EFFECT OF VISITOR ACTIVITIES ON TOPSOIL HYDROPHYSICAL PROPERTIES IN TWO PROTECTED AREAS IN NORTHERN BLACKSEA REGION

Turan YÜKSEK[1], Filiz YÜKSEK[2], Mine EYÜPREİSOĞLU[1]

Esin ERDOĞAN YÜKSEL[3], Ercan SÜTLÜ[4]

[1]Department of Landscape and Ornamental Plants, Rize University, Pazar Vocational School, 53300 Pazar-Rize, Turkey.

[2]Pazar Forest Management Directorate, 53300 Pazar-Rize, Turkey

[3]Department of Forest Engineering, Artvin Coruh University, 08000 Artvin, Turkey

[4]Conservation Officer, WWF-Turkey,53100 Rize/Turkey

Abstract

In this study, the effects of visitor acitivities on topsoil hydrophysical properties in two protected areas in northern Bleacksea region were investigated. For this purpose, soil samples taken from study area that was characterized as heavily trafficked site (HTS), moderately trafficked sites (MTS) and control (non-trafficked site). The soil bulk density and soil penetration resistance increased from 1.02 to 1.39 g cm^{-3} and 0.66 to 1.55 MPa, respectively, saturated hydraulic conductivity decreased from 60.60 to 10.35 mm h^{-1} in moderately and heavily trafficked sites, respectively, at 0–10 cm soil depth in Ayder protected area. The soil bulk density and soil penetration resistance increased from 0.85 to 1.40 g cm^{-3} and 0.68 to 1.50 MPa, respectively, saturated hydraulic conductivity decreased from 58.75 to 10.35 mm h^{-1} in moderately and heavily trafficked sites, respectively, at 0–10 cm soil depth in Kafkasor protected area. The intensity of visitor activities had a negative impact on topsoil

hydrophysical properties in the study area in Ayder and Kafkasor. The principles of management in Ayder and Kafkasor protected areas should be revised, and use of this area without a plan should be stopped as soon as possible.
Keywords: Ayder, Kafkasör, Protected Area, Topsoil Hydrophysical Properties

1. Introduction

Protected areas worldwide, such as national parks, nature reserves and wilderness areas are commonly established and managed to safeguard natural and cultural resources (Yüksek, 2009). Internal and external sources of human impact, including encroaching development, pollution, introduction of exotic species and recreation or tourism visitation, increasingly threaten to compromise these purposes. Among these sources, recreation and tourism visitation presents a perennial and growing management challenge to protected area managers, who are liable to protect park resources while also providing appropriate recreational opportunities. These obligations require managers to carefully manage visitation and any negative environmental effect or impact. Various forms of resource impact have been described, including vegetation loss, soil exposure, compaction and erosion, tree and seedling damage, wildlife disturbance and miscellaneous damage caused by depreciative behaviour (Cole, 1987). Recreational activities significantly damage physical and hydrophysical properties of surface soils. Currently, the demand for recreational diversity has been rapidly increasing and this makes planning and protection difficult in Kafkasor protected area (Yüksek et al., 2008). Intensive recreational use of forested soils leads to soil compaction and increased bulk densities in area. An important consequence of increased bulk density is reduced soil water intake capacity and thus increased losses by surface runoff

(Vimmerstadt et al., 1982). Ball games and other activities may wear out a good stand of grassland and damage topsoil structure (Troeh and Thompson, 1993). The major cause of soil compaction is the traffic over the fields (Short et al., 1986; Yüksek et al., 2008). The most significant impact occurs in surface layer. Then soil compaction reduces soil infiltrability and permeability (Froehlich and McNabb, 1984). Similarly, if the compaction is accomplished with proper moisture control, the movement of capillary water is minimized (Gent and Ballard, 1985). It is well known that root and plant growth significantly decreases when surface soil properties (especially physical and hydraulic properties) are damaged. Kerbiriou et al. (2008) reported that the degree of activity concentration on individual campsites have a substantial effect on the magnitude of vegetation loss and species richness.

The aim of this study was to evaluate the effect of visitor activities on topsoil hydro-physical properties in two protected areas in northern Blacksea region in Turkey.

