Research Paper

Maximizing Urban Vegetalisation

A Comprehensive Data-Driven Strategy for estimating Maximum Vegetation Coefficients

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Abstract

This paper introduces a tool designed to estimate the maximum potential for vegetation in densely populated urban areas. By integrating comprehensive data sets, including transportation mode share, underground constraints, flow data, and other key factors—this tool provides a data-driven approach to urban greening.

As urbanization accelerates, the need for green spaces in city planning becomes increasingly urgent to counteract environmental degradation and enhance residents' well-being. However, identifying suitable areas for vegetation in high-density urban settings remains a significant challenge.

The tool uses advanced spatial analysis techniques and data modeling to assess the feasibility of vegetation integration across diverse urban landscapes. By considering a multiplicity of factors, such as people flow potential, urban morphology, underground infrastructure, and vegetation, it provides a powerful tool for decision making to professionals and policymakers

The tool will be applied to the Montparnasse neighborhood as a case study to demonstrate its effectiveness.

Keywords

Renaturation, Graph theory, Ecology, Connectivity, Urban planning

1. Introduction

A shift from an anthropocentric approach to a life-centric one—where cities support diverse forms of life—is a complex but necessary transition. This shift requires not only a change in the professional field of city planning but also the right tools to guide the process. Renaturing cities is necessary for this transformation, in order to repair the landscape, improve biodiversity and create environments that support all forms of life.

While, urban planners, municipalities, and environmental specialists widely acknowledge the necessity of making cities greener, implementing effective vegetation strategies is however quite hard. City planning is composed by a variety of specialists, engineers, designers, transport planners, which makes the field segmented. In addition, multiple stakeholders are often involved within a project, making the process for improving green infrastructure time-consuming and complex.

So, how can we create a tool that helps planting green infrastructure in cities by taking into account different specialities?

A plethora of factors influence the availability of plantable spaces in cities, which can be grouped into three main categories:

1. **Existing Green Patches** – These form the ecological backbone of urban landscapes, a starting point for renaturation efforts.
2. **People flow** – Understanding people moving patterns, around metro and railway stations, or along major streets let us identify the most appropriate locations for vegetation.
3. **Regulatory Constraints** – Restrictions related to underground networks and infrastructure limit planting opportunities.

By combining these three factors, professionals and specialists can develop a systematic approach to identifying high-priority areas for new green spaces. This paper introduces the **Renaturation Potential Coefficient (RCP)**—a tool that models and visualizes plantable areas based on these combined criteria. With an evidence-based framework, the RCP empowers urban planners to make decisions that supports the ecological transition of cities.

RCP allows planners to quickly assess renaturation potential across neighborhoods, considering ecological continuity, accessibility, and infrastructural constraints. This index is particularly useful for professionals who need an efficient tool to inform renaturation strategies in complex urban settings.

This paper will first present the methodology behind the RCP, the data sources and the calculation methods. It will then present the application of the RCP through a case study on the Montparnasse neighborhood in Paris, a densely populated, high-traffic area marked by extensive underground infrastructure and significant urban mineralization, where AREP with the Paris Municipality is currently exploring renaturation possibilities

Creating a Multi-Metric Index for Identifying Renaturation Potential in Urban Areas: Methodology

2.1. Gathering data

Type of data and data sources

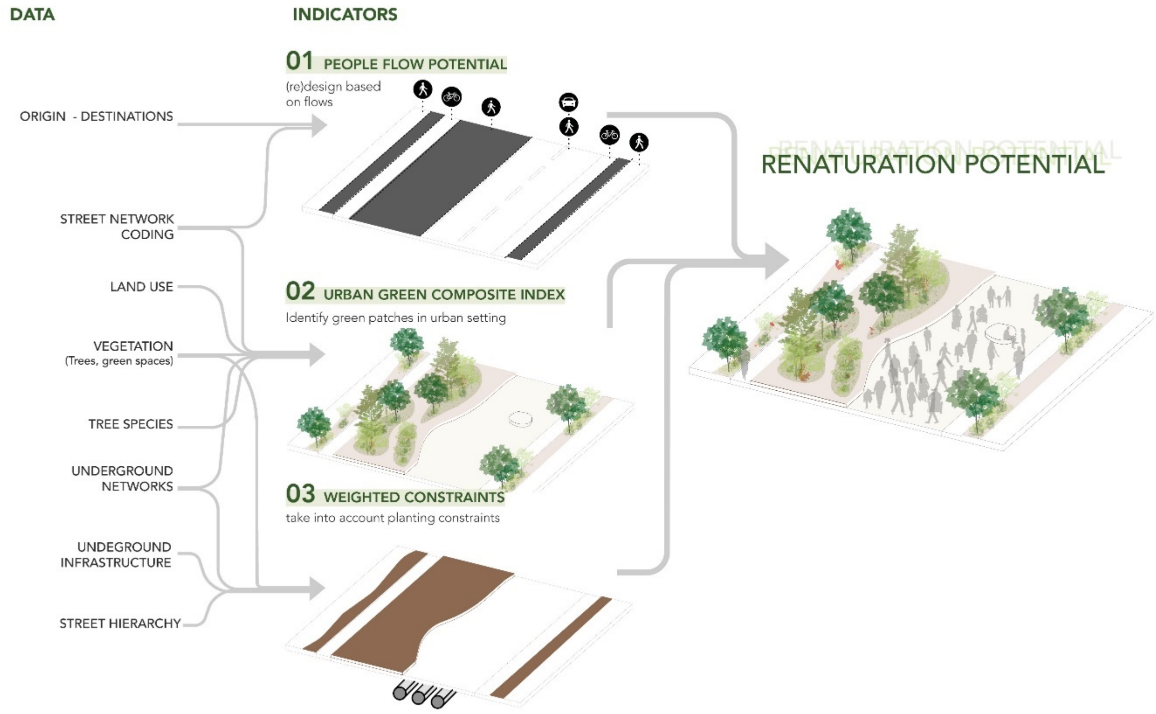

Figure 1 Data sources composing the RCP

Data sources

Data sources are variable they involve :

- Open data from the municipality of Paris [1]
- OpenstreetMap data
- Manual inputs
- Restricted access data

The data was available in GIS format, therefore QGIS an open source software was used to compute the different metrics.

[1] (https://opendata.paris.fr/pages/home/)

Processing the data

In QGIS, we processed the data using a fine-resolution grid of 1x1 meter, enabling detailed spatial analysis across the urban landscape. Data preparation began by categorizing and processing each dataset individually according to three main criteria: green patches, people flow, and constraints.

After processing each dataset within its category, we applied a weighting system within the QGIS Modeler to balance the influence of each metric. Finally, we spatially combined the weighted metrics on the 1x1m grid, yielding an RPC score for each cell. This approach produced a high-resolution map of renaturation potential, which visually highlighted opportunities and limitations for green space development across the area.

2.2. Metrics centred around 3 key themes: green infrastructure, people flow and constraints to define renaturation potential

Urban Greeness Composite Index (UGCI)

Urban greenness composite index is composed by three indicators:

- Green coverage
- Green connectivity
- Green diversity

The computation is based on the spatial network[2] to consider the constraints generated by urban morphology on green connectivity. Trees and their environment are used as the main data source. The metrics integrate both quantitative and qualitative aspects to evaluate green ecosystems in urban areas.

Green coverage

Green coverage measures the number of trees on the spatial network in an infinite radius.

Green connectivity

The connectivity between green spaces (Bunn et al, 2000), measuring how well green areas are connected.

The formula is defined by the following:

$$GC = \sum_{i=1}^{n} \left(C_i \times \frac{1}{d_i} \times E_i \right)$$

Where:

[2] The spatial network modeling is based on graph theory

GC: Green connectivity for a particular reference tree

n: Total number of other trees reachable from the reference tree along the spatial network.

Ci: Green coverage (number of trees) associated with tree i

Di: Distance along the spatial network to tree i

1/di: Inverted distance, giving higher weight to closer trees.

Ei: Environmental score of trees i

Green diversity

Green diversity is based on the tree species and measures their diversity on an infinite range on the spatial network. The formula used is Simpsons Diversity Index (Duelli et al, 2003)., it considers both the number of species present and the relative abundance of each species, it is widely used in ecology to quantify biodiversity.

