Microbial Activity After Fire in a Phryganic East Mediterranean Ecosystem[1]

M. Arianoutsou-Faraggitaki and N. S. Margaris[2]

Abstract: Soil microbial activity, measured as dehydrogenase activity, nitrification, and CO_2 release from the soil, showed that decomposers of phryganic ecosystems are adapted to fire, since no serious perturbations occur. Nitrifying capacity is increased while total soil metabolism remains constant during the first postfire year but in—creases during the second year.

Fire occurrence is generally accepted as a natural and inevitable event in Mediterranean—type ecosystems. High summer temperatures combined with water deficiency provide ideal conditions for fire outburst.

Although information concerning adaptive strategies and recovery of producers is available in a sufficient degree, the same is not true for consumers and decomposers. Preliminary results of a research project started some years ago, dealing with the effect of fire on decomposers in a phryganic (coastal sage) ecosystem in Greece, were presented during the Palo Alto Symposium (Margaris 1977). Additional data now available are concerned with processes such as microbial activity, nitrification, and total soil metabolism.

MATERIALS AND METHODS

The area under study is located close to the Athens University Campus, in Mt. Hymettus, 400 meters above sea level. Data on the structure and function of this system are already presented by Margaris (1976). Part of the site was burned accidentally in July 1976.

Throughout a 2—year postfire period, burned and control sites were frequently surveyed.

For the estimation of soil microbial activity, dehydrogenase activity was taken as parameter (Lenhard 1955).

Nitrate content of the soil was estimated using the phenoldisulphonic method (Barker 1974). For the determination of nitrifying capacity, dried soil samples weighing 20 g each were placed in beakers, brought to 60 percent of field water capacity, and kept in the dark (25±1° C) for 21 days. The nitrifying capacity was calculated from the difference in the nitrate content at the beginning and the end of the 21—day period; it was estimated every second month.

Soil metabolism was measured by the inverted boxes technique (Witkamp 1966, Coleman 1973). We used aluminum cylinders, 20 cm high and 10 an in diameter, in which a 50—m1 beaker contained 20 ml 1 N KOH. Ten 24—hour measurements were made every 20 days in the burned and unburned sites.

RESULTS AND DISCUSSION

Microbial Activity

Using as parameter dehydrogenase activity, we found that microbial activity (fig. 1) in the first 3 an of soil shows no difference between burned and unburned soils. However, the disadvantages of this method must be always taken into account, since general biological parameters are involved, such as activity of free enzymes re—leased by lysed microorganisms or plant roots, or enzymes excreted by integral microbial cells, and meso— and microfauna.

Nitrification

The monthly changes in the nitrate content of the upper 3 to 5 cm of the soil is shown in figure 2. In general, the burned soil contains more nitrates than the unburned, during the whole period of measurements. This difference can be interpreted in terms of either a more intense nitrification process in the burned site or in—creased nitrate removal due to the higher plant biomass absorbing it in the unburned site.

In order to test these two hypotheses, we estimated the soil nitrifying capacity in the laboratory. The results given in figure 3 show that immediately after fire the nitrifying capacity is low; but soon it increases and remains higher in the burned site throughout the 2—year postfire period.

In conclusion, the nitrification process is active and even more intense after fire; this contradicts results by Christensen (1973) and Christensen and Muller (1975), but agrees with data provided by DeBano's research team (DeBano and others 1979, Dunn and others 1979).

Total Soil Metabolism

Results dealing with total soil metabolism, measured as CO_2 released from the soil, are

[1]Presented at the Symposium on Dynamics and Management of Mediterranean—type Ecosystems, June 22-26, 1981, San Diego, California.

[2]Lecturer and Professor of Ecology, respectively, University of Thessaloniki, Thessaloniki Greece.

Gen. Tech. Rep. PSW-58. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1982.

