

# Ecological road design

**A study on the effects of roads on ecosystem services in Leiden**

# Contents

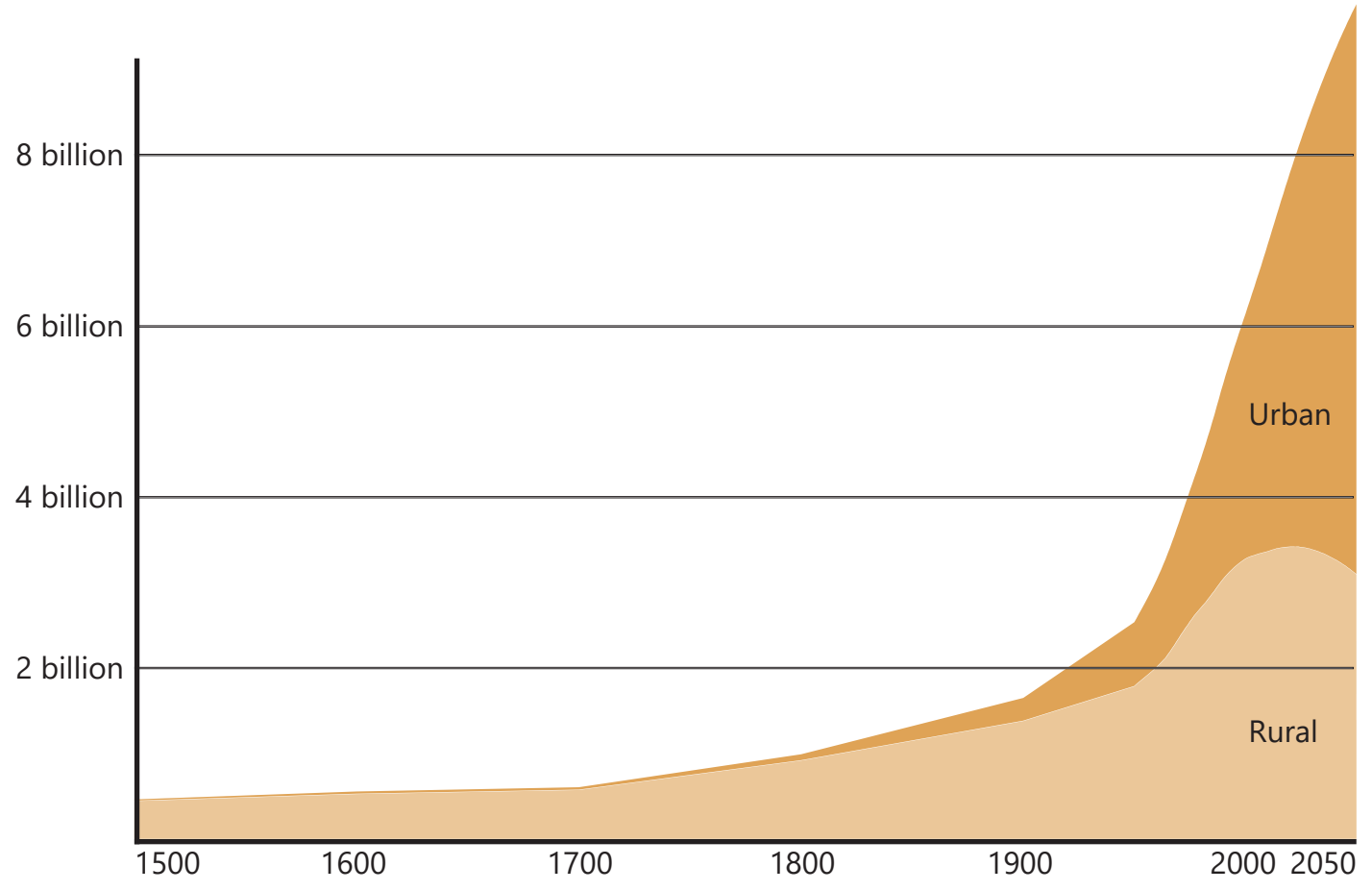
1. Introduction
2. Theoretical framework
3. Analysis
4. Design principles
5. Design exploration
6. Conclusion



# **1. Introduction**

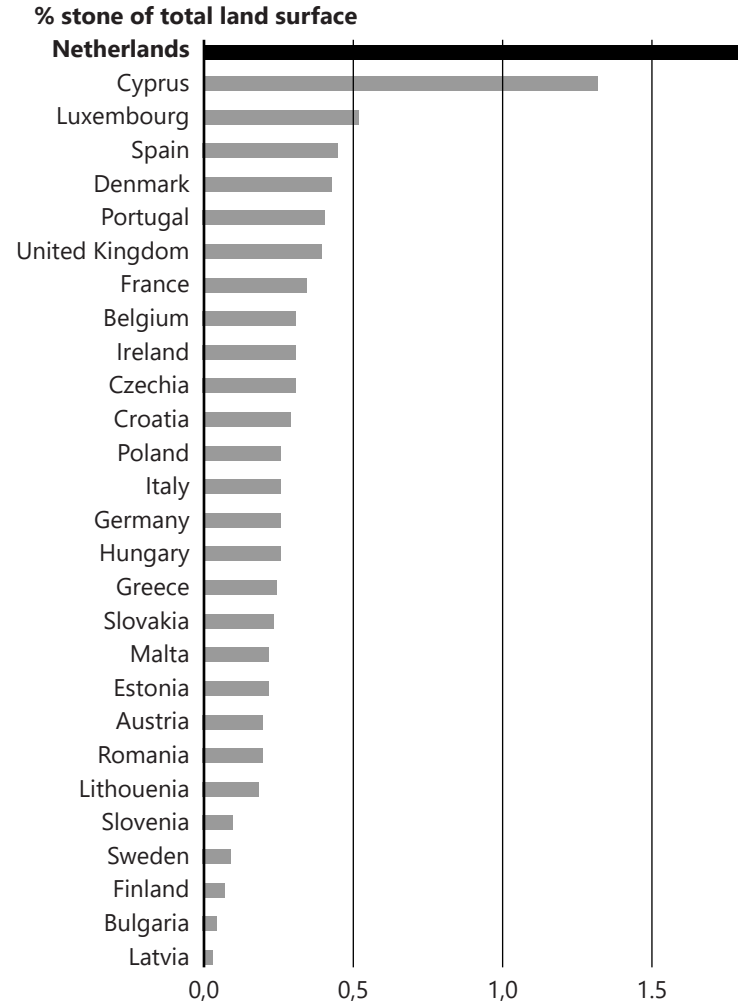
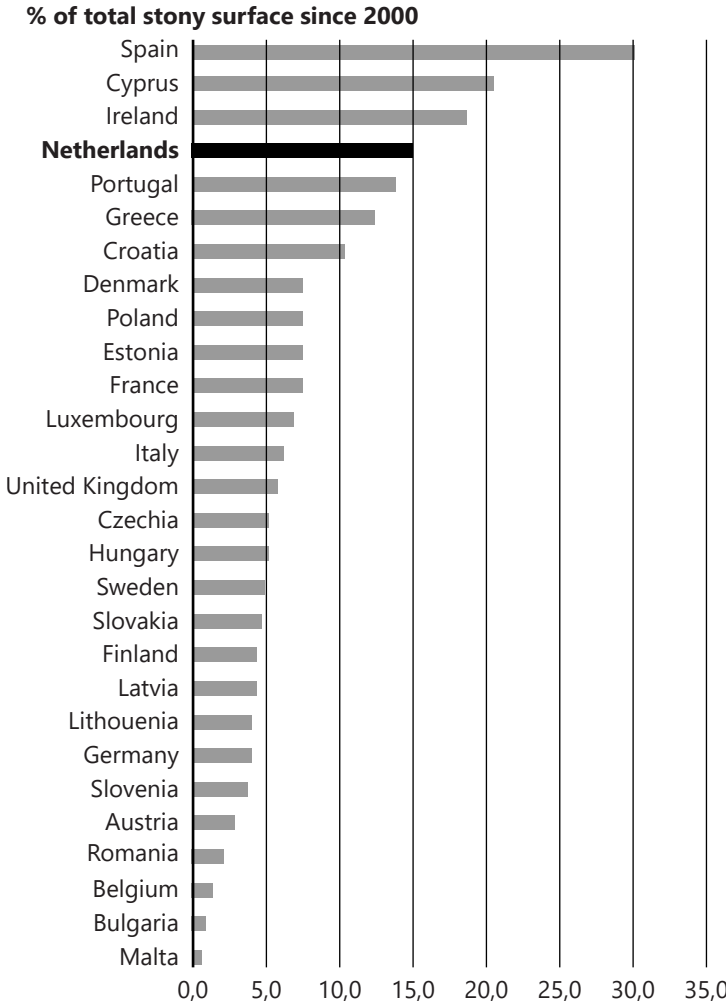
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# Global urbanization trend

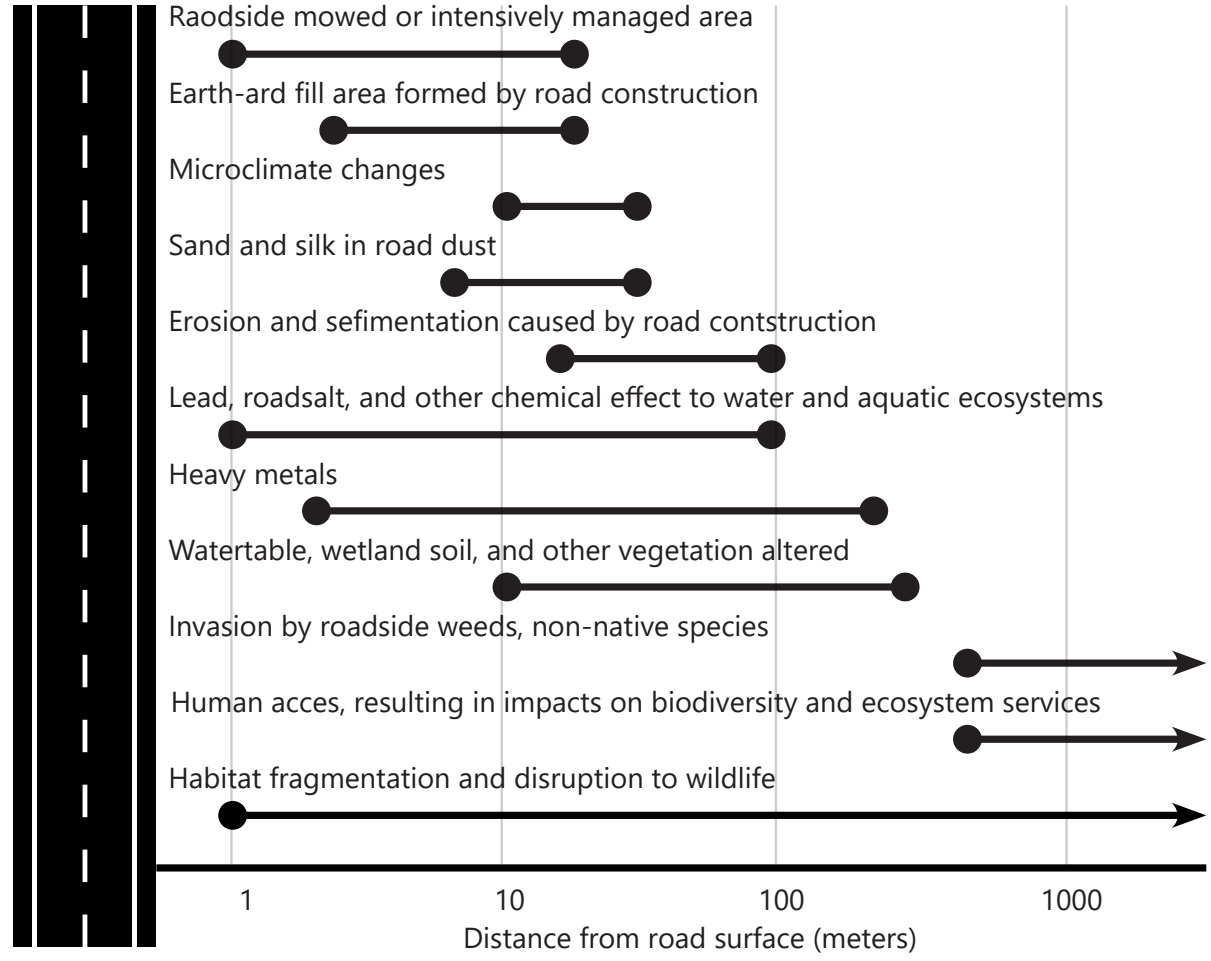


Global urbanization trend (UN World Urbanization Prospects)

# Country of stone



# Ecological road effect



*The range of average and maximum distance from the road across which impacts on ecosystems and ecosystem services have been documented. (Mandle et al., 2016).*

# Ecosystem services

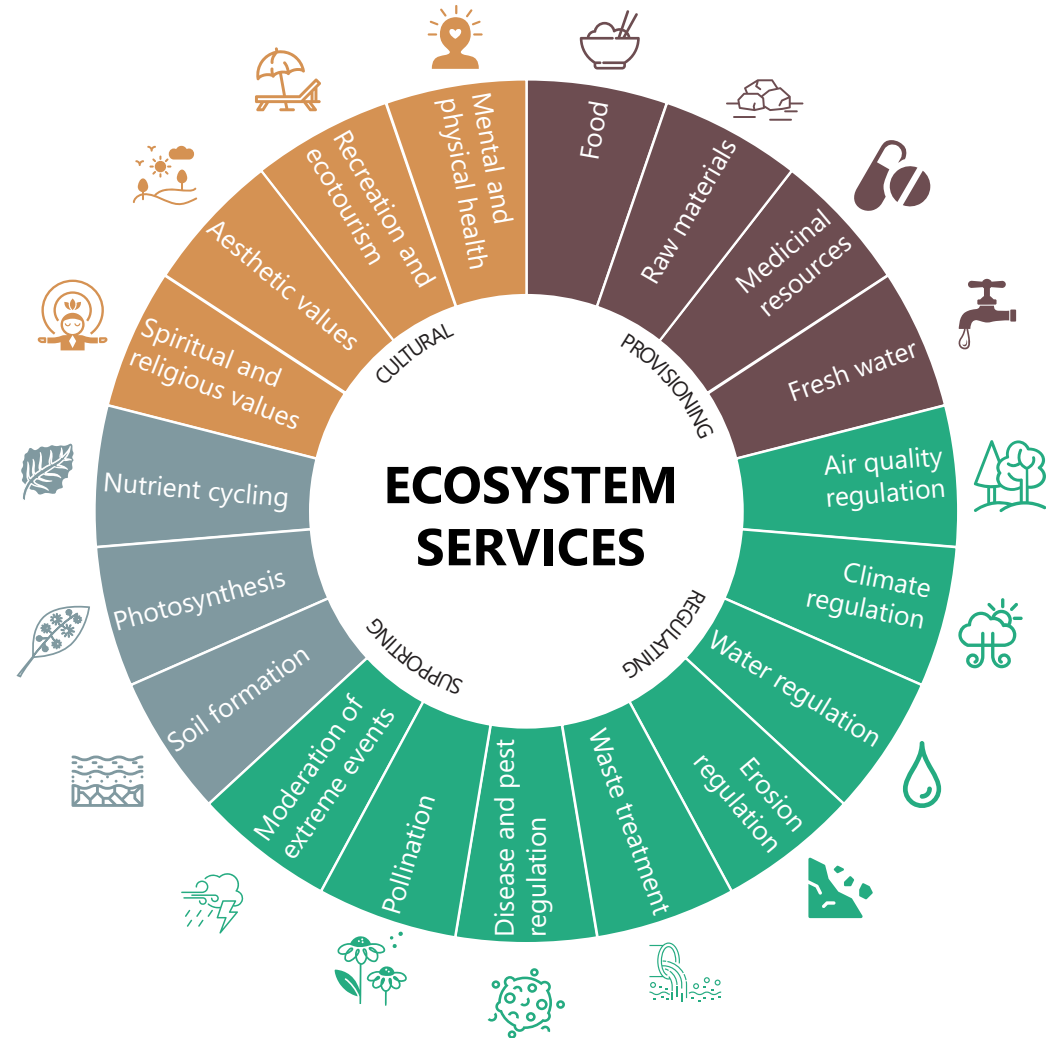
Products or actions of natural systems that benefit people, or advance social welfare, either directly or indirectly

Provisioning services

Regulating services

Supporting services

Cultural services



Ecosystem Services (Fastré, 2020), edited by author

# Objective

To explore the ecological role a road network can have in improving urban ecosystem services.



**Health**



**Climate**



**Flora**



**Fauna**



# Research question

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What is a possible approach to use the road network of Leiden to improve road-related ecosystem services?

# Sub questions

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## **PART 1**

- 1a. How is a road described?
- 1b. Which ecosystem services are related to the road network of Leiden?

## **PART 2**

- 2a. What are economical benefits by improving ecosystem services?
- 2b. Which landscape theory can help with creating ecological road corridors?
- 2c. How can the road-related cultural services be improved?

## **PART 3**

- 3a. How can the roads ecological function be changed to improve urban biodiversity?
- 3b. How can the road be adapted to cope with the effects of climate change?
- 3c. What is needed to improve ecosystem services related to flora and fauna?

## **PART 4**

- 4a. What spatial intervention can be made to improve road-related ecosystem services?
- 4b. How can streets be designed to create benefits for road-related ecosystem services?

