DUSTMARKS AND OZONE TATTOOS: AUTOGRAPHIC DISPLAYS OF AIR POLLUTION

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Abstract
We present two examples of autographic visualizations - displays based on material traces rather than digital data - that aim to make environmental pollution visible and legible. Using particulate matter and ground-level ozone pollution as case studies, this pictorial illustrates the design principles of creating autographic visualizations that make phenomena reveal themselves.

Authors Keywords
Autographic visualization, indexical visualization, physicalization, critical data studies, environmental phenomena

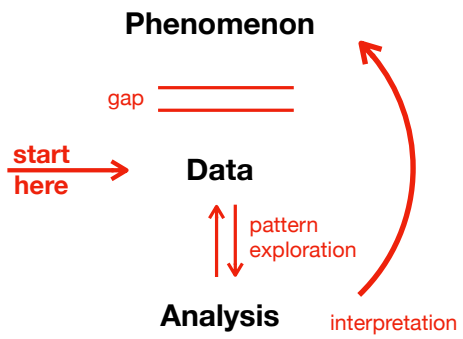
Introduction
The public art projects *Staubmarke* and *Ozone Tattoo* are autographic displays that make aspects of air pollution—usually represented in abstract metrics—accessible to sensory experience. In both projects, the respective phenomena are made to reveal themselves in material traces, unmediated by symbolically encoded data.

Focusing on dust and particulate matter, *Staubmarke* (figure above) makes urban air pollution visible by introducing a visual system to observe and compare the dust patina across urban surfaces and contrast it with data from a citizen science sensor network.

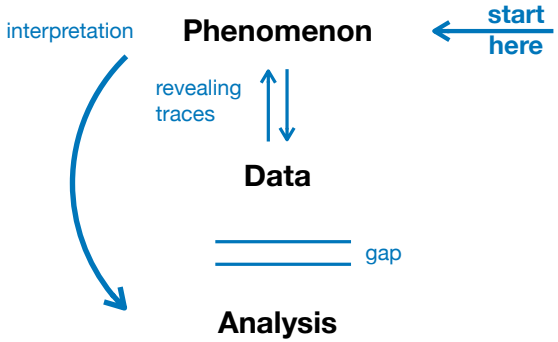
Ozone Tattoo (figure above) uses plants as sensors for ground-level ozone pollution. Similar to Staubmarke, a visual reference pattern shows how ozone damage manifests on the leaves of certain indicator plants (tobacco, snap bean), helping to detect ozone episodes through comparison with the untreated leaves.

VISAP'19, Pictorials and annotated portfolios.

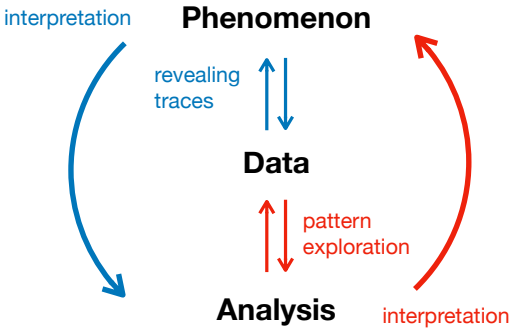
Data Visualization vs. Autographic Visualization



Information Visualization



Autographic Visualization



Combined Model

Data visualization is confined within the borders of symbolic representation. It can only start when data already exist. Therefore, the circumstancess of data generation and the precise relationship of a data set with the phenomenon it describes often remain obscure. While data sets often contain signatures that point to how they were collected, a gap remains between data and the phenomenon of interest. Because of this gap, we often find it difficult to reconcile the results of a data analysis with experiential phenomena, especially in the cases of environmental pollution or global warming.

