

# NBS TO FIGHT URBAN HEAT STRESS

September 25th, 2024

Future Green Cities Congress Utrecht

Effectiveness of Nature-Based Solutions for urban climate adaptation

**Jeroen Kluck**

Professor Climate Resilient Cities

Amsterdam University of Applied Sciences

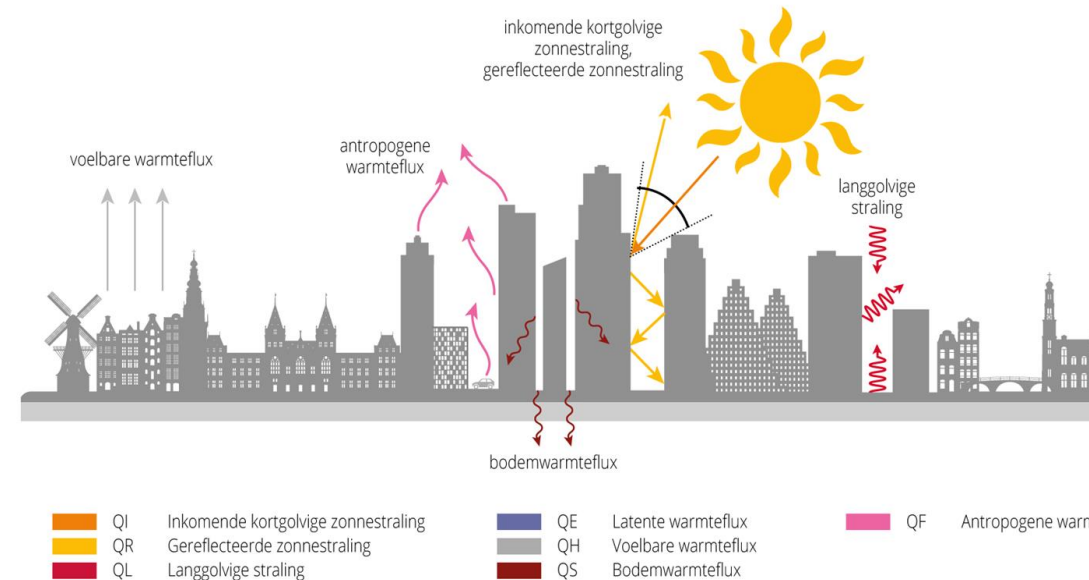
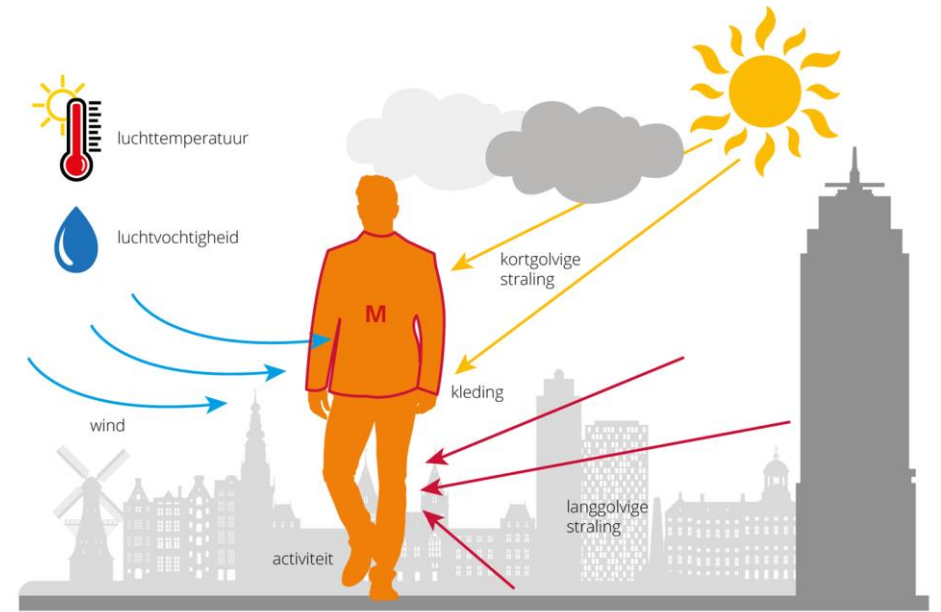
[j.kluck@hva.nl](mailto:j.kluck@hva.nl)

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# URBAN HEAT

- ▶ Liveability → mainly shadow
  - ▶ Shadow PET -15 to -20 degrees
  - ▶ 300 m to a cool spot
  - ▶ 30/40% of shadow no pedestrian routes
  
- ▶ Health → evaporation → green
  - ▶ +10% more green → lower air temp 0,5 °C
  - ▶ Reduce UHI
  - ▶ > 30% of green (Depending in urban typology)



