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Forest soil conditions in the CONECOFOR Permanent Monitoring Plots and in the Level I Network in Italy

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ABSTRACT

The study of forest health is not complete without an assessment of soil condition. Forest soils were monitored in 20 Italian sites in the CONECOFOR programme with different pedological and climatic conditions, the Permanent Monitoring Plots (PMPs). The main objective was the evaluation of the effect of acid depositions on soils and nutrient availability. The FAO classification was applied to all the CONECOFOR soils. Other analyses were carried out on the organic layer and on four mineral layers. Although the number of sites is too small for this monitoring to be considered wholly representative of the state of Italian forest soils, the analyses yield some general information. In addition, a smaller number of determinations were carried out on a higher number of soils (70 soils in the first level monitoring programme (FLP), including the twenty PMPs). Results show that no soils have pH <3 and few soils have pH between 3.0-3.5 (measured in $CaCl_2$ solution). Furthermore, the soils with low pH values are naturally acid, due to the parent material. The parameters that provide information on the sensitivity of soil to acidification, such as base saturation and the sum of exchangeable base cations in the mineral layers, as well as the amount of total K, Ca and Mg in the organic layer, show that there are hardly any soils in poor health. A high proportion of Italian soils have a lower content of organic matter than other European soils, due to Mediterranean climatic conditions; these are very different from those in central and northern Europe, which represent the majority of the European soils monitored. The availability of nutrients (particularly nitrogen and phosphorus) is on the whole sufficient. The results of the determinations of the FLP programme confirm the evaluations expressed for the PMPs, but provide more information, for example regarding the C/N ratio in the different soil layers: several anomalous sites, where the C/N ratio is higher in the surface mineral layer than in the organic layer, were found in this programme, but not in CONECOFOR.

Key words: Soil, forest, acid depositions, monitoring, nutrients

1. INTRODUCTION

The role of soil in forest ecosystems is multiform, and some of its functions may be summarised as follows (Pierzynski *et al*. 1994).

- It is a material in which plants can take root, and which provides nutrition and solid statics for them.
- It acts as a buffer against acidification, immobilises inorganic contaminants and favours the degradation of organic contaminants; though these capacities are not unlimited.
- It receives and gives nutrients back to plants. Clays and humic substances contained in it are the essential materials for ion exchange, a mechanism which collects nutrients and releases them for use by plants and micro-organisms.
- The symbiotic association within the soil between plant roots and micro-organisms results in a variety of beneficial effects, both for the plant and the micro-organism. It is the habitat where organic residues are transformed into humic substances, whose ecological role is fundamental for physical, chemical and nutritional reasons.
- It forms the habitat of an important part of the mesofauna, which is an essential constituent of the balance of the forest environment. Soil also has an influence on the macro-fauna.

Changes to the environment caused by human activity also affect forest soils. One of the major phenomena of environmental pollution affecting forest ecosystems is acid depositions. Acid deposition has an effect on the soil, so determination of soil acidity and sensitivity to acidification is the main object of study of the European programme of forest monitoring. A secondary objective involves determining the presence and availability of nutrients. The Italian programme, CONECOFOR, uses 20 Permanent Monitoring Plots (PMPs).

European monitoring programmes also include a first level investigation (FLP), involving a smaller number of analyses, on samples with fewer replicates, on a higher number of soils (70), including the 20 PMPs.

The parameters which reveal the effects of acid depositions are those that provide the most information on the immediate impact of acid rain on forest soils and those that can give information regarding the possible resilience of soils against acidification. The most significant of these parameters were chosen for the monitoring programme.

We investigated not only the possible consequences of acid depositions, but also other parameters necessary for the assessment of forest soil condition, as FAO classification (Food and Agriculture Organization of the United Nations 1994).

Soil organic matter is one of the most important parameters, and its presence is fundamental for many rea-

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Tab. 1. Location and some characteristics of the forest soils. Climatic data are in the relative chapter.

PMP code	Region	Altitude (m)	FAO classification	Dominant tree
1	Abruzzi	1500	Acrisols	*Fagus sylvatica*
2	Basilicata	1150	Luvisols	*Quercus cerris*
3	Calabria	915	Podzols	*Fagus sylvatica*
4	Campania	1200	Acrisols	*Fagus sylvatica*
5	Emilia1	200	Luvisols	*Quercus robur+ petraea*
6	Emilia2	970	Cambisols	*Fagus sylvatica*
7	Friuli1	15	Phaeozems	*Quercus robur+ petraea*
8	Friuli2	855	Luvisols	*Picea abies*
9	Latium	690	Cambisols	*Quercus cerris*
10	Lombardy	1170	Cambisols	*Picea abies*
11	Marche	800	Luvisols	*Quercus cerris*
12	Piedmont	1150	Podzols	*Fagus sylvatica*
13	Apulia	800	Acrisols	*Fagus sylvatica*
14	Sardinia	700	Cambisols	*Quercus ilex*
15	Sicily	940	Phaeozems	*Quercus cerris*
16	Tuscany	150	Cambisols	*Quercus ilex*
17	Trentino	1800	Podzols	*Picea abies*
18	Umbria	725	Cambisols	*Quercus cerris*
19	Aosta Valley	1740	Leptosols	*Picea abies*
20	Venetia	1130	Luvisols	*Fagus sylvatica*

sons (Stevenson 1994): it improves the structure of the soil and its resistance to erosion, and allows the storage of nutrients, the ion exchange and nutrient support to microflora (Campbell 1978).

The presence of nutrients was also measured. Other determinations regarding ionic exchange were performed; these are also useful in assessing the availability of nutrients. The 20 Italian sites of the CONECOFOR programme are too few to give statistically valid results, especially if we want to compare smaller groups with similar properties (soil type, climatic conditions, vegetal coverage, etc.). However, in some cases we will also try to explain results which refer to soils in particular conditions, but not taking into consideration groups which are too small. The results of the first level programme will be considered separately[1)].