The formula is the following:

$$D = 1 - \sum_{i=1}^{n} \left(\frac{n_i \times (n_i - 1)}{N \times (N - 1)} \right)$$

Where:

- ni: The number of individuals of species i (or category i) in the dataset.
- N: The total number of individuals on the spatial network across all species in the dataset.
- n: The number of different species (in the dataset.
- ∑: The summation symbol, which indicates that you sum over all species

Pedestrian flow potential

Pedestrian flow potential is computed on the spatial network. A spatial network is a type of graph where nodes (representing locations) and edges (representing connections or paths between these locations) are embedded in a geometric space, often reflecting real-world distances and spatial constraints, such as transportation systems, utility networks, or social connections in physical space.

Pedestrian network coding

The pedestrian network is coded to represent pedestrian movement; therefore, obstacles and shortcuts are represented. The network is coded in 3D, including underground and above ground connections.

Betweenness centrality

Pedestrians usually take the shortest and the most direct path. Betweenness centrality computes their movement on the spatial network by overlaying all the possible paths between segments. The higher the value, the higher the flow potential. SDNA+ which is open source and developed by Cardiff university (Cooper et al, 2020) will be used to compute betweenness centrality for the pedestrian network.

Weighted constraints

Constraints are divided into four categories:

Very high

This includes pipelines, underground networks or underground galleries on which tree planting is forbidden in a certain buffer.

High

Tree planting is prohibited in a specific buffer zone due to the presence of underground networks or pipelines, though these can be relocated if necessary.

Planting is highly restricted on primary roads, where high traffic is expected (Marshall,2004).

Medium

The flexibility of the constraints in these areas depends on project conditions, particularly for secondary roads where traffic lanes might be narrowed or public spaces that could undergo regeneration.

Low

This concerns tertiary roads and public spaces that can potentially be pedestrianised and planted.

2.3. Combining the 3 metrics into one calculation to assess renaturation potential in urban areas

Maximum greenness

Maximum greenness is the result of combining all the metrics together. It reveals all the location that can potentially be planted as well as the existing green areas.

$$M = \left(\frac{1}{B} \times G\right) \times C$$

Where:

M: Represents the maximum greenness index

B: is betweenness (inverted to give more weight to lower values because they represent areas where planting is more feasible, while higher values indicate more restricted planting opportunities)

G: Urban Greenness Composite Index

C: Constraints

Potential renaturation coefficient

Potential Renaturation Coefficient is the result of combining all the metrics together minus the existing green areas. It reveals all the locations that can potentially be planted.

$$R = \left(\frac{1}{B} \times G\right) \times C - G$$

Where:

M: Represents the maximum greenness index

B: is betweenness (inverted to give more weight to lower values because they represent areas where planting is more feasible, while higher values indicate more restricted planting opportunities)

G: Urban Greenness Composite Index, which reflects current greenness in the area. Subtracting G helps to focus the index on areas that are not yet green.

C: Constraints

Application: The case of Montparnasse station neighbourhood

3.1. Context

Montparnasse, one of Paris's most emblematic districts, is located on the left bank of the Seine, between the 14th and 15th arrondissements and close to the 6th arrondissment. Renowned for its artistic and intellectual history, Montparnasse is home to a complex environment organized around several structuring urban entities, including Montparnasse Railway station, a major entry point and hub for national rail transport and a city hub with 4 metro lines.

Until the 17th century, the Montparnasse area was essentially rural, made up of waste from the capital around the Montparnasse hill. Over the centuries, a structuring road network emerged, with the creation of roads such as the Cours du Montparnasse.

At the end of the 17th century the Route du Maine was built, followed by the annexation of the area by the City of Paris in 1860. Until 1950, the area remained mainly composed of small workshops and warehouses. In the 1960s, major real estate projects brought about a significant transformation, including the demolition of the Montparnasse train station and the construction of the Montparnasse tower in 1973 and The Maine tunnel was built in the 1960s.

The 1990s saw the creation of the Jardin Atlantique and the arrival of the high-speed railway (HSR), marked by the construction of the Océane façade for the station.

The complex underground infrastructure, combined with the varying types of public spaces like wide streets, narrow alleys, and plazas, makes this area a compelling case study to apply the renaturation potential coefficient.