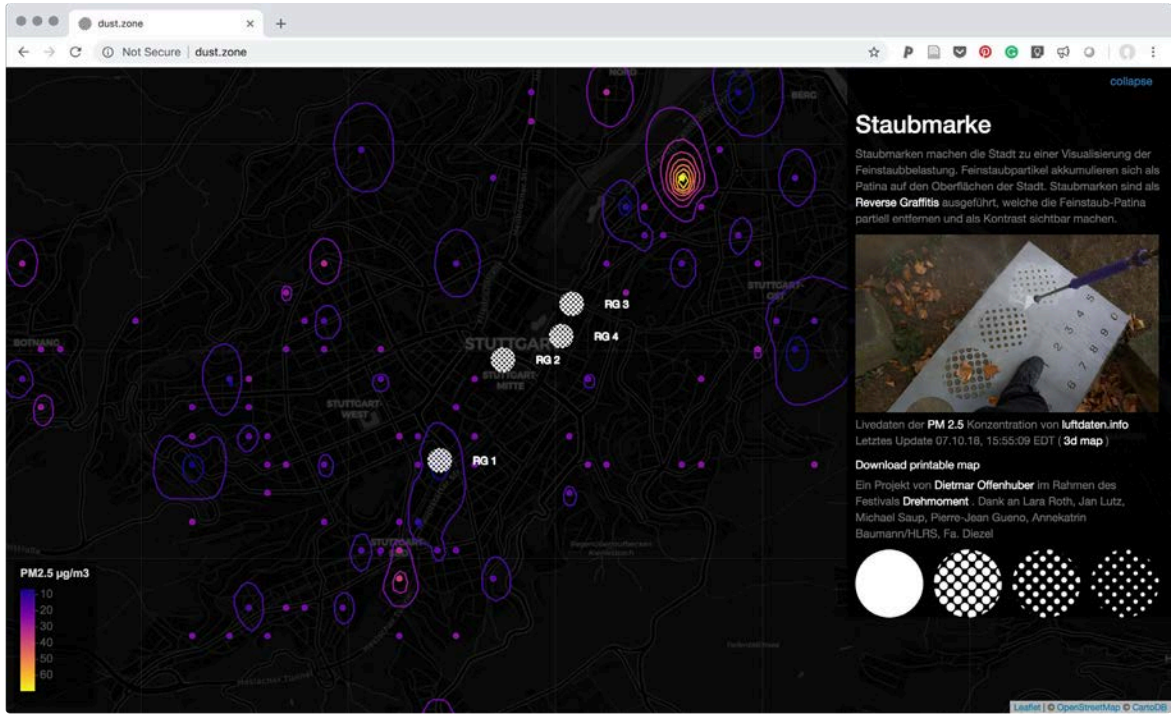
Autographic (and indexical) visualization operate at the material bases of data: physical traces and other forms of environmental information [7,8,9]. Autographic visualization is defined as "a set of techniques for revealing material phenomena as visible traces and guiding their interpretation. Designing an autographic display means setting the conditions that allow a trace to emerge" [7]. A trace is understood as any material structure or constellation that can present itself to the senses. While data visualization supports the interpretation of data, autographic visualization makes the origin of a datum and the process of its generation legible. Since data analysis is more versatile than the manipulation of physical traces, a gap remains between data and analysis.

A combined model of symbolic data analysis and visualization with an autographic display of the underlying physical phenomena allows a transgression of the boundary between vthe world of symbols and the physical realm. It offers a critical approach that makes visible the assumptions and decisions behind acts of measurement and calls attention to the material nature and contexts of data.

Figure: Conceptual model of InfoVis, autographic visualization and a hybrid model, from [7]

Staubmarke (dustmark)
http://dust.zone
Public space installation
Drehmoment Festival Stuttgart, October 2018

Foto: Frank Kleinbach



Stuttgart is one of Germany's cities with the worst air pollution, suffering under frequent episodes of particulate matter pollution exceeeding the WHO criteria values.

