2nd International Meeting of Fire Effects on Soil Properties

11-15 February 2009, Marmaris - Turkey

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Programme & Abstract Book

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2ND INTERNATIONAL MEETING OF FIRE EFFECTS ON SOIL PROPERTIES

11-15 FEBRUARY 2009 MARMARIS, TURKEY

MEETING PROGRAMME

11.02.2009 Wednesday

- 09:00 Registration
- 11:00 Opening session
- 11:30 Coffee break

Session 1 - Chairman: L Wittenberg

- 11:50 Key Lecture 1: **X Úbeda** - THE EFFECT OF FIRE INTENSITY ON SOIL EROSION
- 12:50 Lunch

Session 2 - Chairman: C Chafer

- 14:30 **FC Ferreira Leite, AJ Bento Gonçalves, AA Batista Vieira, CP Oliveira Martins, F Silva Costa** - FIRE CYCLE IN CABREIRA MOUNTAIN (NORTHWEST OF PORTUGAL)
- 14:50 **S Goiran, ÁG Mayor, S Bautista** - POTENTIAL OF ECOSYSTEM FUNCTION INDICATORS TO ASSESS THE HEALTH OF FIRE-PRONE MEDITERRANEAN SHRUBLANDS
- 15:10 **SH Doerr, A Cerda, WH Blake, M Bodi, J Mataix-Solera, R Bryant, M Curran** - ASH DEPOSITS, SOIL CARBON AND ASSOCIATED CARBON BUDGETS IN FIRE-AFFECTED ENVIRONMENTS
- 15:30 Poster session & Coffee break

12.02.2009 Thursday

Session 3 - Chairman: S Bautista

- 10:00 Key Lecture 2: **E Bilgili** - WILDLAND FIRE, FOREST ECOSYSTEMS, AND SOILS
- 11:00 Coffee break

Session 4 - Chairman: AJ Bento Gonçalves

- 11:20 **P Nyman, G Sheridan, PJ Lane** - ANALYSIS OF FLOW PROCESSES UNDERLYING INFILTRATION PATTERNS IN A BURNT FOREST SOIL
- 11:40 **S Evgrafova** - SOIL MICROBIAL POPULATIONS IN POST-FIRE SUCCESSIONS IN BOREAL FORESTS OF CENTRAL SIBERIA
- 12:00 **OC Turgay, J Lumbanraja, S Yusnaini, M Nonaka** - EFFECTS OF POST-FIRE LAND DEGRADATION ON SOIL MICROBIAL BIOMASS IN A HILLY AREA OF SOUTH SUMATRA, INDONESIA

- 12:20 **E Buscardo, P de Angelis, A Vannini, H Freitas, JS Pereira, AM Vettraino** - CHARACTERIZATION OF ECTOMYCORRHIZAL COMMUNITIES IN A PINE FOREST AFFECTED BY WILDFIRE
- 12:40 Lunch

Session 5 - Chairman: S Doerr

- 14:20 **P Pereira, X Úbeda, DA Martin** - A NEW APPROACH TO THE STUDY OF FIRE SEVERITY IN MEDITERRANEAN SPECIES: LOSS ON IGNITION, ASH COLOR AND CARBONATE CONTENT
- 14:40 **MA Alexis, B Richard, N Péchot, G Bardoux, C Rumpel** - LEVOGLUCOSAN: A MARKER OF PAST FIRES IN SOILS?
- 15:00 **A Vergnoux, M Guiliano, N Dupuy, M Domeizel, F Théraulaz, P Doumenq** - EVALUATION OF THE CONDITION OF FOREST SOILS AFFECTED BY DIFFERENT FIRE RECURRENCES USING NIRS COUPLED TO CHEMOMETRIC METHODS
- 15:20 Coffee break

Session 6 - Chairman: X Úbeda

- 15:40 **CR Stoof, S Drooger, AJR Germano, JG Wesseling, AJD Ferreira, CJ Ritsema** - MAPPING AND EXPLAINING SOIL AND SURFACE TEMPERATURES IN A CATCHMENT-SCALE EXPERIMENTAL FIRE
- 16:00 **Ö Küçük, E Bilgili** - FIRE INTENSITY MEASUREMENTS IN CALABRIAN PINE, ANATOLIAN BLACK PINE AND MAQUIS FUELS
- 16:20 **C Chafer** - FIRE SEVERITY AND SOIL EROSION IN THE SYDNEY BASIN, AUSTRALIA: A SUMMARY OF SEVEN YEARS OF POST-WILDFIRE RESEARCH

13.02.2009 Friday – Field trip

- 08:30 Meeting
- 09:30 Turkish traditional breakfast
- 11:30 Visit to the burned sites around Marmaris and discussions
- 15:30 Lunch
- 17:00 Free time

14.02.2009 Saturday

Session 7 - Chairman: J Mataix-Solera

- 10:00 Key lecture 3: **D Kazanis, M Arianoutsou** - LESSONS LEARNED FROM LARGE FIRES IN GREECE: FOCUSING ON THE SOIL SUBSYSTEM
- 11:00 Coffee break

Session 8 - Chairman: E Bilgili

- 11:20 **CR Stoof, W Mol, J van den Berg** - VISUALIZING THE EFFECT OF WILDFIRE ON SOILS AND THEIR HYDROLOGY

- 11:40 **MC Malvar, JP Nunes, JJ Keizer** - OVERLAND FLOW AND SOIL EROSION IN TWO RECENTLY BURNT EUCALYPT STANDS: COMPARISON OF MICRO-PLOT AND HILL-SLOPE SCALE
- 12:00 **P Nyman, G Sheridan, PJ Lane** - THE INFLUENCE OF WILDFIRE ON DEBRIS FLOW OCCURRENCE IN SOUTH EAST AUSTRALIAN CATCHMENTS
- 12:20 **AJ Bento Gonçalves, AA Batista Vieira, AJ Dinis Ferreira, CO Alves Coelho** - MITIGATION OF SOIL LOSS AFTER FOREST FIRES: A GEOMORPHOLOGICAL APPROACH BASED IN GIS MODELLING
- 12:40 Lunch

Session 9 - Chairman: D Kazanis

- 14:20 **SO Danquah** - SOIL RECOVERY AFTER FIRES IN GHANA
- 14:40 **J Llovet, VR Vallejo** - POST-FIRE DYNAMICS OF SOIL SURFACE CHARACTERISTICS AND THEIR ROLE IN SOIL HYDROLOGICAL AND EROSIONAL RESPONSE IN A MEDITERRANEAN LANDSCAPE
- 15:00 **D Malkinson, L Wittenberg** - ECO-GEOMORPHIC RESPONSES OF BURNED MEDITERRANEAN FORESTS ON DIFFERENT SOIL TYPES
- 15:20 Coffee break

16:00 Closing session

- Conclusions
- Poster awards
- Voting for the host and the date of the next FESP Meeting
- Closing

20:00 Farewell dinner

15.02.2009 Sunday

Excursion (Pamukkale)

KEY LECTURES

THE EFFECT OF FIRE INTENSITY ON SOIL EROSION

Xavier Úbeda

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Fire intensity determines the severity of the effects on soil and vegetation during forest fires. Soil erosion is one of the effects of this fire intensity, it is one of the indirect effects due to many factors as lack of vegetation, hydrofobicity, decrease of water infiltration capacity, increased in runoff, aggregate stability, etc. The more intense is a fire, the stronger are the consequences. But, not all the landscapes have the same answer to the same fire intensity. The recovery of vegetation and the recovery of soil physical and chemical soil properties determine whether the effects of this fire intensity and its relation with erosion lead to a short term effect or a longer effect. Some Mediterranean forest has a quick recovery. Many plants help since the first moment to cover the soil surface avoiding splash processes and their roots help the water to infiltrate. In other landscapes this recovery is slow and the accelerated erosion processes can be noticed after many years after the forest fire. There are many studies about the quantity of soil eroded after forest fires, but there is not only one standard methodology which helps us to make comparisons about the erosion in different landscapes with different climate types. Many of the studies about soil erosion after forest fires have been developed because the consequences that there are in the basins in terms of quantity of suspended sediment which cause water contamination and fish mortality. This contamination provoke problems of water distribution in the cities downstream. At the same time there are studies which analyze the effect of different soil treatment in order to prevent soil erosion in places where there are long term erosion responses. In many cases the problems of soil erosion are related to the soil degradation thus making difficult the recovery of vegetation of these burnt landscapes and implying that the effects of the fire are long-term. The solution of all these problems must be found in the prevention, we must be able to do a management in every kind of landscape which avoid, not necessarily the forest fires, but the High Intensity Forest Fire which are mainly responsible for all these environmental problems.

Keywords: Severity, contamination, short and long term effects, prevention.

WILDLAND FIRES, FOREST ECOSYSTEMS AND SOILS

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Ecosystems are a product of complex interactions among geomorphic processes, climate, underlying landforms, and disturbance regime. Fire is a unique disturbance agent that has played and continues to play a major evolutionary role, shaping the forests and ecosystems on Earth. However, fires have historically been viewed as an extremely dangerous and destructive monster, causing great losses in lost timber, suppression costs, recreational values and even lives. It is now being realized that fire may also be an integral part of and natural agent essential for maintaining the natural ecosystems in many parts of the world. Thus, fire is neither all good nor all bad. It is natural, powerful, and is there to be appreciated.

Fires burn, spread and release energy in the form of heat. Fire intensity, fire severity and fire frequency are perhaps the most prominent fire characteristics that account for the ecological role of fire. Here, the effect of fire on soil properties will be taken into account.

Fires affect physical, chemical and biological soil properties directly by consuming the fuels available on the surface floor and transferring heat into soil and indirectly by changing vegetation and the dynamics of nutrients and organic matter. The extent and magnitude of the effects of fire on these soil properties vary considerably depending on fire intensity, fire severity, fire frequency, residence time, and properties of the soil and litter layer.

Depending on the amount of fuel consumed (fire severity) and associated soil temperatures reached, fires may greatly impact several soil properties. Physical soil properties such as soil structure, texture, wetability, infiltration rates, and water holding capacity may be altered over a longer time period due to the consumption of soil organic matter which potentially lead to and increase surface run-off and soil erosion. High soil temperatures can kill soil microbes and plant roots; destroy soil organic matter; and alter soil nutrient and water status. Evidences indicate that fires decrease the amount of nutrients found on a burned site, but that nutrient availability often increases especially when soil nutrients are considered as fire chemically converts nutrients bound in organic matter to more available forms.

Appreciation of the role of fire in forest ecosystems will help fire scientists, land managers, and fire suppression personnel make sound decisions, and balance the overall benefits and costs associated with the use and not use of fire in ecosystem management.

Keywords: Fire, ecosystem, nutrients, soil.

