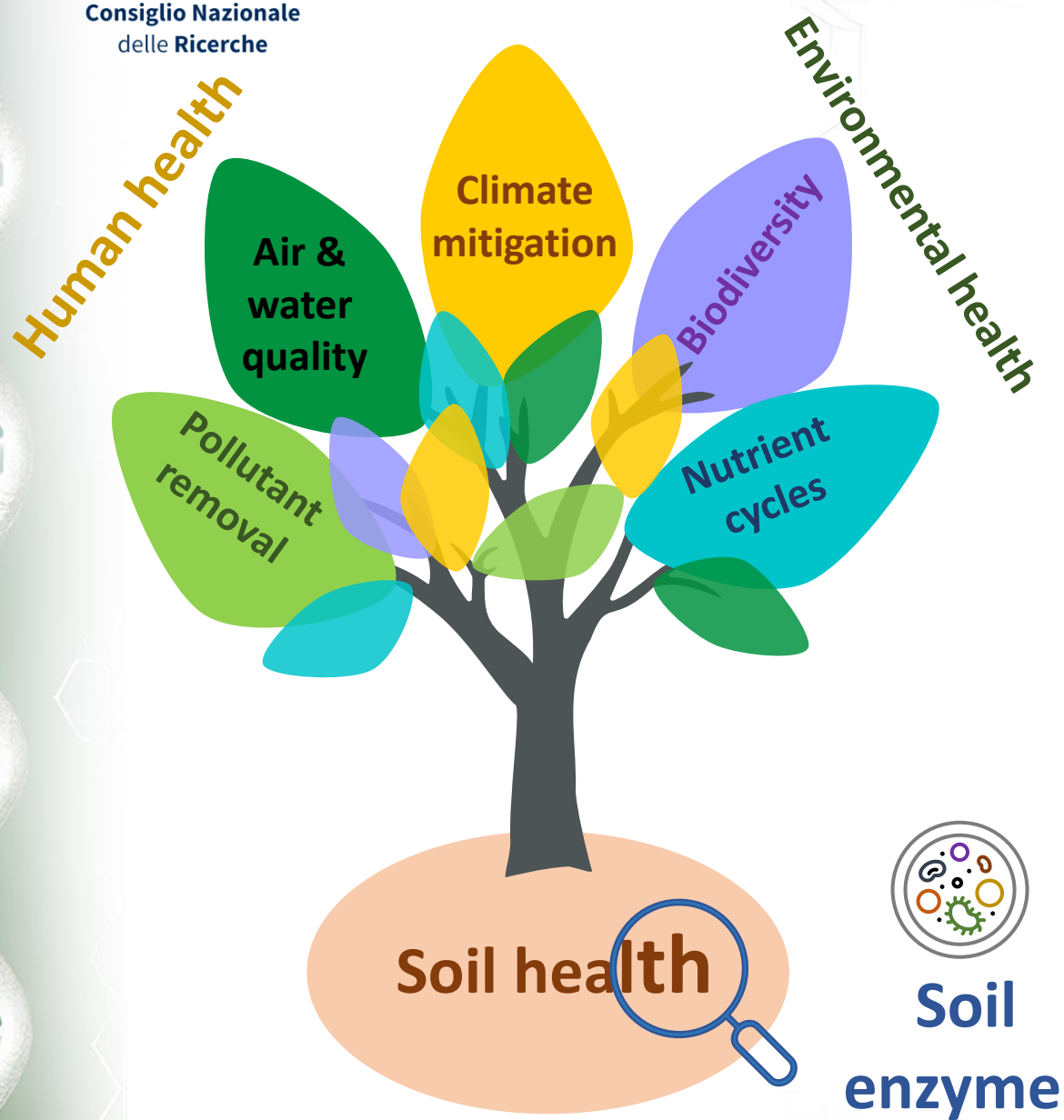
Soil health indicators to assess the effectiveness of nature-based solutions and restoration actions in degraded areas

Francesca Vannucchi
IRET-Sede di Pisa



Ecological indicators

- ✓ **Specific** for processes and functions
- ✓ **Easy** to measure
- ✓ **Sensitive** to stress and disturbances

