DOI: 10.5152/forestist.2020.20004
Forestist 2020, 70(2): 116-121

İSTANBUL UNIVERSITY
CERRAHPAŞA

Original Article

Effect of coppice forest clearance on soil moisture, temperature and certain selected soil characteristics

Baltalık ormanında traşlama kesiminin toprak nem, sıcaklığı ve belirli bazı toprak özellikleri üzerindeki etkisi

Mustafa Aytekin[1], Ferhat Gökbulak[2]

[1]İstanbul University-Cerrahpaşa, Institute of Graduate Education, İstanbul, Turkey
[2]Department of Watershed Management, İstanbul University-Cerrahpaşa Faculty of Forestry, İstanbul, Turkey

ABSTRACT

The main goal of this study was to assess the effect of coppice forest removal on soil moisture and temperature (e.g., maximum, minimum and mean daily temperatures) along with some selected soil properties. The study was conducted in the Belgrad Forest in Istanbul. A coppice forest plot was selected in the forestland. Half of the plot was cleared as a treatment site while other half was left as a control plot. The plots were 100 m by 100 m in size. Soil moisture and temperature values were recorded at hourly intervals at 1 m and 50 cm soil depths, respectively. Soil samples in disturbed and undisturbed areas were collected at 0–5 cm soil depth and analyzed for saturation capacity (SC), hydraulic conductivity (HC), bulk density (BD), particle density (PD), total porosity (TP), sand silt and clay contents, electrical conductivity (EC), pH, loss on ignition (LOI), and organic matter content (OM). Two-tailed paired student t-test were used to compare means at an alpha level of 0.05. Results revealed that daily soil moisture significantly increased from 32% to 37%, daily temperature from 14.5°C to 15.9°C, daily maximum temperature from 14.6°C to 16.2°C, and daily minimum temperature 14.4°C to 15.7°C following coppice forest clearance. Clearcutting of woody vegetation did not affect the soil sand, silt and clay contents, HD, PD, pH, and EC values in the soil; however, it caused a significant increase from 1.3 g/cm^3 to 1.5 g/cm^3 in the BD and decreases from 6% to 3% in the OM content, from 17% to 8% in the LOI, from 52% to 46% in the TP, from 51 cm/min to 32 cm/min in the HC, and from 33% to 24% in the SC of the soil.

Keywords: Forest clearance, soil temperature, soil moisture, Turkish forestry, vegetation removal

ÖZ

Bu çalışmanın amacı, baltalık olarak işletilen bir ormanda traşlama kesimin toprak nemi, sıcaklığı ve bazı toprak özellikleri üzerindeki etkisinin araştırılmasıdır. Araştırma İstanbul'da Belgrad Ormanı'nda gerçekleştirilmiştir. Bu amaçla, traşlama kesimin yapıldığı meşe-gürgen baltalık ormanından bir deneme parseli ile traşlama kesilmiş alanın bitişiğindeki kesilmemiş alandan ise kontrol amaçlı bir parsel alınmıştır. Her iki alanda 0-5 cm toprak derinliğinden bozulmuş ve bozulmamış toprak örnekleri alınmış ve örneklerin permeabilite (HC), tekstür, pH, elektriki iletkenlik (EC), organik madde (OM) içeriği, ateşte kayıp (LOI), hacim ağırlığı (BD), tane yoğunluğu (PD), maksimum su tutma kapasitesi (SC) ve toplam boşluk hacmi (TP) analiz edilmiştir. Veriler çift taraflı eşlenikli t-testi kullanılarak α=0,05 seviyesinde değerlendirilmiştir. Araştırma sonuçları, baltalık ormanının traşlama kesilmesinin, günlük ortalama toprak neminin %32'den %37'ye, günlük ortalama toprak sıcaklığının 14,5°C'den 15,9°C'ye, ortalama günlük maksimum toprak sıcaklığının 14,6°C'den 16,2°C'ye, ortalama günlük minimum toprak sıcaklığının 14,4°C'den 15,7°C'ye ve BD değerlerinin 1,3 gr cm^3'ten 1,5 gr/cm^3'e yükselmesine; buna karşılık toprakların OM içeriğinin %6'dan %3'e, LOI değerlerinin %17'den %8'e TP değerlerinin %52'den %46'ya, HC'nin 51 cm/dak'dan 32 cm/dak'ya ve SC'nin %33'ten %24'e düşmesine yol açtığını göstermiştir. Buna karşılık, sonuçlar baltalık ormanında tıraşlama kesiminin toprakların tesktürü, PD, pH ve EC değerleri üzerinde önemli bir etkisinin olmadığını göstermiştir.

