Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL








Impacts of ozone pollution on food security in Europe

wge
Working Group on Effects of the Convention on Long-range Transboundary Air Pollution

Ozone pollution

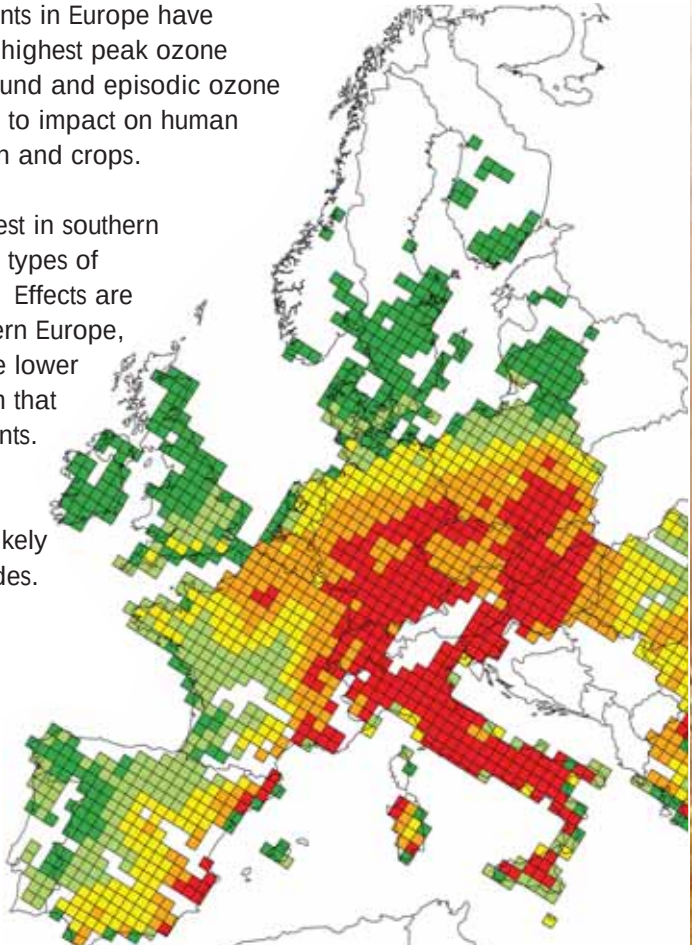
The ozone layer in the upper atmosphere is essential for protecting us from harmful UV light from the sun. However, in ground-level air, ozone is a damaging pollutant with significant impacts on human health and the environment. Ozone is a secondary pollutant - it is formed in the air by chemical reactions involving gases emitted from the combustion of fossil fuels and some industrial processes, in the presence of sunlight.

Ozone concentrations are strongly influenced by the weather. They are highest on warm/hot sunny days in spring and summer, especially in rural areas downwind of major cities. There is always some ozone in ground-level air (the so-called "background" concentration, in part influenced by pollution from other continents). In addition, ozone concentrations can rise to a higher level for several days when conditions are right for ozone formation (ozone episodes).

Although international agreements in Europe have been successful in reducing the highest peak ozone concentrations, current background and episodic ozone concentrations are high enough to impact on human health, (semi-) natural vegetation and crops.

Ozone concentrations are highest in southern Europe where impacts on many types of vegetation have been detected. Effects are also found in central and northern Europe, where ozone concentrations are lower but the climatic conditions mean that more ozone is absorbed by plants.

Models predict that the effects described in this brochure are likely to continue in the coming decades.



