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Trail Impact Management Related to Vegetation Response in Termessos National Park, in Turkish Mediterranean

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1. Introduction

Recreation is a pleasant activity that people realize as function of enjoyment, relaxation and refreshment. Protected natural areas around the world are established and managed to accommodate visitor access and recreation while protecting natural and cultural resources from degradation (Wimpey & Marion, 2011). At the same time, recreation settings alone often include natural areas with special ecological, biological or cultural significance. Therefore recreational impacts on natural areas have become a fundamental concern.

Regarding the disturbances that natural and semi-natural areas are subjected to, hiking trails are largely inevitable wherever recreation use occurs (Cole & Spildie, 1998). Admiting that the enjoyment of scenery is often a positive, desired recreational pursuit in national parks, it can also cause environmental disturbance, particularly in scenic areas (Edington & Edington, 1986). At the same time scenic quality is normally a primary consideration in the development of recreation areas. Therefore care must be taken to ensure that the sources of recreation within a natural environment must be carefully considered to prevent scenic degradation along trails.

Marion & Leung (2001) posited that protection of the natural structure and vegetation along trails is important for establishing sustainable land development in protected areas. Protection of the diversity of flora and fauna found in national parks is one primary basis for nature conservation and is a primary attraction for visitors. But in order to prioritize 'protection' in natural areas, ecological knowledge about the impact of trails can benefit both nature conservation and recreational use.

As a path through a forest or other natural site (Kirkpatric, 1980), trails are the most important element of recreational activities. As linear corridors, trails provide space for walking, viewing scenery, viewing wildlife, studying cultural and for educational visits exploring nature and history. Bell (2001) reported that trails can provide a means of access into the outdoors and nature, stimulating exercise in attractive surroundings and a variety of scenery, where Greer (2000) remarked that trail corridors help people rejuvenate themselves through fitness activities and contact with their environment.

In order to provide safe access to protected areas and to enable facilities for recreational hiking, biking, sightseeing or wildlife observation, a well-designed and managed trail system is crucial. Lynn & Brown (2003) reported that trail-users felt that the naturalness of the site contributed most to their overall recreation experince. On the other hand trail extension and widening had a large effect on all experience indicators, except naturalness.

Trail impact is any undesirable visitor-related change of the natural environment caused by the use of trails. Trail impacts include a variety of problems. Even low levels of trampling disturbance on trails reduce ground vegetation height, cover, and biomass, and may alter species composition by eliminating fragile species (Aust et al., 2005). As a critical issue for protected area management, trail impact has been identified through several different perspectives. Early studies of trail impacts focused on impact severity and environmental factors that affecting trail degradation (Leung & Marion, 2000). Similarly, Farrel & Marion (2002) emphasized trail impacts related to visitation. Nepal (2003) examined trail conditions, Nepal & Nepal (2004) and Turton (2005) summerised visitor impacts on trails, whereas Hall & Kuss (1989) and Bhuju & Ohsawa (1998) examined vegetation responses to trail impacts.

Common trail impacts include vegetation loss, compositional changes in the vegetation, soil compaction, exposure of plant roots (Marion 1994; Marion & Leung 2001; Farrel & Marion 2002; Marion et al., 2006). Nepal & Way (2007) reported that there were significant differences between control and trail-side quadrats in relative vegetation cover and overall species richness. Visitor-based deterioration has also been documented as increased trail incision, muddiness and widening (Cole, 1978; Farrel & Marion, 2002). Overall, the greatest impact of trail construction and maintenance was opening up tree and shrub canopies (Cole, 2004).

Excessive trail-related impacts to vegetation, soil or wildlife could represent an unacceptable departure from natural conditions and processes (Marion & Lueng, 2001). In other words, Cole (1981) remarked that current attemps to minimise changes due to recreation impacts were often inadequate due to lack of ecological information. Similarly Bayfield (1979) underscored that despite a large number of nature trails in Britain, there has been little investigation of their use and effectiveness.

Likewise there is very little information on recreation impacts in Turkey despite the fact that it has a high potential for nature conservation in over 1000 areas, 45 of which are national parks (Atik et al., 2005; Çevre ve Orman Bakanlığı 2010; Çevre ve Orman Bakanlığı, 2011; Resmi Gazete 2008). However, protection of vegetation along the trails is still important for securing sustainable recreation use in protected areas (Marion & Leung, 2001) considering increasing visitation to national parks.

The trail condition depends on trail user-related factors, slope, altitude, and vegetation type. Recreation impact varies depending upon the original environment and different types of ecosystems (such grassland, forest or desert) in which recreation takes place (Liddle 1997, in Nepal 2003). The chapter describes a study of the impact of trail use on vegetation (Mediterranean sclerophyll forest) in Termessos National Park and to develop a code of conduct for trail management. Termessos National Park was selected because hiking is the most intensive human use in this park and because experiencing trail impact may be unacceptable to visitors.

2. Material and method

2.1 Termossos National Park

Termessos National Park was chosen as the research area due to its natural and archeological features, easy visitor access, its status as the most visited protected area in Antalya, and the presence of more than one trail for comparison (Figure 1). Covering 6702 hectares, it is located in the northwestern Antalya and was established as a national park in 1970 (Anonymous, 1970). Found by tribes known as Solymians around 2000 B.C., Termessos was an important city of the ancient Psidian province of Anatolia. Temples, a gymnasium, agora, theatre, odium and infrastructure elements (walls, streets and cisterns) are important cultural assests in the city embedded in the Mediterranean vegetation characterized by sclerophyllous trees and shrubs that are known as macchia. There is high species diversity in this region. Therefore Termessos National Park atrracts people who have interests in both culture and nature (Figure 2). An average of 24.000 people (including both individual visitors and group tours) annually visit the park.