Anahtar Kelimeler: Orman traşlama kesimi, toprak sıcaklığı, toprak nemi, Türk ormancılığı, vejetasyon kesimi

Cite this paper as:
Aytekin, M., Gökbulak, F., 2020. Effect of coppice forest clearance on soil moisture, temperature and certain selected soil characteristics. *Forestist* 70(2): 116-121.

Corresponding author:
Mustafa Aytekin
e-mail:
aytekinn.mustafa@gmail.com

Received Date:
20.02.2020
Accepted Date:
23.03.2020
Available Online Date:
14.04.2020

INTRODUCTION

Forestlands have different microclimate and soil characteristics compared to other land use types. Some studies have shown that forest areas have lower air and soil temperatures, wind speed, soil moisture, and soil bulk density [(BD), Aytekin, 2016; Hashimoto and Suzuki, 2004; Morecroft et al., 1998; Özkan and Gökbulak, 2017]; in contrast, they also have higher soil organic matter (OM), hydraulic conductivity (HC), soil saturation capacity (SC), and total porosity (TP) compared to other land use types (Aytekin, 2016; Bock and Van Rees, 2002; Hajabbasi et al., 1997; Rubio et al., 1999; Zhou et al., 2015). As a result of these differences in the forest ecosystems, vegetation change from woody to herbaceous cover causes significant changes in the soil properties and microclimate of forestlands. Researchers that previously studied soil properties and microclimate in clearcut areas have observed significant changes in the cleared areas compared to the untouched control plots. Rubio and Escudero (2003) reported that the OM and nitrogen contents of soil decreased following clearcutting of forest cover. Similarly, another study found that, compared to control sites, higher ambient temperatures, soil moisture, and saturation capacities were reported for soils in clearcut areas (Jehangir et al., 2012). As seen from these examples, clearance of forest vegetation can negatively affect soil characteristics to some degree, but it is difficult to reach a general consensus regarding the impact of woody vegetation clearance on soil characteristics due to differences in the soil, topography, climate, and logging activities. However, depending on forest management activities, some variation in microclimatic conditions can be expected after forest cover removal. Also, soil moisture and temperature differences between clearcut and control plots can usually be observed after forest clearance due to reduced interception and transpiration capacity of forest cover and increased solar radiation on the soil surface (Bhatti et al., 2000; Carlson and Groot, 1997; Hungerford and Babbitt, 1987; Ritter et al., 2005; Scharenbroch and Bockheim, 2007; Smit and Rethman, 2000).

Soil temperature, air temperature, and soil moisture have significant impacts on soil biological, chemical, and hydrological processes as they influence decomposition, nutrient cycling, and thermal conditions in the soil (Yi et al., 2009). They also influence ecosystem productivity and resilience (Lucas-Borja et al., 2010), runoff generation, soil and nutrient losses through erosion, microorganism activity, seed germination, seedling survival, growth performance and distribution, and the root activity of plants (Cornaglia et al., 2005; Hashimoto and Suzuki, 2004; Wang et al., 2013). The structure of forest vegetation (e.g., tree density and height) also plays an important role on soil thermal and moisture conditions. For instance, grassland soils had a greater soil temperature than coppice land soils (Morecroft et al., 1998). Similarly, Ritter et al. (2005) found greater soil moisture and temperature in forest gaps than in forestlands. Everett and Sharrow (1985) reported on observed increases in soil moisture and temperature, which were determined at 15 cm soil depth in the Shoshone Mountain range of central Nevada following Pinyon-Juniper harvesting. Similarly, larger moisture and temperature increases were described in the soils of herbaceous vegetation-dominated areas than for forest covered areas in other studies (Aytekin, 2016; Özkan and Gökbulak, 2017; Scharenbroch and Bockheim, 2007). Some studies only assessed the effect of clearcutting on soil properties and thermal conditions, but limited information is available regarding the effect of coppice forest clearance on soil characteristics (Morecroft et al., 1998; Rubio et al., 1999; Rubio and Escudero, 2003). Since coppice forest areas are cut frequently, the rotation period for high forests is longer than for coppice forests. Thus, the clearance of high and coppice forests cannot have the same effect on soil conditions. For example, chestnut coppice forests in Spain have a rotation period of between 20 and 50 years (Rubio and Escudeo, 2003), while coppice forests in Turkey have a rotation period of 20 years. Therefore, the impact of clearcutting on soil conditions can vary from region to region depending on forest types subject to clearcutting and harvest activities. Broadleaf forests in some rural regions of Turkey are allocated and managed as coppice forests with a rotation period of 20 years to meet the fuel needs of the local people. Insufficient information is available concerning the effect of coppice forest management on soil characteristics and thermal conditions. Hence, the main purpose of this study was to examine the effect of coppice forest removal on soil characteristics and provide information, which could improve coppice forest management plans to forest professionals and managers. Additionally, this study may give practitioners insight into the consequences of forest degradation that can occur due to global warming in the Mediterranean region.

