Guidelines for optimal tree selection to improve cities air quality

Urban Trees:
A Natural Solution to Air Pollution

2025

AIRFRESH

Life

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NATIONAL BIODIVERSITY FUTURE CENTER

Urban tree guidelines

WELCOME

These guideline are the result of collaborative expertise from leading researchers in plant ecophysiology, air pollution, and urban greening. Together, we explore the critical role of urban greenery in mitigating air pollution, enhancing biodiversity, and improving ecosystem resilience in the face of environmental challenges. Drawing from our collective research, we provide practical insights and evidence-based recommendations to guide urban planners, policymakers, and environmental managers in creating sustainable, greener cities for a healthier future.

Dr. Elena Paoletti is a researcher at the Institute of Research on Terrestrial Ecosystems of the National Research Council (IRET-CNR). Her research emphasizes the role of urban greenery in mitigating air pollution and adapting to climate change. She advocates forest strategic urban planning that incorporates green infrastructure, considering species selection and management practices that optimize resilience against urban stressors.

Dr. Pierre Sicard is a researcher at ACRI-ST in France, specialized in environmental sciences with a focus on air pollution, particularly on its effects on human health and ecosystems. His work includes assessing urban air quality trends, and exploring the role of urban forests in mitigating pollution.

Dr. Yasutomo Hoshika is a researcher at the Institute of Research on Terrestrial Ecosystems of the National Research Council (IRET-CNR). His research explores tree physiological responses to environmental stressors like ozone and water stress, providing insights to enhance urban greenery and environmental resilience.

Dr. Barbara Baesso Moura is a botanical researcher whose work focuses on plant responses to environmental stressors, particularly air pollution. Her studies have examined the physiological and structural impacts of pollutants on plant species.

Jacopo Manzini's research focuses on plant ecophysiology, urban greening, and the effects of air pollution on ornamental trees. He contributed to developing models for estimating pollution removal by urban trees.

CONTENTS

1. Urban Air Pollution

GREEN SPACES FOR CLEANER AND HEALTHIER CITIES

Air pollution is one of the most pressing environmental challenges faced by modern cities. Emissions from vehicles, industrial activities, and energy consumption contribute to increase the concentration of key airborne pollutants such as particulate matter (PM), nitrogen dioxide (NO_2), and ozone (O_3).

These pollutants are closely linked to numerous health problems, including respiratory and cardiovascular diseases, asthma, and even lung cancer.

Urban green spaces, particularly tree canopies, offer a highly effective natural solution for mitigating air pollution.

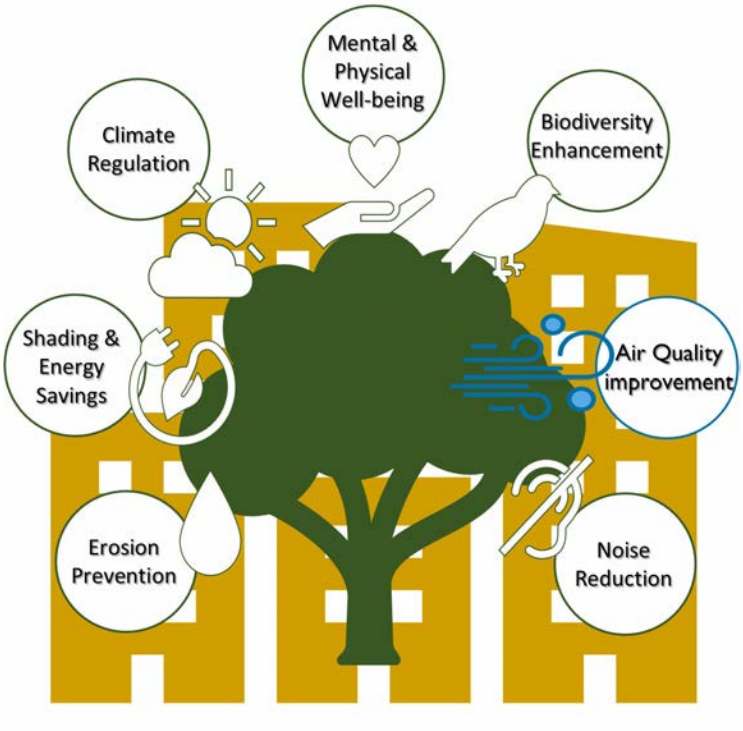
This guide aims to provide urban planners and policymakers with practical tools for selecting optimal tree species to effectively mitigate urban air pollution.

PLANT CAPACITY TO REMOVE AIR POLLUTION

Urban trees act as natural air purifiers, playing a key role in reducing air pollution through various physical, mechanical, and biological processes. Certain tree and shrub species are especially efficient in removing PM, O_3 and NO_2.

Careful selection of species is needed to avoid unintended side effects, such as the emission of biogenic volatile organic compounds (bVOCs), which can contribute to O_3 formation.

Beyond pollution mitigation, urban trees provide additional ecosystem services, including erosion prevention, shading and energy saving, climate regulation, mental and physical well-being, biodiversity enhancement, and noise reduction.



2. Air Pollution Mitigation

2.1 FILTERING PARTICULATE MATTER(PM)

Particulate matter, especially PM_{10} and $PM_{2.5}$, poses significant health risks. Trees reduce PM levels through dry deposition, where airborne particles settle onto leaf, branch, and bark surfaces. Rough-textured leaves and bark are particularly effective at capturing fine particles.

Conifers and evergreens are well-suited for PM removal, as well as trees with dense canopies and large leaf surfaces. Trees planted along busy roads can significantly reduce PM concentrations in nearby residential areas, improving urban air quality.