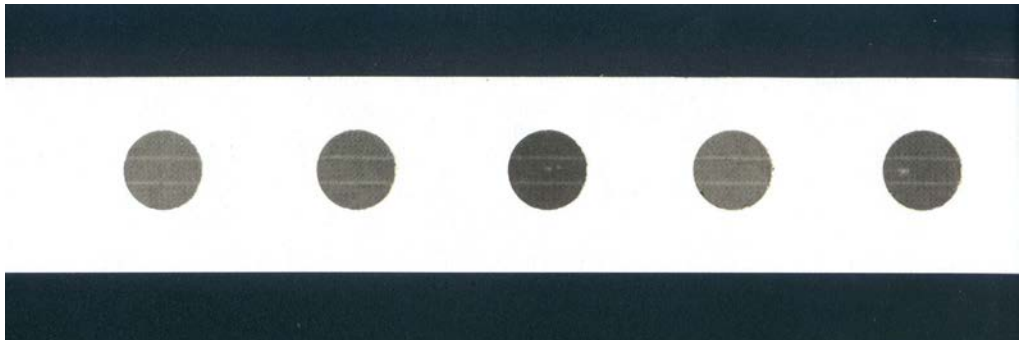
Since the city is a major center of the German car industry, blamed by many for the environmental condition, air quality is an intensely political issue in Stuttgart.

In the course of this controversy, citizens often mistrust and critique official measurements and sensing methodologies. In response, citizen science enthusiasts have founded *luftdaten.info*, a sensing initiative of self-assembled air-quality sensors and an online platform for archiving and disseminating crowd-sourced airquality data.

It is striking that such public controversies often quickly converge on questions of the appropriate methods and tresholds of measurement [4]. It does not help that common metrics for measuring particulate matter are highly reductive, representing only certain qualities of the invisible phenomenon. These circumstances make it tempting to treat air pollution as a single, abstract number.

Above: community-built dust sensor by @ airrohr, source: https://twitter.com/airrohr/status/914154105941237760

Below: staubmarke website with live data from http://luftdaten.info



At the same time, particulate matter is a phyical material, visible on used dustmasks, and accumulating on all surfaces of the city.

Staubmarke introduces a uniform visual pattern to make the urban patina and the process of its accumulation legible. Using the technique of reverse graffiti, which creates visible patterns by partially cleaning surfaces rather than applying paint, visual markers are applied in public spaces of the city.

The chosen locations are monitored by airquality sensors from the *luftdaten.info* initiative, and the highest daily average value during the past month is displayed on the graffiti.

As more dust accumulates, the dustmarks will slowly fade away. Due to the design of the pattern, the finest parts will disappear first, allowing to estimate the speed of the process. Observation of the patterns over the following year will offer new insight into this process.

It might be objected that the patina consists of more than just particulate matter. This is true, but also official metrics do not capture the phenomenon in its complexity. Staubmarke is meant to inspire reflection about the materiality of data and their processes of measurement.

Top-left: sample of particulate matter for gravimetric analysis, courtesy Frank M. Rauch, wikimedia.

All other photos by the author.

Dustmarks, four months after their application

Fotos: Frank Kleinbach

Anatomy of a dustmark

Reference pattern
Making the degree of dust accumulation visible, legible and comparable.