2. METHODS

Forest soils from 20 PMPs, classified according to the WRB system (Food and Agriculture Organization of the United Nations, 1994) and distributed all over Italy were studied (Tab. 1). Sampling and analytical methods are those indicated in the Manual on Methods and criteria for harmonised sampling, assessment, monitoring and analysis of the effects of air pollution on forests (UN/ECE 1994). Total soil carbon (TSC) was determined on all the soil layers; the amount of the organic layer (weight/volume ratio of the organic layer) was also determined in kg m^{-2}. Total carbon was analysed by dry combustion (inorganic carbon was also detected). Soil organic carbon (SOC) was determined by subtracting inorganic carbon from TSC. Total nitrogen was determined on all the layers, while total phosphorus, potassium, calcium and magnesium were determined on the organic layer.

Sampling was carried out taking 5 replicates (mixed together to obtain a combined sample) on the organic layer and on 4 layers of the mineral soil. For unifying criteria, the mineral samples were taken at soil depths: 0-10, 10-20, 20-40, 40-80 cm.

The following definitions are taken from the European Report of the Forest soil Co-ordinating Centre (Vanmechelen *et al*. 1997), and are included to clarify the terminology describing soil layers :

- Organic O-layer: layer dominated by organic materials, consisting of undecomposed or partially decomposed litter, such as leaves, needles, twigs, moss and lichens, which has accumulated at the soil surface; they may be on top of either mineral or organic soils. O-layers are not saturated with water for prolonged periods.
- Organic H-layer: layer dominated by organic materials, formed from accumulations of undecomposed or partially decomposed material at the soil surface which may be underwater. All H-layers are saturated with water for prolonged periods or were once saturated but are now artificially drained.
- Surface mineral layer: consists of the uppermost mineral soil layer, i. e. the 0-5 cm, 0-10 cm or in a few cases 0-20 cm layer.
- Subsurface mineral layer: consists of the sampled mineral soil layer between 10 and 20 or between 10 and 30 cm.

[1)]The Italian data of the first level determinations conducted on the PMPs were available to the editors, but were not published in the report prepared by the Forest Soil Co-ordinating Centre (1997), because of an error committed after the correction of the proofs. This error has never been corrected, to our knowledge.

In this paper, Organic O-layers and Organic H-layers will be called "organic layers" (as is the usual practice in the European Report). Surface layers are 0-10 cm and subsurface layers 10-20 cm deep under the organic layer. In the FLP only the organic layer and the first two mineral layers were sampled, in 3 replicates mixed together to obtain a combined sample.

The determinations carried out were:

On all the layers:	
pH ($CaCl_2$)	PMPs and FLP
Total Carbon (dry combustion)	PMPs and FLP
Total Nitrogen (dry combustion)	PMPs and FLP
$CaCO_3$ (volumetric method)	PMPs and FLP
On the organic layers only:	
Total Phosphorus (Aqua regia extraction, ICP spectrometry)	PMPs and FLP
Total Potassium (Aqua regia extraction, ICP spectrometry)	PMPs and FLP
Total Calcium (Aqua regia extraction, ICP spectrometry)	PMPs and FLP
Total Magnesium (Aqua regia extraction, ICP spectrometry)	PMPs and FLP
Amount of the organic layer (weight/volume ratio)	PMPs and FLP
On the mineral layers only:	
Exchangeable acidity (EA) (titration of a 0.1 M $BaCl_2$ extract to pH 7.8)	PMPs
Exchangeable acid cations (EAC) (extraction with unbuffered 0.1 M $BaCl_2$)	PMPs
Exchangeable base cations (EBC) (extraction with unbuffered 0.1 M $BaCl_2$)	PMPs
Cation exchange capacity (CEC) (extraction with unbuffered 0.1 M $BaCl_2$)	PMPs
Base saturation (BS) (calculated parameter)	PMPs

The FAO classification was applied to all the PMPs.

3. RESULTS

3.1. PMPs

In discussing the results we will follow the Report prepared by the Forest soil Co-ordinating Centre (1997). All soils are relatively young and prevalently conditioned by their parent material. Generally speaking, they present an acid or subacid reaction; only a few are neutral or slightly alkaline.

3.1.1. Soil classification

The results, shown in table 1, are 6 Cambisols, 5 Luvisols, 3 Acrisols, 3 Podsols, 2 Phaeozems and 1 Leptosol. Podzols have mostly been formed on Granite or Schist parent materials (PMPs 3, 8, 10, 12, 17, 19). These are mountain sites with altitudes from 800-1700 m, with average annual precipitation above 1000 mm. Vegetative covering is primarily *Picea abies* followed by *Fagus sylvatica*. They are very acid, with pH (H_2O) between 4 and 5.5 and low basic saturation. This is due both to the presence of naturally acidic substrata because of the presence of quartz and a poor content of alkaline-earth minerals, and to leaching due to abundant rainfall.

The soils originating on sandstone-clayey flisch are almost exclusively Cambisols; they are mountainous environment soils of altitudes from 700-1100 m with heavy erosion, both diffuse and conveyed. More precisely, Dystric Cambisols and Haplic Luvisols are identified in sandstones with siliceous cement (sites 2, 6, 9), with naturally acidic pH. Soils originating on arenaceous flisch with calcareous cement (site 18), classified as Eutric Cambisols, present neutral-subalkaline reaction and 100% basic saturation. A Haplic Phaeozem (site 15) was formed on sandstone detritus with calcareous cement, with a Mollic A horizon and subacid-neutral pH, and medium-high base saturation. Although it is at a relatively low latitude, it is situated in a mountain environment at 950 m a. s. l., exposed to the north.

A highly evolved pedogenesis was found, with formation of Argillic horizon on the calcareous stone substrata. The geo-morphologic situation of the sites has determined the development of Acrisols, particularly in well drained environments where strong eluviation occurred (sites 1, 4, 13), and Luvisols in the less drained sites (11 and 20).