2. Materials and Methods

2.1. Site Description and History

The study area of Kafkasor is located at 41°09' 46"–41° 10' 04" N and 41° 47' 44"–41° 47' 57" E. Thealtitude of the area is between 1150 and 1280m above sealevel. The climate is sub-humid, with a long-term annual average rainfall of 689 mm, while it was 880mm in 2007, with a minimum in summer (103 mm), and maximum in winter (262 mm) and the mean annual temperature is 12 °C in Artvin Meteorological station. The study area is moderately sloped (20±2 per cent) and the rock mass is extensively volcanically disrupted and parent material is andesite (Yüksek et al., 2010). The forest site of study area consists of *Picea orientalis* Link (74.5 per cent), *Carpinus* *betulus* (L.) (2.2 per cent), *Quercus petraea* (L.) (Matt. Liebl.) (6.5 per cent), *Fagus orientalis* (L.) (Lipsky.) (7.2 per cent), *Abies nordmanniana* (Stev.) (7.4 per cent), *Pinus sylvestris* (L.) (2.2 per cent) (Anonymous, 2005) and grassland in forest gap consists of *Brachypodium pinnatum* (L.), *Bromus tectorum* (L.), *Avena sativa* (L.), *Poa annua* (L.), *P. trivialis* (L.), *P. nemoralis* (L.), *P. bulbosa* (L.), *Agrostis stolonifera* (L.), *Dactylis glomerata* (L.), *Cynosurus echinatus* (L.), *C. cristatus* (L.), *Phleum alpinum* (L.), *P. pratense* (L.), *Cynodon dactylon* (L.), *Trifolium pratense* (L.), *T. repens* (L.) and *T. arvense* (L.) (Eminagaoglu and Ansin, 2005). Kafkasor and its environment have different topography, rich and abundant vegetation, clean and fresh air and it is 8 km away from the city centre of Artvin. The landscape beauty of Kafkasor has been advertised often on magazines and television programs after 1990s; therefore, the number of visitors has been increasing from day to day. It was estimated that more than 100 000 people visited Kafkasor during 2006, and most of the visitors visited Kafkasor from July to September. Beside prevalent recreational activities, Kafkasor Culture, Art and Tourism Festival has been carried on since 1984 and tourism is nowadays the main source of income for local inhabitants since the abandonment of traditional agriculture, and there is a strong social and economical pressure for tourism in protected areas. The festival area is about 23 ha and there is no accepted land use plan for this area. Except for the traditional Kafkasor festival, people can enter the area free of charge and can camp in any part of grassland in forest gap and there is randomly light grazing in grassland in forest gap (Yüksek et al., 2008; Yüksek et al., 2010).

The study area, Ayder, is a site close to Çamlihemsin town, in the northeast of Turkey, Rize. (lat. 40° 57' 14" - 40° 57' 30" N, longit. 41° 06' 15"- 41° 06' 24" E, altitude 1250 m above sea level).

The climate is humid, with an annual average rainfall of 1350 mm with a minimum in spring (250 mm), and maximum in autumn (680 mm) and the mean annual temperature is 8.28 °C in the meteorological station, which is located 17 km away at a similar altitude (Yüksek, 2009). The altitude ranges between 1190 and 1285 m, and the slope of the study area is moderate, i. e., 18±%. The study area mainly consists of *Lolium perenne* (L.), and *Poa nemoralis* (L.), *Poa pratensis* (L.), *Trifolium repens* (L.), *Taraxacum* sp., *Alchemilla* sp., *Plantago* sp., *Carex* sp., and *Geranium arundinacea* (Kunth). Ayder and its environment have a different topography, rich and abundant vegetation, clean and fresh air and is located 7 km away from Çamlihemsin county. For these reasons, people who live in the north east of the Black sea region have a major interest in recreational activities in this area. It was estimated that more than 500,000 people visited Ayder during 2006, and most of theses visited during July and August. The prevalent recreational activity, the Ayder culture, art and nature festival has been running since 1994, and nowadays, tourism is the main source of income for local inhabitants since the abandonment of traditional agriculture. As a consequence, there is strong social and economical pressure for tourism in protected areas.

2.2. Sampling

A preliminary study was conducted in the Ayder and Kafkasör protected areas to determine site use type and intensity, e. g., the variety and intensity of the activities of visitors, camping sites, the numbers and average size of tents, etc. For this purpose, a public survey concerning the recreational activities of visitors was carried out using visual observation in the midsummer of 2008. According to the visual observation and public survey, in the present study the research sites are categorized as: (a) “high” disturbance sites (heavily trafficked sites), which are located on the main festival area where a lot of activities, e. g., folk dances, ball games, skiing on grass, and light grazing, have been conducted since 1960, (b) “low” disturbance sites (moderately trafficked sites), which are outside the main festival area and have been used as camping areas since 1980, and (c) the control site, which is located in an adjacent area (closed to festival activities) in grassland in the forest gap (GFG).