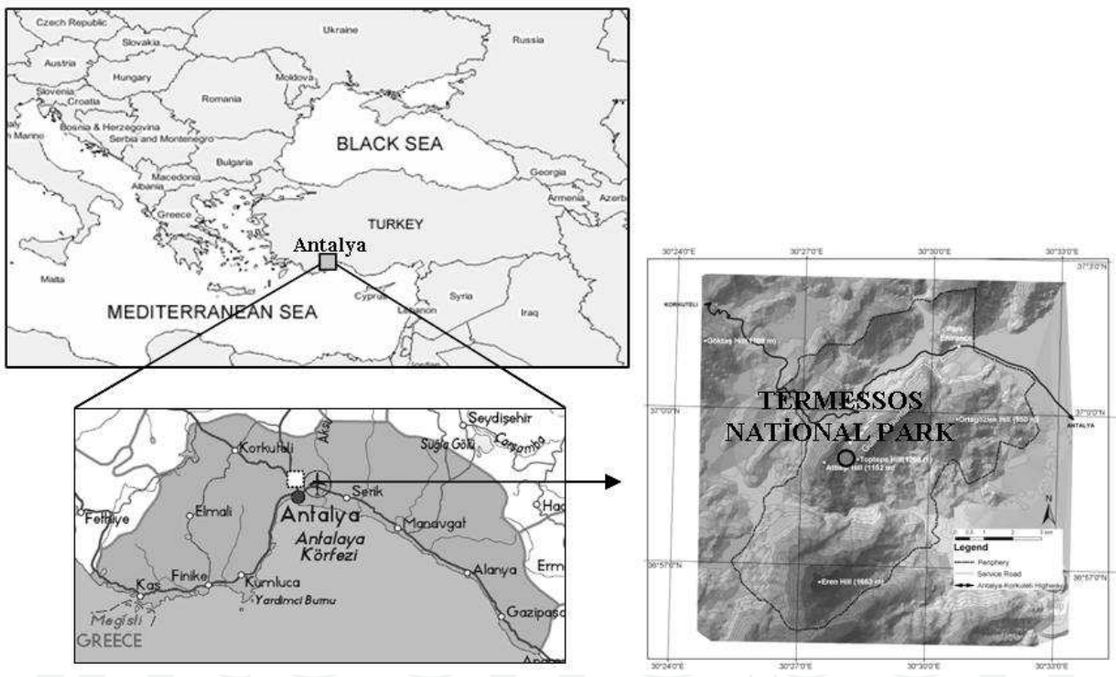

Fig. 1. Location of Termessos National Park

Characterised by very hot and dry summers and rainy, temperate winters, the area occasionally receives snow and frost above the 800-meter elevation level. There are local micro-climates extending into cool to mild conditions that enable greater species diversity than a typical Mediterranean climate.

Unlike other ancient coastal settlements around Antalya, natural characteristics of Termessos were well preserved. Thus rich flora and fauna and numerous natural habitats between 250 and 1265 m elevation are present in the park. The natural diversity of flora, avifauna, lichens, mammals and insects have been studied (Alçıtepe, 1998; Sert, 2000; Yalım & Çıplak, 2002;

Tufan et al., 2005; De Marinis & Masseti 2009). Tufan et al. (2005) noted that the wide variation in its topography composed of high mountains, valleys and deep canyons provide habitats for a rich diversity of lichen. They identified 152 species that are the indicator of air quality.

Fig. 2. Views from natural and historical characteristics of Termessos National Park

Alçıtepe (1998) identified 686 plant species; 80 of them are endemics. Dense vegetation in the national park supports mountain goats, fallow deers and golden eagles. Sert (2000) identified 113 bird species from 32 families and affirmed that natural vegetation was the integral component of bird habitats where thick cover of macchia and includes several tree species: *Pistacia terebinthus, Quercus coccifera, Quercus infectoria, Myrtus communis, Smilax aspera, Laurus nobilis, Daphne sericea, Arbatus andrachne*, *Juniperus oxycedrus* and *J.excelsa*.

2.2 Data analysis

Walking paths have long been present in Termessos National Park. Located in different sections of the park, five trails were chosen for examination of their impacts on vegetation. A sampling point was selected randomly on each of the five trails. At each point, indicators were measured in six plots lined up to traverse the trails: three plots were selected within the 10m straddling the central axis of the trail and three more plots were selected between the 15th and 20th m from the center on either side of the trail. The latter were used as controls (Figure 3).

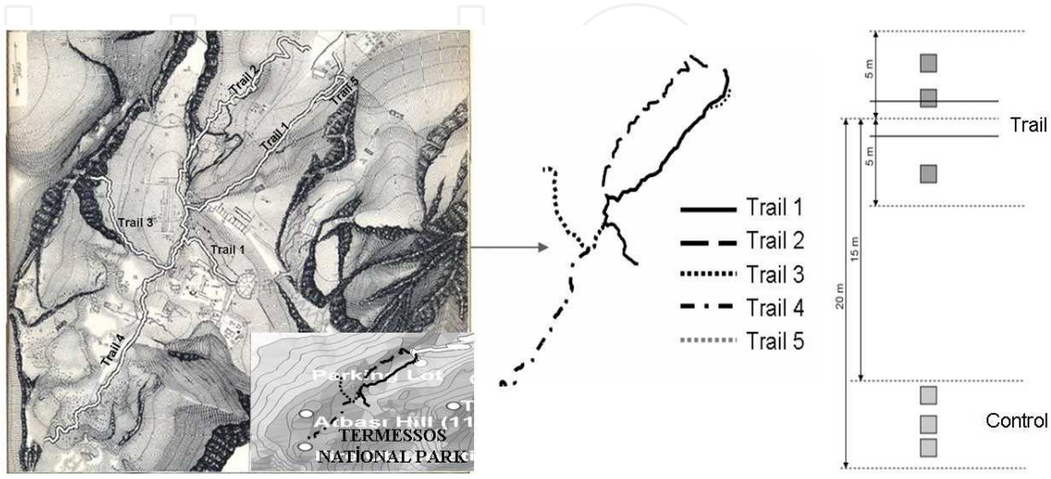

Fig. 3. Location of analysed trail system and sampling design in Termessos National Park

Vegetation sampling was designed according to Kutiel et al. (1999), Leung & Marion (2000) and Whinam & Chilcott (2003). Species richness (#) or the average number of species in each plot, vegetation height (cm) or average height of plants (cm) found in each plot and vegetation cover (%) based on a visual assessment of plant condition in the ground cover in each plot were collected at each plot. Data processing and analyses were conducted with SPSS 9.0 software. Data related to the trail impacts were analysed by ANOVA (McPherson, 1990).

3.Trail Impact on vegetation in Termessos National Park

As the main access into natural environment, trail conditions, and trail impacts may be influenced by use-related factors (Farrel & Marion, 2002). In this study, the 'use' factor was assumed to be the main source of vegetation change on the five main trails in Termessos National Park. Each trail sampling point prossessed different aspect, elevation and slope characteristics (Table 1). Vegetation characteristics varied from macchia to mixed forest to alpine.

Trail characteristics	*Trail 1*	*Trail 2*	*Trail 3*	*Trail 4*	*Trail 5*
Altitude (meters; start-end)	854-998	886-996	982-1060	1003-1107	893-916
Aspect	West	South-east	Noth-East	South	West
Trail length (meters)	952	772	482	676	158
Average slope (%)	15	14	16	15	15
Vegetation	Macchia, Mixed forest	Mixed forest	Mixed forest	Machhia, alpine	Mixed forest

Table 1. Site characteristics of the trails

Data collected for species richness, plant height and vegetation cover revealed a statistically significiant relationship to trail 'use' (Table 2). With regard to species richness, Trail 1, Trail 2 and Trail 4 showed similar variances, while Trail 3 was unlike the others. In terms of plant height, no significant differences were found between trails; however Trail 1 had the lowest apparent impacts from 'use'. Though Trail 2 exhibited higher vegetation cover (50,7%), there were no obvious differences in vegetation cover among the other trails. In terms of trail impact management, the effect of 'use' on trails on selected impact indicators proved that the recreational use significantly affected the vegetation richness (P≤0,05), plant height (P≤0,05) and vegetation cover (P≤0,01) along trails.