The sites on alluvial soils (5 and 7) have different characteristics. Site 5, located in the lower Po Valley, has had a pedogenesis for long enough for a Luvisol to be formed, and shows eutric characteristics due to the heterogeneous sediment with abundant base-rich minerals.

Soil 7, located in a delta where the sediments are principally made up of carbonatic material, presents an "A" Mollic horizon of organic matter, and is therefore classified as Calcaric Phaozem.

Finally, there are two soils in mining areas (14 and 16). Site 14, classified as Eutric Cambisol, is located in the mining area of Inglesiente (south-west Sardinia); it was formed under a vegetative covering of *Quercus ilex* with sandstone substrate, and presents subacid-neutral reaction with medium-high basic saturation. Site 16 is located in the Colline Metallifere of western Tuscany; its parent material is Gabbro, pH is subacid-neutral with high basic saturation, and the prevailing vegetation is *Quercus ilex*.

3.1.2. pH and sensitivity to acidification

pH was measured in $CaCl_2$ solution, for reasons of uniformity in all the European countries. Its values are lower than those measured in water (Backes 1993). Optimal pH (H_2O) values for plant growth are generally between 5.0 and 7.0. Lower values (4.0-5.0) are recommended for conifers (Rikala & Jozefk 1990).

The pH values ($CaCl_2$) of the organic layers and the mineral layers are shown in figure 1. Very low values (below 3.0) were not found. Values below 3.5 were found on 4 organic layers (20%) and on 2 surface soil layers (10%), in three plots under *Picea abies* and in

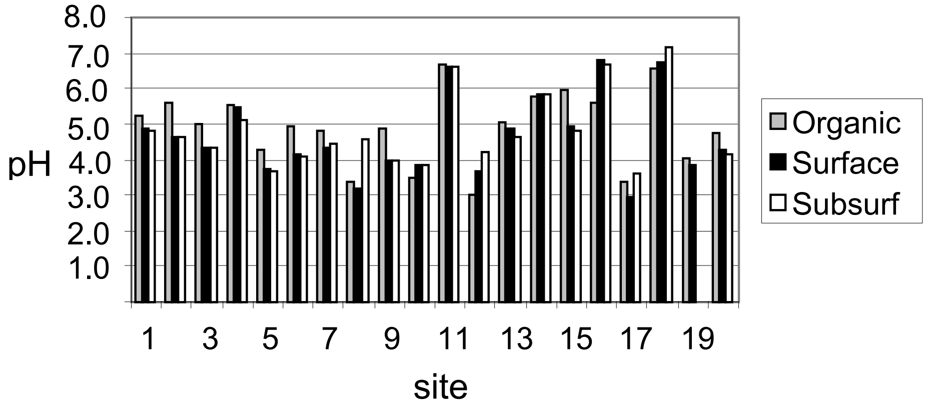

Fig. 1. PMPs: pH ($CaCl_2$) of the organic layers and of the surface and subsurface mineral layers.

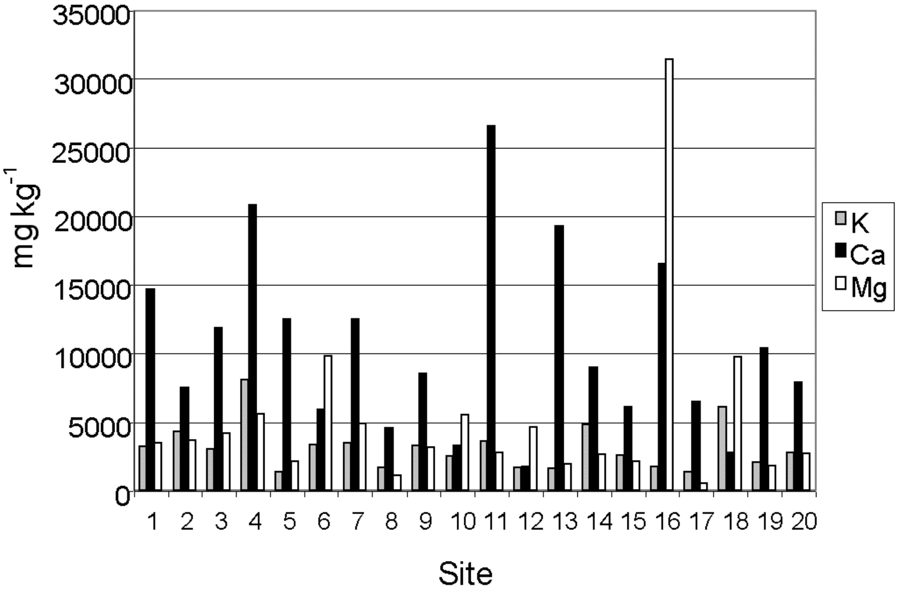

Fig. 2. PMPs: Total content (mg kg^{-1}) of K, Ca and Mg on the organic layers.

one plot under *Fagus sylvatica*, all in mountainous areas higher than 850 m a. s. l.

Sensitivity to acidification is much more important than pH for our knowledge of the state of soil health. An indication of this sensitivity is provided by the difference between the pH of the mineral surface and that of the subsurface layer. If the difference is very high (more than 1 pH unit), then the sensitivity of the soil to acidification is considered high (Forest Soils Conditions Centre 1997). This value was higher than 1 only on PMP 8 (*Picea abies*, Friuli), which seems to be the most sensitive to acidification. The values of total Ca, Mg and K content of the organic layer, as well as those of sum of EBC, base saturation and base cation availability, also confirm this assessment, as shown below.

