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Vegetation exposure to ozone and atmospheric depositions: monitoring in remote sites in the Mont Avic Natural Park

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Abstract

The impact of tropospheric ozone and atmospheric depositions on forest ecosystems is of considerable concern in Europe. Monitoring the dynamics of such pollutants in remote sites is a way to understand how uncontaminated areas are exposed to diffuse atmospheric composition alterations coming from elsewhere.

Since spring 2005 two different ozone and deposition monitoring sites are operating in the Mont Avic Natural Park. The aim of this research activity is to compare pollutants exposition in open field and through canopy sites. The ozone concentration is measured by passive samplers on a weekly basis from May to October, while atmospheric depositions are evaluated on bulk samples collected with continuously exposed collectors.

The impacts of ozone concentration and atmospheric depositions on forest ecosystems are evaluated with weekly chlorophyll fluorescence measurements made on needles of mountain pine, *Pinus uncinata* (MILLER), the most widespread tree species in the Mont Avic Natural Park forests.

The monitoring results will be disseminated through the park communication activities, with the aim of highlighting that even places which are generally deemed as uncontaminated, are affected by alterations in the atmospheric composition.

Keywords

Ozone, Atmospheric depositions, Chlorophyll fluorescence, Pinus uncinata.

Introduction

The evidence of damages on European forest ecosystems due to atmospheric pollutants and the implementation of various monitoring activities in different EU countries have pushed the Mont Avic Natural Park to start a research activity on vegetation exposure to ozone and atmospheric depositions. The project aim is to measure temporal variations of such pollutants in two different remote sites and evaluate their potential effects on forest ecosystems. These objectives will be achieved through a two-year monitoring programme managed by the Environmental Protection Agency of the Aosta Valley (ARPA Valle d'Aosta), with the cooperation of the Mont Avic Natural Park foresters.

Study Area

The Mont Avic Natural Park is the first Regional Natural Park of the Aosta Valley, a mountainous region in northwestern Italy, on the southern side of the Alps.

With a total area of 5747 ha, and a mean altitude of 2270 m a.s.l. (920-3185 m a.s.l.), the protected area lies over two east-west oriented valleys and is characterised by the most typical alpine landscapes: uncontaminated deciduous and coniferous forests, wide alpine pastures and lofty unvegetated areas.

The monitoring sites are located in the Chalamy Valley, in the subalpine layer, at 1550 m a.s.l..

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Fig. 1: Geographic location of the Mont Avic Natural Park (black dot).

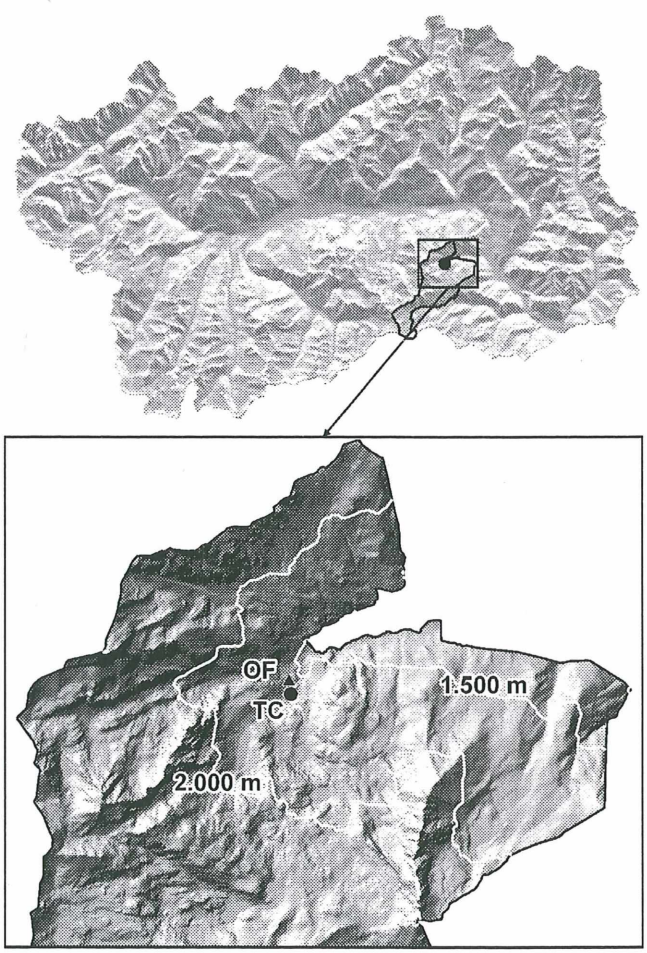

Fig. 2: Geographic location of the monitoring sites (OF: open field; TC: through canopy).