Trails	Species Richness (#)	Plant Height (cm)	Vegetation Cover (%)
Trail 1	4,83 a	26,3 c	26,8 b
Trail 2	4,76 a	33,3 ab	50,7 a
Trail 3	3,47 b	34,0 a	36,2 b
Trail 4	4,76 a	28,2 bc	35,7 b
Trail 5	4,29 ab	28,6 bc	33,5 b
Significance	P≤0,019	P≤0,034	P≤0,004

[z]: Within each characteristic (column) mean separations by Duncan's multiple range test at 0.05 level.

Table 2. Effect of trail 'use' on species richness, plant heigh and vegetation cover

3.1 Response in species richness

Species richness is regarded as one of the thresholds for desirability in many recreation studies. Means of species richness on the trails are presented in Table 3. Species richness on Trail 1, with a mean of 4,58, is higher than found on the other trails. Analysis of data indicated that there was no significant difference between the richness measures of Trail 1, Trail 2, Trail 4 and Trail 5. Only Trail 3 was found to have a significantly different average number of species.

Analysis revealed that each trail's environmental characteristics (P≤0,001) and use impact on those trails (P≤0,01) independently and significantly affected species richness, however there was no significant interactive effect between trail and use factors. In contrast to predicted recreational impacts, the average numbers of species on trail plots were higher than in control plots (for Trails 1, 2, 3 and 4). Similar outcomes were confirmed by Bright (1986) and Bayfield and Brookes (1979) in evergreen vegetation environments. From an ecological perspective this was apparently due to disturbance allowing increased light, water and nutrients in open trail sections compared to those factors in closed tree canopies of the control plots.

TRAILS	**USE**		**Means of Trail**
	Use	Control	
Trail 1	4,83	4,42	4,58a
Trail 2	4,76	4,16	4,46a
Trail 3	3,47	2,76	3,11b
Trail 4	4,76	3,78	4,27a
Trail 5	4,29	4,33	4,31a
Means of use:	4,40a	3,89b	
Significance			
Trail (T):	***		
Use (U):	**		
T XU:	NS		

In each column and line, means that are significantly different at the 5% level followed by different letters according to Duncan's multiple range test
NS , **, *** : Not significiant and significiant at the level of 0,01 and 0,001 respectively

Table 3. Trail impact on species richness (#)

3.2 Response in plant height

Plant height often responds to the physical trail impacts. Sun and Liddle (1993) concluded that plant height appears to be strongly associated with resistance to trampling. Our results showed no statistical differences between trails in terms of plant height (Table 4). But mean plant height on Trail 5 has the highest value with 36,09 cm. There is evidence that plant height was significantly affected by use (U) (P≤0,05) as heights were sigificantly greater in control plots where mean plant height was 38,08 cm higher than in plots along the trails. The environmental context of the trails (T) alone the interaction between the environment and use (T X U) were not significantly related to plant height.

TRAILS	USE		Means of Trail
	Use	Control	
Trail 1	26,32	37,85	32,08a
Trail 2	33,36	38,15	35,76a
Trail 3	34,07	35,66	34,87a
Trail 4	28,25	35,26	31,75a
Trail 5	28,68	43,50	36,09a
Means of use:	30,13b	38,08a	
Significiance			
Trail (T):	NS		
Use (U):	*		
T XU:	NS		

In each column and line, means that are significantly different at the 0,5% level followed by different letters according to Duncan's multiple range test
NS , * : Not significiant and significiant at the level of 0,5%, respectively

Table 4. Trail impact on plant height (cm)

3.3 Response in vegetation cover

Hammit & Cole (1998) stated that the effect of vegetation cover on environmental durability is complex. As well as being impacted by trail use, vegetation cover can also be impacted by site characteristics. A significant variation between trails was observed for vegetation cover (Table 5). The highest mean vegetation cover was found on southeast-facing Trail 2 (49%), where sun intensity and duration might encourage plant growth. Trail 3 and Trail 4 showed similar coverage, and Trail 1 and Trail 5 had the lowest mean coverage amounts. Neither the environmental factors (T), nor the use (U), nor the interaction between two (T X U) were found to be significantly related to mean vegetation cover.

TRAILS	USE		Means of Trail
	Use	Control	
Trail 1	26,878	34,211	30,544c
Trail 2	50,767	48,600	49,683a
Trail 3	36,211	48,222	42,217b
Trail 4	35,778	43,689	39,733b
Trail 5	33,589	31,311	32,450c
Means of use:	36,644a	41,207a	
Significiance			
Trail (T):	NS		
Use (U):	NS		
T XU:	NS		

In each column and line, means that are significantly different at the 5% level followed by different letters according to Duncan's multiple range test
NS : Not significiant

Table 5. Trail impact on vegetation cover (%)

4. Trail impact management

Protected areas offer high quality nature-based recreational spaces for people. Andres-Abellan et al. (2006) pointed out that an increasing visitation to natural areas derives from people's desire to enjoy nature. But it is commonly agreed that even most careful recreational use could cause damage to the natural environment and thus reduces one's experience of nature.

Vegetation change can provide remarkable evidence of the negative impacts of land use on natural environments and can be used as an effective tool in conservation planning and visitor management in national parks. Most previous studies have pointed out that recreational use in protected areas is inevitable. Due to undesirable consequences of visitor use, trail management initiatives are needed.

Trails are generally regarded as an integral to parks and recreation areas, as they provide access to roadless areas and offer recreational opportunities (Aust et al. 2005). According to Wimpey & Marion (2010) a system of formal trails is a fundamental and essential component of the infrastructure of protected natural areas as it facilitates visitor access and supports sustainable recreational opportunities and experiences. However in order to effectively plan recreation, trail conditions and trail impacts must be thoroughly examined. Altan (1990) suggested that ecological principles and ecological relations must be taken into account during the planning phase to guide the human-nature relationship. Planning, on the other hand, requires holistic analysis of all impacts (Sinden, 1976).

Through educational and regulatory actions, managers can influence or control all use-related factors (Aust et al., 2005). Opening new trails would imply diminished natural space and further environmental damage. Dispersed trail use in protected areas can be an alternative for some areas, but park administrations outh to critically consider whether the resulting changes would be acceptible. Other possible solutions are to regulate visitor cycle, to rotate use of trails during specific periods, and to disperse hikers. Trail management measures need to be based on the results of recreation impact studies and thorough the knowledge of trails's characteristics.

The significance of nature conservation and the values of landscapes are closely related, so there is a need for effective management of recreational resources (Tzatzanis et al., 2003). Despite the long presence of numerous hiking trails in Termessos National Park since its establishment in 1970, there has been little investigation of the state of its natural environment. The trail system of Termessos National Park was created to enable views of the cultural heritage scenery, of the interesting topography, and of the diverse nature generally. Here, we have examined five trails in the park to assess vegetation responses to the use of these trails, taking into consideration each trail's site characteristics. We now offer some recommendations for site and visitor management on each trail.