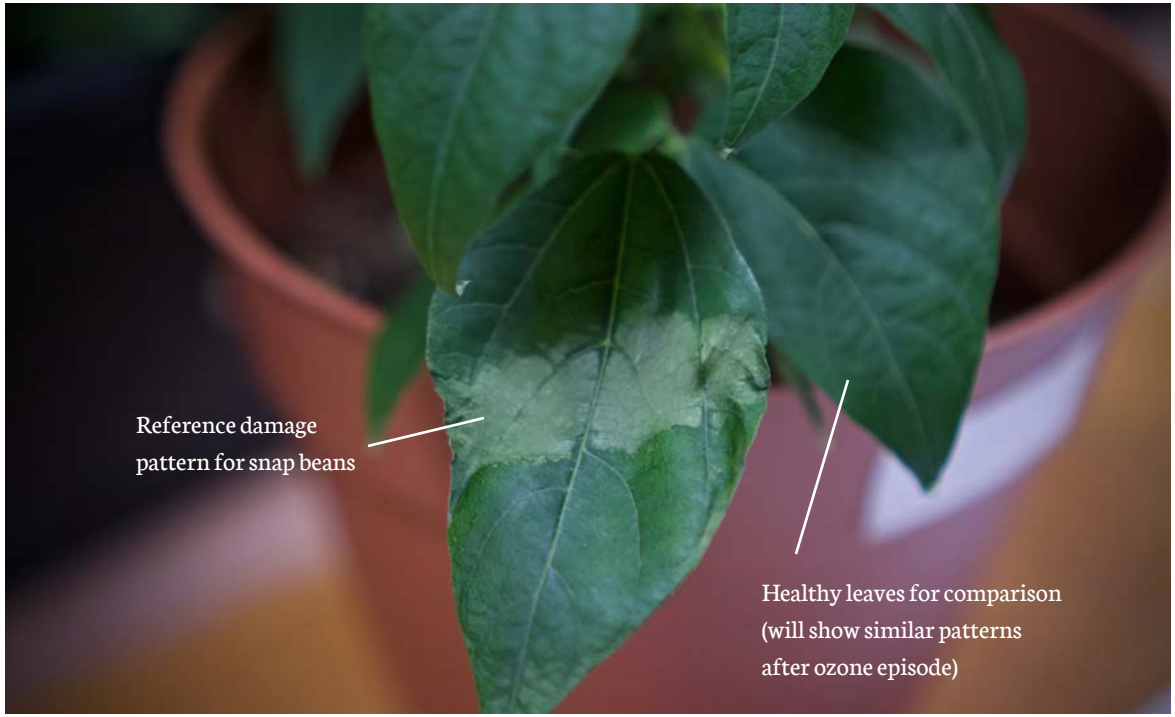
Gradient
The finest part of the pattern will disappear first, revealing the process of reaccumulation

Contextualizing digital information
Link to live visualization, and sensor value.

Ozone Tattoo

Public space installation
Cambridge Arts Council, May 2019

Project partners:
Dr. Vehram Elagoz, Lesley University
Dr. Kent Burkey, USDA ARS Maryland

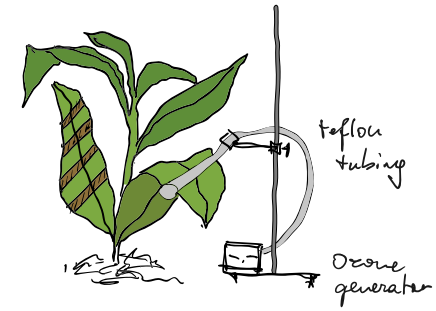


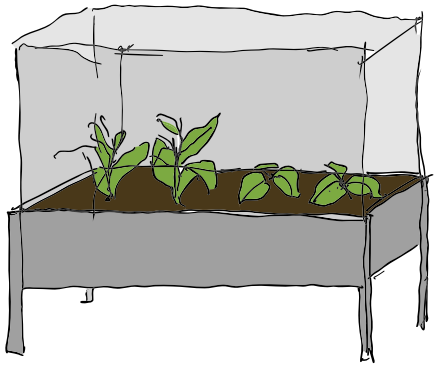
Groundlevel ozone a serious pollutant that puts humans, plants, and animals at risk. It is a side effect of air pollution assciated with fossil fules and is connected to global warming. Groundlevel ozone emerges mainly on hot summer days. Researchers estimate that the increasing intensity of summer heat waves will lead to a 70-100% increase in ozone episodes [10].

Compared to particulate matter, ground-level ozone is more difficult to measure and rarely covered by air quality stations. Ozone (O_3) is highly volatile, and calibration issues make sensors unaffordable for amateurs.

Ozone episodes can be reliably detected by observing certain indicator plants, including tobacco, snap beans, or cone flowers. Each of them responds with characteristic damage patterns.

