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Impact of Recreational Trampling on the Natural Vegetation in Termessos National Park, Antalya-Turkey

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Abstract: Recreation activities could create various impacts on the natural environment. One of the recreation impacts is trampling that largely inevitable wherever nature visits occur. While consequences of trampling disturbance vary by the type of environment; vegetation is a significant indicator representing the form and degree of human-nature relation including recreation use. The aim of this study was to investigate the impact of recreational trampling on the Mediterranean natural vegetation in case of Termessos National Park, Antalya, so to contribute nature conservation planning and management. Based on a field sampling design species richness, vegetation height and vegetation cover were taken as impact indicators and assessed in trail and control plots. Study results showed that trampling impact on vegetation cover and height was already evident with the tendency of being higher on controls and lower on trails by use and use-related variations. But species richness was not on the verge of trampling disturbance yet, due to characteristics of the Mediterranean environment and likely competation for light on the trails. Accordingly species diversity in herbaceous vegetation level was also higher in trampled trail sites. Hereby the level of trampling impact is not at the threshold of alleviating species diversity and is rather in form of physical pressure on the vegetation, therefore most accessible and straightforward measure can be maintaining existing visitor numbers and to line up a visitor management programme such as dispersal of users from very heavily used trails to less used trails. Yet a site management plan that seeking a fine balance between recreation use and nature protection and taking the trampling impacts into account can help to maintain long-term conservation targets.

Key Words: Recreation impact, trampling, vegetation, Mediterranean environment, Termessos National Park

Antalya Termessos Milli Parkındaki Rekreasyonel Çiğneme Faaliyetlerinin Doğal Bitki Örtüsü Üzerine Etkisi

Öz: Rekreasyon faaliyetleri doğal çevre üzerinde olumsuz etkilere neden olabilmektedir. Doğa ziyaretlerinin gerçekleştiği bütün alanlarda kaçınılmaz olarak ortaya çıkan çiğneme, bu etkilerden biridir. Diğer yandan rekreasyonel çiğneme etkisi çoğu zaman çevre koşullarına bağlı olarak değişiklik gösterirken, doğal bitki örtüsü rekreasyon faaliyetleri de dahil olmak üzere insan-doğa arasındaki ilişkilerin şekli ve düzeyini ortaya koyan önemli bir göstergedir. Bu çalışmanın amacı Antalya Termessos Milli Parkı örneğinde rekreasyonel faaliyetler nedeniyle ortaya çıkan çiğneme etkisinin doğal bitki örtüsü üzerindeki etkisini araştırmak ve bu yolla doğa koruma planlaması ve yönetimine katkıda bulunmaktır. Alan örneklemelerine dayalı olarak gerçekleştirilen bu çalışmada etki indikatörleri olarak kullanım ve kontrol parsellerindeki tür çeşitliliği, vejetasyon yüksekliği ve vejetasyon örtü derecesi incelenmiştir. Çalışma sonuçları çiğneme etkisinin vejetasyon örtü derecesi ve vejetasyon yüksekliği üzerinde etkili olduğunu, çiğneme etkisi sonucu vejetasyon örtü derecesi ve vejetasyon yüksekliğinin kontrol parsellerinde daha yüksek ve kullanım parsellerinde daha düşük olduğunu göstermiştir. Fakat kullanım parsellerinde daha yüksek çıkan tür çeşitliliğinin, Akdeniz bölgesinin çevre koşulları ve yürüyüş güzergahlarındaki ışık rekabeti dolayısıyla henüz çiğneme etkisine bağlı değişim düzeyinde olmadığı anlaşılmıştır. Benzer şekilde otsu vejetasyon düzeyindeki tür çeşitliliği çiğnenen kullanım parsellerinde daha yüksek bulunmuştur. Burada çiğnemenin doğal bitki örtüsü üzerindeki etkisi tür çeşitliliğini azaltacak düzeyde olmayıp, daha çok fiziksel baskı şeklindedir. Bu nedenle mevcut ziyaretçi sayısının korunması ve kullanıcıların çok yoğun kullanılan güzergahlardan daha az kullanılan güzergahlara yönlendirilmesi gibi ziyaretçi yönetimi doğrudan alınabilecek önlemler olabilir. Ancak rekreasyonel kullanım ile doğa koruma arasında iyi bir dengeyi hedefleyen ve çiğneme etkisini dikkate alan bir alan yönetimi planı, uzun vadeli koruma amaçlarının gerçekleştirilmesine katkı sağlayacaktır.

