



# Urban greenery for air pollution mitigation

Incorporation of urban greenery as a mitigation strategy in Swedish air quality plans

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**Authors:** Ågot Watne (IVL), Helene Olofson (City of Gothenburg), Jenny Lindén (IVL), Jenny Klingberg (Gothenburg Botanical Garden), Malin Gustafsson (IVL)

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## Summary

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Urban greenery has been identified as a potential strategy for air pollution mitigation. Greenery provides surfaces for pollutant deposition and can effectively reduce PM10 concentrations in urban environments. This report aims to provide an understanding of how to incorporate urban greenery as a measure for air pollution mitigation in air quality management. We have specifically focused on how urban greenery can be used as a measure in air quality plans. An air quality plan is a regulatory strategy aimed at improving air quality in regions that do not meet the standards set by the European Union's air quality directives. This work includes a review of the use of urban greenery as a strategy for air pollution mitigation in Swedish air quality plans.

Five of the total twelve cities that has developed air quality plans have incorporated measures on urban greenery in their plans. The Swedish air quality plans describe urban greenery as a “long-term, strategic and knowledge intensive” measure. The main justification for including urban greenery is not its direct effect of reducing air pollutant concentrations through deposition, but rather its indirect effect of reducing emissions attributed to decreased traffic. Based on available information, it remains unclear if urban greenery has been implemented as a PM10 mitigation measure in Swedish municipalities. Additionally, we found no evidence of municipalities having evaluated the impact of urban greenery on PM10 levels. This lack of data makes it challenging to assess the effectiveness of greenery in mitigating particulate pollution across urban areas.

The air quality directive states that air quality plans should primarily include powerful measures that reduce pollutant levels as quickly as possible. Therefore, the main effort in an air quality plan needs to be on emissions reductions. While urban greenery can be used as a measure for air pollution mitigation it is best used as a long-term strategical measure. Therefore, urban greenery as a measure to reduce air pollution is better to include in the development of preventive air quality strategies, for example in air quality roadmaps. However, urban greenery barriers can be used to prevent transport of traffic pollutants to sensitive locations e.g. between a major road and a school, when a relatively quick measure to reduce school yard exposure is needed.

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# 1 Introduction

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Urban greenery has been identified as a potential strategy for air pollution mitigation. Well-planned urban greenery can reduce ambient particulate matter concentrations through deposition and act as a barrier protecting from transport of polluted air to specific urban areas. However, as vegetation alters air flow patterns, it can potentially reduce ventilation and trap pollutants, increasing their concentration.

This report aims to provide an understanding of how to incorporate urban greenery as a measure for air pollution mitigation in air quality management. We have specifically focused on how urban greenery can be used as a measure in air quality plans. The work includes a review of work with urban greenery for air pollution mitigation in Sweden. The new air quality plan for PM<sub>10</sub> (Particulate Matter with diameter less than 10 µm) for the City of Gothenburg will be discussed in more detail.

This report is part of the FORMAS funded project Urban greenery for clean air (2023-02005).

## 2 Urban greenery impacts on air quality

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The impact of urban greenery on air quality in a street environment is complex. It can have both positive and negative effects, depending on the design, location, and type of greenery. Therefore, it is important to carefully plan the greenery for the best effect. For larger particles, PM<sub>10</sub>, the positive effect from vegetation clearly dominates, while for smaller particles, PM<sub>2.5</sub> and gaseous pollutants, such as NO<sub>2</sub>, the risk is greater that the positive effects are balanced out by the negative. In this report, we will therefore focus on the potential of using vegetation for PM<sub>10</sub> mitigation.

### Deposition of pollutants

A clear positive effect occurs when air pollutants are deposited on the leaves and branches of the greenery, thus reducing concentrations in the air. How much pollution is trapped depends on the surface properties of the leaves, how the vegetation is designed, and the season. For example, more particles are trapped by a hairy, waxy leaf compared to a smooth leaf, and needles are even more efficient due to the irregular shape of a coniferous shoot. Coniferous trees are also usually green year-round, which reduces seasonal effects. For gaseous pollutants, it is mainly the stomata on the leaves that influence the uptake of pollutants, where higher stomatal conductance generally lead to a greater uptake. Although both particulate and gaseous pollutants are deposited to leaves, the effect is strongest for the larger fraction of particles, PM<sub>10</sub>.