Ozone Tattoo uses plants as bio-indicators to visualize ozone pollution. It is based on the established citizen science approach of planting ozone gardens, which allow communities to monitor pollution by observing plants that are sensitive to ozone and react with visible symptoms [3]. To make the damage to plants more legible, we developed the novel method of ozone tattoos. The tattoos are damage patterns on the surface of the leaves, created by localized exposure to ozone. These damage patterns act as a biological visualization that allows us to decode the impact of the pollutant through visual comparison with the healthy portions of the leaf.





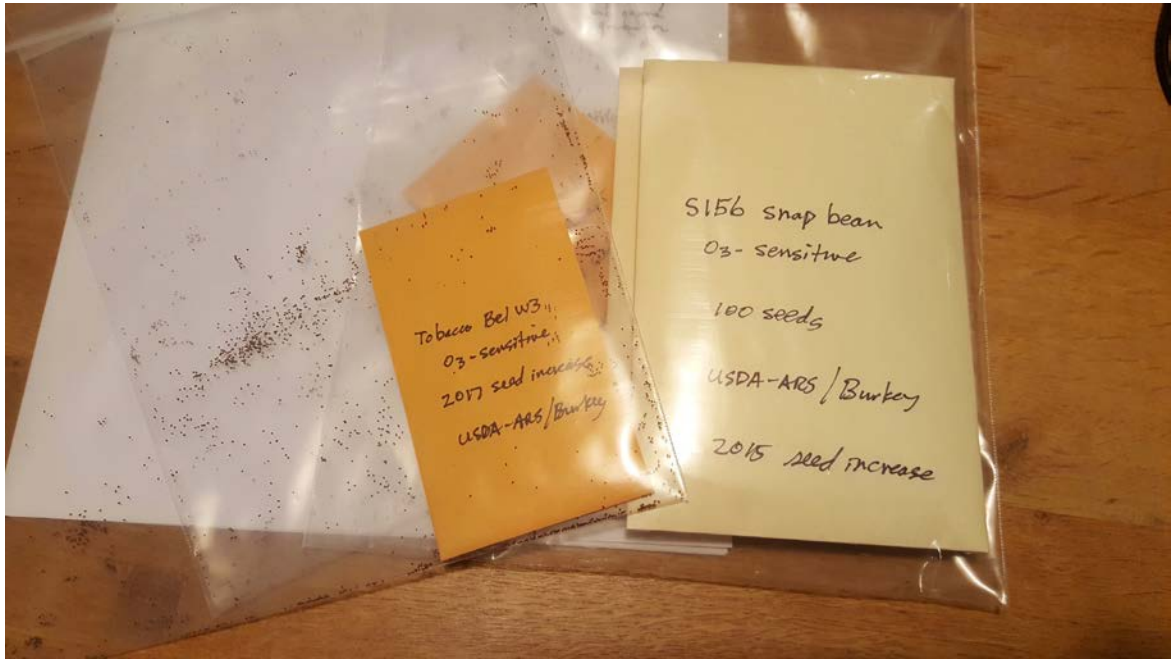
leaf areas exposed to ozone

Exposure to 0,4 ppm Ozone for 24

Tobacco O_3 sensitive O_3 tolerant

Snap bean O_3 Sensitive O_3 tolerant

The ozone tattoo machine uses a weak ozone generator based on electric corona discharge, a fan and and a tubing system of teflon and silicone tubes that bring the ozone to the leaf before it dissipates. Final ozone concentrations used were between 0.1 and 0.3 ppm.