Anahtar Kelimeler: Rekreasyon etkisi, çiğneme, doğal bitki örtüsü, Akdeniz bölgesi, Termessos Milli Parkı

Introduction

Considering the various disturbances that natural areas have been subjected to, the outdoor recreation activities could create various impacts on the natural environment, i.e., erosion, plant damages, wildlife disturbance, etc. Here impact is determined as a undesirable change in environmental conditions (Cole

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and Hammitt 1998), where Cole (2004a) defined that trampling as the most prevalent recreation impact process and particularly problematic, because they are largely inevitable wherever recreation use occurs (Cole and Spildie 1998).

Vegetation is an indicator that representing the type and degree of the recreation impact. The change in the vegetation that associated with trampling impact has been used as an effective ecological tool by many researches. Cole and Bayfield (1993) confirmed that changes in vegetation cover, vegetation height, bare ground cover and the cover of individual species can be assessed for indicating recreation impact. Hammitt and Cole (1998) informed that ground cover vegetation is impacted by visitor use and as a result of trampling plants were broken, bruised and crushed.

Trampling studies are often regarded as the basic research in recreation ecology (Liddle 1997). Impacts of trampling on vegetation as decreasing number of species, decline of plant height and species abundance and vegetation cover loss were confirmed (Bayfield 1979, Bright 1986, Sun and Liddle 1993, Kobayashi et al. 1997).

Since trampling impact has been diverse and severe, vegetation response to trampling can be characterized by different ways. Marion and Leung (2001) and Farrell and Marion (2002) indicated that trail condition assessment, trail maintenance assessment, systematic point sampling and stratified point sampling are some of the assessment methods in trail impact management. More specifically Kutiel et al. (1999) applied point sampling by setting two perpendicular sections as use and control on the each trail with a defined distances from each other as did Whinam and Chilcott (1999) and Whinam and Chilcott (2003) in their works.

From a managerial perspective carrying capacity planning and management frameworks are increasingly being applied by managers according to the trampling and trail resource impacts (Marion and Leung 2001). As a result of their studies, Monz et al. (2000) recommended proper visitor education and regulation, Farrel and Marion (2002) remarked the action to reduce and limit use while Cole and Spildie (1998) committed such measures like zoning protected areas, separating different uses or limiting amount of use.

Vegetation change can contribute better understanding of recreation impacts on natural environment and they can be used as an effective tool in conservation planning and visitor management in national parks. Buckley and King (2003) affirmed that there is only a tiny proportion of data which would be needed to predict the impacts of trampling at any intensity in any ecosystem worldwide. Revealed impacts of trampling provide basic information for the outdoor recreation area managers and enable them to allow recreation activities while preserving the environment (Calson and Godfrey 1989), with an overall assessment of potential effectiveness of management actions such as site rotation or temporary closure (Cole 1987). Therefore it is important to identify impacts of recreation particularly on the vegetation for proactive measures. However Cole (1981) stated that current attemps to minimize these changes were often inadequate due to lack of ecological information.

Although several studies informed a negative correlation between recreational intensity and plant cover, plant height, species richness and species diversity (Hammit and Cole 1998, Kutiel et al. 1999, Nepal and Way 2007), patterns of change should be determined by the original environments (Kobayashi et al. 1997), because site-specific and location factors are highly influential on the degree and form of the impact associated with recreational activities.

Andres-Abellan et al. (2006) reported that recreation impact studies have been conducted majorly in alpine and subalpine ecosystems or humid forests. Few studies have been carried out on dry conditions of the Mediterranean forests. In order to make comparision in recreation impacts across different ecosystem types (Monz et al. 2000) regional surveys are needed for geographical distribution of recreation ecology research.

