Groupe International d'Etudes des Forêts Sud-européennes

G.I.E.F.S

# OZONE EFFECTS

# ON FORESTS AND VEGETATION

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# Presentation of the $FO_3$REST project and reminders on ozone

The main objective of the $FO_3$REST project (www.fo3rest.eu) is to suggest **new standards and critical levels** more appropriated, for Mediterranean forest protection against ozone and climate change, based on the quantity of ozone absorbed by plants rather than on the external exposure as implicit in the AOT40 approach. This project is at the **heart of climate changes** because the Mediterranean region is one of the most affected by the air pollution and will be one of the most affected areas by climate change. Recent studies by the IPCC (Intergovernmental Panel on Climate Change) showed that mean temperatures could increase of 5.2°C by 2080 at the Provence-Alpes-Côte d'Azur regional scale.

In the stratosphere, the ozone plays a role of natural and beneficial screen in relation to the harmful effects of ultraviolet (UV) for the organic matter (= good ozone). In the troposphere, ozone is a secondary pollutant that is produced during the atmospheric photo-oxidation of Volatile Organic Compounds (VOCs) under the presence of nitrogen oxides (NOx), emitted, mainly, by anthropogenic activities (= bad ozone). At the moment, the greenhouse gas tropospheric ozone is the **most worrying atmospheric pollutant** for ecosystems and forests. Furthermore, ozone causes serious health problems and damage to materials. Recent studies show an increasing impact of ozone concentrations on ecosystems and forests.

Ozone enters the leaf through the stomata, and instantly degrades in contact with cells, causing a chain reaction, resulting in the death of them. The **ozone-induced damages** can be a foliar necrosis, an accelerated senescence with premature loss of leaves (or needles), a reduction of the opening ability of the stomata and therefore the photosynthetic activity reduction. These changes engender a growth reduction and a weakened state of tree, more sensitive to the parasitic attacks and climatic aleas (drought).

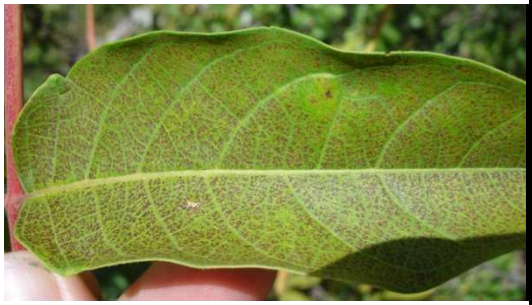
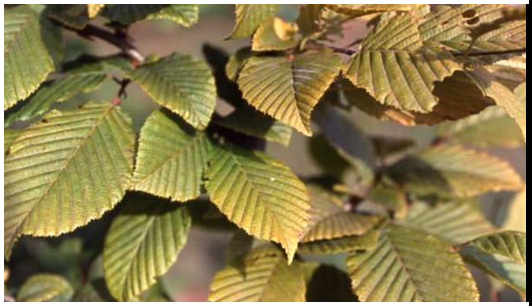
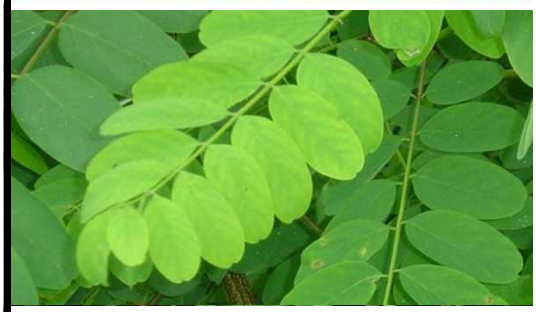
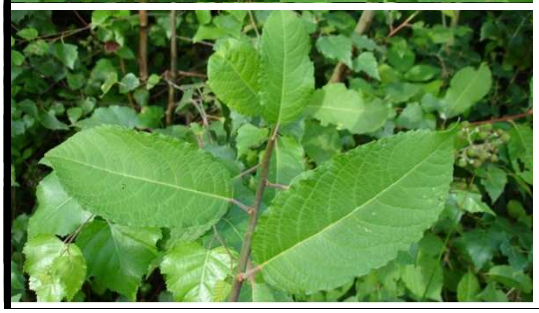
# Ozone symptoms on forest and vegetation

The **visible effects** of ozone are not expressed in the same way depending on the species. However, some features are common: the effects are more frequent on older leaves, the marks are visible between the ribs and on leaves exposed to light. The expression of specific ozone symptoms are different between conifers and broadleaves.

| CONIFERS | BROADLEAVES |
|---|---|
| ***Mottling***: small yellow/light green spots or mottling with diffuse outlines, especially on the upper side and at the tip of the needle | ***Stippling***: small dots with variable color at the leaf surface and between the ribs |
| ***Photobleaching*** : discoloration of portions exposed to light | ***Bronzing***: copper-brown or purplish-brown coloration on the upper part of the foliage |
| | ***Chlorose*** : discoloration of portions exposed to light |

The photographs below were realized by the GIEFS. The ozone-induced symptoms presented were confirmed by the European validation centers of the International Cooperation Programme on assessment and monitoring of the effects of air pollution on forests.

| Sample without ozone symptom | Sample with ozone symptoms | Type of symptom and species concerned |
|---|---|---|
|  |  | *Photobleaching* on silver fir needles |
|  |  | *Mottling* and insect stings on one-year-old needles of Aleppo pine |
|  |  | *Mottling* and insect stings on two-year-old needles of stone pine |
|  |  | *Mottling* on European larch needles |
|  |  | *Mottling* on two-year-old needles of Scots pine |
|  |  | *Bronzing* and *stippling* on beech leaves |

| Sample without ozone symptom | Sample with ozone symptoms | Type of symptom and species concerned |
|---|---|---|
|  |  | *Bronzing* on field maple leaf |
|  |  | *Stippling* on Ailanthus leaf |
|  |  | *Bronzing* on common hornbeam leaves |
|  |  | *Bronzing* on hazel leaves |
|  |  | *Stippling* on robinia leaves |
|  |  | *Stippling* on goat willow leaves |