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# ASSESSMENT OF ATMOSPHERIC DEPOSITION AND OZONE LEVELS IN MEDITERRANEAN FOREST ECOSYSTEMS

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Project founded by **Croatian Science Foundation**

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# Croatia in numbers


4 290 612
Inhabitants

1244
Islands, islets, stacks and reefs

6 278 km
Coastline

1,831 m
Highest peak (Dinara)

# INTRODUCTION


National park Krka


National park Mljet

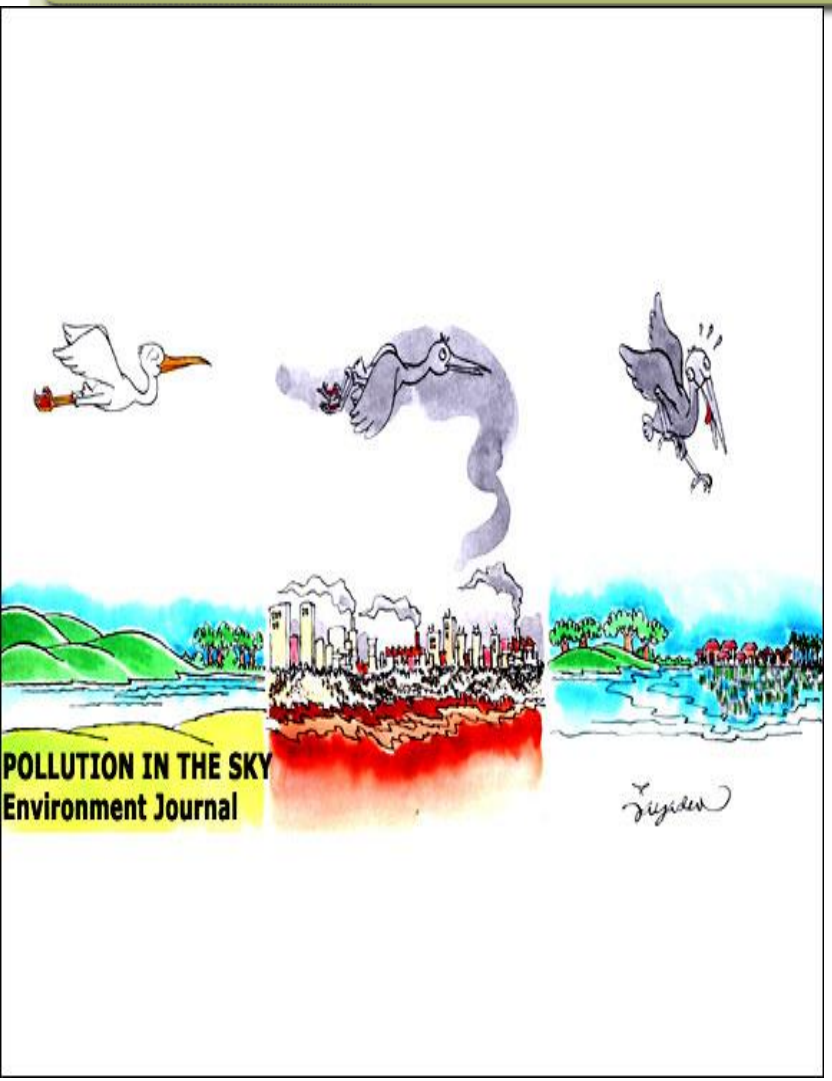
- almost half of Croatian total forest area - highly significant
- provide multiple goods and services

(water-related services, soil protection, and an exceptional richness in terms of biodiversity and unique non-wood forest products like aromatic plants, truffles, mushrooms, etc.) largely related to their environmental and social functions

