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Research Article

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Determination of the Gas Effects Causing Damages on Forests

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Abstract Determination of the natural resources, utilizing them within a plan, and preservation of the ecological balance are all among the important parameters for the development of the economy of a country. Rapid increase in the population of the world and technological developments required more efficient studies on the research and utilization of limited natural resources to afford people's needs. It is important for the economies of countries to get information about to rich natural resources. In recent years, environmental pollution on natural resources, especially on the forests caused by industrial organizations as a result of the technological developments has been a popular problem. The problem is getting more and more important for our country, which is developing industrially. In this study, Karabük, which has become an industrial city after the construction of the iron & steel factory, was chosen as the study area. In 1940 when the factory started to work, the harmful gases emitted to the nature posed a great threat for the surrounding forests. In the study, aerial photos taken in 1984, 1995 and Landsat 5 TM satellite images of 1987 and 2000 were used. The analyses were completed using the ground work and the damage caused by the gases was determined. In the direction of the dominant wind, sample trees were examined and a decrease in the increment of the trees and sprout deaths were observed. Precautions to be taken to reduce the negative effect of the industrial gases on the forest were stated.

Keywords Forest, Gas damage, Aerial photo

1. Introduction

Detection of the gas damage caused by industrial organizations with the help of remote sensing data such as aerial photographs and satellite images provides a basis for understanding the environmental pollution in the existing forest areas, determining their extent, and conducting pollution prevention studies [1-5-6]. In this study, air pollution caused by an iron and steel plant in Karabuk between 1980-2005 and to what extent it affected the individuals in the regional forests has been examined through remote sensing data and complementary terrestrial studies.

In dry air, dust and gases hang in the air for a period of time then they kept and accumulated in the forest ecosystem, particularly by trees, and by the lower flora and soil [2-3]. In rainy weather, harmful substances in the air and dry substances that have accumulated in the ecosystem are carried to the depths of the soil by rainwater. The basic air pollutant (SO_2) gas is dangerous to plants. A small amount of SO_2 (0,1-0,3 ppm) is harmful to the plant in the long term. This situation has a chronic effect on plants. Chlorosis causes decrease in photosynthesis, growth retardation, and scarcity of product . The cause of color change in assimilation organs is explained as follows. SO_2 gas reacts chemically with iron in assimilation organs and thus chlorophyll decomposes [4-7-9]. Apart from that, it changes the chemical structure of chloroplasts, disrupts the colloidal balance in the cell, and causes the stomata not to work properly. As a result, transpiration increases and CO_2 intake decreases.

The signs of gas damage detected on the infrared films are particularly the harm on plant leaves. As a result of this damage, the intercellular spaces that are abundantly present in the mesophyll layer of the leaves are reduced. Leaves are depicted in various colors according to the degree of change occurred in their structure due to causes such as gas and insects. The portrayal of objects in this way allows small damage to become easily visible. However, the accuracy of interpretations should be ensured through terrestrial checks.

With today's high resolution satellite images, gas damage is easily detected on a stand and single tree basis. The use of satellite images with high terrestrial resolution in the detection of gas damage in the stands makes it easier to see the color change clearly in the studies on a single tree basis. However, terrestrial data are very important in such studies. It is necessary for the results obtained to be supported by terrestrial data.

2. Material and Methods

Karabuk is situated in Turkey's western Black Sea region, between the 41° 02' 25"- 41° 11' 35" northern latitudes and 32° 27' 05"-32° 40' 28" eastern longitudes. Karabuk Iron and Steel Works has been established 300 meters above sea level, in the valley where the Soganlı and Arac streams meet. The area within the boundaries of the Keltepe Forest Sub-district Directorate has been chosen as the examination area in the dominant wind direction (Southwest, Northeast).