Trail 1

From a managerial perspective, assessment of the vegetation response to trail use along Trail 1 showed that plants were most affected by physical impacts as average height was higher in control sites. On the other hand species richness was high as well due to plentiful sun light along the trail edges enabling diversity despite the high amount of visitor use. According to Cayuela et al. (2008) water, nutrient-level amelioration, and light deprivation

in the Mediterranean forests in particular might affect species diversity. This also suggests that the natural vegetation is more likely to withstand visitors' use in the environmental conditions of Termessos National Park.

The elevation of Trail 1 climbs from 854 to 998 meters over a distance of 952 meters. The transect crossed vegetation containing mainly macchia and mixed forest (Figure 4). Beginning from a parking area and climbing to theatre, the first half of the trail crosses limestone which slopes steeply in both lateral directions. The most characteristic species on exposed trail slopes that experience surface erosion was *Astragalus hamosus*, which gives way to *Acantholimon acerosum* in control plots. The trail's width varied from 50 to 150 cm. The second half of Trail 1 was nearly flat as it crossed trough settlement ruins and vegetation (both on the trail and in the control plots) predominantly comprised of *Quercus coccifera, Ruscus aculeatus, Osyris alba, Daphne gnidioides.* The most typical plant was *Anagyris foetida* which was only found in control plots, where good shade encouraged *Allium cepa, A. orientale* and *Ornithogalum onites*.

With respect to trail use, Trail 1 functions as a gateway for most visitors to the park. However high trail use is clearly evident through the diminished vegetation cover and reduced plant heights along the trail. Visitor cycling along Trail 1, particularly in spring when vegetation is growing most rapidly, may be an effective management option. Aside from this, surface damage done by wild pigs in the park, should also be considered as it is most common in spring and autumn. Some other management tools may be needed to be developed to manage these impacts along Trail 1.

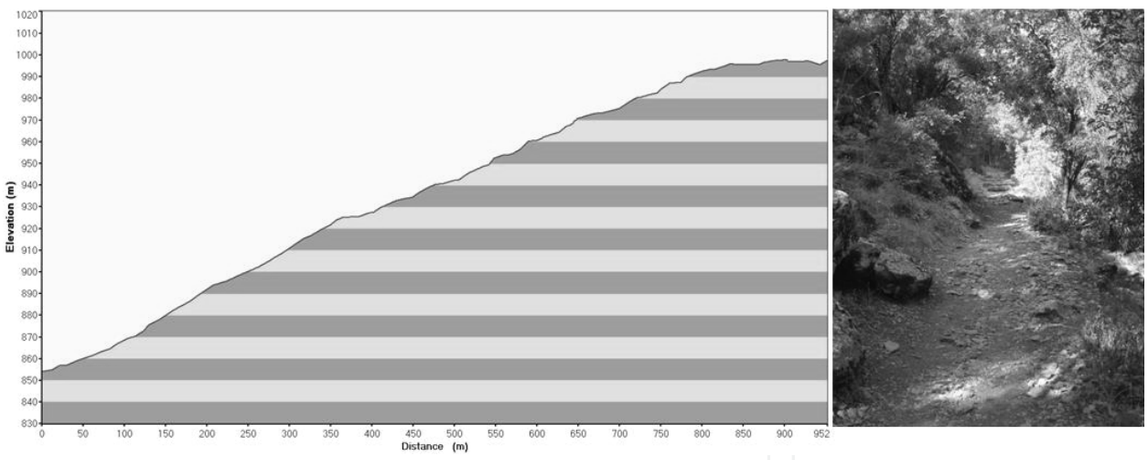

Fig. 4. Elevation profile and a view from Trail 1

Trail 2

Plant morphology is one possible determinant of resistant and resilience to the impacts (Whinam & Chilcott, 2003). Soil compaction due to high visitor use along trails leads to diminishing vegetation cover and deteriorating appearance, but on the other hand it creates a durable surface for walkers and diminishes the propensity to create ancillary trails.

With the second highest rate of visitor use after Trail 1, Trail 2 is mainly a return path or exit to the parking area. This trail descends (or ascends depending on the direction) from 996

meters to 886 meters over a 772-meter distance (Figure 5). Thick vegetation along the Trail 2 limits visitor's impacts and mitigates the erosion risk along its steep slope. *Quercus coccifera, Quercus infectoria* and *Quercus cerris* form a tall tree canopy while common species of *Ruscus aculeatus, Oysris alba, Asparagus acutifolius, Smilax aspera, Jasminum fruticans, Rhamnus oleoides* comprise the understory cover along Trail 2. Only a small number of *Cupressus sempervirens, Juniperus excelsa* and *J. oxycedrus* were found in control plots, where abundance of *Nectaroscordum sicilum* and *Iris albicans* indicated of the abundance of shade and moisture.

Thick vegetation and the abundance of ruins along Trail 2 kept the physical trail impact to a minimum. Because species richness, which was found to be the highest among the trail, vegetation height and vegetation cover were all relatively high, typical trail use could be allowed to continue along Trail 2 with no management change except for a careful monitoring of visitor numbers.

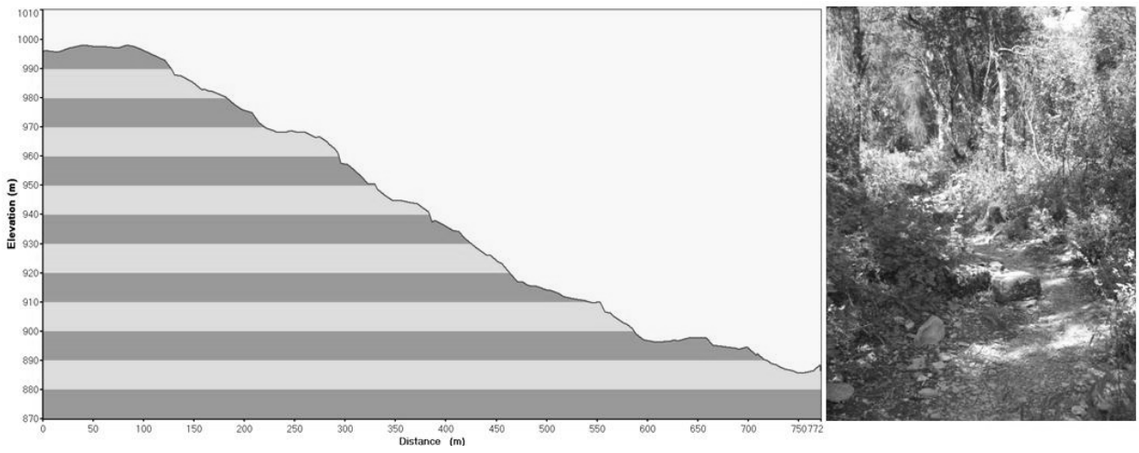

Fig. 5. Elevation profile and a view from Trail 2

Trail 3

Ranging from 982 and 1060 meters, Trail 3 leads to an overview of a grave site of ancient hero Alcetas over a walking distance of 482 meters (Figure 6). General Alcetas was an important figure in the history of Termossos and the people of Termessos were so affected by the death of General Alcetas that they built a magnificent tomb for him. So Trail 3 is a natural corridor that takes people to the historical site.

