

Spectral Signatures of *Pinus Brutia* Post Fire Regeneration in Paphos Forest, Using Ground Spectroradiometers

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Abstract

Fire constitutes the most serious danger of forests in Cyprus. A variety of factors such as the long, hot and dry summers, the frequent strong winds, the configuration of the ground and the inflammability of the vegetation, favour the easy outbreak and quick spread of fires. Furthermore, the abandonment of rural areas due to urbanism and the increasing tourism and the mass exit of population towards forest areas, raises fire hazard to the highest level. During the last years, several attempts have been made in order to monitor plant regeneration using remote sensing techniques. These techniques are mainly based on multispectral/hyperspectral satellite dataset before and after the fire. In this way, damages can be assessed by means of satellite imagery and provide the local authorities with a mapping of the burned areas and monitor the regeneration process. The first task is based in classification techniques while the second task requires vegetation indices and ground inspections. This paper aims to develop a spectral signature library of *Pinus brutia* which will be used for the accuracy assessment of the classification of post fire regeneration using satellite images through remote sensing techniques. The area of interest is the Paphos forest which is situated in the western part of Cyprus. The predominant tree species is *Pinus brutia*. Paphos region is characterised by a Mediterranean-type climate with a mild, subhumid winter and a long xerothermic period. Using the ground spectroradiometer Spectra Vista GER 1500 mounted on a tripod, the spectral signatures of several tree canopies were recorded. GER1500 can record electromagnetic radiation from 350nm until 1050nm covering both visible and near infrared spectrum. The instrument was lifted up to an approximate height of 6-7 m above ground, while the field of view (FOV) was set up to 4°. Emphasis was given to spectral signatures of trees which were planted as an action of post fire artificial regeneration. Such spectral signature libraries can assist local authorities to verify satellite investigations or even to improve the classification techniques. Moreover spectral signature profile may be also used in order to detect different tree species.

Keywords. Spectral signatures, post fire regeneration, ground spectroradiometer.

1. Introduction

The affect of a fire or the magnitude of the burn severity on ground surface characteristics, including char depth, organic matter loss, altered colour and structure, and reduced infiltration. According to the international literature, it is related with the type of the future ecosystem which

will be developed. It is therefore important to evaluate the burn severity levels as soon as possible after fire and this can be done either by field inspections or by using remote sensing techniques.

In Cyprus, any evaluation of the burn severity levels is applied from the competent authorities. The post fire management it is based only on draft and empirical approaches.

The main objectives of this study is firstly, to perform a literature review in order to identify the deferent indices and methodologies that have been developed for the mapping of burn severity levels using remote sensing data and techniques. Secondly, by means of satellite imagery data and field burn severity measures in combination with records from a ground spectro-radiometer, to develop a simple, fast, accurate and reliable methodology for the assessment of burn severity levels on a forest fire scar in Cyprus forests.

Changes in reflectance values caused by the disappearance of ash remains, the increase of vegetation cover and the subsequent decrease of bare soil caused by the recovery process, are targets for remote sensing. After the fire occurrence, monitoring of the forest regeneration response in relation with the observed burn severity levels will be performed by means of remote sensing techniques.

Many terms have been used over time to describe the effects and impacts of fire, fire severity and burn severity (Figure 1). Generally, fire severity can be defined as the direct effect of the combustion process with respect to vegetation mortality, biomass consumption, the heating and physical transformation of soils, and the production of smoke [1].

