

Ecosystem Post-Wildfire Effects of Thasos Island

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Abstract—Fires is one of the main types of disturbances that shape ecosystems in the Mediterranean region. However nowadays, climate alterations towards higher temperatures result on increased levels of fire intensity, frequency and spread as well as difficulties for natural regeneration to occur. Thasos Island is one of the Greek islands that has experienced those problems. Since 1984, a series of wildfires led to the reduction of forest cover from 61.6% to almost 20%. The negative impacts were devastating in many different aspects for the island. The absence of plant cover, post-wildfire precipitation and steep slopes were the major factors that induced severe soil erosion and intense floods. That also resulted to serious economic problems to the local communities and the inability of the burnt areas to regenerate naturally. Despite the substantial amount of published work regarding Thasos wildfires, there is no information related to post-wildfire effects on factors such as soil erosion. More research related to post-fire effects should help to an overall assessment of the negative impacts of wildfires on land degradation through processes such as soil erosion and flooding.

Keywords—Erosion, land degradation, Mediterranean islands, regeneration, Thasos, wildfires.

I. INTRODUCTION

NATURAL disturbances such as fires and floods are part of the ecosystems that help sustain their structure and functions. The impacts of fires can be positive or negative, depending on the type, intensity, and frequency of fires, as well as the effect of other factors such as grazing [1]. In some terrestrial ecosystems, wildfire is an important ecological factor that triggers evolution. Usually, frequent fires occur naturally and despite the fact that they might destroy part or the entire ecosystem, their negative effects are usually reversible. This is mainly due to the ability of the plant species to withstand intense disturbances, such as wildfires, thanks to adaptation mechanisms that they have developed.

High soil temperatures and increased nutrients availability after a wildfire create favorable conditions for specific plant species to occupy the sites [2], [3]. However, when the intensity and frequency of those disturbances exceeds the ability of the ecosystems to cope and maintain levels of natural regeneration then ecosystem sustainability becomes problematic. The negative impacts of wildfires are widely known. Some of those negative impacts are microclimate

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alterations, limited presence (or even absence) of flora and fauna, lack of seed bank, runoff and frequent flood events, as well as reduction of the aesthetic value of the landscape [2], [4], [5].

Nowadays, climate change towards higher temperatures favors the intensity and frequency of fires, with the Mediterranean region experiencing intense alterations. Hence, fires are considered the number one type of disturbance that usually occurs after prolonged drought periods, especially towards the end of summer [6]. The prevailing climatic conditions are the key factors that affect the initiation and spread of fires as well as the ability of those ecosystems to be restored after the disturbance event [7].

Specifically for Greece, for the last few decades frequent and intense wildfires is considered a major problem. According to official data of the Greek Forest Service for the period of 1983-2006 the number of forest fires was 38,085 and the total burnt area was 13,613,121 acres. That was the result of intense dry climate especially during summer time in relation to increased biomass accumulation that was associated with reduced agricultural activities in rural areas as well as poor forest management was main factors [8].

Thasos is a Greek island that faces those problems that are associated with wildfire, in addition to “post-fire” induced problems such as floods and soil erosion. Despite the substantial research work that has been conducted for Thasos regarding the occurrence of wildfires, there is a lack of data for post-wildfire effects on issues such as soil erosion [2], [4], [9]. In this paper emphasis will be given on the wildfires of 1985 and 1989 that are considered the most devastating wildfire events in terms of intensity, duration and total burnt including residential sites for Thasos island. Hopefully, this paper will trigger future research on short- and long-term post-wildfire effects such as soil erosion and floods.

II. MATERIAL AND METHODS

A. Study Area

Thasos is a Greek island located at the most northern part of the Aegean Sea (40°34"-40°48" N, 24°30"-24°46" E). It is 16 and 5.5 nautical miles far from the harbor of Kavala and Keramoti, respectively. The size of the island is approximately 38,000 acres and its shape is almost circular. In addition, the topography is characterized by streams, valleys, and extensive lowlands along the sea coast of the island. Almost 75% of the area is covered by forests and the remaining 25% is cultivated by agricultural crops such as grapes and olive trees. The highest mountain that occupies most of the center of the island is "Ipsario" that reaches the 1,203 m height. The soils are rather shallow with parent material limestone. Rarely, there are areas with deeper soil formations that usually occur in

swales and torrents where the natural vegetation has been rarely disturbed.

The climate is characterized as hot-summer Mediterranean (Csa) at the coasts and warm-summer Mediterranean (Csb) in the center of the inland [9]. Generally, it is characterized by hot, dry summers and mild winters with an average annual rainfall of about 800 mm. The prevailing winds are north-northeastern and the relative humidity ranges from 56% to 77.4%.