Soil enzymes

Stable isotopes

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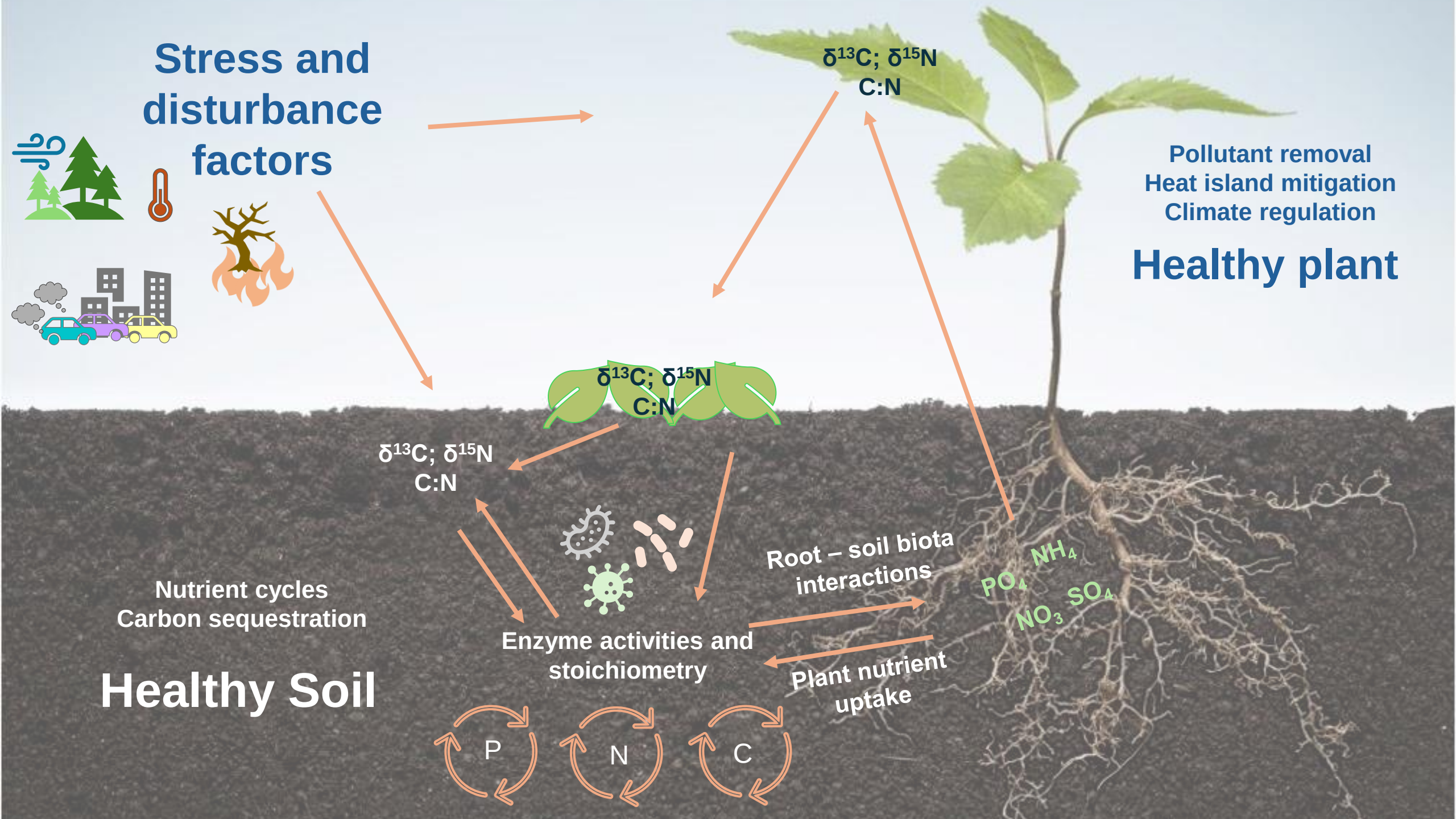
NBFC Land — Spoke 4