## FOREST MONITORING UP TO NOW

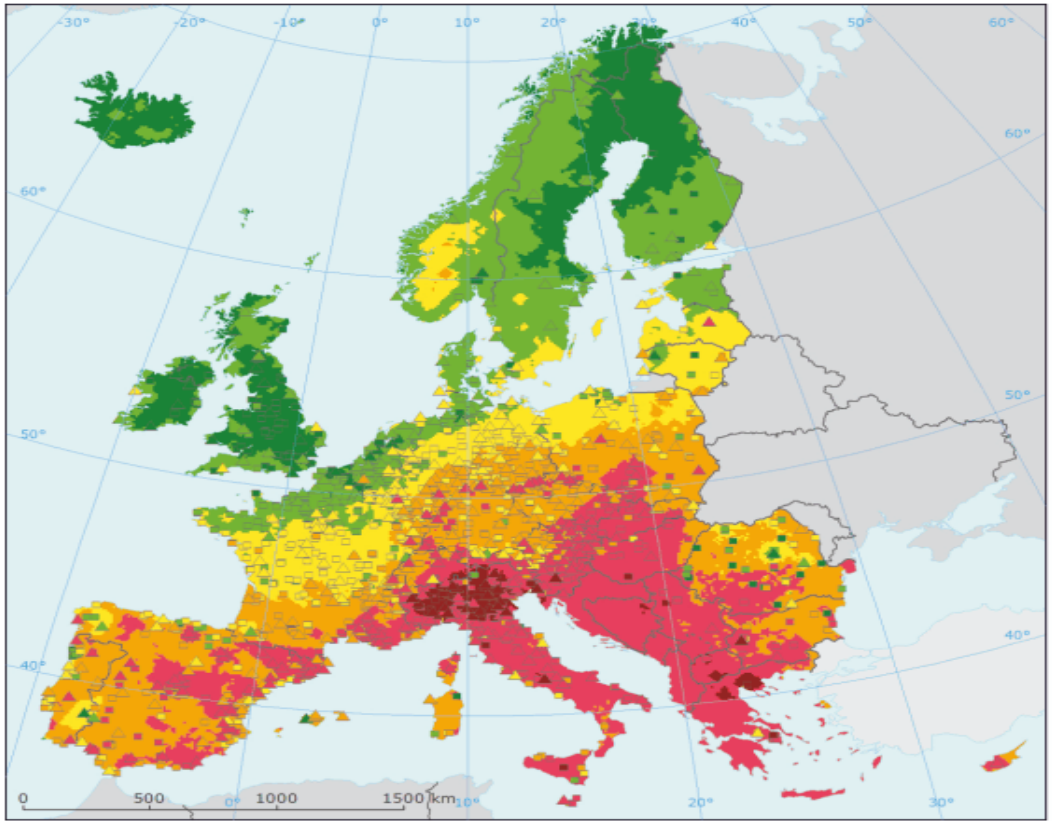
- field visual observations of defoliation included two Mediterranean Croatian regions: Istria and Central Dalmatia showed that in Istria situation is alarming, the the percentage of damages is high, as for all types of total and for individual types
- in Aleppo pine, starting with 2001, there has been a steady rise of significant damage, which in 2006 reached 41.6%
- the research also established links between annual diameter growth and the degree of damage to the pubescent oak (Seletković and Potočić, 2011)
- Our Medeterranean region is ecologically very sensitive, because of its geographic position, complex ortography, specific meteorological conditions and number of pollution sources.

## DEPOSITON AND OZONE




*ENVIROMENT AGENCY REPORT*

- the emission of ammonia in Croatia in 2015 was 44.2 thousand tons, which is more than Limit Values defined EMEP protocol, which is 30 thousand tons
- the biggest contributor is agriculture sector, 91 % as a result of the application and handling of natural fertilizers
- trend transboundary pollution by sulphur compounds is reduced, and nitrogen oxides increases slightly.
- by measuring the chemical composition of precipitation it was determined that the percentage of pollutants came by remote pollution are as follows: sulphur 80%, nitrogen 70% and ammonia about 50%
- these large amounts of pollutants to our area mostly come from neighbouring countries Italy, Slovenia, Hungary, Serbia, Montenegro and Bosnia and Hercegovina




**Ozone – 26th Highest Daily Maximum 8-hour Mean**

Reference Year: 2012
Combined Rural and Urban Background Map
Resolution: 10x10 km

- ≤ 90 µg.m$^{-3}$
- 90 - 100 µg.m$^{-3}$
- 100 - 110 µg.m$^{-3}$
- 110 - 120 µg.m$^{-3}$
- 120 - 140 µg.m$^{-3}$ (120 = TV)
- > 140 µg.m$^{-3}$
- outside data coverage
- poor data coverage
- rural background station
- urban/suburban background station

Source: ETC/ACM 2014

CHMI

Note:
Red and dark red areas correspond to exceedances of the limit value 120 µg.m$^{-3}$ .