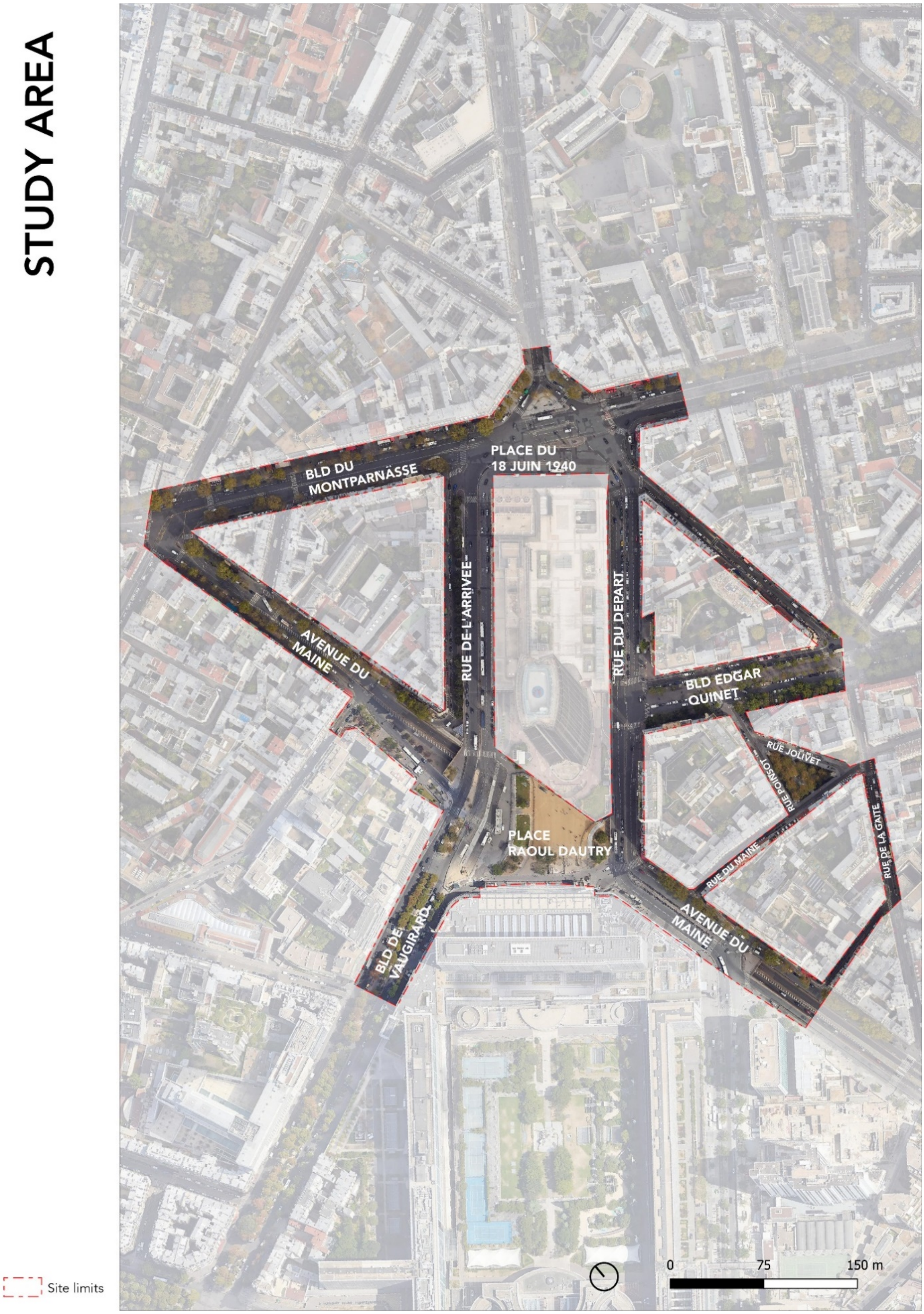

Figure 2 Study area

3.2. Mapping the existing green infrastructure to identify potential green connections

Tree location and planting typologies

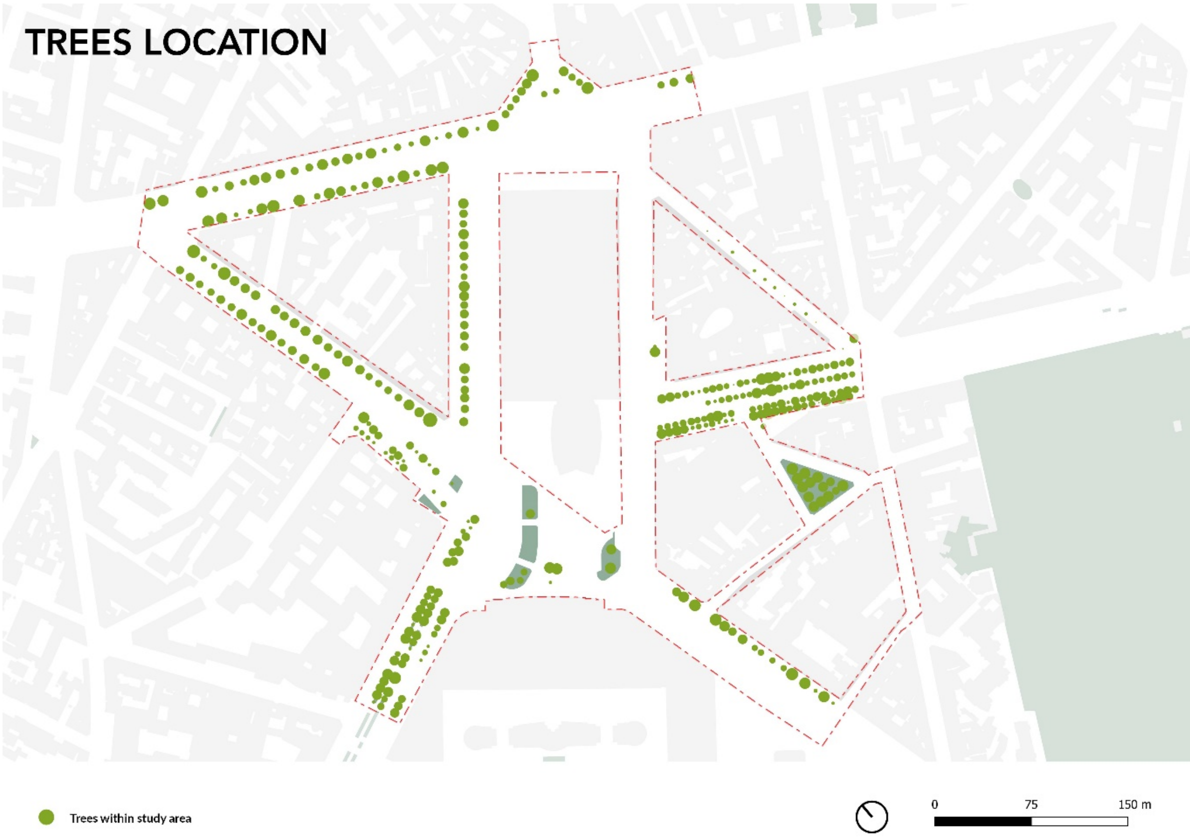

Figure 3 Trees location

Trees are mainly planted on urban alignments along sidewalks. They are clustered boulevard Edgar Quinet, boulevard de Vaugirard and Boulevard du Montparnasse. Plazas are mineral with few plantations and narrower streets as well.

We can identify four typologies of plantation:

- Single pit
- Continuous pit for multiple trees
- Planted green spaces on a slab
- Garden/Urban Parks

Single pit

Continuous pit

Planted green space on slab

Urban park

Figure 4 Typologies of tree planting

Trees planted in individual pits typically lack underground connections to other trees and are not part of a continuous layered green space. Continuous pits offer greater ecological benefits by supporting an herbaceous layer and establishing subterranean connections among trees, but they are constrained by the size of the pit.

Although green spaces on slabs can be larger and more layered than tree pits, they are limited by the underground infrastructure's load capacity. This leads to isolated patches of greenery that benefit the ecosystem but lack underground connectivity, cannot infiltrate water, and provide trees with limited soil volume for growth (Egerer et al, 2024).

In urban parks or gardens, trees are usually part of an extensive underground network and are planted in soil, enabling them to grow more robustly compared to trees that are restricted. They become part of a stratified ecosystem that enhances biodiversity, and with minimal underground restrictions, they can efficiently infiltrate water into the soil.

As a result, trees planted in individual pits receive the lowest score, whereas those in parks and complex ecosystems are given the highest score.

Aligned ornamental street planting: High coverage but low connectivity and diversity impacting biodiversity and wildlife habitats

The study area features aligned street plantings, which help reduce the urban heat island effect (UHI) and offer shaded areas for pedestrians, generally benefiting humans more than ecosystems.

In order to evaluate the quality of urban ecosystems in the study area, we will use the metrics outlined in part two. We will integrate three indicators—green coverage, green connectivity, and green diversity—to calculate the Urban Green Composite Index, which will assess green corridors.

As mentioned in the previous part, green coverage is the number of trees measured on the spatial network in an infinite radius. The darker the colour, the more trees there are.

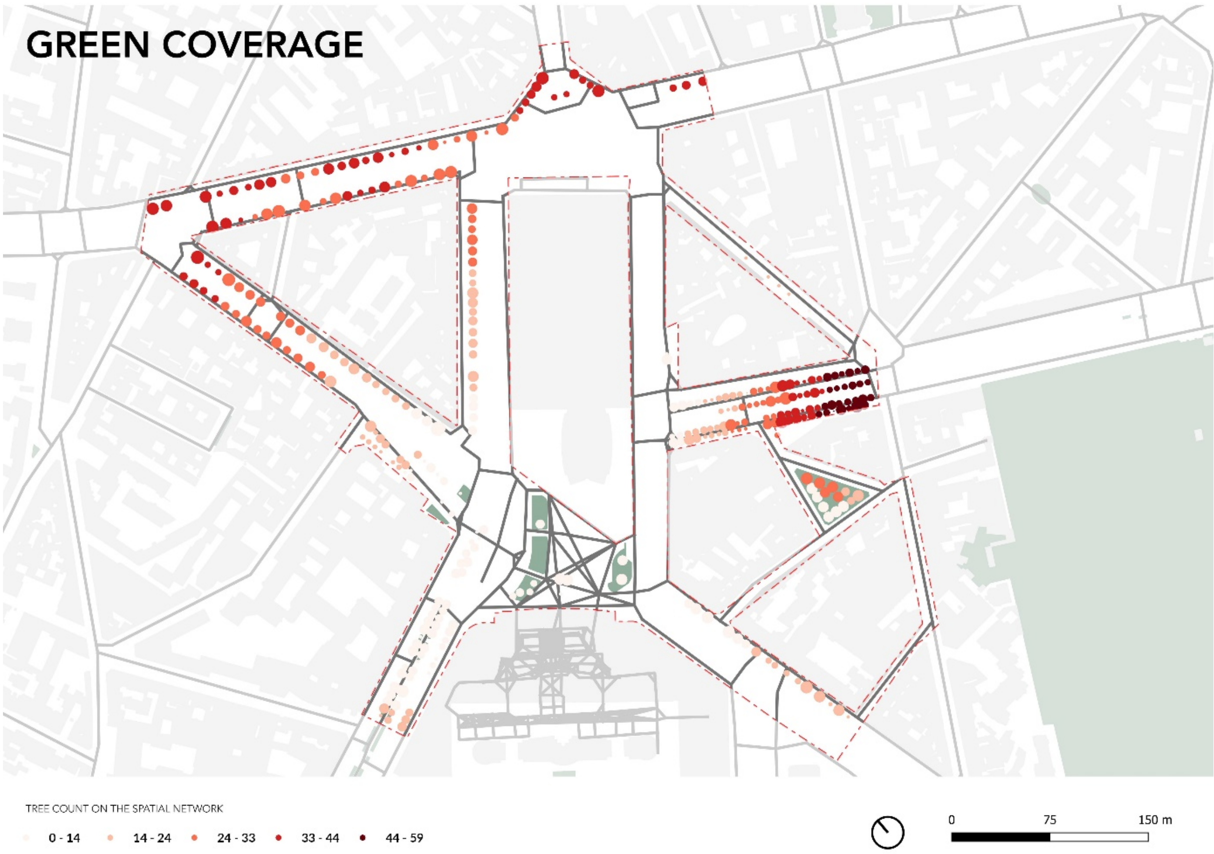

Figure 5 Green coverage

Globally, streets exhibit higher green coverage compared to plazas, largely due to the practice of aligned street planting that is practiced since the 19th century in Paris. The map shows a high cluster of tree coverage of over 44 trees on boulevard Edgar Quinet. Avenue du Maine and Boulevard du Montparnasse

Plazas in this area are quite mineral, due to the presence of underground infrastructure and a car-centric planning around the site, such as the Place du 18 Juin 1940.

