ATMOSPHERIC DEPOSITION AND OZONE LEVELS IN MEDITERRANEAN

FOREST ECOSYSTEMS OF CROATIA

Tamara Jakovljević[1], Nenad Potočić[1], Ivan Seletković[1], Lukrecija Butorac[2], Goran Jelić[2], Željko Zgrablić[1], Krunoslav Indir[1]*

[1]Croatian Forest Research Institute, Jastrebarsko, 10450, Croatia

[2]Institute for Adriatic Crops and Karst Reclamation, Put Duilova 11, Split, 21000, Croatia

**tamaraj@sumins.hr*

Introduction

Mediterranean forest ecosystems in Croatia are highly significant and cover almost half of Croatian total forest area. They provide multiple goods and services largely related to their environmental and social functions. These forests are ecologically very sensitive, because of its geographic position, complex orography, specific meteorological conditions and number of pollution sources. Among all bioclimatic regions, Mediterranean region appears to be the most vulnerable to global change. The vulnerability to climate change is related to the trend of increasing temperature, degradation of water resource and increased of water demand. The chemistry of atmospheric deposition and its transformation in contact with vegetation are of great importance in understanding its effects on forests. It has an impact on forest ecosystem through eutrophication by nitrogen and soil acidification, altering soil properties and processes. Soil acidification by S and N deposition including the loss of base cations (i.e. calcium, magnesium and potassium) from the soil causing deficiency of these nutrients, and inhibiting base cation uptake, and a decrease in pH that may increase the mobility of heavy metals. In this stage, a decrease in forest condition and growth is assumed to occur. Changes in the soil chemistry may lead to imbalances in the nutrient supply and subsequently to unbalanced nutrition of the trees. Nutrient imbalance will affect canopy photosynthesis and in turn decrease forest vitality. The chemical composition of the foliage of forest trees is an important indicator for tree nutrition, providing information on deficiency or excess of nutrients. Ozone as accompanying agent of climate changes is also among key factors resulting in spatial and temporal changes in tree crown condition and productivity. Furthermore, it is the region at the highest ozone risk as ozone formation occurs at high temperatures in presence of solar radiation, which is elevated in the Mediterranean–type ecosystems. Ozone as accompanying agent of climate changes is also among key factors resulting in spatial and temporal changes in tree crown condition and productivity. Therefore, the research of atmospheric deposition and ozone levels and visual symptoms were necessary.

Materials and methods

Four plots in different Mediterranean forest ecosystems amount Adriatic coast will be chosen for the project. Two plots will be located at northern Adriatic coast and two plot in middle and sought Adriatic. This criterions lead to the choice of *Quercus pubescens* Wild. (Pubescent oak) and *Quercus ilex* L. (Holm

oak) in Istria and *Pinus halepensis* Mill. (Aleppo pine) and *Pinus nigra* L. (Black pine) in Dalmatia as the main tree species on the plots (Figure 1).

Figure 1 Established plots in Mediterranean forest ecosystems

The concentrations of ozone were measured with ozone passive samplers. Samplers were put in open filed close to forest. Samples were collected bi-weekly from April to September. Annual means of ozone concentrations was calculated and they were used as an indicator of possible stress due to ozone. The precipitation samples were collected biweekly during one year. Results were used for calculation of annual bulk and throughfall deposition of nitrogen. Atmospheric deposition was measured as bulk open field deposition (BOF) in the vicinity (within 1 kilometer) of the plot and throughfall deposition (THR) below the forest canopy within the plot. The deposition samples were collected using continuously exposed collectors [1]. Three BOF, open field collectors and nine collectors for THR measurement were distributed evenly over the plot. The analyses were performed in laboratory on filtered samples (0.45 µm), except for the measurements of pH and conductivity. The variables examined and the determination methods used are as follows: pH [2], conductivity [3], alkalinity and using ion chromatography, the concentrations of chloride, nitrate, sulfate, phosphate [4], ammonium, sodium, potassium, calcium and magnesium [5] . Average annual N and acid deposition were derived from both bulk deposition and throughfall while accounting for forest canopy exchange [6]. The ozone passive sampler badge was used as passive monitor device for collecting nitrogen oxides (NOx) in the open field close to BOF collectors. The ozone badge uses a coated filter, which traps ozone, while the NOx badge uses other filters to trap nitrogen oxides [7]. Ozone oxidizes the nitrite to nitrate. After two weeks exposure, the filter was extracted with ultra-pure water and the filter extract was analyzed by ion chromatography to determine the nitrate ion concentration [4], which is used to calculate the total amount of ozone collected. Furthermore, in order to detect effects of ambient ozone concentrations on crown condition, ozone induced visible injury on leaves and needles will be assessed on the plots when the seasonal exposure to O3 is maximal and the probability of injury is highest (end of August-September) by 2 observers [8].