Large trees and small-scale greenery, such as green walls, roofs, and hedges, provide surfaces for pollutant deposition and can effectively reduce PM<sub>10</sub> concentrations in urban environments. Trees placed in areas where people spend significant time, like playgrounds and schoolyards, can create healthier microenvironments, while small-scale greenery offers additional local filtering benefits. However, further research is needed to better understand the long-term efficiency and performance of small-scale solutions in varying urban settings and their interaction with local airflow dynamics.

### Barriers and trapping of air pollutants

The airflow in the street space is also affected by greenery, and it is important to plan the greenery so that air quality is not negatively impacted. If greenery is used as a barrier, the transport of pollutants from the emission source to places where

people spend time can be prevented, thus limiting air pollution exposure. However, if greenery is placed so that airflow is reduced in street canyons where emissions occur, such as when trees with dense canopies are placed over a busy road, emissions in the street space may accumulate due to reduced dilution and dispersion, resulting in poorer air quality.

### Contribution to formation of secondary air pollutants

Urban greenery can also impact air quality by contribution to formation of secondary air pollutants. Plants emit biogenic volatile organic compounds (BVOCs) that can react with other air pollutants to form secondary organic aerosols (SOA) and ozone (O<sub>3</sub>). SOA particles contribute to air pollution and may reduce the air quality benefits intended from urban greenery. Choosing low BVOC-emitting plants can help reduce this risk and ensure that greenery effectively improves urban air quality without inadvertently increasing particulate pollution levels.

### Pollen

Pollen, emitted by trees, grasses, and other plants, are biological particles (bioaerosol) that contribute to PM concentrations in the atmosphere. Pollen grains are generally in the size range of 10-100 µm in diameter and therefore, not counted as PM<sub>10</sub>. However, during peak pollen seasons, these particles can cause respiratory issues, particularly for individuals with allergies or asthma.

In urban environments, the choice of vegetation species plays a critical role. High-pollen-producing plants, such as birch, oak, and certain grass species, can lead to elevated levels of bioaerosols.

When designing urban greenery as part of air quality plans, it is crucial to select low-allergenicity plants and consider management strategies to minimise the impact of pollen. This includes diversifying plant species, maintaining vegetation to reduce excess pollen release, and integrating these measures with other strategies to improve urban air quality.

### Other benefits

While the effect on air quality is complex, the overall impact of increased greenery in a street space extends far beyond air quality, due to the many other benefits greenery provides. For example, heat stress and flood risk are reduced, which is increasingly important in a changing climate. Biodiversity increases, as does carbon dioxide (CO<sub>2</sub>) uptake, and noise is reduced. Additionally, there are clear links between urban greenery and improved human health and well-being.

## 3 Incorporating Urban Greenery in air quality plans for PM10

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An air quality plan is a regulatory strategy aimed at improving air quality in regions that do not meet the standards set by the European Union's air quality directives. These plans target specific pollutants, like PM10 and NO<sub>2</sub>, to ensure compliance with health-based air quality limits and improved environmental conditions. Air quality plans typically include a combination of strategies to reduce emissions and improve air quality. Urban greenery can be one of these measures.

### 3.1 Introduction to air quality plans

Chapter IV article 23 in Directive 2008/50/EC of the European parliament and of the council on ambient air quality and cleaner air for Europe<sup>1</sup> states that when, in given zones or agglomerations, the levels of pollutants in ambient air exceed any limit value or target value, plus any relevant margin of tolerance in each case, Member States shall ensure that air quality plans are established for those zones and agglomerations in order to achieve the related limit value or target value specified. In the event of exceedances of those limit values for which the attainment deadline is already expired, the air quality plans shall set out appropriate measures, so that the exceedance period can be kept as short as possible. The air quality plans may additionally include specific measures aiming at the protection of sensitive population groups, including children.