Figure 6 Place du 18 Juin 1940, source Google Streetview

Green connectivity shows how well trees are connected to each other, considering distance and their environment. The higher the value, the better integrated is a tree with other trees.

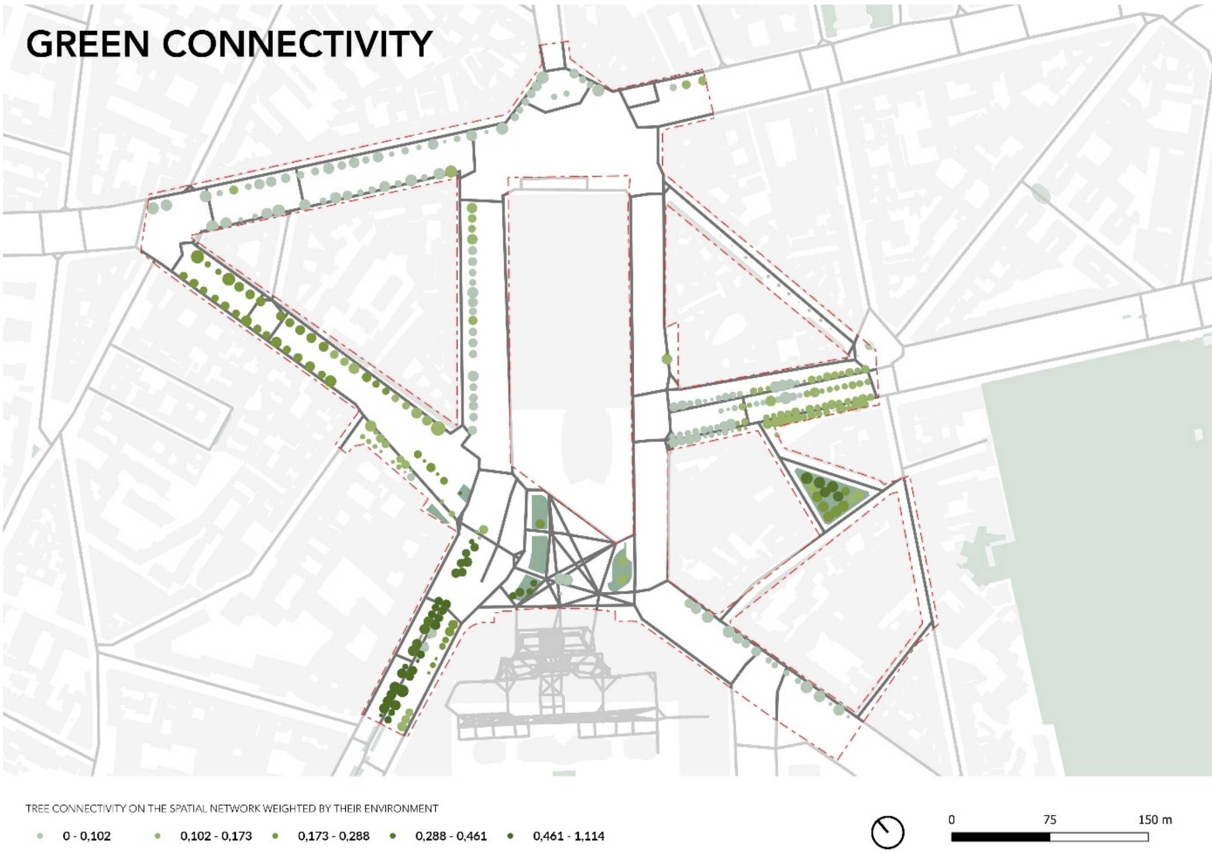

Figure 7 Green connectivity

Connectivity is the highest at Gaston Basty Square and Boulevard de Vaugirard, showing a good integration.

Boulevard de Vaugirard

Square Gaston Baty

Figure 8 Planting within the neighborhood

Boulevard de Vaugirard has a high density of trees which are planted in a continuous pit with a more complex ecosystem, improving green connectivity, supporting a wider range of habitats for wildlife than single pits.

Naturally, connectivity is the lowest on streets with single pits, such as Avenue du Maine, with values under 0.1, even though the tree coverage is quite high. Street trees planted in single pits do not provide the diverse habitats needed to support a wide range of wildlife. The lack of undergrowth, shrubs, and varied tree species means fewer opportunities for birds, insects, and other organisms to thrive, leading to an impoverished urban ecosystem.

In addition, single pits often restrict root growth, leading to compacted soils with poor nutrient cycles. Healthy soil ecosystems require a variety of plant roots, organic matter, and microbial life, which are difficult to sustain in isolated tree pits.

High tree coverage achieved through aligned street planting can create an illusion of a green and healthy city. However, without diversified landscape planning, this can lead to a poorly functioning urban ecosystem with low biodiversity. To build truly sustainable and resilient urban environments, it is essential to integrate a variety of planting strategies that support rich biodiversity and provide comprehensive ecosystem services.

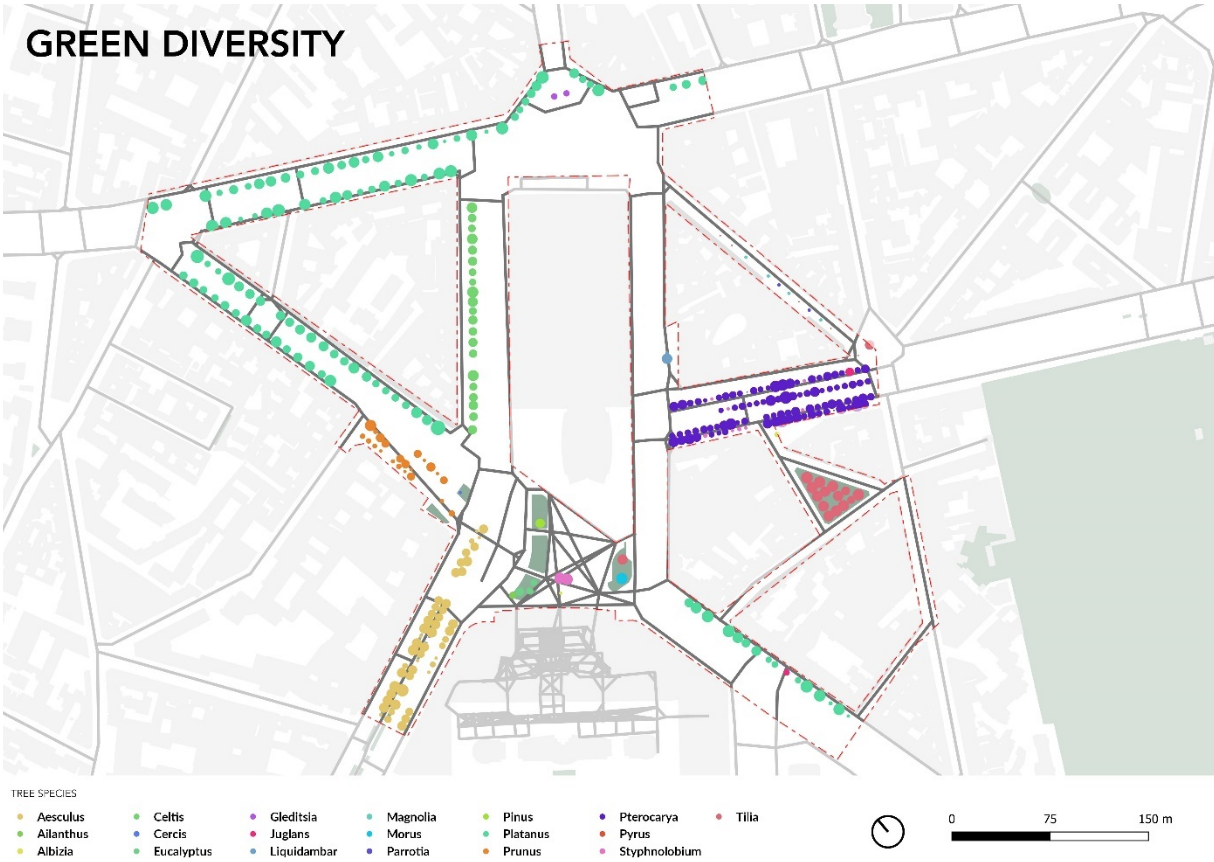

Figure 9 Tree species

There are 18 different essences in the study area, however each street has the same tree species, that are chosen for their uniform appearance, ease of maintenance, or tolerance to urban conditions. This monoculture approach can lead to low biodiversity, where the urban forest lacks a variety of species, both in terms of flora and fauna (Heidt and Neef, 2008). In addition, it makes green spaces more vulnerable to diseases that can spread through monoculture (Andrianjara et al,2021) .

