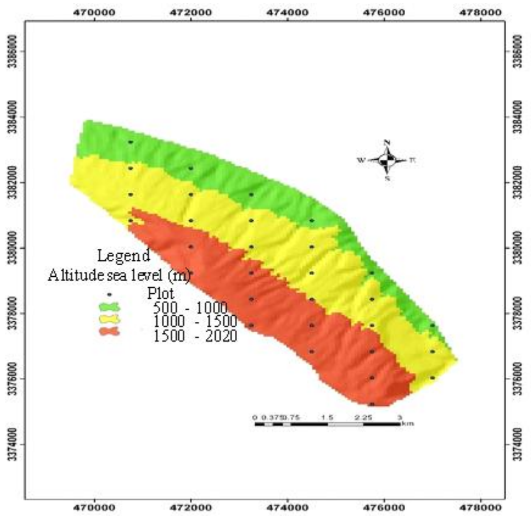

Fig. 3. The map of altitude sea level of case study.

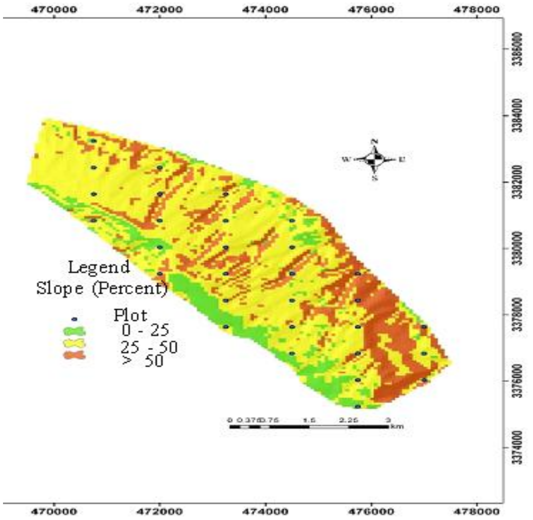

Fig. 4. The map of slope of case study.

Results

Results showed the slope in all sample plots were 28.13% and 26.7 % for control area and burned samples (fig.5.). Slope percent according to a. s. l. classes showed the class 500-1000, 1000-1500, and 1500-2020 were recorded 41.8, 29.4, and 13.2 for control area and 32.2, 27.8, and 13 for burned area, respectively (fig.6.). According to results, when a. s. l. was increased the slope would be decreased. The results of analysis of variance indicated vegetation, quantity, and biomass have significant relationship between frequency and canopy percent of trees and shrubs, quantity and vegetation percent, quantity and length, dry and wet weight as well as diameter of earthworms, and also have no significant relationship for moisture percent (Table1.). According to fig.7. to 11, there were not found a significant relationship according to quantity and biomass in 500-1000 and 1000-1500 meter between burned and control area , but this value was found for less 1500-2020 m. Class 1000-1500 has more quantity and biomass than other classes. In addition, there was found the significant value for properties shown in fig. 11. to fig.12. Between control area and burned area. Accordingly, when the a. s. l. and slope was increased, the fire effects would be increased on reduction of quantity and biomass. Classes 1500-2020 and 1000-1500 have more trees and shrubs than class 500-1000 m. There was not any significant difference between 1500-2020 and 1000-1500 of control samples, but this value has found for burned samples. There was not found a significant difference between class 100-1500 and 1500-2020 in both control and burned area. Class 1000-1500 of control area had maximum canopy percent and had a significant difference with burned area (fig.18.). According to fig.19. And fig.20., although there were not any significant difference regarding trees and shrubs between control area and burned area, this value found for canopy percent. Furthermore, with increasing the frequency of plant spices, the canopy percent also would be increased that the maximum value belonged to slope class of more than 30% (fig.21.). Consequently, control area had more frequency and canopy percent than burned area (fig.17.). There was found a positive correlation between quantity and biomass of earthworm and the maximum value was appeared between dry and wet weight of earthworm (Table2.). However, there was obtained a negative correlation between vegetation and trees for frequency and canopy percent.