MATERIAL AND METHODS

Study Site

This study was conducted in the Belgrad Forest in Istanbul, and the study plots were located between 28 ° 59´ 17´´–29° 32´ 25´´ E (longitude) and 41° 09´ 15´´–41° 11´ 01´´ N (latitude). The mean elevation was about 30 m with a slope of 45%. Clearcutting is performed in the coppice forest every 20 years and the last tree removal took place in the late fall of 2012. All woody, above-ground biomass was removed from the site and some residue (e.g., cones, twigs, stems, and thin branches) left on the site were piled parallel to the contour lines on the site. Following the 2012 forest clearance, the site was left undisturbed until the study was carried out. Some herbaceous plant species grew sparsely during that period in the study site. A control plot was also chosen adjacent to the treatment plot. Soil sampling and soil moisture and temperature monitoring began in the spring of 2014 and lasted one year. Forest site vegetation was composed of mostly *Carpinus betulus* L. and *Quercus sp.* with small mixture of some shrubs which included *Laurus nobilis* L., *Corylus sp.*, *Erica arborea* L., *Sorbus torminalis* (L.) Crantz, *Phillyrea sp.*, *Cistus sp.*, and *Arbutus unedo* L. (Yaltırık, 1966). Tree densities in the forest site were 2800 for oak and 5600 for hornbeam trees per hectare. The trees have diameters varying between 25 and 30 cm at breast with a height of about 6–7 m and canopy cover of around 90%–95%. The coppice forest had a forest floor with an average depth of 3–5 cm. The parent materials of the study plots were carboniferous clay schists and Neogene loamy, gravelly deposits. The soil type was vertic Xerochrept (U.S.D.A., 1996) with a silty clay texture. The study plots had a Mediterranean climate type with a moderate water deficit in the summer months (Özyuvacı, 1999). Long term averages of annual precipitation and temperature are typically approximately 1129 mm and 12.3°C, but they were 1044.5 mm and 13.8°C, respectively, during the study. Long term temperature values of the site vary between 21.7°C in August and 4.2°C in February.

Sampling Method

Soil sampling was carried out randomly along 2 transect lines placed in each plot and the samples were collected from a soil depth of 0–5 cm using soil cores (5.3 cm diameter, 5 cm depth). Ten soil samples were taken for each transect line and sampling was carried out twice (in spring and fall). Thus, a total of 80 samples were taken from treatment and control plots for the study. In the study, soil samples were only collected from topsoil since that part of the soil is most impacted by harvest activities. Air-dried soil samples were sieved using 2 mm mesh and analyzed for certain hydro-physical soil properties that play an important role on the water content of the soil and indicate the impact of the shift from woody to herbaceous cover. Soil samples were analyzed for the following properties: HC (cm/min), soil bulk density (BD) (g/cm^3), soil texture, soil particle density (PD) (g/cm^3), organic matter (OM) (%), loss on ignition (LOI) (%), total porosity (TP) (%), pH, electrical conductivity (EC) (µS/cm), and soil saturation capacity (SC) (%). HC was measured according to the Darcy's law equation (Özyuvacı, 1976). BD was measured by dividing the mass of soil core content by core volume. Soil texture was assessed using the Bouyoucos hydrometer method. PD (g/cm^3) was measured using the Pycnometer method. LOI was measured as a percentage of the oven-dried soil sample weight after igniting soil samples at 700°C for 4 hours. TP values were calculated based on the relationship between BD and PD. pH and EC (soil/water ratio of 1/5) were measured with the WTW Multiline P4 Universal Meter (WTW, Weilheim, Germany). SC was calculated as the percentage of water contained in the saturated core samples as explained by Balcı (1973) and OM content determined via the Walkley-Black chromic acid method (Jackson, 1958).