The aim of this study was to investigate the impact of recreational trampling on the Mediterranean environment in case of Termessos National Park. Turkish Mediterranean flora is typically characterized by sclerophyllous vegetation of shrubs and small trees that are known as macchia, garrique and phrygana depending to their place of origin and particularly to the degree of disturbance. Cayuela et al. (2008) confirm that under the present climate conditions characterized by drought during the hot season; sclerophyllous and evergreen trees and shrubs dominate the Mediterranean environment.

In Turkey, in spite of the trends towards increasing visitation for outdoor recreation in natural protected areas very limited information can be found on the impact of recreational activities. On the other hand a key role of the designated national parks is to serve recreational facilities to all. An available study was conducted by Aslanboğa and Özkan (1986) in camping sites on Agean and Mediterranean coasts of Turkey.

In this study the impacts of recreational trampling on natural Mediterranean vegetation were analysed on the trails of Termessos National Park in Turkey. Vegetation cover, species richness and vegetation height were taken into account as impact indicators. A field sampling design was set by comparison of trail (trampled) and control (untrampled) areas. Experimental approach of this study provides an opportunity to test how natural vegetation responses to trampling and to what extend Mediterranean environment reflects the predicted recreation impacts.

Materials and Methods

Study Area: Termessos National Park was chosen due to its strong natural and cultural assets blended in the Mediterranean environment, easy visitor access and being one of the most visited protected area in Antalya. Located on the northwest part of Antalya, Termessos was designated as "national park" in 1970 (Anonymous 1970). The Park is situating on a steep topography ranging from 250 m to 1265 m from the sea level with a surface area of 6702 ha (Figure 1). The major recreation activity in the park is hiking and sight-seeing through the narrow trails which is appreciated by an average 34.000 visitors per year (Sayan et al. 2005).

Mediterranean climate is typical in the park and in the region which is known hot and dry summer, rainy and temperate winter conditions. However it is also terrestrial with snow and frosts over 800 m from the sea level. Therefore local micro-climate changes from hot to mild, temperate to terrastrail depending on the altitude and this encourages diversity of the species. The flora of the national park was defined considerably rich with 686 plant species, 80 of them are endemics alone (Alçıtepe, 1998).

Methods: Five trails of the Termessos National Park were examined with field sampling techniques (Figure 1). The species richness, vegetation height and vegetation cover were measured and analyzed as impact indicators in the trail and control plots using vegetation analysis methods. The field sampling system was designed according to the studies of Kutiel et al. (1999), Leung and Marion (2000) and Whinam and Chilcott (2003).

Five sampling points were selected randomly on five trails at the national park. Characteristics of selected trails are given in Table 1. In each sampling point, indicators were measured in totally six plots which were selected transverse to the trails: three plots were selected in 5m both sides of the central axis of the trails (trampled) and other three plots were selected between the 15th and 20thm both sides (untrampled) which were taken as control plots (Figure 2).