Trail 3 can be characterised as having low to moderate visitor use. People knowingly take this trail to access the monument. Northeast-facing Trail 3 is characterised by thick mixed forest of tall trees and bushes where *Pinus brutia, Quercus coccifera, Q. infectoria, Rhamnus oleoides, Styrax officinalis, Colutea melanocalyx* compose a tall overstory. *Carex divulsa, Althea cannabina, Bryonia cretica, Doronicum vulgaris* typically cover the forest floor along the trail.

As Hammit and Cole (1998) emphasised, trails' impact on vegetation above tree line is often severe. Specied richness was higher in trail plots than in control plots because there is typically insufficient sun and space for plant growth. Compared to other trails in the park, species richness was lowest along Trail 3. But mean plant height and vegetation cover were higher in control plots and were considerably higher on the trails.

Vegetation response in Trail 3 appeared to be due to the thick vegetation and typically limiting trail characteristic of high slope with 16% and closed tree canopy. Abundance of light on the trail sides encourages species diversity; however physical trail impact was evident with low plant height and vegetation cover in Trail 3.

Because of its vegetation response, the most effected element along Trail 3 was species richness which was linked to the physical site characteristics rather than to trail use. Therefore the tolerable vegetation response in terms of plant heigh and vegetation cover would allow continued moderate levels of use of Trail 3 in combination with monitoring of the changes in vegetation.

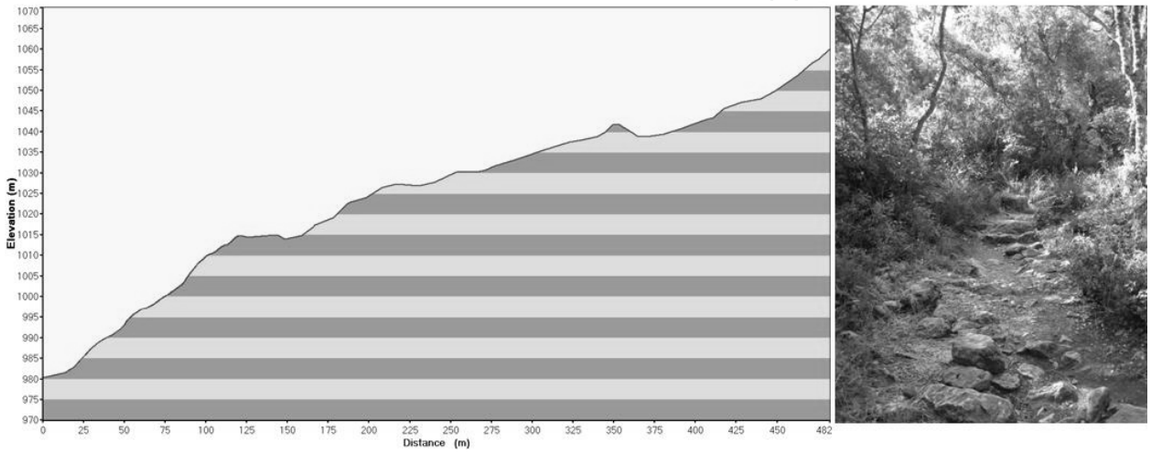

Fig. 6. Elevation profile and a view from Trail 3

Trail 4

Mountain areas are physical environments that very sensitive to change. They are characterised by short growing seasons and a combination of factors that makes subsequent regeneration of damaged vegetation more difficult (Holden, 2000). Located between 1003 and 1107 meters, Trail 4 presents the upper forest line of a mixed forest (Figure 7). Providing a great view of the entirety of the national park and of the Antalya environs particularly, the highest point on Trail 4 is also used as a fire observation centre by the park administration.

Trail 4 faces south and is exposed to high and persistent winds, particularly at the 1107-meter elevation. Characterised by macchia at the lower elevations and alpine flora at the higher elevations, vegetation on Trail 4 becomes dwarfed and stocky by exposure to the constant winds where *Juniperus excelsa* and *J. oxycedrus* morphologically dwindle on a 15% slope. Particularly brisk day and night temperatures promote herbaceous species of *Catapodium loliaceum, C. rigidum, Bromus sterilis, Melica minuta, Poa trivialis, Melica minuta, Brizia humulis, Trifolium arvense, T. resupinatum, T. campestre, T. angustifolium, Cruciata taurica, Crucianella latifolia, Biscutella resupinatum, Geranium purpureum, Buplerium heldreichii* and *Stachys cretica* along the sides of the trail. *Ostrya carpinifoia, Pistacia lentiscus, Pistacia terebinthus, Juniperus excelsa, Rhamnus pyrellus* are woody tree species that are typically found in the control plots.

At tree line, negative trail impacts were observed on Trail 4. Soil erosion and surface exposure exaggerated by the site characteristics of steep slopes and high elevation.

Although species richness was high along the open trail, the impact was clearly indicated by low plant height and vegetation cover values in trail plots. Both plant height and vegetation cover was remarkably higher in control plots. Therefore, visitor use must be reduced on Trail 4, either by orientating visitors towards a more direct descend or by closing the trail during certain seasons to be determined by further ecological research.

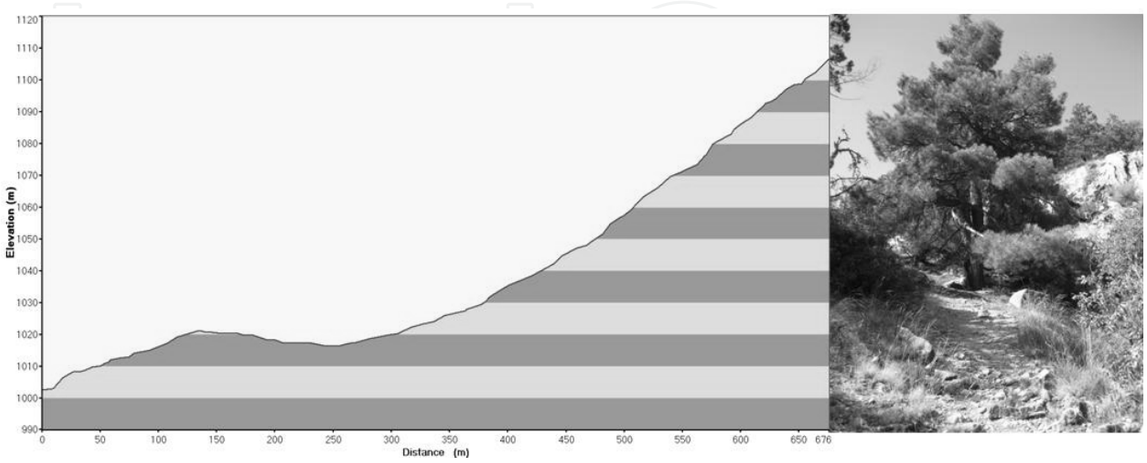

Fig. 7. Elevation profile and a view from Trail 4

Trail 5

As an alternative route to Trail 1, Trail 5 has very low visitor use. The trail's elevation ranges from 893 to 916 meters in a short distance of 158 meters (Figure 8). Located in closed-canopy, mixed-forest vegetation, species richness (particularly of perennial herbs) was enhanced by filtering in light from the sides of the open trail. Typical species were *Clinopodium vulgare, Erodium moshatum, Anthiriscus nemorosa, Cerastium glomeratum, Carex divulsa, Althea cannabiana* along the trail. A dense cover of *Quercus coccifera, Q. infectoria, Q. cerris, Styrax officinalis, Ostrya carpinifolia, Jasminum fruticans, Colutea melanocalyx, Ephedra campylocarpa* was found in the control plots.