Table 1. Average values of certain soil properties (mean±standard deviation) in the clearcut and control plots (Aytekin et al., 2016)

Selected soil characteristics	Clearcut area	Coppice forest	Significance level (P)
HC (cm/min)	32±49	51±58	0.055
BD (g/cm^3)	1.5±0.13	1.3±0.20	0.002
Sand (%)	60±5	61±3	0.270
Silt (%)	18±3	18±3	0.908
Clay (%)	22±3	21±3	0.083
PD (g/cm^3)	2.7±0.12	2.7±0.34	0.862
OM (%)	3±1.8	6±1.2	<0.001
LOI (%)	8±4.2	17±3.1	<0.001
TP (%)	46±6	52±8	0.001
pH	6±0.4	6±0.7	0.088
EC (µS/cm)	101±52	105±21	0.779
SC (%)	24±1.3	33±2	0.003

HC: hydraulic conductivity; BD: bulk density; PD: particle density; OM: organic matter content; LOI: loss on ignition; TP: total porosity; SC: saturation capacity; EC: electrical conductivity

Soil moisture and temperature were recorded using CS616 and CS107-L model probes at 1 m and 0.5 m soil depth, respectively. The data was recorded in a CR1000 model data logger with hourly intervals (Campbell Scientific Inc., Logan, USA). Hourly recorded data was converted to average daily values. Two-tailed paired student t-test were used to compare the means at an alpha level of 0.05 (Zar, 1996).

RESULTS AND DISCUSSION

Our results showed that clearcutting of coppice forest significantly influenced BD, OM content, LOI, TP, and SC ($p<0.05$); whereas, it did not appear to have any influence on HC, sand, silt and clay contents, PD, pH, and EC (Table 1). Soil BD significantly increased from 1.3 (g/cm^3) to 1.5 (g/cm^3); however, the following properties experienced significant decreases: OM content (from 6% to 3%), LOI (from 17% to 8%), and TP (from 52% to 46%) (Table 1). Decreases in the TP, HC, and SC of the soils together with the apparent increase in the BD suggested that soil compaction took place after coppice forest clearance.

The results of our study are consistent with the results of other studies conducted under different ecological conditions. For instance, increases in soil BD values were observed in Canada (Bock and Van Rees, 2002), Southeastern China (Zhou et al., 2015), Iran (Hajabbasi et al., 1997), and India (Jehangir et al., 2012) as were found in the present study. Also, similar decreases in soil OM content, water holding capacity, and total porosity were reported after clearcutting in several studies around the world (Jehangir et al., 2012; Rubio and Escudero, 2003; Zhou et al., 2015). However, pH and EC values did not show any changes in the present study following clearcutting, unlike those found by Rubio et al. (1999), Jehangir et al. (2012), and Albert and Barness (1987). Contrary to our findings, Hajabbasi et al. (1997) observed a decrease in the clay content of soils in the clearcut area, and Albert and Barness (1987) did not observe any changes in OM content or BD values of soils in the clearcut area. As seen from these studies, it is hard to generalize about the effect of clearcutting on all selected hydro-physical soil properties due to differences in climate, soil, topography, and mechanization procedures in harvest practices. However, some generalizations can be made about a few soil properties. Among the chosen soil characteristics, soil BD, TP, OM content, and HC are the soil properties most affected after clearcutting due to soil compaction as a result of harvest activities in the site.

