

POLLUTION **Tracking pollutants and environmental toxins.**

To protect people and the environment, WSL researchers monitor and quantify the pollutants they detect in the forest and other ecosystems with the support of WSL's central laboratory.

Invisible but everywhere: pollutants such as nitrogen oxides, chlorine, heavy metals, ammonia or nitrates are widespread. They get into the air through the combustion of oil and petrol, or through industry and agriculture. Rain washes them into the soil where they are absorbed by living organisms. Some toxins attack plant cells, while others disturb material flows in the natural environment. This means analysing pollutants is essential in ecological research.

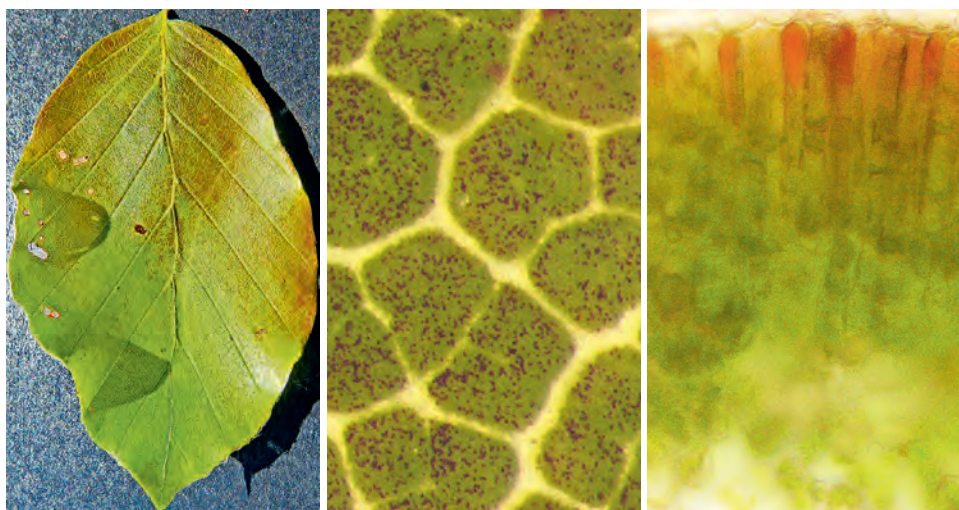
WSL's central laboratory is where this all comes together. Samples taken from forests and fields are put through various analysis steps here, such as with this automatic sampler. It is sucking in a small amount of solution and spraying it into a grey device. Inside a small green flame of argon plasma reaches a temperature of 10'000 degrees – making it the hottest place at WSL. The device, an atomic emission spectrometer, can detect positively charged particles, including heavy metals such as lead, cadmium, copper and zinc. Depending on the concentration, they may be very toxic.

The liquid solutions come from a forest floor somewhere in Switzerland. Stephan Zimmermann, a soil researcher at WSL, is currently collecting soil samples at various depths on over two hundred test plots. He is repeating the systematic, Switzerland-wide soil inventory that was part of the 1993 Sanasilva forest health inventory. "With our data, we can now estimate the state of the soil at most forest sites in Switzerland," he says. This information provides



The soil across the whole of Switzerland is being sampled again. This should enable, for example, the identification of sites contaminated with nitrogen.

Photo: Cécile Bühner, WSL



Ozone, an aggressive gas, damages cells in leaves. The damage patterns serve as bioindicators for high ozone levels.

a basis for deciding on political measures, for example setting stricter limits. “Repeating the inventory will allow us to see what changes have taken place.”

The consequences of industrial production

Chemicals, exhaust fumes and over-fertilisation are the consequences of two hundred years of industrialisation, which markedly intensified in the 20th century as the population grew and prosperity flourished. Since the 1970s, the general public has gradually become more aware of the side effects. At that time, Theo Keller and Madeleine Günthardt-Goerg were two of the first pollutant detectives at WSL. Among other things, they began environmental monitoring in 1971, assessing damage to beech leaves to monitor the effects of chlorine and heavy metals from a waste incineration plant in Canton Glarus.