Since 1965, the occupations of the inhabitants are mainly agriculture, livestock, beekeeping, fishery, and forest exploitation, while recently tourism has also provided a substantial income. Further, an important contribution to the local and national economy is the marble mining that is worldwide known as the "Thasos-marble ornamental rock" due to its massive equigranular characteristics and its pale white color [10]. It consists of nearly 100% of calcite, with rare quartz and dolomite grains.

B. Flora – Fauna

The island's size, position, altitude, soil, climate and exposure to the sea horizon, provides the ideal conditions for the development of rich flora. Hence, there is a wide variety of plant species of different ecological demands. One of the main tree species that occupies the lowlands and semi-mountainous regions is *Olea Europaea* that is also highly cultivated for the well-known "Thasos olives" and olive-oil. Areas of mid-altitudes are occupied by *Pinus brutia*, while at higher altitudes *Pinus nigra* tends to dominate the sites. *Abies borissii regis* and *Taxus baccata* are conifer species that can also be found at higher altitudes of Ipsario mountain.

Shrubs species also occupy large areas that can be either characterized as understory or dominant species. Specifically some of those are: *Quercus coccifera* (with the greatest distribution range), *Arbutus unedo*, *Arbutus adrachnae*, *Erica arborea*, *Erica verticillata* and *Juniperus excelsa*. Also, many aromatic plants can be found such as *Thymus vulgaris*, *Salvia divinorum*, *Origanum vulgare*, *Sideritis scardica* and *Mentha spicata*. In riparian areas, formations of *Platanus orientalis* and *Alnus glutinosa* can be found, while in some semi-mountainous sites groups of *Castanea sativa* can also be found. On contrary to the flora, the fauna is not particularly rich. The main endemic preys are hares and partridges, while during winter large populations of thrushes, blackbirds and woodcocks can also be found.

C. Wildfires-Historical Retrospect

Before 1984, the forest cover of Thasos island reached 61.6%, while for the rest of Greece it was only 19.1% (Forests Management Plans 1969, 1973, 1982). Out of this forested area, 126,239 acres belonged to the Greek Government and 165,309 acres to the Municipality of Thasos. Since 1984, a series of disastrous intense wildfires resulted to a total of 220,000 acres (2/3 of forested areas) of burned area.

D. Wildfire of 1985

For the period 1983-2006, the wildfire of 1985 is considered so far, the third largest all-over Greece. It occurred

on the 15th of August from an unknown cause. The incident started at a high altitude (1,150 meters) fully developed understory dense forested area of a southern aspect with slopes of 40-60%. During that day, the weather conditions favored the occurrence of a fire event. Specifically, there were prevailing strong northerly winds (7,0 BF) with relative humidity reaching 45% and temperature of 33 °C. Firefighting forces arrived within 15 minutes after the announcement of the fire. Despite the fact that both terrestrial and aerial means were used to put off the fire, it took 10 days and 12 hours to put it off (Archive of Forest Service Thasos). A total of 118,665 acres were burned out of which, 104,050 acres were forests and 14,615 acres were agricultural areas. During this wildfire, six people lost their lives, 213 animals and two houses were destroyed.

E. Wildfire of 1989

Again, for the period 1983-2006, the wildfire of 1989 is considered the fifth largest all-over Greece. It occurred on the 16th of August from malicious arson that evolved into a crown fire. On the day of the event, the relative humidity was 70% the temperature reaching 28 °C with strong easterly winds (7,0 BF) (Archive of Forest Service Thasos). Both, immediate terrestrial and aerial means were used (19 minutes from the announcement) and it took 21 days and 10 hours to put off the wildfire. A total of 96,176 acres were burned, out of which, 83,013 acres were forests and 12,163 acres were agricultural areas. At this fire 600 animals and 23 houses were burned.

III. RESULTS AND DISCUSSION

A. Erosion-General

Fires, particularly for fire-prone ecosystems are considered a natural and essential element that shapes species composition [11], [12] and induces geomorphological alterations [13]. The dynamics of those semi-dry ecosystems have associated flora where natural regeneration occurs rapidly. For example, species like *P. brutia* have serotinous cones that have the ability to maintain viable seeds in closed cones that open only when they are exposed to higher temperatures similar to those that occur during a fire event. That allows immediate release of viable seeds that enables seedling growth and establishment. Fig. 1 (a) indicates a good example of such a site (Kassandra Chalkidiki, Greece), where the level of natural regeneration can be seen after four years of a severe fire event that occurred in 2007.