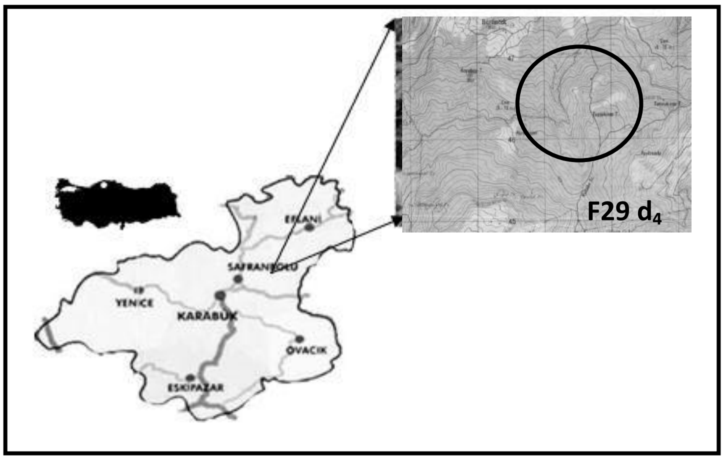

Figure 1: Study area

Topographic maps numbered ZONGULDAK-F29-d1 and ZONGULDAK-F29-d4 with a scale of 1/25000 were used to identify the areas most affected by air pollution (Figure 1). In addition, the forest management plan and stand types map of the Keltepe Forest Sub-district Directorate were also utilized. In the study area, 20 different-aged, diseased fir trees were detected and their ages were found by increment borer. In this study, to compare the detected dimensions of the gas damage, measured SO_2 data were needed and therefore the data of the project conducted by Zonguldak Karaelmas University, Karabuk Technical Education Faculty, Marmara University Technical Education Faculty, and supported by the State Planning Organization were utilized [8-10].

Received from the Forest Map and Photogrammetry Directorate of the General Directorate of Forestry and covering the study area, aerial photographs numbered 4106, 4107 of the 1984 flight and aerial photographs numbered 95, 96 of the 1995 flight were utilized (Figure 2). The aerial photographs were interpreted with the help of mirrored stereoscopes. Through the interpretation and evaluation of infrared color films, the communities of plants affected, sick, or dead for various reasons (gas, insect, etc.) are recognized and distinguished. The reason behind this is that the different emission values of needles and leaves can be detected as different gray tones in infrared black and white or colorful intakes. Leaves reflect infrared rays to a great extent. This is related to leaf tissue. The intercellular spaces present in the mesophyll layer in the leaf tissue reflect infrared rays to a great extent. In the research area, the characteristics of diseased and healthy trees regarding their appearance on the photographs were determined with a stereoscopic view as a single tree.

In black-and-white infrared films, healthy-unhealthy individuals were identified according to gray-tone differences. In colored aerial photographs, this distinction was determined by the color mixtures of three main colors (blue, green, red) that constitute colored aerial photographs. Given the human eye's sensitivity to color, colored aerial photographs are very important in photographic interpretation. Healthy trees are perceived as red or yellowish red in colored aerial photographs. Unhealthy individuals on the other hand are perceived as green, blue, gray-brown, greenish gray, brownish redbud, and redbud according to the degree of damage. In addition, Landsat 5 TM satellite images dated 25.07.1987 and 12.07.2000 were used to detect the existing gas damage from satellite images.

To examine the effect of gas damage on the increase, 20 damaged stand specimens of Abies bornmülleriana (fir) were found in the research area. Conifers are very sensitive to SO_2. Abies bornmülleriana was chosen as the tree species with respect to sensitivity to gas damage. In order to determine the extent to which the sample trees are affected as a result of the air pollution, the annual increments were determined and the annual increment curve was viewed.

Coniferous species are observed in dark tones in infrared black-and-white intakes due to the lack of intercellular spaces in their leaf tissue. Firs selected as the sample trees were identified in dark tones due to their needles. The healthy-unhealthy distinction of fir trees detected in the effective area was made through different gray tones among the individuals identified. There were some difficulties encountered in the identification and healthy-unhealthy distinction of the fir tree, which reflects in dark tones, due to the shadow element.