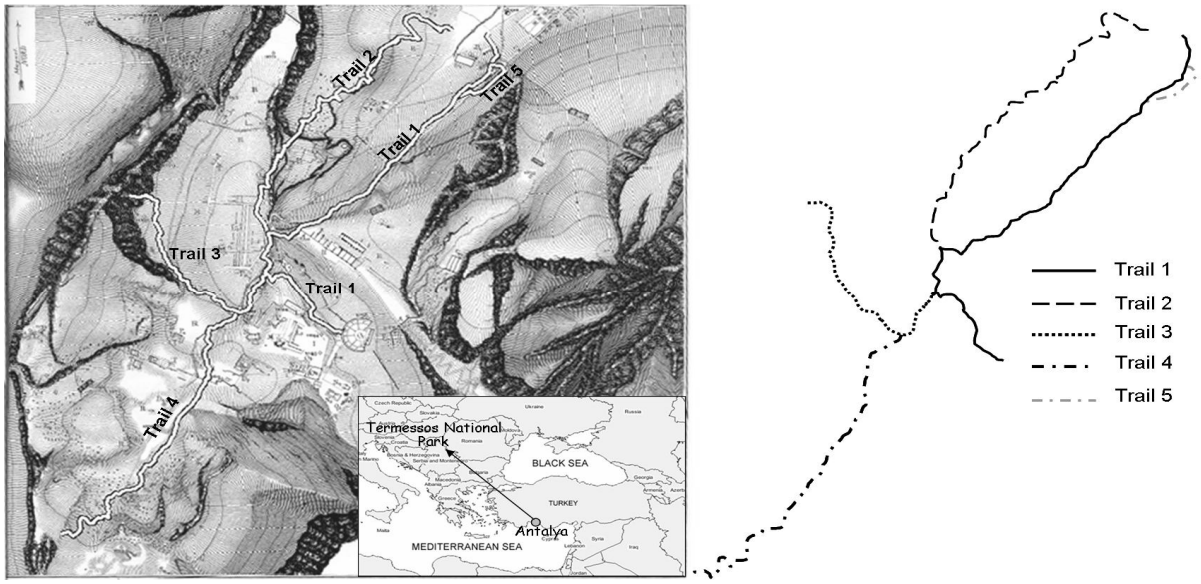

Figure 1. Location of Termessos National Park and the Trail System

Table 1. Site characteristics of the trails

Characteristics	*Trail 1*	*Trail 2*	*Trail 3*	*Trail 4*	*Trail 5*
Level of use	Very high	High	Moderate	Low	Very low
Elevation (meters; start-end)	880-1021	883-992	1003-1066	1021-1129	886-910
Trail length (meters)	980	843	473	696	144
Average slope (%)	14	13	13	15	16

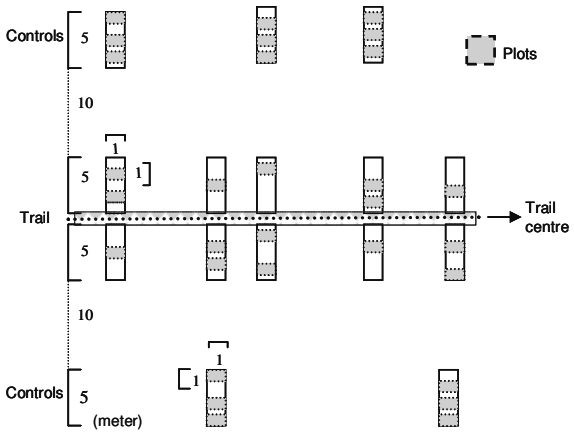

Figure 2. Sampling system on the trails

For each sampling plot overall percentage of vegetation cover, species richness and vegetation height were measured. A summary of impact indicators is given in Table 2. Here trampling "***use***" was the main impact for change of the vegetation with all selected impact indicators that were affected individually by variation of use, altitude and season. Season was taken as spring, summer and autumn as an indicator of visitor density where altitude was the rising elevation. Information on the vegetation was taken from the edges of the trail not in the middle of heavily trampled trail centre with bare ground. The study was carried out in one year.

Analysis of variance (ANOVA) was applied to test significiant relation between single factor of use, elevation, season and their interactions on the field sampling results based on the comparison of trail (trampled) and control (untrampled) areas. Data processing and analyses were conducted with SPSS 9.0 software.

Species richness, vegetation height and vegetation cover were tested by ANOVA (McPherson, 1990) to account for the relative trampling impact as did Whinam and Chilcot (2003), Cole and Monz (2004), Cole and Spildie (1998), Pellerin et al. (2006) in their recreation impact studies. The significant value at the 0.01, 0.05 and 0.001 levels was evaluated.