Figure 10 Boulevard Edgar Quinet street planting

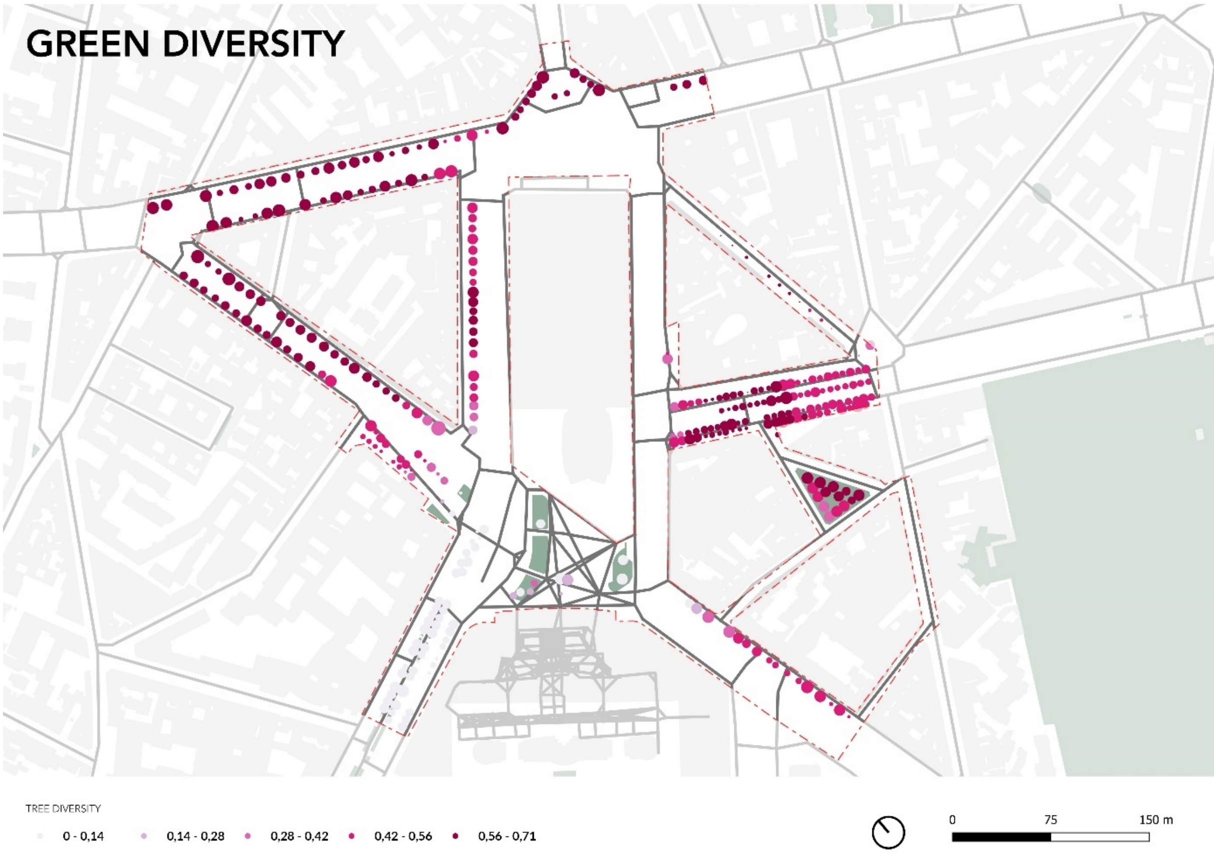

Figure 11 Green diversity

Green diversity has a mean of 0.46 and a median of 0.54, 1 being the most diverse. The fact that the median (0.54) is higher than the mean (0.46) suggests that the distribution of tree diversity is likely right-skewed. This means that while most areas have moderate diversity (as indicated by the median), areas like Boulevard de Vaugirard and Parvis Raould Dautry have very low diversity that are pulling the mean down. Specific strategies should be implemented in areas with the lowest diversity.

Green patches scattered across the site

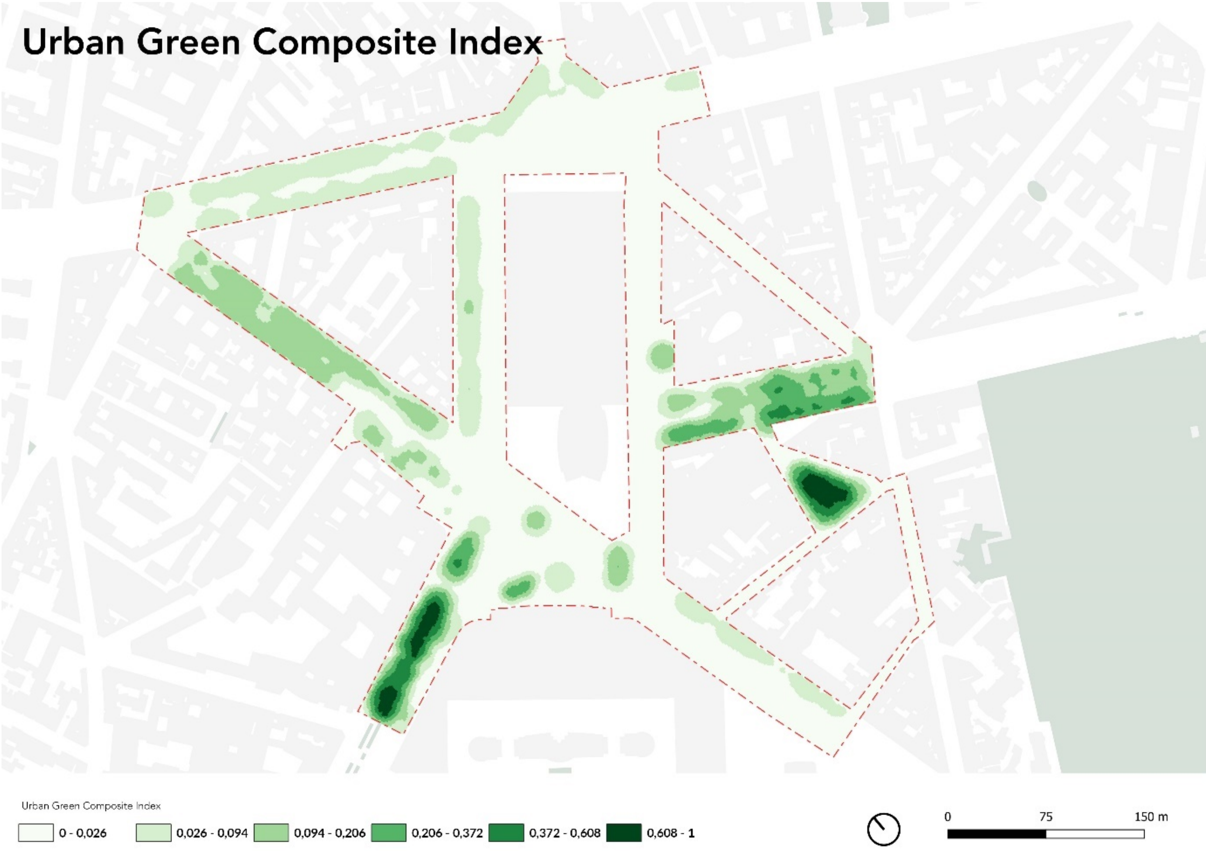

Figure 12 UGCI Output

UGCI values range from 0 to 1, 1 being the highest. High values represent high quality continuous green space. The green patches are clustered in three areas according to the map: Boulevard de Vaugirard, Park Gaston Baty and Boulevard Edgar Quinet.

Existing green patches can be preserved and improved with buffer, while connecting elements can be added to create a continuous and more complex ecosystem. To achieve this, streets need to be thought of an integral part of the green network.