**Fig. VIII.6 The 26th highest maximum daily 8-hour average of $O_3$ concentration in Europe, 2012**

- **Results of calculations of ground-level ozone concentrations** show that the daily mean values of ozone **can be high** and that there is a gradient of **increasing concentration** going from continental to Mediterranean because *the highest ozone risk as ozone formation occurs at high temperatures in presence of solar radiation, which is elevated in the Mediterranean–type ecosystems*

# DepOMedFor

- **up to today** only the simplest methods that include various **visual indices** based on foliage colour, degree of leaf damage and the degree of crown defoliation were used in monitoring Mediterranean forest of Croatia

- the project is to establish and **develop forest monitoring** that will give for the first time the unique possibility to analyse the biogeochemical cycle of elements, at local scale, but also the assessment of **the environmental impact of pollutants on forest ecosystems compartments**, following the uptake and the fate, from the sources to the receptors.

- The processing of data resulting from monitoring in selected Mediterranean forests, will give the necessary information on the status of the **environment and ecosystem services** provided by these forests and the reaction of these forests to climate change

# DepOMedFor

Project objectives are strictly related to the European policy and governance acts, especially to **Mediterranean Forest Research Agenda** for the period 2010-2020

***the monitoring of the environmental status of the forests within the EU territory***

*promote new forest monitoring and data collection activities, and therefore contribute to sustainable forest management by data collecting of the ecosystem services*

# OBJECTIVES


**O1 Establishment of forest environmental**

**monitoring in Mediterranean forest ecosystems**

*Defining study sites*

the main broadleaved and conifer tree species/forests of sub-Mediterranean and eu-Mediterranean area

***ISTRIAN PENINSULA***

*Quercus pubescens* Wild.

*Quercus ilex* L.

***DALMATIA REGION***

***Pinus halepensis* Mill**

***Pinus nigra* L.**

# OBJECTIVES

**O2 Estimation of atmospheric inputs to forest ecosystems and Identification of the possible impact of acid deposition and ozone on crown condition, tree nutrition, growth, soil and water availability, estimation of the present deposition loads and calculation of the critical load for nutrient N and acidity**

MEASUREMENTS

A2.1 atmospheric deposition (*THR, BOF*)
estimation of present loads and calculation
of the critical load for nutrient N and acidity
A2.2 Evaluation of ozone
(*passive samplers, visual assesment-first result*)

A2.3 Soil condition
A2.4 Tree nutrition
A2.5 Tree growth and crown condition

# PLOTS

# The impact of ground level ozone on vegetation – the first result







Ozone-induced symptoms on **1st plot in Istria** LESS (Light Exposed Sampling Site) in 2017 (validated by the ICP Forests Expert Panel on Ambient Air Quality). Symptoms suggesting oxidative stress caused by high ground-level ozone concentrations found in ***Ligustrum vulgare***, ***Pinus halepensis***, ***Cornus mas***.

Symptoms recorded on LESS in 1st plot in **Dalmatia** (*Clematis vitalba*) and **2nd plot in Istria** (*Fraxinus ornus*, ***Laurus nobilis***, ); no symptoms found on LESS 2nd plot in Dalmatia

# OBJECTIVES

**O3 Identification of the cause-effect relationships between physiological and biochemical parameters of trees, forest condition, meteorological parameters and atmospheric inputs by using different statistical tools**

## ANALYSES

**A3.1** Analyses and processing the collected data by using different statistical tools

- Relationships between individual deposition, soil, foliar and tree growth variables will be described by **single factor regression**
- **An individual tree growth model** with measured basal area increment of each individual tree as responding growth factor and tree size, tree competition, site factors (soil C/N ratio, temperature), and environmental factors as influencing parameters **will be developed**
- Acid and N deposition from plots will be used for calculation of **critical loads** Only steady state **Simple Mass Balance model** will be considered

# ANALYSES

- **Random Forest Analysis** - meteorological parameters, soil water content, solar radiation and nitrogen deposition, ozone concentration and ozone uptake as data **to estimate the predictor importance** on the insurgence of the main symptoms directly measured into the forests (i.e. defoliation, visible injury occurrence, crown discoloration, etc).