Table 2. Impact indicators

Indicator	Measurement
Species richness (#)	Average overall number of species in each plot
Vegetation height (cm)	Avarage initial height of plants (cm) found in each plot
Vegetation cover (%)	A visual assessment of plant cover in each plot

Results

The potential vegetation of Termessos National Park is Mediterranean evergreen forest and sclerophyllous macchia (Atalay 1983, Alçıtepe 1998, Altan 2000, Yılmaz 2001). Macchia vegetation can turn into primer macchia or evergreen forest by its regeneration ability when the anthropogenic effects dissappear as it did in Termessos. Natural vegetation in the research area is characterized by sclerophyllous trees of Kermes oak (*Quercus coccifera*), olive (*Olea europea*), mastic tree (*Pictacia lentiscus*), terebinth (*Pistacia terebinthus*), carob tree (*Ceratonia siliqua*), Turkish pine (*Pinus brutia*), laurel (*Laurus nobilis*), strawberry tree (*Arbutus andrachne*), cistus (*Cistus creticus*), oleander (*Nerium oleander*) and over 1000 meters junipers (*Juniperus excelsa, J. oxycedrus*) and Lebanese cedar (*Cedrus libani*) (Altan 2000, Yılmaz 2001).

Field observations revealed that vegetation cover was diverse along the trails. Trail 1 has very high visitor use and most characteristic species on the exposed trail slopes were *Astragalus hamosu*s shifting its place to *Acantholimon acerosum* in control plots with dominant species of *Quercus coccifera, Ruscus aculeatus, Osyris alba* and *Daphne gnidioides*. Having high visitor use, thick vegetation along the Trail 2 consisted of *Quercus coccifera, Quercus infectoria* and *Quercus cerris*. Trail 3 has moderate visitor use where *Quercus coccifera, Q. infectoria, Styrax officinalis, Colutea melanocalyx* composed a tall tree layer. Trail 4 has low visitor use and due to high altitude vegetation became dwarf and stocky by constant wind. Having very low visitor use species diversity in perennial herbs was exaggerated by carriage and light on Trail 5.

Species Richness: One of the main indicators in determining trampling impact on vegetation is the species richness. Results showed that species richness in Termessos National Park was significantly affected by all single factors of use, altitude, period and interactions between these variations (Table 3). It was clear that use *trampling* factor was significantly effective on species richness that species richness was changing and likely to change over single factors of *use* (P≤0,001), *altitude* (P≤0,001) and *season* (P≤0,001) as well as multiple interactions over *use x altitude* (P≤0,001), *use x season* (P≤0,001) *altitude x season* (P≤0,05) and *use x altitude x season* (P≤0,01).

However as seen in Figure 3, trampling has been appeared to have an adverse effect in Mediterranean environment that species richness was generally higher in trail plots than controls. Similar outcomes were confirmed by Bright (1986) and Bayfield and Brookes (1979) in evergreen vegetation environments. From an ecological perspective this is apparently due to increased light, water and nutrients in open trail sections contrary to closed tree canopy in the control plots.

The ground cover composition in Termessos National Park was primarily characterized by herbaceous plants. Most representative species are *Scabiosa rotate, Silene vulgaris, Clinopodium vulgare, Nectaroscordum scilum, Doronicum vernalis, Arisarum vulgare, Ornithogalum narbonense, Umbilicus erectus* in trail plots and *Althea cannabiana, Anchusa indulata, Anthemis chia, Cerastium glomeratum, Lysimachia linum-stellatum, Valeriana disocoridis, Rosularia libatonica, Ricotia sinuata, Origanum onites, Malcolmia flexuosa, Verbascum sinuatum, Lagoecia cuminoides, Cruciata taurica* in control plots. They often associated and become competitive with some macchia species, i.e., *Rhamnus oleoides, Styrax officinalis, Anagris foetida, Fontanesia phillyroides, Smilax aspera, Ruscus aculeatus, Quercus coccifera, Colutea melonocalyx, Rhamnus pyrellus* which are grown under shady tree canopies.

Vegetation Height: Sun and Liddle (1993) underlined that plant height and morphological structure appear to be strongly associated with resistance to trampling. As seen in Table 3, a significant relationship was found between impact indicator of vegetation height and main factors of use, altitude and season (P≤0,001). The vegetation height which was typically decreasing in trail plots was the most visible and detectable evidence of the physical trampling effect on the vegetation (Figure 4). Multiple statistical interactions over *use x altitude* and *altitude x season* (P≤0,001) provided more relatively influential effect on vegetation comparing to *use x altitude x season* (P≤0,05) multiple interaction. This shows an eventual change of the plant morphology by rising elevation reaching up to 1265 m in the national park.

