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FOLIAR INJURY OF OZONE ‐ LEVEL II ‐ MONITORING PLOT

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Abstract

The aim of our study was to investigate the long-term, cumulative ozone concentrations in relation to the occurrence and development of visible foliar injury to leaf mass. In addition, in order to assess the impact of environmental factors (abiotic and biotic) that modify the information on air quality in a given forest ecosystems and is evaluated experimentally established symptoms in the field, in order to develop a regional risk assessment based on monitoring of ozone and data modeling. So, it will be necessary to evaluated visible ozone depletion in the selected area (Level II) and evaluated the effect of tropospheric ozone at locations where monitors ozone injury, as well as risk assessment of ozone effects on forest ecosystems. Methodologies, including quality assurance, such as data harmonization, completeness and plausibility tests have been applied according to the ICP Forests Manual, Parts VIII - Assessment of Ozone Injury. Specific targets are set as follows: quantification of injuries ozone on the selected parcel level II in Europe; detection of temporal trends in the selected plot level II in Europe (significant changes within 10 years with a 95% level of significance of individual plots). Results from a Level II will be documented in maps covering Europe, characterized by an area of increased risk of ozone to European forest ecosystems. However, the development of ozone-induced injury is specific to inter and intra - species, and depend on the local ambient concentrations of ozone and other environmental as well as biotic and climatic factors. Due to the complex nature of diagnosis and investment limitations, the findings of trees and vegetation assessment should be considered as semi-quantitative.

Keywords: *Ozone, injury, monitoring plot.*

Introduction

Ozone (O3) is a pollutant that is in the lower part of the atmosphere and is formed due to the reaction of hydrocarbons and nitrogen oxides in the presence of sunlight. Natural sources of ozone exists, but these are much smaller than those produced by the action of a man's process. However, there is growing concern about how to lower atmospheric ozone affects the health of our forests (Smith, 1990). One way to assess the impact of ozone on plant life is documenting visible injuries on sensitive plant species, which are known as bioindicators. Bioindicators are actually plants that exhibit well-defined symptoms of elevated concentrations of ozone in the air. Foliar injury on plants from ozone has been documented in studies in a number of national parks (Bartholomay et al., 1997; Benoit et al., 1982; Chappelka et al., 2003; Chappelka et al., 1997; Chappelka et al., 1999a; Chappelka et al., 1999b; Duchelle and Skelly, 1981; Duchelle et al., 1983; Eckert et al., 1999; Hildebrand et al., 1996; Neufeld et al., 1992; Peterson et al., 1987.).

From July to September, many plant species that are sensitive to elevated ozone concentrations, show visible injuries on the upper surface of the leaf mass. In addition to the apparent symptoms, the leaves of plants damaged ozone is smaller, and the plant may produce a smaller amount of healthy seed. Moreover, injuries may result in depletion of the sensitivity of plants to other damaging agents, such as harmful insects and fungi. In our climate, the best time to observe violations of ozone is from mid-July to mid-September. At higher altitudes, however, a violation of the ozone can be masked by staining the leaves in early fall.

Since the 1980s there are higher concentrations of tropospheric ozone, especially in the warmer half of the year, when the value of the ozone increase depending on weather conditions and increased anthropogenic activities. While at humans ozone irritates the mucous membranes and restricts lung capacity, in plants attacks and destroys the cell walls or individual cells in the leaves. Over the past 50 years, a large volume of literature has documented O3 impacts on forest trees (see reviews by Kickert and Krupa, 1990; Miller, 1993; Skelly et al., 1997; Chappelka and Samuelson, 1998; McLaughlin and Percy, 1999; Krupa et al., 2000; Bytnerowicz et al., 2003; Percy et al., 2003).

Depending on the sensitivity of plant species and the concentration of ozone, depends and the visibility of damage to leaves or needles. The harmful effects of ozone is difficult to prove, because there is no chemical residues that can be analyzed and measured. Visibility damage on the leaves or needles is the only effect that professionals can easily detect. Tropospheric ozone background concentrations have increased 36% since pre-industrial times (IPCC, 2001). Ozone is known to impact forest trees in many ways including inducing visible foliar symptoms (Chappelka et al., 1999a; Schaub et al., 2005).

The aim of this study was to investigate the long-term, cumulative ozone concentrations in relation to the occurrence and development of visible foliar injury to leaf mass. In addition, in order to assess the impact of environmental factors (abiotic and biotic) that modify the information on air quality in a given forest ecosystems is evaluated experimentally established symptoms in the field, in order to develop a regional risk assessment based on monitoring of ozone and data modeling. So, are evaluated visible ozone depletion in the selected area (Level II) and evaluated the effect of tropospheric ozone at locations where monitors oštećanja ozone, as well as risk assessment of ozone effects on forest ecosystems. Methodologies, including quality assurance, such as data harmonization, completeness and plausibility tests have been applied according to the ICP Forests Manual, Parts VIII - Assessment of Ozone Injury. Specific targets are set as follows: quantification of injuries ozone on the selected parcel level II in Europe; Detection of temporal trends in the selected plot level II in Europe (significant changes within 10 years with a 95% level of significance of individual plots).