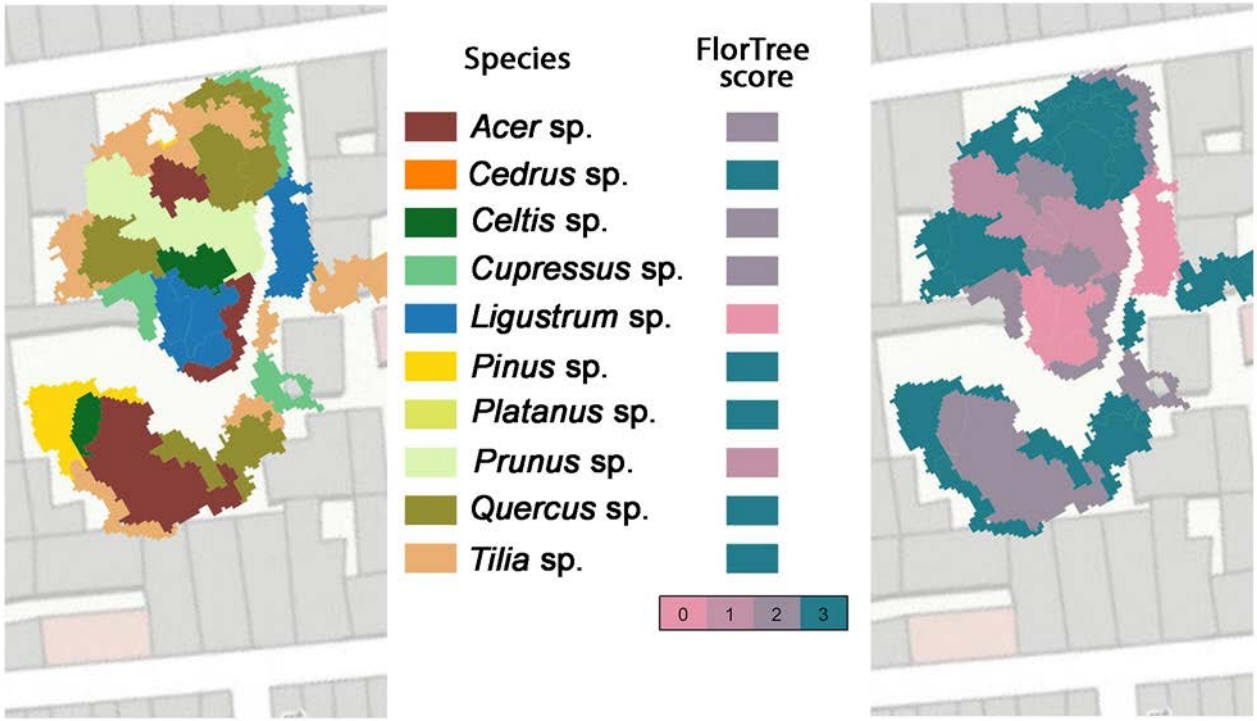
by Trees

CASE STUDY: PM_{10}

Classification of Urban Greenery for PM_{10} Mitigation: A case study of a Playground in the city center of Florence, Italy.

Methodology

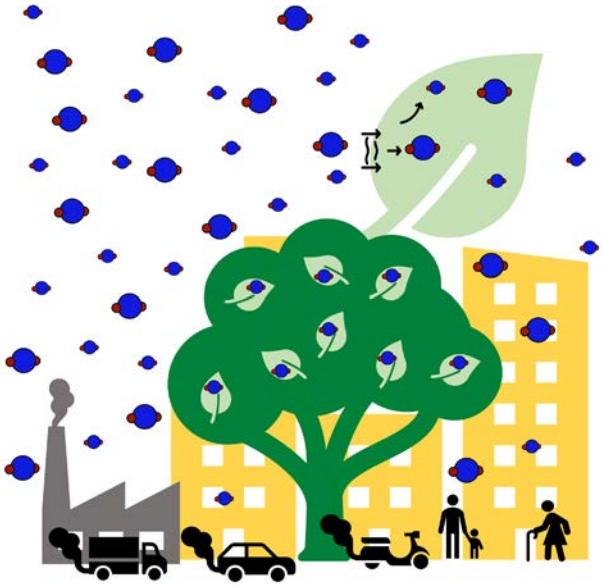
- Urban Tree Mapping: High-resolution satellite imagery used to identify the tree species.
- Pollution Removal Classification: A species-specific approach (FlorTree, see pages 16 and 18) used to score the capacity of tree species to remove PM_{10}.



2. Air Pollution Mitigation

2.2 ABSORBING NITROGEN DIOXIDE (NO_2)

Nitrogen dioxide (NO_2), a toxic gas and major urban pollutant largely produced by vehicles and industrial activities, is absorbed by tree leaves through stomatal openings - small pores that control gas exchange and water loss.



Broad-leaved species with durable foliage are particularly effective due to their high stomatal conductance and large leaf area. Environmental factors like temperature, humidity, and pollution levels can influence the stomatal behavior and thus the efficiency of NO_2 absorption.