Other criteria used for assessing sensitivity to acidification are based on several parameters: hydraulic conductivity, whose classes of values are established on the basis of soil type (Forest soil Co-ordinating Centre 1997), presence of $CaCO_3$, base saturation and, limited to the organic layer, the sum of the total content of Ca, Mg and K (Fig. 2). The values of base saturation are reported in table 2 together with cation exchange properties (CEC, exchangeable acidity, EBC and EAC). It should be remembered that more than 50% of the European soil sites were found with EBC values below 2, and about 70% were below 4 (data from the Report of the Forest Soil Co-ordinating Centre 1997). About 50% of the European soils were found with base saturation values below 30. Italian soils, on average, show values higher than European soils (few sites, 8, 10 and 12, show low values of total K, Ca and Mg and base saturation, together with low values of pH). This is due to factors linked to the substratum.

Tab. 2. EA (cM kg^{-1}), sum of EBC (cM kg^{-1}), sum of EAC (cM kg^{-1}) BS (%) in the first two mineral layers of the PMPs.

PMP code and region	depth (cm)	EA	EBC	EAC	CEC	BS	pH	TSC
1 Abruzzi	0-10	1	11.7	0.9	12.5	93	4.9	103
	0-10	1	7.9	1.3	9.1	86	4.8	77
2 Basilicata	0-10	1	5.9	0.7	6.6	89	4.6	37
	0-10	1	5.0	0.8	5.9	86	4.6	27
3 Calabria	0-10	4	5.1	3.7	8.9	58	4.3	113
	0-10	3	3.2	3.5	6.7	48	4.4	93
4 Campania	0-10	nd	nd	nd	nd	nd	5.5	164
	0-10	nd	nd	nd	nd	nd	5.1	125
5 Emilia1	0-10	4	2.2	4.3	6.4	34	3.8	40
	10-20	5	0.9	4.6	5.5	17	3.7	18
6 Emilia2	0-10	2	3.8	2.5	6.3	60	4.1	36
	10-20	2	2.6	2.4	5.0	51	4.1	23
7 Friuli1	0-10	2	8.2	1.8	10.0	82	4.3	39
	10-20	1	8.6	1.2	9.8	88	4.4	29
8 Friuli2	0-10	11	2.1	11.5	13.6	15	3.2	105
	10-20	2	3.8	1.9	5.7	67	4.6	40
9 Latium	0-10	4	1.9	4	6.0	33	4.0	23
	10-20	3	2.1	3.6	5.7	36	4.0	12
10 Lombardy	0-10	5	2.5	4.9	7.4	34	3.9	95
	10-20	4	0.5	3.7	4.2	12	3.8	47
11 Marche	0-10	0	7.7	0.2	7.9	97	6.6	24
	10-20	0	7.7	0.2	7.9	98	6.6	21
12 Piedmont	0-10	7	0.5	7.2	7.7	6	3.7	59
	10-20	nd	nd	nd	nd	nd	4.2	25
13 Apulia	0-10	1	7.5	0.7	8.2	92	4.8	61
	10-20	1	6.0	0.9	6.8	88	4.6	58
14 Sardinia	0-10	0	9.3	0.2	9.5	98	5.8	47
	10-20	0	5.2	0.3	5.6	94	5.8	26
15 Sicily	0-10	0	8.5	0.6	9.1	94	4.9	44
	10-20	0	6.7	0.6	7.3	92	4.8	30
16 Tuscany	0-10	0	19.7	0.2	19.9	99	6.8	40
	10-20	0	14.3	0.2	14.5	99	6.7	40
17 Trentino	0-10	3	14.0	3.8	17.8	79	3.0	270
	10-20	7	7.2	7.5	14.7	49	3.6	61
18 Umbria	0-10	nd	nd	nd	nd	nd	6.7	49
	10-20	nd	nd	nd	nd	nd	7.2	40
19 Aosta Valley	0-10	nd	nd	nd	nd	nd	3.9	16
	10-20	nd	nd	nd	nd	nd		
20 Venetia	0-10	3	4.3	2.9	7.2	60	4.3	41
	10-20	3	3.4	3.7	7.1	48	4.1	26

3.1.3. Ca CO_3

Calcium carbonate was found (4g kg^{-1}) in the organic layer only on site 11. On two other sites it was found only in mineral layers. A calcareous substratum was found on three sites, two of which (Campania and Apulia) are near the sea coast, where the influence of sea salt causes a loss of carbonates from the upper layers. A similar loss in the Abruzzi site is due to the high amount of rainfall in the region.

3.1.4. Total carbon (TSC)

Results of total carbon in the organic layer and in the surface mineral layer are given in figure 3: all mineral surface layers (0-10 cm) show total carbon values lower than those of organic layers. Carbon concentration always decreases with depth, as is to be expected (data not shown).

The total carbon of the organic layer is below 100 g kg^{-1} on one site (15) and below 200 g kg^{-1} on 7 other sites. Generally the TSC content of the organic layer is low compared with the soils of Europe as a whole. In fact, less than 10% of European soils have TSC concentration in the organic layer below 180 g kg^{-1}, while 35% of our PMPs show these values. Furthermore, TSC above 280 g kg^{-1} has been observed in 70% of European soils, but only in 45% of Italian soils. The total amount of the organic layers (data not shown) is also generally lower than the European average (the Italian data are not given in the European Report).