NBFC Urban — Spoke 5


Stress and disturbance factors
δ13C; δ15N
C:N
Pollutant removal
Heat island mitigation
Climate regulation
Healthy plant
δ13C; δ15N
C:N
δ13C; δ15N
C:N
Root – soil biota interactions
NH4
PO4
SO4
NO3
Nutrient cycles
Carbon sequestration
Enzyme activities and stoichiometry
Plant nutrient uptake
Healthy Soil
P
N
C

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Design, application, and management of restoration actions for degraded land recovery

NBFC Urban

Nature-based solution efficiency in providing ecosystem services in urban areas

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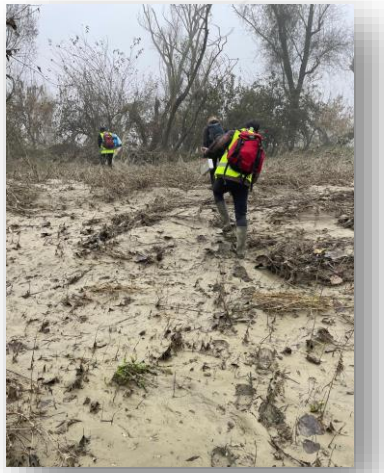
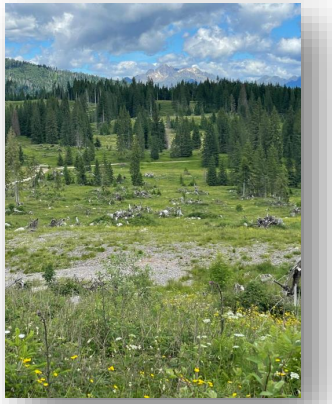
Spoke 4 activity 4.5.2

Post-fire sites



Riparian areas

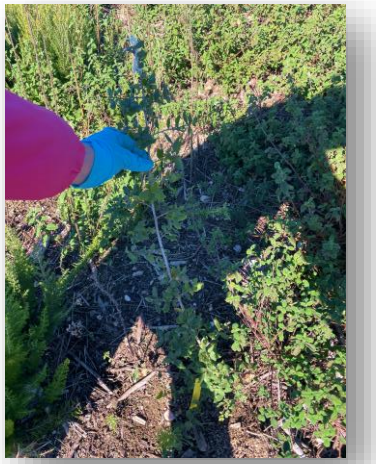


Restoration action

Post-storm sites

Validation

Application



Nature-based Solutions

Post-fire: Monte Pisano

Stable isotopes and enzymes are **efficient indicators** to **fire intensity**

	Unburned sites	Burned sites	2 years post-fire	5 years post-fire
Chestnut			**No** nutrient cycle **alterations** 	**Fast** soil and vegetation recovery 
Pine tree			Nutrient cycle **alterations**  Nutrient availabilities	**Slow** soil and vegetation recovery 

Vannucchi et al. *Evaluating postfire soil recovery in pine and chestnut forests under Mediterranean climates* **in preparation**

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Post-fire: La Verruca

UNIVERSITÀ DEGLI STUDI FIRENZE

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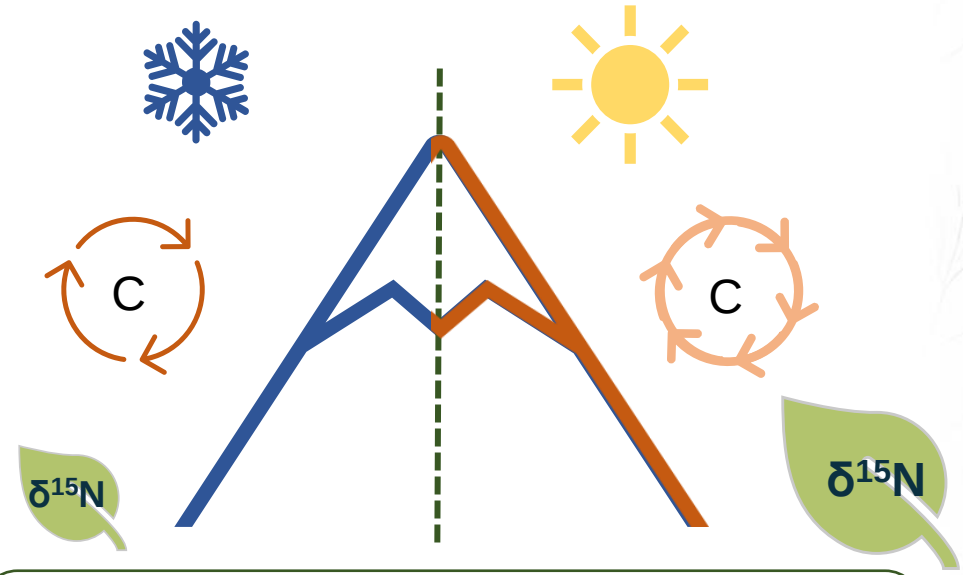
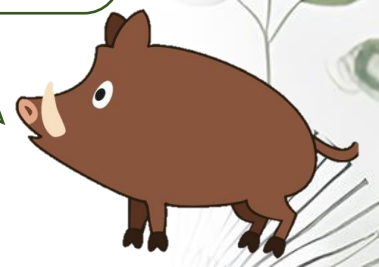
NbS suitability for soil quality recovery in **post-fire** sites

