# GRAZING IMPACT ON SOIL CHEMICAL AND BIOLOGICAL PROPERTIES UNDER DIFFERENT PLANT COVER TYPES IN A MOUNTAIN AREA OF SOUTHERN ITALY

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## ABSTRACT

Grazing can contribute to soil degradation by compaction due to roaming of livestock and loss of herbaceous cover, affecting also soil microbial community. Aim of this study was to assess grazing impact on soil microbial community and nutrient status under different plant cover types (i.e., fernery, chestnut wood, garigue). Grazed and ungrazed soils were analysed for water holding capacity, pH, organic carbon, N, S, K, Mg, Fe, Mn, Zn and Cu content, microbial biomass, fungal mycelium and potential respiration. Moreover, some ecophysiological indices, as microbial quotient, coefficient of endogenous mineralization (CEM), metabolic quotient ($qCO_2$) and fungal fraction of microbial carbon were calculated. The results of present study showed that a moderate intensity grazing had low or no impact on chemical characteristics of soils and affects microbial community mainly in grazed areas with lower vegetation cover and lower content of nutrient and organic carbon, compared to areas with a thick layer of vegetation.

*Keywords: soil nutrients, fungal mycelium, microbial biomass, potential respiration, ecophysiological indices*

## INTRODUCTION

Since Neolithic, human activity converted large habitats in grazed fields (Le Coz 1990). This activity modified natural landscapes affecting terrestrial ecosystems, also causing often changes in chemical and biological properties of soils. In fact, grazing may contribute significantly to soil degradation mainly because of soil compaction and reduction, or even loss, of herbaceous cover, that bring to an increase in soil erosion and changes in chemical and biological properties of soil. The qualitative and quantitative shift in plant litter, associated with the transaction from a natural ecosystem to a pasture land, may affect nitrification and N-mineralization rates (White 1986; White and Gosz 1987). Moreover, the increase in soil bulk density, due to the roaming of livestock, and the changes in microclimate, due to the reduction in vegetation cover, may affect soil microbial activity and thus the overall cycling of soil nutrients (Van Veen and van Elsas 1986).

This study aimed to analyse changes in soil microbial community and nutrient status in a grazed areas of the "Valle delle Ferriere" Nature Reserve, assessing also the grazing effect in relation to different plant cover types.

## METHODOLOGY

### STUDY AREA AND EXPERIMENTAL DESIGN

The study was carried out within the "Valle delle Ferriere" Nature Reserve (at 1000 m a.s.l., in South Italy) where a moderate intensity grazing occurred (about 800 ovines on 20 ha). In this

Reserve, grazing impact is not equivalent in different seasons: it is quite intense in summer, absent in winter, when sheep are in fold and feed on maize, and have the highest intensity in spring and autumn, when shepherds lead flocks to lower altitude areas crossing the Reserve.
These changes in grazing intensity let us hypothesize a different input to soil of dung in different seasons and, in turn, a different input to soil of carbon and nitrogen. Moreover, also soil compaction, due to roaming of livestock, may be affected by seasonally transfer of sheep.
In the "Valle delle Ferriere" Nature Reserve, three neighbouring areas with different plant cover types, i.e. a fernery (*Pteridium aquilinum* (L.) Kuhn), a chestnut wood (*Castanea sativa* Miller) and a garigue dominated by *Santolina neapolitana* Jordan et Fourr, were selected. These areas, with South-Western exposure, were characterized also by different slopes (very low for fernery, about 35° for chestnut wood and 45° for garigue) favouring in a different way soil erosion processes.