LESSONS LEARNED FROM LARGE FIRES IN GREECE: FOCUSING ON THE SOIL SUBSYSTEM

Dimitris Kazanis*[1] and Margarita Arianoutsou[2]

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The phenomenon of large fires (or mega-fires, i.e. fire events where more than 500 ha are burned) is not new around the Mediterranean Basin. Still, it could be argued that it shows trends of increasing frequency during the last years, in particular at the eastern Mediterranean Rim (source: data from the annual reports of the *'European Forest Fire Information System'*). The year 2007 will be regarded as a landmark for the environmental history of modern Greece, since it was the worst year for forest fires ever recorded for this southeastern European country. According to the official data of the Hellenic Forest Service, there were 1983 fire events that burned 196263 ha of forests. Still, more than 70% of the overall burned area was the result of seven (7) fire events alone.

The extent of the affected areas raised the public concern which in turn demanded measures to be taken so as to minimize fire impact and ensure the restoration of the burned lands. Still, in most cases the burned landscapes are heterogeneous and no common post-fire treatments can be proposed and applied. Evaluation of the regeneration and resilience capacity of the various landscape units is needed prior to any application of post-fire management.

Regarding the soil sub-system, what concerns most authorities, public and scientists after a fire event – in particular at the wildland-urban interface – is the risk of soil degradation due to erosion and nutrient loss. From a biological point of view, we shall review here our scientific knowledge and expertise related to fire effects on these soil properties, which in turn affect or are affected by the regeneration and resilience of plant communities. Knowledge and expertise gained from our long-term studies across heterogeneous burned landscapes of Mediterranean climate in Greece.

In most wildfire cases, the above ground plant biomass is almost entirely consumed leaving the soil totally uncovered by plants. This risk of soil loss is higher in sites with low rock and stone cover and in sites with steep physiography. However, the vegetation of Mediterraenan-climate ecosystems (McE) is, usually, resilient to fire, meaning that the plant cover will develop rapidly after the fire event, reducing the rate of erosion.

Still, there is always the risk of erosion after intense precipitation events during the first post-fire year. This risk decreases considerably when plant communities with high representation of obligate resprouters are concerned. Resprouting is a regeneration procedure that starts within a couple of weeks after the fire event, thus before the onset of the raining season. By the time the first rainfalls will be encountered, resprouters will have developed a notable plant cover. The higher the participation of resprouters in a given plant community, the higher is the protection against soil erosion.

Another consequence of fire is nutrient loss. Most of the nutrients are deposited in the ash (e.g. phosphorus) in forms readily available for utilization by the regenerating flora. Some nutrients however, are lost in fire's smoke usually by forming volatile chemical compounds. This is the case of nitrogen. Nitrogen is a very important nutrient for plant growth. Consequently, its replenishment is essential for the ecosystem. In most Mediterranean climate ecosystems this key-function is mediated by herbaceous legumes (plant species of the Leguminosae family). Data from Greece and McE elsewhere show the high diversity and abundance of herbaceous legumes during the first post-fire years. This high legume participation ensures the quick soil N replenishment in two ways actually: directly through the N-fixation and indirectly through the quick decomposition of their plant material.

Finally, we have conducted several studies related to the post-fire response of the soil biota. Data from various field experiments on soil respiration and cellulose decomposition indicate effects of fire on the soil microflora is rather minimal and it is mostly concentrated upon the relative representation of bacterial versus fungal populations. As far as the soil arthropod fauna is concerned, there is a short term shift in the structure of the animal community towards the under-representation of saprophagous-microphytophagous taxa. As vegetation develops and litter is accumulated on the soil surface, the abundance of saprophagous-microphytophagous taxa is being restored.

Even though McE are regarded as resilient to fire, there are several exceptions to this rule. Fire history, land-use patterns and microhabitat characteristics may result in low resilience and high risk of soil degradation. In order to help land managers to take the correct decisions, we have built a tool that provides the necessary information for them so as to realize the various soil-related post-fire risks that may emerge across a burned landscape and act accordingly. As a pilot area the case of the 2000-summer large fire in Sounion National Park (the southeastern-most continental National Park of EU) has been used. Parameters used were related to those key-factors affecting soil system status under the Mediterranean environment.

Keywords: Resilience, plant cover, soil erosion, legumes, nitrogen, soil biota.

ORAL PRESENTATIONS

FIRE CYCLE IN CABREIRA MOUNTAIN (NORTHWEST OF PORTUGAL)

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The recurrent forest fires are degrading an important part of Portuguese patrimony, the soils, which suffer important losses in sediments and nutrients after burn.

To develop mitigation techniques and strategies to reduce soil and water degradation immediately after forest fires, easily adopted by forest managers and forest owners, its necessary they be accepted by the key actors and stakeholders.

To achieve that aim, in order to have a strong participatory dimension, to take account of the key actors and stakeholders perception and proposed solutions, it's important to understand human ignition causes that leads to a reduction of length of time for burn an area (fire cycle).

In this paper we'll present the study case of Cabreira Mountain (Northwest of Portugal), where in recent decades, with particular importance in the 70's, there was a strong increase in the number of forest fires and in the areas burnt annually. There is thus a turning point between a period when fire was an integral part of ecosystems, and timeliness, where fire is a serious threat to management and forestry development (Bento Gonçalves, 2006).

The reduction of length of time for burn an area (fire cycle) implies that in these areas the fire tolerant species become dominant and the changes of composition, caused by fire, are small.

Starting with a thorough characterization of forest fires, and based on the mapping of burnt areas between 1990 and 2006, we've proceeded to the verification of the annual pattern of recurrence and the definition of the fire cycle in Cabreira Mountain, producing up thus a valuable document to support management and forestry development in general and to develop mitigation techniques and strategies to reduce soil and water degradation immediately after forest fires, in particular.

Keywords: Forest fires, fire recurrence, fire cycle, soil and water degradation.

POTENTIAL OF ECOSYSTEM FUNCTION INDICATORS TO ASSESS THE HEALTH OF FIRE-PRONE MEDITERRANEAN SHRUBLANDS

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We evaluated the potential of the Landscape Functional Analysis (LFA) methodology to characterise the functional status of fire-prone shrublands in eastern Spain. This methodology assesses ecosystem function through indicators relative to the spatial structure of bare soil and vegetation patches and critical ecosystem functions (infiltration, stability and nutrient cycling). The indicatory potential of the ecosystem function indicators was tested trough their relationships with soil enzyme activity (acid phosphatase and ß-glucosidase). The study was conducted in 19 sites selected to capture a significant range of the variability of fire-prone shrublands in the study area. The LFA methodology classified the study sites along a degradation/functionality gradient due to variations in both the spatial structure of the vegetation and the soil surface status. In each site, the functional status of the soil surface under vegetation patches was higher than on bare soils. Soil surface quality was also higher under patches of resprouter species than under patches of seeder species, which we attributed to the faster post-fire recovery and older age of resprouter patches in fire-prone ecosystems. Soil enzyme activity was also higher in vegetation patches than in bare soils and higher in patches of resprouters than in patches of seeders probably due to the higher long-term accumulation of enzyme substrates and enzymes in older resprouter patches. The index of nutrient cycling reflected correctly the contrasted differences in enzyme activity between bare soils and vegetation patches, as well as the variation within each type of surface. The results obtained in this study support the use of the LFA indices to characterise the ecological status and indicate the nutrient cycling functioning of dry Mediterranean shrublands. The highest functional status and soil enzyme activity of resprouter species support their relevant role in the functioning of these fire-prone ecosystems.

Keywords: Ecosystem function, fire-prone shrublands, Mediterranean drylands, ecological indicators, resprouter species.

ASH DEPOSITS, SOIL CARBON AND ASSOCIATED CARBON BUDGETS IN FIRE-AFFECTED ENVIRONMENTS

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A fraction of the biomass consumed during wildfires is typically deposited as ash on the ground, containing both organic (e.g. charcoal) and inorganic (e.g. alkali and alkaline oxides) material. Some of the carbon (C) in ash is highly resilient to breakdown, and likely to remain stored in soils, sediments and aquifers for longer than it takes for full biomass recovery. Furthermore, alkali and alkaline earth mineral components in ash react with aqueous CO_2 (in rainwater) and atmospheric CO_2 to form bicarbonates and carbonates, leading to additional C accumulation in ash following burning. This could result in net sequestration of C during a fire-regrowth cycle. However, the role of ash is rarely considered in wildfire C-flux studies. This neglect may arise from ash being (a) present at the soil/above-ground biomass interface (hence falling between disciplines) and, (b) removed by wind and water erosion before the onset of most field studies.

The limited data available in the literature of (dark) ash suggests organic C contents of around 50% and ash bulk densities of 0.5. In forest or shrub environments with substantial pre-fire fuel loads close to the ground, ash deposits following a severe burn can be 2-10 cm thick. These equate to ash loads of 1-5 kg/m^2 and an estimated C storage of 0.5-2.5 kg of C/m^2 (=5-25 t/ha). Estimates of C emissions from Canadian conifer forests, for example, are 2-100 t/ha. The C deposited in ash (5-25 t/ha) may therefore represent a significant fraction (of up to ~25 %) of these emissions.

This presentation aims to (i) highlight and evaluate the importance of ash in carbon flux assessments of wildfires and (ii) presents new data on C contents from ash samples taken immediately following forest fires at various locations in Europe and North America, enabling increased accuracy in wildfire-carbon budgeting.

Keywords: Wildfire, carbon budget, ash, black carbon.

ANALYSIS OF FLOW PROCESSES UNDERLYING INFILTRATION PATTERNS IN A BURNT FOREST SOIL

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The effect of hydrophobicity on runoff and erosion processes has been the focus of a number of recent research articles. Several contrasting findings concerning soil hydrophobic properties and the associated hydrological response at plot and hillslope scales has been attributed to heterogeneous infiltration patterns resulting from patchy distribution of hydrophobic soil. While hydrophobicity is considered to be a key hydraulic property of burnt soils, its effect on infiltration patterns is largely unaccounted for in runoff and erosion models. This study examined the spatio-temporal infiltration patterns in a severely burnt forest soil at the plot scale, in a wet eucalypt forest in south-east Australia. The aim of the study was to isolate the effect of hydrophobicity on hydraulic conductivity using both water and 5M ethanol as infiltration fluids in a conventional tension infiltrometer. A simplified representation of the soil as a bundle of cylindrical tubes was used to obtain a measure of the effective contact angle of the wettable soil, as well as the spatial contribution by various pores size classes to saturated hydraulic conductivity. The study showed that the interacting effects of ponding, macropore flow and hydrophobicity can produce extreme spatial variability in infiltration rates at small scales. The dominant contribution of macropores to the total flow potential of the soil resulted in infiltration patterns that were highly sensitive macropore distribution and small changes in the hydraulic head near saturation. This finding has significant implications when accounting for the effect of increasing scale on runoff response in hydrophobic soils. It highlights the limitations of using conventional measurement techniques to obtain hydraulic conductivity as an infiltration parameter in burnt soils. Furthermore, the findings demonstrate that for post-fire runoff and erosion models to produce valid output, they must incorporate transient runoff-runon processes and the effect of spatially variable infiltration.