Quercus suber L.

- Seed collection
- Nursery cultivation
- *In situ* plantation



Microclimatic condition seems to affect **carbon cycle** and **plant isotopic composition** in NbS



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Riparian plantations

Po Vercellese

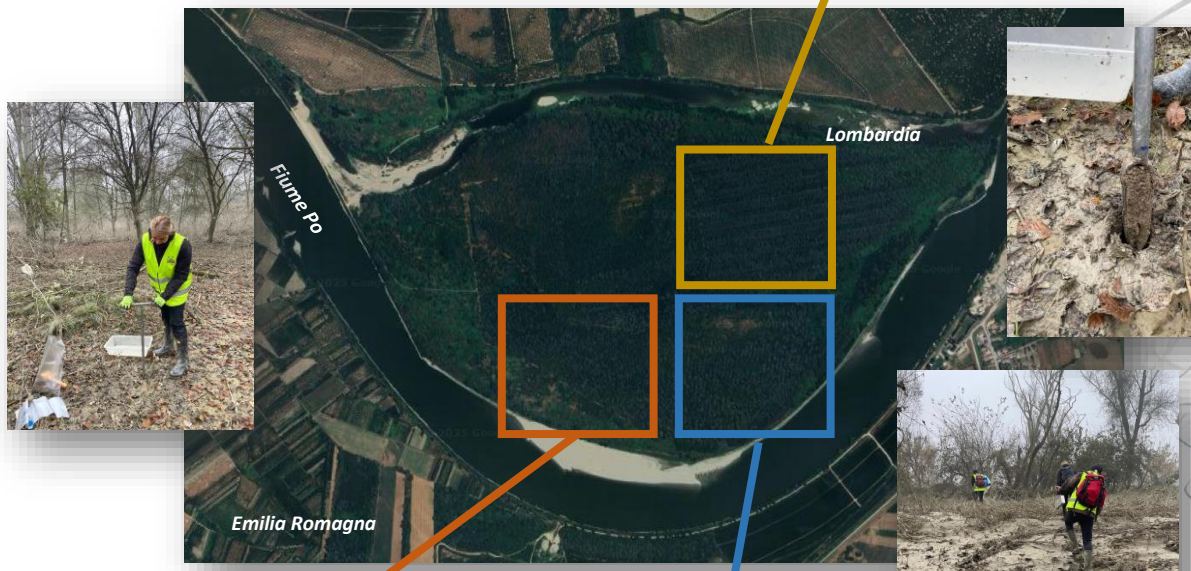
Spolier Alert

What are the drivers of plant diversity in poplar plantations?

Poster session: Trentanovi et al.