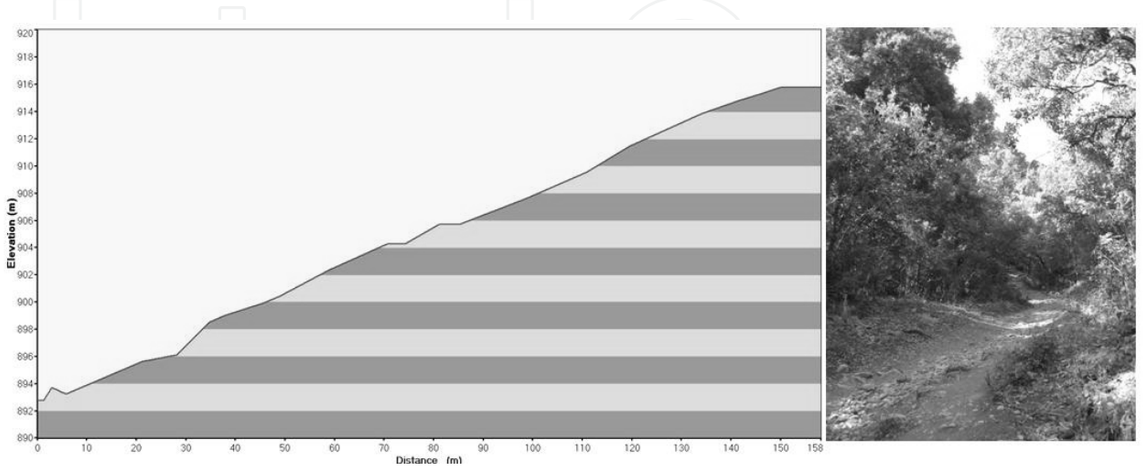

Fig. 8. Elevation profile and a view from Trail 5

Vegetation cover and species richness were supported along the trail by low levels of disturbance and where control plots were characterised mainly by bushes and trees. Unlike other trials in Termessos National Park, there has been regular vegetation clearance on Trail 5 to avoid trail closure by dense vegetation and to allow visitors an easy access. Kobayashi et al. (1997) specified that after vegetation removal there was a rapid recovery leading to more diverse vegetation with many more species lingering under different shade conditions. As an example of very low vegetation disturbance along the trail, Trail 5 can continue to be used as it has been, but must be closely monitored for changes.

5. Conclusion

Impacts of trails and other forms of recreation are concern, because activities like hiking and wildlife-viewing are popular in developing countries. Trails often receive the most intensive use within protected areas (Ouma et al., 2011). In the absence of trail management, resource degradation often occurs along trails and varies greatly in terms of type and severity (Marion & Leung, 2004).

As tourism and recreation in protected areas continue to increase, an accurate knowledge of their ecological impacts and ways to reduce them becomes increasingly important for conservation and visitor management (Buckley & King, 2003). Buckley (2004) stated that the significance of ecological impacts from tourism and recreation has been recognised widely by protected area managers. Site managers need to know the impacts of recreation activities on the natural environment of their units. According to Wimpey & Marion (2010) resource impacts associated with trail use can conflict with natural area resource protection mandates, thereby challenging land managers to implement visitor and resource management actions that avoid or to minimize impacts.

Termessos National Park contains sites of high cultural, ecological and historical values and is therefore an attraction for local, national and international tourists. Because the trails provide opportunities for nature walks and hikes to scenic vistas, most visitors to the park are entirely dependent upon the trails.

Trail impact usually depends on the characterics of the setting in which the trails were established. Talbot et al (2003) remarked that the response of an ecosystem to recreation-related impacts is primarily determined by the ecological characteristics of the biophysical system. The aim of the study was to measure the impacts of trails on the vegetation and to determine the necessary trail management actions that must be taken to avoid further negative vegetation responses.

The impacts of trails and their relative use intensity in Termessos National Park were significantly important based on the assessment of vegetation response in terms of species richness ($P \leq 0,05$), plant height ($P \leq 0,05$) and vegetation cover ($P \leq 0,01$). Generally species richness was higher along trails than in control plots distant from the trails. This was generally a function of opening the typically closed canopy of Mediterranean evergreen sclerophyllus vegetation and competition for light and nutrions. With similar results, Hall & Kuss, (2003) found out that cover and species diversity increased as one moved closer to the trail in eight out of ten cases they studied.

As Hammitt & Cole (1998) noted that the most significiant aspect of vegetation structure is the effect of tree canopy closure on diminishing vegetation amounts. Water and nutrient amelioration and light deprivation along trails become major factors influencing impacts. Similarly Valladares and Gianoli's (2007) confirmed that competition for water tends to accentuate the adverse (to growth) combination of shade and drought among understory plants in Mediterranean forests.

With respect to recreational impacts, site management actions may include relocating use to resistant sites, permanent or temporary site closures, control of the spatial distrubution of use, site hardening and shielding, rehabilitation of closed sites. Some visitor management actions might include use limits, length-of-stay limits, visitor dispersal or concentration, seasonal limitations and low-impact recreation training (Hammitt & Cole, 1998). While knowledge of the role of environmental factors in causing vegetation change can be applied to trail management, trail impact management deals with understanding and managing the role of the visitors (behaviour, timing, frequency or total numbers) in vegetation impacts (Whinam & Chilcott, 2003).

As expressed by Leung & Marion (2000) trail impacts are influenced by a diverse array of use-related and environmental conditions. Analysis of the trail conditions in Termessos National Park has proven that the characteristics of the vegetation, the proximity to cultural ruins, elevation, and slope combine to challenge trail impact management.

Leung & Marion (2000) confirmed that without proper trail management efforts, trail use can alter natural patterns. Visitor use regulations and educational programs can help to reduce impacts associated with trail use. Regulating visitor cycles along Trail 1, particularly when vegetation is most active and/or sensitive, maintaining current levels of use along Trail 2 and Trail 3 in combination with a monitoring program, reducing use of Trail 4, and allowing current levels of hiking along Trail 5 (with new monitoring programs) are the trail management options that would seem to be most in line with reducing vegetation impacts from hiking trails.