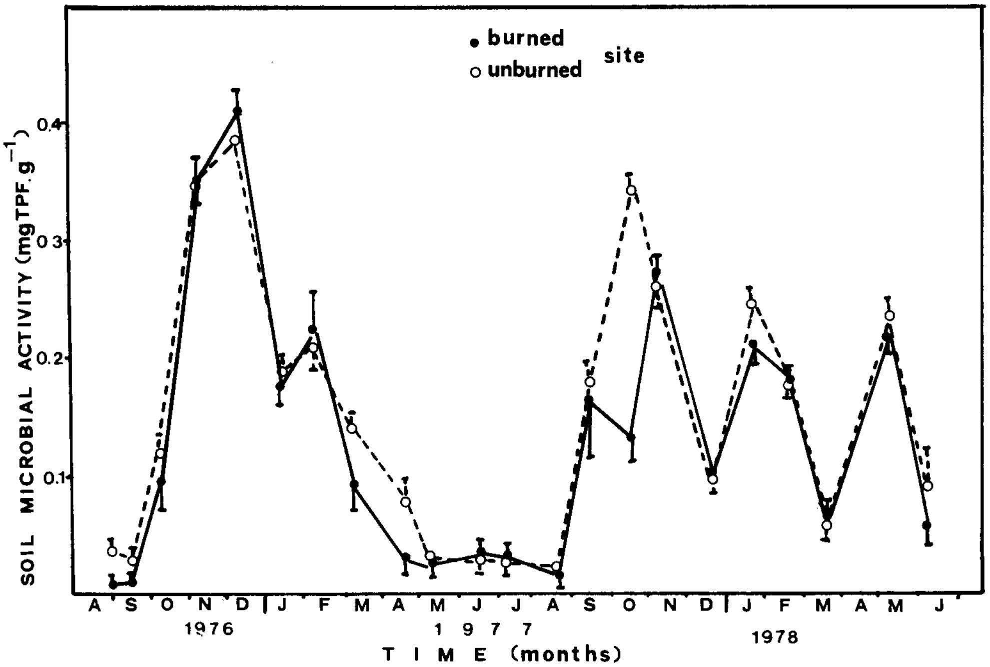

Figure 1--Soil microbial activity of a phryganic ecosystem (burned and unburned) during the period of August 1976 to June 1978.

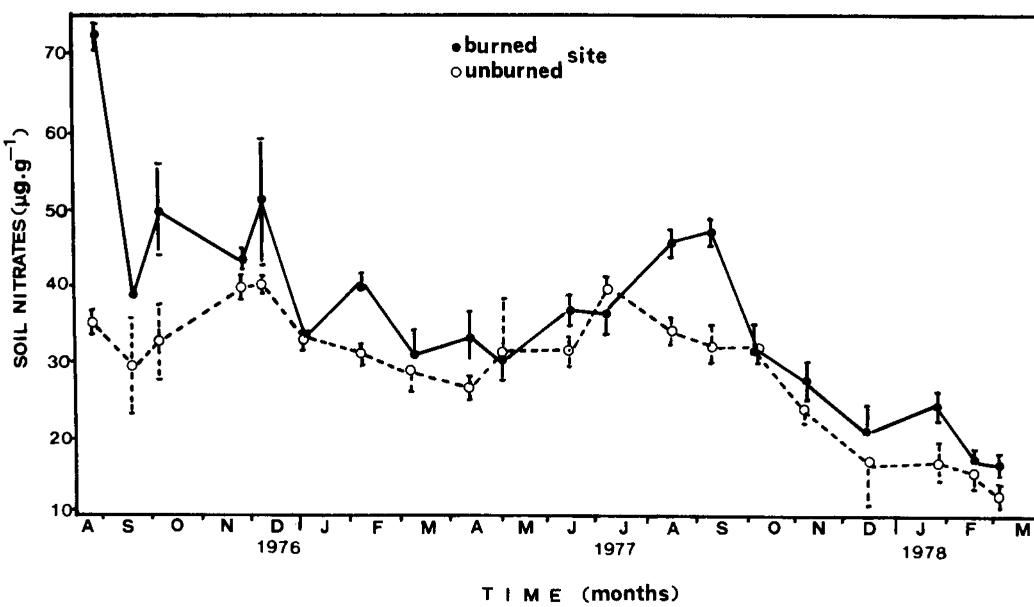

Figure 2--Nitrate content in the upper 3 cm of the burned and unburned soil of a phryganic ecosystem.

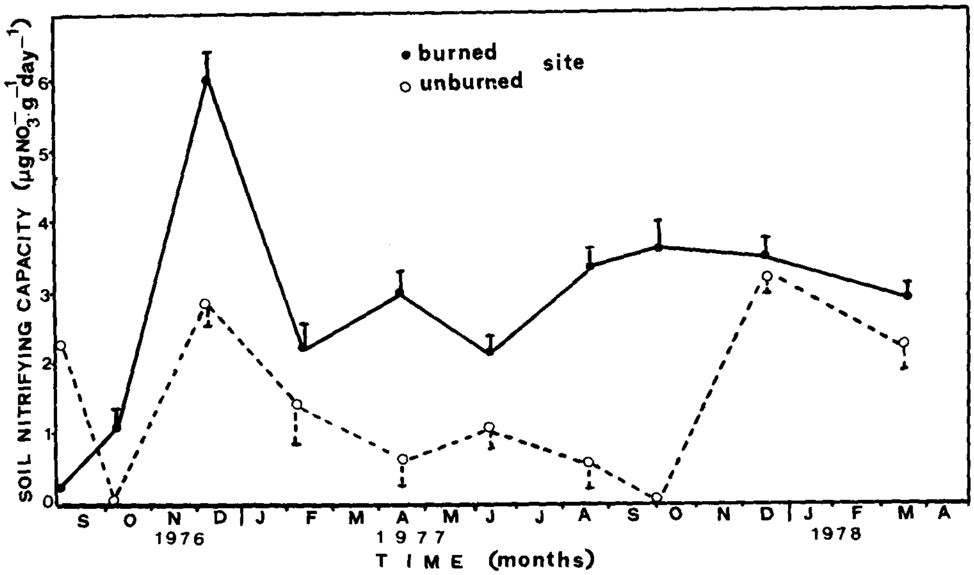

Figure 3--Nitrifying of the burned and unburned phryganic soil.