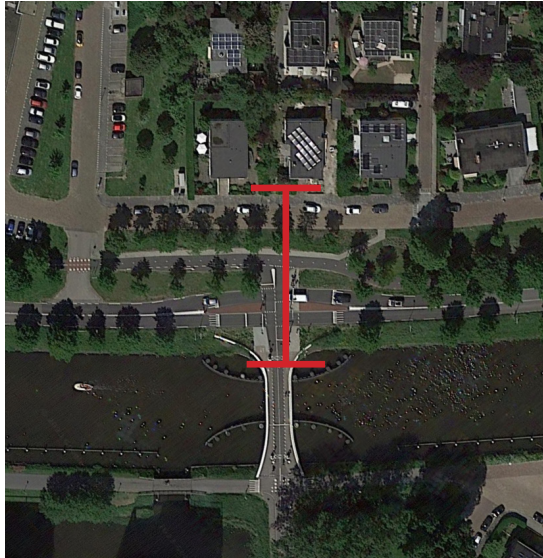
# City of Leiden



## **2. Theoretical framework**

# Road definition

**Any spatial or non-spatial component that is in-between the two outer buildings, streams, or meadows (or a combination of these).**



*Road between water and building*

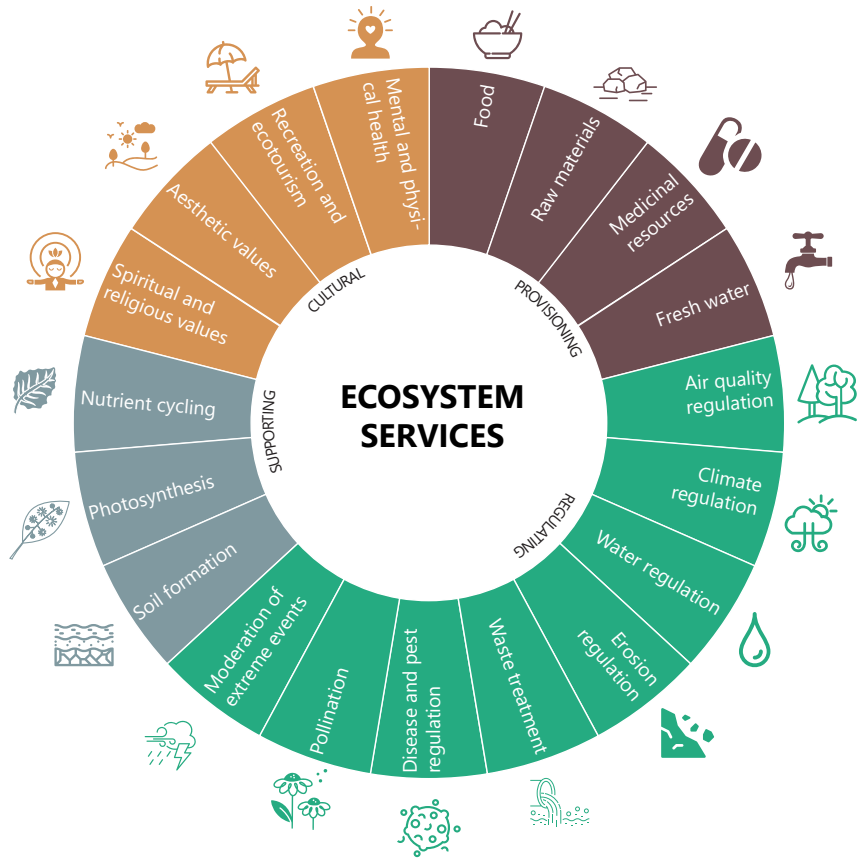


*Road between 2 buildings*

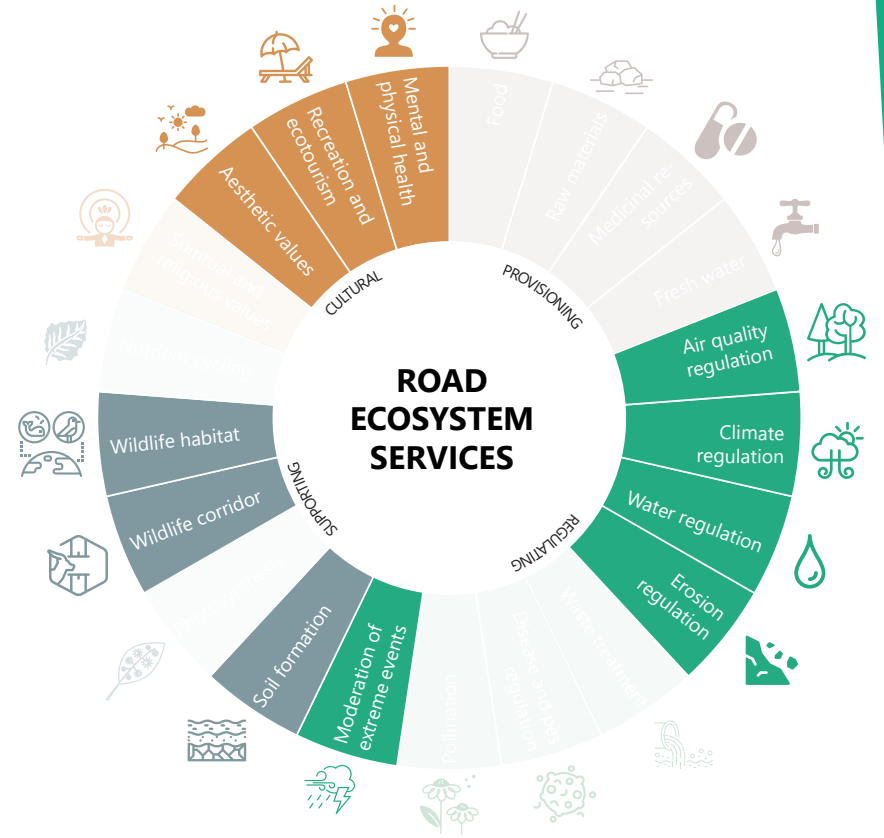
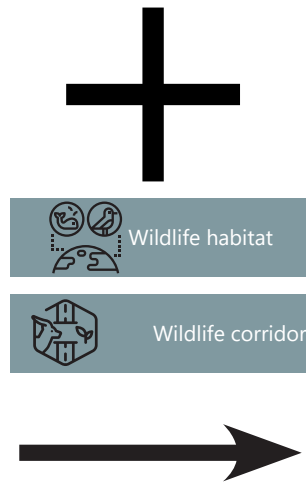


*Road between 2 meadows*

# Road ecosystem services



*Ecosystem Services (Fastré, 2020), edited by author*



*Road-related ecosystem services*

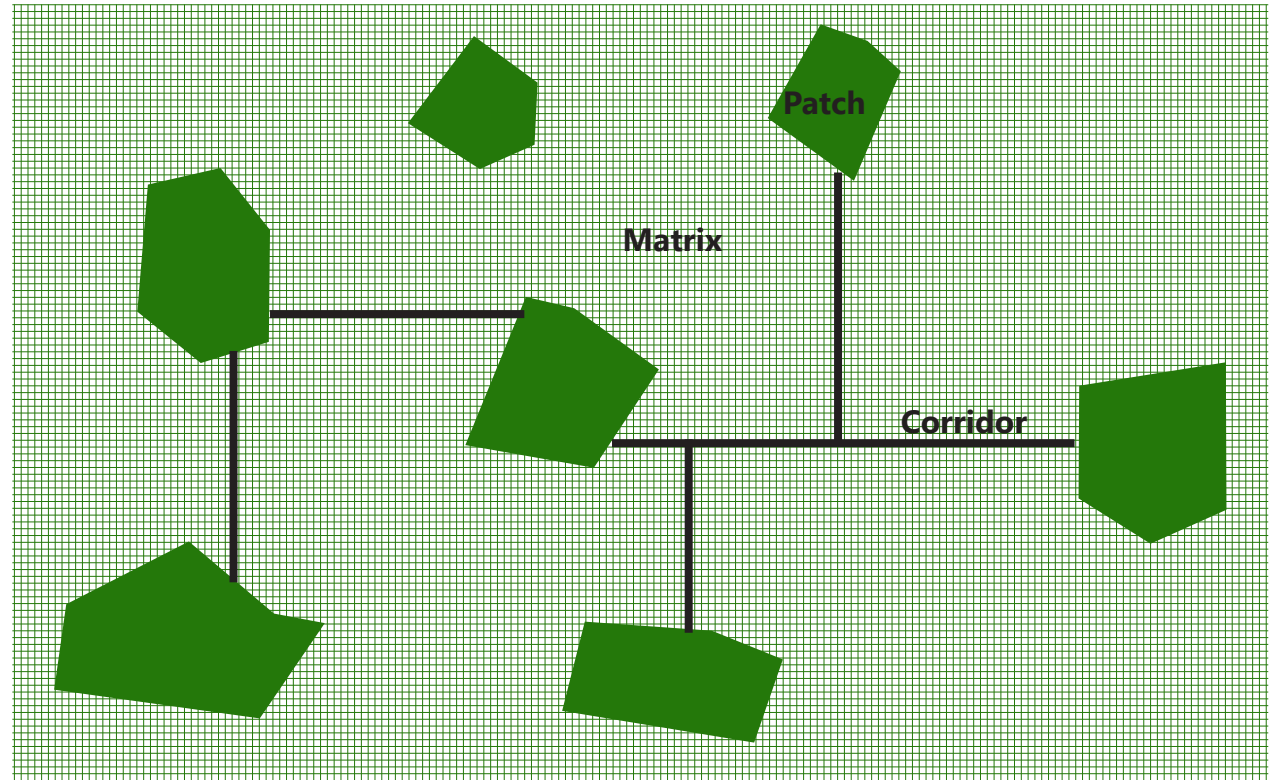
# Landscape ecology

## Patch corridor matrix

**Patch:** A region that differs from its surroundings

**Corridor:** A strip of a specific type that is distinct on both sides from the surroundings

**Matrix:** The built area

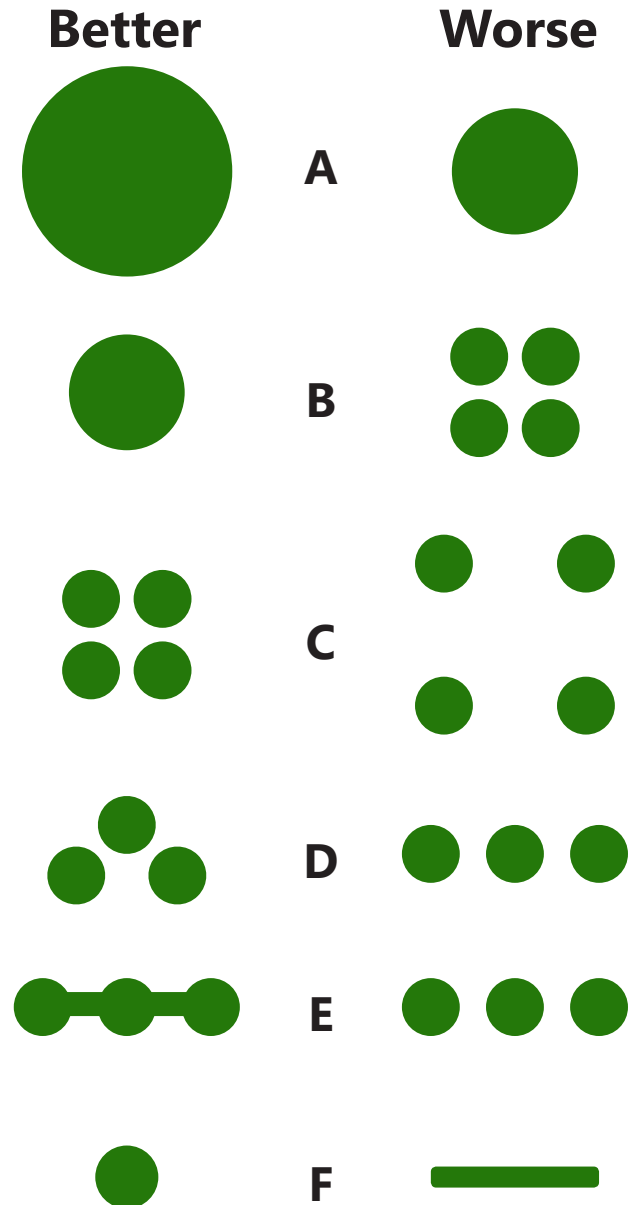


*The patch-corridor-matrix landscape model. The landscape consists of habitat, patches, corridors connecting habitat patches and a surrounding matrix, which is unsuitable for the species in the habitats (Levin et al., 2014). Edited by author.*

# Landscape ecology

## Island biogeography

Design principles to minimize wildlife extinction rates



*Suggested design principles, derived from island biogeographic studies (Diamond, 1975). Edited by author.*

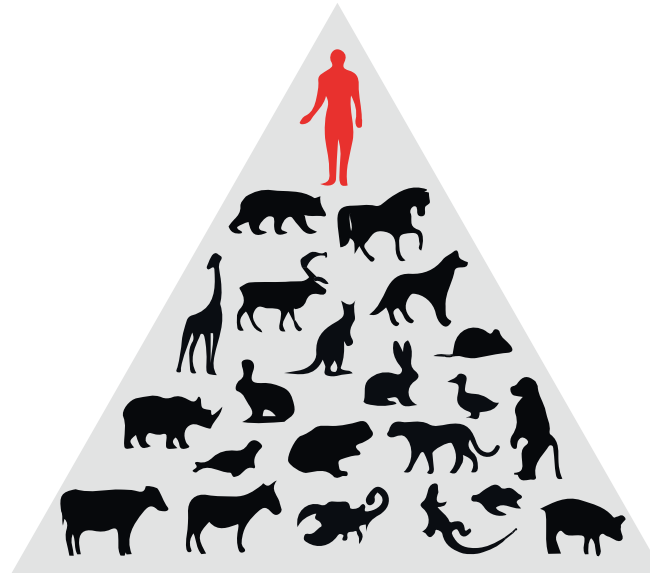


# Ego to eco

Improvement for:

- Mental well-being
- Physical well-being
- Education
- Decreasing crime rate
- Social networking