Results and discussion

Aaccording to the new revised set of empirical critical values for the introduction of nitrogen compounds into the forest ecosystem, the amount of nitrogen deposition on the surfaces is below the limits of literal critical values in plots Poreč and Šišan, deciduous forests and for the coniferous forests

Muć and Vransko jezero in 2017. Revised literary values N are critically 15-20 kg/Nhay for deciduous forests and evergreen and 10 -15 kg/Nhay for coniferous forests [10]. The estimates will continue also in the second and the third year of the project. Annual means of ozone concentrations was calculated and was used as an indicator of possible stress due to ozone. The results of the ozone concentration measured on the above mentioned surfaces showed that the ozone concentration on the surfaces in Istria (Figure 2) are highest in June and August and in September and the highest concentrations were measured in Dalmatia (Figure 3) in the period May, June and August and September. The concentrations do not exceed the shelf life of 120 ppb, the target limit value. Many plant species respond to elevated ambient levels of ozone (O3) with distinct specific foliar/needle symptoms [9]. In order to detect effects of ambient ozone concentrations on crown condition, ozone induced visible injury on leaves and needles were assessed on the plots. The assessment of ozone visible injury serves as a means to estimate the potential risk for forest ecosystems that are exposed to elevated ambient ozone concentrations [8]. In order to detect effects of ambient ozone concentrations on crown condition, ozone induced visible injury on leaves and needles were assessed on the plots. Symptoms suggesting oxidative stress caused by high ground-level ozone concentrations along Croatian Adriatic coast were found at Poreč LESS on *Ligustrum vulgare* (validated by the ICP Forests Expert Panel on Ambient Air Quality), *Pinus halepensis* and *Cornus mas*. Possible symptoms were also recorded at LESS Muć on *Clematis vitalba* and at Šišan on *Fraxinus ornus* and *Laurus nobilis*. No symptoms were found on LESS Vransko lake.