### SOIL SAMPLING AND ANALYSIS

Soil sampling was carried out in February, May and June 2000, in the three areas differing for plant cover types and in three fenced areas, included in grazed areas, preserved by grazing since 1993 and used as control. Soil was sampled in three separate points for each area, collecting 4-5 soil cores for each point by a cylindrical plastic sampler (7 cm diameter and 10 cm height) from soil surface up to a depth of 10 cm.
On undisturbed soil cores, water holding capacity (WHC) was determined by gravimetric method. On sieved soil (mesh 2 mm) chemical analyses (on 75 °C dried soil) and biological analyses (on fresh soil, kept at 5 °C) were performed: pH was determined by potentiometric method on soil-water suspension (1:2.5); organic matter was evaluated by loss-on-ignition at 550°C for 2 h and converted in organic carbon ($C_{org}$) considering it as 58% of organic matter (Allen 1989); total N and S content was determined by N,C,S Elemental Analyser (Carlo Erba Instruments, Na 1500 series 2); total K, Mg, Fe, Mn, Zn and Cu content was determined by atomic absorption spectroscopy (Varian, Spectra AA-20) on soil samples mineralized with microwave oven by hydrofluoric acid and nitric acid (1:2); total microbial biomass carbon ($C_{mic}$) was measured by fumigation-incubation method (Jenkinson and Powlson 1976); fungal mycelium was estimated by membrane filter technique (Sundman and Sivelä 1978) and intersection method (Olson, 1950) at optical microscope; soil potential activity was determined measuring $CO_2$ produced by soil samples incubated for 10 d in standard conditions (55% WHC, 25° C) with NaOH and following titration with HCl (Froment 1972).
Soil properties that are well-known to be more sensitive to seasonally variations (i.e. biological parameters) or that can be affected by changes in grazing intensity (i.e. WHC, pH, $C_{org}$ and total N and S content) were determined on soils collected in all sampling times (February, May and June), whereas other soil properties (i.e. total K, Mg, Fe, Mn, Zn and Cu content) were reported only for soil collected in the first sampling (February 2000).

### DATA ANALYSIS

Ecophysiological indices were calculated using chemical and biological data, i.e. microbial quotient (mg $C_{mic}$ $g^{-1}$ $C_{org}$), coefficient of endogenous mineralization (CEM: mg $C_{CO2}$ $g^{-1}$ $C_{org}$ 10 $d^{-1}$) and metabolic quotient ($qCO_2$: mg $C_{CO2}$ $g^{-1}$ $C_{mic}$ 10 $d^{-1}$). Moreover fungal fraction of microbial carbon ($C_{fung}$ %$C_{mic}$) was calculated, as reported by Rutigliano *et al*. (2002), converting mycelium biomass into fungal carbon content ($C_{fung}$) on the basis of mean values reported for C/N ratio (Killham 1994) and N content (Swift *et al*. 1979) in fungi.
Means and standard errors, reported in Tables and Figures, were calculated using values from 3 sampling data and from 3 field replicates for each studied area (grazed and ungrazed fernery, chestnut wood and garigue). For each parameter significant differences between grazed and control soil were tested by t-test, using $P<0.05$ as the significance threshold level (Sigma Stat 1.0).

## RESULTS

Results of the present study show the occurrence of changes in soil characteristics of grazed compared to ungrazed soils, but only for few considered parameters. Significant decrease in pH (5%) was found between grazed and ungrazed soils in fernery soil (Table 1).
Nutrient content showed few significant reductions in grazed soils compared to control. In particular, in fernery a significant reduction in Zn content (7%) was found in grazed soil compared to control, but also an increase in Mg (33%) and K (9%) content was observed (Table 2). In chestnut wood grazed soil showed a reduction in Fe (29%) and Zn (9%) content (Table 2). No significant reduction was found in grazed soil from garigue, compared to control, for all the considered nutrients with the exception of Cu content (10%) (Table 2).
Moreover, in grazed fernery no value of biological properties or ecophysiological indices of soil was reduced (Fig. 1) and in chestnut wood only a reduction in fungal mycelium (20%) was found (Fig. 1). On the contrary, grazed soil from garigue (Fig. 1) showed significant reduction in some biological properties and ecophysiological indices, i.e. fungal mycelium (32%), fungal fraction of microbial carbon (45%), coefficient of endogenous mineralization (26%).