According to the European Environment Agency EEA, 944 air quality plans from 21 Member States were reported over the period 2014-2020<sup>2</sup>. In terms of pollutants, 62% of the measures focused on reducing emissions of nitrogen oxides (NO<sub>2</sub>), while 26% focused on coarse particles (PM10) and 10% on fine particles (PM2.5). A small number of measures targeted benzo(α)pyrene (BaP).

Figure 1 aggregates information on the type and number of measures in the air quality plans reported for PM10, categorized into Traffic (34%), Awareness raising (23%), Public procurement (11%), Fuels (21%), Industry (1%) and Other (9%). The

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<sup>1</sup> A new air quality directive was formally adopted by the European Council in October 2024. The new directive will, among other things, include stricter air quality standards to be met by 2030 at the latest. It will also include reinforcements and improvements in several of the directive's more technical provisions regarding e.g. air quality plans.

<sup>2</sup> [Managing air quality in Europe – European Environment Agency \(europa.eu\)](https://www.eea.europa.eu/en/press-releases/2021/04/managing-air-quality-in-europe)



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main category Other is not further specified and may include measures on urban greenery. However, given the information provided, it can be concluded that measures incorporating urban greenery are not common in European air quality plans.

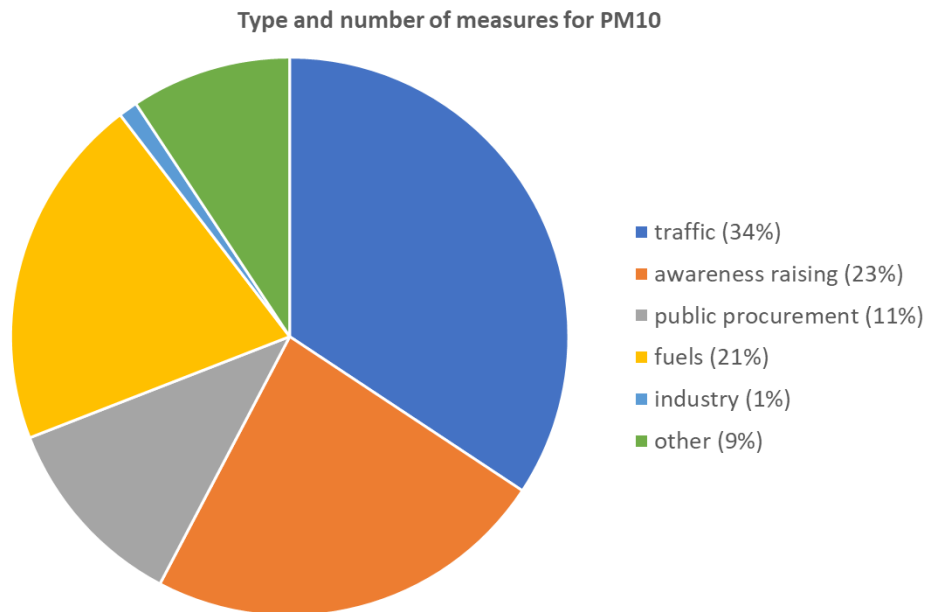


Figure 1 Type and number of measures for PM10 in air quality plans in Europe 2014-2020. The total number of measures is 1809. Source: [Managing air quality in Europe – European Environment Agency \(europa.eu\)](https://www.euro.who.int/en/health-topics/air-quality)

## 3.2 Urban greenery in Swedish air quality plans

Seven cities in Sweden have established air quality plans for PM<sub>10</sub>. These are Visby<sup>3</sup>, Gothenburg<sup>4</sup>, Linköping<sup>5</sup>, Stockholm<sup>6</sup>, Hedemora<sup>7</sup>, Sundsvall<sup>8</sup>, Östersund<sup>9</sup>, Örnköldsvik<sup>10,11</sup> and Piteå<sup>12</sup>. Yet another three cities; Köping<sup>13</sup>, Västerås and Skellefteå, are in the process of establishing such plans. Five of the total twelve cities have incorporated measures on urban greenery in their air quality plans: Gothenburg, Sundsvall, Östersund, Örnköldsvik, and Piteå. The measures are described in the following sections. . Table 1 shows a summary of measures in Swedish air quality plans that incorporate urban greenery, along with a short description on how each measure contributes to reducing PM<sub>10</sub> levels.