3.1.5. Total Nitrogen and C/N

Nitrogen is the most important nutrient for plants. Figure 4 shows the values of total N of the organic layer and of the surface and subsurface mineral layers. No sites were found with N concentration above 20 g kg^{-1}

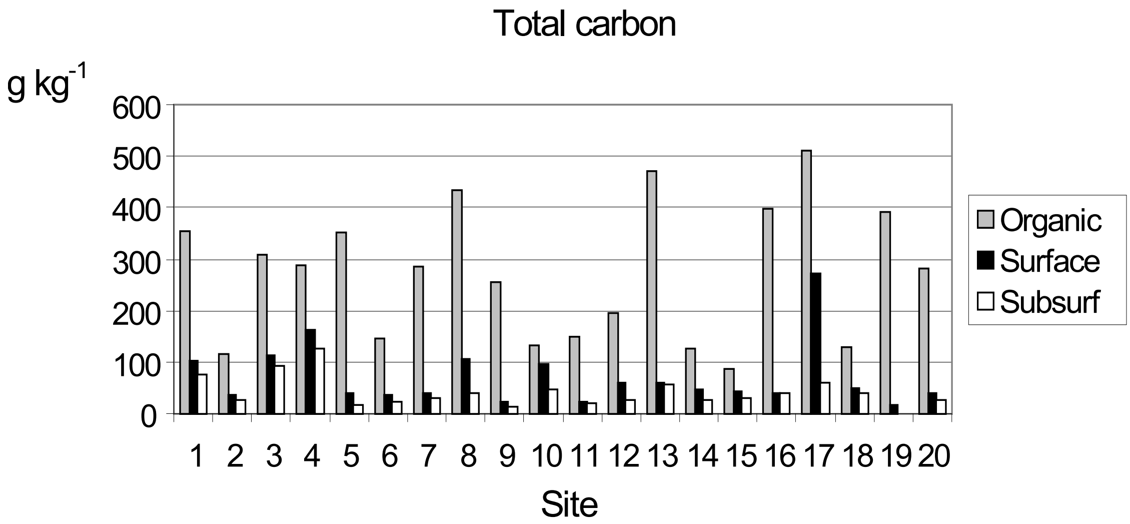

Fig. 3. PMPs: Total carbon (g kg^{-1}) of the the organic layer and of the two mineral upper layers.

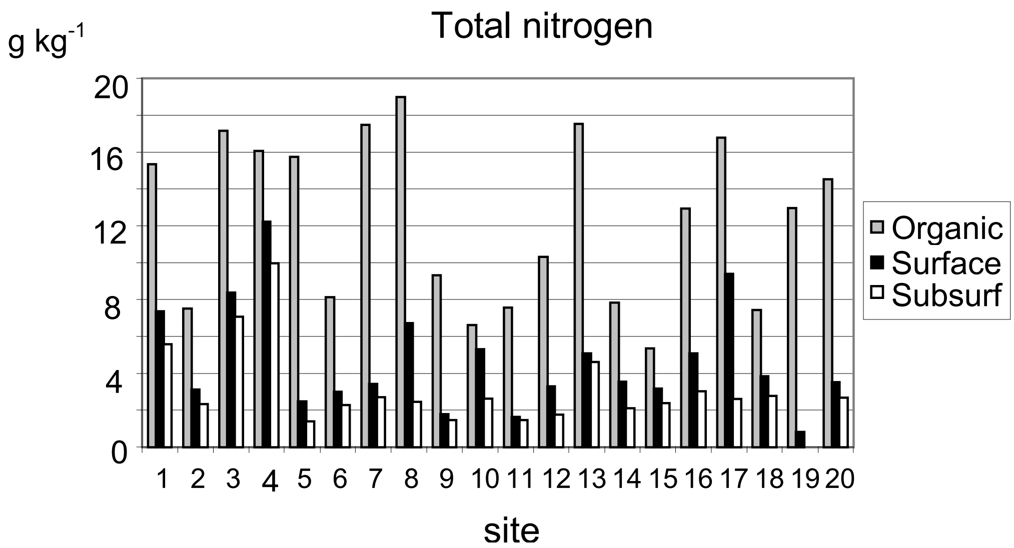

Fig. 4. PMPs: Total nitrogen (g kg^{-1}) on the organic layer and of the two mineral upper layers.

in the organic layer. In 6 cases (30%) N concentration was below 8 g kg^{-1}. These values are generally lower than the European average. In the European report, less than 15% of values are below 8 g kg^{-1}, and more than 10% are above 20 g kg^{-1}. Eleven PMPs were found with N content higher than 12 g kg^{-1}; these are located mostly above 850 m altitude, 5 with *Fagus sylvatica* coverage, 2 *Quercus robur+petraea*, 1 *Quercus ilex* and 3 *Picea abies*.

A low C/N ratio value in the organic layer indicates rapid mineralisation of the organic matter, and hence a higher availability of N. The C/N ratio everywhere decreases from the organic to the mineral layers (Fig. 5). Organic layers of 12 plots show C/N values lower than 20, and they are higher than 30 only on 3 plots. The average C/N ratio in the organic layers of PMPs (between 10 and 31) is in general lower than the mean European values, which are mostly between 20 and 40.

3.1.6. Phosphorus and C/P

Phosphorus is one of the most important nutrients, together with N and K. More than in the case of N, its availability is determined by the rate of decomposition of the SOM (Waring & Schlesinger 1985), indicated by the C/P ratio. A low C/P ratio is an index of high P availability (Staaf & Berg 1982; Pritcher & Fischer 1987). Other factors, such as free sesquioxide content (Syers & Curtin 1988), could also be considered for this property. Other parameters, such as pH, the concentration of some cations (Ca, Al, Fe), and climatic zone, can also assist in the evaluation of phosphorus availability. Calcium phosphate is mainly present in basic soils, Fe

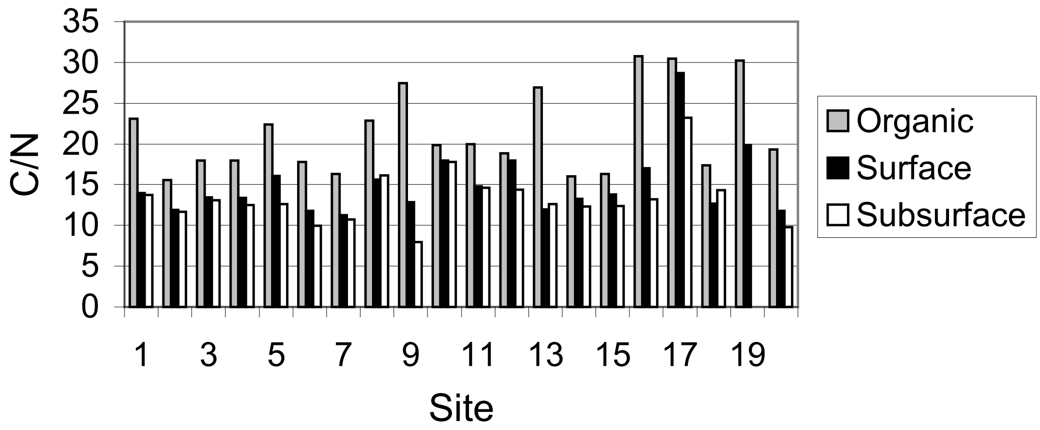

Fig. 5. PMPs: C/N ratio of the organic layers and of the two mineral upper layers.

