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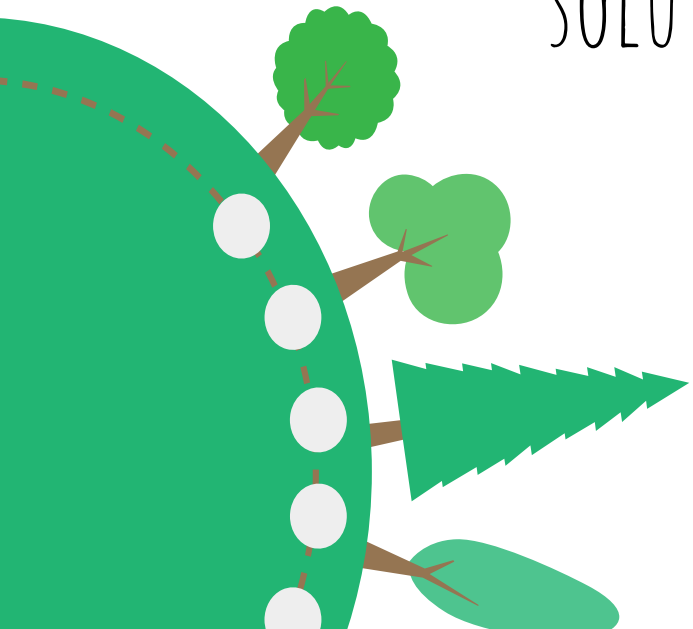
Should we see urban trees as effective solutions to reduce increasing ozone levels in cities?



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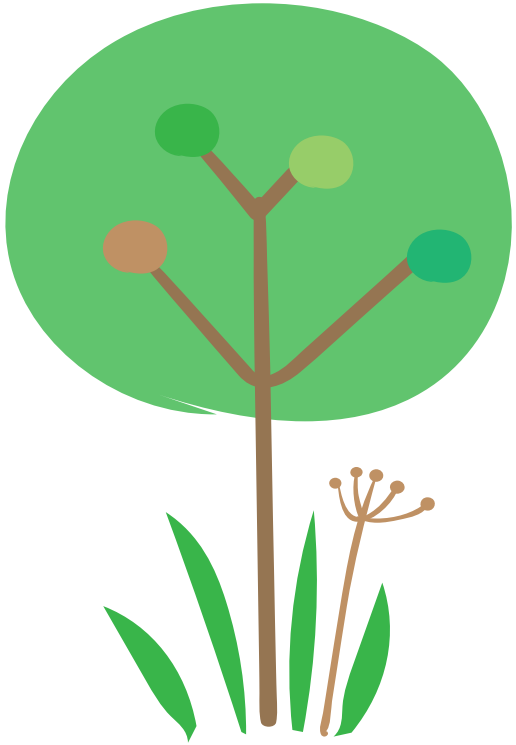


Results in a nutshell

Our observation

Should we see **electric vehicles** as effective solutions to reduce increasing ozone levels in cities?

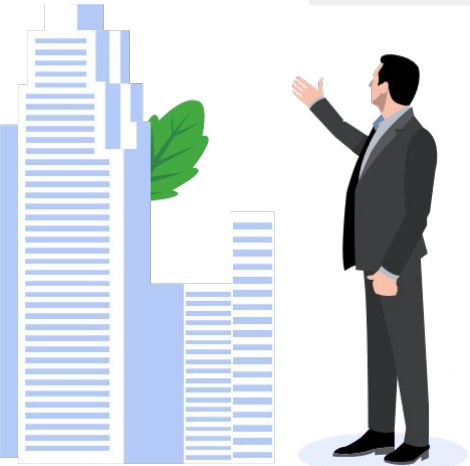
DESCRIPTION OF THE PROBLEM

The rising surface ozone pollution in cities is a public health concern worldwide

Exposure to air pollutants such as **particulate matter (PM)**, **nitrogen oxides (NOx)**, **sulfur dioxide (SO2)**, and **surface ozone (O3)** are associated with respiratory and cardiovascular diseases and mortality. Ozone and PM are the most threatening air pollutants in cities in terms of harmful effects on human health

Annual mean concentrations of O3 have been increasing by on average 0.16 ppb year-1 in cities across the globe over the time period 1995-2014.