As we have been part of the work to develop and establish the new air quality plan for the City of Gothenburg, insights and learnings for this city will be discussed in more detail.

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<sup>3</sup> Region Gotlands informationssida om åtgärdsprogram: [Luften utomhus | Region Gotland](#)

<sup>4</sup> Göteborgs Stads informationssida om åtgärdsprogram: [Lagar och miljömål för luften - Göteborgs Stad](#)

<sup>5</sup> Linköpings kommuns informationssida om åtgärdsprogram: [Åtgärdsprogram för kvävedioxid NO<sub>2</sub> - linkoping.se](#)

<sup>6</sup> Länsstyrelsen i Stockholms informationssida om åtgärdsprogram: [Åtgärdsprogram för kväveoxider och partiklar i Stockholms län | Länsstyrelsen Stockholm](#)

<sup>7</sup> Hedemora kommuns informationssida om åtgärdsprogram: [Åtgärdsprogram för luftföroreningar PM<sub>10</sub> - Hedemora kommun](#)

<sup>8</sup> Sundsvalls kommuns informationssida om åtgärdsprogram: [Frisk luft i Sundsvall | Sundsvalls kommun](#)

<sup>9</sup> Östersunds kommuns informationssida om åtgärdsprogram: [Luften i centrala Östersund - Östersund.se](#)

<sup>10</sup> Örnköldsviks kommuns informationssida om åtgärdsprogram: [Se policy eller strategi - Välkommen till Örnköldsviks kommun](#)

<sup>11</sup> Örnköldsviks kommuns informationssida om samråd kring nytt åtgärdsprogram: [Samråd kring åtgärdsprogram för bättre luft i centrala Örnköldsvik - Välkommen till Örnköldsviks kommun](#)

<sup>12</sup> Piteå kommuns informationssida om åtgärdsprogram: [Luftkvalitet - Miljö och hälsa](#)

<sup>13</sup> Köping kommuns informationssida om åtgärdsprogram: [Överskridande av miljökvalitetsnormen för partiklar i Köping - Köpings kommun](#)

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Table 1. Summary of measures in air quality plans that incorporate urban greenery.

Air quality plan	Measure	How the measure contributes to reducing PM10 levels	
		Primary	Secondary
Gothenburg	Develop methods within the City of Gothenburg to strengthen the competence of the positive effects of greenery on air quality	Strategic city planning	Particle barriers and particle deposition
Sundsvall	Green space strategy and green space plan	Strategic city planning	Particle barriers and particle deposition
Sundsvall	Investigate the use of green spaces and vegetation for improved air quality along central streets with particle pollution	Particle deposition	-
Östersund	Green barriers against particle pollution	Particle barriers and particle deposition	Strategic city planning
Örnsköldsvik (current)	Increase the urban feeling	Reduce traffic	Particle deposition
Örnsköldsvik (current)	Investigate how urban greenery can be used to stop or direct wind	Particle barrier	-
Örnsköldsvik (on consultation)	Introduce greenery along streets	Particle barriers and particle deposition	Strategic city planning
Piteå	Rebuilding Lillbrogatan	Reduce traffic	Particle deposition

### 3.2.1 Gothenburg

The City of Gothenburg's air quality plan, established in 2024, includes the measure "*develop methods within the City of Gothenburg to strengthen the competence of the positive effects of greenery on air quality*". The aim of the measure is to increase the status of greenery in urban planning by more carefully comparing and weighing its values to that of other infrastructures.