## EGO



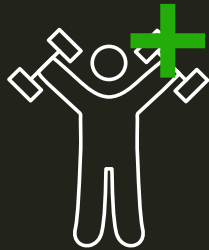
## ECO



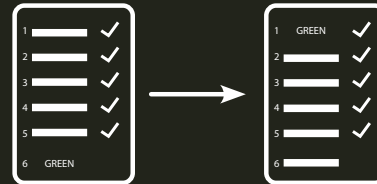
*From ego to eco (Lehmann, 2019)*

# Design principles to improve health

Promote exercising



Reverse greenification



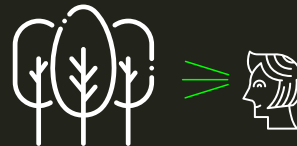
Promote walking



Promote biking



Seeing green



Education



# 3. Spatial analysis

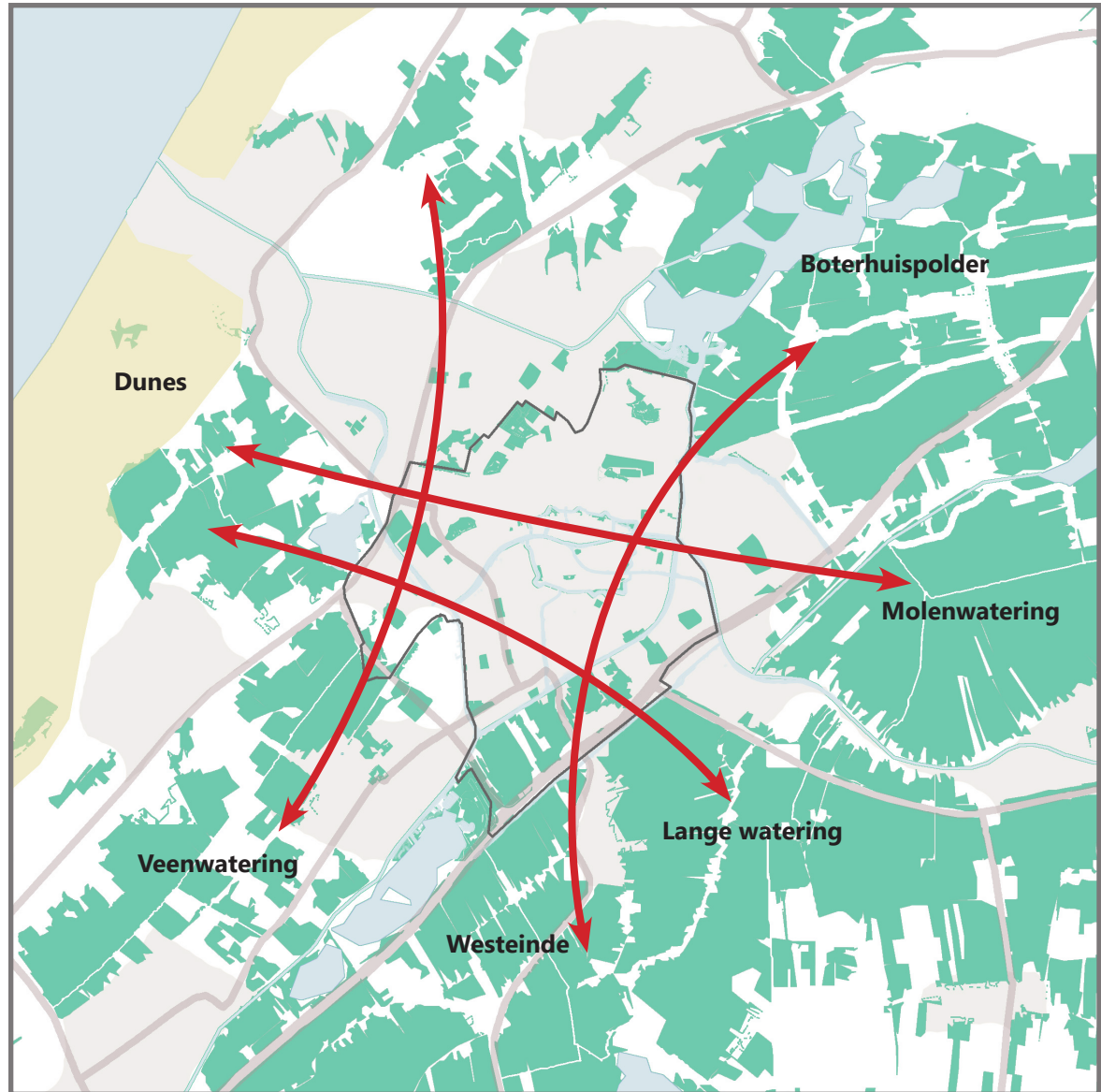
# Ecological analysis

Missing links

Wildlife needs to go around

Bad for climatic effects

Loss of biodiversity

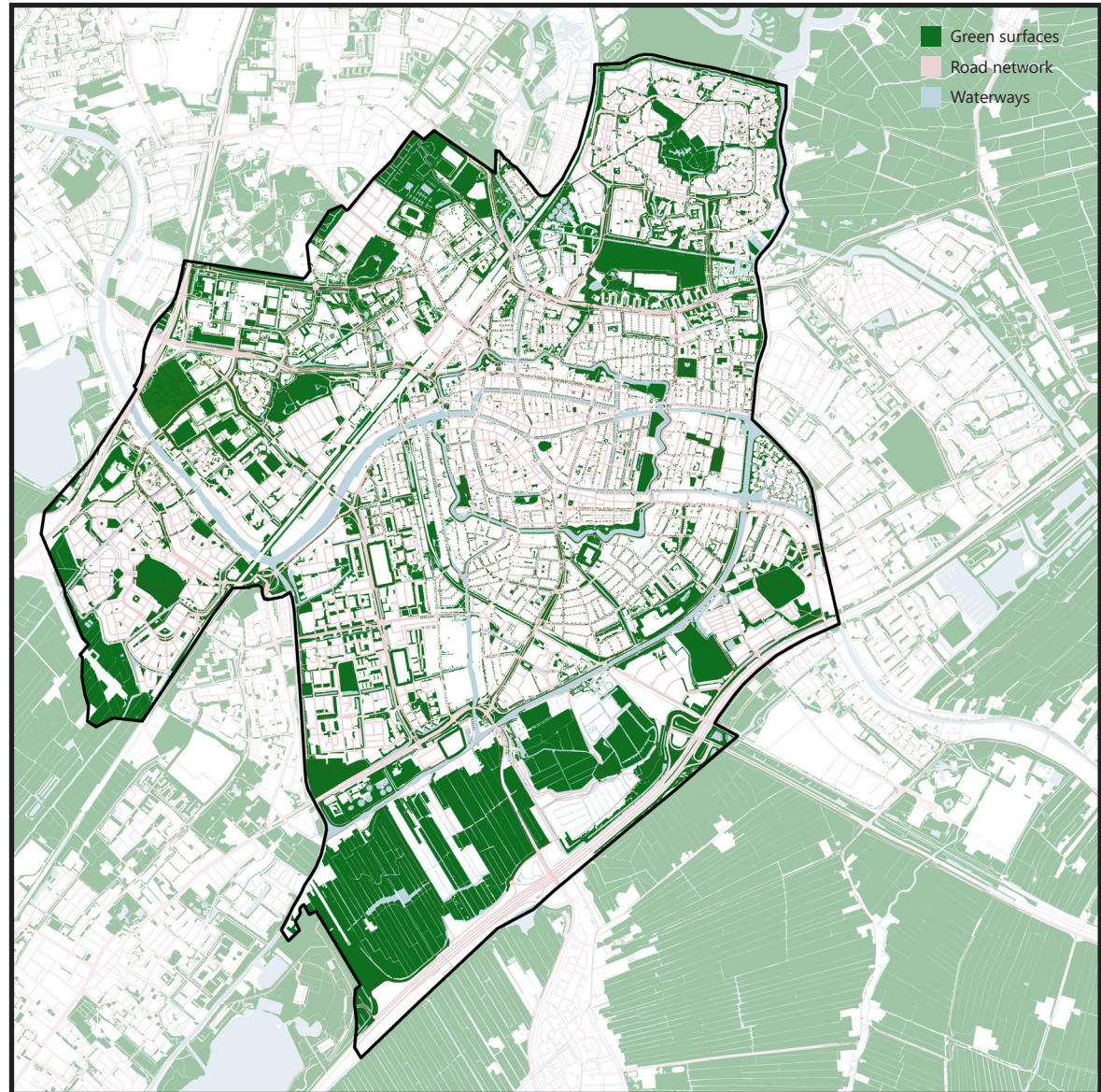


# Ecological analysis

All present green patches

Not equally valuable

Almost no ecological corridors



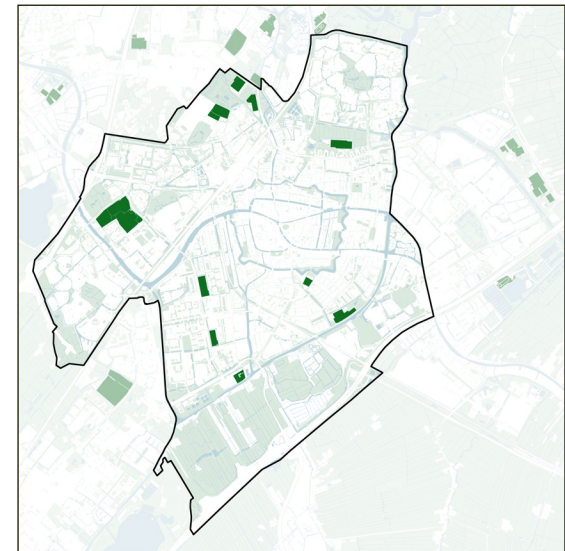
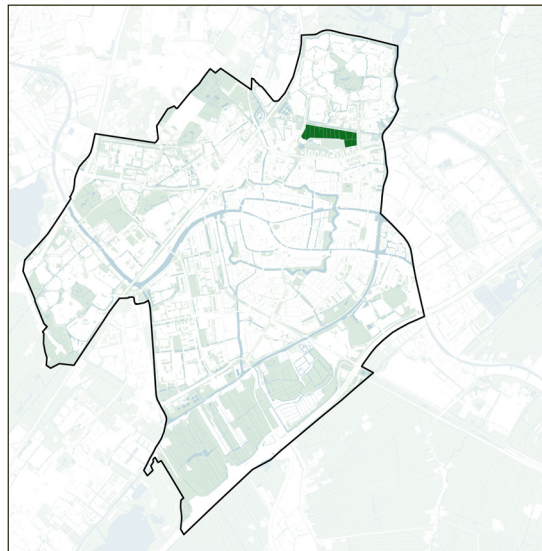
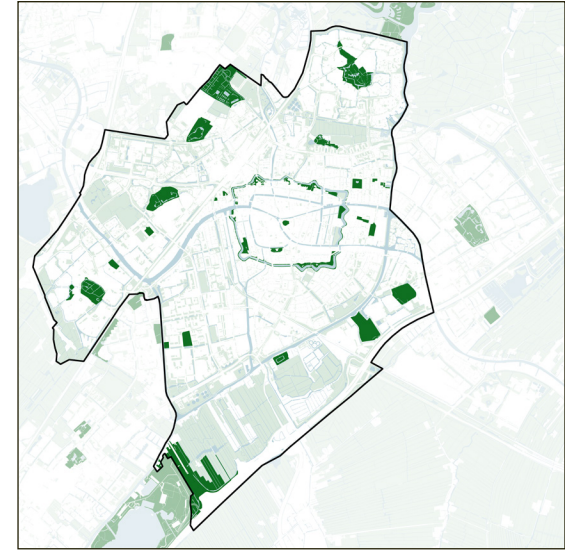
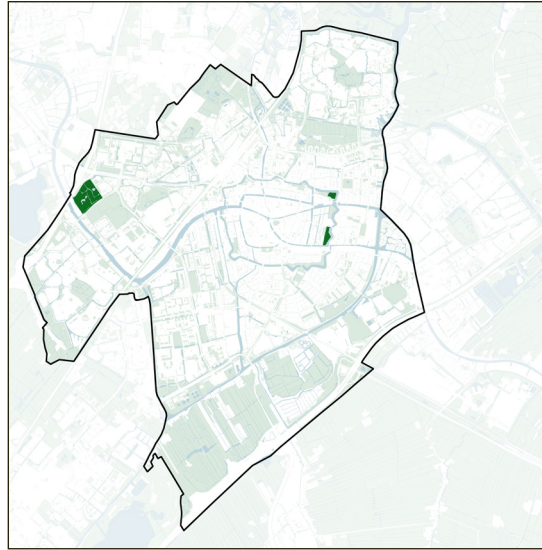
# Ecological analysis

**Parks**

**Cemeteries**

**Communal gardens**

**Sport field edges**

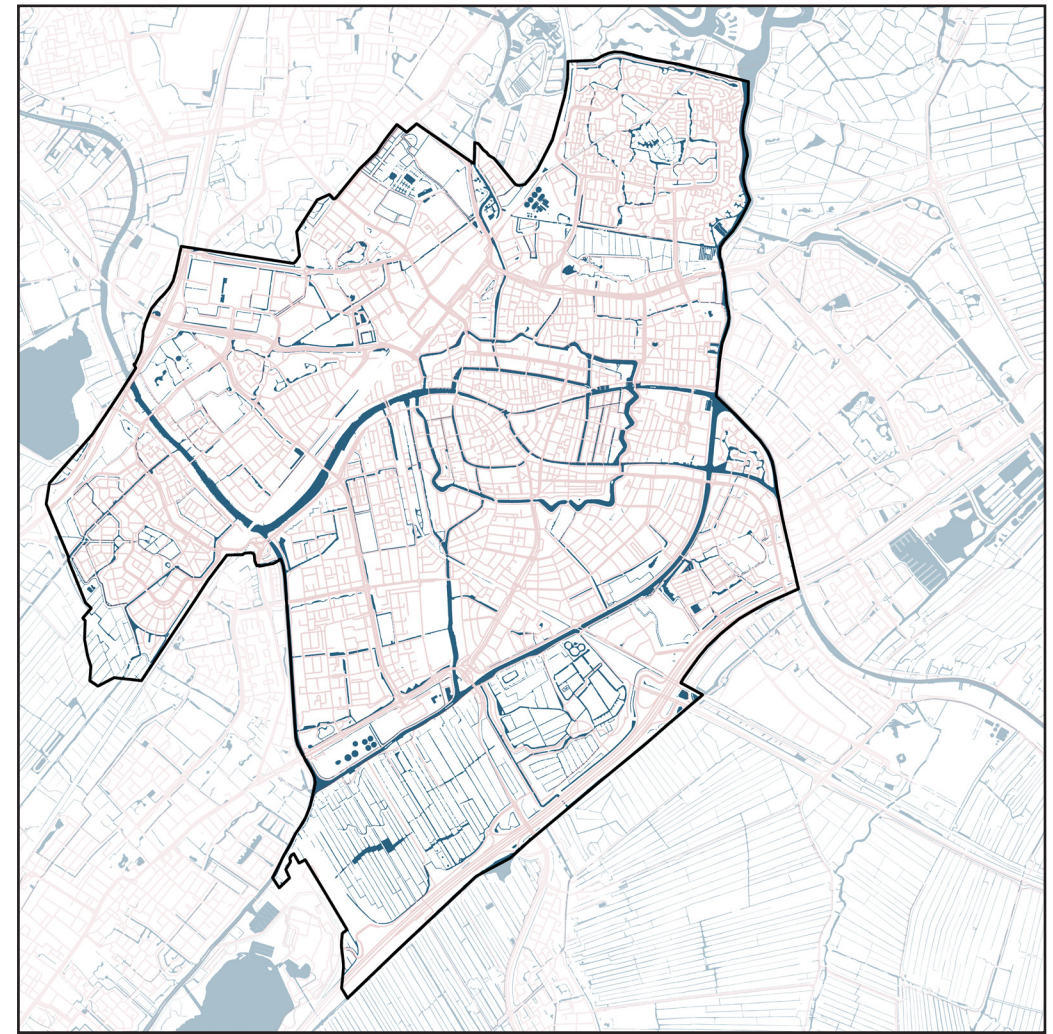
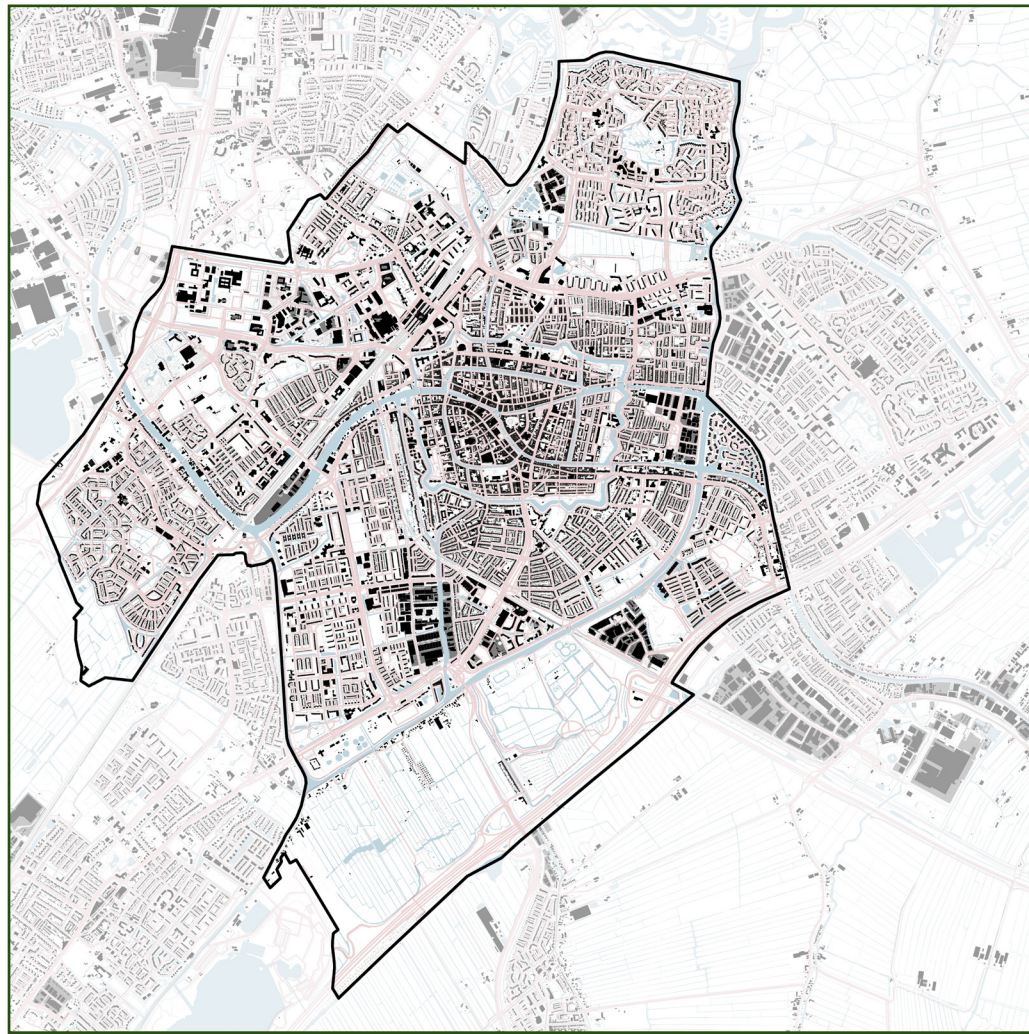