Considering the sensitivity of the human eye to color, the interpretation and information extraction of the colored infrared photographs of 1995 was conducted more easily compared to the black-and-white infrared photographs. The identification of the fir tree within the effective area was done easily. The distinction between healthy and unhealthy fir trees within the research area was made according to color tones. While healthy fir trees are seen in a red tone, unhealthy individuals are identified in brownish red, yellowish red tones.

In the one-on-one interviews held with people who lived in the region, it was emphasized that the red/yellow visual pollution in the air was insignificant between 1970-1990 before the korf system was activated, and that the red/yellow mixture visual pollution increased with the introduction of the Kardemir korf system.

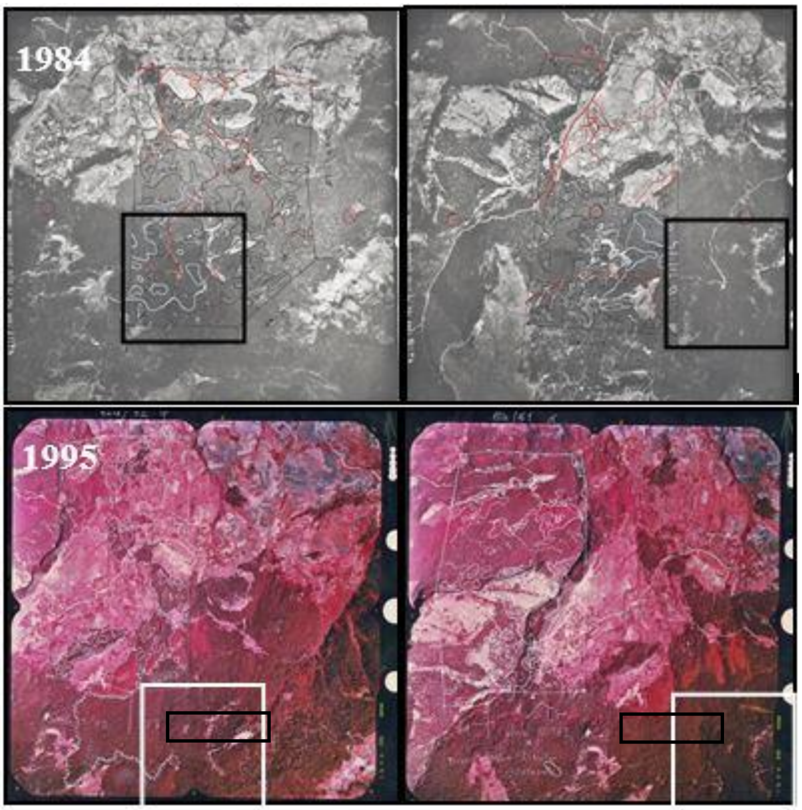

Figure 2: Aerial photographs of the 1984 and 1995 used in the study and the effective area

The minimum diameter increment occurred between 1970-1990, showing a development of about 0,1-0,5 mm [8]. During this time period, the korf system caused a very high concentration of red/yellow mixture PM emissions (iron oxide, sulfur oxide). With the deactivation of the korf system in 1995, a reduction in PM emissions has been observed. This decrease was also reflected in the diameter increment (Figure 4). In 1995, an increase in the diameter was observed compared to previous years.