Clearcutting of coppice forests also caused a significant increase in volumetric daily soil moisture values ($p<0.05$). Average soil moisture content was 37% and varied from 24% to 57% in the soil of the clearcut area, while it was 32% and changed between 17% and 50% in the soil of the coppice forest. Moisture content in the soils of both plots followed a similar trend, but the soil of

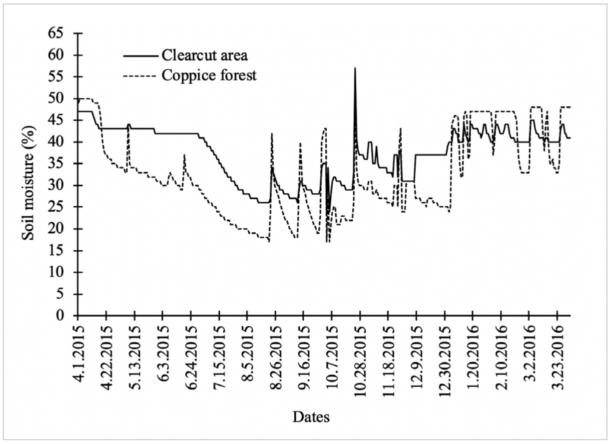

Figure 1. Comparison of daily volumetric soil moisture content in the soils from the clearcut area and coppice forest (Aytekin et al., 2016)

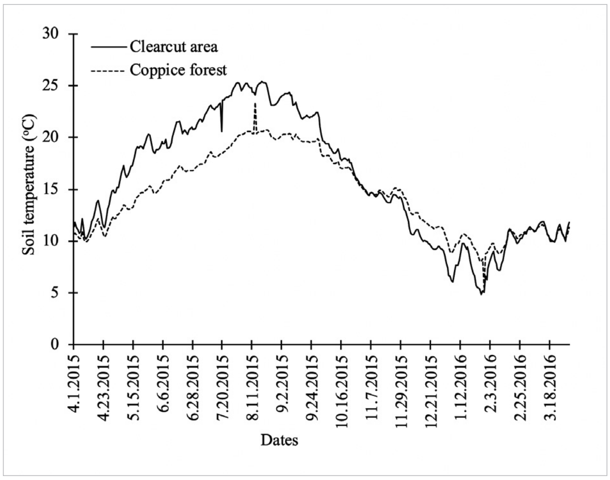

Figure 2. Comparision of daily soil temperature in the clearcut area and coppice forest (Aytekin et al., 2016)

the coppice forest typically had less moisture content than soil in the clearcut area (Figure 1). The difference between soil moisture content in the clearcut and coppice forest was high during the vegetation period due to higher transpiration, interception losses from the canopy cover of coppice forest, and the absence of trees in the clearcut area. In contrast, the difference between moisture content of the soil from both sites decreased in the dormant season, and forest soils had greater moisture content during rainy days when trees had no leaves (Figure 1).

Moisture increases occurred after clearcutting, as expected. On the other hand, the results of different studies supported our findings that forest vegetation removal increased the moisture content of the soils in the clearcut area compared to the undisturbed coppice forest area (Garduńo et al., 2010; Gray et al., 2002). In fact, in a study conducted in the Oregon Cascade, clearance of Douglas-fir forest resulted in a moisture increase of over 10 cm in the site (Adams et al., 1991). Also, Ritter et al., (2005) reported greater moisture values in the gaps created in the Suserup forest in Denmark compared to the forest plot. Similarly, Jehangir et al. (2012) found higher moisture content in the soils from clearcut areas compared to forest areas. Moisture increases in the areas could be attributed to decreases in the interception and transpiration capacities of forest canopy following timber removal. Moreover, clearance of coppice forest affected soil temperatures significantly; daily temperature increased from 14.5°C to 15.9°C (Figure 2), maximum temperature from 14.6°C to 16.2°C (Figure 3), and minimum temperature from 14.4°C to 15.7°C (Figure 4).

As expected, mean daily, maximum, and minimum soil temperatures increased after clearcutting, and all temperatures followed the same trend both in the clearcut and coppice forest areas. The differences between soil temperatures of the clearcut areas and coppice forestlands started to increase as the vegetation period progressed and canopy closure increased as well. In contrast, soil temperatures decreased in the clearcut area during

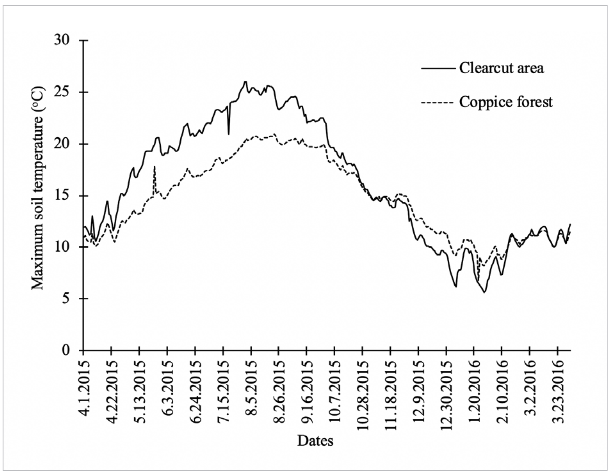

Figure 3. Comparision of daily maximum soil temperatures in the clearcut area and coppice forest (Aytekin et al., 2016)