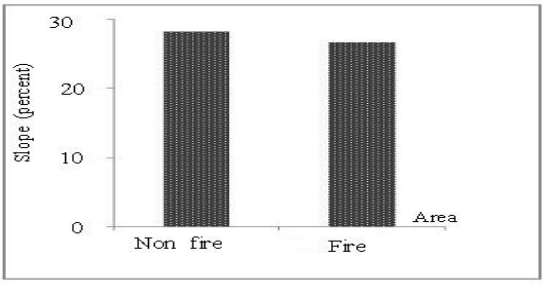

Fig. 5. The slope of fire and non-fire area.

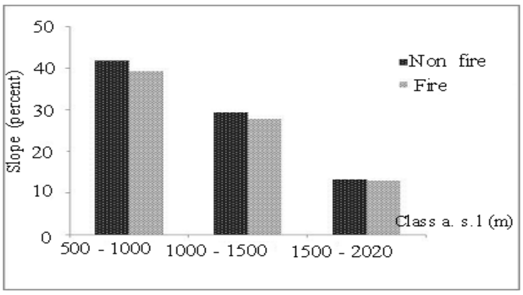

Fig.6. The slope in altitude sea level of fire and non-fire area

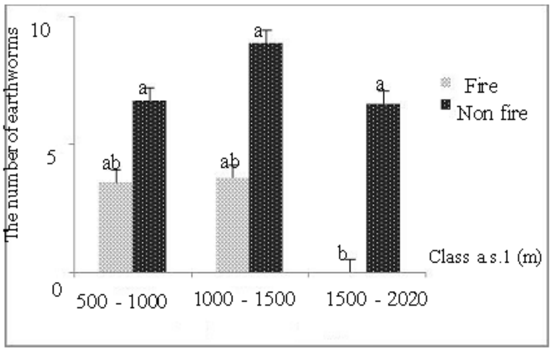

Fig. 7. The number of earthworms in the sample plot.

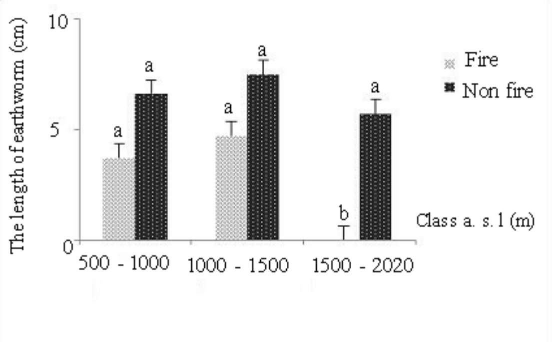

Fig. 8. The length of earthworms according to a.s.1 classes.

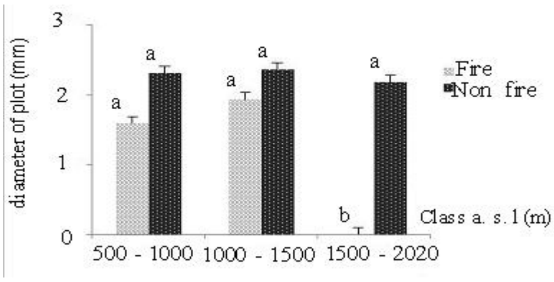

Fig. 9. The diameter of earthworms according to a.s.1classes.

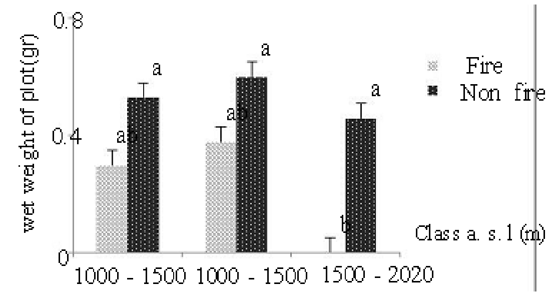

Fig. 10. The wet weight of earthworms according to a.s.l classes.

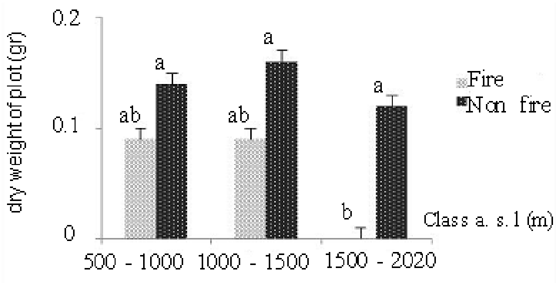

Fig. 11. The dry weight of earthworms in burned and control area.