Green urban infrastructure can improve air quality **by removing O3** and reduce air pollution and greenhouse gas emissions, regulate air temperature, mitigate storm-water runoff, reduce noise, as well as provide recreational, social, psychological, and aesthetic benefits



Trees show higher O3 removal capacity (3.4 g m2 year-1 on average) than green roofs (2.9 g m2 year-1 as average removal rate), with lower installation and maintenance costs (around 10 times).

In urban densely populated areas, where it is not always easy to plant trees, **green walls and green roofs** can be used **to supplement the use of urban trees** in air pollution control improving air quality in cities.

The green urban infrastructure

Defined as **a network of natural and semi-natural green spaces** such as forests, parks, green roofs and walls, can provide **nature-based and cost-effective solutions** and contribute to ecosystem resilience and human well- being through ecosystem services from urban centers to peri-urban areas.

It showed the **ability to ameliorate urban air quality** (including PM, NOx, SO2) across urban areas worldwide and thereby enhance citizen well-being

Results in a nutshell

1

More than 80% of people living in cities are exposed to levels exceeding WHO guidelines for PM2, PM10, and O3 (WHO, 2016).

2

Tree planting could be a viable strategy to improve air quality in urban areas and is beneficial for citizens' well-being;

3

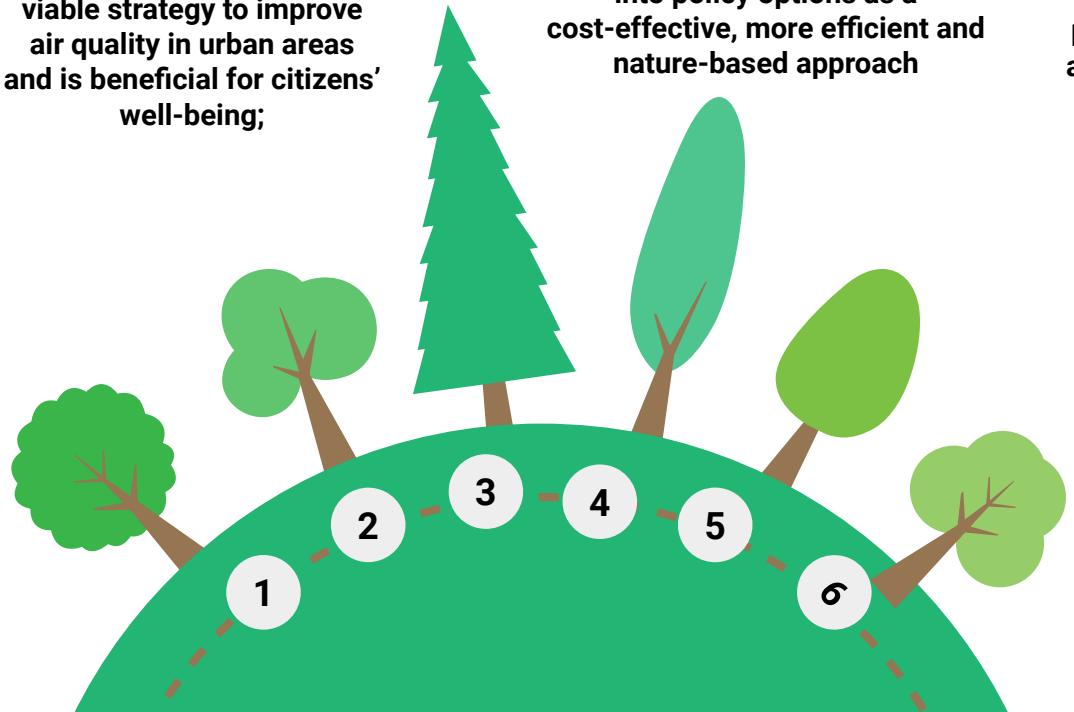
Urban vegetation can be considered into policy options as a cost-effective, more efficient and nature-based approach

4

Urban forests hold a key role in O3 removal and provide a perspective for achieving healthier cities.