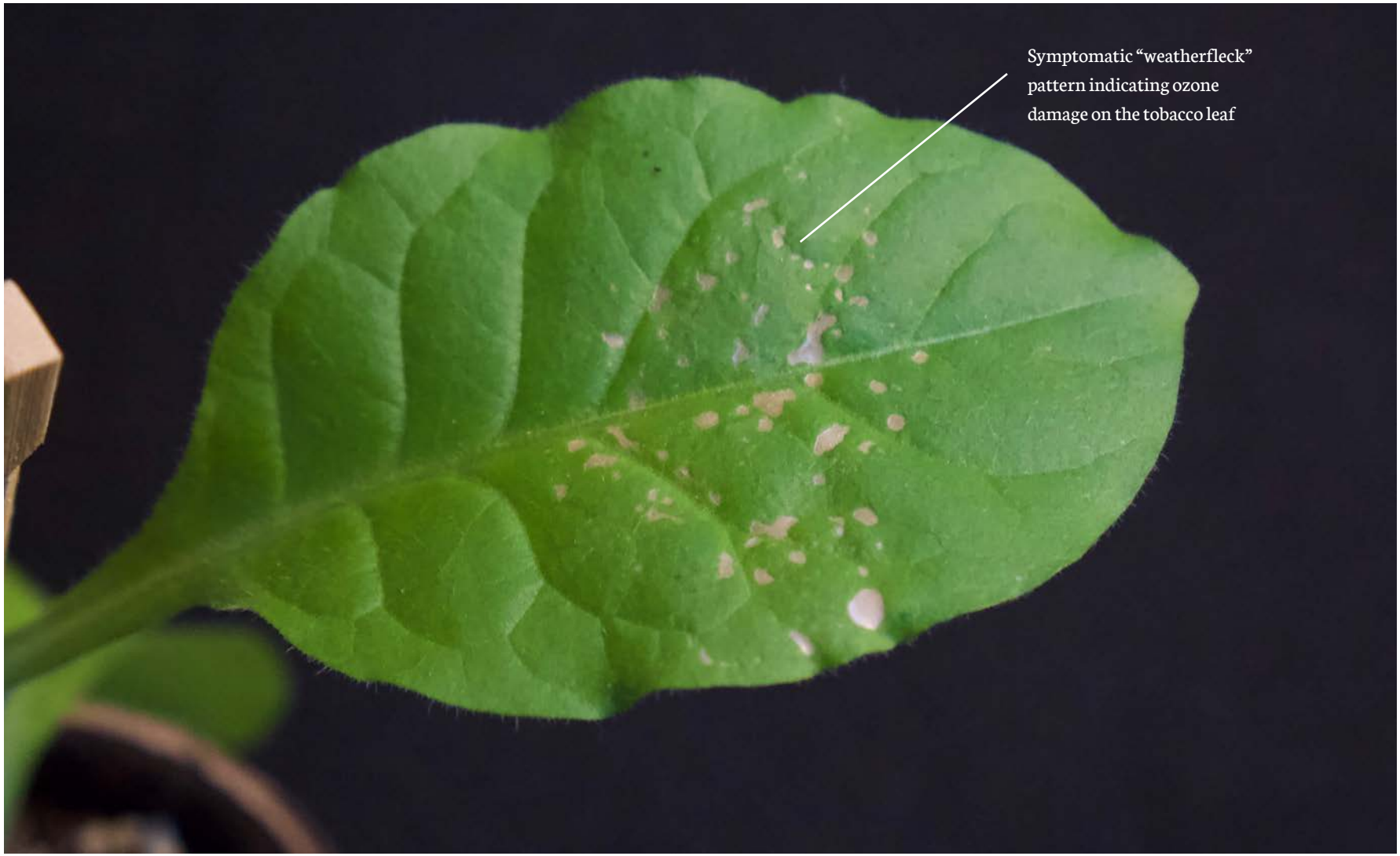
Ozone indicator system based on a combination of ozone-sensitive and tolerant variations of the same plant. Comparison of ozone damage on both allows estimating the ozone concentration [1,2,5].

