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ANALYZING EFFECTS OF BURNED FOREST AREAS IN THE NEIGHBORING PATCHES WITH USE OF DATA-SETS FROM GOOGLE EARTH ENGINE: CASE OF IZMIR FOREST FIRE

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ABSTRACT

The aim of this study is to investigate the effects of neighborhood relations on existing landscape patches in the assessment of landscape patch quality.The quality of a landscape patch is directly related to the biodiversity and the land uses adjacent to the patch. In other words, the land use of neighboring patch can have a multifaceted effect on that patch. While these neighborhoods increase the biodiversity of the landscape patch, its connection with other patches, also cause degradation and loss of habitat. Therefore, when evaluating the quality of the landscape patch, neighboring relations should be taken into consideration. In this study, neighboring relationships of forest fire severity patches in existing land cover were analyzed with use of data-sets from Google Earth Engine (GEE) which is a cloud computing platform. The data have been selected from Izmir which is the biggest city in Aegean Region of Turkey, and the neighboring relations have been analyzed. As an example, the forest fire occurred in 18th August 2019 case has been selected which is one of the biggest forest fire happened in Izmir from the past. This burned area is neighbor with the center of Menderes town in East, and the other directions are covered by unaffected forests. The relation between burned area and these patches are analyzed with use of Google Earth Engine derived NDVI data-sets from Landsat 8 and Sentinel 2 from the dates of pre- and post-forest fire event The burned area has been automatically detected, converted to vector, then the boundary of the patches have been converted to the points. The ratio of the points which belong to the patch with total number of points along the boundary of burned area gives the relationship ratio which is used to evaluate the effect.

KEYWORDS:
Landscape patch analysis, forest fire, remote sensing, numerical analysis, Google earth engine

INTRODUCTION

Many anthropogenic environmental problems, especially global climate change, create serious pressure on natural resources [1]. Since the 1950s, the decrease of natural resources resulting from these pressures has determined the world's agenda [2]. In this context, many conservation-use strategies such as Biodiversity Convention and Green Deal have started to be implemented based on sustainability for natural resources [3,4]. The main goal of these strategies is to provide a more livable environment for future generations [5,6].

Conservation of natural resources such as air, soil, water, and forest and supporting biodiversity constitute the basis of ecological sustainability [7,8,9]. However, the forests, which are an important landscape patch, are shrunk, drilled, and fragmented as a result of various anthropogenic effects [10,11]. In addition, the biological diversity in these forests is also damaged [12]. To eliminate and manage these negative effects, the current status of these landscape patches should be determined. Many landscape metrics that measure the landscape structure are used to determine the status of the landscape patches [13]. Many indexes such as number of patches, mean patch size, edge density, mean patch edge, patch shape complexity, isolation / proximity and connectivity are frequently used in the evaluation of the existing landscape patch [14,15,16,17]. These indexes evaluate the landscape patch within the scope of composition and configuration and create interpretable numerical data for strategic management of these landscapes [18,19].

In addition to determining the current structure of the landscape, the evaluation of other landscape patches adjacent to that landscape is important in terms of sustainability [20]. For example, an urban settlement adjacent to a forest puts pressure on that forest patch, and both the loss of trees and the deterioration of microclimatic comfort can reduce the forest patch quality. Therefore, forest habitat can also be damaged by this situation. However, the river adjacent to a forest can support forest patch quality with its various ecological and physical char-

acteristics [21]. Therefore, determining the neighborhood relationships of landscape patches is important for the health and sustainability of those landscapes [22].

Forest fires, which occur because of various natural and mostly anthropogenic effects, adversely affect the quality of the forest patch, its physical and biological characteristics, forest habitat and microclimate [23,24]. The forest patch is shrinking, fragmenting, and disappearing because of fires. At the end of the fire, new landscape patches are formed, which differ greatly from the old version. Determining the relations of these landscape patches with neighboring landscapes and their current situation is important within the scope of making strategic plans for sustainability and constitutes the subject of this study [25].

In this study, the condition of pre-fire and post-fire forest patches was analyzed within the context of neighborhood relations. The main goal of the study is to determine the existing land cover and neighborhood status of the forest patches after the fire semi-automatically by means of remote sensing and geographical information systems and to compare the forest patches before and after the fire in this context. In this way, tangible data will be obtained to create fast and effective plans for the rehabilitation of these forest patches after a forest fire.