In order to achieve well-planned urban greenery, it is important to be able to determine which factors are most important for each specific case, and to use the right tree in the right place. Tree specialists within the City of Gothenburg already work with these issues, however more knowledge is needed also among project managers, urban planners, consultants, and contractors. With the right expertise, the City of Gothenburg can become better at tailoring the urban greenery to the functions required for a specific location. Air pollution is rarely a focus when trees are selected. Other examples of ecosystem services that greenery can deliver are spatial formation, place-identity, shading, temperature reduction, wind regulation, stormwater management, biological diversity, and aesthetic qualities.

It is important to note that the intention of the measure is to strengthen competence and develop methods to better plan for, and design, primarily trees in urban development. The measure does not have a direct impact on the area or amount of greenery. The amount of greenery needs to be managed within the usual urban development process and within the existing guidelines for development and management.

The City of Gothenburg's environmental and climate program 2021-2030<sup>14</sup> includes the strategy "*we plan for a green and robust city*". Part of the strategy is to promote blue- and green infrastructure as an obvious part of urban planning. Some of the orientations found in the strategy are to develop guidelines for how blue- and green values can have an impact on as well as to harmonize and coordinate with the existing guidelines in Gothenburg, to develop ways to rate green and blue values so that they can be prioritized higher in relation to other values, to develop tools and working methods to make these values visible, and to increase knowledge in blue – and green values. There is much to be gained by coordinating

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<sup>14</sup> Göteborgs Stads sida om miljö- och klimatprogrammet: [Miljö- och klimatprogrammet - Miljö och klimat Göteborg 2030 - Göteborgs Stad](#)

the work with the air quality plan and the strategy work in the environmental and climate program.

### 3.2.2 Sundsvall

Sundsvall municipality's air quality plan, established in 2020, includes the measures *"green space strategy and a green space plan and investigate the use of green spaces"* and *"vegetation for improved air quality along central streets with particle pollution"*. The rationale for both measures is that greenery can have a positive effect on air quality as plants can function as a kind of air filter when particles deposit to the leaves of the plants. At the same time, plants in a dense city can reduce air flow and thus retain air pollution in the street space. How to use vegetation as a measure to improve air quality is therefore not a simple question.

A green space strategy is currently being developed, which will be included in Sundsvall municipality's comprehensive plan. Once the green space strategy has been established, work will begin to develop a green space plan. The green space plan is a plan for how the goals and guidelines of the green space strategy are to be met. It is estimated that a green space strategy and green space plan, that takes the factors of particle deposition and air flow into account, can generate a slightly positive effect on air quality in the city.

Investigation of an increased use of greenery on specific streets where particle concentrations are high is a long-term strategic measure that includes dialogue and consultation with relevant property owners. It is stated in the air quality plan that investigation without action has no effect on air quality.

### 3.2.3 Östersund

Östersund municipality's air quality plan, established in 2022, includes the measure *"green barriers against particle exposure"*. The measure falls under the category *"measures that require further investigation"*, meaning that its inclusion in the air quality plan has not been decided by the municipal council, nor has its effects or costs been calculated. The measure is described as long-term, strategic and knowledge intensive. It has major synergies in society e.g. but does not contribute significantly towards reduced particle concentrations within the short time span required in an air quality plan.



Since the air quality plan was established, it has been decided that the measure on green barriers needs to be further investigated before possibly being implemented. The reason for this is that the use of green barriers is a complex topic, and that the current evidence base showing their benefit for air pollution reduction is small. More information is needed to avoid making wrong decisions, which could risk lower air flows and increased particle exposure. Furthermore, as the effect of the measure is assessed as small and resources are limited, Östersund has decided to focus on more powerful measures.<sup>15</sup>

### 3.2.4 Örnsköldsvik

Örnsköldsvik municipality's current air quality plan, established in 2011, includes a measure to *"increase the urban feeling"* along the central esplanade. Increased urban feeling is here defined as e.g. narrower streets, fewer lanes and better pedestrian crossings. Planting of bushes and trees is also mentioned. The measure contributes to decreased traffic flows in general, with the additional effect that the greenery also can deposit particles and decrease exposure. It is also mentioned that vegetation has a calming effect on traffic speed, which in turn has a positive effect on particle generation. Another measure, aiming at reducing particle exposure, is to *"investigate how urban greenery can be used to stop or redirect wind"*.