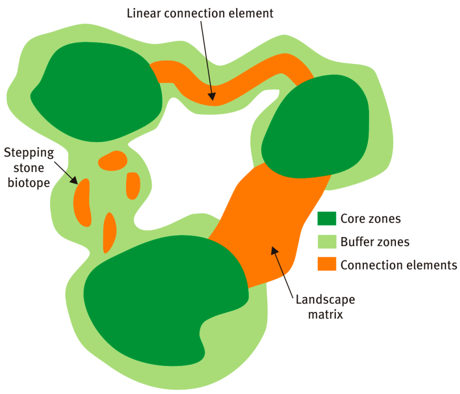

Figure 13 Diagram of an ecological network with its elements, source Revue SET

Based on the UGCI results, a set of measures can be implemented:

- Create a new patch on the Parvis Raoul Dautry. There is an opportunity to create continuous green spaces by vegetating the plaza.
- Improve green connections: The street between Boulevard Edgar Quinet and Gaston Baty Park could benefit from street planting to improve the local ecosystem.
- Use narrow streets to create linear connections: improve their green infrastructure in order to integrate them into a more complex ecosystem.

3.3. Differentiate existing pedestrian flow potential for a tailored vegetation strategy

The spatial network is coded in an 800m buffer of the study area to take into account the site and its surroundings.

To better assess pedestrian movement patterns, the flow potential was calculated from three different origin-destinations on an 800m network radius:

- At the neighbourhood scale to understand movement patterns across and through the site
- From the metro stations to the neighbourhood to evaluate main paths from public transport
- From the railway station to the neighbourhood to assess flow patterns to the HSR station on Raoul Dautry Plaza

These three pedestrian flow potential calculations are combined into one set that reveals the highest flow potential that can happen at peak hour (i.e. from work to the metro station or to the railway station).

The pedestrian flow potential can then be used to have a differentiated street design and propose a tailored vegetation strategy. It can help optimise people's movement through space to respect desire lines and make routes more efficient.

A loose pedestrian network in a car-centric environment

The site was regenerated in the 1960s-1970s, prioritising cars over vegetation and people. This led to wide spaces that are underused and can potentially be planted.

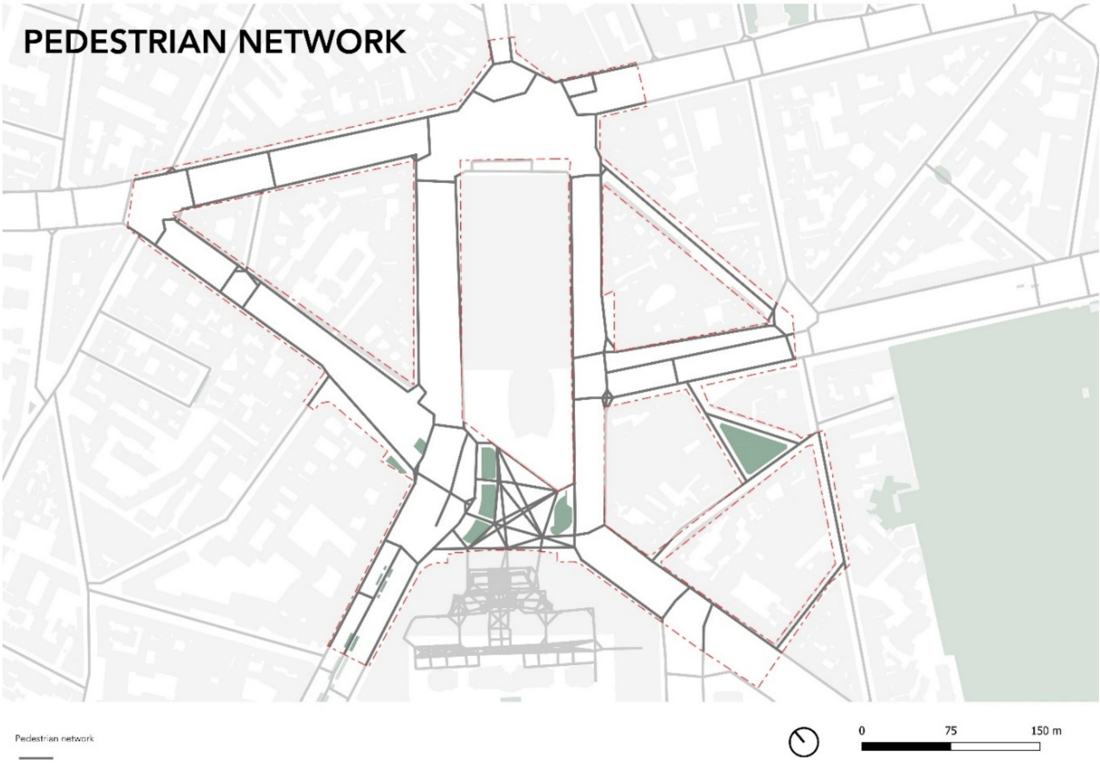

Figure 14 Pedestrian network in Montparnasse neighbourhood

Moreover, pedestrians face many detours and obstacles because of such planning. For example, the lack of crossings can lead to dangerous situations, especially where desire lines do not offer safe passage for pedestrians.

Figure 15 Rue de l'Arrivée, a large street where crossing is difficult for pedestrians

A strong desire line across the Avenue de Maine

The Avenue du Maine – Raoul Dautry plaza – Avenue du Maine has a strong diagonal desire line and high flow potential. It is an efficient route to access the neighborhood, metro stations and the railway station.

High flow potential streets need to have wide footways for pedestrians, well-dimensioned crossings. Additionally, incorporating trees along the footways not only provides shade, enhancing comfort during hot weather, but also contributes to creating green corridors where planting complex and stratified ecosystems is restricted.

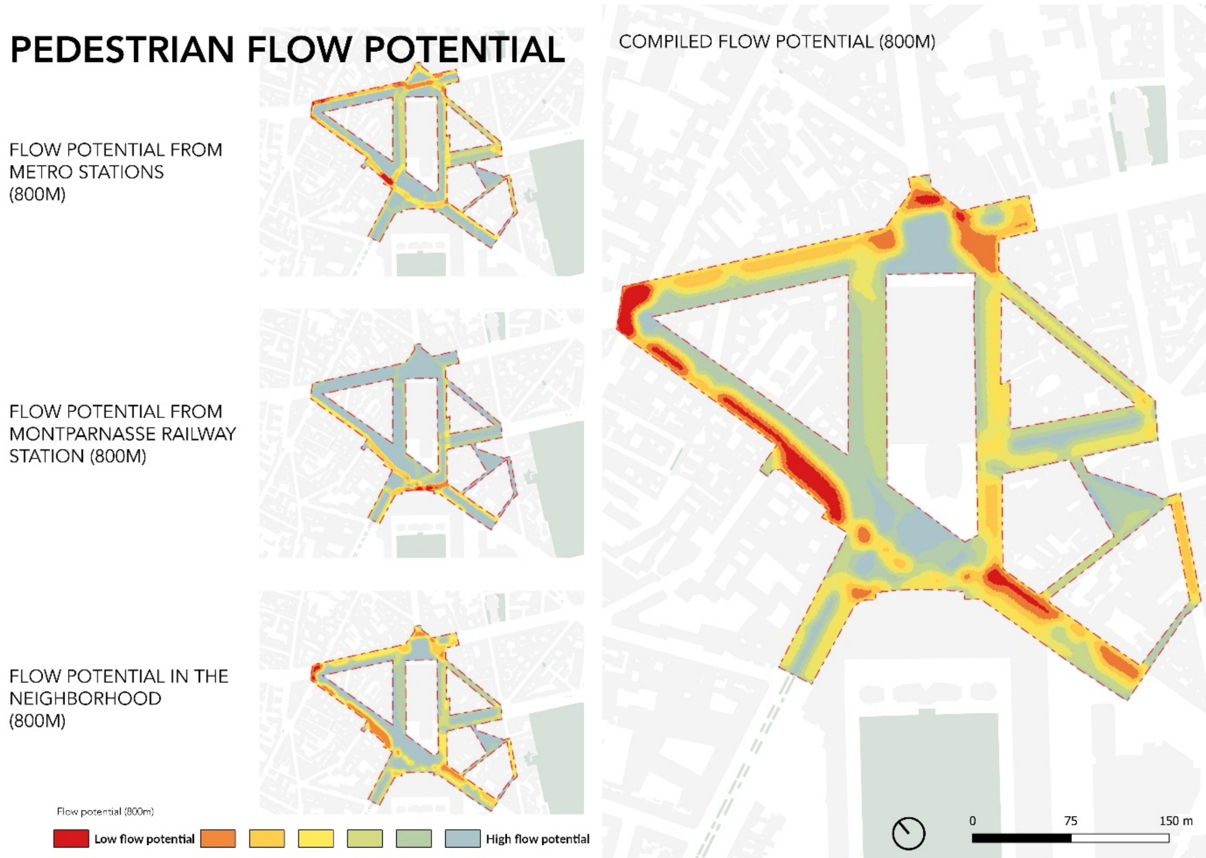

Figure 16 Pedestrian flow potential output

The footway for pedestrians on Avenue du Maine is narrow and cluttered with restaurants terraces, on street clothes selling, which can cause safety issues, reduce accessibility, and create discomfort for walkers.