The first site, called open field (OF) site, is in the middle of a scarcely exploited pasture, while the second, the through canopy (TC) site, is located in a coniferous forest stand, whose main tree species is the mountain pine, *Pinus uncinata* (MILLER). The distance between the two sites is less than 200 m. In both, the ozone concentration, atmospheric deposition composition and mountain pine needles chlorophyll *a* fluorescence are measured or analysed.

Methods

Ozone concentration measurements

Ozone measurements are carried out using passive samplers which are continuously exposed. These diffusive tube type samplers rely on the reaction of 4,4'-dipyridylethylene with ozone to 4-pyridylaldehyde, which can be determined spectrophotometrically. The limit of detection is 2 $\mu g/m^3$ for 7 days exposures. The uncertainty at 2σ is 14.5% over the whole sampling rate linearity range.

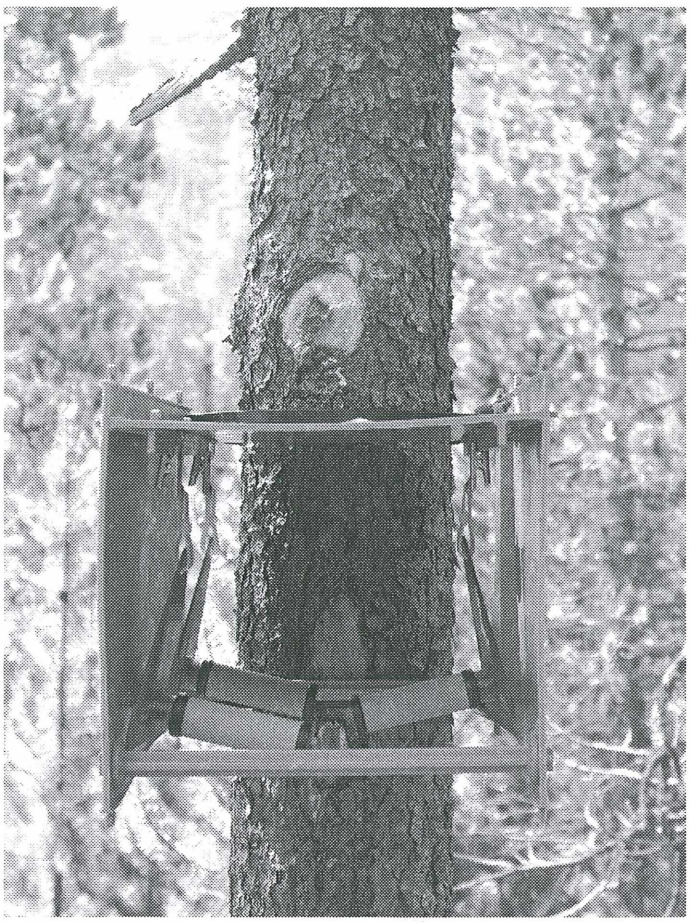

Fig. 3: Passive samplers exposed in the through canopy site.

The weekly samplers substitution and analysis yields a mean weekly O_3 concentration for the two monitoring site. Measurement are made from April to October and will last two years.

Atmospheric depositions

The composition of atmospheric depositions is evaluated on bulk samples collected on continuously exposed collectors.

The two monitoring sites have a different number of such collectors due to the expected differences in samples heterogeneity: the open field site is equipped with only 3 samplers, while the through canopy site has 8. Samples will be collected each week for 12 months starting from August 2005. In winter, because of snow, the samplers exposed will be different from the one shown in Fig. 4. The parameters analysed on each sample collected are listed below.

pH	Sulphate
Conductivity	Calcium
Alkalinity	Magnesium
Ammonium	Potassium
Nitrate	Sodium
Total nitrogen	Chloride
Total phosphorous	