Isola Maria Luigia

Future interventions

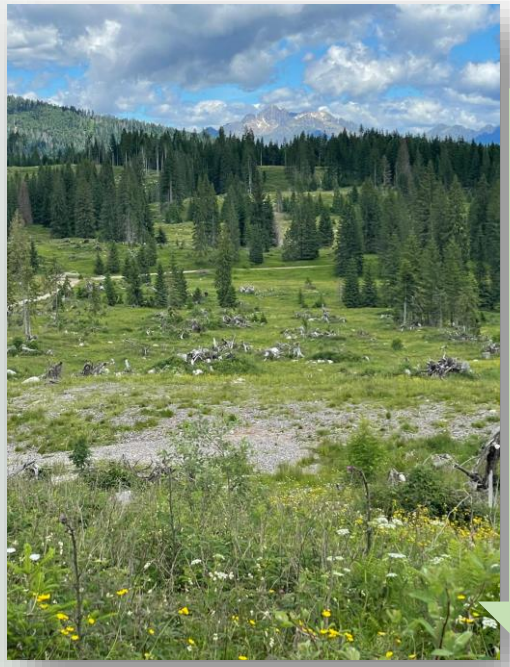


Thinning and 20% biomass removal (2021-2022)

Control (no thinning)

The **thinning** and 20% **biomass removal** did **not affect** the soil **nutrient cycles**

Post-storms: Asiago



- Inner woodland stand
- Transition area
- Restoration area (new plantations)
- Spontaneous vegetation evolution

Changes of **carbon and nutrient sources** seems to affect the **soil carbon cycle**

? *Soil carbon sequestration*

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Spoke 5 activity 4 task 4.1

Selection of the main **Italian metropolitan cities**

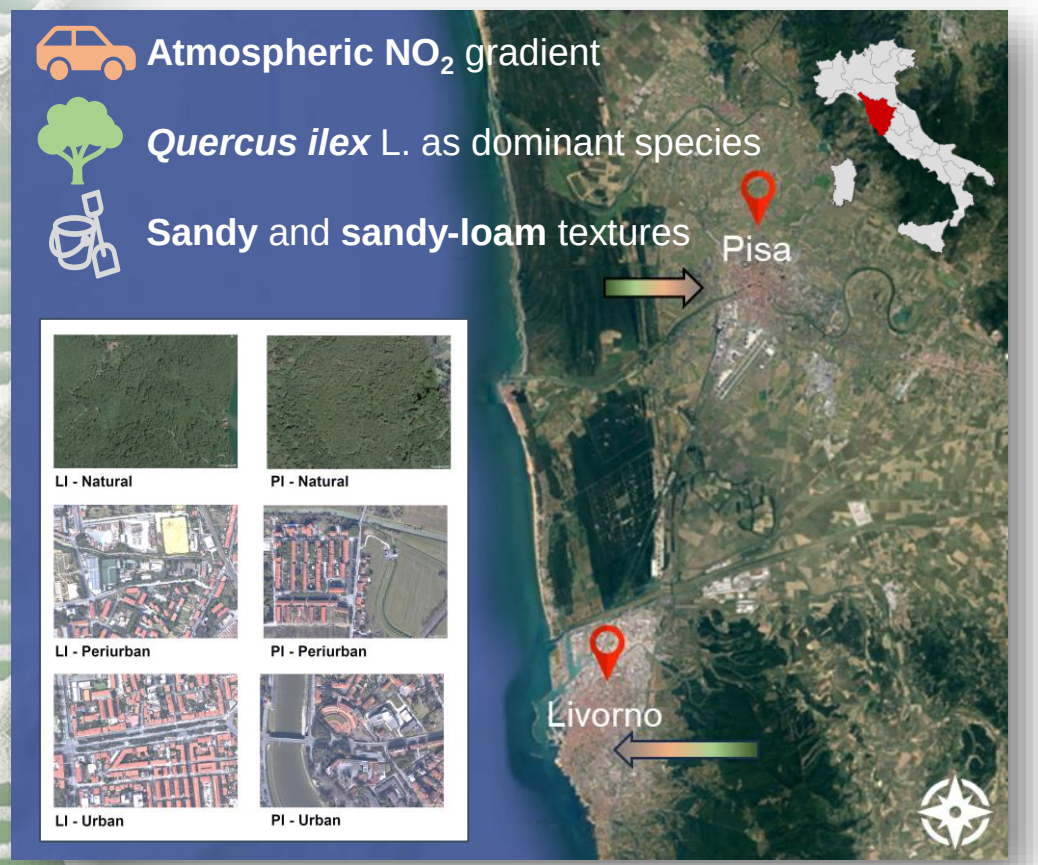
Design of sampling plots in urban **NbS** and along an **urbanization gradient** close to weather and pollution monitoring stations