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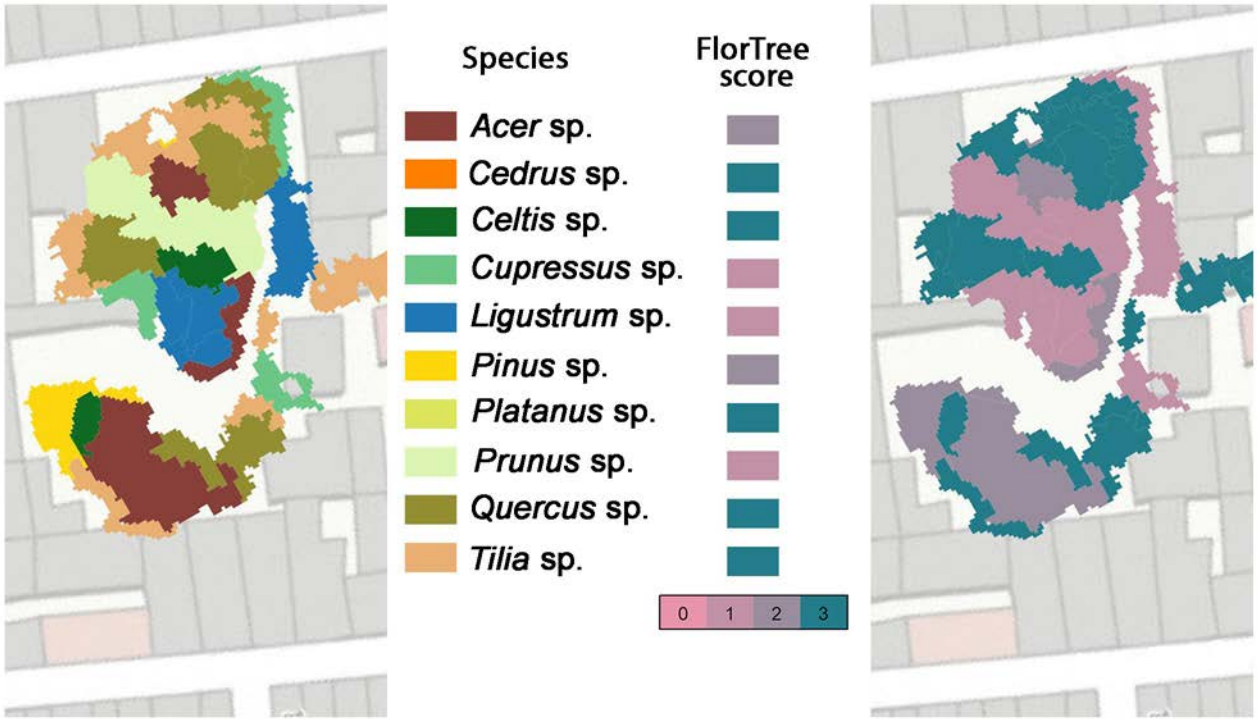
CASE STUDY: NO_2

Classification of Urban Greenery for NO_2 Mitigation: A case study of a Playground in the city center of Florence, Italy.

Methodology

- Urban Tree Mapping: High-resolution satellite imagery used to identify the tree species.
- Pollution Removal Classification: A species-specific approach (FlorTree, see pages 16 and 18) used to score the capacity of tree species to uptake NO_2.



2. Air Pollution Mitigation

2.3 REDUCING TROPOSPHERIC OZONE (O_3)

Tropospheric ozone (O_3), a secondary pollutant formed by chemical reactions between nitrogen oxides (NO_2), volatile organic compounds (VOC), and sunlight, is harmful to both human health and vegetation.

Trees reduce O_3 through direct stomatal absorption and by lowering urban temperatures, which slows the photochemical reactions that form O_3.
Species with high stomatal conductance and low or negligible bVOC emissions are ideal for reducing O_3 levels. Conversely, bVOC-emitting species should be avoided in areas prone to O_3 pollution.

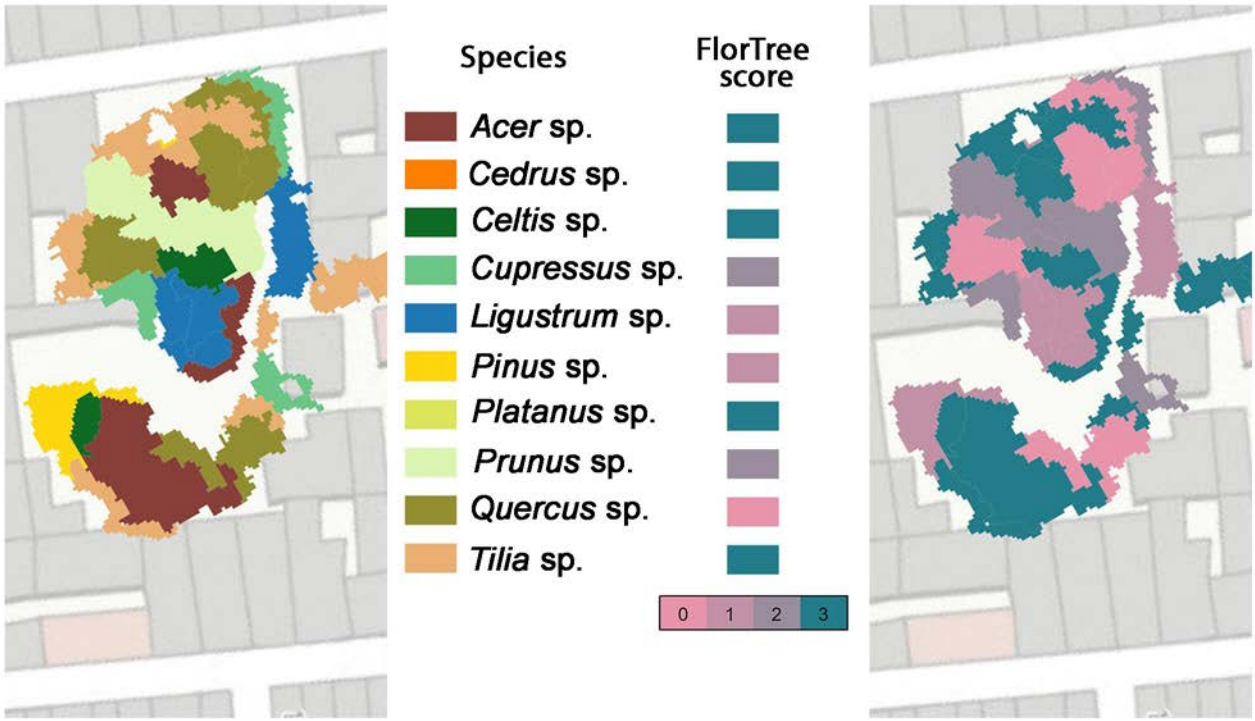
by Trees

CASE STUDY: O_3

Classification of Urban Greenery for O_3 Mitigation: A case study of a Playground in the city center of Florence, Italy.