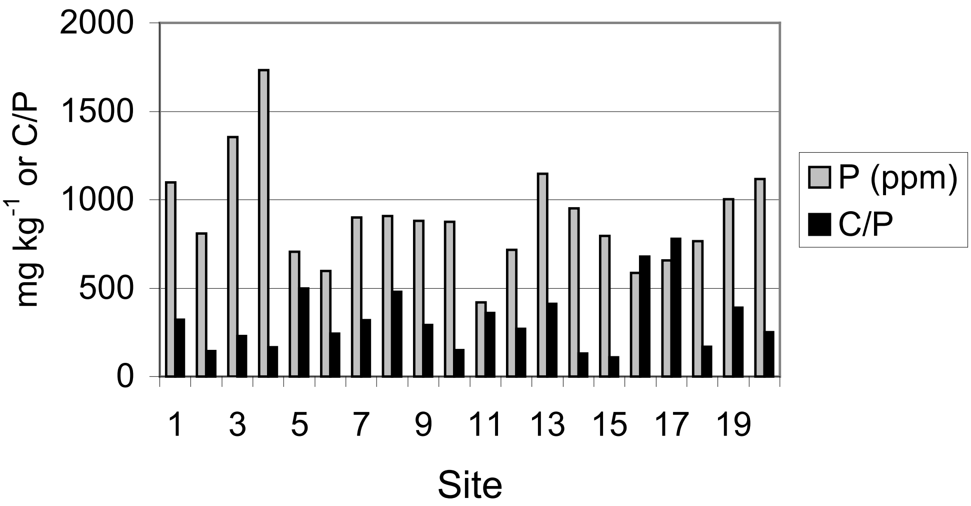

Fig. 6. PMPs: Total phosphorus (mg kg^{-1}) and C/P ratio on the organic layers. The measure units on the ordinates of the two groups of values are different (ppm and pure number), but the absolute values on the axis correspond.

and Al phosphates in acid soils, and all of them are largely insoluble. In the Italian sites only two PMPs (6 and 11) show values of total P below 700 mg kg^{-1}, while in 6 PMPs (30%) the values are in excess of 1000 mg kg^{-1}; this is the case in less than 20% of sites at European level. In some cases the C/P ratio of Italian PMPs is high (sites 5, 8, 16 and 17) (Fig. 6).

3.2. First level Programme sites

Results of the first level monitoring are shown in figures 7-15, divided according to value class. Box plots are used to illustrate the distribution of values more concisely. Generally speaking, the results obtained on a greater number of sites do not contradict those obtained on the smaller number of sites of the CONECOFOR programme, but reveal some particular characteristics.

Four PMPs were found to have pH lower than 3.5; other than these, no sites with this characteristic were found in the FLP. The distribution of pH values in the organic layer (Fig. 7) does not show the classic distribution curve, but has two peaks: one about pH 4.5-5.0, and the second at pH 6.5. Something similar happens in the subsurface layer (Fig. 8) , where the first peak occurs at pH 4.0-4.5, and many more sites are found over pH 7.0, probably due to the abundance of sites with calcareous parent material. This does not emerge at a European level, where calcareous soils are not very well represented. In fact, another difference between the first level data and the PMPs is the presence of $CaCO_3$ on more than 20 sites (30%).

No other site, with the exception of no. 8 of the PMPs, was found to have a difference greater than 1 between the pH of the subsurface and the surface layers (Fig. 9). Figures 10 and 11 show the distribution of K, Mg and Ca concentrations; there are no major differences from the results of the CONECOFOR programme.

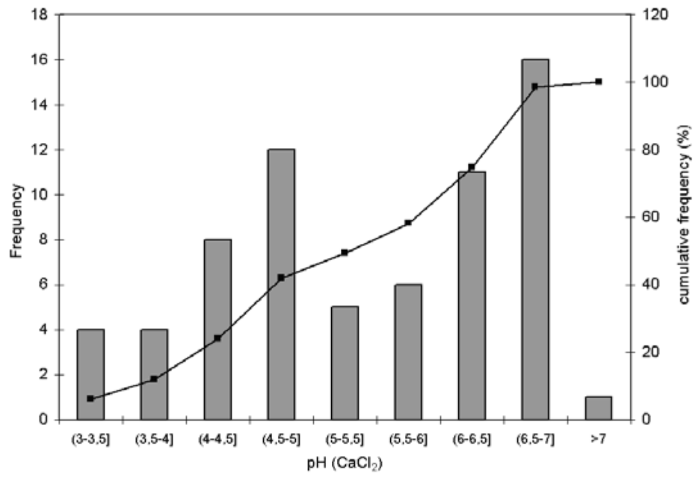

Fig. 7. FLP: pH distribution ($CaCl_2$) on the organic layer.