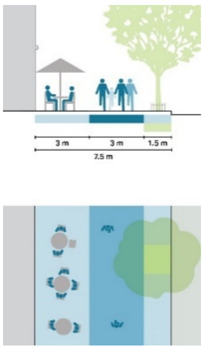

Figure 17 Global Street design guidelines pedestrian path design

Referring to the principles of the Global Street Design Guidelines, the avenue should ensure a clear path of at least 3 meters to facilitate continuous pedestrian flow, allowing people to pass one another comfortably. To enhance the vibrancy of the sidewalk, ground-floor activities from adjacent buildings can be encouraged by providing flexible and dedicated spaces along the sidewalk, adjacent to the clear path.

The street already has planted trees, however green strategies could include green pavements to integrate an herbaceous layer around them and differentiate pedestrian spaces.

Figure 18 Avenue du Maine and Raoul Dautry plaza crossing, source Google Streetview

The pedestrian crossing at the intersection of Avenue du Maine and Raoul Dautry Plaza is insufficiently wide and poorly designed to accommodate the heavy foot traffic, resulting in congestion and potential safety risks. This area could be reconfigured into a plaza with an at-level crossing, unified surface material, and central plantings for shade.

Existing low flow potential streets are designed for motorised vehicles

Streets with low flow potential are designed for cars with minimum footway space, such as rue Vandamme perpendicular to Avenue du Maine. This causes safety issues for pedestrians who are forced to walk on the roadway in order to pass one another. In addition, street parking is occupying one side of the road.

This space can be repurposed for green infrastructure, such as rain gardens, bioswales, or tree pits, which help manage stormwater runoff and improve urban resilience. Incorporating porous pavement within these areas allows water to permeate the surface, reducing the burden on traditional drainage systems and minimizing the risk of flooding.

These streets can be integrated into the ecological network of the site as mentioned in the previous section (30) They offer ecological benefits, such as improving air quality, providing habitat for urban wildlife, mitigating the urban heat island effect.

Figure 19 Rue Vandamme, source Google Streetview

3.4. Identify site constraints for plantation

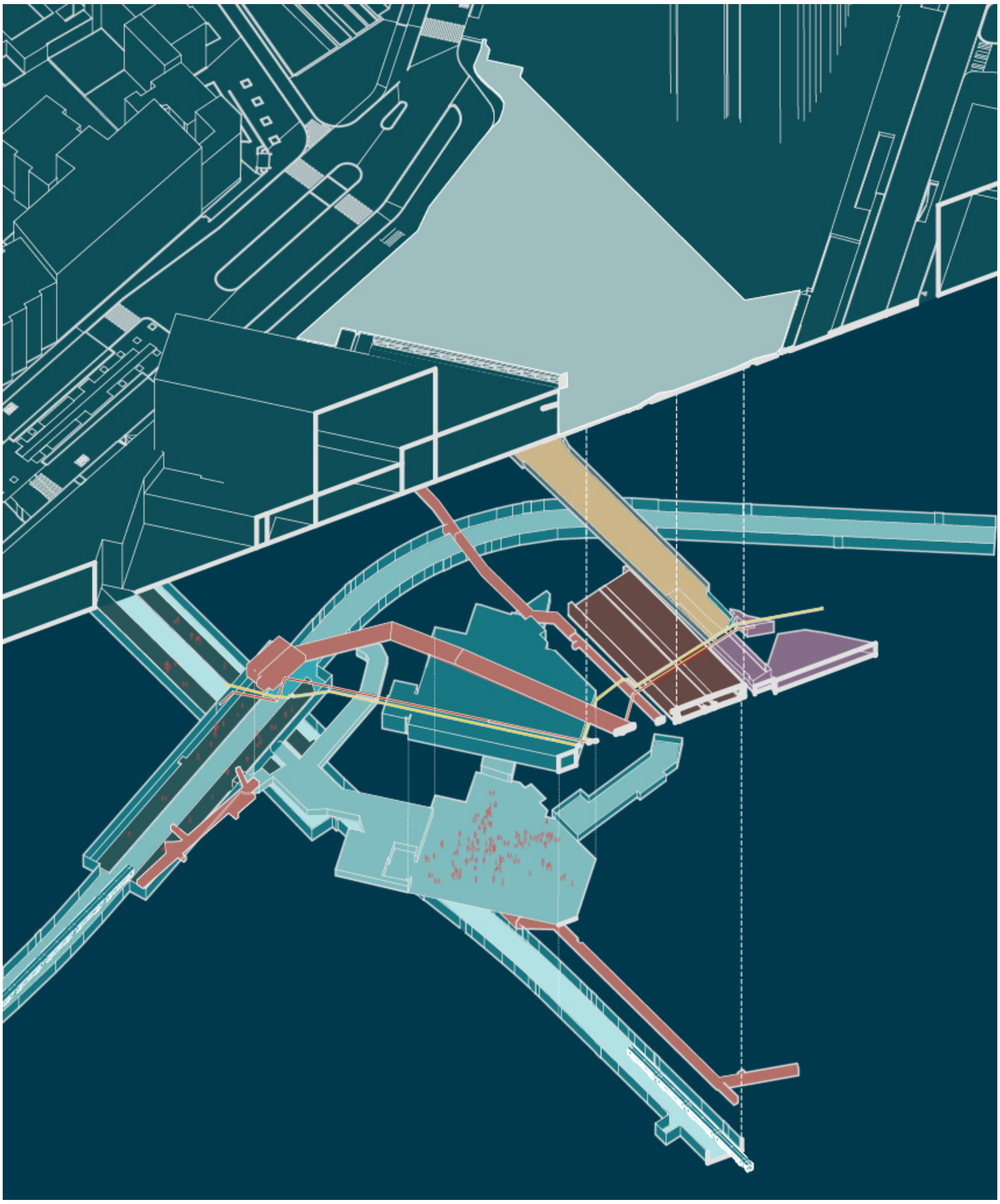

Figure 20 Exploded axonometry of the underground, source AREP

The site has multiple constraints that impact the planting strategy, as mentioned in section 0 the constraints weights are different according to their typology.

For example, as shown in the illustration above, under the Raoul Dautry plaza there are numerous underground infrastructure:

- Two subway lines (line 6 and 13)
- One interchange hall that belongs to the RATP (Parisian Autonomous Transport Administration)
- The Maine tunnel
- A bikepark,
- An abandoned underground ventilation factory
- Underground galleries and cables.

Complex underground infrastructure

Planting above metro stations, the interchange hall, tunnel and the abandoned ventilation factory is allowed according to the regulations. However, the infrastructure needs to be waterproofed to avoid any issues related to water infiltration into the underground infrastructure. For the purpose of this study, no restrictions have been applied to them, since planting is allowed.

Underground galleries and pipes

Figure 21 Planting restrictions across the site

The technical services of the City of Paris have defined protective perimeters around the networks in which tree planting is prohibited. These perimeters vary according to the type and depth of the networks.

The protection perimeters shown in the figure below have been defined as follows:

2m protection buffer for:

- SAP galleries (Paris sanitation department): it is possible to plant trees at 2.00m in XY without any special protection.
- Gas networks
- District heating
- HV/LV
- Eau de Paris (Paris Water department)

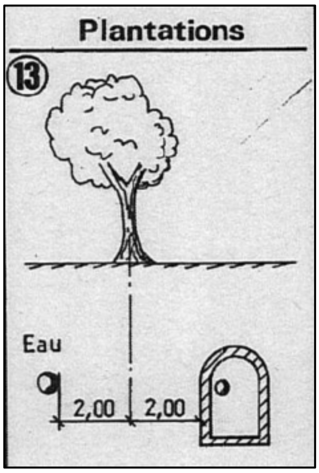

Figure 22 Underground network protection buffer

2m buffers have been computed around such networks, however different weights have been attributed according to their type. Gas, district heating and underground galleries have the highest restrictions whereas HV/LV networks have a high restriction weight.