Methodology

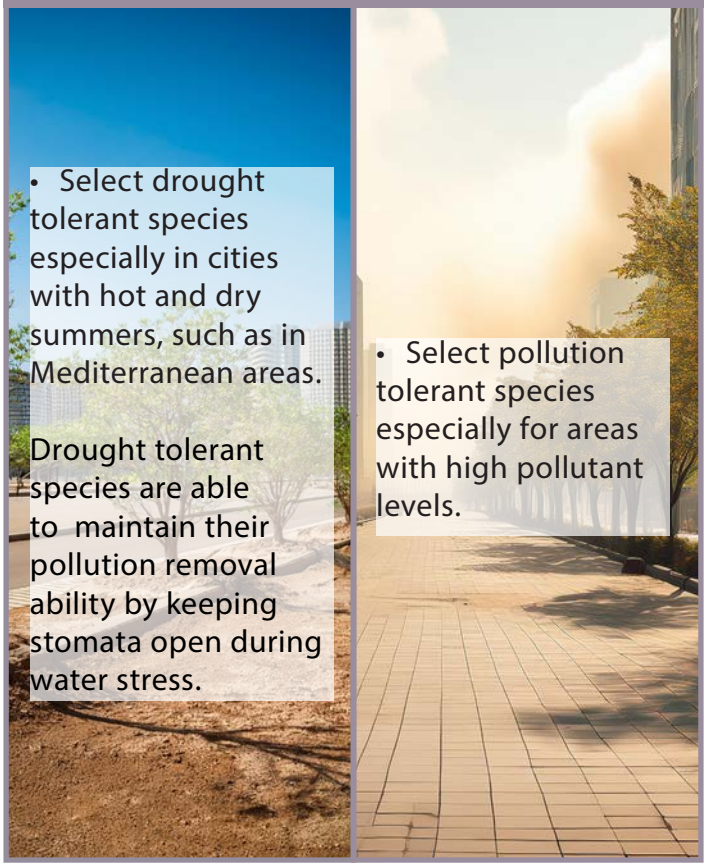
- Urban Tree Mapping: High-resolution satellite imagery used to identify the tree species.
- Pollution Removal Classification: A species-specific approach (FlorTree, see pages 16 and 18) used to score the capacity of tree species to uptake O_3.



3. Resilience and Suitability

Additional Factors for Urban Tree Selection

ABIOTIC STRESS

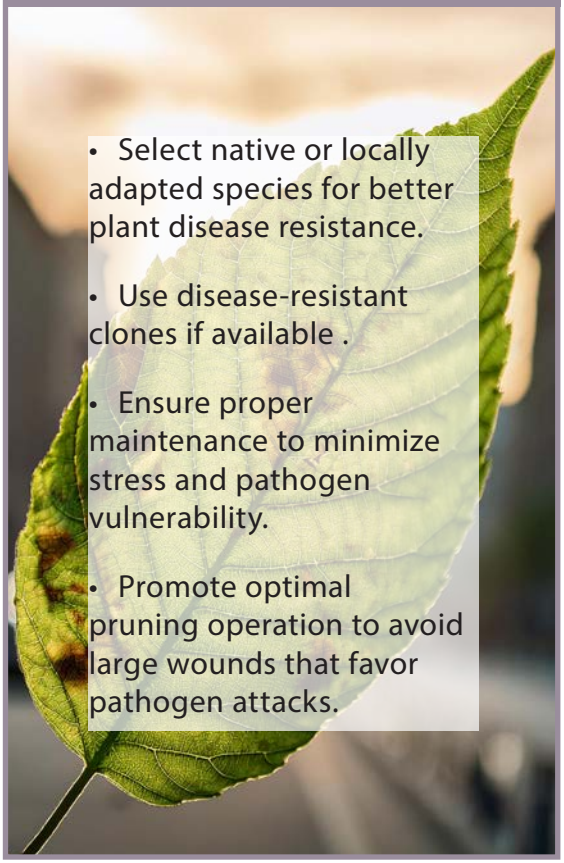


- Select drought tolerant species especially in cities with hot and dry summers, such as in Mediterranean areas.

Drought tolerant species are able to maintain their pollution removal ability by keeping stomata open during water stress.

- Select pollution tolerant species especially for areas with high pollutant levels.

BIOTIC STRESS

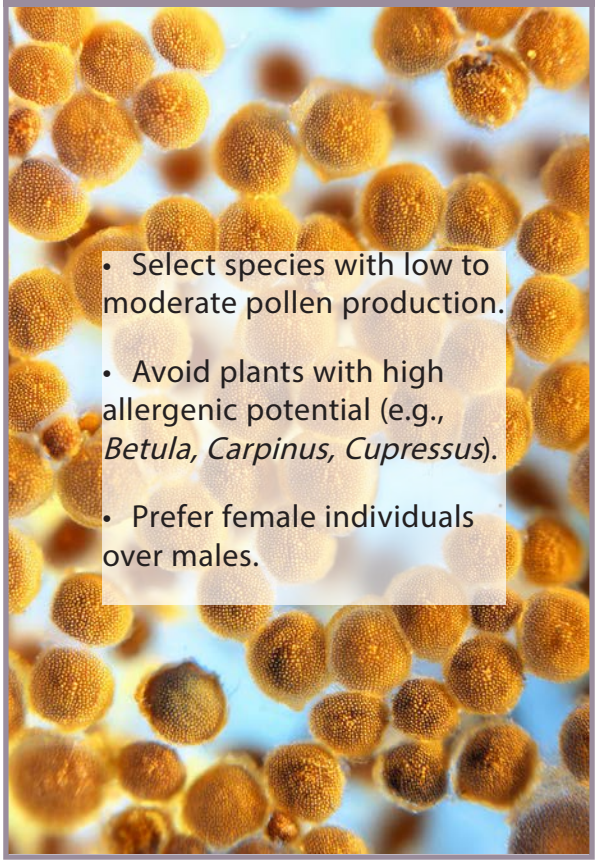


- Select native or locally adapted species for better plant disease resistance.
- Use disease-resistant clones if available .
- Ensure proper maintenance to minimize stress and pathogen vulnerability.
- Promote optimal pruning operation to avoid large wounds that favor pathogen attacks.