5

Green roofs can be used to supplement the use of urban trees to improve air quality in a densely populated city.
But they are less effective than urban trees to remove O3 due to lower species-specific stomatal conductance, surface roughness and LAI



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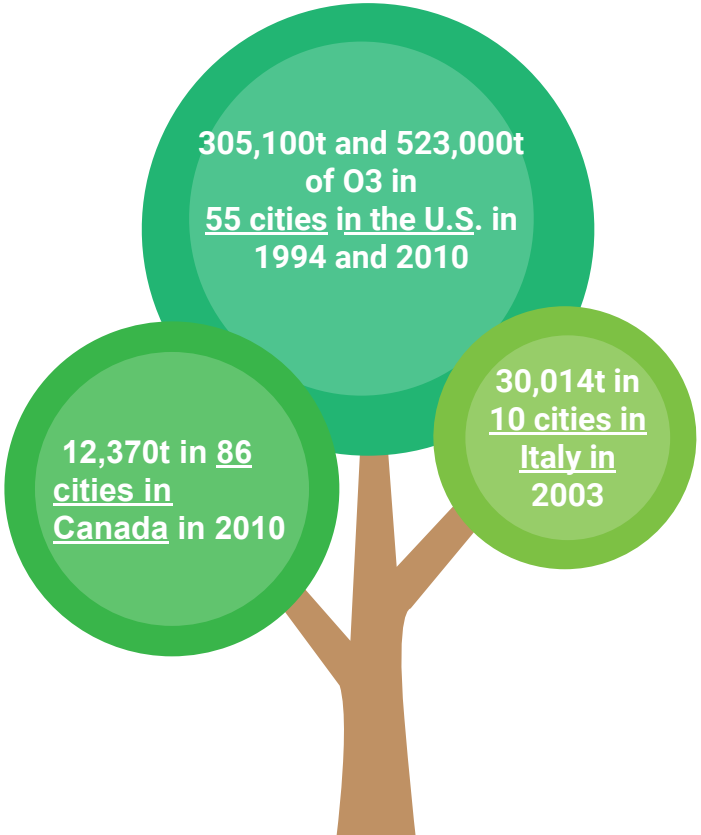
Public trees 03 removal rate shows higher results

By **applying the UFORE/i-Tree dry deposition mode** a number of studies showed that public trees, i.e. trees managed by the municipal authorities, removed…



The **O3 removal rate** widely **vary worldwide:**

1

The **highest standardized O3 removal rates** (>0.30 g m2 per ppb of O3) are observed in Los Angeles, San Diego, Chicago,Toronto and Perth
The **lowest removal rates** (<0.10 g m2 per ppb of O3) are found in Santiago, Mexico, Quebec, Melbourne and Northern Europe

2

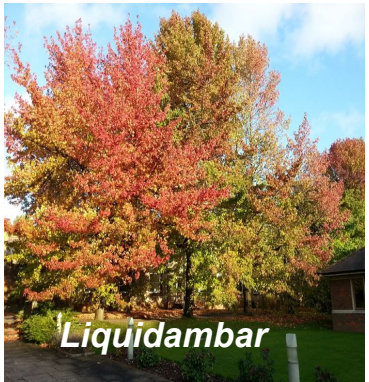
The **standardized removal rates differ among cities** according to the amount of air pollution, length of in-leaf season, precipitation and other meteorological variables

3

The **optimal effect** is observed **during the daytime of the in-leaf season** while the O3 removal by trees at night is limited due to stomatal closure

Species-specific ozone removal capacity

Based on standardized O3 removal rates, estimated by dry deposition models and expressed per leaf area and day of growing season, the **tree species** considered as **top rated species for reducing O3 pollution** are:



Overall, broadleaf tree species remove more O3 than conifers because of higher stomatal uptake

Mediterranean evergreen tree species remove more O3 than deciduous tree species because of a longer growing season

Dry deposition processes account for about 25% of the total O3 removed from the troposphere

How authors faced it:

Ozone Removal By Green Roofs

From 20% to 30%

Roofs can represent up to 20% to 30% of the horizontal surface of built-up areas

Green roofs are ideal for

Short grass, Tall perennial herbaceous plants and shrubs and Small trees

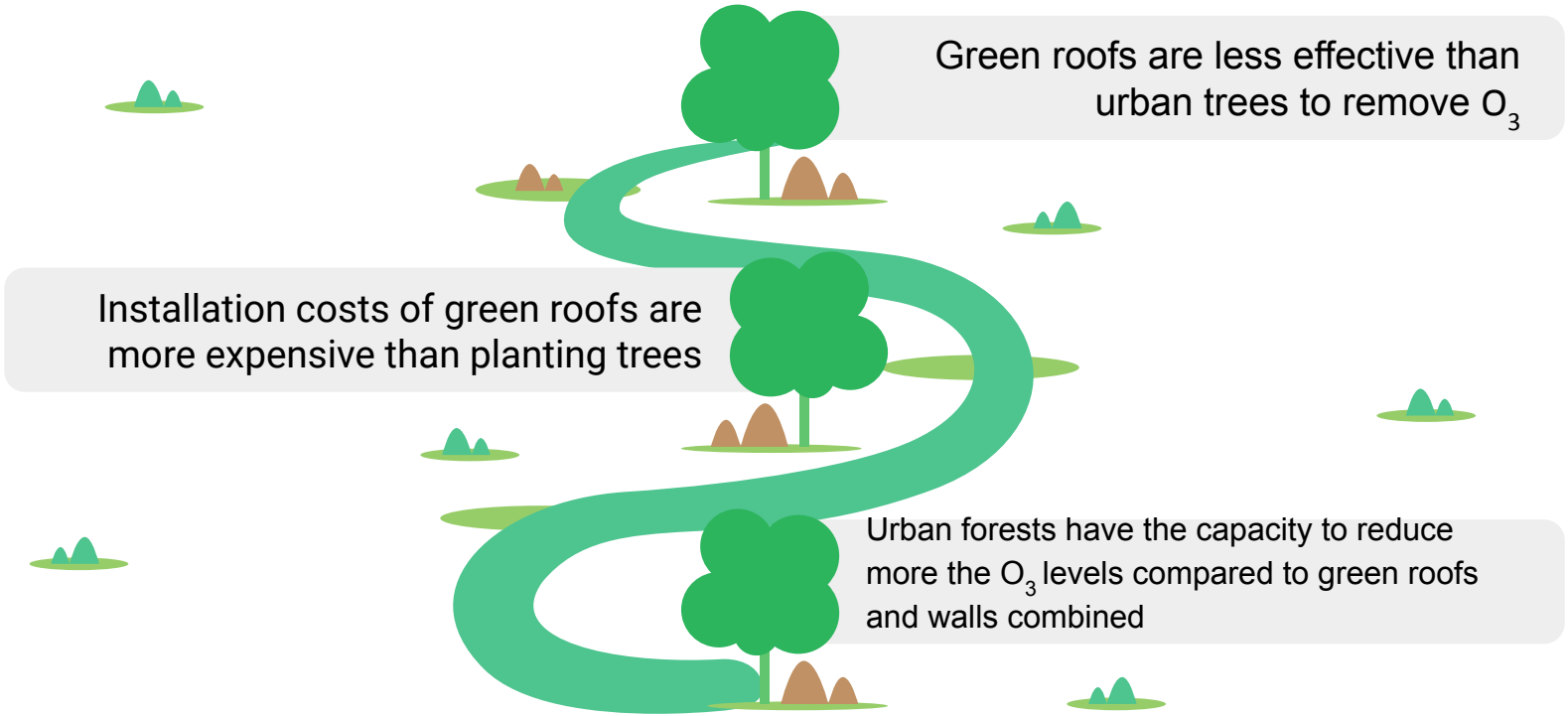
Vertical Greening Barrier

Vertical greening can also be a barrier between a high source of air pollutants like roads, for example

Annual Removal of Ozone

According to the (UFORE/i-Tree) dry deposition models, the annual removal by green roofs ranged 1.2 to 4.4 g m^{-2} $year^{-1}$, with standardized O_3 removal rates from 0.07 to 0.23 g m^{-2} per ppb of O_3:

Urban trees are a more efficient and cost-effective nature based solution



Green roofs are less effective than urban trees to remove O_3

Installation costs of green roofs are more expensive than planting trees

Urban forests have the capacity to reduce more the O_3 levels compared to green roofs and walls combined

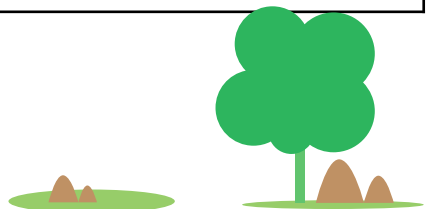
Urban forests have the capacity to reduce more the O_3 levels compared to green roofs and walls combined