The experimental design at each site was a randomized complete block with five replications. Soil samples were collected from control (closed festival activities), moderately trafficked (MTS), and heavily trafficked sites (HTS). Soil research on the festival site was conducted and monitored in August 2008 when the soil moisture was typically low. The four disturbed and four undisturbed soil samples were randomly taken at a soil depth of 0 to 10 cm in each plot in the GFG area. The undisturbed soil samples were taken by using a steel core sampler of a 98.18 cm3 volume (5 cm in diameter and 5 cm in height).

2.2.1. Field Measurements

The soil penetration resistance (SPR) (Bradford, 1986) was measured from ground level to 10 cm depth, using a manual (hand-pushed) 13mm diameter cone (30°) penetrometer and 20 measurements were done on each plot. Measurement of SPR was done simultaneously in all land use types. Cumulative infiltration in the field was determined using a single ring infiltrometer (Bouwer, 1986) with 20 cm diameter and by a 20 cm height cylinder and three measurements were done on each plot. The site was prepared by removing all residues and any large clods (in tilled soils) that would interfere with achieving a level surface. The cylinder was pounded approximately 5 cm into the ground. The change in water depth of the cylinder was measured over a period of 2 h at times 5, 10, 15, 20, 30, 40, 60, 75, 90, 105 and 120 min.

2.2.2. Laboratory Analysis

Particle size distribution was determined by using disturbed soil samples sieved through a 2mm by the Bouyoucos hydrometer method (Bouyoucos, 1962). Field capacity (FC) was measured by subjecting saturated soil samples <2mm to tensions of 1/3 bars, permanent wilting point (PWP) was measured 15 bars until equilibrated in pressure membrane and pressure plate extractors (Cassel and Nielsen, 1986). Plant available water (PAW) content was calculated by the difference between the FC and the PWP (Klute, 1986). Bulk density, total porosity and saturated hydraulic conductivity were determined using the undisturbed soil samples. The dry bulk density (D_b) was determined by core method (Blake and Hartge, 1986; Grossman and Reinsch, 2002). Particle density (D_p) was determined by pycnometer method. The total porosity (P_t) was calculated by the following equations: [P_t (%)= (1- D_b/D_p)* 100, where P_t is total pore spaces, D_b is bulk density and D_p is soil particle density (Flint and Flint, 2002). Saturated hydraulic conductivity (Ksat) was measured by falling-head method according to Klute and Dirksen (1986).

2.3. Statistical Analysis

Statistical analysis was performed by analysis of variance (ANOVA), and the means were subjected to the Duncan test (P a 0.05) to obtain the main differences between the treatments (sites). The data were also subjected to correlation with SPSS software packages. The mean values found for all properties are shown in relevant tables.

3. Results and Discussion

in Ayder Location

Soil textures were sandy loam in all experimental sites. Mean sand was the highest in the control. Mean sand content slightly decreased in the MTS, and HTS compared to the control site, and mean clay content increased significantly ($p<0.034$) in the HTS site compared to the control site. Mean silt content slightly decreased significantly in the MTS and HTS sites, compared to the control site. Mean FC decreased significantly ($p< 0.020$) in HTS site compared to the control site. PAW was significantly lower ($p<0.016$) in all experimental sites compared to the control site. Mean PWP increased significantly ($p<0.042$) in HTS site compared to the control site. The significant increase in bulk density and SPR, and significant decrease in total porosity possibly affected FC, PWP, and PAW values, (see Table 1). It was reported that soil compaction has a variable effect on the water holding capacity of soils (Froehlich and McNab, 1984; Yüksek et.al, 2009; Yüksek et.al., 2010). Soil bulk density (Db) increased significantly ($p<0.010$) and total porosity (Pt) decreased significantly ($p<0.011$) in all experimental sites compared to the control site. The bulk density (Db) and soil penetration resistance (SPR) increased with disturbed conditions, and accompanying clay content increase and soil organic matter (SOM) decrease. The bulk density and soil compaction are known to vary under the influence of particle size distributions in a soil layer (Tuttle et al., 1988; Carter 1990). Saturated hydraulic conductivity (Ksat) decreased in HTS and MTS sites and it was significantly ($p<0.012$) lower than that of control site. The values of cumulative infiltration (Ic) were significantly ($p<0.001$) lower at the trafficked sites compared to that of the control site. SPR increased significantly ($p<0.014$) in all experimental sites compared to the control site (Table 1).