y for Urban Planting

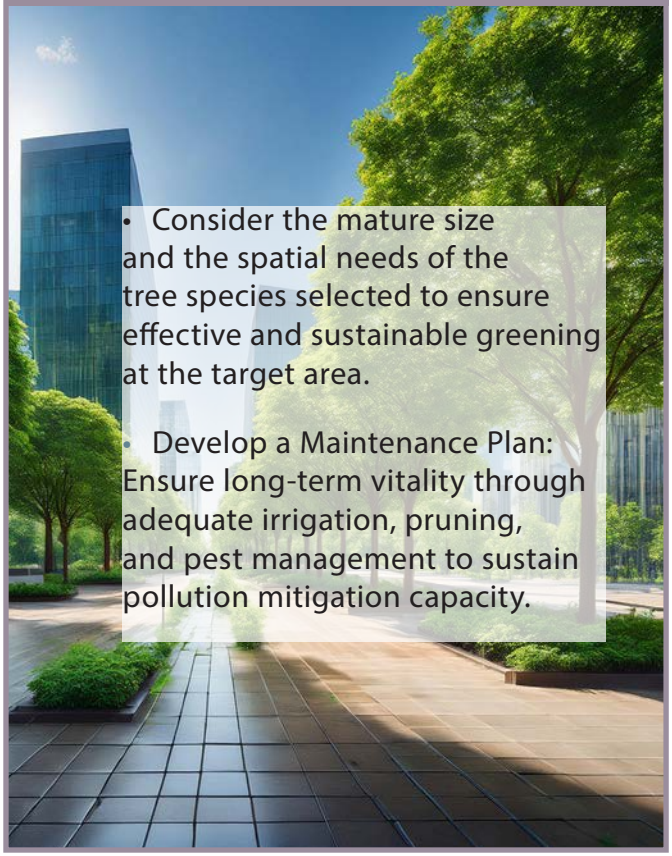
In addition to mitigating air pollution, tree species must be resilient to the harsh environmental conditions often found in urban settings.
Urban trees frequently face elevated temperatures, irregular water availability, soil compaction, pathogen attacks and high pollution levels, requiring species with strong adaptive capabilities.

ALLERGENICITY



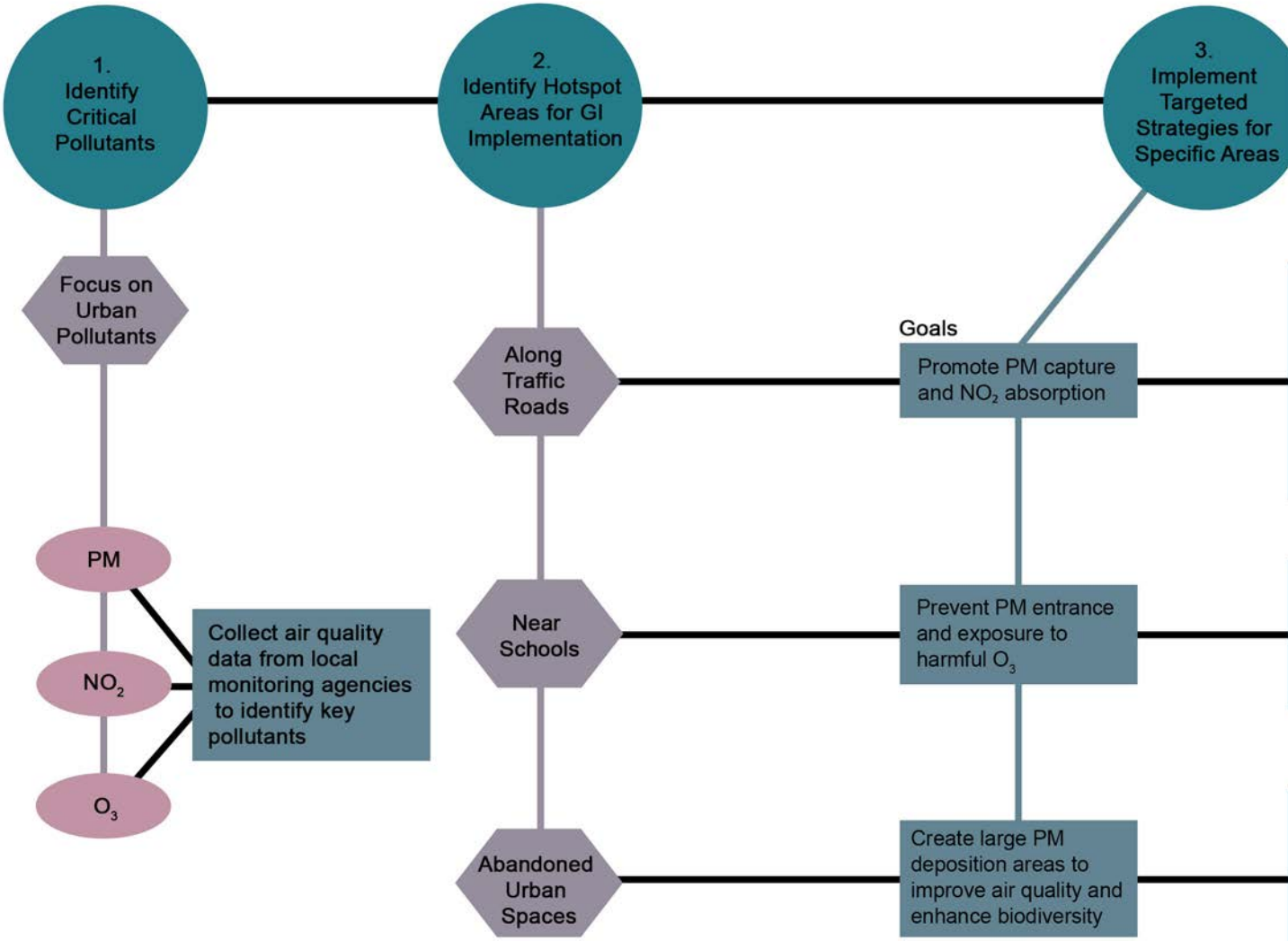
- Select species with low to moderate pollen production.
- Avoid plants with high allergenic potential (e.g., *Betula, Carpinus, Cupressus*).
- Prefer female individuals over males.