Seeds provided by USDA Agricultural Research Service (ARS):

- Snap beans: S156 (O_3 sensitive) and R123 (O_3 tolerant) genotypes of Phaseolus vulgaris L.
- Tobacco: Bel-W3 (O_3 sensitive) and Bel-B (O_3 tolerant)

Ozone Tattoo on a tobacco leaf

Tobacco BEL-W3 (O_3 - sensitive)



Experimental Ozone Tattoos with different fumigator end pieces

Tobacco BEL-W3 (O_3 sensitive)

This pattern indicates acute rather than chronic ozone damage, the damaged areas are larger due to higher ozone concentration.

Ozone Tattoo resin casts

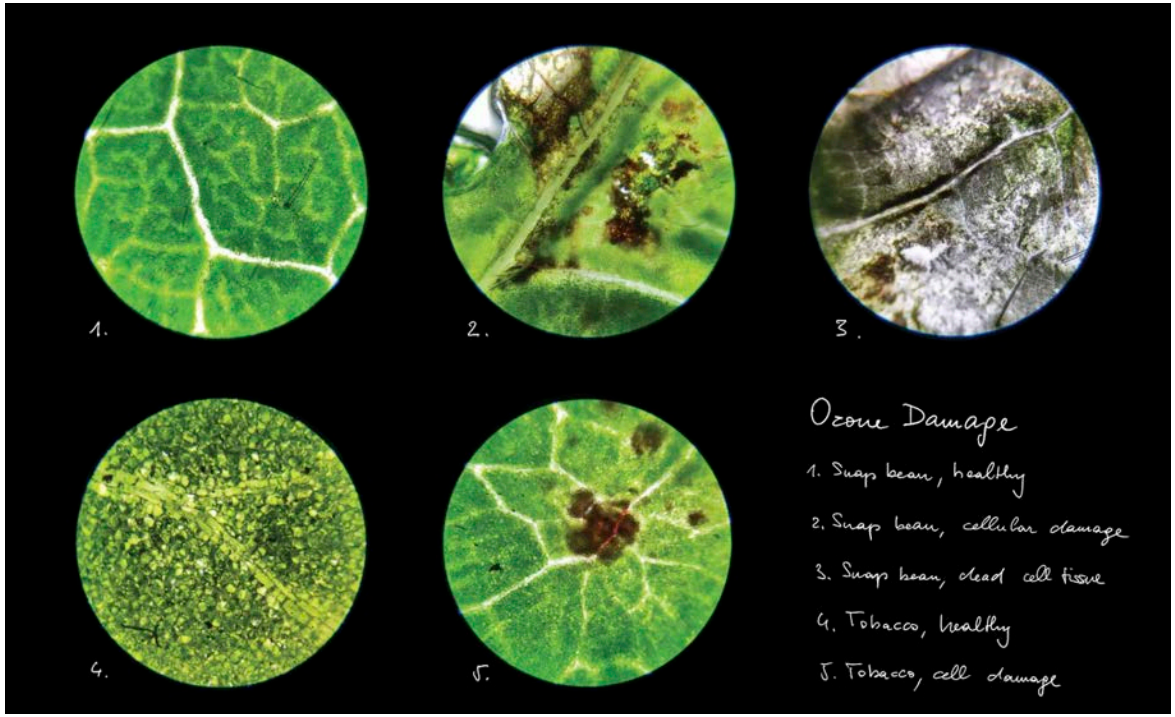
Documenting different ozone tattoo experiments as physical specimen.

Ozone tatoo showing different degrees of ozone damage.

Ozone tatoo with extensive damage, could occurr in extreme episodes of summer ozone.

Weatherfleck - chronic ozone damage, typical for environmental ozone episodes.

Ozone tattoo machine and tobacco plants exhibited at Cambridge Art Council Gallery, https://www.untoldpossibilities.org



Views of leaf damage on snap bean and tobacco plants through a light microscope views.

Ozone Tattoo Ozone Garden

Different sections of O_3 sensitive and tolerant varieties of tobacco and snap bean allow the detection of ozone episodes and the estimation of their severity. The tattoos on each plant help identifying the damage and serve as a contrast for comparison.

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