The highest SPR was measured in HTS site while the lowest was measured in control site (Table 1). The number of visitors and the density of visitor activities may lead to an increase in soil bulk density and SPR in the study area. Many researchers express that SPR increases as a result of the increase in the topsoil traffic density (Craul, 1994; Brady and Weil, 1999; Yüksek et al., 2009; Yüksek et al., 2010).

Table 1. Soil properties at 0 – 10 cm soil depth in the study area in Ayder

Soil Properties	Experimental Sites		
	Control site	Moderately Trafficked Site (MTS)	Heavily Trafficked Site "HTS"
Sand (%)	70.70 a)	68.55 a)	65.40 a)
Clay(%)	12.10 ab)	14.30 b)	18.20 a)
Silt (%)	17.20 a)	17.15 a)	16.14 a)
FC (% vol.)	26.40 a)	23.10 ab)	21.20 b)
PWP (% vol.)	11.95 b)	12.20 ab)	13.25 a)
PAW (% vol.)	14.45 a)	10.90 b)	7.95 c)
Db (gcm^{-3})	1.02 c)	1.18 b)	1.39 a)
Dp (gcm^{-3})	2.35 a)	2.35 a)	2.36 a)
Pt (%)	56.60 a)	49.78 b)	41.10 c)

Ksat (mmh^{-1})	60.60 a)	24.80 b)	10.35 c)
Cumulative infiltration (Ic), (mm)	451 a)	376 b)	171 c)
Soil penetration resistance (SPR)*, (MPa)	0.66 c)	1.05 b)	1.55 a)

N = Number of samples (N = 12), * mean number of sample is 20, c) Different letters after means indicate a significant difference between the means (Duncan Test, P = 0.05).

in Kafkasor Location

Soil textures were loam in all experimental sites. Mean sand was the highest in the MTS. Mean sand content slightly decreased in the HTS, while it slightly increased in the MTS compared to the control site, and mean clay content increased significantly ($p<0.034$) in the HTS site compared to the control and MTS sites. Mean silt content slightly decreased significantly in the MTS and HTS sites, compared to the control site. Mean FC decreased significantly ($p<0.029$) in HTS site compared to the control and MTS sites. PAW was significantly lower ($p<0.021$) in HTS site compared to the control site. Mean PWP increased significantly ($p<0.048$) in HTS site compared to the control and MTS sites. The significant increase in bulk density and SPR, and significant decrease in total porosity possibly affected FC, PWP, and PAW values, (see Table 2).

It was reported that soil compaction has a variable effect on the water holding capacity of soils (Froehlich and McNab, 1984; Yüksek et.al, 2009; Yüksek et.al., 2010). Soil bulk density (Db) increased significantly ($p<0.019$) and total porosity (Pt) decreased significantly ($p<0.008$) in all experimental sites compared to the control site. The bulk density (Db) and soil penetration resistance (SPR) increased with disturbed conditions, and accompanying clay content increase and soil organic matter (SOM) decrease. The bulk density and soil compaction are known to vary under the influence of particle size distributions in a soil layer (Tuttle et al., 1988; Carter 1990). Saturated hydraulic conductivity (Ksat) decreased in HTS and MTS sites and it was significantly ($p<0.018$) lower than that of control site. The values of cumulative infiltration (Ic) were significantly ($p<0.002$) lower at the trafficked sites compared to that of the control site. SPR increased significantly ($p<0.018$) in all experimental sites compared to the control site. The highest SPR was measured in HTS site while the lowest was measured in control site (Table 2). The number of visitors and the density of visitor activities may lead to an increase in soil bulk density and SPR in the study area. Many researchers express that SPR increases as a result of the increase in the topsoil traffic density (Craul, 1994; Brady and Weil, 1999; Yüksek et al., 2009; Yüksek et al., 2010). The intensity of visitor activities compacts the soil to considerable depths and significant changes occur in soil strength and saturated hydraulic conductivity because of traffic. The impacts were the greatest in the surface layer (Froehlich and McNabb, 1983). Soil compaction caused by human trampling, wheel traffic or animal grazing can destroy large pores and therefore reduce saturated or near saturated hydraulic conductivity (Drewry and Paton, 2005). After the soil compacted, soil infiltrability and permeability decrease. Similarly, if the compaction is accomplished with a proper moisture control, the movement of capillary water is minimized (Gent and Ballard, 1985).