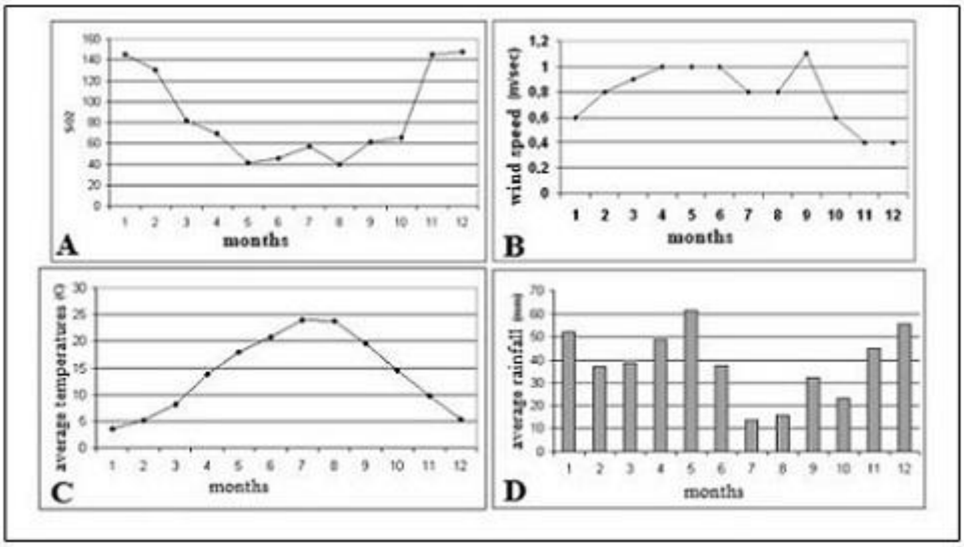

Figure 3: SO_2 measurement values of Karabük province (μ/m^3) (A); Average wind speed values (B); Average temperature values (C); Average rainfall (D)

It has been observed that trees exposed to gas damage start to first dry out from the top, and later the branches and shoots die, turning the tree into a skeleton.

Landsat 5 TM satellite images of the region dated 1987 and 2000 were used to determine whether or not there was a visual difference (Figure 5). In this application, 6 different bands (except the thermal band) of the Landsat 5 TM satellite images dated 1987 and 2000 were compressed into 3 different bands using the Principal Components Transformation, which is an enrichment technique. From the image obtained using all three bands, the test area where gas damages were detected as individual or locally clustered were extracted as polygon using the relevant remote sensing software. There was no visual difference determined between the two images in the test area. For this reason, the spectral reflection values between the two images were extracted using the relevant software. Detecting a difference using DNs was attempted.

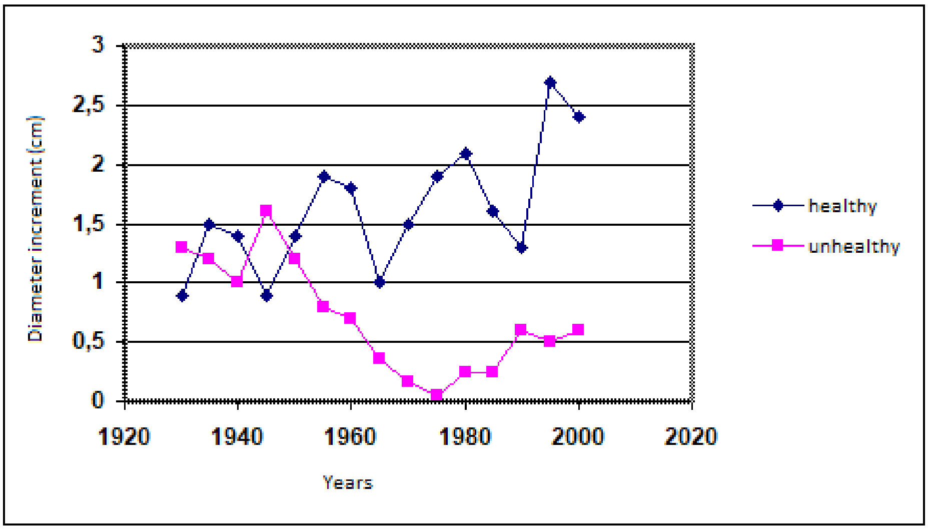

Figure 4: Comparison of diameter increment graphs of two healthy and unhealthy individuals (Abies bornmülleriana) exposed to gas damage

The t-test was performed to determine whether there was a difference between the DNs in the test areas of the different two dated images. The mean, standard deviation, variance, and standard error values of a total of 363 spectral reflection values in the test area were calculated (Table 1). As a result of the analysis made by assuming the different dated satellite images to be two factors, it was determined that there was a significant difference of 95% confidence level because the t-account value was higher than the t-table value. It was determined that the spectral reflection difference between 1987 and 2000 of the stands whose species and diversity are intact in the test area is caused by individuals whose natural structure was deteriorated due to various reasons including gas damage. PM emissions decreased with the deactivation of the korf system in 1995. The satellite images of 1987 and 2000 were preferred since they were the images taken after the korf system was activated and deactivated.