# Patch-corridor-matrix

**Parks**  
**Cemeteries**  
**Communal gardens**  
**Sportfield edges**



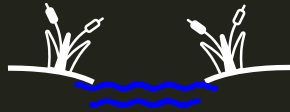
# Built environment & blue structure





# Design principles increase ecological resilience

Soft borders



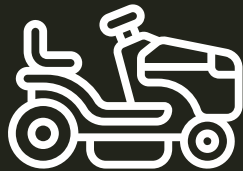
Continuous green structure



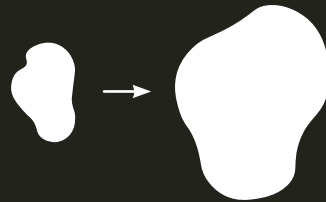
Add vegetation



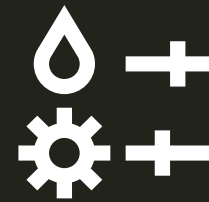
Maintenance



Larger over smaller

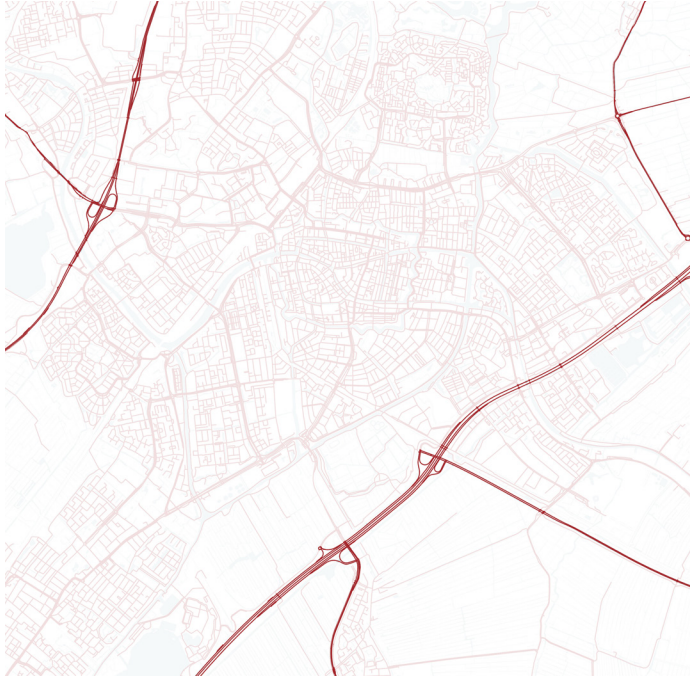


Design conditions

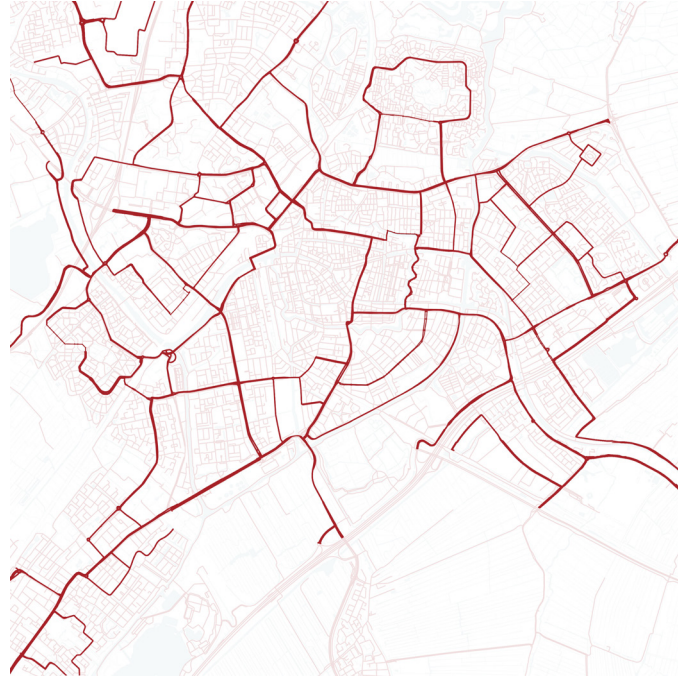


# Road analysis

**Highways & N-roads**



**Distributor roads**



**Residential roads**



# Road analysis

**Buildings = black**

**Public space = white**

**Possibilities for improvement**

**Identify ecological road corridors**



# Design principles to reduce roads effect on ESS

Remove parking



Car free spaces



Bundling lanes



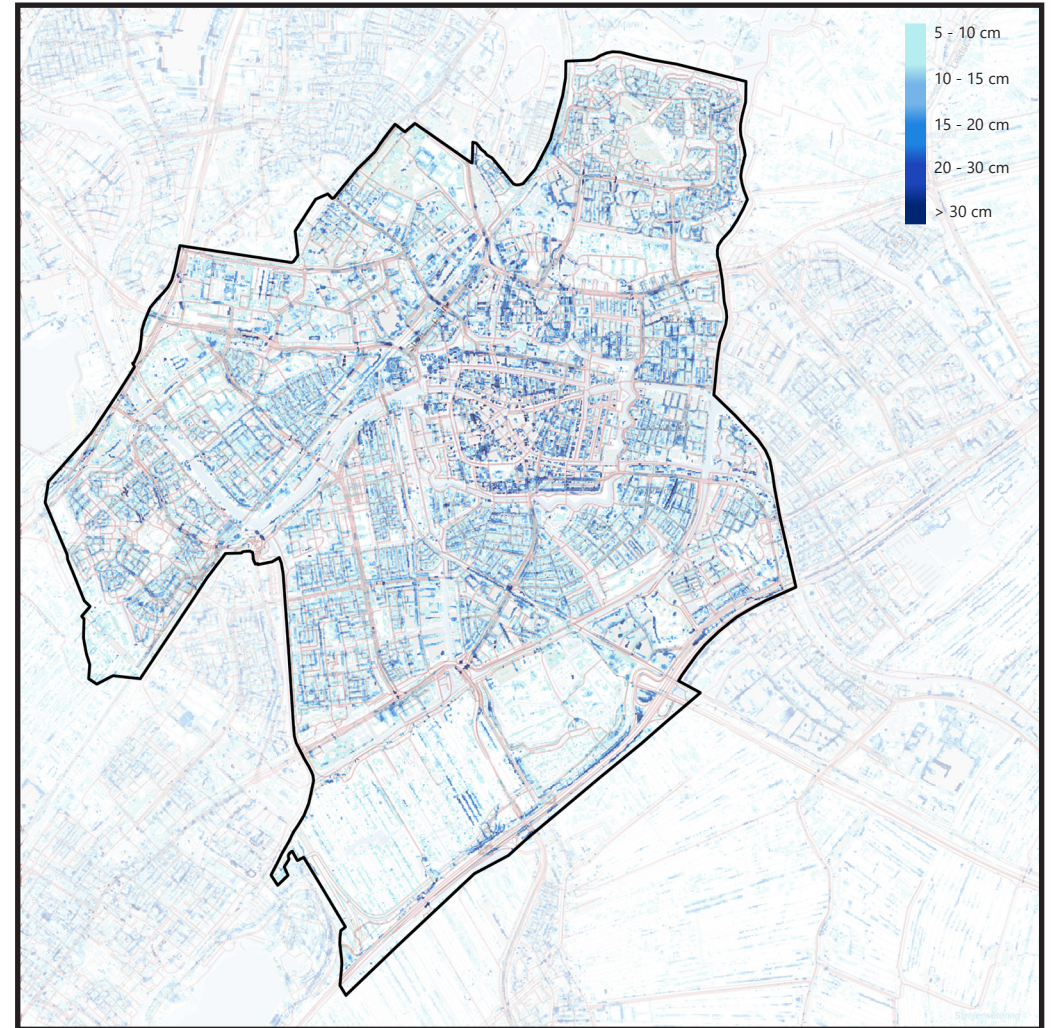
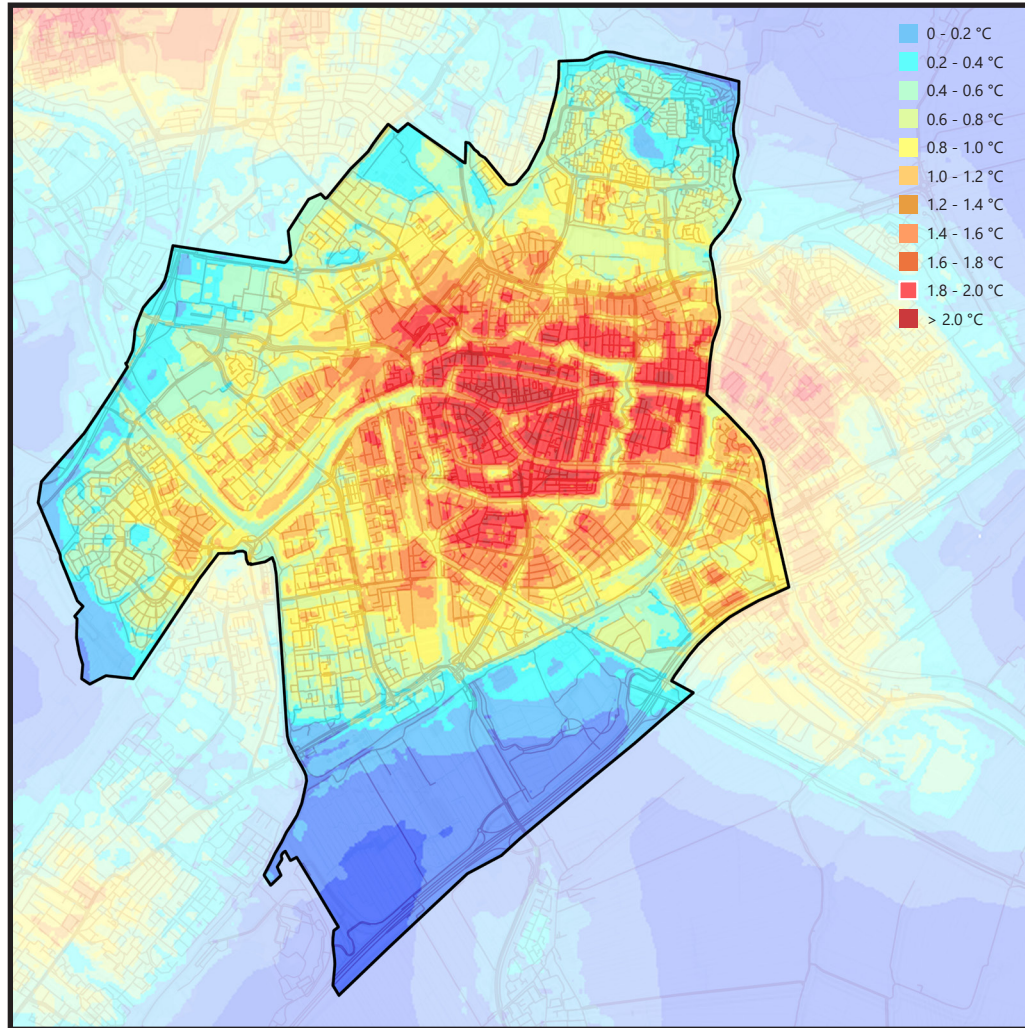
Reduce speed



Reduce lanes



# Climatic analysis



# Design principles to increase climatic resilience

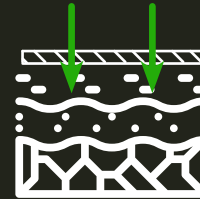
Add waterbodies



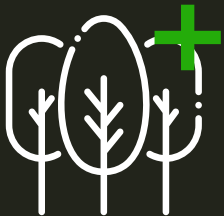
Turn stone to green



Permeable pavements



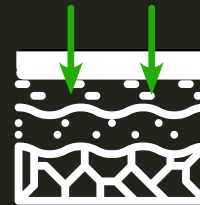
Add trees



Create shadows



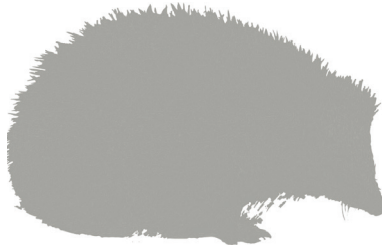
Porous asphalt



# Flora & Fauna

# Target species

West-european hedgehog



Bumblebee



Common dwarf bat



Starling





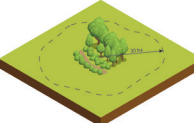


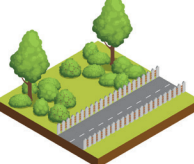

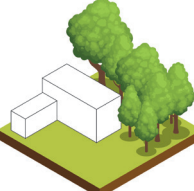
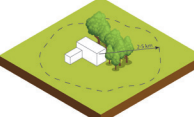
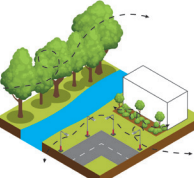

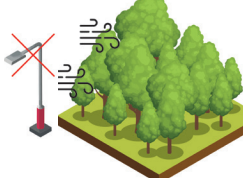

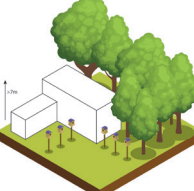
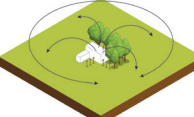
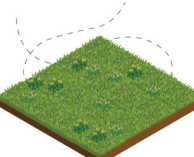
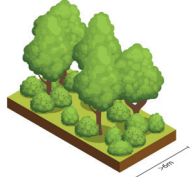
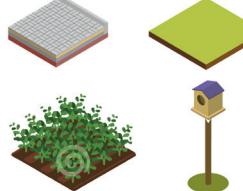

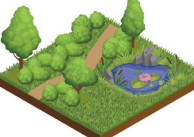
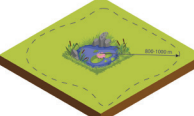

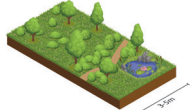
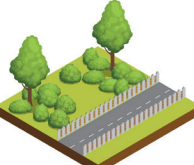


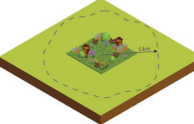




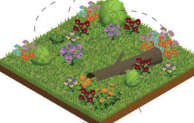
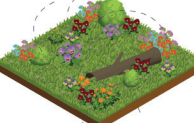

Atalanta



Brown frog



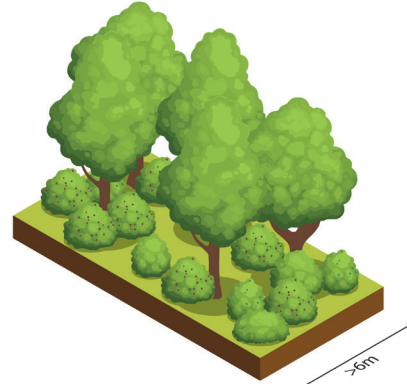


	Residence	Habitat	Hunting	Minimal width	Protection
					
					
					
					
					
					

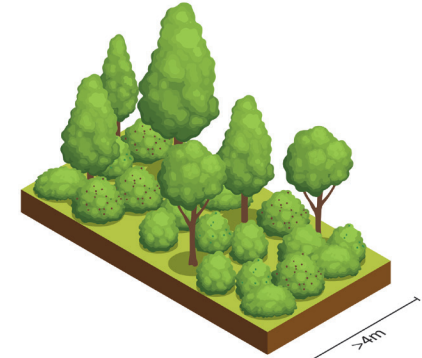
# Minimal corridor width



Atalanta



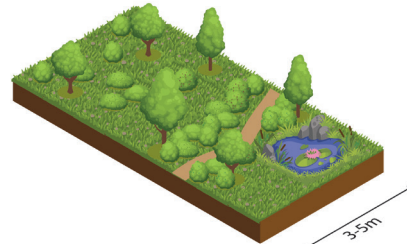
Starling



West-European hedgehog



Common dwarf bat



Brown frog



Bumblebee

# Flora

Upper canopy layer

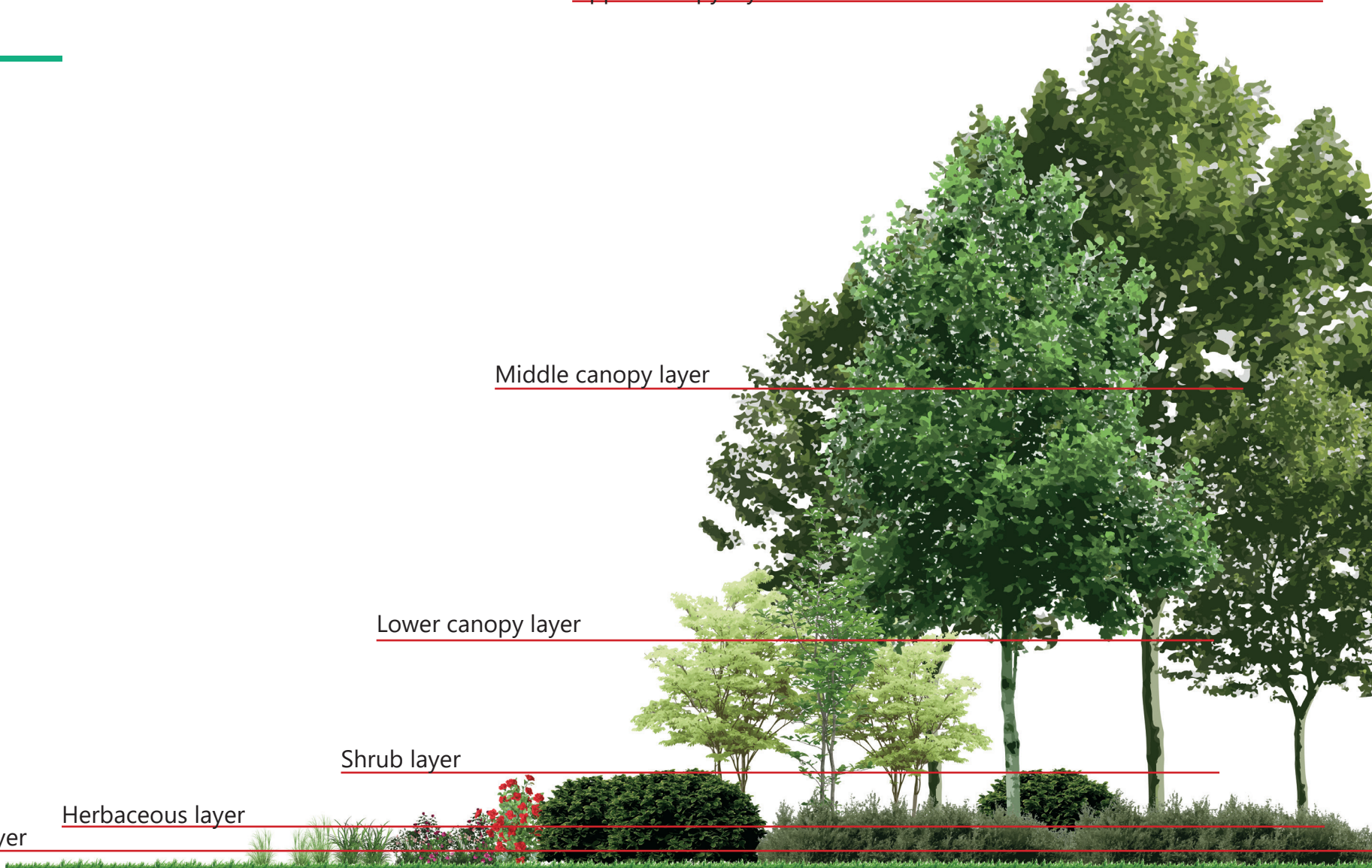
Middle canopy layer

Lower canopy layer

Shrub layer

Herbaceous layer

Ground layer

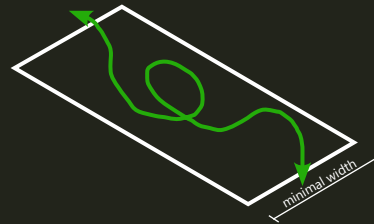


# Design principles to improve wildlife habitats/ corridors and flora

Animal habitat



Minimal width



Protection from roads



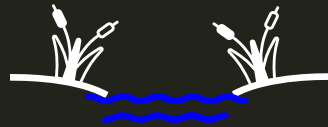
Diversity



Animal corridor



Soft borders



No nuisance



Animal-friendly lighting



# **4. Design principles**

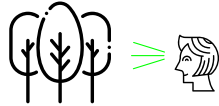
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# Design principles