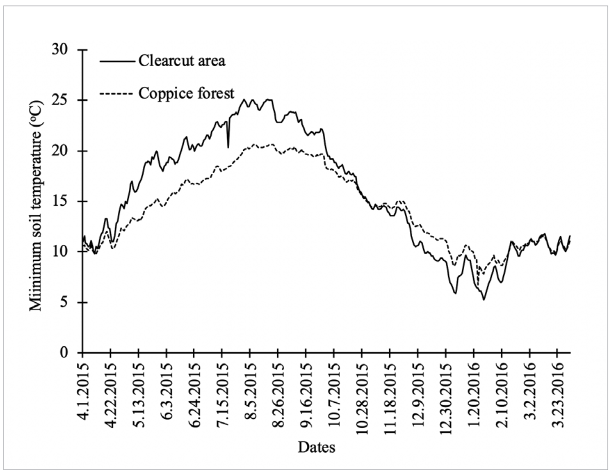

Figure 4. Comparision of daily minimum soil temperatures in the clearcut area and coppice forest (Aytekin et al., 2016)

the dormant season (Figures 2-4). The findings of the present study are consistent with results of other studies (Bhatti et al., 2000; Carlson and Groot, 1997; Morecroft et al., 1998; and Ritter et al., 2005) which note that coppice forest removal triggered increases in the soil temperature and moisture but the magnitude of the increases was not similar. The differences can be the result of variations in the climate, soil, and vegetation cover (Song et al., 2013), time frame of study period, and plot size, as well as differences in research methods, implementation techniques, applications, and approaches. In general, increases found in the soil moisture and temperature of the treatment site could be result of the availability of solar radiation on the soil surface and lower transpiration and interception capacity of the coppice forest cover after clearance (Bhatti et al., 2000; Carlson and Groot, 1997; Hungerford and Babbitt, 1987; Ritter et al., 2005; Scharenbroch and Bockheim, 2007; Smit and Rethman, 2000).

CONCLUSION

Findings from this study revelaed that the clearcutting of coppice forest has a negative impact on soil properties and soil thermal conditions. Some soil properties that were negatively influenced by tree harvesting were soil BD and TP. Significant decreases in these soil properties occured as a result of soil compaction due to harvest practices, and they significantly affected soil HC and SC, hence, the mositure regime of the soils. Decreases in OM content and LOI took place and could be attributed to the removal of plant residues from the soil surface. Results of previous studies have already shown how results varied among the several studies because of differences in site conditions and harvest practices. In contrast, some soil characteristics such as pH, EC, texture, and PD did not show any significant changes because these soil properties can not drastically change in a short-term study period. Moreover, soil temperature and moisture content are the soil properties that are undoubtedly affected by forest removal. Moisture and temeperature are important factors in forest ecosystems because they have great influence on hydrological, biological, and chemical processes that take place in the field. Therefore, forestry professionals and practitoners could consider both soil temperature and moisture parameters as indicators in the recovery of degraded forest ecosystems. Since biological, physical, and chemical soil characteristics can be changed by human intervention, these properties can be misleading for understanding recovery of degraded forest soils. Additionally, monitoring soil temperature and moisture is relatively easy and simple to achieve compared to undertaking the monitoring some vegetation attributes in order to find out recovery period of degraded lands. Since changes in the soil moisture and temperature of clearcut areas influence most of the processes in forest soils, forestry professionals should aim to monitor soil temperature and moisture trend in these areas and be aware of the consequences of their forestry practices. On the other hand, the Mediterranean region is one of the regions where global warming may have a greater impact. Therefore, the results of this study also give some clues about potential changes in the region's soils if forest cover becomes replaced by herbaceous cover as a result of global warming.