Keywords: Infiltration, hydrophobicity, wildfire, macropores, tension infiltrometer.

EFFECTS OF POST-FIRE LAND DEGRADATION ON SOIL MICROBIAL BIOMASS IN A HILLY AREA OF SOUTH SUMATRA, INDONESIA

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We investigated the impact of land-use changes on the soil biomass at several soil sites in Indonesia under different types of land-use (primary forest, secondary forest, coffee plantation, traditional orchard and a six-month old fire-induced deforestation area), located within a small geographical area with similar parent material and climatic conditions. Various parameters of soil microbial biomass, (biomass C, biomass N, content of anthrone-reactive carbohydrate carbon and soil ergosterol content) were examined. Our results suggested that the removal of the natural plant cover did not cause any appreciable decrease in the amount of microbial biomass; on the contrary it led to a short-time increase in the amount of microbial biomass which may be due to the availability of readily decomposable dead roots and higher sensitivity to the decomposition of residual litter in recently deforested soils. However, the amount of microbial biomass tended to decrease in proportion to the duration of the land history in coffee plantation soils. This may be ascribed to the effect of the loss of available substrates associated with soil erosion in the long term. Lower ergosterol contents in recently deforested areas reflected a reduction in the amount of fungal biomass which may be due to the destruction of the hyphal network by the slash and burn practice. On the other hand, the higher soil ergosterol content at the sites under bush regrowth indicated that microbial biomass was able to recover rapidly with the occurrence of a new plant cover.

Keywords: Anthron reactive carbon, ergosterol content, microbial biomass, soil degradation.

CHARACTERIZATION OF ECTOMYCORRHIZAL COMMUNITIES IN A PINE FOREST AFFECTED BY WILDFIRE

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In this study we analysed the species richness and composition of ectomycorrhizal fungi colonizing seedlings of *Pinus pinaster* Aiton in a Mediterranean ecosystem, naturally regenerated after wildfire. We tested the hypothesis that the composition of the ectomycorrhizal community in different areas of the open forest would affect the performance of the regenerating pine seedlings.

One hundred and thirty-five seedlings were harvested in nine areas characterised by a variable seedling regeneration presence, both in terms of cover percentage and seedling height. Ectomycorrhizal fungi colonizing the roots were characterised with molecular techniques (ITS and DNA sequence analysis).

The association between the fungal communities of the different study areas and the natural processes of regeneration of maritime pine were investigated through the use of ordination techniques.

Keywords: *Pinus pinaster*, natural regeneration, fire, ectomycorrhizal communities, seedling performance.

A NEW APPROACH TO THE STUDY OF FIRE SEVERITY IN MEDITERRANEAN SPECIES: LOSS ON IGNITION, ASH COLOR AND CARBONATE CONTENT

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Fire severity is a product of the fire intensity and duration of the heat pulse and depends of biophysical conditions of the environment. Laboratory simulations can help us to understand the effects of fire temperature that could differ according to plant species. In this sense, to show and validate our methodology, leaf litter of four different Mediterranean species, *Quercus suber, Quercus robur, Pinus pinea and Pinus pinaste*r, were subjected to different fire temperatures, 150º, 200º, 250º, 300º, 350º, 400º, 450º, 500º and 550ºC, throughout two hours in a muffle furnace. One of the main consequences of heating vegetation is the loss of mass. We measured the loss on ignition (LOI%) based on the mass height difference before and after heating samples, at the mentioned temperatures. Our results showed that up to 250ºC the LOI% is not substantial, rising abruptly between 250ºC-400ºC, and after 400-º450ºC the LOI% is higher than 90% in all species. Another excellent indicator of fire severity is the ash color, which also imparts also information about their chemical composition. The changes in ash color according the temperature gradient, can be measured with the help of the Munsell color chart and we observed that, generally, at low temperatures (150ºC) the colors were mainly yellowish, becoming reddish (200º-300ºC), black (300ºC), grey (350ºC) and white (>450ºC). However, this pattern is different according to the species under study and the thermal degradation is especially noticeable in Pinus leaf litter. The $CaCO_3$ content of the ash is an indication of high fire severity. In order to analyze its presence in ash we used the Bernard's calcimeter and after 350ºC we found carbonate in the ash, that increased with temperature gradient, mainly in the *Pinus* species.

Keywords: Fire severity, laboratory simulations, loss on ignition, ash colors, carbonate content.

LEVOGLUCOSAN: A MARKER OF PAST FIRES IN SOILS?

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Pyrogenic organic matter presents a continuum of properties, deeply influenced by the fire intensity. Depending on the temperature, pyrogenic molecules produced by the fire have variable carbon storage potential. Levoglucosan originates from the combustion of holocellulose only and has been widely used as a marker of biomass burning in aerosols. It has been reported to form between 150 and 350°C and to reflect a relatively low thermal alteration degree of OM. Its stability with regards to microbial utilization and/or leaching losses in organic matter affected by fire has never been studied. Considering its chemical structure, one could expect a low resistance to biodegradation. However a close physical association with charred material could diminish its degradation rate in soils. The stability of this molecule is determinant for its use as a tracer of past biomass burning in soil and sediments.

In this work the biodegradability of levoglucosan produced during a natural burning was studied. Litter was collected after the fire and separated into different fractions considering the particles size (45-250 µm, 250 µm-2 mm, >2 mm) and the alteration of the leaf color (black versus brown). Samples were incubated in litter bags settled 2-3 cm under the soil surface. They were collected after 1 and 3.5 years. Levoglucosan was extracted with MeOH then derivatised (BSTFA-TMCS) and quantified in a GC-FID.

The total pyrogenic OM presents a high resistance to degradation as about 90% of initial C remained after 3.5 years. The brown litter collected after the fire presented the highest levoglucosan content. We also showed that most of the levoglucosan was lost from the incubated samples during the first year of incubation. Our results highlight the thermal sensitivity of levoglucosan that is degraded at temperatures, when black carbon forms. Levoglucosan can thus be considered as an indicator of organic matter slightly affected by fire. However levoglucosan did not appear stable enough to serve as a long term tracer of biomass burning in soils.

Keywords: Levoglucosan, molecular marker, thermal alteration, biodegradability, soils.

EVALUATION OF THE CONDITION OF FOREST SOILS AFFECTED BY DIFFERENT FIRE RECURRENCES USING NIRS COUPLED TO CHEMOMETRIC METHODS

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Near infrared reflectance spectroscopy (NIRS) is a fast, simple and non destructive analytical method, with no chemical reagent need and cost effectiveness. Moreover, the sample preparation is very easy and "in situ" technology application is available. It is difficult to directly interpret a spectrum, but NIRS can be coupled to statistical data treatments.

In the south of France, forest fires are recurrent and cause a great deal of damage each year. The studied site is a Mediterranean ecosystem in "Maures Mountains", near Saint Tropez, where 30 stations were sampled, in 2 layers. This site was chosen because it presents more or less often burned areas, damaged by more or less recent fire events. This work is about the evaluation of the condition of soils impacted by different forest fire recurrences using NIRS coupled to chemometric treatments.

First, some important physico-chemical properties of soils were determined. At the same time, NIRS spectra of soils were computed. Then, a fire recurrence index was defined, validated and calculated according to the different fires extents affecting soils, including the occurrence of fires as well as the time elapsed since the last fire.

The evaluation of the time elapsed since the last fire is possible using principal component analysis (PCA) from NIR spectra. This study shows that NIRS coupled to partial least square (PLS) is a valuable tool for the soil monitoring, particularly for the prediction of the total organic carbon, total nitrogen, organic carbon and aromaticity index of humic substances, phosphorus, Mg^{+}, Ca^{2+} and NH^{4+}. Furthermore, the proposed recurrence index can be predicted in a very good way. NIRS appears to be a very valuable tool to evaluate the condition of soils affected by different fire recurrences in order to study the spatial variability, to map more or less burned areas and to apply adequate rehabilitation techniques.

Keywords: Fire, soil, NIRS, PCA, PLS.

MAPPING AND EXPLAINING SOIL AND SURFACE TEMPERATURES IN A CATCHMENT-SCALE EXPERIMENTAL FIRE

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Experimental fires provide the opportunity to monitor above and belowground temperatures, although detailed spatio-temporal field studies are scarce. In addition, most studies focus on the plot and hillslope scales, leaving the catchment scale largely ignored. Plot- or hillslope-scale studies cannot be simply extrapolated to the catchment scale amongst others because of the spatial variability of soils (regarding i.e. depth, moisture, organic matter content) and vegetation (species, biomass) within a catchment.

Here, we present a unique study in which an entire catchment is burned by experimental fire to study soil and surface temperatures, including the causes and effects of the variation in soil heat propagation. For an interdisciplinary study on the effect of fire on soil hydrology, erosion, vegetation recovery and greenhouse gas emission, the 10-ha Valtorto catchment in north-central Portugal is completely burned by experimental fire in Winter 2008/9. This catchment is covered with dense shrubs; soils are developed on schist, organic matter-rich, and range in depth from 5-10 cm on the slopes to over 50 cm in the alluvial parts.

During the experimental fire, soil and surface temperatures are monitored at high spatio-temporal resolution using a dense network of dataloggers (45 locations; at 0, 2, and 5 cm depth) to investigate relationships between fire intensity and the magnitude of fire-induced changes. These ground-based measurements are complemented with airborne photo- and video imagery in the visible and infrared spectra. Here, soil and surface temperature maps and imagery will be presented and soil heat propagation will be discussed. Data on pre-fire soil and vegetation properties will be used to explain the results.

Keywords: Experimental fire, spatio-temporal monitoring, temperature, catchment-scale, thermal imagery.

FIRE INTENSITY MEASUREMENTS IN CALABRIAN PINE, ANATOLIAN BLACK PINE AND MAQUIS FUELS

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This study investigated the intensity of experimental fires in young calabrian pine, Anatolian black pine and maquis. Experimental fires were conducted under limited weather and fuel conditions to gather quantitative data on fire intensity, used to develop fire intensity models for fire management purposes. Frontal fireline intensity was calculated by using the Byram's equation. Correlation and regression analyses were undertaken to investigate the relationships between fire intensity and fuel and weather conditions. The dominant factor influencing fire intensity was wind speed. Different regression models were developed to predict fire intensity. Regression models developed using the data gathered are able to predict fire intensity in terms of wind speed, fuel loading and fuel moisture. Results of this study should be invaluable in overall fire management practices.

Keywords: Fire intensity, Byram's fire intensity equation, *Pinus nigra, Pinus brutia*, maquis.