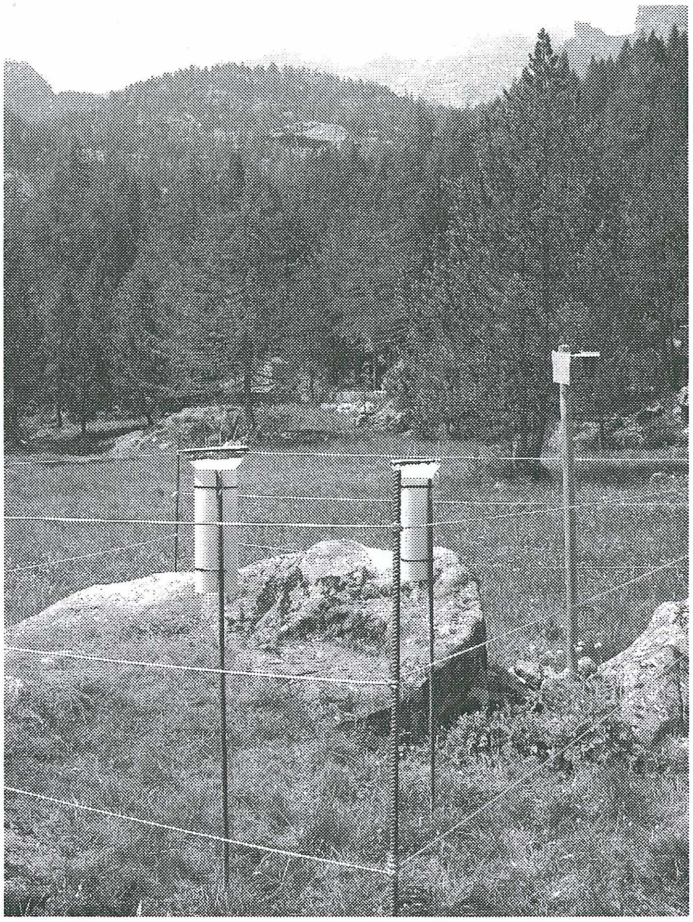

Fig. 4: Atmospheric depositions bulk collectors in the open field site.

Chlorophyll a fluorescence

The effects of atmospheric pollutants on forest ecosystems are investigated through measurements of chlorophyll a fluorescence, carried out with an active fluorimeter (Handy PEA). The fluorescence transients of 10 samples, taken from three *Pinus uncinata* trees in each monitoring site, are analysed on a weekly basis. Each sample comprises of four needles and in order to allow a complete understanding of damage spreading, measurements are carried out both on the apical and the basal portion of the needles. Before each measurement, the needles are dark adapted for 60 min with leaf clips; the rising transients are induced by a red light (peak at 650 nm) of 1300 W/m^2 which is readily absorbed by the chloroplasts of the leaf.

Fluorescence transients are then analysed with the JIP test, which takes into account the fluorescence values at different time steps. This test is widely accepted and has been successfully used to analyse stress conditions in plant samples subjected to high levels of ozone exposure.

Preliminary Results

Ozone

The data on ozone concentration gathered over the first eight weeks show a high degree of correlation between the measurements at the two sites. These first results also indicate an interesting pattern of differentiation between the two monitoring sites, outlying significantly lower concentrations in the through canopy (TC) one.