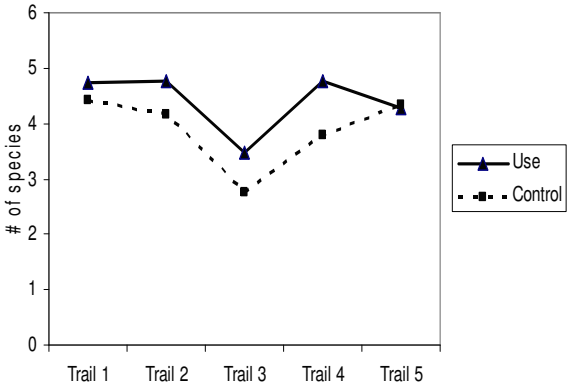

Figure 3. Change in species richness along use and control plots

Table 3. Statistical probabilities (ANOVA) for species richness, vegetation height and vegetation cover

Main factors and their interactions	Species Richness (#)	Vegetation Height (cm)	Vegetation Cover (%)
	P Values		
Use	0,000***	0,000***	0,038*
Altitude	0,000***	0,001***	0,000***
Season	0,000***	0,000***	0,339
Use x altitude	0,000***	0,008**	0,000***
Use x season	0,020*	0,109	0,772
Altitude x season	0,000***	0,002**	0,044*
Use x altitude x season	0,002**	0,014*	0,725

****, ** and * refer 0,001, 0,01 and 0.05 in the text, respectively.*

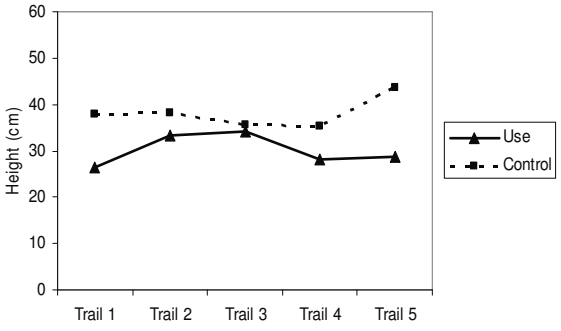

Figure 4. Change in vegetation height along use and control plots

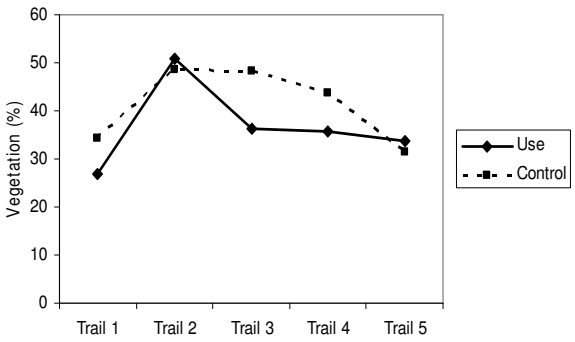

Figure 5. Change in vegetation cover along use and control plots

Vegetation Cover: When a recreational use has already occurred, impact can be identified by comparing vegetation cover on recreation sites over on adjacent undisturbed sites (Cole 1995). ANOVA analysis in Table 3, showed that vegetation cover was strongly influenced by the *altitude* and *use x altitude* interaction (P≤0,001). Single factor of use and *altitude x* season interactions were also significantly effective on vegetation cover (P≤0,05). Impact on vegetation in zones above tree line is often severe (Hammit and Cole 1998). Thus applies that vegetation cover was more prone to altitude and altitude related factors. However vegetation cover was generally high in control plots than trail sites as a result of trampling in walking trails (Figure 5).