GROWTH MANAGEMENT



- Consider the mature size and the spatial needs of the tree species selected to ensure effective and sustainable greening at the target area.
- Develop a Maintenance Plan: Ensure long-term vitality through adequate irrigation, pruning, and pest management to sustain pollution mitigation capacity.

4. Good Practices for desig
Urban Green Infrastruct



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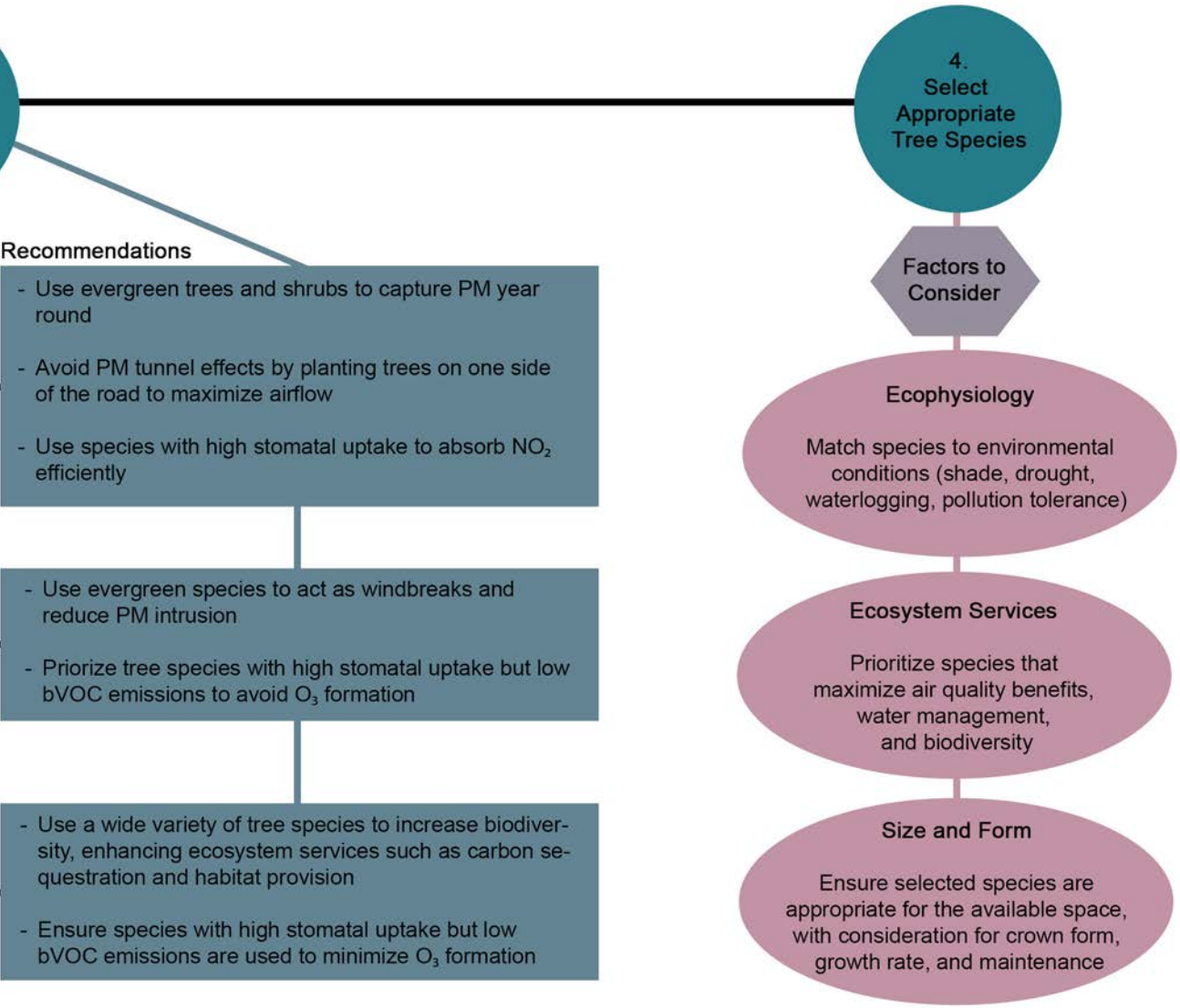

5. Practical Tools for Decisi

Urban planners and environmental managers need practical tools to select tree species that maximize air pollution mitigation.

FlorTree: A TOOL FOR URBAN TREE SELECTION

FlorTree is a “single-tree” model designed inside the frame of the Life Project “AIRFRESH - AIR pollution removal by FoRESts for a better human well-being” (https://www.life-airfresh.eu/) to assist decision-makers in selecting tree species most suitable for air pollution mitigation. The model evaluates species-specific traits and environmental conditions, integrating critical factors such as tree morphology, stomatal conductance, leaf surface area, and bVOC emissions.
FlorTree allows users to input site-specific data, such as local climate, pollution levels, and urban design constraints, to generate tailored recommendations.