We have not been able to find any information on whether the above measures have been implemented, nor on their effects on PM10 levels in Örnsköldsvik.

A new air quality plan for Örnsköldsvik municipality is currently in public consultation. The new plan includes a measure to *"introduce greenery along streets"*. The measure involves reviewing and evaluating the greenery along streets that are at risk of exceeding air quality standards for NO<sub>2</sub> and PM10. The evaluation needs to include other benefits and ecosystem services that trees provide. Only focusing on their benefits on air pollution may result in losses of other ecosystem services such as stormwater management, perceived noise and temperature regulating properties as well as carbon storage and carbon uptake. The following sub measures are suggested:

- Investigate the possibility of introducing more greenery along the streets where limit values are exceeded or are at risk of being exceeded,

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<sup>15</sup> Personlig kommunikation med Hanna Lundqvist, projektledare Östersunds kommun

- investigate which greenery is suitable at different locations in Örnköldsvik,
- revise the municipality's green plan with the aim of improving air quality in central Örnköldsvik,
- investigate the possibility of new technical solutions suitable in Örnköldsvik, also taking other ecosystem services into account,
- replace existing greenery with trees and plants that benefit air quality and remove the greenery that deteriorate the air quality, while also considering other ecosystem services, and
- introduce new greenery along certain streets to alter local wind characteristics.

The measure is estimated to have a small positive effect on both NO<sub>2</sub> and PM<sub>10</sub> levels. It is also estimated to have a positive on biodiversity, ecosystem services and temperature regulation in the city.

### 3.2.5 Piteå

Piteå municipality's air quality plan, established in 2023, describes a measure aimed at "*rebuilding Lillbrogatan*", a street with high particle concentrations, with the aim to decrease traffic. The main focus of the measure is to rebuild and redesign the street to prioritize unprotected road users, and to reduce the number of parking spaces from 54 to 24. In addition, 14 trees will be placed in the area, which is estimated to contribute to the deposition of particles. However, the trees may also prevent circulation of air.

Lillbrogatan has been rebuilt according to plan. The biggest advantage of placing trees on Lillbrogatan is that the trees take up space in the street. This means fewer parking spaces and reduced road traffic, which was one of the main goals of the redevelopment project. Generally, city planners in Piteå try to incorporate greenery in street space and parking, not specifically with air quality in mind but rather to create pleasant environments.

## 4 Discussion

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The impact of urban greenery on air quality in a street environment is complex. The overall impact of increased greenery in a street space extends far beyond air quality, due to the many other benefits greenery provides. Preserving existing greenery, particularly mature trees, is crucial for achieving immediate and lasting air quality benefits. Large trees provide extensive surface areas for pollutant deposition and play a vital role in reducing particulate matter concentrations, particularly PM<sub>10</sub>, in urban environments. Studies have shown that placing trees in areas where people spend significant time, such as playgrounds, schoolyards, and residential courtyards, can markedly lower PM<sub>10</sub> levels and create healthier microenvironments.

Different air quality mitigation measures vary in their applicability and effectiveness. The Air Quality Directive states that air quality plans should primarily include powerful measures that reduce pollutant levels as quickly as possible. Urban greenery can be used as a local measure by creating barriers of greenery, e.g. between a major road and a school, relatively quickly to reduce exposure. However, to achieve a powerful, long term and robust reduction in pollutant levels in a larger area (e.g. a whole city), measures are required that lead to reduced road traffic and reduced road wear. If urban greenery is to be used as a measure on a larger scale, it is better suited as a long-term strategic measure integrated in urban planning or in a preventive air quality program (air quality roadmap, as defined in the Air Quality Directive).