The evergreen Mediterranean forest provides more shade throughout the whole year than in the deciduous forests. Therefore open belts created by walking trails in the forest environments offer suitable conditions mostly for the herbaceous species. Field analysis showed that herbaceous vegetation appeared to be rather encouraged in trail plots. Competition for light and water tends to create an adverse combination for understory plants in the Mediterranean forests. Regarding to the feature of the original environment in Termessos National Park, maltitude of ancient ruins largely scattered on the ground with tall macchia species creates very deep shade that limits the species richness on the understory in control sites

The herbaceous plant diversity was encouraged in the abundance of sun light on the edges of the trails which is comparatively open than the shady underneath of the tree canopies (Figure 6). Particularly, the dense cover of *Ruscus aculeatus, Quercus coccifera, Hedera helix, Smilax aspera* in control plots in prostrate form enables few species to grow.

Discussion

By this present study, the impact of recreational trampling on Mediterranean natural vegetation in Termessos National Park was carried out in order to maintain and record the scientific data for the Mediterranean environment and increase the comparable results from different studies as mentioned by Cole and Bayfield (1993).

We believe that recreation impact greatly varies by the original environments. As Cole and Spildie (1998) and Hammit and Cole (1998) emphasized that trampling impacts were dependent on user-related and environmental factors and determined major variables were the type and amount of use, user behaviour and particularly the durability of trampled environment.

This study showed that recreational trampling in the Termessos National Park causes an evident impact on the vegetation cover, species richness and vegetation height.

The impact of visitor trampling becomes more influential by the locational factors of elevation and use-related factors such season representing the time of the year when trampling impact created. Under impact factor of season, recreational visits in Termessos National Park were taken into account as spring to summer and finally autumn in parallel with vegetation analysis related to visitor use density.

We have found out that trampling impact in the Termessos National Park have clearly affected the vegetation height and vegetation cover. However species richness was encouraged in the sunny trail sections. Our study results corroborated some of the conclusions of other trampling studies. MacPherson and DeStefano (2003) found that species richness is

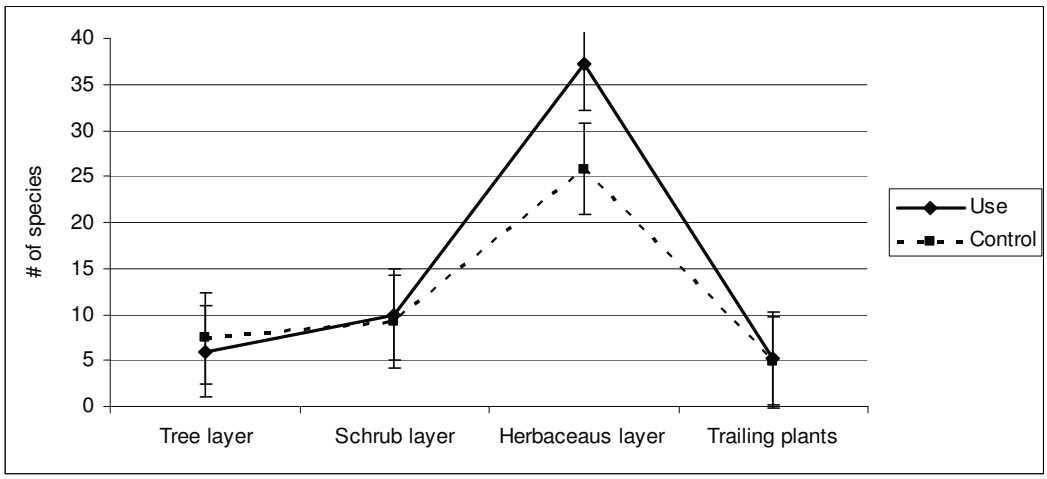

Figure 6. Change in species richness over different vegetation layers

the most simple and straightforward measure of diversity, which found higher on trails and lower on controls. Bright (1986) also found that herbaceous species were more diverse in trail plots than off-trail control plots on the evergreen vegetation trails of Central Texas. Bayfield and Brookes (1979) analyzed similar results in Scotland, and they were recorded no decline in the mean number of species on trails, and found minimal on untrampled areas.