Melbourne

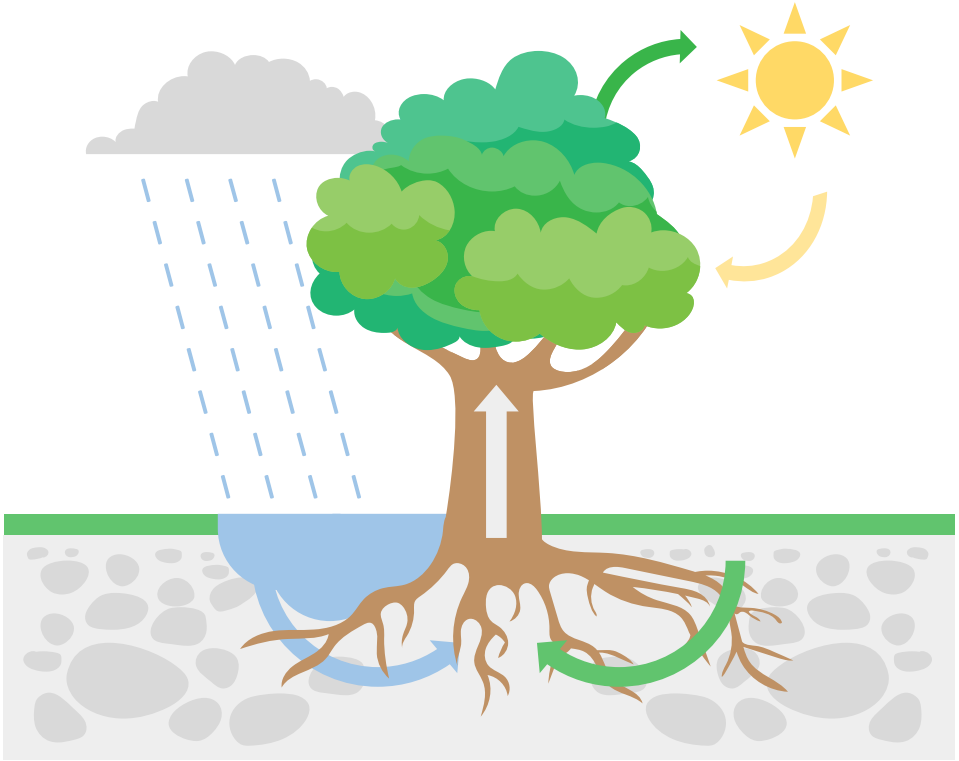
	Amount of trees	O3 Removed annually
Urban forest	10 trees per ha	246 kgs of O_3
New Trees	80 trees per ha	1885 kgs of O_3
Green Roofs	28,9 ha	357 kgs of O_3
Green Walls		298 kg of O_3

Toronto

	Amount of O3 removed annually
Trees and Shrubs	10,7t of O3
Green walls	1,1t of O3
Green Roofs	1,3t of O3

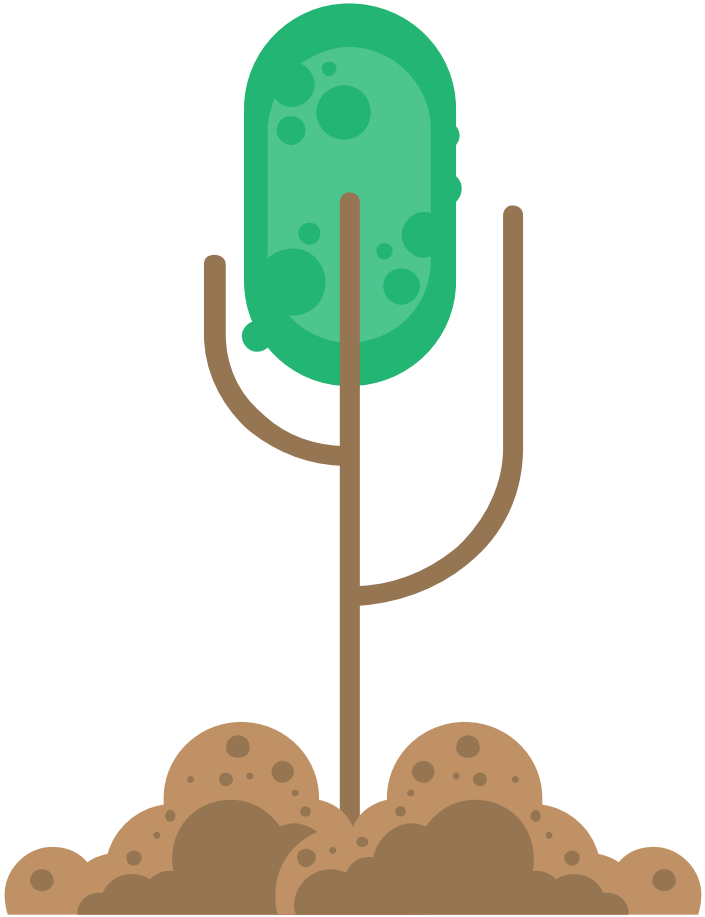


Model Improvements



Although parameters were the same for all the cities evaluated, when reading the results, it is important to take in consideration the particularities of each place, to understand the results better