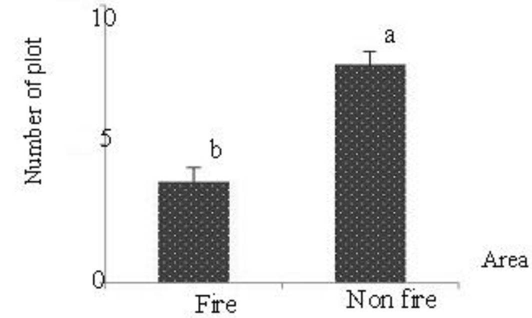

Fig. 12. The number of earthworms in burned and control area.

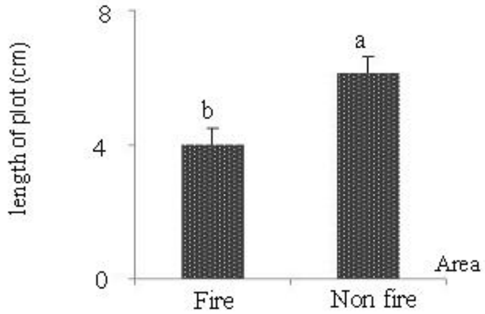

Fig. 13. The length of earthworms in burned and control area.

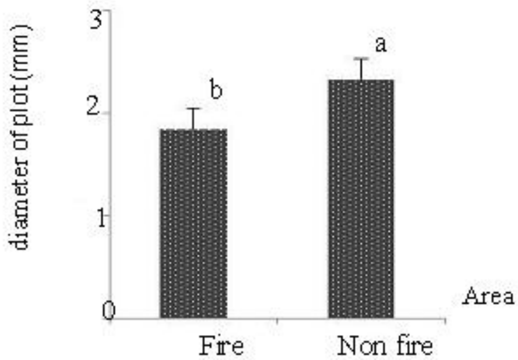

Fig. 14. The diameter of earthworms in burned and control area.

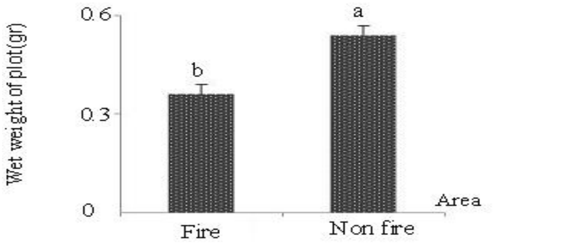

Fig. 15. The wet weight of earthworms in burned and control area.

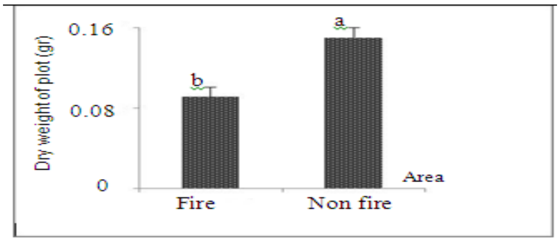

Fig. 16. The dry weight of earthworms in burned and control area.

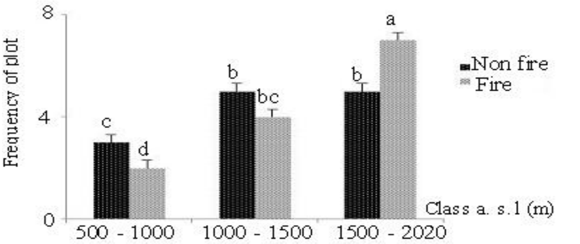

Fig. 17. The frequency of trees and shrubs in burned and control area.

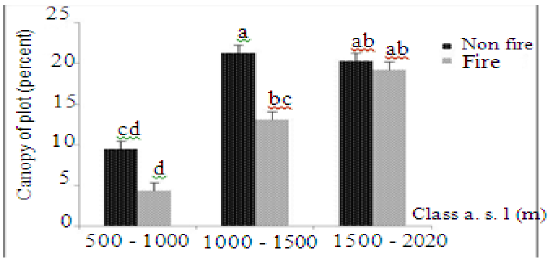

Fig. 18. The tree and shrub canopy in burned and control area.