High species diversity in trampled plots that we found in this study can be explained by the ecology of the Mediterranean environment. According to Cayuela et al. (2008) diversity of herbaceous communities by favouring a particular assemblage of species during early establishment is followed by woody vegetation that will exert an influence on the herbaceous community by modifying resource levels, particularly water and nutrient level amelioration and light deprivation in the Mediterranean. With similar results Valladares and Gianoli's (2007) confirmed that competition for water tends to render an adverse combination of shade and drought for understory plants in Mediterranean forests.

Morphological characteristics are primary factors influencing plant resistance to trampling (Leung and Marion 2000). According to Andres-Abellan et al. (2006) trampling affect has proved to produce a different effect on different herbaceous and wood species. Whinam and Chilcott (1999) pointed out that shrubs and shrublands appeared to be more vulnerable to sustained trampling damage than other vegetation forms and types. Vegetation cover assessment in our study indicated that there was higher species diversity in herbaceous vegetation level in trampled trail plots than untrampled controls.

Relevant researches have also found that grasses and grass like plants such as sedges and rushes possess more adaptation and survival strategies that allow them to resist impact than other growth forms (Hammitt and Cole 1998) and more fragile were woody plants (Leung and Marion 2000). On the other hand in closed forest canopies light has become another factor that affecting the vegetation along modified trail conditions.

Methodologically plot sampling was carried out along the trails which were rather trail edge regardless of 0,5-1 m wide heavy trampled trail centre with null vegetation was avoided and control plots were selected in either side of the trail. Considering that Kutiel et al.(1999) described the plant cover on trails in 3-sequence as *trail, edge* and *control,* this study can be characterised in 2-sequence as *"edge-control"* sampling because heavy trampled part of 0,5-1 m wide trail centre with "0 %" vegetation was neglected prior to trail examination.

Here the species richness in Termessos National Park was found lower in controls and higher *on edges* in consistency with the results of Kutiel et al. (1999) which showed a tendency for increase in the number of species on the edges than in the controls. Cole (2004b) also indicated that the vegetation composition adjacent to the trails is often more diverse comparing to undisturbed site controls.

Several studies have shown that there is a delay between trampling impact and vegetation decline and long-term data is required for appropriate management of areas receiving sustained recreation use (Cole, 1987). Kutiel et al. (2000) and Tzatzanis et al. (2003) stated that the low intensity human impact can be alleviated by careful planning of access paths to avoid excessive trampling.

Here, we have seen that (1) recreation impact on vegetation is evident with the tendency of being higher on controls and lower on trails; (2) however, unlike previous studies, species richness among impact indicators is not on the verge of trampling disturbance yet due to characteristics of the original environment and likely competition for light on the trails; which is also related with the durability of plant morphology (3) herbaceous understory vegetation in particular was encouraged despite the high use.

According to Whinam and Chilcott (2003) effects of trampling on the vegetation as vegetation damage, soil compaction, loss of organic material are inevitable and land managers can prefer measures such controlling visitor numbers and keeping them on the minimum.

Our study results indicated that all selected impact indicators of species richness, vegetation height and vegetation cover were significantly affected by use “trampling” and use-related impacts in Termessos National Park (Table 3). However the level of trampling impact is not at the threshold of alleviating species richness (Figure 3) and is rather in form of physical pressure on the vegetation (Figure 4 and 5). Thus was also notable over different vegetation layers (Figure 6).

Sayan et al. (2005) reported that number of people visiting Termessos National Park per year is precisely closer to the maximum acceptable visitor number and thus must be taken as an advantage and sustained by the national park management. Therefore, most accessible and straightforward measure can be maintaining existing visitor numbers and to line up a visitor management programme such as rotation of trails or dispersal of users from very heavily used trails to less used trails as each trail has different use level. Yet a site management plan that seeking a fine balance between recreation use and nature protection and taking the trampling impacts into account can help to maintain long-term conservation targets.

An eventual conclusion can be made that a complete understanding of the functioning of the Mediterranean environment and trampling impacts is still need to be far-examined and monitored and a careful trail and visitor planning is necessary to avoid excessive trampling in Termessos National Park in the coming years.

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