Table 2. Soil properties at 0 – 10 cm soil depth in the study area in Kafkasor

Soil Properties	Experimental Sites		
	Control site	Moderately Trafficked Site (MTS)	Heavily Trafficked Site ”HTS”
Sand (%)	65.40 a)	66.75 a)	63.60 a)
Clay(%)	14.25 ab)	14.85 b)	19.30 a)
Silt (%)	20.35 a)	18.40 a)	17.10 a)
FC (% vol.)	25.50 a)	24.60 ab)	21.25 b)
PWP (% vol.)	11.30 b)	11.50 ab)	13.35 a)
PAW (% vol.)	14.20 a)	13.10 ab)	7.90 b)
D_b (gcm^{-3})	0.85 c)	1.10 b)	1.40 a)
D_p (gcm^{-3})	2.39 a)	2.35 a)	2.36 a)
P_t (%)	64.44 a)	53.19 b)	40.67 c)
Ksat (mmh^{-1})	58.75 a)	24.80 b)	10.35 c)
Cumulative infiltration (Ic), (mm)	430 a)	304 b)	208 c)
Soil penetration resistance (SPR), (MPa)*	0.68 c)	1.15 b)	1.50 a)

N = Number of samples (N = 12); * mean number of sample is 20, c) Different letters after means indicate a significant difference between the means (Duncan Test, P = 0.05).

4. Conclusions and Recommendations

In this research, we tried to explain the long-term impacts of visitors' activities that are carried out for many years (more than 30 years) on the surface soil properties in Ayder and Kafkasor protected areas. We determined that the intensity of visitor activities had a negative impact on surface soil physical and hydro-physical properties in different land use types in Ayder and Kafkasor protected areas. Significant changes occurred in mean clay content, soil water characteristics (FC, PWP and PAW), bulk density, total porosity, SPR, cumulative infiltration and saturated hydraulic conductivity because of traffic density in the study area. The impacts were the greatest in the heavily trafficked site and, to a lesser degree, in moderately trafficked in the study area. Although Ayder and Kafkasor are protected area, there is not accepted land use plan and management strategy. The ownership of Kafkasor protected area belongs to Forest General District, but Artvin City Municipality, Governor of Artvin and Artvin Forest Regional Manager are influential in land use types in Kafkasor protected area. Although there is no available land use plan for Ayder and Kafkasor protected area, the administrators of these bodies declare the principles of land use types in this site. It implies that, there are serious management and ownership problems regarding this protected site. Except festival days, it is free of charge to enter this protected area, and any visitor can camp at any part of this area without asking for permission, which leads to soil and vegetation degradation. We can conclude that in Ayder and Kafkasor protected area the land is used quite heavily, especially in festival days. Consequently, this leads to destruction of not only surface soil properties but also vegetation structure and plant growth. The principles of management in Ayder and Kafkasor protected area should be revised, and use of this area without a plan should be stopped as soon as possible. First of all, the ownership problem of this area should be solved. Afterwards, Ayder and Kafkasor protected area planning and management Office should be established. The manager of these office and his team who are specialized in protected area planning and management should prepare an acceptable and sustainable land use plan for this area. Visitor activities should be categorized and the most suitable places should be planned for each recreational activity. Some alternative places could be planned to suit each type of visitor activity.

References

Anonymous, 2005. Central chieftaincy planning project of Artvin. Artvin: Republic of Turkey Ministry of Environment and Forestry, District of Artvin Forestry, pp. 32–139 [in Turkish].

Blake, G.R. and Hartge, K.H., 1986. Bulk density. In Methods of Soil Analysis. Part I. Physical and Mineralogical Methods, Agronomy Monograph no. 9, 2nd ed, Miller AL, Keeney RH (eds). ASA and SSSA: Madison; 363–374.

Bouyoucos, G., 1962. Hidrometer method improved for making particle size analysis of soils. Agronomy Journal, 54, 464–465.

Bradford J.M., 1986. Penetrability. In Methods of How farmers Assess Soil Health and Quality. Journal Soil Water Consoil Analysis. Part 1. Agronomy Monograph no. 9, 2nd edn, Klute A (ed.). ASA and SSSA, Madison, WI; 229–236.

Brady, N.C. and Weil, R., 1999. The nature and properties of soils. Prentice Hall Publishing: Engelwood Cliffs, NJ.

Carter, M.R., 1990. Relationship of strength properties to bulk density and macro porosity in cultivated loamy sand to loam soils. Soil and Tillage Research, 5, 257–268.

Cassel, D.K. and Nielsen, D.R., 1986. Field capacity and available water capacity. In Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods-Agronomy Monograph no. 9, 2nd edn, Klute A (ed.). ASA and SSSA, Madison, WI; 901–926.

