Giacomo Giovannini

FIRE IN AGRICULTURAL AND FORESTAL ECOSYSTEMS THE EFFECTS ON SOIL

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EV4V-010 "Factors causing and controlling erosion in soils subjected to the action of fire" (1988-1990)

EV5V-0017 "Post-fire and vegetation dynamics in natural and afforested areas in southern Europe: the role of fire intensity" (1990-1994)

EV5V-CT94-0482 "Management techniques for optimization of suppression of wildfire effects "PROMETHEUS" (1993-1994)

ENV4-CT96-0320 "Land Use Change Interaction with Fire in Mediterranean Landscape "LUCIFER" (1994-1998)

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PREFACE

This book is written for ecologists, foresters, wildlife and park managers and young scientists who work in the field of forest fire and soil.

The book is intended to serve at least two purposes.

The first purpose is to give an overview of the great and interconnected complexity of the impact of fire on soil.

Fire consists of specific components: heat and ash production, which act according to their specific temporal dynamic sequence. Then there is the soil, which behaves as described in traditional soil sciences, but is made even more complex when interacting with fire. Finally, there is the elapse of time and the action of meteorological events such as rain.

Young scientists, in their enthusiastic passion tend, correctly, to study the phenomenon of specific interest in depth, but often neglect the collateral effects. Such effects are discussed in Chapter 1.

Another problem not always well solved by young researchers is the appropriate choice of soil samples for their investigations.

For successful results, in all research focused on the environment, the congruence of the examined samples with the topics to be investigated and how representative they are of the whole system is of primary importance.

Planning an appropriate sampling procedure also entails having a clear knowledge of both the dynamics of the perturbation and structure of the system under examination.

Recommendations and suggestions for a correct soil sam-

pling in burned areas are reported in Chapter 4.

Although it might appear to be more logical to discuss the problem of soil sampling at the beginning of the book, I preferred to discuss it at the end. I feel that at the end of a maieutic journey some recommendations and suggestions may be accepted and shared more willingly.

The second purpose is to offer a guide for three types of users: i) colleagues involved in basic research on the effect of fire on ecosystems, ii) people dealing with the preparation of computer managed programs, and iii) managers involved in fire fighting activities.

This guide is designed to predict, in the event of the fire, the temperatures that may develop at the soil's surface and the resulting modifications to the soil, starting from a simple evaluation of the available burnable fuel, as in Chapter 2, or for prediction and prevention of soil erosion risks as in Chapter 3.

G.G.

Pisa, December, 2012

CONTENTS

1. THE IMPACT OF FIRE ON SOIL

1.1. Fire in the Ecosystems

Saepe etiam steriles incendere profuit agros
atque levem stipulam crepitantibus urere flammis:
sive inde occultas vires et pabula terrae
pinguia concipiunt, sive illis omne per ignem
excoquitur vitium atque exsudat inutilis umor,
seu pluris calor ille vias et caeca relaxat
spiramenta, novas veniat qua sucus in herbas,
seu durat magis et venas astringit hiantis,
ne tenues pluviae rapidive potentia solis
acrior aut Boreae penetrabile frigus adurat.

Oft, too, 'twill boot to fire the naked fields,
And the light stubble burn with crackling flames;
Whether that earth therefrom some hidden strength
And fattening food derives, or that the fire
Bakes every blemish out, and sweats away
Each useless humour, or that the heat unlocks
New passages and secret pores, whereby
Their life-juice to the tender blades may win;
Or that it hardens more and helps to bind
The gaping veins, lest penetrating showers,
Or fierce sun's ravening might, or searching blast
Of the keen north should sear them.

Thus wrote Virgil in the first book of *Georgics* (I-84-93) thirty years before Christ.

Other historical documents, recalled by Seaver and Clark

(1912), report that American Indians occasionally set fire to prairie grasses to stimulate greater production.

Sertsu and Sanchez (1978) reported the particular practice of burning the soil, called *guie* and performed in parts of Ethiopia which appears to have ancient roots.

The deliberate use of fire in agro-ecosystems has therefore been well documented for several thousand years.

Early ecologists considered fire as a destructive and undesirable force in ecosystems. However more recently, critical scientific evaluation has indicated its potential for use in the management of forest, shrublands and agricultural systems. (Daubenmire 1968, Hanes 1971, Heinselman 1973).

This has led to the continually increasing use of fire in land management practices.

Thus vast areas of the world continue to be annually burned by both natural and man-made fires.

Burning is a widely practised method of land management in the humid and dry tropics.

In both forest and savannah zones, burning is essential under traditional farming systems, to rid the land of a great amount of plant debris following a fallow period and to clear the land in order to obtain a suitable seedbed for cropping.