FIRE SEVERITY AND SOIL EROSION IN THE SYDNEY BASIN, AUSTRALIA: A SUMMARY OF SEVEN YEARS OF POST-WILDFIRE RESEARCH

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Seven years after the severe wildfires in the drinking water supply catchments of the Sydney basin, Australia, a considerable amount of research has been undertaken. In this review I summarise several important results have become apparent in relation to wildfire intensity and its impacts on soils and enhanced erosion in the Sydney basin of south-eastern Australia:

1. It is clear that the level of soil desiccation immediately after a wildfire is strongly related to the intensity of the fire, which in itself is related to available vegetative fuel loads and moisture retention during the wildfire.

2. The El Nino Southern Oscillation (ENSO) is the main limiting climatic factor affecting the occurrence of heavy rainfall events through south-eastern Australia. Extensive wildfires usually occur during periods of prolonged negative ENSO events that result in local drought conditions and the chance of widespread, heavy post-wildfire rainfall events is low.

3. Subsequent soil erosion is therefore driven by highly localised convective thunderstorm events. During these localised storms, soil erosion can be locally extensive once saturation of the now wettable soils is exceeded and overland flow commences. Nevertheless, the rapid development of extensive post-fire litter dams and bioturbation limits the distribution of coarse sediment and only fine sediments are usually delivered to the drainage network in any abundance.

4. These results have led to the development of a predictive risk map that incorporates vegetation structure, fuel load and topography to inform land mangers of areas of potentially high erosion should a major wildfire be followed by a heavy rainfall event.

Keyword: Soil erosion, fire severity, fire intensity, erosion risk map.

VISUALIZING THE EFFECT OF WILDFIRE ON SOILS AND THEIR HYDROLOGY

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Traditional studies on the effect of fire on soils are usually based on point-sampling, yielding little insight on small-scale variation of moisture and hydrophobicity that affect hydrological processes. Detailed depth-profile sampling can give this information. We created depth-profile images of five Portuguese soils burned by low/medium intensity wildfire in Summer 2008. We sampled burned and adjacent unburned soils shortly after the fire, before the first rains. Soils were shallow, organic matter-rich and covered with shrubs and/or pine trees. Samples were taken using 50cc soil cores in three replicate transects (eight samples wide, three samples deep). Samples were analyzed on volumetric soil moisture content, hydrophobicity, organic matter content and bulk density; results were visualized.

Fire considerably affected the soils, despite the relatively low fire intensities. Organic matter contents significantly decreased throughout the 10-cm profile at most sites. Bulk density significantly increased or remained unchanged. Fire significantly decreased topsoil moisture contents (0-2.5 and 4-6.5 cm), likely because of the direct drying effect of the fire and increased post-fire soil evaporation. Contrary, fire slightly increased 'subsoil' moisture contents (7.5-10 cm). This might be a sign for upward moisture flow during the fire caused by the steep soil temperature gradient. Hydrophobicity showed high small-scale variation and was variably affected by fire: it increased, decreased or remained unaltered. Where pre-fire hydrophobicity was absent, it increased throughout the profile. Conversely, where pre-fire hydrophobicity was high, it decreased throughout the profile. Despite this decrease, hydrophobicity still had a pronounced effect on water movement during the first post-fire rains, when runoff was observed through the thin wettable ash layer overtop the repellent soil.

Detailed depth-profile images visualize the effect of fire on a variety of soil properties and can give valuable insight into the effect of small-scale variation on hydrological processes such as runoff and preferential flow.

Keywords: Wildfire, soil moisture, hydrophobicity, hydrological processes, spatial variability.

OVERLAND FLOW AND SOIL EROSION IN TWO RECENTLY BURNT EUCALYPT STANDS: COMPARISON OF MICRO-PLOT AND HILL-SLOPE SCALE

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The work to be presented was carried out in the framework of the EROSFIRE project (POCI/AGR/60354/2004) as well as of the associated PhD research of the first author, both of which are funded by the Portuguese Foundation for Science and Technology (FCT). The project's overall objective is to try to develop a software tool for soil erosion hazard mapping at the hill-slope scale that, in essence, is based on rainfall simulation experiments (RSEs) at the micro-plot scale and the modeling of these RSE results with selected erosion models. Notwithstanding the fundamental role of RSEs in the EROSFIRE project, runoff plots are employed as well. Micro- plots were used to address the representativeness of the RSE-results for natural rainfall conditions, whereas slope-scale unbounded plots are used to evaluate the scaling-up of the RSE-based modeling results. The current presentation will compare the runoff and erosion results at these two spatial scales, addressing measurement as well as modeling results obtained with MEFIDIS. This will be done for two adjacent eucalypt plantations during the first year after fire.

The two neighboring study sites are located in the Albergaria-a-Velha municipality, north-central Portugal, and were affected by a medium-severity wildfire during the summer of 2006. The sites were selected for their contrasting pre-fire land management, i.e. un-ploughed vs. ploughed in down-slope direction. During the second half of September 2005, both sites were equipped with two pairs of micro-plots located on the slopes' lower and upper halves as well as with four unbounded plots at the slopes' bases. The plots were read out at weekly intervals and selected soil parameters (e.g. water repellency) were monitored at mostly two-weekly intervals.

Spatial scale was found to have a significant impact on the observed runoff and erosion rates and MEFIDIS is currently being explored to help explain these differences.

Keywords: Erosion, modeling, spatial scale.

THE INFLUENCE OF WILDFIRE ON DEBRIS FLOW OCCURRENCE IN SOUTH EAST AUSTRALIAN CATCHMENTS

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Most erosion studies in burnt catchments are unlikely, and in most cases unable, to capture extreme erosion events associated with major floods and debris flows. While the frequency of these events is low, the impact on water quality is large and they should therefore be treated as high risk scenarios in water resource management. In south east Australia, mass erosion events have been reported in a range of catchments following major wildfires over the last 50 years. The circumstances under which these events occurred, the processes involved, the volumes of material exported and the impacts on water quality have remained largely unexplored. In 2007, severely burnt catchments in north east Victoria produced a large number of mass erosion events following high intensity convective storms. Data on rainfall duration and intensity was available from nearby locations. More than 30 catchments were studied and mapped in detail to provide quantitative data on the conditions required for initiation of major erosion events after fire, and to estimate loads of sediment and other constituents delivered from eroded areas. The study established that the erosion events were comparable to fire-related debris flows reported from research in the western USA. Debris flows were triggered by runoff processes and sediment entrainment rather than mass failure. Indirect estimates of peak discharge show that the runoff response was higher than that expected under similar rainfall in unburnt conditions. We hypothesise that the elevated runoff response is linked to strong and uniformly distributed hydrophobicity, which resulted in low areal infiltration compared to unburnt soils. Our findings suggest that the probability of extreme erosion events in these catchments is dictated by the frequency and duration of high intensity rainfall and the timing of hydrologic recovery of burnt hillslopes.

Keywords: Wildfire, runoff, erosion, debris flow.

MITIGATION OF SOIL LOSS AFTER FOREST FIRES: A GEOMORPHOLOGICAL APPROACH BASED IN GIS MODELLING

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The RECOVER (Immediate soil management strategy for recovery after forest fires) project[i] aims to develop mitigation techniques and strategies to reduce soil and water degradation immediately after forest fires. Forest fires are becoming increasingly frequent as a result of climate change and poor forest planning, with deleterious impacts on soil fertility and structure. It erodes the top soil layers, where is located the only nutrient pool of the majority of Portuguese soils. This nutrient mobilization happens during the first autumn rainfall events, and therefore sediment and nutrient exportation typically occurs in the first 4/6 months after fire. The speed at which nutrient loss occurs and the extension of forest fires limits in terms of costs and logistics the solutions that can be taken to reduce soil and water degradation.

RECOVER will test a set of feasible solutions to reduce ash flush. The proposed approach presents an innovative integration of field measurement techniques and will perform a perception analysis to all those with responsibilities in forest management. This is essential to produce feasible solutions that will be easily adopted by forest managers and forest owners.

RECOVER presents an innovative approach based on field surveys of soil and vegetation properties following forest fires, which will be used to perform a GIS database from which the critical spots will be identified with the help of a Dynamic Geomorphology Conceptual Model that will be validated by subsequent visits to the field after the autumn rains.

This will allow us to implement a GIS analysis model, able to predict the reaction of the geomorphologic factors inside the parcels in study.

Keywords: Forest fires, soil degradation and recovery, GIS database and modeling.

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SOIL RECOVERY AFTER FIRES IN GHANA

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This submission captures report on the perennial occurrence of fires and their accompanying effects on the Soil and the fringe forest communities in the Worobong Forest Reserve within the Eastern part of Ghana.

Fire continues to be the single serious threat to the sustainable development and management of forest and wildlife resources in Ghana, thus depriving indigenous fringe forest communities of enormous socio-economic benefit of the forest. Locally, fire is used in the preparation of farm lands, tapping of palm-wine, charcoal production, honey harvesting, etc. these as a result affect the soil but afterwards some crops such as beans, legumes etc are grown on the soil to bring back the fertility of the soil back.

This paper identifies some of the effects of soil after fire has been used on it and the maintenance tool use to bring it to it normal posture. Many interventions are made to address the recovery of soil after fire menace in the area of study over the years.

Keywords: Soil maintenance, fringe forest communities, sustainable development resources, soil-socio-economic benefits.

POST-FIRE DYNAMICS OF SOIL SURFACE CHARACTERISTICS AND THEIR ROLE IN SOIL HYDROLOGICAL AND EROSIONAL RESPONSE IN A MEDITERRANEAN LANDSCAPE

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Fire produces a sudden change in soil cover. The soil surface becomes less protected against rain impact, and this in turn modifies the soil surface properties. The first year after fire is characterised by rapid changes in the soil cover (i.e., ash deposition and removal, stone cover and position, and plant response). As a consequence, the key factors affecting soil hydrological and erosional response can change profoundly. The aim of this work is to evaluate the changes in soil surface characteristics in the short-medium term after fire and to relate these changes to the soil hydrological and erosional response. The study area is located around the border of the provinces of Alicante and Valencia (E Spain). The climate is dry-subhumid mesomediterranean. The dominant soil type is Calcaric Leptosol. Prior to the fire, the vegetation was dense shrublands with sparse pines, developed after wildfires of 8-13 years ago. We installed 30 plots (0.24 m^2) distributed along 8 slopes, which included the dominant aspects of the area (NW and SE). We carried out 3 sets of rainfall simulations (55 m h^{-1}), together with soil surface characterizations, at 3, 12 and 15 months after the fire. Results showed a significant decrease in soil infiltration throughout the 15 months following the fire. Three months after the fire, soil infiltration was positively related to charcoal and negatively related to embedded stones, whereas soil loss was positively related to ash cover and negatively related to bare soil and charcoal. One year after the fire, plant cover and bare soil became the main factors, enhancing and diminishing, respectively, soil infiltration, and diminishing and enhancing, respectively, soil losses. In conclusion, charcoal, ashes and stoniness significantly explained soil hydrological and erosional behaviour in the short term after the fire, while plant cover and bare soil were the main factors in the medium term.