Planning the green infrastructure



When planning the Green Urban infrastructure, it is important to keep in mind the environmental conditions of the available areas in the urban centers to optimize the plant's choices.

Ranking plant species for air quality improvement

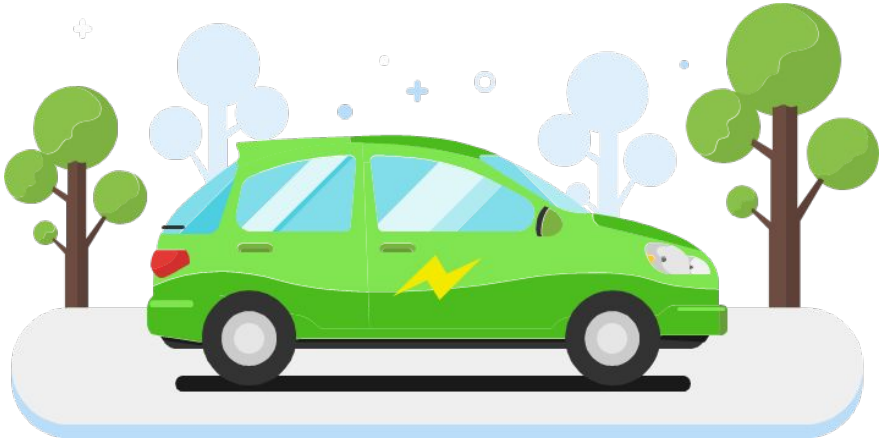
Allergenic Trees

When choosing the plants, it is important to find the species where the pollen emissions are not so high

BVOCs Emissions

Where we should consider the ones with low rates and keeping in mind the temperature of the city in question

Should we see **electric vehicles** as effective solutions to reduce increasing ozone levels in cities?



The problem and puzzle of ground-level ozone
Ozone is a significant environmental problem, to which road transport contributes significantly.

→ **Ozone (O3)** is both a toxicant and a greenhouse gas. **At ground level, it is a noxious pollutant**. In the higher atmosphere, it is beneficial to life

→ **Ground-level ozone is created by nature**, but the primary **cause of exceedances** is ozone **created by human activity**