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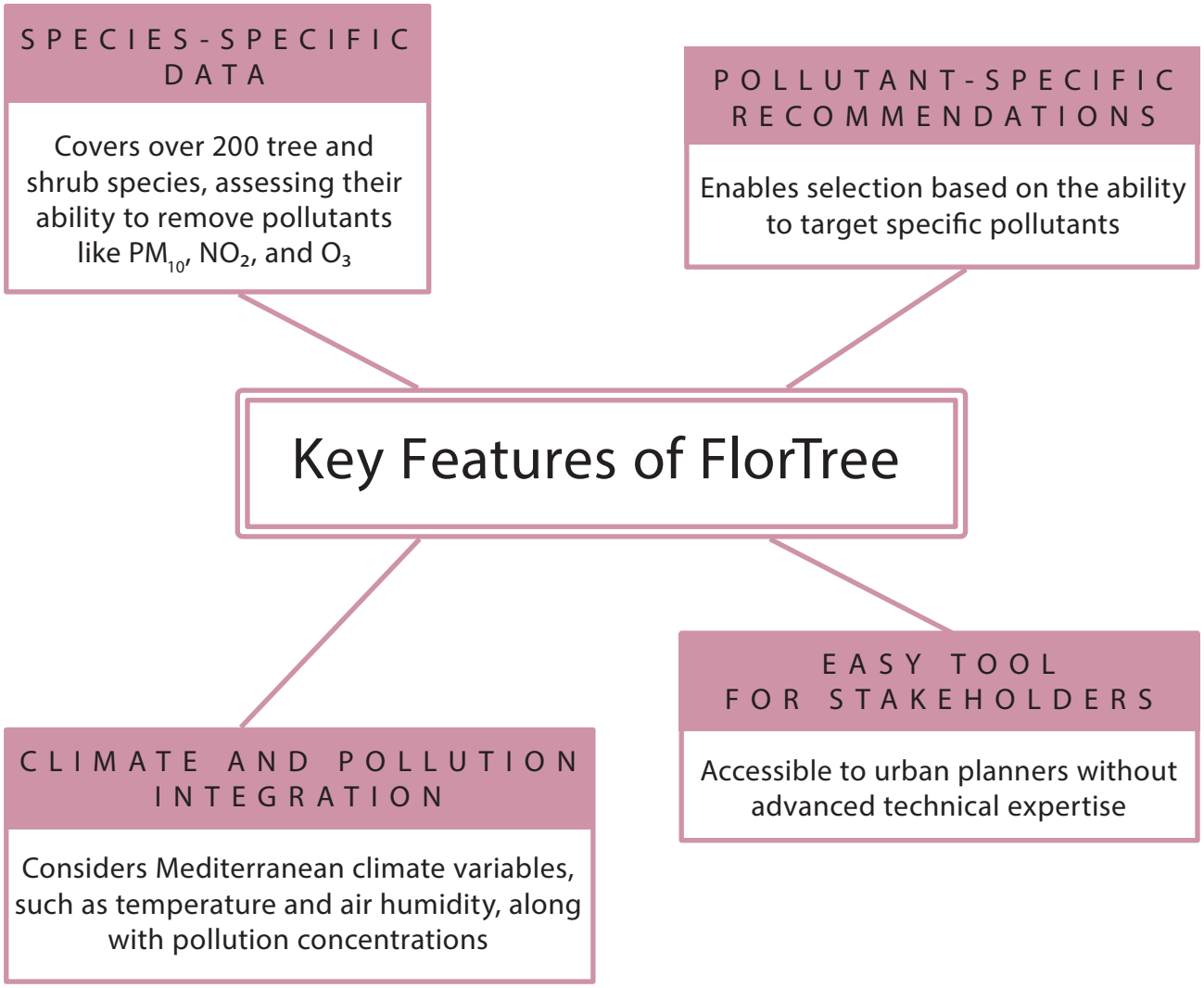
PRACTICAL APPLICATIONS

Web platform currently accessible at:
https://servizi.toscana.it/RT/statistichedinamiche/piante/

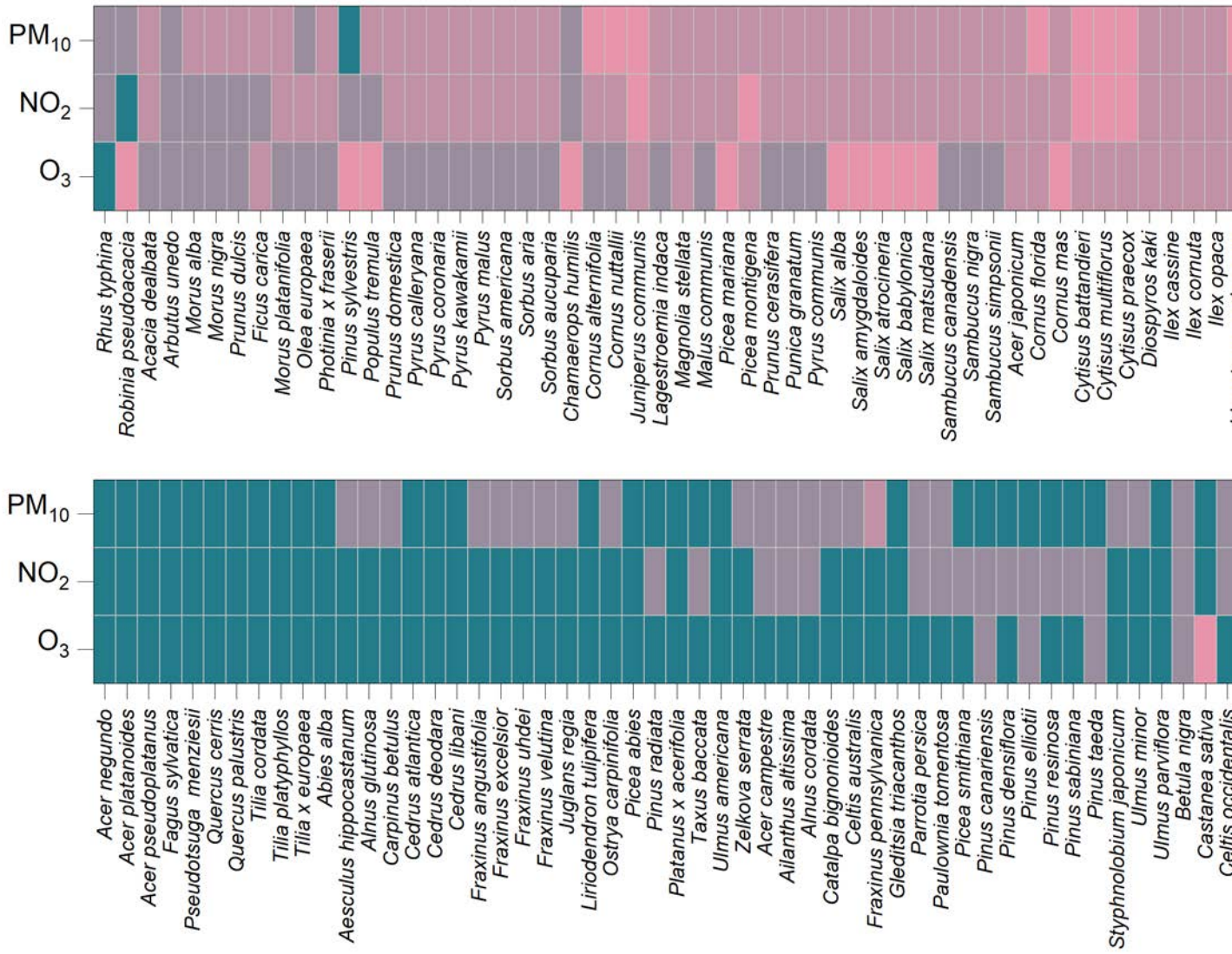
Applied by the Regione Emilia-Romagna (Italy) in the catalogue named "Alberi per la Città"
https://serviziambiente.regione.emilia-romagna.it/abalberi/Volume_alberi_pagina_singola.pdf