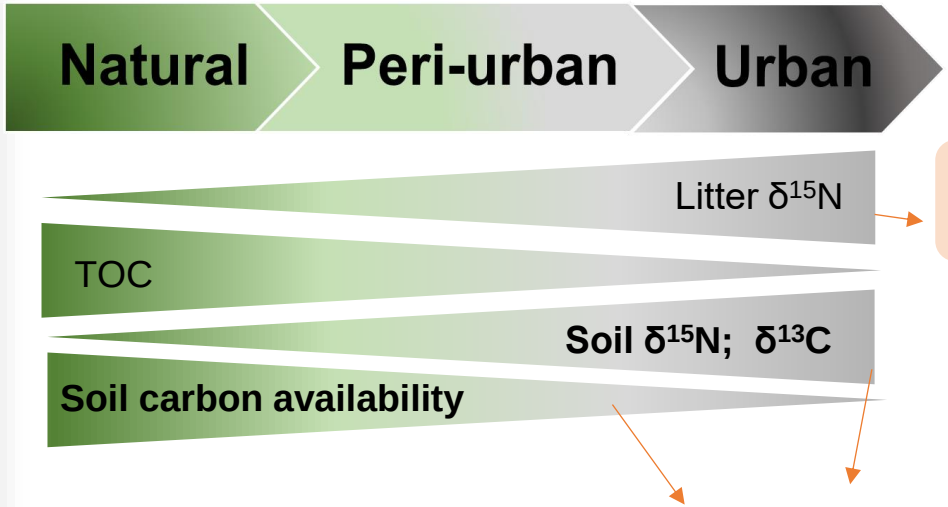
Natural → **Peri-urban** → **Urban**

Climate and **air quality** data monitoring (open data sources)