Trails management requires management of the type, amount and timing of visitor use and visitors' behaviors to ensure resource protection (Marion & Leung, 2004). Classification of the Termessos National Park trails according to their popularity would have been subjective. Because no direct relationship of vegetation response and use of the trails was apparent (Trail 1 was most used and Trail 5 was the least), an initial use assessment of the trails of the park would provide the basis for understanding the trail-impact threshold of users.

Sayan et al. (2005), in their effort to determine the recreational carrying capacity of Termessos National Park, reported that the number of people visiting the national park each year is nearing the maximum acceptable visitor number. Thus must be seen as an important problem and must be addressed by park management. Termessos National Park has recently been added to the list of UNESCO World Heritage Sites (UNESCO, 2011) and therefore will see an increase in the number of visitors to the estimated 24.000 visitors per year. Therefore, challenges to the protection of the natural environment and cultural heritage of Termessos will become increase with time.

The provision of safe, accessible, and environmentally friendly recreational trails is a key managerial focus for protected areas. The current trail system in Termessos National Park

provides opportunities for hiking based on high cultural and natural qualities. The addition of a trail-design programme (supplemented by construction and maintenance) in combination with a visitor management programme would be an effective, long-term site management inititiative.

Trail management for the protection of ecosystems and cultural heritage can provide aesthetically pleasing landscapes and keep recreational uses in harmony with the natural environment. However a complete understanding of the functioning of the Mediterranean environment and trail impacts thresholds is still a far-reaching objective requiring further studies.

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7. References

Alçıtepe, E. (1998). *Termessos Milli Parkı (Antalya) Florası Üzerinde Bir Araştırma.* Akdeniz Ü., Fen Ed. Fak., Biyoloji Bölümü Doktora Tezi, 194 sayfa, Antalya.

Altan, T. (1990). *Ekolojik Riziko Analizi ve Turizm Planlaması.* Türkiye Çevre Sorunları Vakfı, Turizm ve Çevre Konferansı, 3-5 Ekim 1990, Ankara.

Andres-Abellan, M.; Lopez-Serrano, F.R.; Morote, F.A.G. & Del Cerro-Barja, A. (2006). Assessment of trampling simulation impacts on native vegetation in Mediterranean sclerophyllous forest. *Environment Monitoring and Assessment,* Vol. 120, pp. 93-107.

Atik, M.; Karagüzel, O. & Ortaçeşme, V. (2005). Türkiye'de Doğa Koruma Yapısı ve Biyolojik Çeşitliliğin Korunması. *Korumada 50 Yıl Sempozyumu,* pp.63-72, Mimar Sinan Güzel Sanatlar Ü., 17-18 Kasım 2005-İstanbul.

Anonymous, (1970). *Termossos Milli Parkı Uzun Devreli Gelişme Planı*. TC Orman Bakanlığı Orman Genel Müdürlüğü Milli Parklar Dairesi-Ankara, 55p.

Aust, M.W., Marion, J.L. & Kyle, K. (2005). Research for the Development of Best Management Practices to Minimize Horse Trail Impacts on the Hoosier National Forest. In: *U.S. Forest Service* Final Research Report, Available from http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5292110.pdf

Bayfield, N.G. (1979). Recovery of four montane heath communities on Cairngorm, Scotland, from disturbance by trampling. *Biological Conservation,* Vol.15, No 3, pp.165-179.

Bayfield, N.G. & Brookes, B.S. (1979). Effects of repeated use of an area of heather *Calluna vulgaris* (L.) *hull* moor at Kindrogan, Scotland, for teaching purposes. *Biological Conservation,* Vol.16, No.1, pp: 31-41.

Bright, J.A. (1986). Hiker impact on herbaceous vegetation along trails in an evergreen woodland of Central Texas. *Biological Conservation,* Vol.36, No.1, pp: 53-69.

Bell, S. (2001). *Designing for Outdoor Recreation.* Published by Spon Press, 11 New Fetter lane, London ISBN 0 419 20 350 8.

Bhuju, D.R. & Ohsawa, M. (1998). Effects of nature trails on ground vegetation and understory colonization of a patchy remnant forest in an urban domain. *Biological Conservation*, Vo.85, No.1-2, pp: 123-135.

Buckley, R. & King, N. (2003). *Visitor-impact Data in a Land-management Context.* In: Nature-based Tourism, Environment and Land Management, CABI Publishing, London.

Buckley, R. (2004). Using Ecological Impact Measurements to Design Visitor Management. In: *Environmental Impacts of Tourism* (ed.R.Buckley), CABI International, Oxfordshire, UK.

Cayuela, L.; Mari, J.; Benayas, R.; Maestre, F.T. & Escudero, A. (2008). Early environments drive diversity and floristic composition in Mediterranean old fields: Insights from a long-term experiment. *Acta Oecologica,* Vol.34, No.3, pp: 311-321.

Cole, D.N. (1978). Estimating the susceptibility of wildland vegetation to trailside alteration. *Journal of Applied Ecology*, Vol.15, pp: 281-286.

Cole, D.N. (1981). Vegetational changes associated with recreational use and fire suppression in the Eagle Cap Wilderness, Oregon: Some management implications. *Biological Conservation,* Vol.20, Vol.4, pp: 247-270.

Cole, D.N. & Spildie, D.R. (1998). Hiker, horse and Ilama trampling effects on native vegetation in Montana, USA. *Journal of Environmental Management,* No.53, Vol.19, pp: 61-71.

De Marinis, A.M. & Masseti, M. (2009). Mammalian Fauna of the Termessos National Park, Turkey. *Zookeys*, Vol.31, pp: 221-228.

Cole, D.N. (2004). Impacts of Hiking and Camping on Soils and Vegetation: In: *Environmental Impacts of Tourism* (ed.R.Buckley), CABI International, Oxfordshire, UK.

Çevre ve Orman Bakanlığı, (2010). Türkiye'deki Koruma Alanları; Milli Parklar, Tabiat Parları, Tabiat Anıtları, Tabiatı Koruma Alanları, Yaban Hayatı Geliştirme Sahaları. In: *Çevre ve Orman Bakanlığı,* Available from http://www.milliparklar.gov.tr

Çevre ve Orman Bakanlığı, (2011). Çevre Durum Raporu. In: *Çevre ve Orman Bakanlığı,* Available from http://www2.cevreorman.gov.tr/durum_rapor/ockkb/ockkb_ild.pdf

Edington, J.M. & Edington, M.A. (1986). *Ecology, Recreation and Tourism.* ISBN 0 521 30646, Published by the Press Syndicate of the University of Cambridge, UK.

Farrel, T.A. & Marion, J.L. (2002). Trail Impact and Trail Impact Management Related to Visitation at Torres del Paine National Park, Chile. *Leisure/Loisir,* Vol.26, No.1-2, pp: 31-59.

Greer, D.L. (2000). Nebraska Rural Trails: Three Studies of Trail Impact. In: *National Park Service*, Available from http://www.unomaha.edu/recadmin/trails/omahatrails.pdf

Hall, C.N. & Kuss, F.R. (1989). Vegetation alteration along trails in Shenandoah National park, Virginia. *Biological Conservation,* Vol.48, No.3, pp: 211-27.