Keywords: Temporal dynamics, changes in soil surface characteristics, infiltration, erosion, rainfall simulation.

ECO-GEOMORPHIC RESPONSES OF BURNED MEDITERRANEAN FORESTS ON DIFFERENT SOIL TYPES

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Fire can impact a variety of soil physical and chemical properties. These changes may result in decreased infiltration and increased runoff and erosion rates. Most of these changes are caused by complex interactions among eco-geomorphic processes which affect, in turn, the rehabilitation dynamics of the soil and the regeneration of the burnt vegetation. Following wildfire events in two forests growing on different soil types, we investigated runoff, erosion and vegetation recovery dynamics. The Mt. Carmel site is characterized by terra-rosa and brown rendzina soils while the Birya forest site by light rendzina soils.

At each site several 3X3 m monitoring plots were established to collect runoff and sediment. In-plot vegetation changes were monitored by a sequence of aerial photographs captured using a 6 m pole-mounted camera.

At the terra-rosa sites (Mt. Carmel) runoff coefficients were 2.18% during the first year after the fire and 1.6% in the second. Erosion rates also decreased, from 42 gr/m^2 to 4 gr/m^2. The recovering vegetation was dominated by shrub and resprouting trees, and values of 31.5% and 24% were found in the north and the south facing slopes, respectively. In the second study year vegetation cover reached 65% and 54%.

In spite of similar precipitation variability, different patterns were observed at the light rendzina sites where both runoff and erosion rates remained high along the two-years study period. Mean runoff coefficients exceeded 10% on both slopes, during the first year and only a slight decrease was noted during the second one, erosion rates increased from 123 gr/m^2 to 180 gr/m^2. After the first rainy season only 5.7% of the plots were covered by herbaceous vegetation on both slopes. At the beginning of the second season vegetation cover remained low, and towards the end of it mean cover increased to 38.7% / 52% on the north and the facing slopes.

Keywords: Runoff, soil erosion, soil type, vegetation regeneration, forest fire.

SOIL MICROBIAL POPULATIONS IN POST-FIRE SUCCESSIONS IN BOREAL FORESTS OF CENTRAL SIBERIA

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Fire is a particularly important factor under permafrost. Being an active forest ecosystem component, microorganisms are among the first to respond to fire. Post-fire microbial community dynamics and functioning in cryogenic areas are of great scientific interest.

This study was conducted in 1-, 11-, 15-, 20-, 24-, 40- and 54-year-old surface fire-caused burns and in adjacent unburned sites. The mineral soil layer (0-10 cm deep) microbial biomass and respiration dynamics was recorded as related to microrelief. Heterotrophic microorganism biomass was determined by kinetic method with using the equation (Sparling at al, 1995). Basal soil respiration was estimated from CO_2 emission rate from soil samples and expressed as C-CO_2 g^{-1} day^{-1}. Phospholipid fatty acid (PLFA) and phospholipid etherlipid (PLEL) methods were used to look at the metabolizing microbial structure.

Microbial biomass and activity were found to increase in burned soils (both on mounds and trough) during several years after fire. These two parameters of upper soil microbial communities exhibited different further microrelief-specific stabilization dynamics. Heterotrophic respiration and microbial biomass appeared to recover to the pre-fire levels about 15 years after-fire on mounds, while microflora showed considerable changes in trough. Its biomass was determined to decrease to pre-fire values 15 years following fire and increase again in 25-yr-old burns. Thus, microbial activity appeared to be strongly correlated with the unburned organic matter consumption by microorganisms under favorable hydrothermal conditions. Fatty acids and phospholipid etherlipids were determined to change structurally during a year after fire, with further recovery in 54 years. Ground vegetation type was concluded to have a remarkable influence on microbial complexes, since the community identified under a lichen-dominated plant group appeared to be structurally different from that found under feather moss.

Keywords: Boreal forests, post-fire successions, soil microbial populations.

POSTERS

SOIL TYPE AS A FACTOR CONTROLLING WATER REPELLENCY IN FIRE AFFECTED AREAS: EVIDENCES FROM FIELD TRIALS IN MT. CARMEL (ISRAEL)

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Soil water repellency (WR) is one of the properties most affected by combustion during a forest fire. Previous laboratory findings have demonstrated that soil properties can be a key factor controlling the development of WR by burning, terra rossa being a type of soil with a low susceptibility to develop WR. The main objective of this research was to confirm laboratory findings under field conditions. On July 2008 WR was assessed in three areas recently affected by fire in Mt. Carmel (Israel). Wildfires occurred during middle June and early July with a moderate severity. The main difference between areas was the type of soil. These are classified in Israeli soil maps as: Grey Rendzina (GR), Brown Rendzina (BR) and Terra Rossa (TR), and classified in Soil Taxonomy as a Typic Xerorthent, a Calcixerept and a Lithic Rhodoxeralf respectively. In each one of the study areas WR was tested beneath Pinus halepensis in both burned and unburned (control) adjacent sites. WR test were conducted under field conditions in triplicate in the top of the A horizon. A total of 180 field measurements were done. Soil samples were also taken for laboratory analyses.

In general terms, without distinguishing between areas, fire has increased the frequency of occurrence of WR in affected soils from 47% in control to 80% in burned. The magnitude of this effect is however quite different depending on the studied area, i.e., the type of soil. Whereas in the area with GR soil the change is from 40% in control to 100% in burned, the persistence of WR also increasing, the area with TR soil showed the lowest WR values. In this area, the difference was from 30% in control to 50% in burned, with lower values of WR (ranging in the lowest classes of WDPT: 10-60 s). In the area with BR soil, the change is from 70% to 90%. In this case, control soil showed a significant occurrence of WR as consequence of the highest organic matter content. These results are in agreement with those from our previous laboratory experiments. Organic matter and clay content together with the mineralogy of the clay fraction seem to be responsible for the different soil behaviour.

Keywords: Water repellency, fire, burning, terra rossa, hydrophobicity.

TEMPERATURE EFFECTS ON THE RELEASE OF SOME MICRONUTRIENTS FROM ORGANIC MATTER IN MEDITERRANEAN FORESTS: A COMPARISION BETWEEN A LABORATORY EXPERIMENT AND A PRESCRIBED FIRE

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There is a lack of studies about the fire temperature effects on micro-elements release from litter, the organic matter on the soil surface. In order to contribute to this knowledge, a laboratory experiment was conducted by subjecting leaf litter of tree Mediterranean species, Quercus suber, *Quercus robur* and *Pinus pinea* to temperatures of 150º, 200º, 250º, 300º, 350º, 400º, 450º, 500º and 550ºC in a furnace for 2 hours to identify the release of aluminium (Al), iron (Fe) and zinc (Zn) from ashes. Subsequently, in a forest dominated by the mentioned species, mainly *Quercus suber*, we applied a prescribed fire in a plot (50 x 80 m). We collected litter samples before the fire, and the ashes following the fire in order to compare the results obtained in the laboratory experiment with prescribed fire with low to medium temperatures. The majority of ash collected is brownish or black, indicating incomplete combustion of the organic matter. The results showed that in laboratory experiments at low to medium temperatures (150º-350ºC) Al had higher levels in solution than unburned samples. In the prescribed fire, ashes released a significant higher quantity (p<0.01) of Al in solution in relation to litter, however with a lower spatial variability. The coefficient of variation (%CV) before fire was 76.48 and after 65.14. In the laboratory experiment, water leaches of ash produced at higher temperature showed decreases in Fe and Zn concentration relative to the unburned sample. After the prescribed fire we found a reduction of these elements in the ashes in relation to litter. For Fe a significant decrease occurred (p<0.01) in the concentration and the %CV decreased from 179.35 to 82.29. For Zn the reduction in the ash was more significant (p<0.0000) after prescribed fire and also the spatial variability decreased, % CV 90.32 before and 79.89 after. Overall, the results of this study show that laboratory experiments can simulate the effects of a prescribed fire on these metals. It is also important to point out that after prescribed fires the levels of Al in water resources could be higher in Mediterranean forests, inducing toxicity in the environment.

Keywords: Heavy metals, laboratory experiment, prescribed fire, litter, ashes.

TOTAL CARBON AND NITROGEN IN ASHES AND PHOSPHORUS RELEASE AFTER A PRESCRIBED FIRE IN A QUERCUS SUBER PLOT IN THE NORTHEAST OF THE IBERIAN PENINSULA

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After a fire, the majority of the nutrients remain in the ashes and will contribute to landscape recuperation. Carbon, nitrogen and phosphorous are all affected by fire and the study of their presence in ashes after a fire is of major importance, because they are key elements in ecosystems. The aim of this work is study the effects of a low to medium severity prescribed fire on Total Carbon (TC), Total Nitrogen (TN) and C/N and the release of water soluble Phosphorus (WSP) from ashes collected from a Quercus suber plot (50 x 80 m) located in the northeast of the Iberian Peninsula. The majority of the ash collected is brownish or black. Our results demonstrate a reduction of the relative content (%) of TC in the ashes after the fire in relation to litter; however this is not statistically significant. The coefficient of variation (%CV), used as measure of the spatial variability, increased from 16.91 before the fire to 18.05 after the fire. The % of TN present in the ashes was enhanced significantly (p<0.0000) as a consequence of the prescribed fire and an increase of CV% from 16.91 to 18.05 was also observed. The C/N ratio was significantly reduced (p<0.0000), however, the CV% rise, before the prescribed fire was 18.77 and after was 25.30. Also, WSP release from ashes after the fire was higher in comparison with litter collected before the prescribed fire, however this was without statistical significance. A reduction of CV% was observed after the fire, from 71.01 before to 66.00 after. The results obtained from this study show that these ashes produced in this low to medium severity prescribed fire are rich in TN, without substantial changes in TC content and they have a lower C/N ratio with respect to litter collected before the prescribed fire application. The release of WSP was not statistically different with respect to the litter. The spatial variability increases as a result of the fire except for WSP.

Keywords: Prescribed fire, total carbon, total nitrogen, C/N, *Quercus suber* plot, Spain, Iberian Peninsula, ash.