Promote exercise



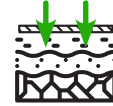
Seeing green



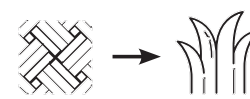
Promote biking



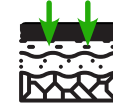
Permeable pavement



Stone to green



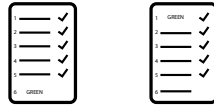
Porous asphalt



Promote walking



Put green first



Education



Remove parking



Car-free zones



Decrease speed



Add vegetation



Soft borders



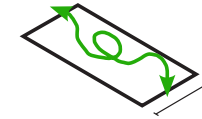
Maintenance plan



Animal friendly lighting



Minimal width



Wildlife corridor



Design conditions



Continuous structure



Add trees



Fence protection



Bundling lanes



Plant diversity



Waterbodies



Large over small



Create shadows



Wildlife habitat



Remove lanes



Avoiding nuisance



# Design principles

### Health

- Promote exercise
- Promote biking
- Seeing green
- Promote walking
- Education
- Put green first

### Flora

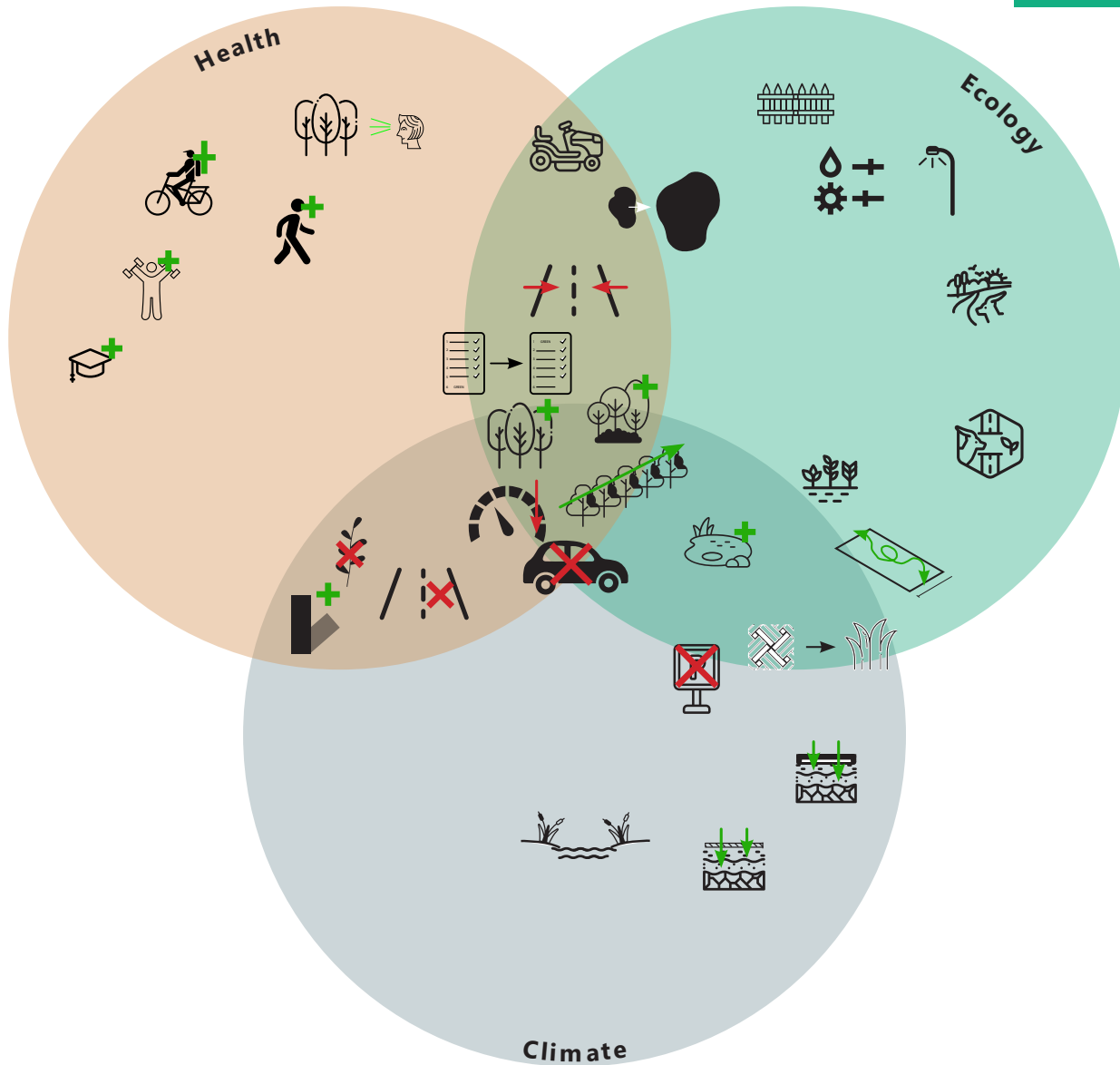
- Plant diversity
- Avoiding nuisance
- Design conditions
- Maintenance plan
- Continuous green structure
- Add vegetation

### Climate

- Add waterbodies
- soft water-land borders
- Add trees
- Permeable pavements
- Stone to green
- Porous asphalt

### Fauna

- Animal friendly lighting
- Minimal width verge
- Wildlife corridors
- Wildlife habitats
- Protection from roads



# **5. Design exploration**

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# Noorderkwartier



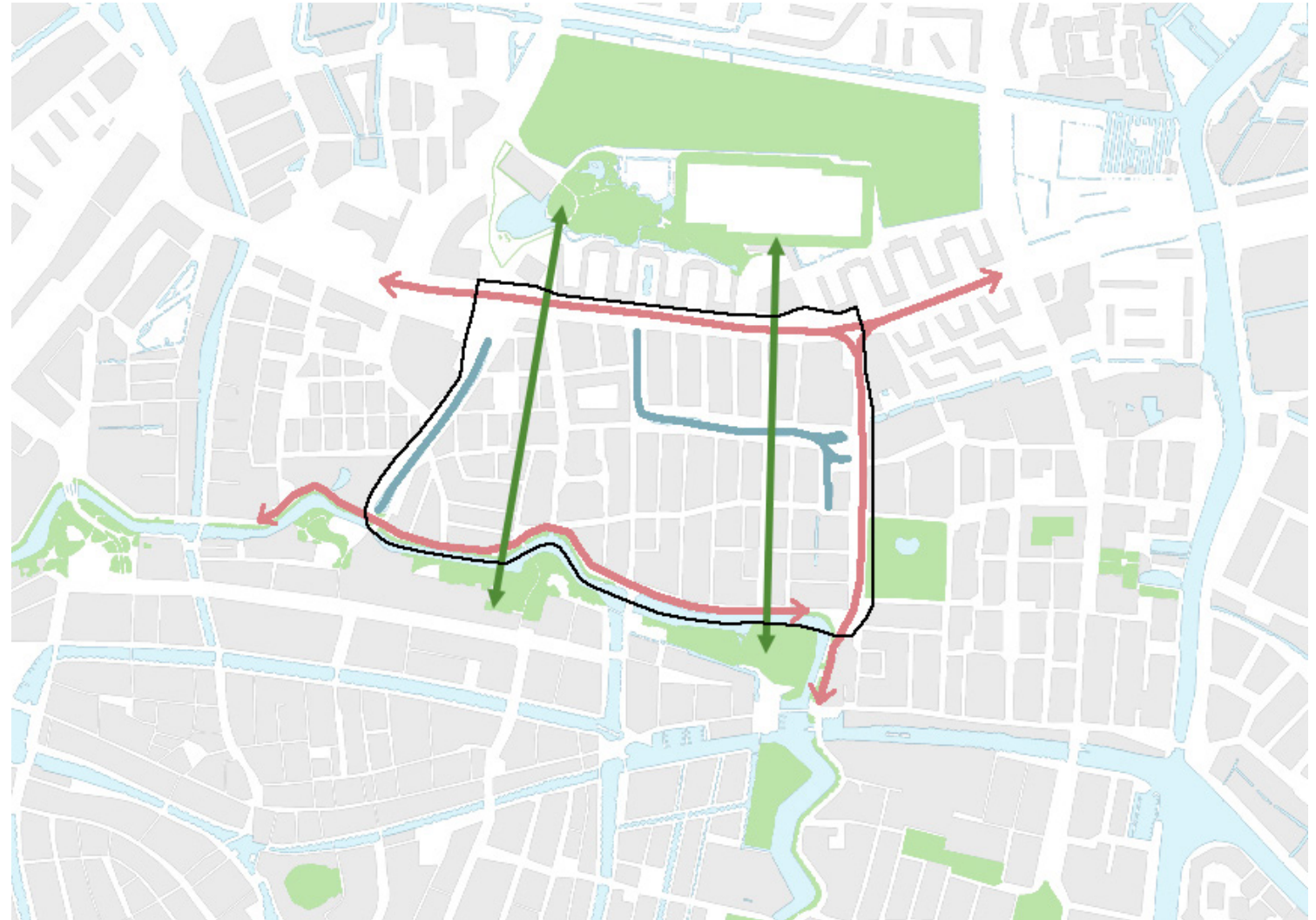
# Noorderkwartier

**Barrier**














**Between patches**

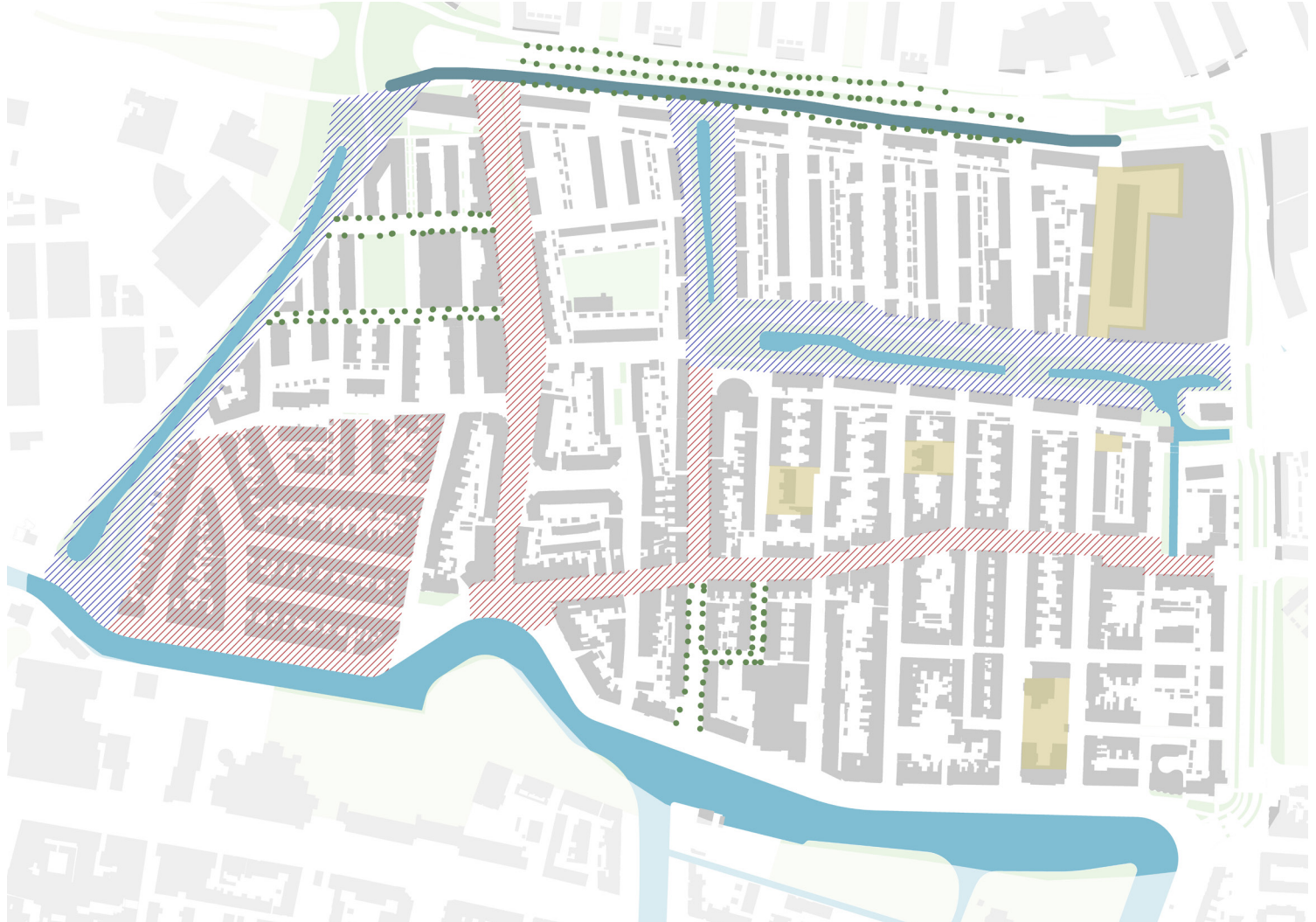
**Between important roads**

**Can serve as passway**

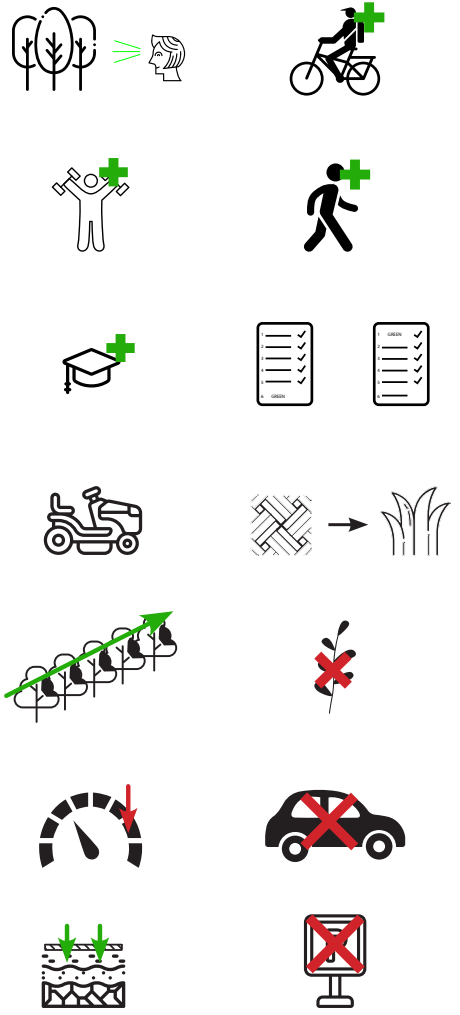


# Climatic strategy

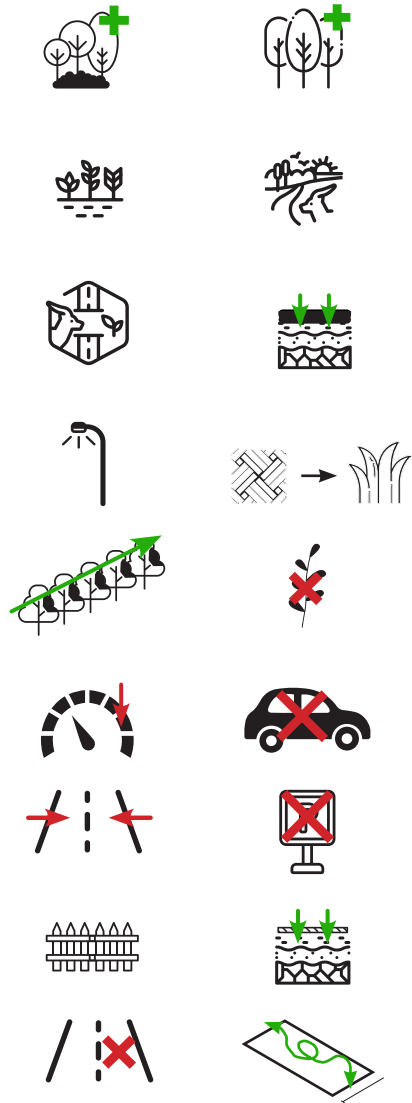
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# Health strategy