## DISCUSSION

Data show few changes in soil characteristics, among considered parameters, for grazed compared to ungrazed soils from fernery and chestnut wood. In particular, pH, and Zn content were reduced in fernery, Fe and Zn contents and fungal mycelium were reduced in chestnut wood. On the contrary, in grazed soil from garigue Cu content, fungal mycelium, fungal fraction of microbial carbon and coefficient of endogenous mineralization were lower than in control. Insam (1996) found small changes in biological properties and ecophysiological indices in grazed grassland and forest soils, as compared to controls.
Tracy and Frank (1998) found that chronic grazing neither depleted soil C nor reduced microbial biomass and, to explain these results, hypothesized that microbial populations are sustained mainly by inputs of labile C from dung deposition and by increased root turnover and root exudation beneath grazed plants.
Results of present study suggest that a moderate intensity grazing causes low or no impact on chemical characteristics of soil in areas with a thick layer of vegetation (chestnut wood and fernery) but it can affect microbial community in grazed areas with low vegetation cover (garigue).

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Table 1: pH, organic carbon and total N and S content in studied soils. Significant differences between grazed and ungrazed soils, for each plant cover type, are indicated by asterisks (t-test, P<0.05).

| Plant cover type | | WHC (%) | pH | $C_{org}$ (%) | N (%) | S (%) |
|---|---|---|---|---|---|---|
| fernery | control soil | 120.94 (±6.63) | 5.61 (±0.04) | 14.82 (±1.97) | 0.83 (±0.05) | 0.07 (±0.01) |
| | grazed soil | 96.28 (±13.87) | 5.35* (±0.08) | 12.89 (±2.90) | 0.69 (±0.05) | 0.06 (±0.01) |
| chestnut wood | control soil | 88.65 (±18.09) | 5.66 (±0.05) | 12.06 (±1.65) | 0.69 (±0.03) | 0.06 (±0.00) |
| | grazed soil | 104.45 (±13.67) | 5.76 (±0.10) | 13.21 (±3.30) | 0.69 (±0.07) | 0.05 (±0.01) |
| garigue | control soil | 50.81 (±8.80) | 6.47 (±0.10) | 8.46 (±1.28) | 0.54 (±0.04) | 0.04 (±0.00) |
| | grazed soil | 61.15 (±7.97) | 6.24 (±0.06) | 9.71 (±1.71) | 0.59 (±0.03) | 0.05 (±0.00) |

Table 2: Total nutrient content in grazed and ungrazed soils, reported as mg·g$^{-1}$ of dried weight (with the except of Cu content that is reported as g g$^{-1}$ d.w.). Significant differences between grazed and control soils, for each plant cover type, are indicated by asterisks (t-test, P<0.05).

| Plant cover type | | K | Mg | Fe | Mn | Zn | Cu |
|---|---|---|---|---|---|---|---|
| fernery | control soil | 28.244 (±0.515) | 15.240 (±0.370) | 36.333 (±0.649) | 0.965 (±0.012) | 0.135 (±0.003) | 59.816 (±2.852) |
| | grazed soil | 30.733* (±0.225) | 20.290* (±0.947) | 38.467 (±0.991) | 0.998 (±0.021) | 0.125* (±0.003) | 52.367 (±1.251) |
| chestnut wood | control soil | 33.844 (±0.251) | 16.836 (±0.369) | 38.000 (±0.855) | 0.926 (±0.010) | 0.126 (±0.002) | 64.054 (±1.658) |
| | grazed soil | 32.444 (±0.979) | 14.292 (±1.687) | 26.889* (±1.650) | 0.886 (±0.019) | 0.115* (±0.003) | 58.122 (±1.416) |
| garigue | control soil | 32.567 (±0.482) | 16.939 (±0.821) | 38.056 (±1.219) | 0.983 (±0.018) | 0.118 (±0.003) | 54.426 (±1.059) |
| | grazed soil | 33.711 (±1.372) | 16.907 (±1.034) | 41.022 (±0.798) | 1.007 (±0.060) | 0.126 (±0.001) | 48.966* (±0.646) |