Ethics Committee Approval: Ethics committee approval was not needed for this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – F.G.; Design – F.G. ; Supervision – F.G.; Resources – F.G., M.A.; Materials – F.G., M.A.; Data Collection and/or Processing – M.A.; Analysis and/or Interpretation – F.G., M.A.; Literature Search – F.G., M.A.; Writing Manuscript – F.G.; Critical Review – F.G., M.A.; Other – F.G., M.A.

Acknowledgements: The authors thank the Scientific Research Project Unit (BAP) of Istanbul University Cerrahpaşa for supporting the project with funding (grant number 49755).

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study received financial support from the Scientific Research Project Unit (BAP) of Istanbul University Cerrahpaşa with grant number of 49755.

REFERENCES

- Adams, P.W., Flint, A. L., Fredriksen, R. L., 1991. Long-term patterns in soil moisture and revegetation after a clearcut of a Douglas-fir forest in Oregon. *Forest Ecology and Management* 41 (3-4): 249-263. **[CrossRef]**
- Albert, D.A., Barnes, B., 1987. Effects of clearcutting on the vegetation and soil of a sugar maple-dominated ecosystem, Western upper Michigan. *Forest Ecology and Management* 18: 283-298. **[CrossRef]**
- Aytekin, M., 2016. Tıraşlama kesiminin toprak nemi ve sıcaklığı ile otsu bitkilerin gelişimi üzerindeki etkisi. Yüksek Lisans Tezi, İstanbul Üniversitesi Fen Bilimleri Enstitüsü, Istanbul.
- Aytekin, M., Gökbulak, F., Tekin, H., 2016. Response of soil moisture, temperature and some soil properties to forest removal in a broadleaf forest ecosystems. International Forestry Symposium. 07-10 December, Kastamonu-Turkey.
- Balcı, A.N., 1973. Physical, Chemical and Hydrological Properties of Certain Western Washington Forest Floor Types. Istanbul University Publication No.: 1849, Faculty of Forestry (Publication Number: 200, Istanbul (In Turkish)).
- Bhatti, J.S., Fleming, R.L., Foster, N.W., Meng, F.R., Bourque, C.P.A., Arp, P.A., 2000. Simulations of pre- and post-harvest soil temperature, soil moisture, and snowpack for jack pine: comparison with field observations. *Forest Ecology and Management* 138: 413-426. **[CrossRef]**
- Bock, M.D., Van Rees, K.C.J., 2002. Forest harvesting impacts on soil properties and vegetation communities in the Northwest territories. *Canadian Journal of Forest Research* 32: 713-724. **[CrossRef]**
- Carlson, D.W., Groot, A., 1997. Microclimate of clear-cut, forest interior, and small openings in trembling aspen forest. *Agricultural and Forest Meteorology* 87: 313-329. **[CrossRef]**
- Cornaglia, P.S., Schrauf, G.E., Nardi, M., Deregibus, V.A., 2005. Emergence of dallisgrass as affected by soil water availability. *Rangeland Ecology & Management* 58: 35-40. **[CrossRef]**
- Everett, R.L., Sharrow, S.H., 1985. Soil water and temperature in harvested and nonharvested pinyon-juniper stands. USDA Intermountain Research Station Ogden, UT. Research Paper INT-342.
- Garduńo, H.R., Fernald, A.G., Cibils, A.F., VanLeeuwen, D.M., 2010. Response of understory vegetation and soil moisture to infrequent heavy defoliation of chemically thinned juniper woodland. *Journal of Arid Environments* 74: 291-297. **[CrossRef]**