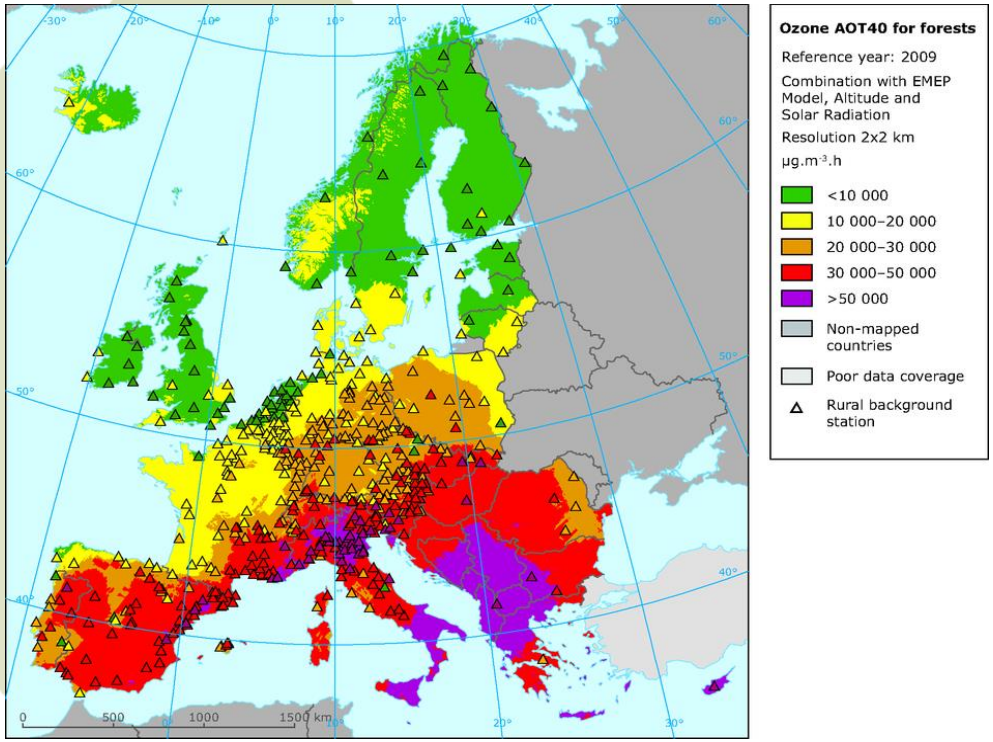
- Impacts of ozone will be estimated as relationship between both ozone concentration and uptake into leaves and needles **by DO3SE model**-***Deposition of O3 for stomatal exchange*****.** It estimates O3 flux to vegetated surfaces as a function of O3 concentration, meteorology and plant-specific characteristics (including phenological, physiological and structural characteristics

# 3D MODEL


**tree growth, wood production**
**forest carbon budget**

- To asses the integrated effects of changes in N deposition, ozone pollution, and climate change on tree growth, wood production and forest carbon budget, we will use the **process- and individual-based model NOTG.** The model incorporates the main biophysical processes involved in the water, carbon, and nitrogen cycles in trees and soil.