FIRE TEMPERATURE EFFECTS ON TOTAL CARBON, TOTAL NITROGEN, C/N AND RELEASE OF WATER SOLUBLE PHOSPHOROUS ON LITTER FROM TWO QUERCUS SUBER TREES LOCATED IN DIFFERENT PLOTS ON THE IBERIAN PENINSULA

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Carbon, Nitrogen and Phosphorous are key elements in a healthy ecosystem but they are also very vulnerable to alteration or loss as a result of fire. In order to study the effects of fire on these nutrients we subjected leaf litter from two Quercus suber trees located in different plots on the Iberian Peninsula, Albuferia (Alb) and Mas Bassets (MB), to the temperatures of 150º, 200º, 250º, 300º, 350º, 400º, 450º, 500º and 550ºC in a muffle furnace for 2 hours to identify the temperature effects in relative percentage (%) on Total Carbon (TC), Total Nitrogen (TN), C/N ratio and the release of Water Soluble Phosphorous (WSP). The goal was to identify different vulnerabilities to fire effects between ecosystems. The results showed a decrease of % TC content in the ashes in relation to the unburned sample, mainly in the sample of Alb. At low temperatures the values are slightly higher than the control. At temperatures of 450ºC for the Alb litter and 500ºC for the MB litter, the %TC is less than 80% relative to the unburned sample. Both litter samples showed a rise in the content of %TN in relation to the unburned sample up to 400ºC, especially in the Alb sample, followed by an abrupt reduction also more evident in this sample. At 450ºC for the Alb sample and 500ºC for the MB sample, TN is nonexistent in the ashes. The C/N ratio decreases with increasing temperatures. At low temperatures, 150º-300ºC, C/N is higher in the Alb samples, and at higher temperatures this ratio is reduced. At 450ºC for the Alb sample and 500ºC for the MB sample, this ratio is zero because of the absence of TN. From 150ºC to 300ºC, both samples showed a rise in WSP in solution, decreasing thereafter. The effect of temperature is especially evident in the Alb litter, where at 300ºC the increase in WSP is 90-fold higher than the control sample. Overall it is observed that the effects of temperature are more severe on the Alb litter sample than the MB sample and that the environment has an important influence on the response to heating.

Keywords: Carbon, nitrogen, C/N, phosphorous, fire temperature, *Quercus suber*.

EFFECTS OF ASH TYPE AND DEGREE OF COMBUSTION ON SOIL WATER REPELLENCY

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Enhanced runoff and erosion following fire, and the role of soil water repellency therein have been the focus of many studies. However few studies have paid attention to the role that ash may play in affecting these parameters although an ash layer composed by a heterogeneous material (from charred vegetation to white ash) often covers the ground after the fire. Where ash is considered in runoff responses, it is reported to be highly hydrophilic, yet its effect on soil hydrological properties when incorporated into the soil has not been explored. In the current study, we therefore examined the wettability and pH of a soil (hydrophilic and hydrophobic after being heated) mixed with different type of ash. The factors studied were: 1) degree of ash combustion by heating vegetation debris at different temperatures (250, 350, 500, 700°C), 2) type of ash, by using material from different Mediterranean species (*Rosmarinus officinalis, Pinus halepensis and Quercus coccifera*), and 3) the quantity of ash, by using two doses (low and high). Water repellency and pH was measured immediately after ash application to the soil, and also after the samples were wetted and dried. Our results show that ash with a low degree of combustion can exhibit hydrophobic properties, whereas a high degree of combustion results in the commonly observed hydrophilic ash. After application to the soil we observed that a hydrophilic soil can become water repellent as a consequence of ash incorporation into the soil. On the contrary, the application of ash with a high degree of combustion can reduce the persistence of water repellency of a hydrophobic soil. On the other hand the wetted and dried samples present lower degrees of hydrophobicity. Finally, there are some negative relationships between soil pH and water repellency. The factors that control the wettability behavior of ash appear to be mainly the degree of combustion, but also the type and the ash dose applied and the fact of being wetted after the treatment. Our findings imply that although an improvement in wettability for water repellent soils would normally expected from ash incorporation, under certain combustion scenarios, ash may contribute to water repellency development in soils after burning.

Keywords: Ash, water repellency, degree of combustion, pH, vegetation.

ASSESSING THE SENSITIVITY OF TWO SOIL QUALITY INDICES TO THE HEATING TEMPERATURE

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Wildfires can be one of the most degradation agents in Mediterranean areas, but the effects on soils mainly depend on the severity of the fire. It is necessary to develop techniques to evaluate the magnitude of the perturbation in wildfire affected soils. In this work we assess the sensitivity of two soil quality indices in samples of a soil heated at different temperatures under controlled laboratory conditions.

The soil quality indices used in this work were calibrated using different soils from undisturbed climacic forest soils (soils in equilibrium conditions) in SE Spain. The indices were constructed using the relationships (multiple linear regressions) between some soil parameters. Model 1 showed that Soil Organic Carbon (SOC) can be estimated by a linear combination of six physical, chemical and biochemical properties. Model 2 showed that SOC can be calculated by means of seven chemical and biochemical properties. The residuals (difference between the real SOC content and the estimated SOC by the models) are used as the soil quality indices. These indices were applied in samples of a forest soil heated at different temperatures during 20 minutes (unheated, 100º, 200º, 300º, 400º, 500ºC) with the aim to evaluate the sensitivity of the indices to the heating perturbation.

Many changes in the soils properties were observed when samples heated were heated at 200-300ºC. As expected, the enzymatic activities were strongly affected, and the organic carbon and the cation exchange capacity were progressively decreased. The typical increase in available phosphorous were also observed, but no differences have been found in the aggregate stability.

Interestingly, it was observed the progressive increase of the residuals according with the temperature of heating in the two models. The residuals were out of the confidence intervals established in the models when samples were heated above 200ºC.

According with our results, these indices could be used to measure the magnitude of the heating perturbation on the soil quality after wildfires.

Keywords: Indices, models, wildfire, enzymatic activities, forest soils.

PLANT SPECIES INFLUENCE ON FUNGAL AND BACTERIAL RESPONSE AFTER SOIL HEATING

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Plant species can affect fire intensity and severity causing different immediate and post-fire responses of the microbial community. This was studied in a laboratory heating experiment (300ºC during 20 min) using soil collected under *Pinus hallepensis* (PIN) and *Quercus coccifera* (KER). Dried plant material was added (1g per 20g soil) before heating resulting in six different treatments: non-heated control samples amended with the original plant material (PIN_0 and KER_0); PIN samples heated with pine (PIN_p) or kermes oak litter (PIN_c); KER samples heated with kermes oak (KER_c) or pine litter (KER_p). Heated soils were inoculated with the original soil (1g per 20g soil) and water to achieve 60% WHC was added. Bacterial and fungal abundance (plate count) and biomass index (phospholipid fatty acid analysis) were measured 3 and 28 days after inoculation.

Bacterial numbers were higher in heated than in control samples at both measurement occasions. Added litter only affected KER samples immediately after heating, where soil amended with kermes oak had more bacteria than those amended with pine litter. Fungal abundance decreased below control values immediately after heating. After 28 days KER showed significant higher fungal abundance than PIN samples in both heated and control samples. Plant material was important in PIN samples, where PIN_p had lower fungal abundance than PIN_c.

Contrary to the plate count data, both fungal and bacterial biomasses indices decreased due to heat treatments. Plant litter only affected to a minor degree. Fungal and bacterial biomasses were higher in KER than PIN heated samples. Soils amended with kermes oak had higher fungal biomass than those amended with pine litter.

Thus, plant species was shown as a significant factor determining the microbial response after heating, most likely due to different fuel nature and possible presence of different soil microbial communities associated with each plant species.

Keywords: Microbial abundance, microbial biomass, plant species.

BACTERIAL AND FUNGAL GROWTH IN SOIL HEATED AT DIFFERENT TEMPERATURES

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Fire intensity is one of the most important factors determining fire severity and the subsequent effect on soil microorganisms, since it can alter the quality and quantity of carbon sources or induce the appearance of toxic compounds. Fire intensity will thus influence both short and long-term response of the soil microbial communities.

In this work a Mediterranean pine forest soil was subjected to different heating temperatures to study the short-term effect of fire intensity on bacterial and fungal growth, estimated using leucine incorporation for bacteria and acetate incorporation into ergosterol for fungi. Soil samples were heated during 15 minutes at each temperature (non-heated control, 50, 80, 120, 200, 300, 400, and 500 ºC). After heating the soil samples were inoculated with fresh soil (1g per 100g heated soil), and distilled water to achieve 60% WHC was added. The total incubation period at 20ºC was 21 days.

Bacterial growth was initially inhibited by heating above 50 ºC, but recovered within days to levels much higher than the control, except for the 500 ºC treatment, where bacterial growth remained low all the time. The bacterial response decreased after the first week to values close to the control. Samples heated at 200ºC showed the highest cumulative bacterial growth and it was still higher than the control values at the end of the experiment. Fungal growth was initially lower than the control in all high temperature treatments. Although fungal growth recovered slowly during the experiment, it never became much higher than the control in the three highest heating treatments.

That bacteria are favoured compared to fungi in heated soil has earlier been reported in other studies, but this is the first time growth has directly been estimated. Usually increased pH after fire due to ash deposition has been suggested as the reason for bacteria being favoured. High soil pH can also explain our result, although pH in heated soil did not change due to initial high soil pH. However, fungal and bacterial activities showed opposite behaviour in the experiment, indicating possible competitive interaction between these microorganism groups.

Keywords: Bacterial activity, fungal activity, soil, fire intensity.

INFLUENCE OF FIRE SEVERITY ON PHYSICAL DEGRADATION IN TWO PINE FOREST SOILS IN NW SPAIN

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The aim of this work is to determine the effects of wildfires of different severity on soil physical degradation on two pine forest of NW Spain and compare it with the changes observed with the heating under controlled laboratory conditions using the temperatures of 25, 170, 220, 380 and 460ºC.

The soil properties analyzed in this study were dry aggregate size distribution, water aggregate stability, total porosity, pore size distribution, organic carbon content, soil water repellency and hydraulic conductivity.

In both study sites, samples of burned soils were collected at a depth of 0-5 cm one month after the fire. The same was done at two unburned sites with comparable conditions as the neighboring burnt site.

Comparison of the alterations caused by the fire with the changes observed when the soil is heating in the laboratory suggest that changes in the physical properties of burnt soils are directly related to the highest temperatures reached at the soil surface during a fire.

In one of the soils the temperature reached in the burnt area never exceeded 220ºC because no changes in organic carbon content or in aggregation were observed and the soil. Water repellency remained very high after burning which accounts for the low hydraulic conductivity of the soil.

In the other studied soil was observed a disaggregation and a decrease in soil aggregate stability related with the important loss of organic carbon content. Soil water repellency was also considerably reduced in the surface. The low hydraulic conductivity of the soil after the burning can be due to the disaggregation and diminished soil aggregate stability observed. In this case the results indicate that in this soil the fire was of greater intensity.

Keywords: Forest fires, soil physical degradation, soil aggregation, water repellency.