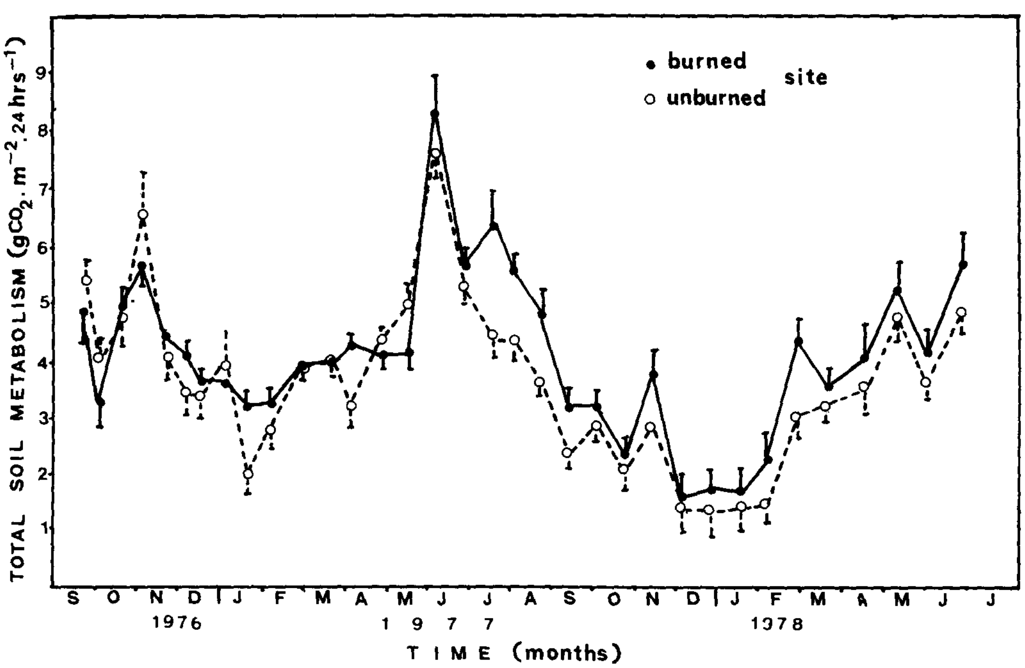

Figure 4--Total soil metabolism measured as CO_2 released from the burned and unburned site of the phryganic ecosystem.

are presented in figure 4. A strong seasonality is observed, characterized by high values at the end of spring (when temperature ceases being a limiting factor) and autumn (when drought is no more a limiting factor).

Statistical tests (t-paired) have shown that soil respiration in the first postfire year does not differ in the burned and unburned sites. Herman and Kucera (1975) came to the same conclusion for Missouri grasslands. During the second postfire year, total soil metabolism is higher in the burned site. If we consider the outgrowth of herbaceous plants during the first postfire year and the subsequent production of easier decomposable litter offered to the decomposers subsystem, we can explain in some degree the above-mentioned increase in the total soil metabolism.

LITERATURE CITED

Barker, A. V. Nitrate determination in soil, water and plants. Mass. Agric. Exp. Stn., College of Food and Natural Resources. Univ. of Massachusetts Bull. 611; 1974; 5-9.

Christensen, N. L. Fire and the nitrogen cycle in Adenostoma chaparral. Science 181:66-68; 1973.

Christensen, N. L.; Muller, C. H. Effects of fire on factors controlling plant growth in Adenostoma chaparral. Ecol. Monogr. 45:29-55; 1975.

Coleman, D. C. Soil carbon balance in a successional grassland. Oikos 24:195-199; 1973.

DeBano, L. F.; Eberlein, G. E.; Dunn, P. H. I. Soil nitrogen. Soil Sci. Soc. Amer. J. 43:504-509; 1979.

Dunn, P. H.; DeBano, L. F.; Eberlein, G. E. II. Soil microbes and nitrogen mineralization. Soil Sci. Soc. Amer. J. 43:509-514; 1979.

Herman, R. P.; Kucera, C. L. Vegetation management and microbial function in a tallgrass prairie. Iowa State J. Res. 50:255-260; 1975.

Lenhard, D. Die dehydrogenase aktivitat des Bodeus als Mass fur Microorganismentatigkeit in Boden. Z. Phlernahr. Dung. Bodenk 73:1-11; 1955.

Margaris, N. S. Structure and dynamics in a phryganic (East Mediterranean) ecosystem. J. Biogeogr. 3:246-259; 1976.

Margaris, N. S. Decomposers and the fire cycle in Mediterranean ecosystems. Proceedings of the symposium on the environmental consequences of fire and fuel management in Mediterranean ecosystems; Palo Alto, Calif.; 1977; 37-45.

Witkamp, M. Rates of carbon dioxide evolution from the forest floor. Ecology 47:492-494; 1966.