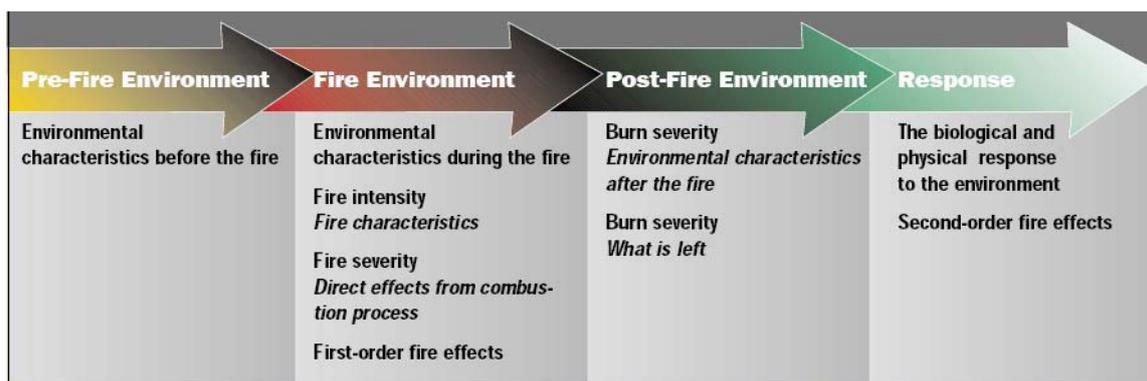


Figure 1: The fire disturbance continuum. Fire severity is seen as a first-order fire effect, while burn-severity is a factor of the post-fire environment [1].

Obtaining quantitative information about the recovery of fire-affected ecosystems is of utmost importance from the managerial and decision-making point of view. Nowadays, the concern about natural environment protection and recovery is much more critical than in the past. However, the resources and tools available for its management are still not sufficient. Thus, attention and precision is needed when decisions have to be taken. Quantitative estimates on how the vegetation is recovering after a fire can be of help to evaluate the necessity of human intervention on the fire-affected ecosystem, and their importance will grow as the problem of forest fires, climate change and desertification increases [2]. Careful evaluation of forest regeneration and vegetation recovery after a fire event provides vital information in land management [3]. Vegetation regeneration in post-fire environments varies across the landscape of a burned area. Variations are caused by interacting factors, including soil properties, vegetation characteristics, hydrology, land management history and burn severity [4]. Fire severity impacts soil degradation and vegetation consumption, which in turn affect regeneration patterns and biomass emissions [5]. Changes in satellite reflectance over multiple years reveal the dynamics of vegetation and fire severity as low burn areas have lower changes in reflectance relative to high burn areas [6]. In general terms,

the Normalised Difference Vegetation Index (NDVI) is the best performing spectral index to assess patterns of vegetation recovery. NDVI is likely the most widely utilized index in vegetation applications, showing reasonably good results in all phases of the fire cycle. It separates green vegetation from other surfaces because chlorophyll absorbs red light and reflects NIR wavelengths [7]. NDVI shows sensitivity to post-fire plant cover changes and indirectly expresses the diversity dynamics [8]. The NDVI estimates more accurately the vegetation cover in environments with heterogeneous vegetation layers and a single soil type [9]. Soil burn severity, estimated through different indicators, plays a relevant role in the post-fire regeneration process by enhancing not only seed dispersal but also germination success and seedling establishment [10].

This paper aims to develop a spectral signature library for Pinus Brutia trees which have been derived from natural and artificial regeneration on selected burned areas, using the ground spectroradiometer Spectra Vista GER 1500. The spectral signature libraries will be used for the accuracy assessment of the classification of post fire regeneration using satellite images and remote sensing techniques.

2. Methodology

The area of interest is the Paphos forest (Figure 2) which is situated in the western part of Cyprus. The predominant tree species is Pinus Brutia. Paphos region is characterised by a Mediterranean-type climate with a mild, subhumid winter and a long xerothermic period. The main threat to the forest is the fire.