# Ecological strategy





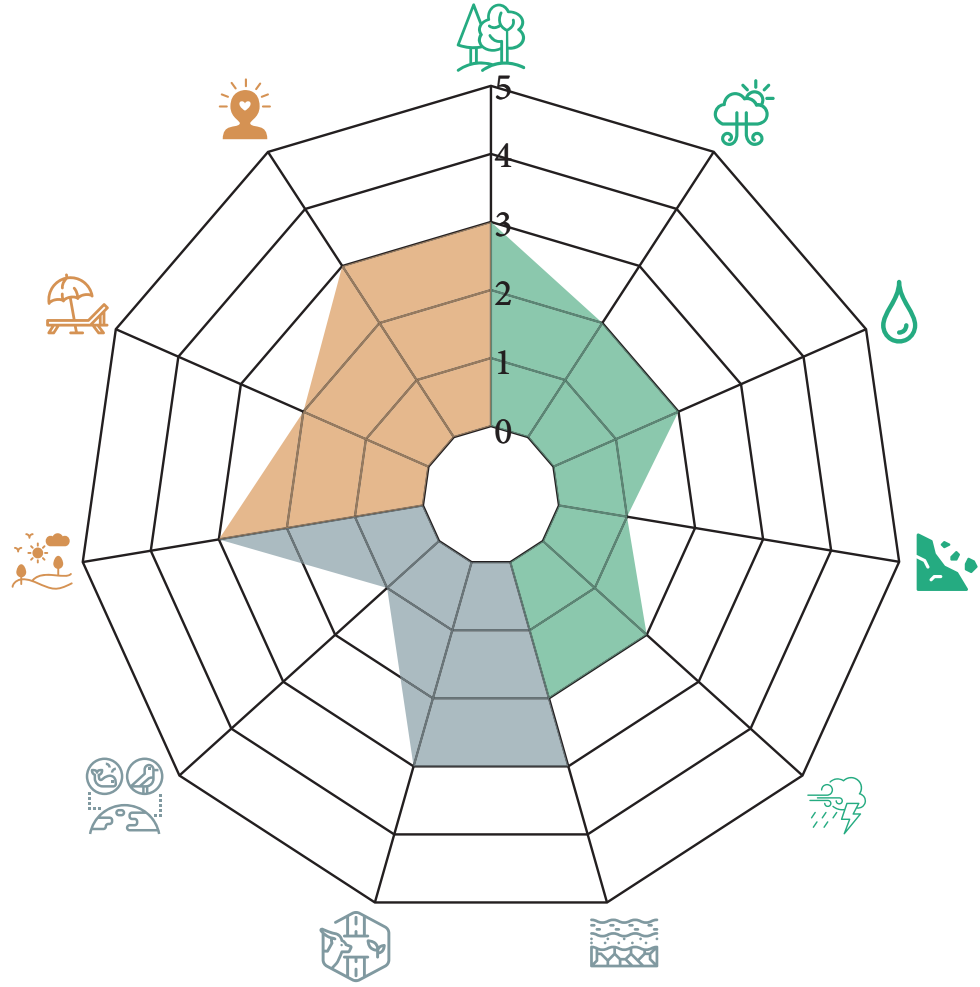
# Willem de Zwijgerlaan



# Willem de Zwijgerlaan

## Current situation

**Score 0 to 5**  
 0-1: Non-existing  
 1-2: Weak  
 2-3: Acceptable  
 3-4: Very good  
 4-5: Excellent

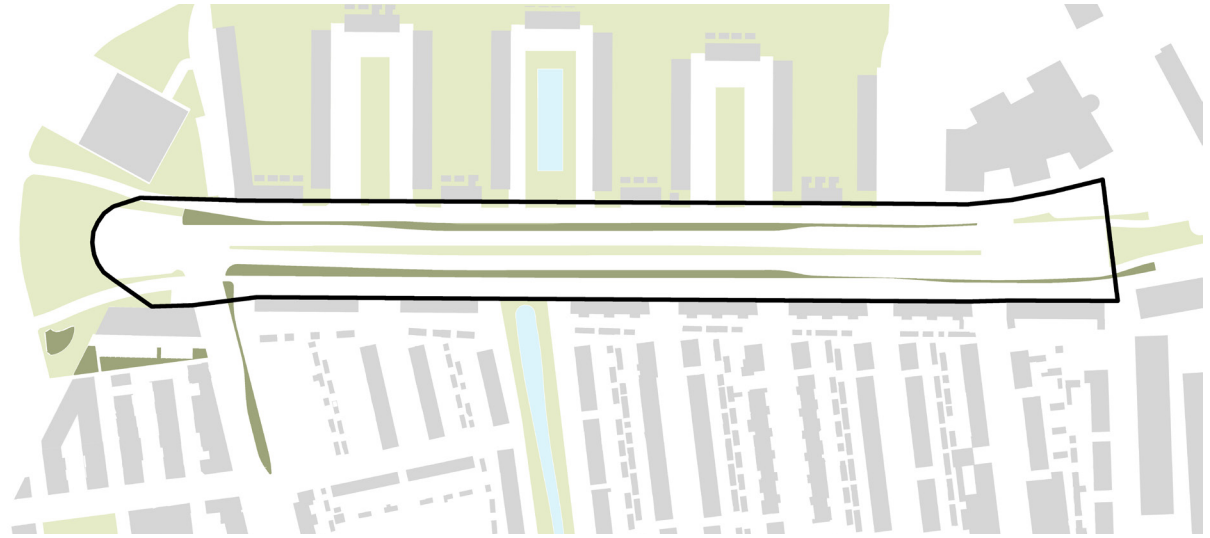




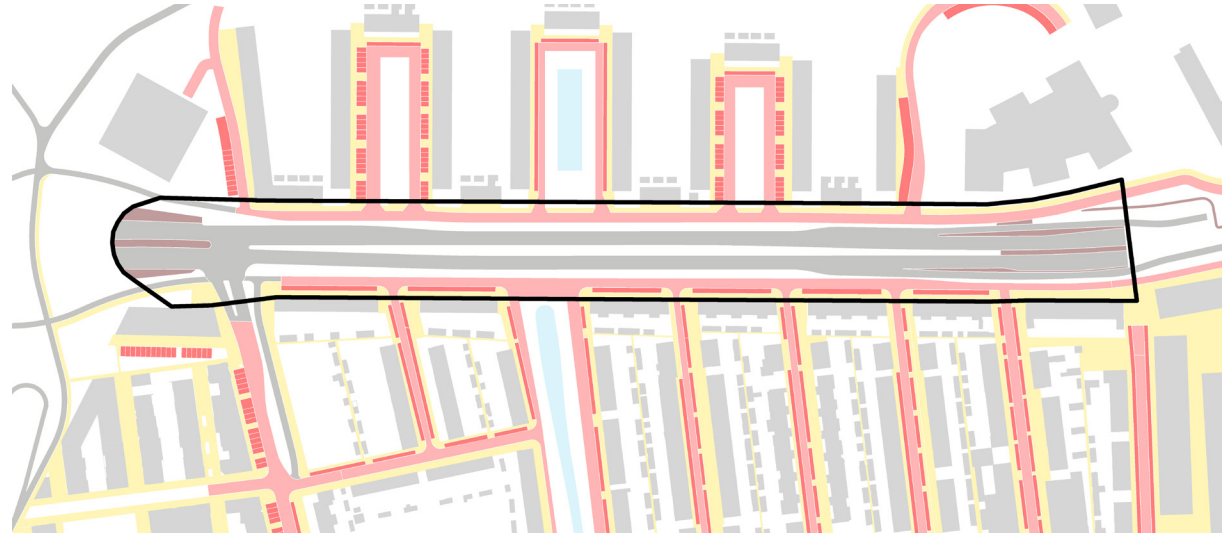
# Ecological analysis

22% Green surfaces

Habitat borders

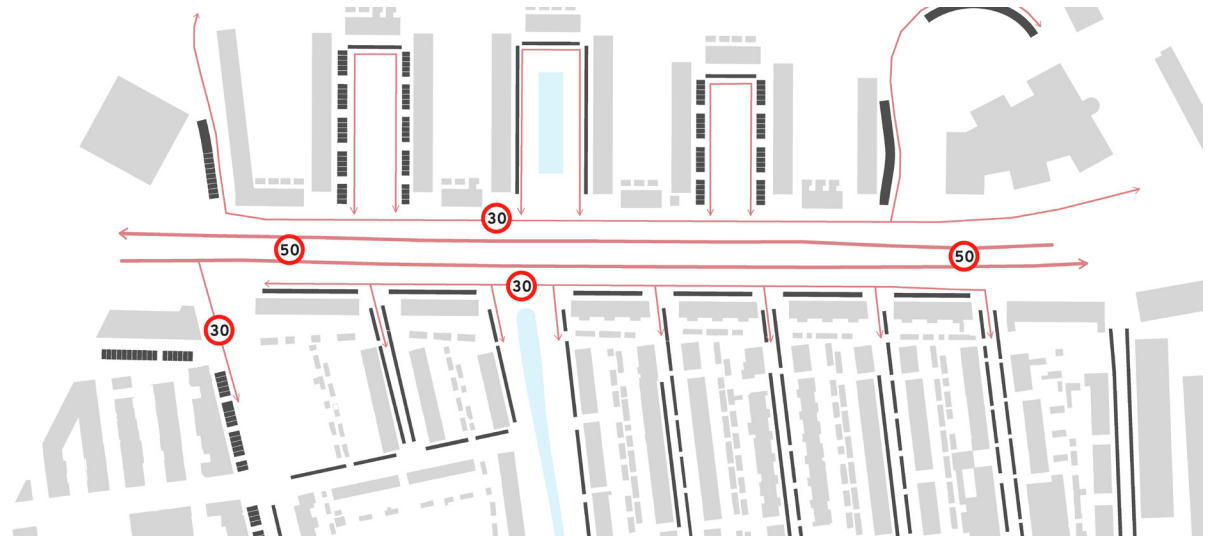


# Road analysis



78 % hard surfaces

Street lines



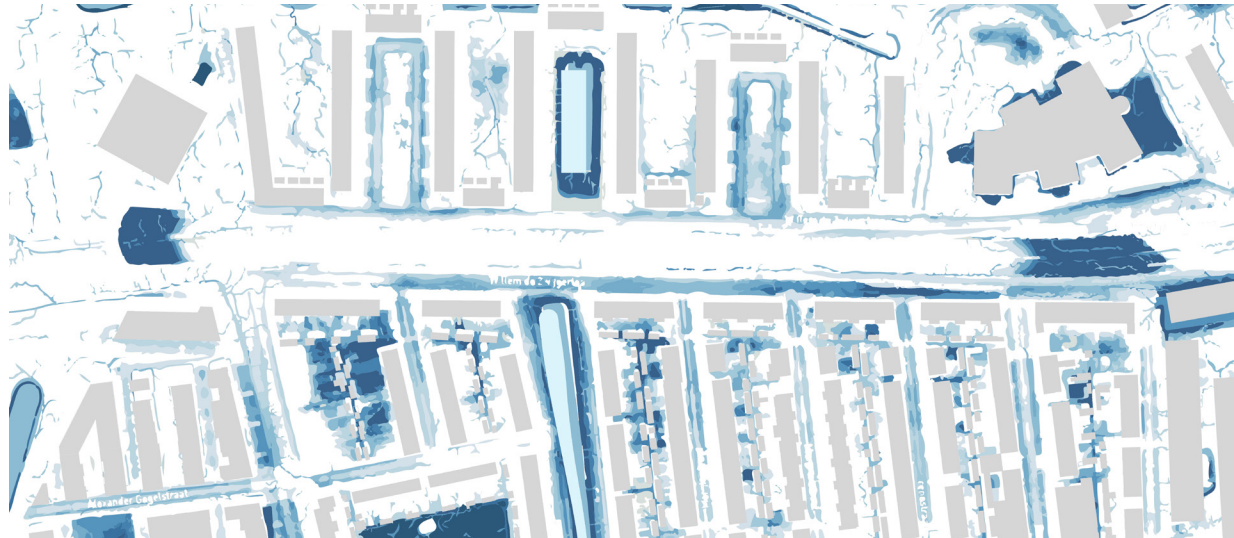
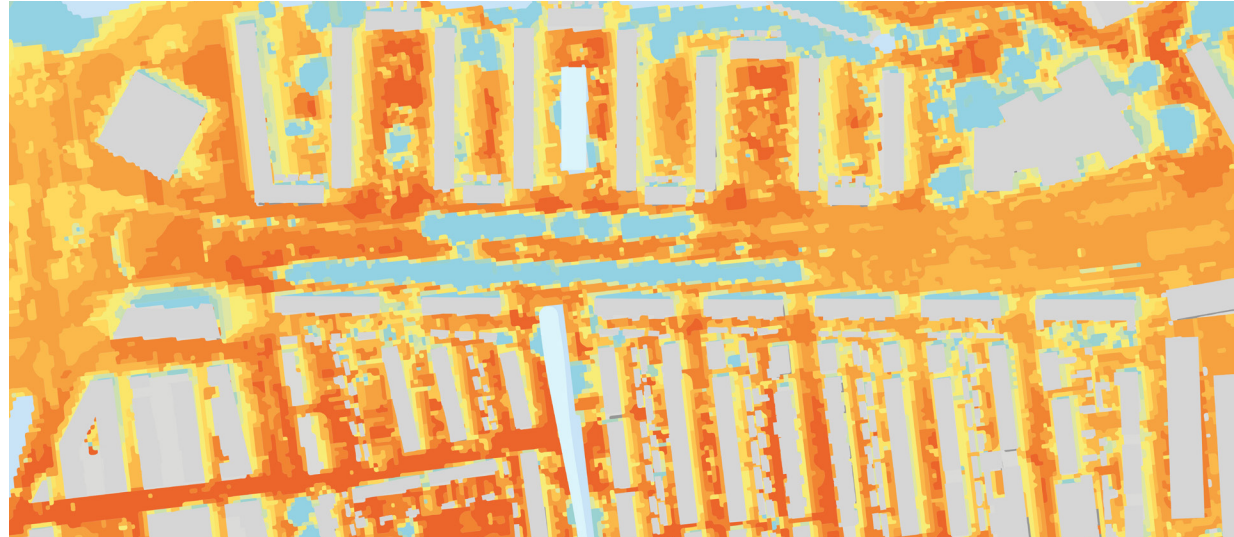
# Climatic analysis

Cool areas around trees

Water is cooling

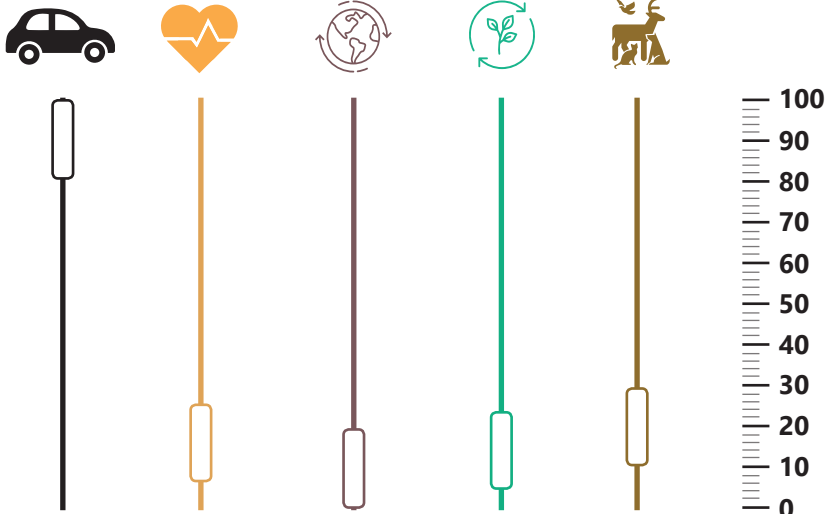
Tunnels are inaccessible

Vulnerable surfaces

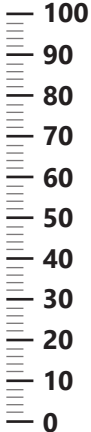
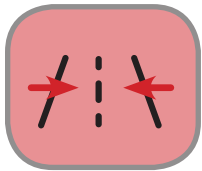


# Adjusting sliders

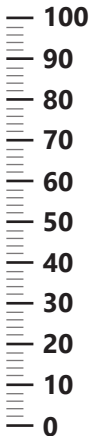
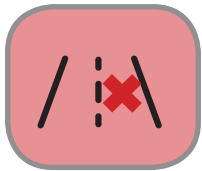
Current situation



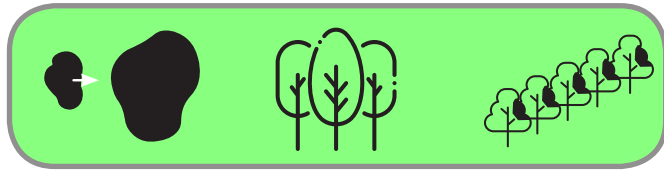
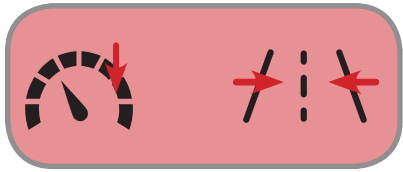
# Applied principles



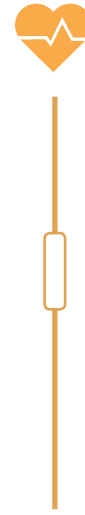
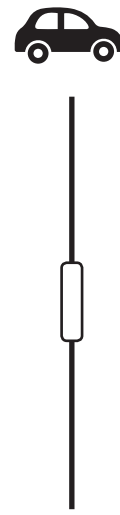
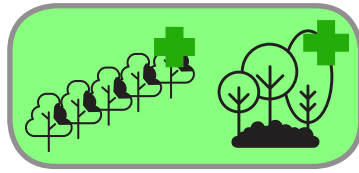
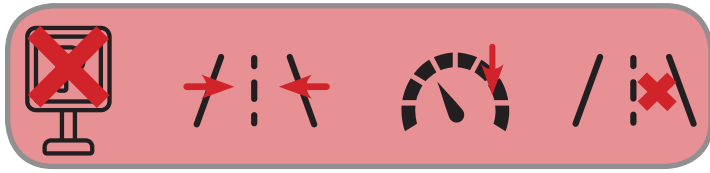
# Applied principles