Ozone Concentration in Europe in 2000 (as the 3 month AOT40, ppm h, for wheat)

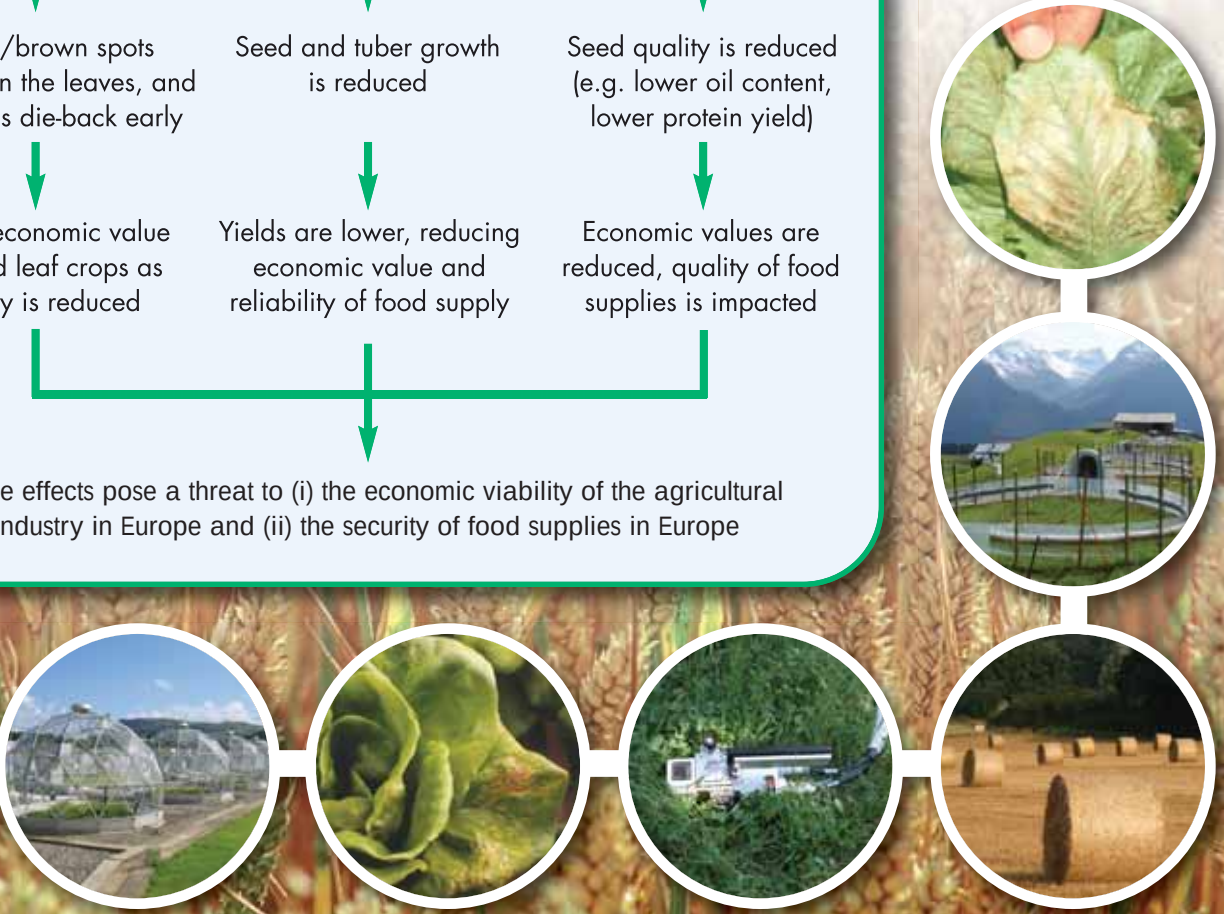
Why are we concerned about ozone effects on crops?

Almost all of Europe's most important agricultural crops respond to ozone pollution as described below and are classed as sensitive or moderately sensitive to ozone pollution. These crops include **wheat, maize, barley, sugar beet, potato, oilseed rape** and **soybean**. Many horticultural crops also respond to ozone by reducing yield (e.g. **tomato, water melon**) and/or by developing visible damage to leaves (e.g. **lettuce, spinach, salad onions, chicory**), reducing both the quality and value of the crop.