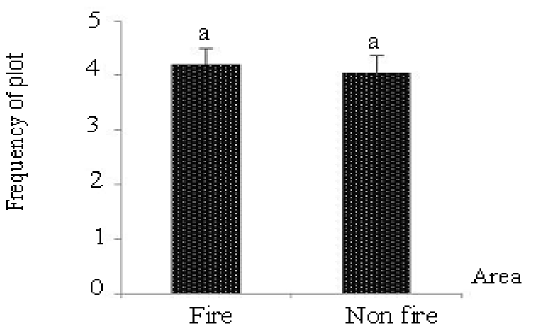

Fig. 19. The frequency of trees and shrubs in the sample plot of burned and control area.

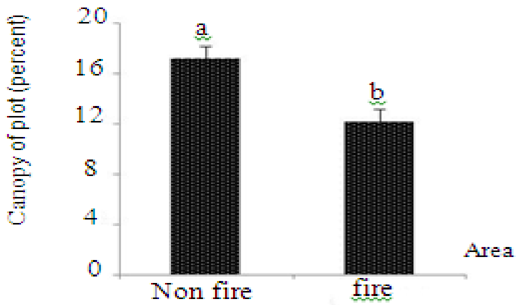

Fig. 20. The tree and shrub canopy in the sample plot of burned and control area.

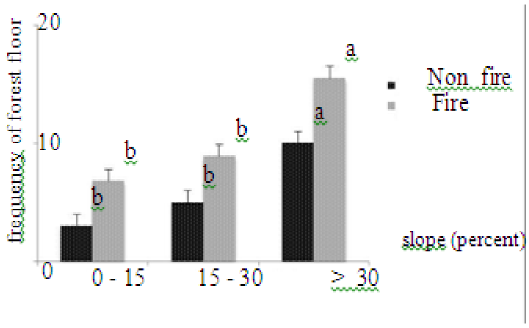

Fig. 21. The slope effects on frequency of forest floor.

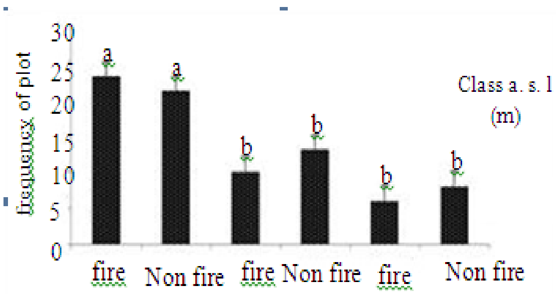

Fig. 22. The herbal spices frequency in burned and control area considering to a.s.l. classes.

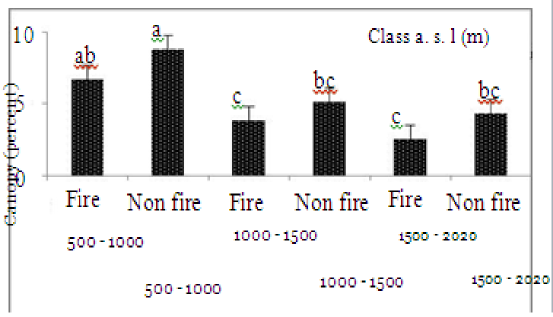

Fig.23. Herbal canopy percent in burned and control areas.

Table1. The analysis of variance for measured properties of vegetation and earthworm.

						Earth worm					
Variables	df	Tree And shrub numbers	Tree And Shrub canopy	Vegetation numbers	Vegetation canopy	Numbers	Length (cm)	diameter (mm)	Wet weight (gr)	Dry weight (gr)	Moisture (percent)
Area (place)	1	0.13^{ns}	184.1^{*}	2.7^{ns}	90.13^{*}	286.67^{**}	92.72^{**}	5.34^{**}	0.16^{**}	0.08^{**}	17201^{ns}
a.s.l	2	27.23^{*}	472.7^{**}	140.4^{**}	206.1^{**}	33.99^{ns}	12.44^{ns}	0.69^{ns}	0.07^{*}	0.22^{ns}	114347^{ns}
Area*a.s.l	2	8.6^{**}	27.7^{ns}	0.4^{ns}	1.63^{ns}	16.79^{ns}	0.41^{ns}	0.38^{ns}	0.001^{ns}	0.002^{ns}	3172^{ns}
Coefficient of variance		24.97	11.04	12.11	12.1	18.64	11.72	8.86	15.37	14.6	16.6
Significant level		0.001^{**}	0.003^{**}	0.0001^{**}	0.003^{**}	0.0001^{**}	0.0001^{**}	0.03^{*}	0.002^{**}	0.001^{**}	0.06^{ns}

ns, *, ** show no significance and significance at 1% and 5% level, respectively.