Soil health and plant functionality monitoring

Urbanization



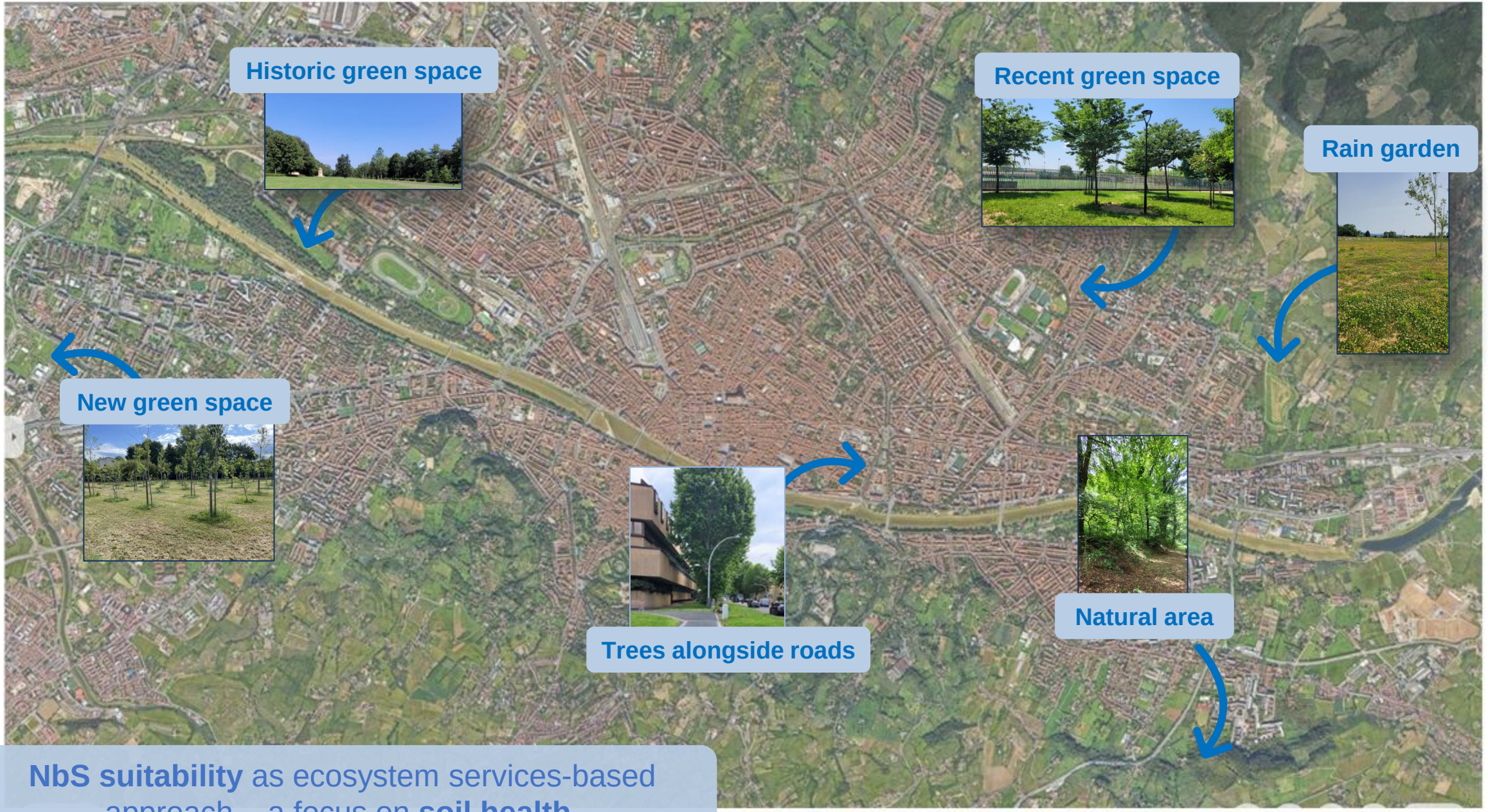


Sensitive indicator of atmospheric N deposition

Faster mineralization process

Changes in stable C and N isotopes and enzyme activity ratios were correlated to soil properties and atmospheric N deposition

Vannucchi et al. (2024). *Isotope signature and ecoenzyme stoichiometry as key indicators of urban soil functionality*. **Journal of Soils and Sediments**



NbS suitability as ecosystem services-based approach – a focus on **soil health**

FIRENZE (ITALY)

Natural area

=

Historic green space

$\delta^{15}N$

carbon availability

Recent green space

New green space

Rain garden

Trees alongside roads

Historic green space was similar to **natural site** for nutrient availability and isotope composition

Scartazza, Vannucchi * et al. (2025). *Nutrient interaction in the soil-plant system and tree physiological functional traits in an urban green infrastructure*. Journal of Soil Science and Plant Nutrition. **In press**

Macci, Vannucchi* et al. (2025) *Soil-plant indicators for assessing nutrient cycling and ecosystem functionality in urban forestry*. Urban Science. **Submitted**

Faster mineralization process

Conclusions

Soil enzymes and stable isotopes

Sensitive to **disturbances**, related to fire and urbanization

Promising indicator to assess the **soil health recovery**

Loading...

Next step

NBFC Land

Microbiome characterization

Nursery experiment

NBFC Urban

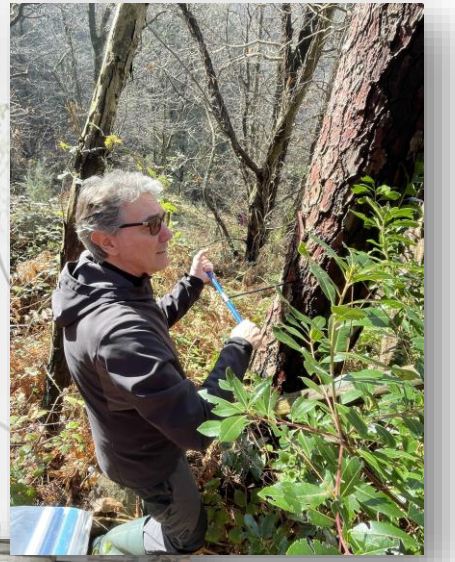
Microbiome characterization

Air

CO CO_2 PM O_3

Soil

Air quality data using open data sources








Thank you!