Road hierarchy

Different restrictions have been applied on roads according to their typology:

- Transport oriented roads that connect major points in the city such as Boulevard du Montparnasse have a high restriction
- Local connectors such as rue de l'Arrivée, rue du Départ have a medium restriction
- Service roads such rue Jolivet or rue Poinsot have low restrictions

This tiered approach allows for tailored planting strategies that align with the functional needs of each road type while maximizing environmental and aesthetic benefits.

3.5. Integrating the three metrics to evaluate the site's potential for renaturation

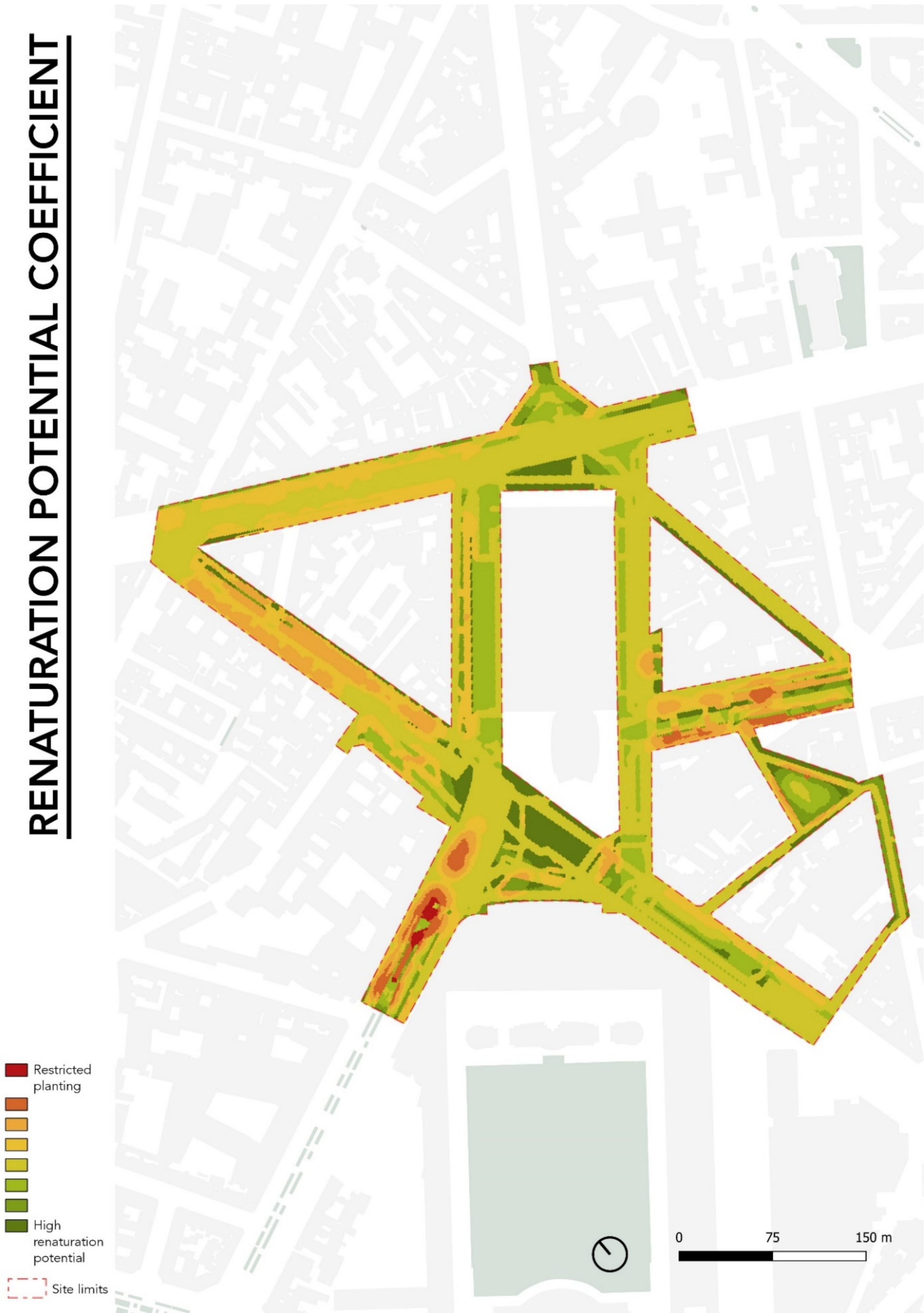

Figure 23 Renaturation Potential Coefficient

Results interpretation

Values range from 0 to 1, where 1 is the highest renaturation potential. Tree planting is possible in green areas, without any specific restrictions other than waterproof the green space in case of underground infrastructure. For example, plazas have the highest renaturation potential score, therefore they can benefit from a planting strategy.

Values in light green represent areas where tree planting is possible but should be discussed or analysed more thoroughly by specialists. For example, rue de l'Arrivée is four lane road which could be transformed into a linear park if car lanes were reduced to two lanes. This could create a new corridor connecting the two squares. On the other side, rue du Départ could benefit from continuous pits for tree planting. The presence of constraints such as pedestrian flow and underground galleries make it difficult to create a linear park or a continuous garden.

Orange to red areas represents either already planted or presents with restrictions such protection buffers around networks that don't allow tree planting.

Limitation and discussion

While the tool is efficient to quickly assess areas that can be potentially planted, there are still some limitations:

Dependence on data accuracy

The tool's effectiveness is limited by the accuracy and completeness of spatial and environmental data, especially regarding infrastructure and green space distribution and underground networks.

While open data is becoming more and more accessible through platforms like OpenStreetMap, remote sensing platforms or official government agencies, specific data are still not available to the public and are difficult to harness. For instance, tree data (including species, height, width) is not available in all the cities and manual coding, on site survey may be necessary. Underground network data can be considered as sensitive and might only be available upon request.

Simplification of complex urban factors

The tool may oversimplify dynamic urban elements such as people flow or green patches, which are critical for successful renaturation projects.

Challenges in balancing multiple metrics

Properly weighting different factors like accessibility, greenness, and constraints can be difficult, potentially leading to overemphasis on certain metrics at the expense of others. Balancing these metrics together need the involvement of specialist from related disciplines.

Conclusion

Supporting the development of green infrastructure is essential in an era where cities face challenges like climate change, urban heat islands, and biodiversity loss.

This paper introduces a valuable tool designed to estimate potential plantable areas within urban environments, employing a methodology that integrates three factors:

Existing Green Patches: By recognizing and utilizing existing green spaces, the tool enhances the ability to identify sites where biodiversity can thrive and ecosystem services can be maximized for all forms of life.

People Flow: Estimating people flow in urban environments involves analyzing how individuals move through spaces, which can inform the planning of pedestrian-friendly areas. In this context, creating a hierarchy of streets based on pedestrian movement is essential. High-flow streets, characterized by greater pedestrian activity, are typically more suitable for planting in a mineral environment while low-flow street are suitable for stratified green infrastructure.

Constraints: The tool hierarchies constraints into four levels, depending on their nature, which has a technical impact on the planting of cities.

The design of this tool enables urban planners to engage with multiple factors simultaneously, allowing for a comprehensive analysis. Municipalities can simulate various scenarios based on different planning strategies. This dynamic capability not only aids in understanding the immediate impacts of proposed interventions but also promotes long-term strategic thinking regarding urban green infrastructure development.

Furthermore, the tool has an adaptable scale, providing both micro-planning and macro-level information. This functionality assists municipalities in prioritizing green infrastructure implementation at a higher level. Identifying high-priority renaturation areas is another significant advantage of this tool. Emphasizing accessibility, green space continuity ensures that renaturation projects are ecologically viable and socially inclusive (Gill et al, 2007).

The tool's ability to simulate project changes and outcomes is a great asset for adaptive management. Planners can monitor how renaturation potential shifts in response to modifications, thus enabling real-time amendments as projects evolve. By visualizing the spatial relationships between existing green patches, pedestrian flow, and urban constraints, planners can develop targeted strategies that maximize environmental benefits by having a holistic understanding of urban ecosystems, leading to more informed decision-making processes (McPhearson et al., 2016).

In conclusion, the tool serves as a robust platform for urban planners and municipalities, facilitating a comprehensive understanding of urban green infrastructure and enhancing the potential for successful renaturation projects. By providing insights into the interplay of multiple factors influencing urban spaces, it allows professionals and stakeholders to make evidence-based decisions that foster the ecological transition in urban spaces.

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