SO_2 production was observed to be higher specifically in the January-February and November-December months. Sources of SO_2 emissions in the winter are low quality fuels used for heating purposes, Kardemir A.S., rolling mills, and traffic density in some regions [11-12]. Of the meteorological parameters, wind speed is the most effective in reducing pollution. In the months when wind speed is the highest, SO_2 values are observed to be the lowest (Figure 3). With lower wind speed and the increase in fuel consumption for heating purposes due to low temperatures, SO_2 pollution also increases. SO_2 measurements in January, February, March, October, November, and December revealed that the average rainfall was also high.

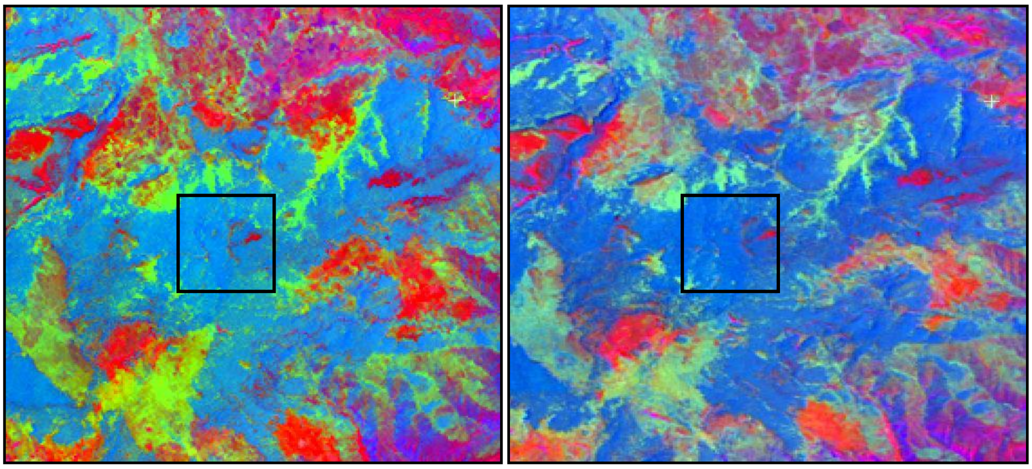

Figure 5: Landsat 5 TM satellite imagery of the 1987 and 2000 applied principal components transformation

Table 1: Statistical data on spectral reflection values of the test area in 1987 and 2000 satellite images applied PCA principal component analysis

Measured values	Mean	Std dev.	Var.	Std er.	Min	Max
1987 Landsat 5 TM (DN)	96.36	1.919	3.684	1.919	92.0	107.0
2000 Landsat 5 TM (DN)	73.0	3.150	9.923	3.150	67.0	87.0

3. Conclusions

Aerial photographs from 1984 and 1995 and satellite images from 1987 and 2000 were used to determine the gas damage in the research area and to compare the extent of the damage in terms of years. Particularly in the 1995 infrared colored photographs, individuals exposed to gas damage were clearly identified. In observational studies, aerial photographs taken at different times are needed. It is only in this way that the extent of damage on both dates is determined and compared with each other. In order to detect gas damage, high resolution satellite images are needed rather than medium resolution satellite images such as Landsat. Rather than aerial photographs taken on different dates, the use of high resolution satellite images which can provide snapshots in the desired time periods will provide more accurate results. As in the case of Karabuk, it is necessary to take the necessary precautions through time-wise monitoring of the gas damage in the existing forests.

Remote sensing data and techniques are an important tool for the restoration of the current ecosystem balance in terms of recovering the damaged ecosystem that is destroyed due to various reasons such as gas damage. A stand or each diseased individual in the stand that is harmed as a result of gas damage becomes vulnerable to external secondary damages (insects, fungi, etc.). This can lead to the destruction of gas-damaged trees more quickly, resulting in individual damages turning into mass damages and increasing destruction areas.

Acknowledgement

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