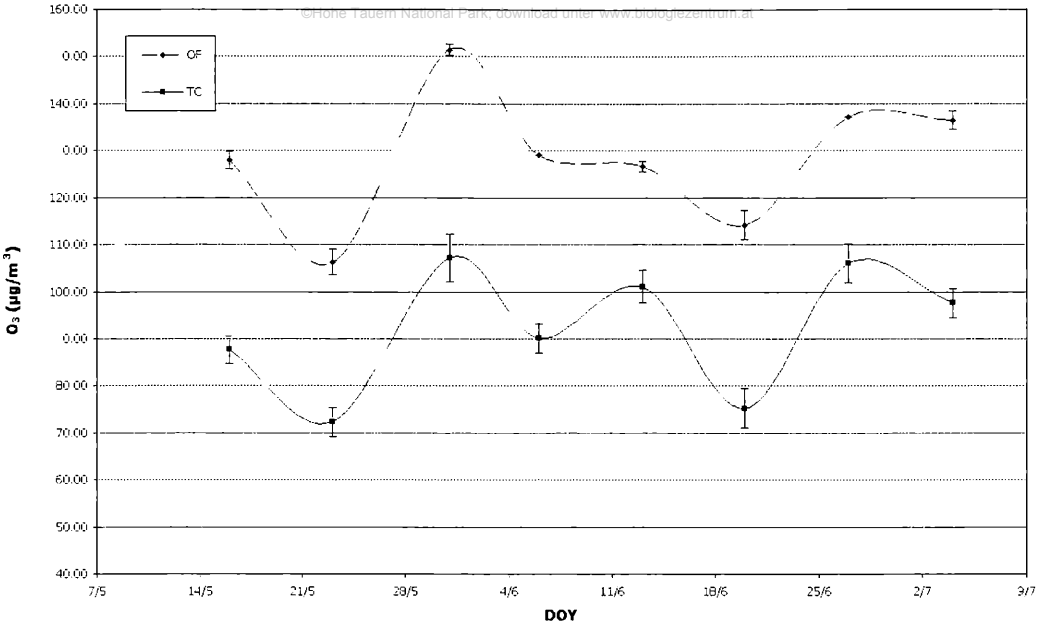

Fig. 5: Ozone concentration during the first eight weeks of the monitoring project (TC: through canopy; OF: open field)

Chlorophyll a fluorescence

At the time of drafting of the present document, data on fluorescence transient derived vitality index (PI) were not enough to see any ozone induced damages. The period when stress phenomena are expected to be detected is actually late summer, when a higher degree of ozone exposure may lead to damages in the forest ecosystems. However, favourable indications are given by the clear-cut difference observed between the two sites after the first measurements. Such situation should provide a better understanding of the effects of different ozone exposures on the same tree species. Fig. 6 shows such first results.

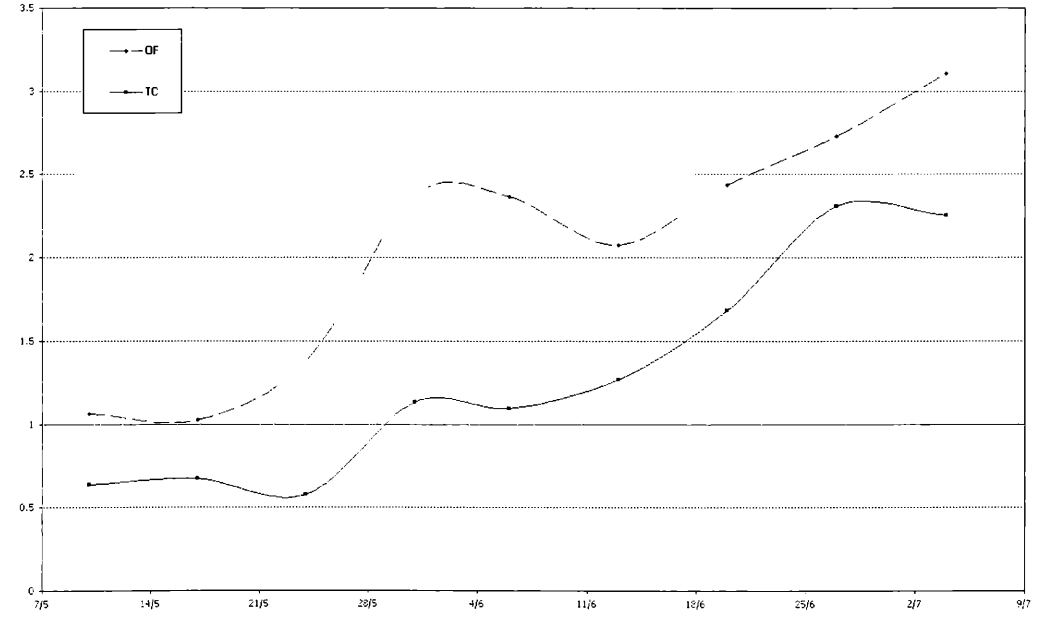

Fig. 6: Performance index (PI) variations during the first nine weeks of the monitoring project (TC: through canopy; OF: open field)

Discussion

The research activity presented has two main purposes: providing the Mont Avic Natural Park with the first data on air quality - seen from an ecological point of view - and investigating, with a basic approach, the main differences experienced by sites with different micrometeorological conditions.

Measurements of ozone concentrations and the analysis of atmospheric depositions will be compared to the same data collected in the more urbanized area of the Aosta Valley and in other forest ecosystems in Italy and Europe. Even if atmospheric pollutants dispersion dynamics act on a bigger scale, providing protected areas with such information is of considerable importance, both for communicating with the general public and for management plan development purposes.

On a more local scale, comparing the measurements made in the open field and through canopy site is a way to analyse the atmospheric pollutants dynamics that forest ecosystems experience. Keeping in mind that only flux modelling techniques can lead to a complete quantification of the pollutants dose to which plants are exposed, the strategy suggested is a first step for a better understanding of vegetation damages induced by atmospheric pollutants.

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