Tree pollination and its impact on human health as indicators of air pollution and climate change

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Pollen transport

Anemogamy: by the wind

Entomogamy: by insects
Aerobiology: a multidisciplinary approach

Dispersion & Transportation

Emission
Source

Deposition
Impact
Receiver

Atchoum!
RNSA presentation

RNSA is the French aerobiology network responsible for analyzing biological particles in the air, and giving some information about their health impact.

The coordination center and training RNSA is located at Brussieu (69) in the heart of the Monts du Lyonnais, 40 km west of Lyon.
Pollen exposure measurement: pollen trap

Current standard method in Europe

Breathing orifice (10 L air/min)

Horizontal reading

Adhesive band on the drum

| 1st day | 2nd day | etc... |

1h = 2mm

Measurements were made with Hirst-type pollen traps.
Pollen exposure measurement: analysis

1. Collection of the drum band
2. Dividing the band into daily sections
3. 1 slide by day
4. Counting with a vocal recognition system
5. Daily amounts (grains/m³)
Difference between allergy potency and allergy risk

The **allergy potency** is specific to a pollen grain whatever the location while the **allergy risk** is a measure of health impact and depends on several factors such as the amount of pollen, the weather, the phenology, the symptoms observed by doctors...
Allergy potency of plants

• The allergy potency of a plant species is the ability of its pollen to cause an allergy to a significant part of the population

• The allergy potency can be:
  – **Low or negligible**: This means that a very large amount of pollen is needed to trigger an allergy and this applies only to the most sensitive people
  – **Moderate**: These species may be present locally to bring diversity into plantations, but they should not represent the majority of planted species
  – **High**: A few number of pollen is enough to cause an allergic reaction
Allergy potency of trees

**Birch**

<table>
<thead>
<tr>
<th>Species</th>
<th>Family</th>
<th>Allergy potency</th>
</tr>
</thead>
<tbody>
<tr>
<td>maple*</td>
<td>Aceraceae</td>
<td>Moderate</td>
</tr>
<tr>
<td>alder*</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>birch*</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>hornbeam*</td>
<td>Betulaceae</td>
<td>High</td>
</tr>
<tr>
<td>hop hornbeam</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>hazel*</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>baccharis</td>
<td>Asteraceae</td>
<td>Moderate</td>
</tr>
<tr>
<td>cade</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>common cypress</td>
<td>Cupressaceae</td>
<td>High</td>
</tr>
<tr>
<td>Arizona cypress</td>
<td>Cupressaceae</td>
<td>High</td>
</tr>
<tr>
<td>juniper</td>
<td></td>
<td>Low or negligible</td>
</tr>
<tr>
<td>thuja*</td>
<td></td>
<td>Low or negligible</td>
</tr>
<tr>
<td>locust*</td>
<td>Fabaceae</td>
<td>Low or negligible</td>
</tr>
<tr>
<td>chestnut-tree</td>
<td>Fabaceae</td>
<td>Low or negligible</td>
</tr>
<tr>
<td>oak*</td>
<td>Fagaceae</td>
<td>Moderate</td>
</tr>
<tr>
<td>beech*</td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td>walnut*</td>
<td>Juglandaceae</td>
<td>Low or negligible</td>
</tr>
<tr>
<td>paper mulberry</td>
<td>Moraceae</td>
<td>High</td>
</tr>
<tr>
<td>white mulberry</td>
<td>Moraceae</td>
<td>Low or negligible</td>
</tr>
<tr>
<td>ash*</td>
<td>Oleaceae</td>
<td>High</td>
</tr>
<tr>
<td>olive-tree</td>
<td>Oleaceae</td>
<td>High</td>
</tr>
<tr>
<td>privet*</td>
<td>Oleaceae</td>
<td>Moderate</td>
</tr>
<tr>
<td>pine*</td>
<td>Pinaceae</td>
<td>Low or negligible</td>
</tr>
<tr>
<td>plane-tree**</td>
<td>Platanaceae</td>
<td>Moderate **</td>
</tr>
<tr>
<td>poplar*</td>
<td>Salicaceae</td>
<td>Low or negligible</td>
</tr>
<tr>
<td>willow*</td>
<td>Salicaceae</td>
<td>Moderate</td>
</tr>
<tr>
<td>yew</td>
<td>Taxaceae</td>
<td>Low or negligible</td>
</tr>
<tr>
<td>Japanese red-cedar</td>
<td>Taxodiaceae</td>
<td>High</td>
</tr>
<tr>
<td>linden*</td>
<td>Tiliaceae</td>
<td>Moderate</td>
</tr>
<tr>
<td>elm*</td>
<td>Ulmaceae</td>
<td>Low or negligible</td>
</tr>
</tbody>
</table>

* several species

** The pollen of the plane trees is weakly allergenic. On the other hand, the microneedles contained in the waders resulting from the degradation of the female heads of the previous year are very irritating.
Urban Vegetation & Air Quality

Absorption of pollutants

Effect on well-being
Fight against stress

Absorption of particulate pollutants
Trees and pollution

Advantage:
Planting trees in the city would have a protective effect because they reduce the presence of pollutants in the air by filtering and absorbing pollutants, small fine dust and aerosols suspended in the air.