EFFECTS OF A FOREST FIRE ON A PEAT ORGANIC SOIL IN THE SCOTTISH HIGHLANDS

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The Rothiemurchus forest fire took place on 16 July 2006 and burnt a total of 12 ha over a six-week period due to smouldering of organic peat. The forest is a *Pinus contorta* plantation and the cause of the fire was thought to be accidental, starting at the roadside and spreading into the forest from the nearby *Calluna* moorland. A field visit was made on 24 February 2008 when an inventory was made of the damage caused directly and indirectly by the fire to the soil and vegetation. A direct effect was the total consumption of the organic part of the soil where smouldering persisted, but there are also changes in the chemical properties of the soil. One of the indirect effects is, for example, that many of the trees have fallen down due to the consumption of the organic peat beneath their roots. Many trees were not killed directly by the fire but died later as a consequence of the fire. During the fieldwork, soil samples were also taken along transects in the burnt area and also in the adjacent unburnt area for comparison. The analyses show that in the burnt parts of the forest the pH of the soil had increased from 4.08 to 4.31, still being a very acidic, the electrical conductivity decreased from 74.5 $\mu S\ cm^{-1}$ to 64.7 $\mu S\ cm^{-1}$, possibly due to the facilitated erosion of the burnt soils in a very rainy climate. The percentage of fines also decreased after fire (89.2% and 82.9% respectively), which can be a result of the disaggregation of the soil caused by fire. Not unexpectedly, the organic matter content showed a dramatic decrease, still evident even two years after the fire (27.0% SOM compared to 44.2% in unburnt patches). Considering the results presented here in conjunction with the evidence from previous research, we conclude that the effects of this kind of peat fires, have significant consequences for the organic and chemical properties of the soil.

Keywords: Peat, smouldering fire, Scotland, organic matter.

SOIL-VEGETATION DYNAMIC CHANGES AFTER FOREST FIRES MT. CARMEL, ISRAEL

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Long-term effects of forest fires on soil properties may last a couple of decades, depending mainly on fire severity. Previous studies conducted in Mt. Carmel indicated that major chemical elements in the topsoil such as organic matter, phosphorus and electric conductivity have not returned to their pre-fire levels even after 20 years. Soil properties, in turn, are an important factor in vegetation recovery, thus, it is essential to further study the effect of the recovering soil on vegetation.

During the last 30 years more than 9 large fires (>120 hectare) and 500 smaller fire events occurred in the Mediterranean ecosystem of Mt. Carmel. Statistical analysis of fire frequency in the region indicated that the return interval of large fires varies between 6 years for a 120 hectare fire to 15 years for 500 hectare fires; small fires (5-10 hectare) occur every year.

The study aims at: 1) examining whether the vegetation stage coincides with the soil rehabilitation dynamics throughout the recovery phases and successional processes and 2) analyzing temporal and spatial changes in vegetation cover. Methods include: a) land cover classification analysis of the vegetation cover using aerial photos and Feature Analyst tool based on Arc/Info, in area that have been previously burnt in 4 different fires: 1983, 1989, 1999, 2005 and a control area. b) Field surveys in the same area for mapping and validation of the vegetation cover, structure and diversity.

Preliminary results show that vegetation cover is similar for all sites, regardless the time elapsed since the fires, as well as for the control sites - 90%-100% coverage. Nevertheless, there are clear differences in vegetation architecture. For example, in the area of the 1983 fire, the forest canopy has not reached the height of the control sites, whereas in the 1989 fire there is differentiation between trees and understorey and the large diversity may testify for the low recovery of soil properties. In the 1999 fire the vegetation is at a stage of competition and all the vegetation – trees and bushes are at the same height.

Keywords: Forest fire, Mt. Carmel, rehabilitation, soil properties, vegetation cover.

NEAR INFRARED SPECTROSCOPY FOR THE EVALUATION OF BURNED SOILS

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Effects of fire on soil properties are mainly caused by the temperature reached. As consequence, tools for the rapid, easy, cheap and accurate estimation of the temperature reached on soils are needed. Near-infrared (NIR) spectroscopy meets with these requirements. Different quantitative (partial least squares regression [PLSR]) and qualitative (discriminant analysis [DA]; clusters analysis [CLA]) statistical methods were used to asses the fire severity using NIR spectroscopy. For this, samples of different soils were heated in laboratory conditions, and the maximum temperatures reached (MTR) on the samples were recorded (using thermocouples). PLSR was an accurate method for the quantitative estimation of the MTR. DA offered an interesting alternate method despite of the qualitative information. Considering that a NIR spectrum could be used as an integration of many properties, thus the different patterns of clustering obtained with the CLA could be used to detect what temperatures induced the abrupt changes in the whole soil characteristics. Thus, CLA can offer a natural vision of changes in the whole soil.

Anyway, it is also interesting the measurement of specific soil properties with the aim to select the most appropriate restoration strategy. In this sense, it should be noted that some changes on soil properties don't follow a linear relationship with the temperature of heating (such as basal respiration [BR] and soluble organic carbon [SOC]). Moreover, the degree of changes as consequence in some properties could be different depending of soil type. Thus, we also studied the ability of NIR to estimate BR and SOC in heated soils. As expected, BR and SOC changed drastically as consequence of heating, and these changes didn't followed a lineal correlation with the temperature of heating. Accurate models relating NIR spectra with BR and SOC (r^2>0.90) were obtained using PLS as chemometric method, confirming the usefulness of NIR spectroscopy.

Keywords: NIR spectroscopy, fire severity, temperature, basal respiration, soluble organic carbon.

ORGANIC CARBON AND SEDIMENT REDISTRIBUTION AFTER FOREST FIRE. THE NAVALÓN FIRE IN EASTERN SPAIN

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Soil erosion is often enhanced after forest fire due to the reduction in vegetation and litter cover and fire-induced changes in soil properties. The immediate post-fire soil erodibility is highly dynamic due to the continued changes occurring at the soil surface. Litter and ash are redistributed by wind and water, and rock fragment cover increases on the soil surface. Ash can form crusts or clog soil pores. Litter can fall from charred trees, and remaining vegetation may die, re-sprout or germinate. However, very little is known about the evolution of the soil erodibility and associated erosion rates immediately after the fire, mainly due to the time necessary to install a complete soil erosion research station. The aim of the ongoing research described here is to assess the spatial and temporal dynamics of soil and associated organic carbon erosion rates after a forest fire. A typical Mediterranean scrubland-Aleppo pine stands covering two watersheds were selected in Eastern Spain. A fire took place April 12th 2008 and measurements were initiated the month after, before the first rains. Data collected so far from twelve 0.30 m^2 bounded plots, ten sediment fences (1.5 x 200 x 2000 mm iron sheets), and natural ponds as collectors for sediment deposits (old abandoned terraces) shed light on the organic carbon and sediment redistribution within the study catchments.

The measurements carried out at the slope-scale show that the water and sediment redistribution is heterogeneous. Soil and organic carbon losses to date are higher on the slopes (6 Mg ha^{-1}) than at the catchment scale (2.5 Mg ha^{-1}). This is to some degree due to the natural soil erosion dynamics being affected by abandoned terraces acting as sediment traps. Organic carbon-rich deposits accumulated in the catchment, containing ~20 % organic carbon, compared to the ~6 % present in the soils. The sediment redistribution was highly dependent on the rainfall intensity. A short but intense rainstorm in July 12th 2007 accounted for almost 95 % of the total sediment redistributed sediment so far. This 10-minute (15 mm) rainfall event connected the pedon, slope and catchment-scale surface runoff. The organic rich sediments buried on the bottom of the slopes and in fluvial channels have the potential to act as medium- to long-term carbon stores. They are likely to be stabilized as vegetation recovers and the pyrolized (black) carbon contained therein is highly resilient to degradation. Once (and if) full vegetation, soil biomass, and ecosystem recovery is completed, these deposits could be responsible for this fire to lead cause overall net carbon sequestration.

Keywords: Forest fire, sediment redistribution, soil erosion, organic carbon, plots, Spain.

EFFECTS OF POST-FIRE REGENERATION TREATMENTS ON PLANT COMMUNITY ON SERPENTINE SOILS IN MARMARIS REGION, TURKEY

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Effects of post-fire regeneration treatments on plant community on serpentine soils were studied in a *Pinus brutia* Ten. forest that was burned in 2002 in Marmaris region, one of the most fire-prone area in Turkey. 24 study sites were randomly selected in areas with different post-fire regeneration treatments, and also in a mature forest that was not burned at least for the last 50 years and was used as a control site. Three main treatments were compared in this study: natural regeneration pine plantation, and a nature protected area that had no relevant human impact.

To examine the treatment effects on the plant community, several plant community parameters such as species richness, species diversity, similarity and dominance, and a vegetation structure parameter (cover of plant species) were estimated.

The results showed that pine plantation areas have the highest diversity, probably because these areas give a better chance to opportunist species to live. The results also indicated that the natural regeneration areas have similar species composition that nature protected areas probably due to the low human impact. The pine plantation treatment caused an increase in the growth rate of *Pinus brutia*, though in the following years it may result in weaker forests that may increase fire sensitivity.

The values obtained were discussed and compared with previous studies in other Mediterranean ecosystems.

Keywords: Forest fires, regeneration techniques, plant community, serpentine soils, Mediterranean ecosystems, Marmaris.

SOIL MICROBIAL COMMUNITY COMPOSITION AND MICROBIAL RESPONSE TO FOREST FIRE IN MEDITERRANEAN SPANISH SOILS

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Soil microbiology is of key importance for soil system functioning and is one of the soil components most affected by wildfires. Analysis of fire effects on soil microbes was undertaken from a conifer forest soil at Sierra de Gredos (Ávila, central Spain) in fire-impacted soils collected ten months and twenty years after a wildfire of low-to-moderate intensity. The microbiological study was carried out using both, conventional culture techniques to determine viable organisms in the appropriated medium, and specific molecular techniques using PCR amplification using 16 S rRNA probes and electrophoresis in poliacrilamide denaturing gels. We observed that fungi and bacteria decreased in the whole sampling period when comparing burned to unburned soils. Microbial population was higher and showed a greater variability in samples twenty years after fire than those collected ten months after wildfire. In addition to that our study includes a set of soil characteristics analysis as pH, organic C and N and exchangeable Ca and K in burned soil samples respect to control soil, after ten months or twenty years post fire. Ten months after fire a strong increase in soil pH, organic C and N, and exchangeable Ca and K was observed in burned soil with respect to the control soil. The results of samples collected twenty years after the fire showed that after this time organic C and N levels in burned soil are lower than in control soil, whereas higher pH, exchangeable Ca and K were still evident.

Keywords: Forest fire, soil microbiology, PCR, microbial diversity.