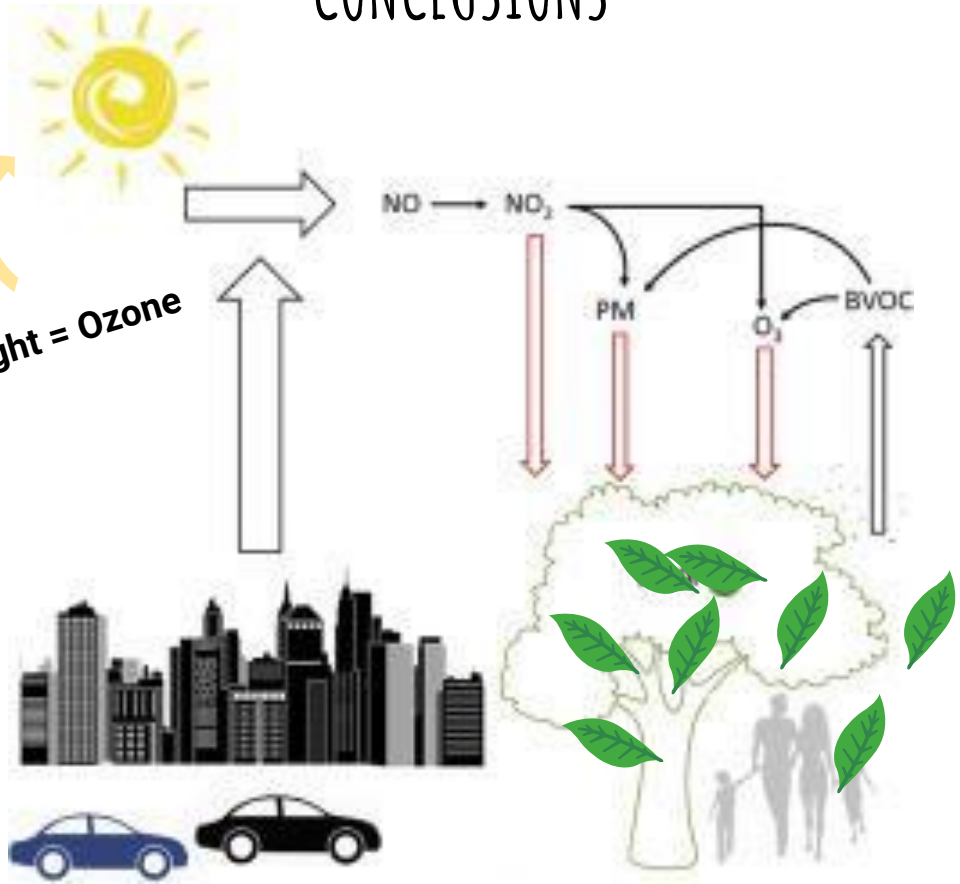
Two surprises

Reductions in urban NO emissions can lead to increases in ozone concentrations

$$NO + O3 \rightarrow NO2 + O2$$

Ozone concentrations over time tend to be **higher in rural than in urban areas**

CONCLUSIONS



NOx + VOC + Sunlight = Ozone

We conclude that the most advantageous proposal, for the moment is in fact the urban green areas mainly because of its capacity to filter air pollutants.

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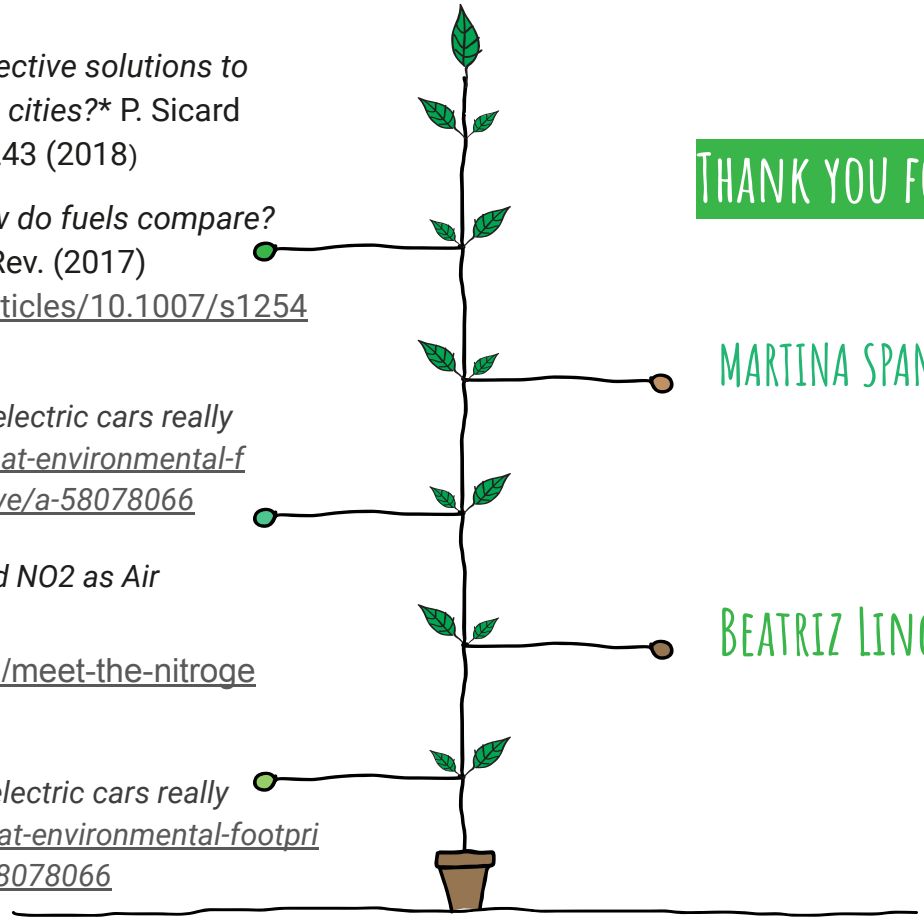

Thank you for your attention

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