MATERIALS AND METHODS

The main material of the study is the pine forests and its surroundings, which are located within the boundaries of Izmir province and suffered a great fire in 2019. The burnt forest patches are located at 38 ° 13'37.28 "N and 26 ° 57'7.34" E coordinates. The fire zone generally has a high slope and a deep valley topography. The altitude of the region varies between 200 m and 900 m (Figure 1).

The fire has been effective in the Güzelbahçe, Seferihisar and Yeniköy Forest Management Chiefs of the Menderes Forestry Operation Directorate affiliated to İzmir - Turkey. The burned area is neighbor with the center of Menderes town in East, and the other directions are covered by unaffected forests. The forests in the burnt area generally consist of *Pinus brutia* trees.

Remote sensing and geographic information systems have been used to detect the fire severity area. Google Earth Engine service and Landsat 8 with Sentinel 2 satellite images were used as auxiliary materials in the study.

Google Earth Engine software is an interface that can perform web-based online analysis. This software can be used to evaluate and analyze web-based remote sensing images [26]. This web-based system, which prevents unnecessary data storage and enables data processing speed to be independent from the computer, provides fast analysis and decision making. These systems can also use images obtained from satellites such as Landsat, MODIS, ASTER, Sentinel.

Landsat 8 images can be used for monitoring and understanding many natural resources such as water and forest. Images of this satellite are frequently preferred for monitoring environmental changes [27,28,29]. Landsat 8 satellite captures images in visible, near-infrared, short-wave infrared, and thermal infrared ranges, and has a mid-spatial resolution between 15 and 100 meters depending on the spectral range. On the other hand, Sentinel 2 images were also used to make a comprehensive comparison and evaluation. Sentinel 2 images are a part of ESA Copernicus program, the sensor provides Level 2A multispectral images which were already atmospheric corrected.

The method consists of three main steps which include data collection, analysis, and evaluation. The all process has been performed in Google Earth Engine and Python environment. Google Earth Engine is cloud processing service for Geospatial data analysis, which includes a large data archive such as satellite imagery both optical and radar, climate, and topographical datasets. The platform allows users to do programming in JavaScript. Previously several studies used GEE platform to analyze the vegetation or identify the forest fires' effects [30-33].



FIGURE 1
Test area, Izmir-Turkey

TABLE 1
Acquisition Dates of the Used Satellite Images

Date	Image
August 11th ,2019,Pre-fire	Sentinel 2
August 21th ,2019,Pre-fire	Sentinel 2
August 16th 2019, Pre-fire	Landsat 8
August 23th, 2019, Post-fire	Landsat 8



FIGURE 2
Pre- and Post-Fire Images, Left: Landsat 8 Images, Right: Sentinel 2 Images

Detection of the fire severity areas and classification of the severity. The Normalized Burn Index (NBR) was used to determine the burn severity. The formula of the NBR can be described as (NIR-SWIR2)/(NIR+SWIR2), and dNBR is calculated with the formula of NBRpre-NBRpost which are calculated for before and after occurred forest fire. The test site is shown in Figure 1. The severity mapping is repeated for Landsat 8 and Sentinel 2 images both, then the results are compared. The whole process was performed in Google Earth Engine Platform with implementation of UNSPIDER provided JavaScript codes [34].The properties of the used images are shown in the following Table 1, the images are shown in Figure 2.

Analysis of the neighboring patches. In this method the boundary of the extracted severity classes from the satellite images were converted from the linear features to the points with 10 meters interval distances. For each cluster, the total number of points from the nearest land cover category were calculated for each severity class. Thus, the percentage of the neighboring land cover was determined. The land cover categories of the test area were created with applying ISODATA classification in SAGA GIS Platform.

RESULTS AND DISCUSSION

The severity maps are created both for Landsat and Sentinel images. The severity situations are classified into seven sub-categories Enhanced Regrowth High, Enhanced Regrowth Low, Unburned, Low Severity, Moderate-low Severity, Moderate-high Severity, and high severity. The total area of each category for both datasets are shown in the following Table 2.

The detected classes from two different images are shown in Figure 3.