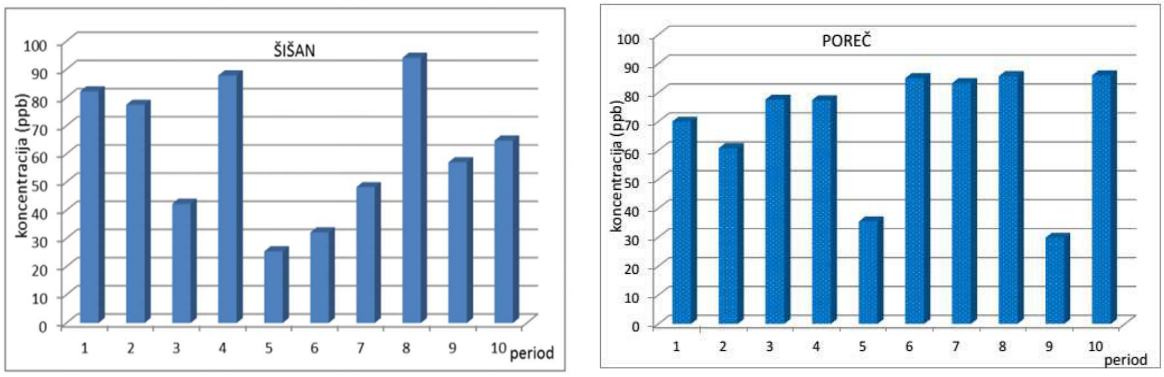

Figure 2 Ozone levels in in Istrian plots

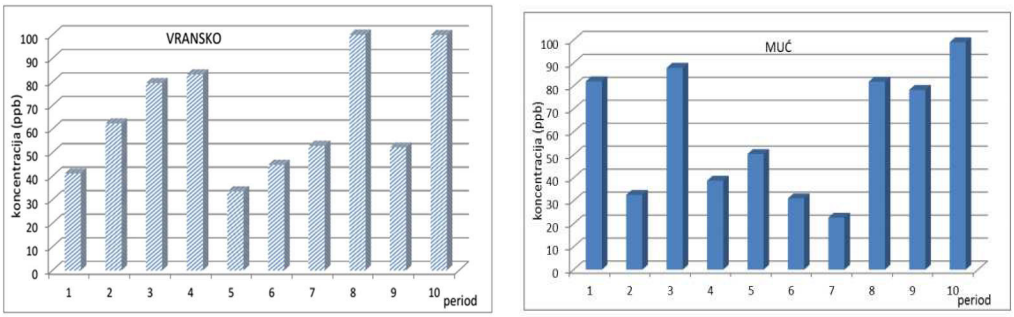

Figure 3 Ozone levels in in Dalmatian plots

Conclusions

For the assessment of ecosystem response to deposition and ozone is crucial to know critical load for every plot under consideration. The oxidative stress induced by air pollutants exposure along with that derived from the Mediterranean conditions during summer months might exceed the plant ability to react to both pollutant and climatic stress. Responses of plants to oxidative stresses include a number of physiological and biochemical changes. Future studies should therefore focus on calculation of critical load because it depends on biogeochemical processes in forest ecosystem. Therefore, the investigations of the mentioned plots will contribute to better understanding of the cause-effect relationships between crown defoliation and environmental, biochemical, deposition and ozone parameters for Mediterranean forest ecosystems.

Acknowledgment: This work has been fully supported by Croatian Science Foundation under the project 3337 DepoMedFor.

References

1. UN-ECE ICP Forest, Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests, Part XIV, Sampling and Analysis of Deposition (2016).
2. ISO 10523 Water quality – Determination of pH (1998)
3. ISO 7888 Water quality – Determination of electr. Conductivity (1998)
4. ISO 10304-1 Water quality – Determination of F-, Cl- , Br-, NO3-, NO2- , PO43-, SO42- , using liquid chromatography of ions (1998)
5. ISO 14911 Water quality – determination of dissolved Na+, NH4+, K+, Mn2+, Ca2+, Mg2+ using ion chromatography (1998)
6. Jakovljević, T, Marchetto, A, Berkovic, K, Rosa, J, Potocki, A, Atmospheric deposition measurement in the lowland forest ecosystem of Pokupsko basin in Croatia. Periodicum Biologorum 115 (3): 363-370 (2013)
7. Ogawa Protocol for ozone measurement; Using the ozone passive sampler badge (2001)
8. UN-ECE ICP Forests, Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests. Schaub, M., Calatayud, V., Ferretti, M., Brunialti, G., Lövblad, G., Krause, G., Sanz, M.J., Part VIII, Assessment of Ozone Injury (2016)
9. Calatayud, V., Marco, F., Cervéro, J., Sánchez-Peña, G., Sanz, M.J. Contrasting ozone sensitivity in related evergreen and deciduouss hrubs. Environ. Pollut. 158, 3580-3587 (2010)
10. Ferretti M., MARCHETTO A., Arisci S., Bussotti F., Calderisi M., Carnicelli S., Cecchini G. Fabbio G., Bertini G., Matteucci G., de Cinti B., Salvati L., Pompei E On the tracks of Nitrogen deposition effects on temperate forests at their southern European range – an observational study from Italy Glob Chang Biol. 20 (11) : 3423-38 (2014)