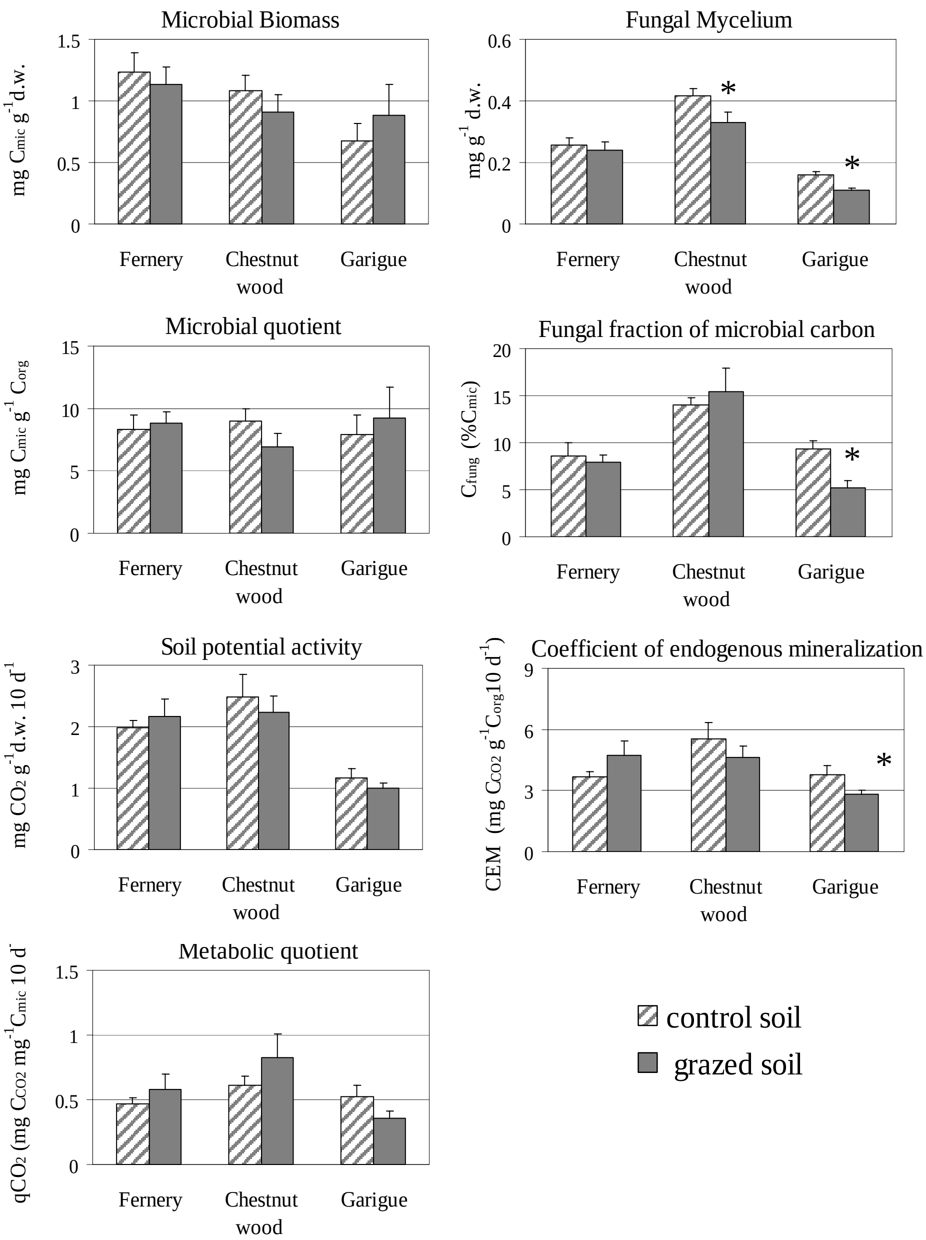


Fig. 1 Biological properties and values of ecophysiological indices in grazed and ungrazed soils. Significant differences between grazed and control soils, for each plant cover type, are indicated by asterisks on bars (t-test, $P<0.05$).