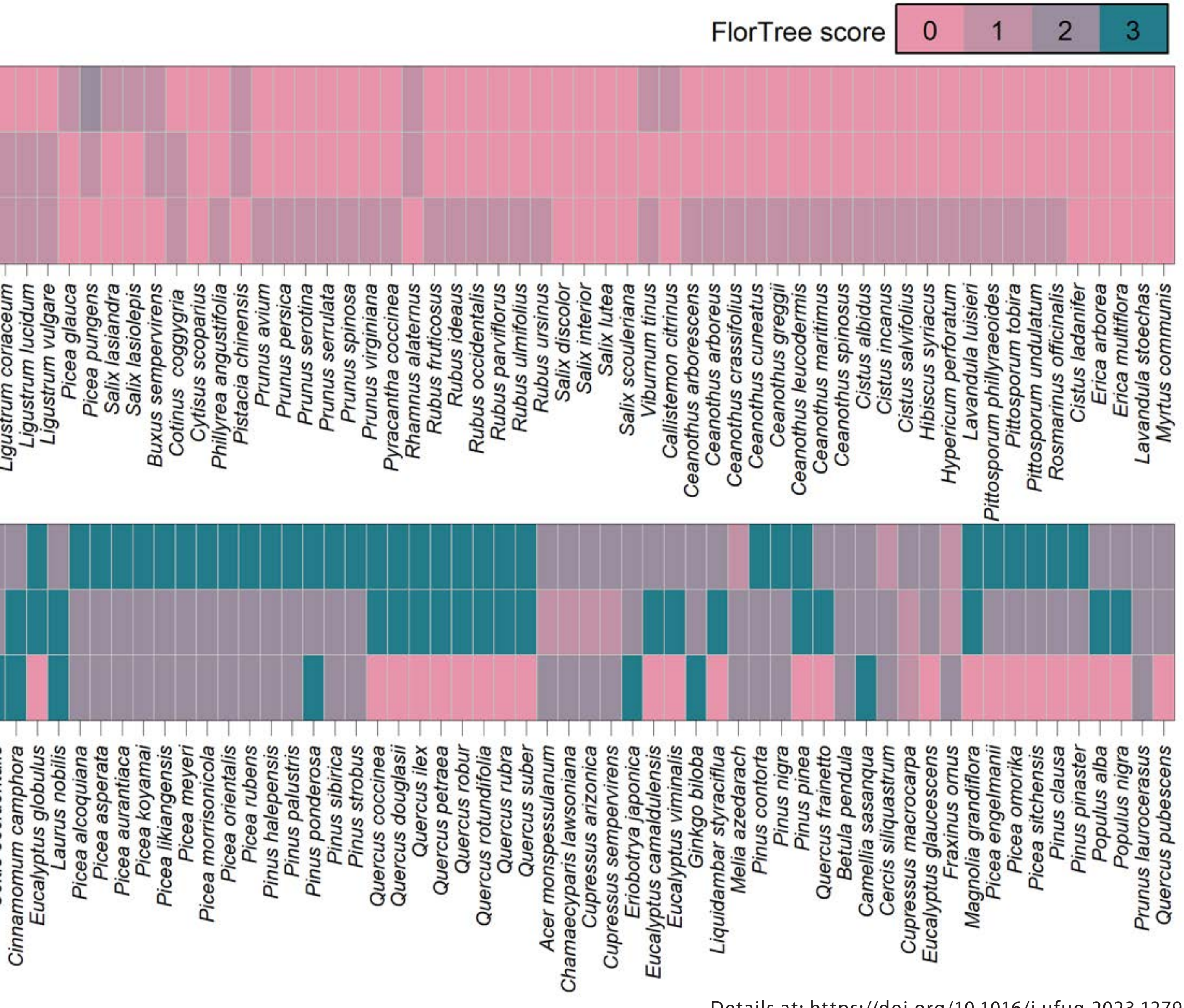
WebApp available soon

on-Makers


SPECIES-SPECIFIC DATA
Covers over 200 tree and shrub species, assessing their ability to remove pollutants like PM_{10}, NO_2, and O_3
POLLUTANT-SPECIFIC RECOMMENDATIONS
Enables selection based on the ability to target specific pollutants
Key Features of FlorTree
CLIMATE AND POLLUTION INTEGRATION
Considers Mediterranean climate variables, such as temperature and air humidity, along with pollution concentrations
EASY TOOL FOR STAKEHOLDERS
Accessible to urban planners without advanced technical expertise

5.1 FlorTree ranking





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This guide aims to provide urban planners and policymakers with practical tools for selecting optimal tree species to mitigate urban air pollution effectively

LIFE19 ENV/FR/000086

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Ministero dell'Università e della Ricerca