In Mediterranean areas the burning of stubble and crop residues is still common practice in order to facilitate seedbed preparation, to reduce the weed population and any phytotoxicity arising from the decomposition of diseased plants.

Another well-known and largely applied practice in the Mediterranean agro-pastoral system is the burning of brushland to manipulate vegetative cover and composition in order to convert the chaparral to grassland and thus to favour the grazing.

The uses of fire to modify the environment are very numerous and it is not surprising considering how fire has accompanied the history of human settlement throughout the world.

Fire is thus an essential factor in the development of various

ecosystems. Man influenced ecosystems, at least as we know them today, have been largely designed and modelled by fire.

Nevertheless, the fact that fire is such an important factor within the ecosystem does not mean that it is always beneficial. Common experience shows, for instance, that the soils over which repeated fires have passed appear to be largely degraded and profoundly eroded.

This is an "environmental disease" that we must avoid.

A profound and complete knowledge of the whole phenomenon is therefore essential in order to plan appropriate actions to modify the current performance of fires, thus maintaining the positive and beneficial responses and avoiding, as much as possible, environmental diseases.

1.2. How Fire acts on the Soil

Fire is a powerful and rapidly acting modifier of the soil environment.

The soil environment, during and immediately after a vegetation fire, is directly affected by heat and ash. In the field, the effects of these two factors are concomitant, thus making it difficult to identify the individual causes of change in soil properties. Thus there is a need to study the two effects separately in order to understand how fire acts on soil.

The characteristics of the soil environment are altered both as sudden modifications induced by the passage of the fire and also as delayed changes derived from the simultaneous modifications of the soil's physical and chemical composition, of the plant covering capacity and of the biological spectra. Sudden modifications are caused by both the heat wave that accompanies the fire and by the ash deposited on the soil surface as a consequence of fire; such modifications are very striking and immediately perceptible. The delayed changes, in contrast, leave their mark on the soil and determine its future evolution.

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Baby Koala, survivor of a eucalypt forest fire,
and Giacomo Giovannini, Adelaide 1976.

Giacomo Giovannini is "Doctor in Chemistry" graduated at the University of Pisa.
At the Institute of Soil Chemistry (ICT), which later merged into the larger Institute for Studies on Ecosystems (ISE) of the National Council of Research (CNR), in Pisa, he studied the organo-mineral complex and soil cementing substances of soil, soil structure and soil erosion, the hydrophobic substances and water repellence of soil.
He has directed the research, funded by CEC DG XII, on the impact of fire on soil.
Giacomo Giovannini is the author of 75 scientific papers published in international journals, proceedings of meetings and monographs.

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Firefighters often refer to this combination of elements as the fire triangle. On a hot day, drought conditions peak and something as small as a spark has the potential to create a large wildfire with devastating consequences. Although fire can occur naturally from the sun or a lightning strike, most wildfires are started by human carelessness. Unextinguished campfires, lit cigarette butts, improperly burned debris, and arson are responsible for 84% of wildfires started.Â Wildfires can have immediate and long term effects on the quality of rivers, lakes, and streams. The most noticeable impact of wildfires is stormwater runoff. After the loss of vegetation, the groundâ€™s soil becomes hydrophobic and prevents the absorption of water. Keywords: ecosystem, fire effects, fire regime, fire severity, soil, water, watersheds, rehabilitation, soil properties, hydrology, hydrologic cycle, soil chemistry, soil biology, fire effects models.Â In the late 1970s, the USDA Forest Service published a series of state-of-knowledge papers about fire effects on vegetation, soils, water, wildlife, and other ecosystem resources. These papers, collectively called â€œThe Rain-bow Seriesâ€ because of their covers, were widely used by forest fire personnel.Â chapters which specifically discuss the effect of fire on the hydrologic cycle, water quality, and aquatic biology in chapters 5, 6, and 7, respectively. Part C has five chap-ters that cover a wide range of related topics. Temperate conifer forests in the Colorado Front Range are fire-adapted ecosystems where wildland fires leave a legacy in the form of char and charcoal. Long-term soil charcoal C (CC) pools result from the combined effects of wildland fires, aboveground biomass characteristics and soil [...] Read more. Temperate conifer forests in the Colorado Front Range are fire-adapted ecosystems where wildland fires leave a legacy in the form of char and charcoal.Â Many scientists and managers have an interest in describing the environment following a fire to understand the effects on soil productivity, vegetation growth, and wildlife habitat, but little research has focused on the scientific rationale for classifying the post-fire environment. We developed an [...] Read more.