A review of measures in European air quality plans, conducted by the European Agency EEA, does not provide specific insights on how, or even if urban greenery is used as an air quality measure<sup>16</sup>. Urban greenery is, however, often listed as a possible measure for particle pollution mitigation. For the scope of this report, we have limited the review to only include Swedish air quality plans. Urban greenery has been proposed as a mitigation strategy in five out of twelve air quality plans for PM<sub>10</sub>. The main argument of including urban greenery is not its direct effect of reducing air pollutants through deposition, but rather its indirect effect of reducing emissions attributed to decreased traffic. Integrating urban greenery in cities can reduce the space available for traffic, as green areas, trees, and planted barriers can be used to replace parking spaces or be added alongside roads and other urban

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<sup>16</sup> [Managing air quality in Europe – European Environment Agency \(europa.eu\)](https://www.eea.europa.eu/en/press-releases/2018/04/16-managing-air-quality-in-europe)

infrastructure. It is only three out five air quality plans that mention the effect of deposition as a main reason to include urban greenery as a measure.

Based on available information, it remains unclear if urban greenery has been introduced as a PM10 mitigation measure in Swedish municipalities. Additionally, we found no evidence of municipalities having evaluated the impact of urban greenery on PM10 levels. This lack of data makes it challenging to assess the effectiveness of greenery in mitigating particulate pollution across urban areas. To address knowledge gaps and reduce barriers to implementing urban greenery, the city of Gothenburg has actively participated in research projects aimed at evaluating the effects of greenery on air quality<sup>17 18</sup>. Key lessons from Gothenburg indicate that successful integration of greenery as a PM10 mitigation measure relies on collaboration and cross-departmental dialogue within the city's administrative framework. This suggests that implementing greenery in air quality management should be seen as a long-term strategic measure, embedded within routine urban development, and governed by established guidelines for planning and maintenance.

The Swedish regulation of the air quality directive was updated in 2024. A new tool now included in the regulation is the preventive air quality strategy which should be developed when pollutant levels exceed or are expected to exceed the upper assessment threshold. The strategy can include a variety of long-term measures, such as behavior change and information measures, infrastructure measures, investigations, and policy instruments. The air quality plans, on the other hand, should primarily include powerful measures that reduce levels as quickly as possible to comply with the environmental quality standard.

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<sup>17</sup> <https://www.ivl.se/vart-erbjudande/forskning/luft/urban-gronska-for-ren-luft.html>

<sup>18</sup> <https://www.ivl.se/vart-erbjudande/forskning/luft/cityairsim-visar-hur-gronska-paverkar-stadsluften.html>

## 5 Recommendations

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Based on the review and our experience from the development of the Air Quality Plan, we recommend the following to incorporate urban greenery as a mitigation strategy to improve air quality:

1. Include urban greenery in long-term urban planning as a complementary measure for PM10 reduction in development of air quality strategies.
2. Promote collaboration across city departments to streamline the inclusion of urban greenery in urban planning strategies.
3. Preserve existing greenery, with a strong focus on protecting large, mature trees, which provide substantial and immediate air quality benefits.
4. Use urban greenery as barriers to protect specific sites, such as bike lines, preschools, and nursing homes to reduce air pollution exposure.



## 6 Further reading

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**STOCKHOLM**

Box 21060, 100 31 Stockholm

**GOTHENBURG**

Box 53021, 400 14 Gothenburg

**MALMÖ**

Nordenskiöldsgatan 24  
211 19 Malmö

**KRISTINEBERG**

(Center for Marine  
Research and Innovation)  
Kristineberg 566  
451 78 Fiskebäckskil

**SKELLEFTEÅ**

Kanalgatan 59  
931 32 Skellefteå

**BEIJING, CHINA**

Room 612A  
InterChina Commercial Building No.33  
Dengshikou Dajie  
Dongcheng District  
Beijing 100006  
China

*This report has been reviewed and approved in accordance with IVL's audit and approval management system.*



Swedish Environmental  
Research Institute