Ozone enters crops through small pores on the leaf surface

Yellow/brown spots develop on the leaves, and the leaves die-back early	Seed and tuber growth is reduced	Seed quality is reduced (e.g. lower oil content, lower protein yield)
Loss in economic value of salad leaf crops as quality is reduced	Yields are lower, reducing economic value and reliability of food supply	Economic values are reduced, quality of food supplies is impacted

These effects pose a threat to (i) the economic viability of the agricultural industry in Europe and (ii) the security of food supplies in Europe



Impacts of ozone pollution on wheat production in Europe

Europe's most important and most-widely grown crop, wheat, is also one of the most sensitive to ozone pollution. Using a response function derived from experiments conducted in Belgium, Finland, Italy and Sweden, together with ozone, wheat production and value data for the year 2000, the economic impacts of ozone on wheat production were modelled for each 50 x 50km grid square of Europe where wheat is grown (Map 1). The biggest impacts were predicted for grid squares in countries such as France, Germany, the UK and Italy. Taking into account expected reductions in ozone pollution in Europe due to national/international controls on the emissions of chemicals leading to ozone formation, effects are only expected to be reduced by one third in 2020 (Map 2, prepared using 2000 prices and crop production data to allow comparison).

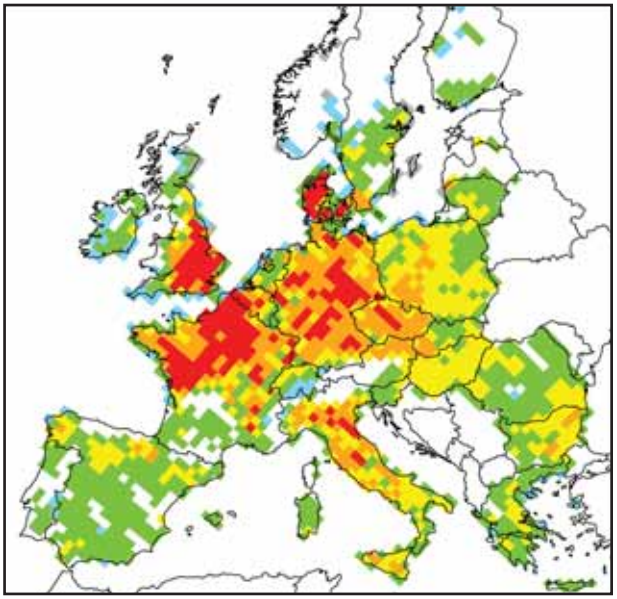
Across the EU 27 countries plus Switzerland and Norway, an estimated € 3.2 billion was lost in 2000 due to ozone effects on wheat grain yield (representing 20.2% of economic value, Table 1). Even with current legislation to reduce ozone pollution in Europe, economic losses are predicted to be € 2 billion (representing 12.4% of economic value). Given the rising price of wheat, these economic losses could be substantially higher than those provided here that are based on wheat prices in 2000.

	2000	**2020**
Loss in production (t)	26.9 million	16.5 million
Loss in value[1]	3.2 billion Euro	1.96 billion Euro
Area at risk of losses[2]	24.5 million ha	24.5 million ha

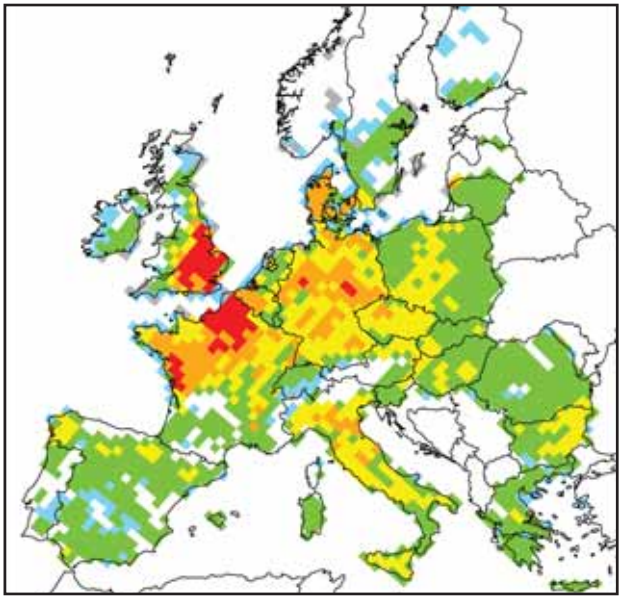
Table 1: Loses in wheat production due to ozone pollution in EU27+CH+NO
[1]calculated for prices in 2000 using the flux method, [2] estimated from the mean t/ha per country