THE USE OF NEAR INFRARED SPECTROSCOPY (NIR) TO ESTIMATE SOIL ORGANIC CARBON IN BURNED SOILS

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Wildfires can affect soil physical, biological and chemical properties such as organic matter quantity and quality. In Mediterranean conditions, wildfires can start degradation processes of soils and the conventional analytical methods for soil organic carbon (SOC) and other soil properties are time consuming, destructive of samples and often use many chemical reagents. For these reasons, it is important to explore the potential of rapid methods of soil analysis such as near infrared spectroscopy (NIR), to assess responses to fire, evaluate the effectiveness of restoration practices, or select the most sustainable management practices. Near infrared spectroscopy has been shown to be an efficient method for estimating SOC in unburned soils. The objective of this study was to evaluate the use of this technique in fire affected soils. For this purpose, we constructed models (empirical calibration function) with unburned forest samples (n=366), with burned samples (n=48) and mixing unburned and burned samples from the Province of Alicante using partial least squares (PLS) regressions.

For unburned soils, models were successfully calibrated and validated with r^2 greater than 96 and the root mean square error (RMSE) less than 7. The residual predictive deviation or RPD (Standard deviation (SD) measured data / RMSE) was greater than 5.5. These values indicated that the models can be considered as excellent. In models constructed with unburned and burned soils we also obtained excellent models with r^2 above 92, RMSE less than 9.5 and RPD greater than 3.6. Good predictions were obtained in models constructed with burned soils, where the r^2 were greater than 81, the RMSE below 8 and RPD greater than 2.5. Our results indicate that NIR reflectance offers a useful and rapid method for estimating SOC in burned soils using excellent models constructed mixing unburned and burned soils. Further studies on soil properties of burned soils should be done to check if they could be predicted with NIR.

Keywords: Burned soils, near infrared spectroscopy (NIR), soil organic carbon.

SOLUTE BEHAVIOR OF MAJOR CATIONS, S AND SiO_2 RELEASED FROM LEAF LITTER FROM A PLOT LOCATED IN A MEDITERRANEAN FOREST. A COMPARASION BETWEEN BEFORE AND AFTER A PRESCRIBED FIRE

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After a fire the water soluble elements rises due the mineralization of organic matter. In order to understand this dynamic, we collected leaf litter before an application of a prescribed fire and thereafter the ashes produced, and analyzed the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), S and SiO_2, released in a Mediterranean forest. The prescribed fire was done conducted in a plot 50x80 m dominated by *Quercus suber* located in Gavarres Mountains, Iberian Peninsula, and it was of low and medium intensity, because the ash colors were brownish or black. To simplify our task, we applied a Factor Analysis (FA), extracted by the method of Principal Components (PCA) and rotated with the Varimax normalized method with the aim of observe the effects of fire application in the release of the nutrients. The results showed that the levels of water soluble ions were affected by the prescribed fire in the decreased order Na^{+} >SiO_2 >Ca^{2+} > Mg^{2+}> K^{+} and S. Although, in the great majority of the sample points, it was observed an increase of the water soluble elements and also a higher variability between points. Outliers were observed in two sample points after the prescribed fire due the higher fire intensity and the higher flammability of the *Pinus pinea* leaf litter, were we identified a greater amounts the water soluble elements analyzed.

Keywords: Water soluble ions, prescribed fire, mediterranean forest, Iberian Peninsula, factor analysis, principal components.

SOIL PHYSICAL AND CHEMICAL PROPERTIES OF BURNED AND UNBURNED *PINUS BRUTIA* TEN. FOREST SITES IN MARMARIS REGION, TURKEY

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The aim of this study was to determine long-term post-fire changes in soil physical and chemical properties of *Pinus brutia* Ten. forest ecosystems found on ophiolithic rocks in Marmaris region, southwestern Turkey. Six sites burned at different years (3,6,8,9,16,26 years ago) and two sites that had not burned for a long time (at least 50 and 100 years) were selected. Three plots 1 ha in size were randomly selected within each site, and three soil samples were collected from randomly selected points within each plot. Soil texture, pH, $CaCO_3$ content, organic matter content, electrical conductivity, and exchangeable cation concentrations of soil samples were determined.

Soil texture did not change among the study sites, and percentages of sand, silt and clay did not significantly differ among study sites. Organic matter content was significantly higher in unburned sites, but was similar in all burned sites. There was no important difference between three-years-old site and other sites in terms of exchangeable cation concentrations, electrical conductivity, pH, and $CaCO_3$ amounts.

Although some slight trends with time since fire were found for some of the variables evaluated, actually soil properties did not change drastically with time, or at least changed without a trend among study sites. This was attributed both to the importance of studying early post-fire years to detect a change in soil properties, and to the importance of site heterogeneity.

Keywords: Marmaris, post-fire changes, site heterogeneity, soil chemistry, soil texture.

EROSFIRE II – INITIAL RESULTS

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The EROSFIRE-II project (PTDC/AGR-CFL/70968/2006), funded by the Portuguese Foundation for Science and Technology, is intended as a continuation as well as an extension of the recently terminated EROSFIRE project (POCI/AGR/60354/2004). Thus, on the one hand, it aims to validate the measurement and modelling results of the EROSFIRE project for other geographical areas, i.e. with different physical-environmental characteristics (e.g. rainfall), distinct land-cover types (especially pine stands), different post-fire land management practices and/or more severe fire intensities. On the other hand, it intends to assess and predict post-fire erosion hazard beyond the scale of individual hill-slopes by also addressing road, channel and catchment-scale processes, including by means of hydrometric stations.

Since the start of the project, in May 2007, however, the selection of a suitable study area has presented major difficulties since the last two summers produced comparatively few and especially also relatively small wildfires in Portugal, particularly when compared with the summers of 2003 and 2005.

At present, work is centring on a small catchment that burnt almost entirely during late August near the locality of Colmeal, Serra de Lousã, central Portugal. So far, focus has been on instrumenting: i) the catchment with 8 rain gauges; ii) individual hill-slopes (or, more precisely, separate hill-slope sections) with micro- and slope-scale runoff plots (5x) and/or with slope-scale sediment fences (10x); iii) various concentrated flow paths (valleys/gullies) with sediment fences (5x) and/or analogue water-level recorders (6x). Plans for the immediate future include: i) installation of a flume and fully equipped hydrometric station; ii) initial profiling of selected concentrated flow paths and road sections; iii) dedicated mission of digital aerial photography for the generation of a high-resolution Digital Terrain Model.

The proposed presentation will provide further details on the project's progress in the Colmeal study area, and present initial results, hopefully across the various scales.

Keywords: Soil erosion, multi-scale approach.

SOIL ATTRIBUTES DYNAMICS EVALUATION AFTER PRESCRIBED BURNING PRACTICE IN NORTHWESTERN PORTUGAL FOREST

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The Portuguese northern forests are often and severely affected by wildfires during the summer season. These occurrences affect significant and rudely all ecosystems, namely soil, fauna and flora. Preventive actions such as prescribed burnings and clear-cut logging are frequently used and have showed a significant reduction of the natural wildfires occurrences. In Portugal, and due to some technical and operational conditions, prescribed burnings in forests are the most common preventive action used to reduce the existing fuel hazard. The overall impacts of this preventive action on Portuguese ecosystems are complex and not fully understood. This work reports to the study of a prescribed burning impact in soil chemical properties, namely pH, humidity and organic matter, by monitoring the soil self-recovery capacity. The experiments were carried out in soil cover over a natural site of Andaluzitic schist, in Gramelas, Caminha, Portugal, who was able to maintain itself intact from prescribed burnings from four years. The composed soil samples were collected from five plots at three different layers (0-3cm, 3-6cm and 6-18cm) 1 day before prescribed fire and after the prescribed fire. The results have shown that the dynamic equilibrium in soil was affected significantly.

Keywords: Prescribed fire, forest soil, pH, humidity, organic matter.

TOTAL ORGANIC CARBON AND INFRARED CHANGES OF HUMIC SUBSTANCES FROM MEDITERRANEAN BURNED SOILS

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The repetition of fires can lead to quantitative and qualitative effects on organic matter. The most important and abundant fraction of the organic matter is humic substances. They contribute to the soil structuring and structural stability, to its permeability for water and gas, to its water holding capacity, to nutriments availability, to pH buffering and to interact with metal ions.

In the south of France, forest fires are recurrent and cause a great deal of damage each year. The studied site is a Mediterranean ecosystem in "Maures Mountains", near Saint Tropez, where 30 stations were sampled, in 2 layers. This site was chosen because it presents more or less often burned areas, damaged by more or less recent fire events. This work is about the evaluation of the quantitative and qualitative effects of different forest fire recurrences on humic substances.

The humic substances (HS) extracted by NaOH can be fractionnated by an acid extraction into two fractions, e.g. humic acids (HA) and fulvic fraction. Then, the fulvic acids (FA) and the non humic fraction (NHF) can be obtained from the fulvic fraction by a fractionation using XAD-8 resins. Then, these 4 fractions were quantitatively analyzed with a TOC-meter and qualitatively by three different spectroscopic methods (UV, 3D fluorescence and mid-infrared).

Results show that forest fires lead to a significant quantitative impact on humic substances. Soils present a surface layer more impacted than the deeper one. The fire effects are detectable more than 16 years after the last fire, but, the soil reconstruction has begun by the surface layer. The date of the last event appears to be an important controlling factor, whereas the frequency of the fires appears to be less important. Qualitatively, the humic substances show a more important aromaticity after fires with less carbohydrates, hydroxyl, alkyl, and carbonyl groups.

Keywords: Fire, humic substances, TOC, UV, fluorescence, mid-infrared.

LEVELS AND DISTRIBUTIONS OF POLYCYCLIC AROMATIC HYDROCARBONS: DETERMINATION OF AN INDICATOR OF FOREST FIRES

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Polycyclic aromatic hydrocarbons (PAHs) are persistent organic pollutants. They are produced by the incomplete combustion of organic matter and their resistance to environmental degradation has led them to become ubiquitous in the environment. The principal sources of PAHs are the combustion of fossil fuels or heat and power generation, and automobiles. In addition, natural events such as volcanic eruption and forest fires are believed to act as natural sources of PAHs into the environment.

In South of France, forest fires are of particular concern and cause a great deal of damage each year. This work aimed to assess the potential of forest fire to be a significant source of PAHs in soils. The studied site, called "Massif des Maures", is mainly covered by Mediterranean forest and was chosen because it presents unburned portions and more or less often burned area damaged by more or less recent fire events. 30 stations were sampled in two layers.

A simple method for the analysis of the 16 US EPA PAHs was implemented. The method involved a one extraction and purification step by pressurized fluid extraction (PFE) followed by high performance liquid chromatography coupled to programmable fluorescence detection (HPLC/PFD). The accuracy and the repeatability of the method were evaluated analyzing a certified soil samples. The method was then applied to measure PAHs concentrations in burned and unburned soils.

Results show that forest fire is an important and remnant source of PAHs. The fire recurrence and the date of the last event of fire show different influences on the levels and distribution profiles of PAHs. A principal component analysis (PCA) was used to interpret the great number of results. An index was defined from the PCA results. This index takes into account levels of some PAHs and can be considered as an indicator of forest fire.

Keywords: Fire, PAH, HPLC, PFE, PCA.

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