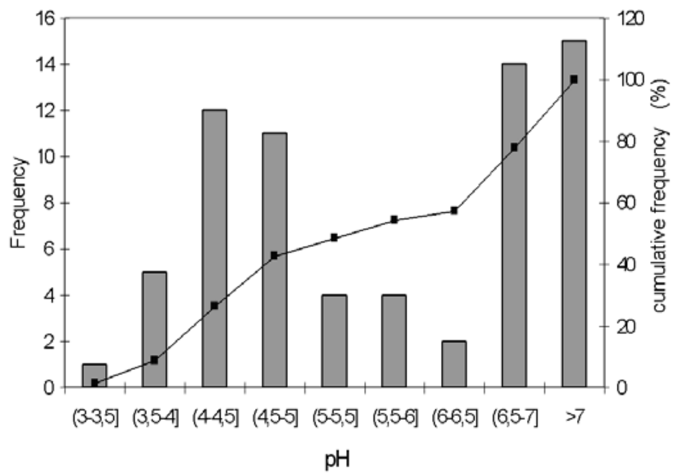

Fig. 8. FLP: pH distribution on the subsurface layer.

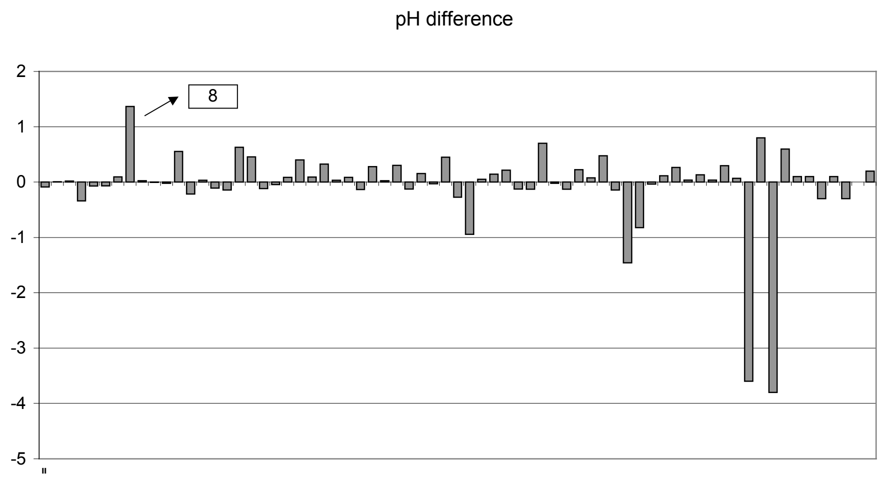

Fig. 9. FLP: pH difference between layers: pH of surface layer minus pH of the subsurface layer. The number in the box indicates the sole plot with difference >1.

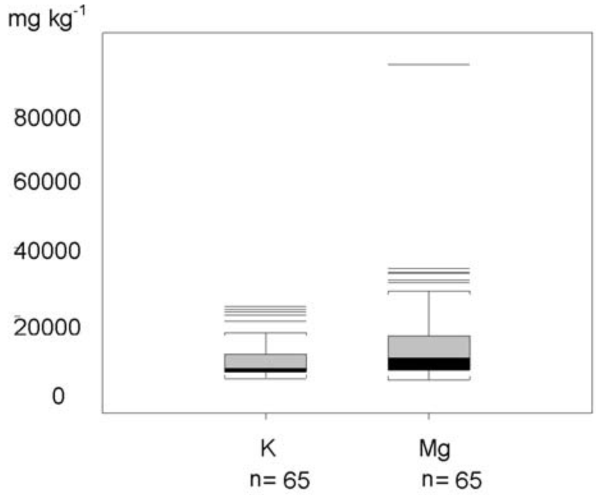

Fig. 10. FLP: Total Mg and K distribution on the organic layer.

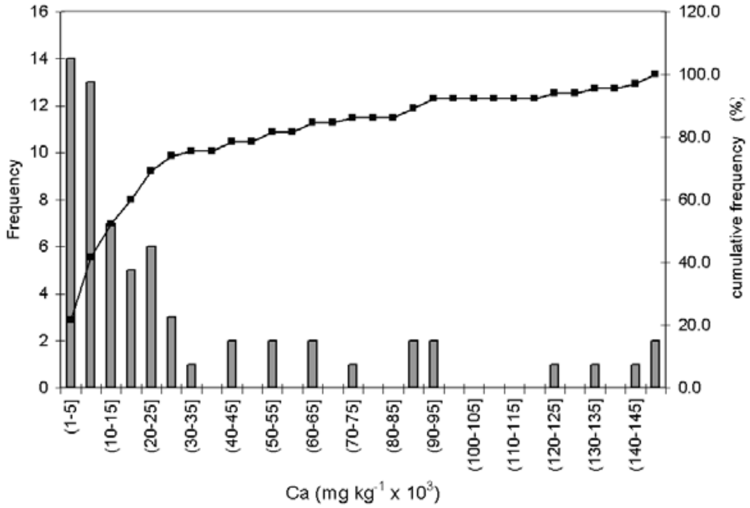

Fig. 11. FLP: Distribution and cumulative frequency of Ca in the organic layer.

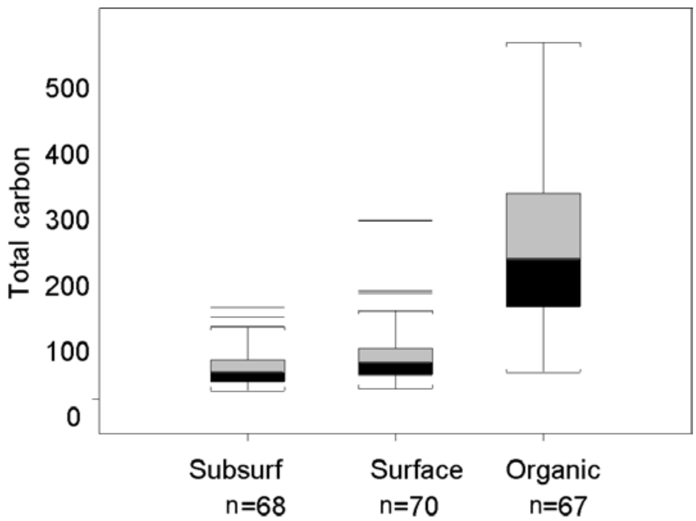

Fig. 12. FLP:Total Carbon distribution in the organic layer.