Table2. The colleration between quantity and biomass of earthworms.

	earthworm				
	Quantity	Length	Diameter	Dry weight	Wet weight
Quantity	1.000				
Length	0.79	1.000			
	.0001				
Diameter	0.79	0.9	1.000		
	.0001	.0001			
Dry weight	0.79	0.9	0.9	1.000	
	.0001	.0001	.0001		
Wet weight	0.8	0.89	0.93	0.97	1.000
	.0001	.0001	.0001	.0001	

Discussion

When the vegetation burns, most efficient nutrients will be released. Therefore the food supplies will be decreased and the soil characteristics and plant growth will have been aborted for a short time due to lack of food sources for macro and microorganisms such as earthworms (Baker *et al.*, 1999). Wood and jims (1993) concluded mineral section of soil was the indispensible factor for growing earthworms and the soil with low C/N has high biomass. Neirynck *et al.* (2000) showed the low C/N leads to appear more earthworms in forest soil. Sampling was done in summer and also according to the climate of our case study, semiarid, can be resulted that in those areas where fire occurred, the quantity and biomass of earthworms will be decreased due to reducing tree and shrub frequency and canopy and increasing evaporation (fig.7. to fig.16.).

Table3. The correlation of vegetation in the case study.

	Vegetation			
Vegetation	Tree and shrub numbers	Canopy percent	Herbal spices numbers	Herbal canopy percent
	1.000			
Canopy percent	0.73	1.000		
Herbal canopy	.0001			
	0.62	0.58	1.000	
Herbal spices	0.0003	0.0008		
	0.51	0.45	0.9	1.000
Tree and shrub	0.004	0.0120	.0001	

When the canopy percent is decreased, leaching and acidity of soil certainly will be amplified and leads to destroy earthworm habitants (comparing fig.17. and fig.18. with fig.12. to fig.16.). There was found a significant relationship between biomass and quantity of earthworms (Table2.) that increasing earthworms cause to increase biomass. This result is similar to those obtained by Haynes, *et al.* (2003). The life of macro and microorganism in soil are depends the organic compounds of carbon (Navvabzadeh, 2007). Hence, there are appropriate layer of litterfall and moisture in the areas without fire events. There are some factors that affect biomass and quantity of earthworms. For instance temperature as an important factor for this issue so if the a. s. l. increases, the temperature will decrease. Because there was not any significant reduction in earthworm's biomass and quantity, it can be concluded that the major factor considering to this value is fire (fig.5. to fig.11.). Consequently, fire is the first factor and other factor such as temperature and human activities are subsidiary for variations of soil characteristics and then on earthworm's properties (Eliasazar, 1995). As regards, almost the reason of all fire events due to human activities, so we can conclude human activities in direction of firing is the major factor for earthworm's characteristics. Reducing earthworm's biomass and quantity leads to make a disturbance in soil characteristics for example decreasing fertility and essential nutrients as well as omitting most spices of earthworm (Person, 1988) and also this value cause to reduce growth and regeneration of trees (Koch *et al.*, 2007; Koch, 2006). The results showed plants would increase with increasing a. s. l. (fig.22. and fig.23.). This result is similar to those obtained by Ebrahimi (2002) and Fisher *et al.* (2004) that its reason due to favorite temperature in low elevation. The quantity and canopy percent of trees and shrubs had a negative relationship with slope (20 and 21). The chemical and physical characteristics of soil are the factors which affect the existence of spices (Enright, *et al.*, 2005). The positive relationship between the frequency of trees and shrubs and elevation that this issue may be due to pressuring human activities which cause to move woody species to upward. Therefore, increasing herbal species than woody spices is the prohibited variable in order to reach climax stage in forest ecosystems. Fire events cause to make a reduction in litterfall density and then decrease fertility and earthworm's biomass and quantity. The results of this research showed effective organisms of soils are the appropriate factor for evaluating the quality of soil. Class 500-1000 m of elevation faces the maximum damages so that this area needs more consideration.

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