As shown in Table 2 and Figure 3, the results from Landsat and Sentinel sensors differ especially for the low severity. The total area for the medium and high severity has a difference of 250 ha, which is reasonable for the resolution of the used images. The percentage of the neighborhood with the moderate and severity classes are listed as shown in Table 3.

TABLE 2
The Calculated Areas for Each Category

Category	Area (ha) _ Landsat 8	Area _ Sentinel 2
Low Severity	2973.60	1241.10
Moderate-low Severity	2764.53	2760.48
Moderate-High Severity	1773.99	1686.24
High Severity	1397.70	1241.10
Total	8909.82	6928.92
Moderate+ High Severity Total	5936.22	5687.82

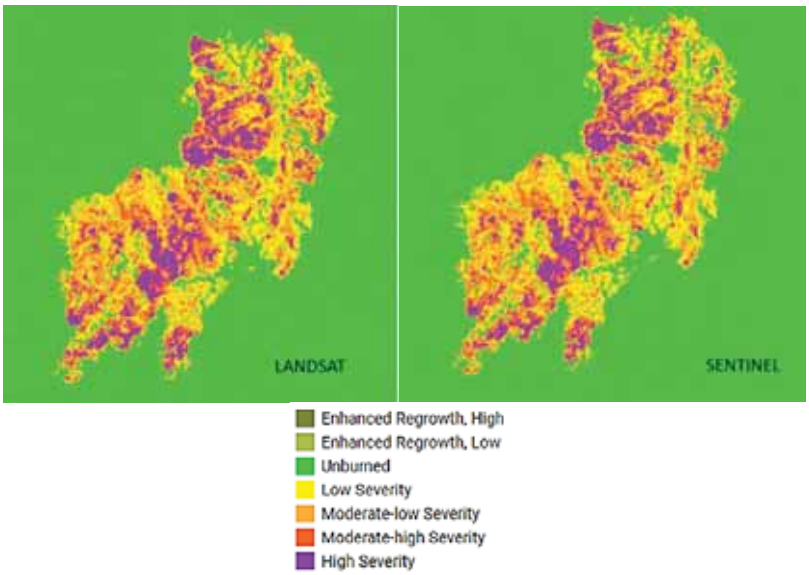


FIGURE 3
Burned Areas, left: from Landsat, right: from Sentinel

As presented in Table 3, the land class of urban area has the maximum risk with extension of the fire severity with rate 44%. This analyze shows that the urban area is under high-risk condition with the forest fires in the specific test area. In literature we find the detailed analysis of the fire severity [11,12,30]. In our study, we have proposed a method which evaluates the neighborhood of the fire severity with other land cover classes to investigate the future forest fire risks.

TABLE 3
Percentage of the Neighboring Land Cover

Land Class	Percentage (%)
Forest	30
Urban Area	44
Bare Ground	26

CONCLUSION

This study uses remote sensing technologies to analyze the environmental effects of the forest fire that occurred in Izmir in 2019 at the neighborhood level. The severity levels are calculated with use of Google Earth Engine Platform with use of UNSPIDER provided Google Earth Engine codes [34]. The method relies on calculating the difference between pre and post normalized burn indices. The neighboring patches with the burned area was automatically analyzed, and the ratio of the patches which are adjunct to the fire severity areas are calculated. This may be useful for investigating the reasons of the fire and planning of the future conservation activities accordingly.

The obtained results show that the burnt forests spread throughout the study area. Therefore, the burned areas adjacent to the living forest cover are in interaction with each other. It is necessary to rehabilitate both the burned forest cover and the soil structure that has lost its biological characteristics. Because it is predicted that forests deprived of their physical and biological characteristics will negatively affect the living forest habitat. In addition, the neighborhood relationship between urban areas and burned forests will be adversely affected due to microclimatic factors. In this context, Soil cover, which is the habitat of burnt forests, should be rehabilitated. After soil rehabilitation, afforestation works should be carried out urgently, and the area should be restored to its former state. In case of possible fire, buffer zones should be created between landscape patches that will not prevent wildlife movement. In addition, ecological corridors should be created between independent forest patches, and these corridors should be built based on ecology and engineering. Thus, the study area will be able to sustain ecosystem services physically and biologically.

The future work may include to develop an interface to allow any user to make their own analysis accordingly. This interface can also aim to display the positive and negative relationships between adjacent landscape patches in the form of numerical values.

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