For more on LWF, see wsl.ch/lwf-en

When the Chernobyl nuclear reactor exploded in 1986, the importance of regular monitoring of pollutants became particularly apparent. A cloud of radioactive caesium-137 spread over northern and eastern Europe, and in Switzerland radioactive fallout fell on Ticino, the Jura and north-eastern Switzerland. It turned out to be a stroke of luck that soil samples had been collected from all 12'000 test sites during the first Swiss National Forest Inventory from 1983 to 1985. After the 1993 soil inventory mentioned above, it was possible to compare the caesium levels with those before the accident. According to Stephan, the findings confirmed that, in those places where it had rained at the time, the caesium was still in the topsoil. This was further support for taking such precautionary measures as not eating any mushrooms collected in those areas.

Pollutants in the forest

It was also in the 1980s that the spectre of forest dieback started causing alarm: Were air pollutants making the trees sick? Intensive monitoring of pollutant depositions and the health of forests began throughout Europe and has continued to this day. Switzerland contributes, among other things, the data from the nineteen test plots of the Long-term Forest Ecosystem Research (LWF) programme, which has, since 1994, meticulously recorded concentrations of pollutants in the air, water, soil and plants to establish the material flows.

Since then, WSL's central laboratory has had a standing order, so to speak, to analyse the samples from the LWF sites. Negatively charged ions can be detected, using so-called ion chromatography, in extracts from soil, plant and needle samples, as well as in rain- and soil-water. Depending on the quantity involved, chlorides, nitrates, phosphates and sulphates can act as either fertilisers or pollutants.

The LWF programme confirmed that the air pollution control measures of the 1990s had been successful. These included making it compulsory to use catalytic converters in cars, desulphurised oil for heating and flue gas filters in industry. As a result, sulphates, one of the sources of 'acid rain', decreased considerably, as did aluminium in soil water. These decreases could be shown in Europe-wide forest monitoring data, which includes LWF findings.

Nitrogen depositions in forests have also dropped, but they are still too high. The main sources of these air pollutants are traffic and agriculture. Although nitrogen is actually a nutrient, very high depositions can inhibit tree growth, according to Sophia Etzold, an LWF staff member. "An imbalance of nutrients can throw a forest ecosystem out of equilibrium."

According to the Swiss Forest Report 2015, the critical loads for nitrogen are still exceeded on about ninety percent of the forest area – despite improvements. Here Stephan Zimmermann's soil inventory provides useful information: "When we know where large depositions occur, measures can be taken there," he says. The Federal Office for the Environment (FOEN) is conducting pilot tests to treat particularly acidified forest soils with lime. "However, reducing emissions at the source must be the main strategy," says Stephan.

This approach has worked with heavy metals. Thanks to stricter environmental regulations, heavy metal emissions have decreased and these substances are no longer at the forefront of monitoring. WSL's central laboratory has scaled down its heavy-metal analytical capacities accordingly. "We are a service provider," says Daniele Pezzotta, head of the central laboratory. "We focus on what the researchers want us to analyse."

However, heavy metals are extremely persistent, so the problem has not been solved. In an ongoing study in Canton Valais, WSL microbiologist Beat Frey is investigating how mercury affects the diversity of soil microorganisms. This heavy metal entered the environment from the Lonza factory in Visp between 1930 and 1990. The results surprised Beat: "The soil microflora can adapt to the high mercury levels in the soil in the long term." The microorganisms convert the toxic soluble mercury in the cells into a gaseous form and emit it.

Diagnosing poisons on the basis of the damage pattern

One still unsolved pollution problem is ozone. The aggressive gas is formed near the ground under solar radiation from nitrogen oxides in traffic exhaust. Leaves and needles damaged by ozone show typical yellowish to reddish-brown spots and discolouration. "The diagnostic potential of ozone injuries was recognised quite early," says Pierre Vollenweider, a plant physiologist at WSL. "Today, they are systematically used in all forest monitoring programmes in Switzerland and Europe as bioindicators of ozone stress."

The work of the WSL pollutant detectives does not end with documenting damage and pollutant concentrations. Detective work in science also in-



A climber on a spruce at the LWF Seehornwald site near Davos. She is collecting needles for laboratory analysis.

volves bringing together and interpreting the various measurements and results. This is sometimes like putting together a jigsaw puzzle, but the complex task then provides policy-makers with a basis for taking the right measures.
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Photo: Kathi Liechti, WSL