- Comparing simulations **with and without N deposition and ozone damage** with tree ring data **will provide** information on the respective roles of N deposition and ozone damage




## A3.2 Comparation of field measured and modelled data and future predictions on input of atmospheric pollutans and climate change

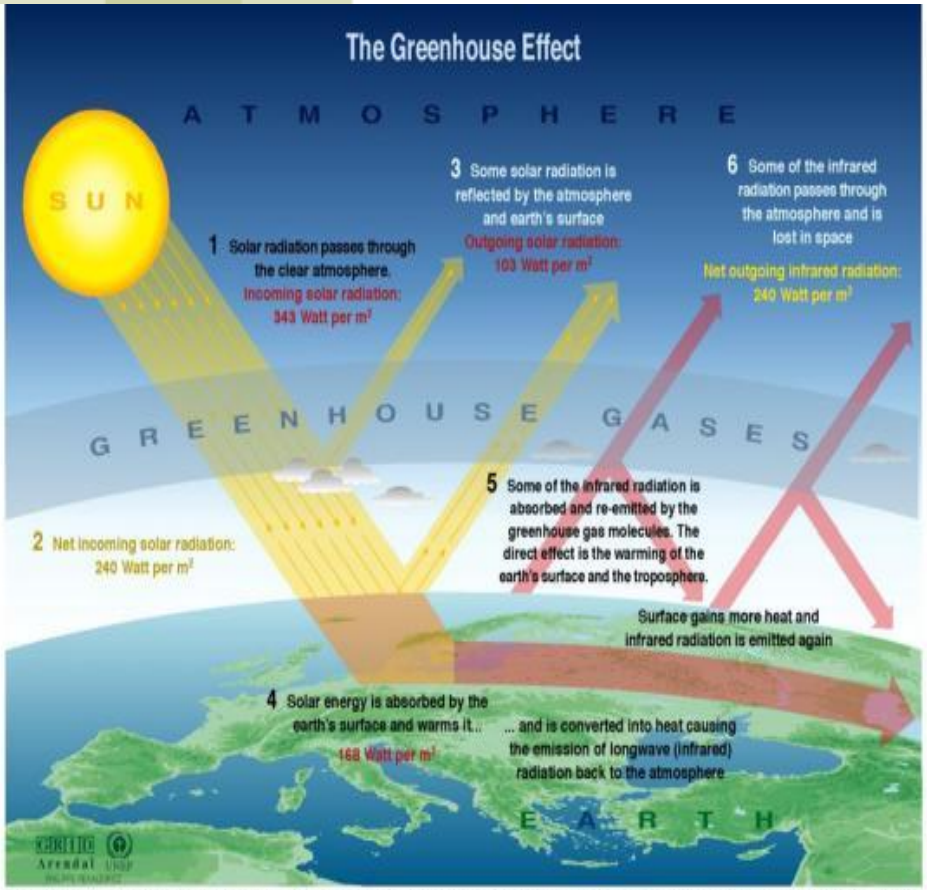
The field measurements data on the selected Croatian sites will be used to **validate the modeling chain.**

*For example, data from passive samplers have so far not been compared with modeled data from e.g. EMEP. Yet,* ***ozone risk maps*** *that are based on different methodologies have already been* ***produced for Croatia.***

*According to* ***EMEP models risk of damage from ozone to Mediterranean forests*** *of Croatian growing season from April to September levels is high. In Istria even higher than the critical level for forest damage of 5000 ppb/h*

*These maps of ozone correspond to regional background levels and they are not representative of* ***local point measurements****, where these values can be much higher and it is crucial to be investigated in forest ecosystems.*

# FUTURE SCENARIO




Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography, United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996

The models will be applied to future scenarios for climate change and air pollution in the future. In particular for climate change **RCP-Representative Concentration Pathways** scenarios will be used, with different severity degrees (RCP 2.5, 4.5, 8.5).

The severity degrees refer to radiative forcing values measured in W/m2 by the year 2100. Radiative forcing values include the net effect of all anthropogenic **greenhouse gases and other forcing agents** (van Vuuren et al., 2011).

# CONCLUSION

- ✓ **A better understanding of the cause-effect** relationships between crown defoliation and environmental and deposition and ozone parameters is needed.

- ✓ The results of this research and collaboration with Italian and French scientific institutions will contribute to the **wider overview on impacts of atmospheric inputs** in Mediterranean forests ecosystem of Eastern Adriatic coast at the regional and European level.

- ✓ The role of meteorological conditions and atmospheric inputs on **forest health status** is a key task at European level in order to identify **the best policies** able to counteract and mitigate the impacts of future climate and air pollution.

National park Kornati

# THANK YOU FOR YOUR ATTENTION!

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