Distribution of ozone-caused losses in wheat value in Europe[1]

Map1 : Economic losses in 2000



Map 2: Economic losses in 2020



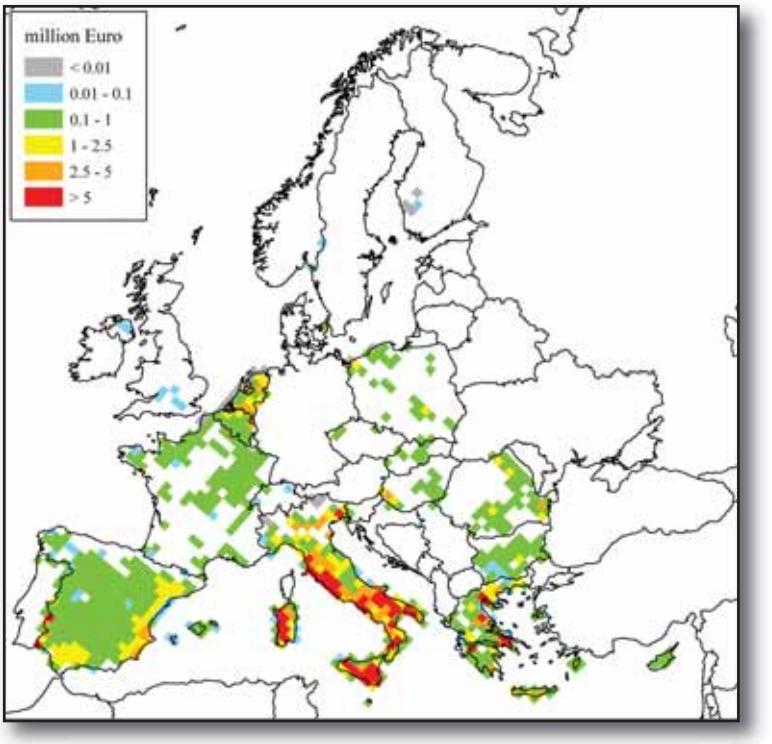
Losses are in million Euro per 50 x 50 km grid square:

< 0.01 | 0.01 - 0.1 | 0.1 - 1.0 | 1.0 - 2.5 | 2.5 - 5.0 | > 5

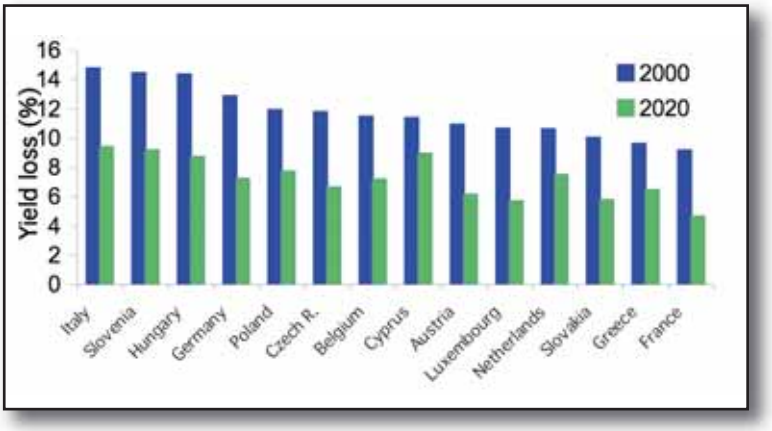
[1] calculated using the ozone flux method, the mean economic value in 2000 and assuming irrigation is used when needed