Disadvantages:
Urban pollution aggravates allergenicity of pollens by weakening the surface of the grains and allowing the exit of granules containing allergenic proteins. It also causes an increase in bronchial, nasal and ocular hyperresponsiveness, altering the threshold of sensitivity to pollens. Moreover, the introduction of trees in the city (cypress, birch, plane tree ...) contributes to the increase of respiratory allergies.
Moreover...

Other environmental aspects related to vegetation should be taken into account

*Urban climate - greenhouse effect*

*Energy expenditure in buildings*

We must also consider the health aspects linked to urban vegetation.

*:smiley: Physical and psychological well-being
*:sweat: Allergies*

Vegetation has a cost:

*In France, the average cost for a planted tree is 1250 euros*

*(Soil preparation, planting, maintenance)*

Pollution and pollen

- Pollutants (NO₂, O₃, PM₁₀ et PM₂.₅) act:
  - By weakening the respiratory system
  - On the aeroallergens contained in the pollen grains
  - On the structure of the pollen grains
  - On allergenicity of the pollen grains
Pollution and pollen

Birch pollen in the countryside  Birch pollen in town

Trees exposed to a CO₂ concentration in excess of 200 ppm “normal” concentration begin to produce large amounts of pollen at an age and size where the species is still normally sterile and continue to produce up to one very advanced age.

S.L. LaDeau & J.S. Clark, 2006: *Funct Ecol* 20, 541-547
The report of the Intergovernmental Panel on Climate Change edited by Houghton and al. (1990) projects CO₂ increasing from present day concentrations of about 350µL/L (1) to over 800µL/L by the end of the present century if no steps are taken to limit emissions.

(1) $1\mu L/L = 1$ microliter $CO_2$ per liter of air $= 1$ ppmv $= 1$ part per million by volume $= 1 \mu$mol/mol

**CO₂ evolution**

Effects of increasing atmospheric $CO_2$ on vegetation
B. A. Kimball and all - *Environmental and Plant Dynamics Research Unit,*
Photosynthesis and CO₂

CO₂ + H₂O → CH₂O (carbohydrate) + O₂

**Fig. 1.** Net photosynthesis of typical C₃ and C₄ plants versus CO₂ concentration, adapted from Taiz and Zeiger (1991). The vertical dotted lines at 350 and 700 μL/L indicate the present-day CO₂ concentration and the doubled concentration projected to occur sometime near the end of the next century (Houghton *et al.* 1990), respectively. The double arrows indicate the amounts of increase in photosynthesis due to the CO₂ doubling.
Pollen: Health indicator of climate change

Phenological phases of trees
Source: GLOBE Suisse
Study ONERC-RNSA: Pollen: Health indicator of climate change

First phase of the study taxon choice:

✓ Tree
✓ High allergenic potential
✓ Representation on a large part of the territory

Second phase of the study cities choice:

✓ Representation of different climates
✓ Areas of birch presence
✓ Reliable data

Map of the distribution of birch pollen in France
The phenological year for birch is from July to June. The birch pollen quantity which is released in March-April depends on the temperatures and weather he has done before, since July of last year.

The period July-June (year N+1) has been chosen.
Moving average(-4 years) birch pollen quantity and annual T° for 6 cities across France from 1989 to 2017
Simulation/Projection

Moving average (-4 years) birch pollen quantity and annual T° for 6 cities across France from 1989 to 2100

Mean Temperatures from July to June
Evolution of the average temperature in metropolitan France from 1900 to 2015

- Temperature difference
- 10-year average
Atmospheric CO₂ concentration and trend in earth temperature, 1900-2012 (concentration in ppm; temperature in °C)

Source: calculations performed by Berruyer according to data from NASA
Theories/Projection

![Graph showing projected global temperature and CO₂ levels over years]
The appearance dates of horse-chestnut bud burst in Geneva from 1808
According to the biologists: The increase of 1 °C in mean annual temperature is equivalent to a translation of plant species 200 km to the north or to a rise up of about 150 m in altitude.

Source: Science & Vie, 2003
- Species migration from South to North (ragweed, trees, grasses, cypress and oak. ...).
- Forecast: warming of 3.5 °C by 2100.
- The area of green oak by 2050 could exceed a line Bordeaux-Saint-Etienne and cross the Loire by 2100.

Source: INRA
The range of beech, by a hundred years, could significantly decrease due to higher summer temperatures and lower rainfall. The same phenomenon could be observed for mountain species: Larix, Abies, Picea ...
With a warming of 3.5 °C by 2100 the Olive tree could go back to the gates of Luxembourg. 

**Because of the Photoperiod which is an essential element for plants it will certainly never happen**
Pollen allergy

Asthma

Rhinitis 90%
Urticaria and eczema 20%

I am itchy

Conjunctivitis

I weep for its prick
Conjunctivis 75%

I cough
Tracheitis, asthma 50%
Thank you for your attention

www.pollens.fr
http://www.vegetation-en-ville.org/