Cole, D.N., 1987. Research on soil and vegetation in wilderness: a state-ofknowledge review. Proceedings-National Wilderness Research Conference. State of Knowledge, Future Directions: Fort Collins, CO, 135–177.

Drewry, J.J. and Paton, R.J., 2005. Soil physical quality under cattle grazing of a winter-fed brassica crop. Australian Journal of Soil Research, 43, 525–531.

Eminagaoğlu, O. and Ansin, R., 2005. The flora of Cerattepe, Meydanlar, Demirci, Gavur Creek and near environment in Artvin. Journal of Istanbul University, Faculty of Forestry A 55: 32–46.

Flint, A. and Flint, L.E., 2002. Particle density. In Methods of Soil Analysis, Part 4-Physical Methods, Dane JH, Topp GC (eds). SSSA Book Series No. 5. Soil Science Society of America: Madison, WI; 229–240.

Froehlich, H.A. and McNabb, D.H., 1984. Soil wetness at the time of skidding and the level of in Pacific Northwest forests. Trafficking Dominate the Compaction Process in Boreal Forest Soils and Treatment Impacts Conference, University of Tennessee, Knoxville, TN, 159–192.

Gent, J.A. and Ballard, R., 1985. Impact of intensive forest management practices on the bulk density of lower Coastal Plain and Piedmont soils. Southern Journal of Applied Forestry, 9, 40–44.

Grossman, R.B. and Reinsch, T.G., 2002. The solid phase, bulk density and linear extensibility, In Methods of Soil Analysis, Part 4- Physical Methods, Dane JH, Topp GC (eds). SSSA Book Series No.5. Soil Science Society of America: Madison, WI; 201–228.

Kerbiriou, C., Leviol, I., Jiguet, F. and Julliard, R., 2008. The impact of human frequentation on coastal vegetation in a biosphere reserve. Journal of Environmental Management, 88, 715–728.

Klute, A. and Dirksen, C., 1986. Hydraulic conductivity and diffusivity. In Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods-Agronomy Monograph no. 9, 2nd edn, Klute A (ed.). ASA and SSSA: Madison, WI; 687–734.

Klute, A., 1986. Water retention. In Methods of Soil Analysis, Part 1:Physical and Mineralogical Methods, Agronomy Monograph no. 9,2nd edn, Klute A (ed.). ASA and SSSA: Madison, WI; 635–662.

Short, J.R, Fanning, D.S., Mc Intosh, M.S., Foss, J.E. and Patterson, J.C., 1986. Soils of the Mall in Washington, D.C: I. Statistical summary of properties. Soil Science Society America Journal, 50, 699–704.

Troeh, F.R. and Thompson, L.M., 1993. Soils and Soil Fertility.Oxford University Press: NY.

Tuttle, C.L., Golden, M.S. and Meldahl, R.S., 1988. Soil compaction effects on Pinus Taeda establishment from seed and early growth. Canadian Journal of Forest Research, 18, 628–632.

Vimmerstadt, J., Scoles, F., Brown, J. and Schmittgen, M., 1982. Effects of Use Pattern, Cover, Soil Drainage Class and Overwinter Changes on Rain Infiltration on Campsites, J. Environental Quality, 11, 25 – 28.

Yüksek, T., 2009. Effect of Visitor Activities on Surface Soil Environmental Conditions and Aboveground Herbaceous Biomass in Ayder Natural Park, CLEAN- Soil, Air, Water, 37,(2), 170–175.

Yüksek, T., Cengiz, T. and Yüksek, F., 2008. Doğal Alanlarda Festival Etkinliklerinin Koruma-Kullanma Açısından Değerlendirilmesi: Kafkasör Kültür, Sanat ve Turizm Festivali Örneği, Ekoloji 17,(67), 37–45.

Yüksek, T., Göl, C., Yüksek, F. and Yüksel, E.E., 2009. The Effects of Land-Use Changes on Soil Properties: The Conversion of Alder Coppice to tea Plantations in the Humid Northern Blacksea Region, African Journal of Agricultural Research, 4, (7), 665-674.

Yüksek, T., Kurdoglu, O. and Yüksek, F., 2010. The Effects of Land Use Changes and Management Types on Surface Soil Properties in Kafkasor Protected Area in Artvin, Turkey, Land degradation & development, Published online in Wiley InterScience (www.interscience.wiley.com) DOI: 10.1002/ldr.1000, (2010), (Article in press).