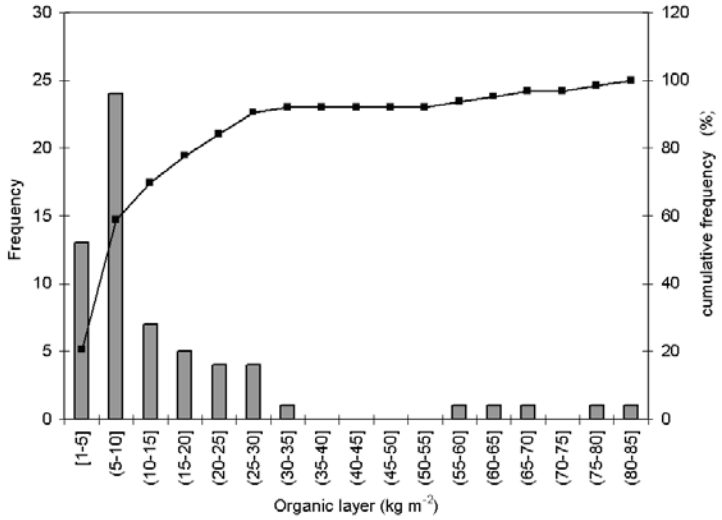

Fig. 13. FLP: Organic layer amount distribution and cumulative frequency.

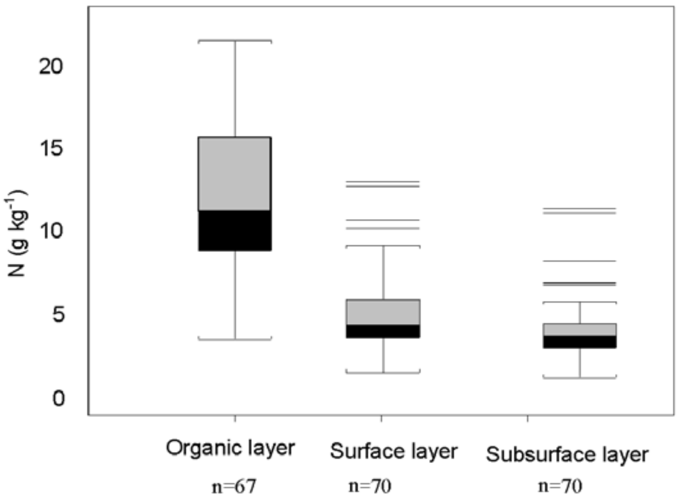

Fig. 14. FLP: N distribution in organic surface and subsurface layer.

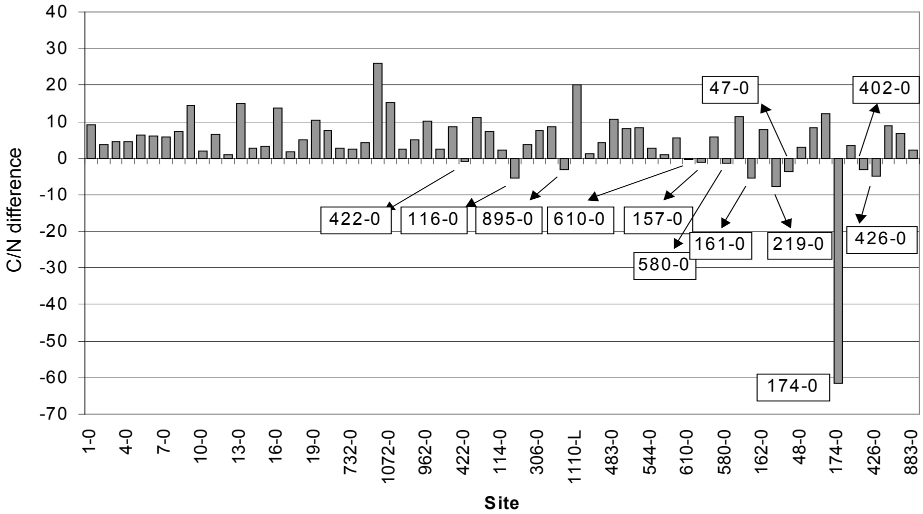

Fig. 15. FLP: C/N difference between layers: C/N of organic minus C/N of surface layer. The number in the boxes indicate the plots with negative difference.

Total carbon distribution is shown in figure 12, and total nitrogen in figure 14. They confirm the low values of organic matter found in the PMPs, together with the values of the amount of organic layer, illustrated in figure 13.

The C/N ratio is significantly different from that of the PMPs (Fig. 15); some sites (12) have higher values in the organic layer than on the surface mineral layer. Nine of these are in the North (in an area representing 40% of the total Italian area). A very high C/N value found in the mineral surface layer (90.4) is probably an error.

4. CONCLUSIONS

The number of CONECOFOR sites observed is too small for us to draw general conclusions about the state of health of Italian forests, but some elements of evaluation emerge from them. Few Italian forest sites were revealed to be undergoing acidification, and any acidification was ascribable to the nature of the substratum rather than to pollution, so that the general situation of forests as regards acidification looks better than in the rest of Europe. In addition, the availability and presence of nutrients appears to be greater than in the rest of Europe. Only total N is lower, due to the lower content of organic matter. This can be explained by the climatic conditions of the Mediterranean, where the mineralization rate of organic matter is much higher than in the colder areas of central and northern Europe, which are the most represented in the European report. On the other hand the C/N ratio is more favourable in Italian soils.

The first level programme roughly confirms the assessment of forest health suggested by the CONECOFOR data, but shows that a higher number of sites provides information which does not emerge from a mere 20 PMPs.

Proof of this is offered by the fact that $CaCO_3$ is found in a greater number of sites in this programme than among the PMPs, where it is found only in a small number of sites. Further monitoring for a long enough period to permit the detection of possible differences would undoubtedly yield more reliable results.

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