Results from a Stage II will be documented in maps covering Europe, characterized by an area of increased risk of ozone to European forest ecosystems.

Material and methods

The locality on which is a measuring station for monitoring the meteorogical data, within the IPCC project, is located in 74a department, GJ "Samokovska river" in the national park "Kopaonik". The locality is placed directly below the road Kopaonik-Bruce, over place alias „Marin source“.

Basic features of forest ecosystems on this site are as follows: elevation of 1700 m; exposure is northwestern; slope is a gently sloping to moderately steep; geological surface granite and granitmonconit, compact structure; soil type - brown podzolic soil deeply; dead cover medium-present unfavorable process of humification; ground vegetation is very dense, with rare shrubs present; the locality belongs to the type of spruce forest (*Picetum excelsae oxalidetosum*) on brown podzolic soil.

Stands of this type inhabit a large plateau, saddles and slopes. On the Kopaonik it is the most presented type of forest. The stands are well closed, dense (circuit 0.9-1.0), with poorly developed the shrub. Stands in which is the experimental station can be classified as uneven-

aged pure stands of spruce. The circuit is dense (0,8 - 0.9.) Spruce trees are right with developed treetop, what is logical where are they located.
The stands in terms of production may fall into more productive. The average population density is about 690 units/ha, the average volume is 460 m3/ha, increment is 8.30 m3/ha, mean stand diameter is 27 cm, and the mean stand height is 18.8 m.
The goal is to collect needles from trees representative of the experimental plot from which the sampling is performed again, twice during the growing season. Sampled needles should then be divided by categories, the one-year and two years.
Score of experimental samples for the presence of damage of ozone is carried out at certain chemical reactions, and the special equipment, by laboratory methodology. For sample preparation is necessary related equipment and a certain amount of dedicated substances. The analytical techniques are used because on the narrow vegetation or tree needles it is difficult to determine damage by ocular methode. In the tables damages are grouped according to the degree of damage and the manner in which recorded occurrence was shown (Tables 2 and 3).
The main objective of assessing ozone visible injury on a selected number of Level II plots is to assess the effect of tropospheric ozone at the sites where ozone monitoring is performed, and to contribute to an ozone risk assessment for European forest ecosystems.

Results and discussion

Ozone visible injury on conifer species is expressed at the upper parts of the crown, in the upper side of branches and needles. A minimum of 3 branches per tree and 5 trees per plot are assessed. For off-Plot are measured variable, and they are shown in Table 1.

Tabele 1. Scoring and definition for the percentage of symptomatic leaves on a branch with approximately 30 leaves

Score	Frequency class (%)	Definition
0	No injury	None of the leaves are injured
1	1 - 5 %	1 – 5% of the leaves per branch show ozone symptoms
2	6 - 50 %	6 – 50% of the leaves per branch show ozone symptoms
3	51 - 100 %	51 – 100% of the leaves per branch show ozone symptoms

Samples were taken for laboratory analysis from 3 branches for all five trees on which were done evaluation of damage (trees numbered 9, 20, 54, 76 and 108). Also, samples were taken (three branches) from five trees from the edges of the stand. Needles are cut to length by 3 mm and placed in an Eppendorf cuvettes, in which are prepared solution (2.5% glutaraldehyde in Sorrensenovom buffer pH 7.0). Results are presented in Tables 2 and Table 3. In Table 2 are showen ozone injury of the trees within stands (trees numbered 9, 20, 54, 76 and 108).

Tabele 2. Assessment of damage from ozone on the assimilation organs of *Picea abies* L in the stand

No	**9**			**20**			**54**			**76**			**108**		
Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	+		+	+		+	+	+	+	+	+	+	+	+	+
1		+			+										
2															
3															

The results presented in Table 2 show that damages are different depends of possition of the tree in the stands, or from their exposure. Tree numbered 54, 76 and 108, were sheltered in the strong part, and practically no damage, and tree numbered 9 and 20 have some slight damage of leaves, because they are on the open part of the stand. Table 3 shows the damage to the trees from the edges of the stand (trees I, II, III, IV and V).

Tabela 3. Assessment of damage from ozone on the assimilation organs *Picea abies* L from edges of the stand

No	I			II			III			IV			V		
Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
1															
2															
3															

The trees on the edges of the stand (Table 3) haven't expressed the damage, although they are more exposed to the sun. The visible damage of the ozone in conifers are expressed in the top of the tree, the most exposed to the sun, at the top of needles.

The bole and other crown variables that are associated with growth and overall tree vigor can respond to elevated ozone exposures. Branch mortality in the lowest portion of the crown has been observed in southern California (Parmeter, 1968.) leading to a decrease in vertical crown length, as measured by percent live crown (Stark, 1968.). A reduction in the vertical and radial growth of stems has been documented for ozone-stressed trees in southern California and southern Sierras (McBride, 1975.).

Conclusion

In Europe, ambient ozone levels are high enough to cause visible injury in native species.

Assessment of visible injury is a feasible way to detect the impacts of this pollutant in forest plants and to identify potential risk areas.

Chlorotic mottle caused by ozone injury were on the toop of the tree, in first part of the conifer.

Minimum 3 brances by tree and 5 trees by parceles are controled. Experiment were made on red fir in locality Kopaonik- Rtanj.

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