The Paphos forest covers an extended area of 60.000 ha at west – northwest hillsides of mountain of Troodos, equal at about 50% of public forest land (under the effective control of the Cyprus government). It covers part of Lefkosia, Lemesos and Paphos districts, with oversea height of 1352m (Tripilos). The Paphos Forest includes large number of ecosystems and particularly important biotopes and habitats, where important and rare vegetation and animals live and are developed. The unique and most important plant society of the Cyprus Cedrus along with the unique population of the Cyprus "Agrino" (moufflon), gives to the compact area of the Paphos Forest a huge ecological and environmental value. The Paphos forest is the biggest and most important biotope of Cyprus where rare raptor birds nest. The aforementioned reasons along with the large number of endemic plants and fauna species, the hydrologic functions and the geomorphologic formation status, create a significant scientific interest for local and foreigner's scientists. Regarding the protection regime, Paphos Forest area is characterized as Special Protection Area (SPA), Important Community Site of NATURA 2000, National Park (12.000ha), Nature Protection Area (5.000ha) and Permanent Forest Area according to forest law. Forest management is conducted under the Department of Forests of Cyprus.



Figure 2: Study area.

Using the ground spectroradiometer Spectra Vista GER 1500 mounted on a tripod, the spectral signatures of several trees canopy were recorded as well as records from an adjoining burnt area. GER1500 can record electromagnetic radiation from 350nm until 1050nm covering both visible and near infrared spectrum. The instrument was lifted up to a height of approximately 6-7 m above ground while the field of view (FOV) was set up to 4°. Emphasis was given to spectral signatures of trees which were planted (artificial regeneration) as a post fire management action.



Figure 3: Use of GER1500 field spectro-radiometer.

The resources used were:

The ERDAS IMAGINE 2011 Professional & ER mapper (image processing) software, Field Spectroradiometers (GER 1500), Landsat TM/ETM+, SPOT, Quickbird and IKONOS satellite imagery and GPS measurements.

3. Results

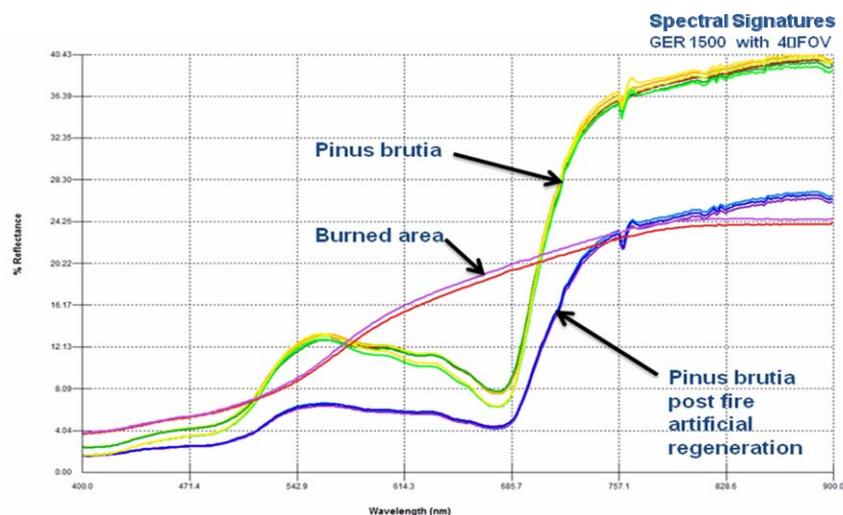


Figure 4: Spectral Signatures of burned area, Pinus brutia and Pinus brutia post fire artificial regeneration.

The Spectral Signatures of burned areas (Pinus brutia) which have been measured deviates from the normal once it does not follow the ‘red’ edge. At 680 nm, reflectance is near to 20 %.

Fire severity impacts soil degradation and vegetation consumption, in turn affect regeneration patterns. Changes in reflectance reveal the dynamics of vegetation and fire severity as low burn areas have lower changes in reflectance relative to high burned areas.

4. Conclusions

The development of a detailed spectral signature library of burned, unburned and post fire regeneration plots, using a ground spectroradiometer in combination with satellite data, is expected to improve significantly the accuracy of the post fire forest regeneration, classification and monitoring.

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