Effects of ozone pollution on the horticultural industry - crop yield

Several horticultural crops are sensitive or moderately sensitive to ozone pollution, including tomato, lettuce and water melon. To illustrate economic impacts, the same approach described for wheat was used to predict losses for tomato. The greatest economic impacts were predicted for southern European countries (e.g. Italy, Spain), with losses also predicted for more northern countries such as Belgium and the Netherlands where tomato is also grown extensively.



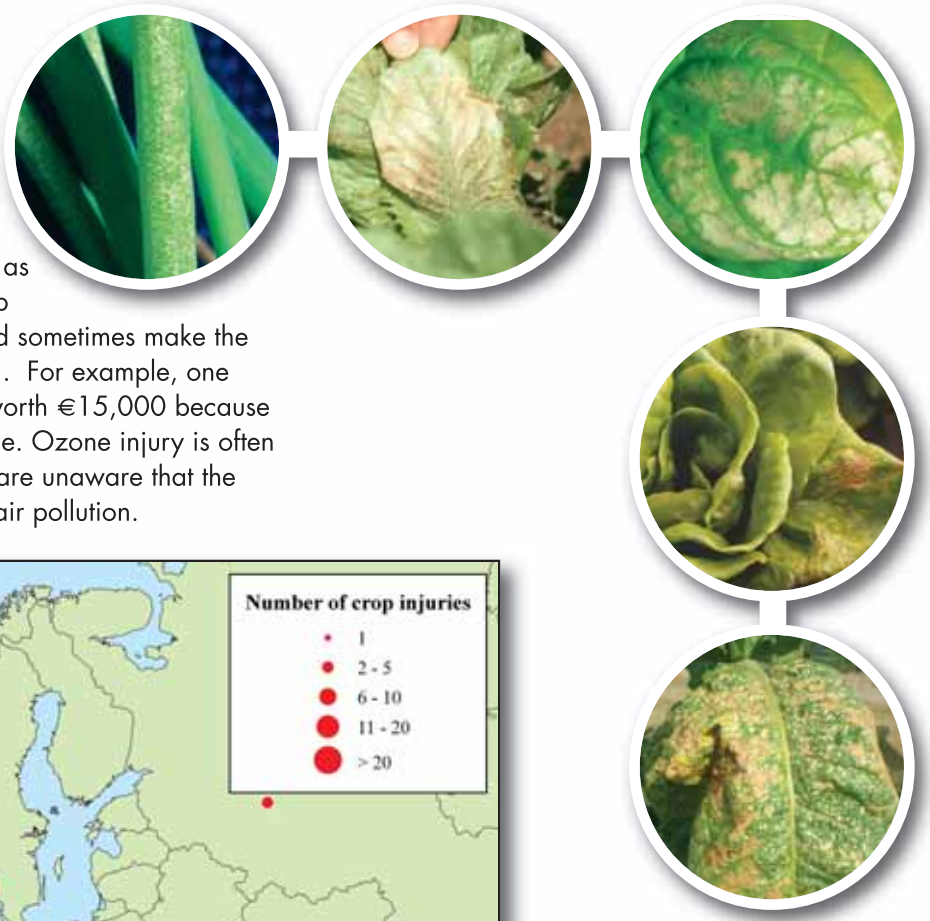
Economic losses for tomato in 2000 (million Euro per grid square)[1]