- Gray, A. N., Spies, T. A., Easter, M.J., 2002. Microclimatic and soil moisture responses to gap formation in coastal Douglas-fir forests. *Canadian Journal of Forest Research* 32: 332-343. **[CrossRef]**
- Hajabbasi, M., Jalalian, A., Karimzadeh, H.R., 1997. Deforestation effects on soil physical and chemical properties, Lordegan, Iran. *Plant Soil* 190: 301-308. **[CrossRef]**
- Hashimoto, S., Suzuki, M., 2004. The impact of forest clear–cutting on soil temperature: a comparison between before and after cutting, and between clear-cut and control sites. *Journal of Forestry Research* 9 (2): 125-132. **[CrossRef]**
- Hungerford, R.D., Babbitt, R.E., 1987. Overstory removal and residue treatments affect soil surface, air, and soil temperature: implications for seedling survival. USDA Intermountain Research Station Ogden, UT. Research Paper INT-377. **[CrossRef]**
- Jackson, M.L., 1958. Soil chemical analysis. Englewood Cliffs: Prentice Hall.
- Jehangir, A., Yousuf, A. R., Reshi, Z.A., Tanveer, A., Ahmad, A., 2012. Comparison of physical, chemical and microbial properties of soils in a clear-cut and adjacent intact forest in North Western Himalaya. India. *International Journal of Soil Science* 7 (3): 71-81. **[CrossRef]**
- Lucas-Borja, M.E., Bastid, F., Nicolás, C., 2010. Influence of forest cover and herbaceous vegetation on the microbiological and biochemical properties of soil under Mediterranean humid climate. *European Journal of Soil Biology* 46: 273-279. **[CrossRef]**
- Morecroft, M.D., Taylor, M.E., Oliver, H.R., 1998. Air and soil microclimates of deciduous woodland compared to an open site. *Agricultural and Forest Meteorology* 90 (1-2): 141-156. **[CrossRef]**
- Özkan, U., Gökbulak, F., 2017. Effect of vegetation change from forest to herbaceous vegetation cover on soil moisture and temperature regimes and soil water chemistry. *Catena* 149, 158-166. **[CrossRef]**
- Özyuvacı, N., 1976. Hydrologic characteristics of the Arnavutköy Creek Watershed as influenced by some plant-soil-water relations. Ph.D. Thesis. Istanbul University Faculty of Forestry, Istanbul-Turkey.
- Özyuvacı, N., 1999. Meteorology and climatology. Istanbul University Publications No. 4196, Istanbul (in Turkish).
- Ritter, E., Dalsgaard, L., Einhorn, K.S., 2005. Light, temperature and soil moisture regimes following gap formation in semi-natural beech-dominated forest in Denmark. *Forest Ecology and Management* 206: 15-33. **[CrossRef]**
- Rubio, A, Gavilán, R., Escudero, A., 1999. Are soil characteristics and understorey composition controlled by forest management? *Forest Ecology and Management* 113: 191-200. **[CrossRef]**
- Rubio, A. Escudero, A., 2003. Clear-cut effects on chestnut forest soils under stressful conditions:lengthening of time-rotation. *Forest Ecology and Management* 183: 195-204. **[CrossRef]**
- Scharenbroch, B.C., Bockheim, J.G., 2007. Impacts of forest gaps on soil properties and processes in old growth northern hardwood-hemlock forest. *Plant Soil* 294: 219-233. **[CrossRef]**
- Smit, G.N., Retman, N.F.G., 2000. The influence of tree thinning on the soil water in a semi arid savanna of southern Africa. *Journal of Arid Environments* 44: 41-59. **[CrossRef]**
- Song, Y.T., Zhou, D.W., Zhang, H.X., Li, G.D., Jin, Y.H., Li, Q., 2013. Effects of vegetation height and density on soil temperature variations. *Chinese Science Bulletin* 58, 907-912. **[CrossRef]**
- U.S.D.A. 1996. Keys to soil taxonomy. 7th ed. Washington, DC Wang, Y., Shao, M., Liu, Z., 2013. Vertical distribution and influencing factors of soil water content within 21-m profile on the Chinese Loess Plateau. *Geoderma* 193-194: 300-310. **[CrossRef]**
- Yaltırık, F., 1966. Floristic analysis of Belgrad Forest and main stand composition. General Directorate of Forestry Publication Number: 6, Ankara, Turkey (in Turkish).
- Yi, S., McGuire, A.D., Harden, J., Kasischke, E., Manies, K., Hinzman, L., Liljedahl, A., Randerson, J., Liu, H., Romanovsky, V., Marchenko, S., Kim, Y., 2009. Interactions between soil thermal and hydrological dynamics in the response of Alaska ecosystems to fire disturbance. *Journal of Geophysical Research* 114: 1-20. **[CrossRef]**
- Zar, J.H., 1996. Biostatistical analysis. 3rd ed., NJ: Prentice Hall, Upper Saddle River, USA.
- Zhou, X., Zhou, Y., Zhou, C., Wu, Z., Zheng, L., Hu, X., Chen, H., Gan, J., 2015. Effects of cutting Intensity on soil physical and chemical properties in a mixed natural forest in Southeastern China. *Forests* 6: 4495-4509. **[CrossRef]**