Hall, C.N. & Kuss, F.R. (2003). Vegetation alteration along trails in Shenandoah National Park, Virginia. *Biological Conservation*, Vol.48, Vol.3, pp: 211-227.

Hammitt, W.E. & Cole, D.N. (1998). *Wildland Recreation Ecology and Management*. John Wiley&Sons, Inc. ISBN 0-471-19461-1.

Holden, E. (2000). *Environment and Tourism.* London: Routledge 11 New Fetter Lane, London, ISBN 0-415 20717.

Kirkpatric, E.M. (1980). *Chambers Dictionary.* Printed in Britain by Clay Ltd Bungay, Suffolk, ISBN 0 550 10634 0.

Kobayashi, T.; Hori, Y. & Nomoto, N. (1997). Effects of Trampling and Vegetation Removal on Species Diversity and Micro-Environment under Different Shade Conditions. *Journal of Vegetation Science,* Vol.8, No.6, pp: 873-880.

Kutiel, P.; Zhevelev, H. & Harrison, R. (1999). The effect of recreational impacts on soil and vegetation of stabilised coastal dunes in the Sharon Park, Israel. *Journal of Ocean & Coastal Management,* Vol.42, pp: 1041-1060.

Leung, Y.F. & Marion, J.L. (2000). Recreation Impacts and Management in Wilderness: A State-of-Knowledge Review. *USDA Forest Service Proceedings* RMRS-P-15, Vol 5, pp: 23-48.

Lynn, N.A. & Brown, R.D. (2003). Effects of recreation use impacts on hiking experiences in natural areas. *Landscape and Urban Planning*, Vol.64, pp: 77-87.

Marion, J.L. (1994). *An assessment of trail conditions in Great Smoky Mountains National Park*. US Department of Interior, National Parks Sevice, Southeast Region, Georgia.

Marion, J.L. & Leung, Y.F. (2001). Trail resource impacts and an examination of alternative assessment techniques. *Journal of Park and Recreation Administration*, Vol.19, No.3, pp: 17-37.

Marion, J.L. & Leung, Y.F. (2004). Environmentally Sustainable Trail Management. In: *Environmental Impacts of Tourism* (ed.R.Buckley), CABI International, Oxfordshire, UK.

Marion, J.L.; Leung, Y.F. & Nepal, S.K. (2006). Monitoring Trail Conditions: New Methodological Consideration. *The George Wright Forum,* Vol.23, No.2, pp: 36-48.

McPherson, G. (1990). *Statistics in Scientific Investigation: Its Basis, Application and Interpretation.* In: Fienberg, S., Olken, I. (Eds.), Springer-Verlag, pp. 1–666.

Nepal, S.K. (2003). Trail Impacts in Sagarmatha (Mt.Everest) National Park, Nepal: A Logistic Regression Anaysis. *Environmental Management,* Vol.32, No.3, pp: 312-321.

Nepal, S.K. & Nepal, S.A. (2004). Visitor Impacts on Trails in the Sagarmatha (Mt. Everest) National Park, Nepal. *Ambio*, Vol.33, No.6, pp: 334-340.

Nepal, S.K. & Way, P. (2007). Comparison of vegetation conditions along two backcountry trails in Mount Robson Provincial Park, British Columbia (Canada). Journal of Environmental Management 82 (2): 240-249.

Ouma, K.O., Stadel, C. & Eslamian, S. (2011). Perception of tourist on trail use and management implications for Kakamega Forets, Western Kenya. *Journal of Geography and Regional Planning,* Vol.4, No.4, pp: 243-250, April 2011

Resmi Gazete, (2008). 2008/14355 nolu Bakanlar Kurulu Kararı. In: *Resmi Gazete*, 06.12.2008 tarih ve 72075 sayı, Available from: http://www.resmigazete.gov.tr

Sayan, M.S.; Ortaçeşme, V.; Karagüzel, O.; Atik, M.; Şahin, T.; Yıldırım, E. & Avcı, Ü. (2005). *Termessos (Güllükdağı) Milli parkı'nda Rekreasyonerl Taşıma Kapasitesinin Belirlenmesi*. TÜBİTAK-TOGTAG-3197 Proje Raporu 65 sayfa.

Sert, H. (2000). *Termessos Milli Parkının (Antalya) Avifaunası ve Ekosistemdeki İlişkileri.* Akdeniz Üniversitesi, Fen Edebiyat Fakültesi, Biyoloji Bölümü Yüksek Lisans Tezi, Antalya.

Sinden, J.A. (1976). Carrying capacity as a Planning Concept for National Parks: Available Diserable Capacity? *Landscape Planning,* Vol.2 pp: 243-247.

Sun, D. & Liddle, M.J. (1993). A survey of trampling effects on vegetation and soil min 8 tropical and subtropikal sites. *Environmental Management,* Vol.17, No.4, pp: 497-510.

Talbot, L.M.; Turton, S.M. & Graham, A.W. (2003). Trampling resistance of tropical rainforest soils and vegetation in the wet tropics of North east Australia. *Journal of Environmental Management*, Vol.69, pp: 63-69.

Tufan, Ö., Sümbül, H. & Türk, A.Ö. (2005). The lichen flora of the Termessos National Park in Southwestern Turkey. *MYCOTAXON,* Vol.94, pp: 43-46 P

Turton, S.M. (2005). Managing Environmental Impacts of Recreation and Tourism in Rainforests of the Wet Tropic of Queensland World Heritage Area. *Geographical Research,* Vol.43, No.2, pp: 140-151.

Tzatzanis, M.; Wrbka, T. & Sauberer, N. (2003). Landscape and vegetation responses to human impact in sandy coasts of Western Crete, Greece. *Journal Nature Conservation,* Vol.11, pp: 187–195.

UNESCO, (2011).Güllük Dağı – Termessos National Park. In *UNESCO World Heritage Centre,* Available from: http://whc.unesco.org/en/tentativelists/1412/

Valladares, F. and E. Gianoli. 2007. How much ecology do we need to know to restore Mediterranean ecosystem. *Restoration Ecology*, Vol.15, No.3, pp: 363-368.

Wimpey, J. & Marion J.L. (2010). The influence of use, environmental and managerial factors on the width of recreational trails. *Journal of Environmental Management,* Vol.90, pp: 2028-1037.

Wimpey, J. & Marion J.L. (2011). A spatial exploration of informal trail networks within Great Falls Park, VA. *Journal of Environmental Management,* Vol.92, pp: 2012-1022.

Whinam, J. & Chilcott, N.M. (2003). Impact after four years of Experiemental trampling on alpine/sub-alpine environments in Western Tasmania. *Journal of Environmental Management*, Vol.67, pp: 339-351.

Yalım, B. & Çıplak, B. (2002) Termessos Milli Parkı (Antalya) Orthoptera (Insecta) Faunası: Fauna Elemanlarının Zoocoğrafyaları ve Vejetasyona Göre Dağılışları. *Türk Entomoloji Dergisi*, Vol.26, No.4, pp: 267-276.

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