Initially, right after a fire event, increased levels of ash are considered beneficial, since the extra short-term release of nutrients favors the regenerated seedlings [14], [15]. In addition, the infiltration capacity increases and prevents or delays runoff. Once the ash has been removed, infiltration capacity that tends to reduce recovers with time [16]. In addition, it alters the chemical and physical properties of soils as well as the composition of the organic matter [17], [18]. Further, after a fire event, the vegetative cover is diminished that results on reduced transpiration and evaporation levels, reduced storage capacity for retention and detention of water

and the overland flow [17]. Consequently, abnormally frequent and intense wildfires are also considered a major cause for soil erosion, land degradation and severe implications for post-fire hydrological response [19], [20]. The effect is a more rapid response of a larger proportion of the rainfall in the form of overland flow and runoff. The nature of the changed response, however, is affected by the aspect and slope of the terrain as well as the amount of ash and soil depth. As a consequence of the altered soil properties and cover after a fire event is the increased sediment yields [21], [22].

Fire severity is a key factor that controls the amounts of eroded soil [20]. Although wildfires have a long history in the Mediterranean region, research on post-wildfire soil erosion is limited with the earliest publication being dated since the 1980s (e.g. [23]). In the United States related research was conducted in the 1930s (e.g. [24]).

B. Post-Wildfire Erosion Effects for Thasos Island

Despite the fact that Thasos Island has suffered from major wildfires, there are no specific studies on their effects on soil erosion. However, based on the facts after the severe fire events of 1985 and 1989, the lack of vegetative cover coupled with the steep slopes of the island, created intense floods during the autumn and winter rains. This resulted in surface soil leaching resulting in many cases to exposure of the parent material (limestone). This is indicated in Fig. 1 (b) where the rocky surfaces can be very easily being spotted at the burned area. Nonetheless, the impact of intense grazing by sheep and goats on soil erosion after fire events should not be neglected. Despite the fact that the Forest Service took drastic actions, such as fencing of the burned areas in order to prevent grazing, the large number of animals in conjunction with the denial of farmers to cooperate, led to the enhancement of the problems. That resulted in increased soil compaction and alleviation of the regenerated seedlings.



Fig. 1 (a) Naturally regenerated site after four years of severe fire event in 2007 in Kassandra, Chalkidiki, and (b) exposure of parent material in a burnt forested areas of "Koinira" Thasos after the wildfire of 1985 (Spanos, 1988)

After the fires of 1985 and 1989, serious problems also appeared in the lowlands of the island. The deposition of ash, which was transferred during the floods, created an impermeable layer to the top soil that resulted to reduced soil aeration. That had also an immediate negative impact on the crop yields. Additional problems were created within residential areas when large amounts of debris after rainfall events reached the alluvial fans where most villages were located, causing damages to the houses and other

infrastructures. A typical example was the area of "Limenaria" Thasos, where after the last fire in 2013, it faced serious floods problems endangering many lives.

C. Management Practices after the Fires of 1985 and 1989

Based on the current legislation, the Forest Service is responsible for the protection of forests, while for the firefighting is the Fire Department. After the intense fires of 1985 and 1989, the Forest Service of Thasos took drastic actions. They built a 450 km of forest roads and a firebreak network of 169 km length. In addition, they build three fire-guardhouses and 25 water tanks at areas that had no direct access to water. In addition, the foresters took actions by removing all the burned debris and slight thinned the remaining forested areas. Further, partial reforestation took place, particularly near residential areas and rural roads mainly for aesthetic reasons.

Overall, Thasos island, as part of the Mediterranean region, faced and will continue to face intense, frequent and fast-spreading wildfires. Despite the fact that those ecosystems are fire-prone, the increased frequency and intensity of wildfires diminishes their ability to naturally regenerate. The absence of plant cover due to wildfires, increased precipitation and steep slopes were the major factors causing soil erosion and intense flooding events. That resulted to serious ecological and economic problems to the local communities of the island. Despite the fact that there is a significant amount of published research regarding the occurrence of wildfires and burnt area of Thasos, there is limited research related to post-wildfire effects on factors such as soil erosion. To tackle wildfires more effectively regarding their impacts on the environment and the community it is necessary to know all the parameters that are associated with them. Addressing the impacts of wildfires is as important as preventing wildfires in order to achieve "long-term" sustainable management. Overall, more research efforts are recommended that could help improve the integration of wildfire into an overall assessment of the processes and the impacts that they might have on land degradation, through processes such as soil erosion and flooding.

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