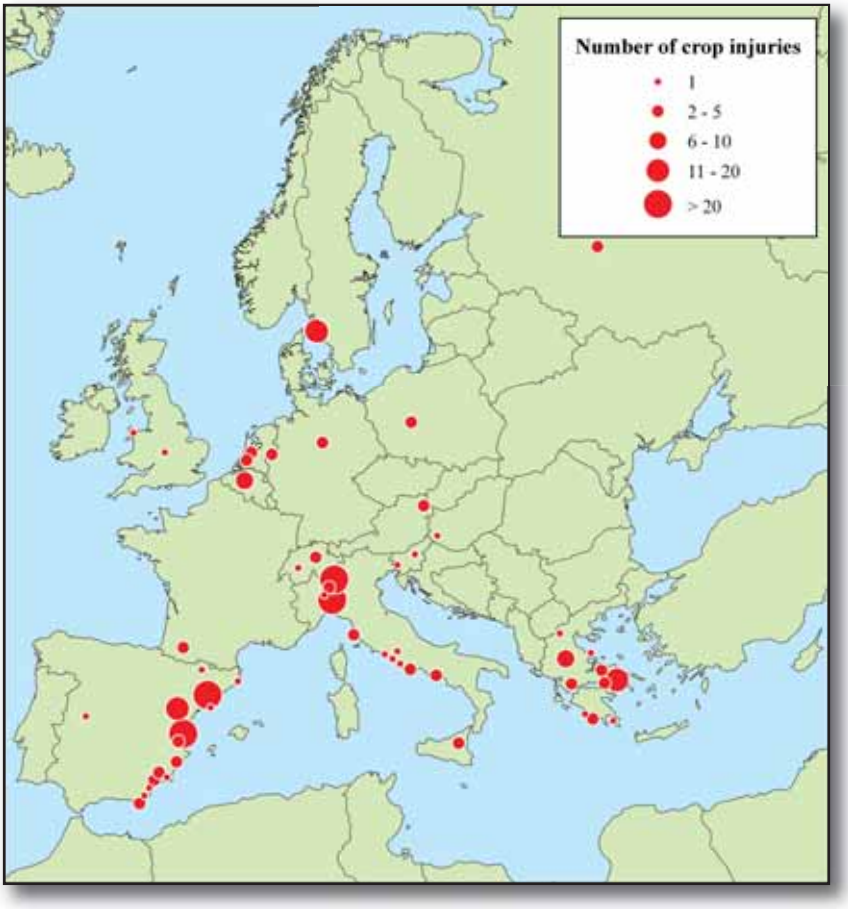
Percentage loss in tomato yield in 2000 and 2020[1]

[1] calculated using the ozone flux method, a mean economic value in 2000 for tomato in open air and assuming irrigation is used when needed

Ozone damage to leaf crops

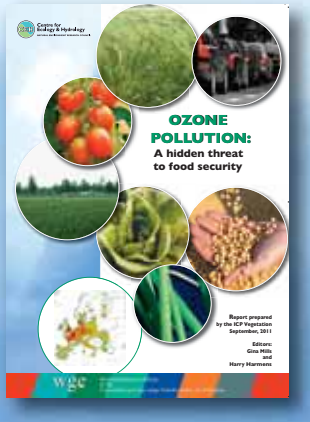


Following an ozone episode, leaf crops such as lettuce, chicory, spinach and tobacco develop yellow/brown spots that reduce the value and sometimes make the crop un-marketable (see photos for examples). For example, one farmer in Greece lost his entire lettuce crop worth €15,000 because of ozone damage following an ozone episode. Ozone injury is often mis-diagnosed by farmers and advisers who are unaware that the damage they see could be being caused by air pollution.



Locations where visible ozone damage has been confirmed on crops

This brochure was produced by the ICP Vegetation, an International Cooperative Programme reporting to the UN Convention on Long-range Transboundary Air Pollution on effects of air pollutants on vegetation.



For a more detailed assessment, including summaries of concerns in northern and southern Europe, case studies for the UK and Germany, crop sensitivity indices and a review of current knowledge of impacts in South Asia, please see:

Ozone Pollution: A Hidden Threat to Food Security

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