# Applied principles

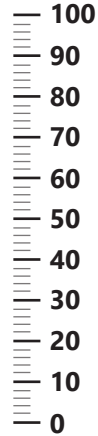
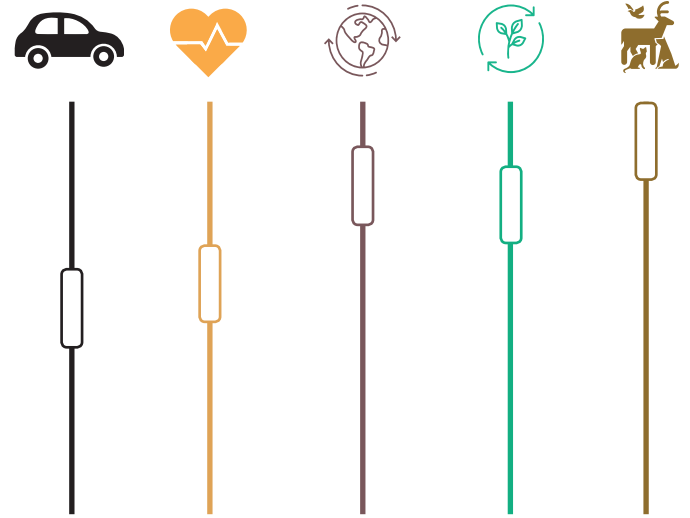
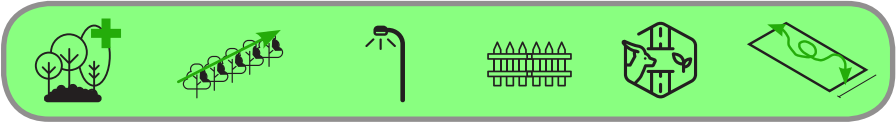


# Maximized flora

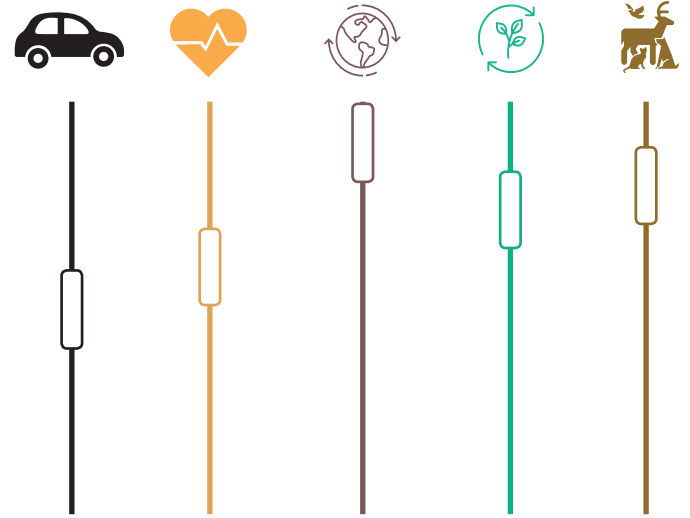
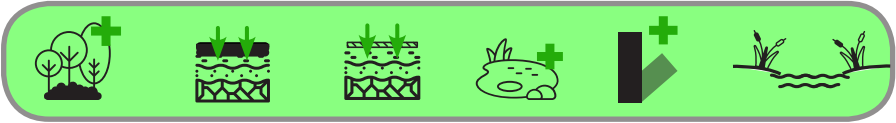




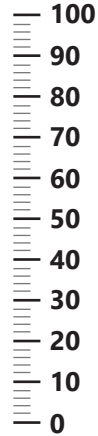
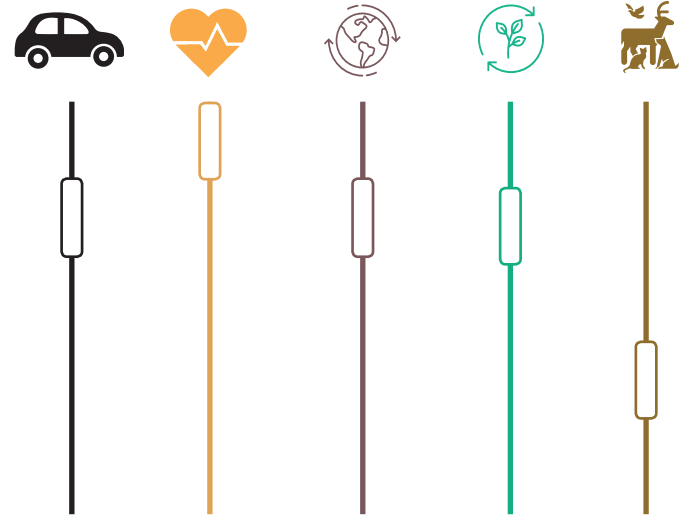
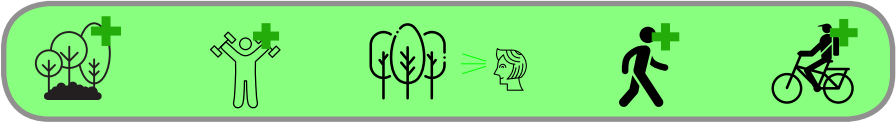
# Maximized fauna



# Maximized climate



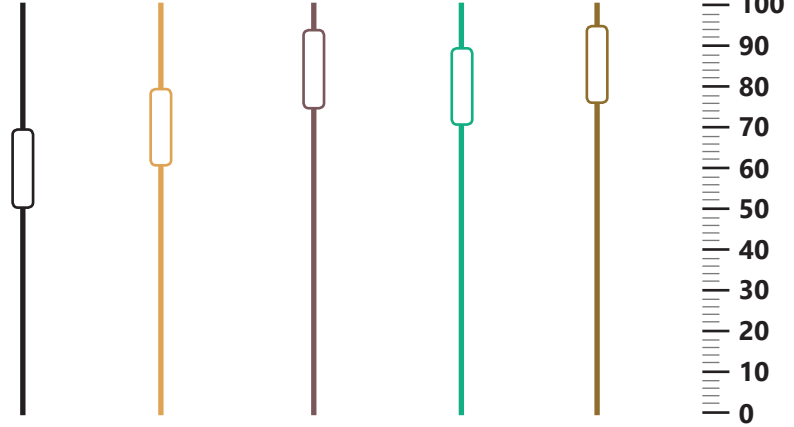
# Maximized health



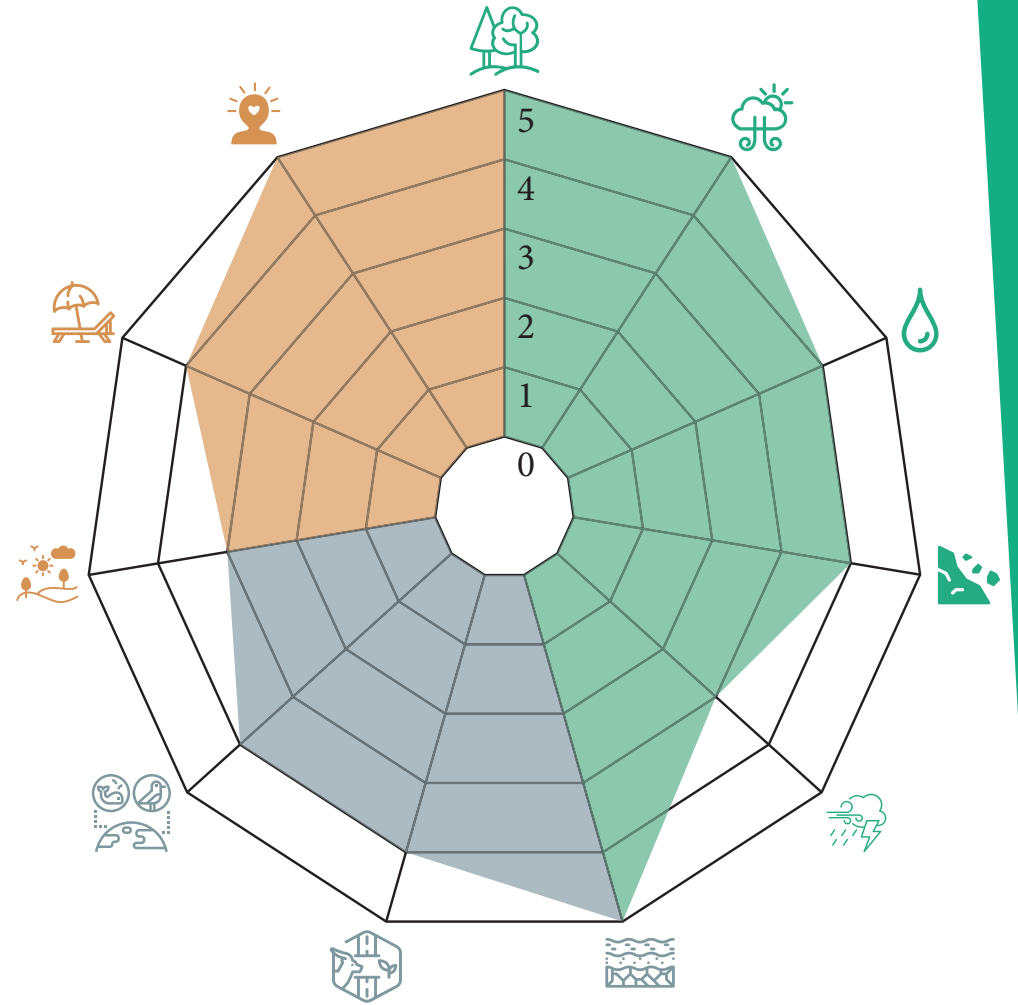
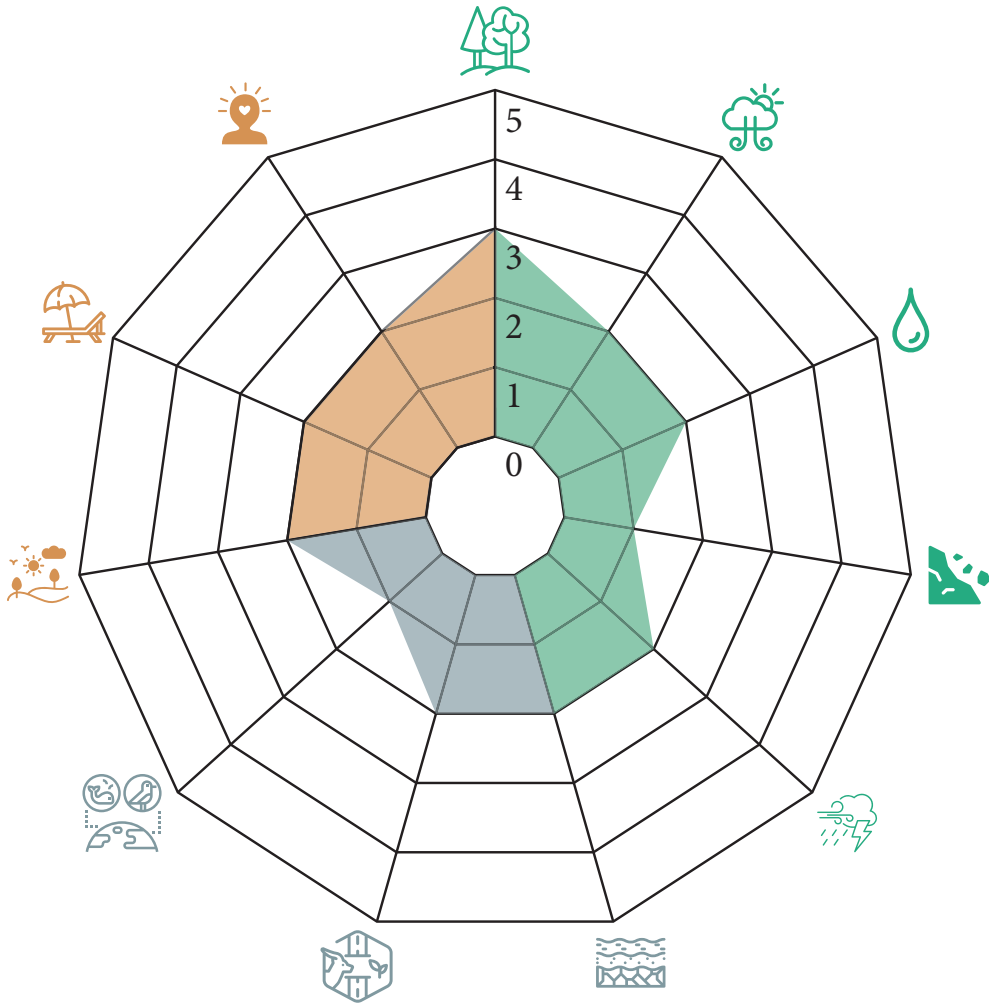
# Conclusion



# Conclusion



# Conclusion



# **7. Conclusion**

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# Conclusion

What is a possible approach to use the road network of Leiden to improve road-related ecosystem services?



**Health**



**Climate**



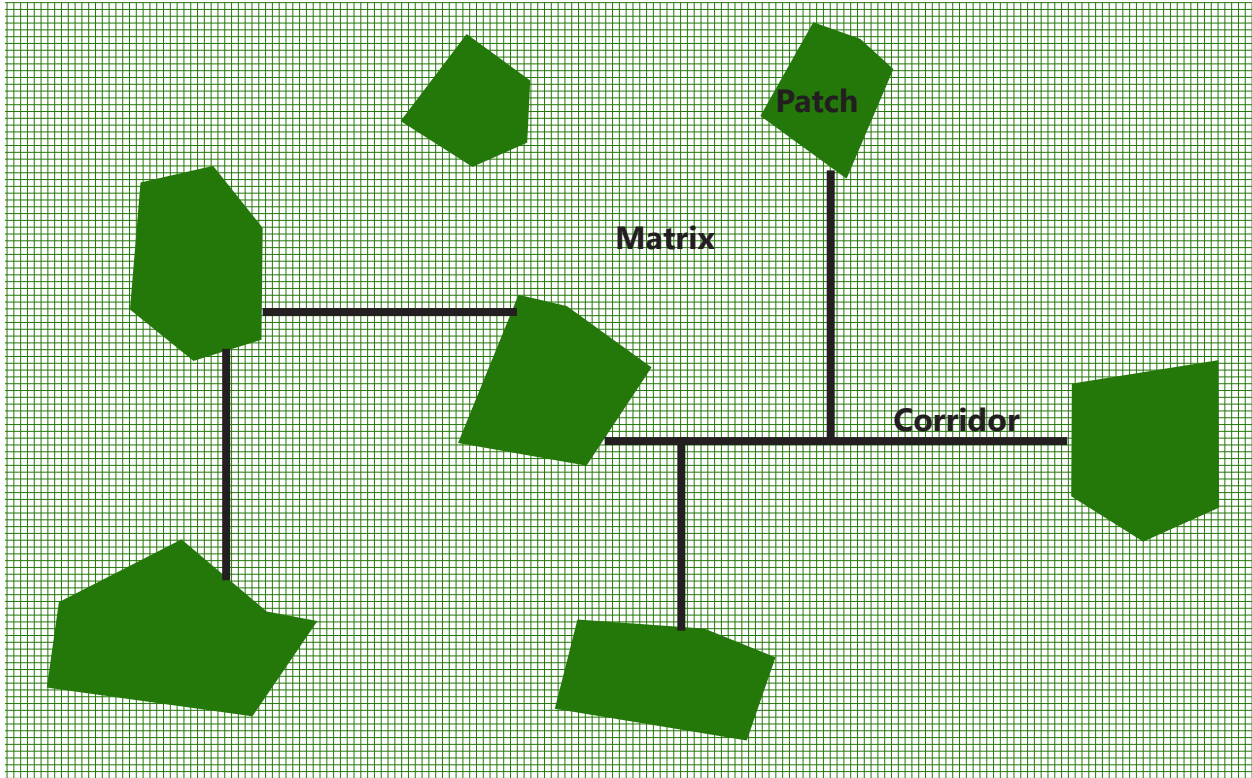
**Flora**



**Fauna**

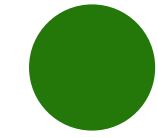
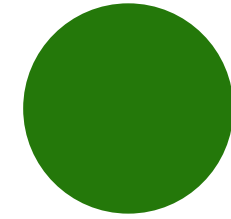


# Theoretical background

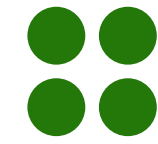


Better

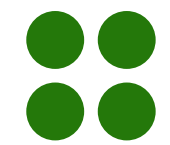
Worse



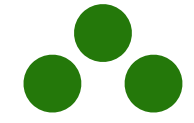
A



B



C



D



E



F

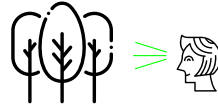


# Design principles

Promote exercise



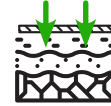
Seeing green



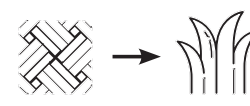
Promote biking



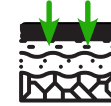
Permeable pavement



Stone to green



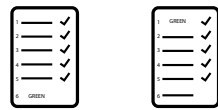
Porous asphalt



Promote walking



Put green first



Education



Remove parking



Car-free zones



Decrease speed



Add vegetation



Soft borders



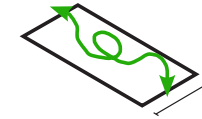
Maintenance plan



Animal friendly lighting



Minimal width



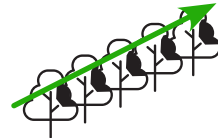
Wildlife corridor



Design conditions



Continuous structure



Add trees



Fence protection



Bundling lanes



Plant diversity



Waterbodies



Large over small



Create shadows



Wildlife habitat



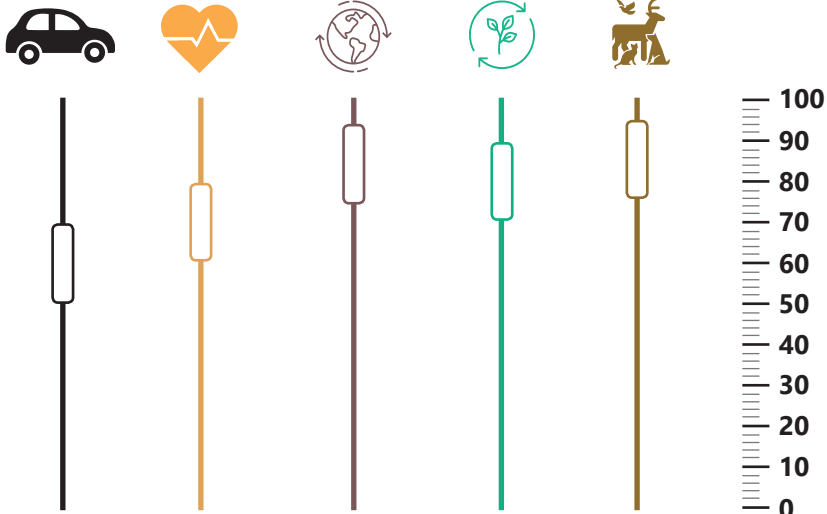
Remove lanes



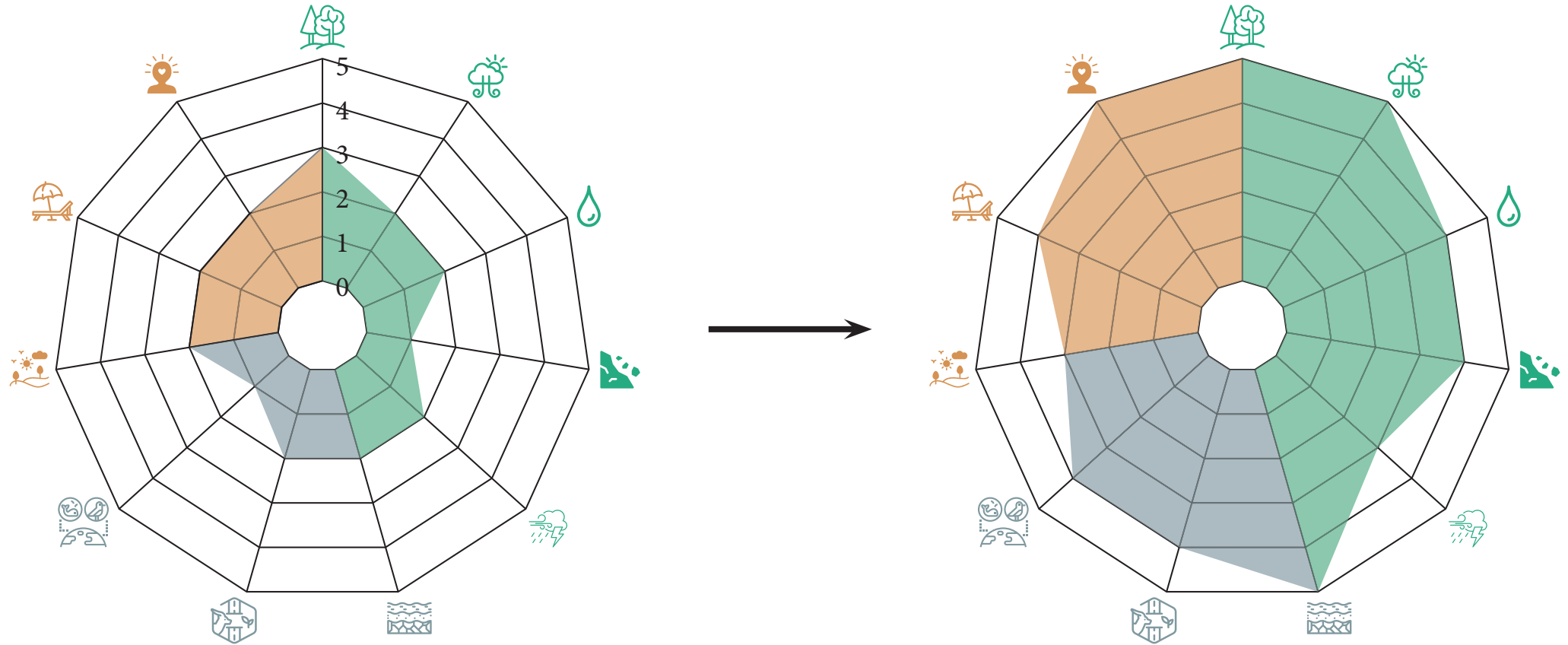
Avoiding nuisance



# Applying design principles

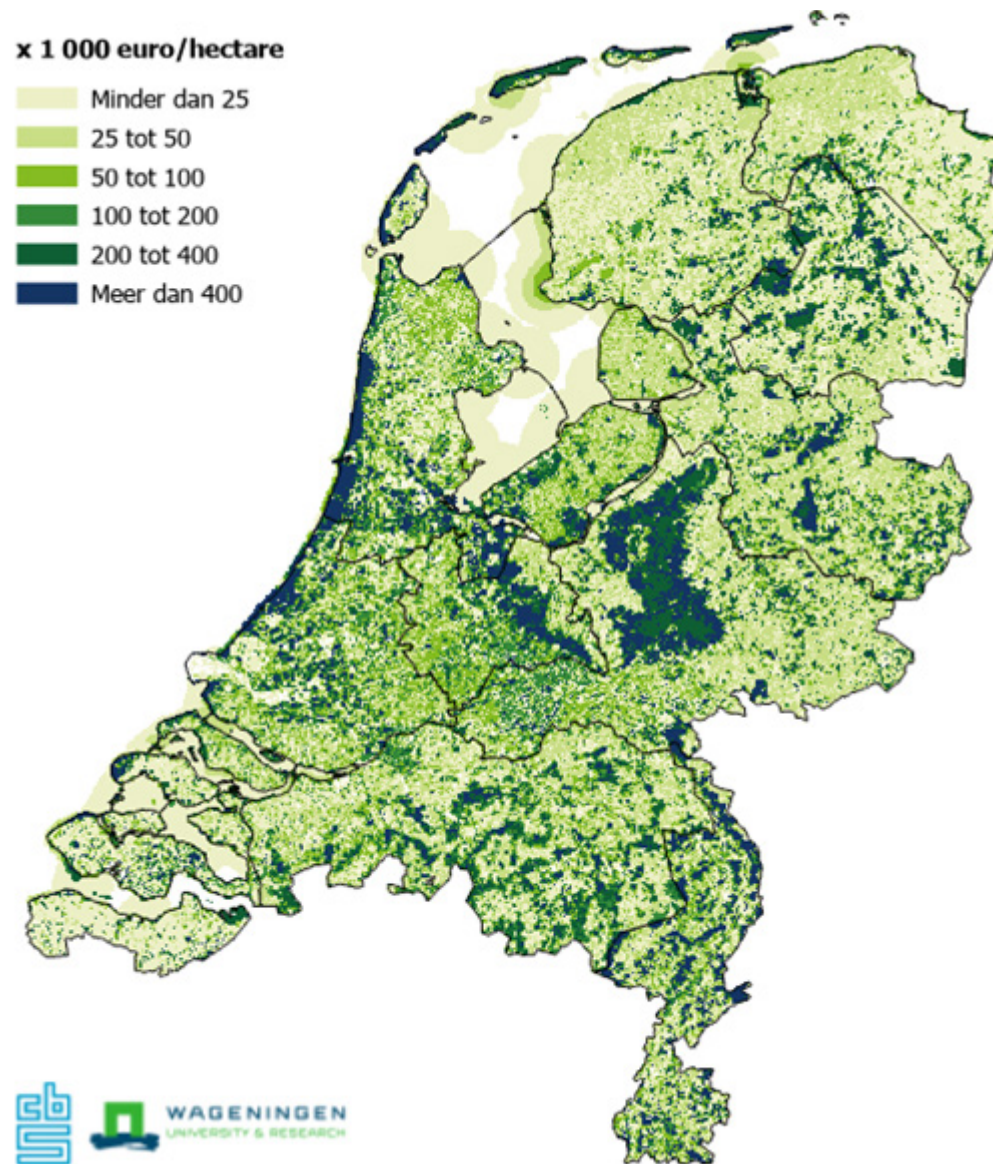


# Applying design principles

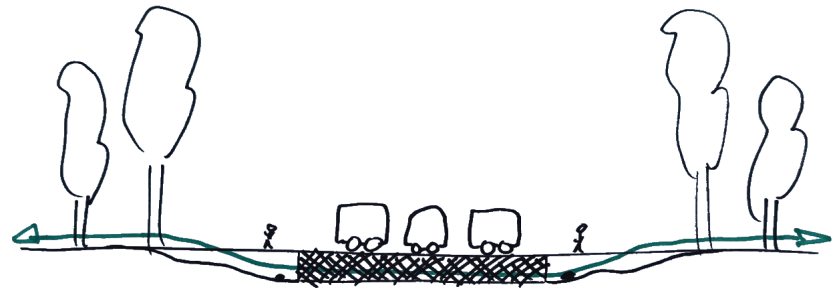
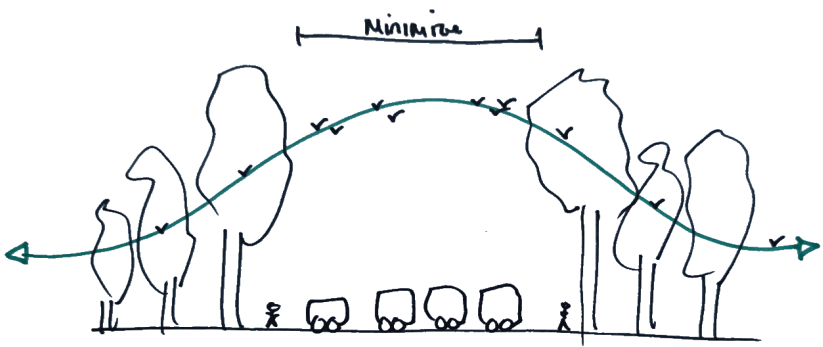


**Thank you**

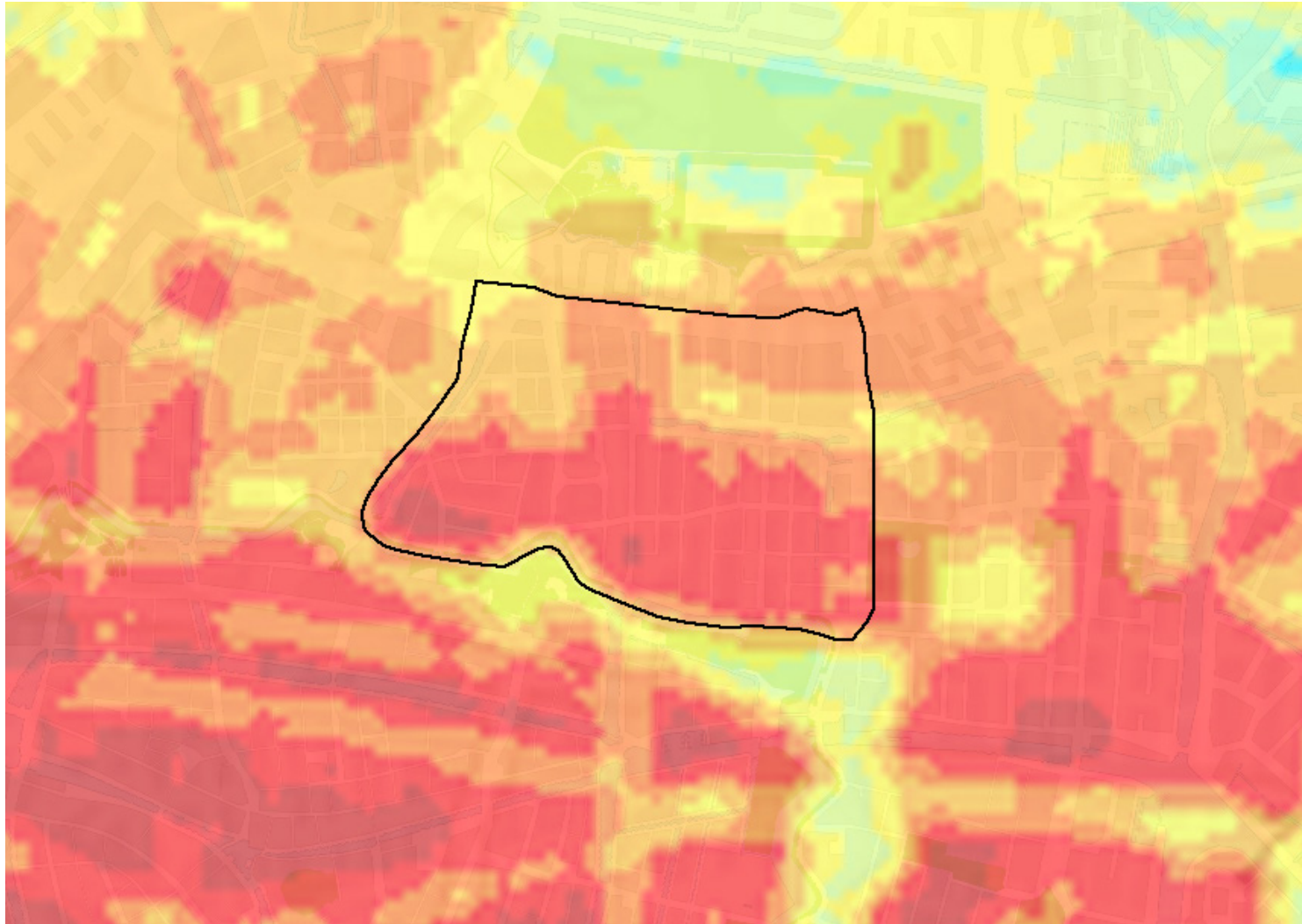
# Natural capital



# Intersections



# Climatic analysis





# Climatic analysis



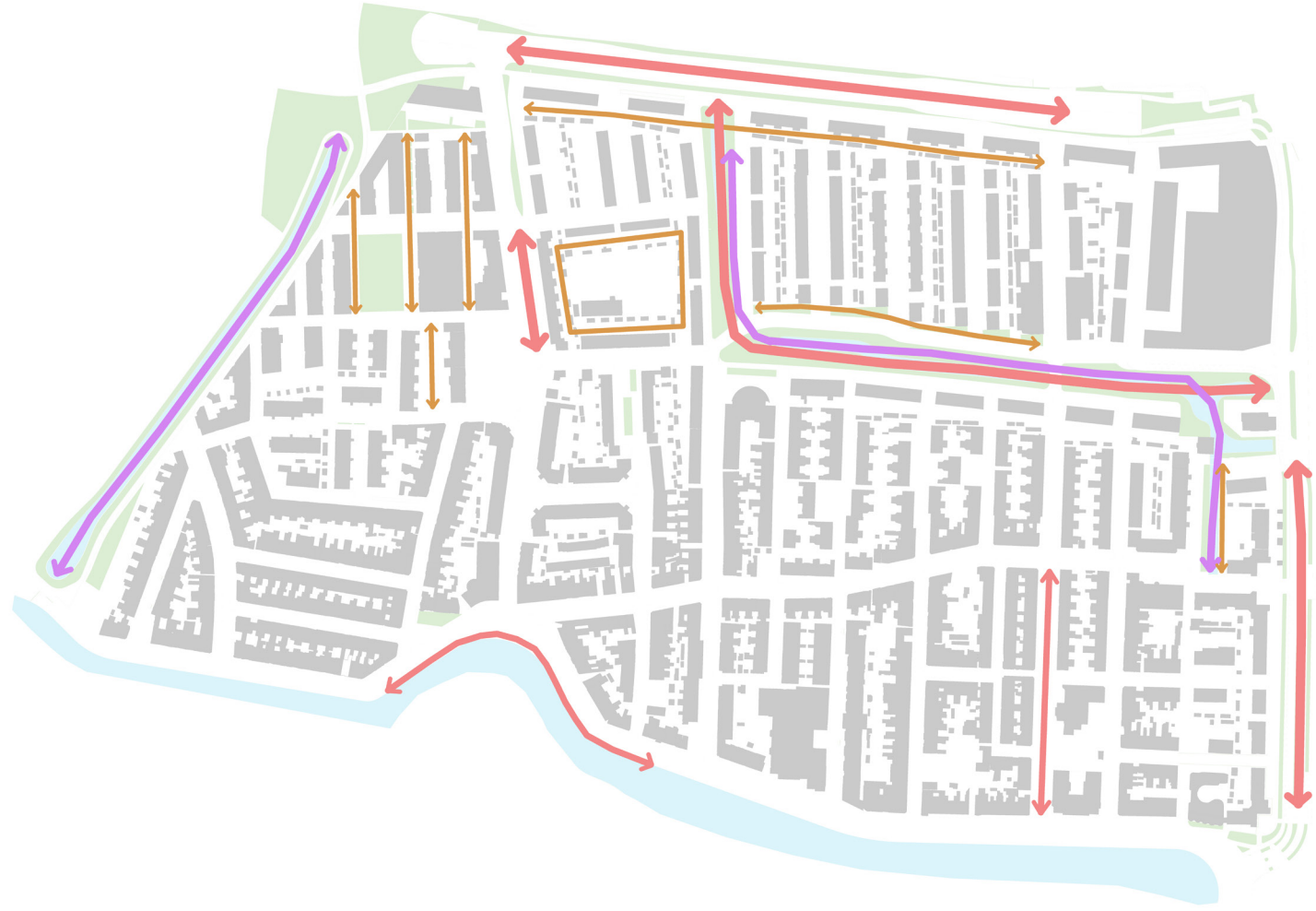
# Health analysis



# Road analysis



# Flora & Fauna



**Development of variety of habitats**

**Soil quality**

**Reduced maintenance costs**

**More efficient urbanization**