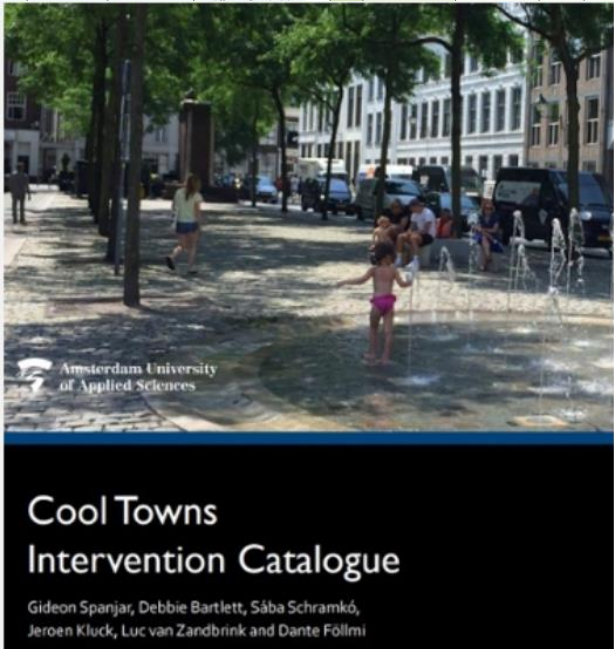
# EFFECT OF COOLING INTERVENTIONS (GREY, BLUE, GREEN)

| Soort | Maatregel   | Verkoelings-principe        |       | Maatregel<br>vooral voor |        | Typisch schaal-<br>niveau waarop<br>maatregel<br>effectief is |      | Verkoelende<br>effecten gevonden in literatuur |        |                                     | Extr    |    | Soort | Maatregel | Verkoelings-<br>principe |  | Maatregel<br>vooral voor |  | Typisch schaal-<br>niveau waarop<br>maatregel<br>effectief is |  | Verkoelende<br>effecten gevonden in literatuur |        |                                     | Extra informatie |  |  |  |  |  |  |  |  |  |  |  |   |
|-------|---|-----------------------------|-------|--------------------------|--------|---|------|--|--------|-------------------------------------|---------|----|-------|-----------|--------------------------|--|--------------------------|--|---|--|--|--------|-------------------------------------|------------------|--|--|--|--|--|--|--|--|--|--|--|---|
|       |   |                             |       |                          |        |   |      | Luchttemperatuur [°C]                          |        | Gevoels-<br>temperatuur<br>[°C PET] |         |    |       |           |                          |  |                          |  |   |  | Luchttemperatuur [°C]                          |        | Gevoels-<br>temperatuur<br>[°C PET] |                  |  |  |  |  |  |  |  |  |  |  |  |   |
|       |   |                             |       |                          |        |   |      | Stad   | Lokaal | Lokaal                              |         |    |       |           |                          |  |                          |  |   |  | Stad   | Lokaal | Lokaal                              |                  |  |  |  |  |  |  |  |  |  |  |  |   |
|       |   | Dag                         | Nacht | Stad                     | Lokaal | Lokaal  | Stad | Lokaal   | Lokaal |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  |  |   |
| Grijs | Parasols/<br>doeken/per-<br>gola's/arcades/<br>loggia's/luifels/<br>schuttingen | beschaduwing                |       | X                        |        |   |      |  |        |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  |  |   |
|       | Zonneschoor-<br>steen   | ventilatie                  |       | X                        |        |   |      |  |        |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  |  | Effect afhankelijk van boomtype en -grootte en het lokale klimaat. Referenties zie voetnoot <sup>13</sup>   |
|       | Windcorridors   | ventilatie                  |       | X                        |        |   |      |  |        |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  | Effect van een gezond goed verdampend grasveld. Gras heeft ook effect op oppervlakte-temperatuur (tot 20°C kouder dan beton). Referenties zie voetnoot <sup>14</sup> |   |
|       | Grote oppervlaktes  | ventilatie                  |       | X                        | X      |   |      |  |        |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  | Hoe smaller de straat, hoe groter het effect op de luchttemperatuur. Groter effect voor gevels met meer zonnestraling. Referenties zie voetnoot <sup>15</sup>        |   |
|       | Hoogte-<br>breedte<br>verhouding<br>straten                                     | ventilatie,<br>beschaduwing |       | X                        |        |   |      |  |        |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  |  | Een met sedum bedekt groen dak geeft weinig verkoeling 's nachts (vergeleken met een wit dak). Effect op stadsniveau is als 100% van alle daken in de stad groen zijn. Referenties zie voetnoot <sup>16</sup>         |
|       | Oriëntatie straten  | ventilatie,<br>beschaduwing |       | X                        |        |   |      |  |        |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  |  | Effect op stadsniveau is als 100% van alle daken in de stad groen zijn. Referenties zie voetnoot <sup>17</sup>  |
|       | Lichte gevels   | reflectie                   |       | X                        |        |   |      |  |        |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  |  | Effect afhankelijk van vegetatietype (boom versus gras), boomgrootte, grootte van het park en het lokale klimaat. Effect op PET gemeten in schaduw is groter dan hier genoemd. Referenties zie voetnoot <sup>18</sup> |
|       | Lichte bestrating   | reflectie                   |       | X                        |        | X   |      |  |        |                                     | max 1,9 | ?? |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  |  |   |
|       |   |                             |       |                          |        |   |      |  |        |                                     |         |    |       |           |                          |  |                          |  |   |  |  |        |                                     |                  |  |  |  |  |  |  |  |  |  |  |  |   |

Een koele kijk op de inrichting van de buitenruimte  
**De hittebestendige stad**



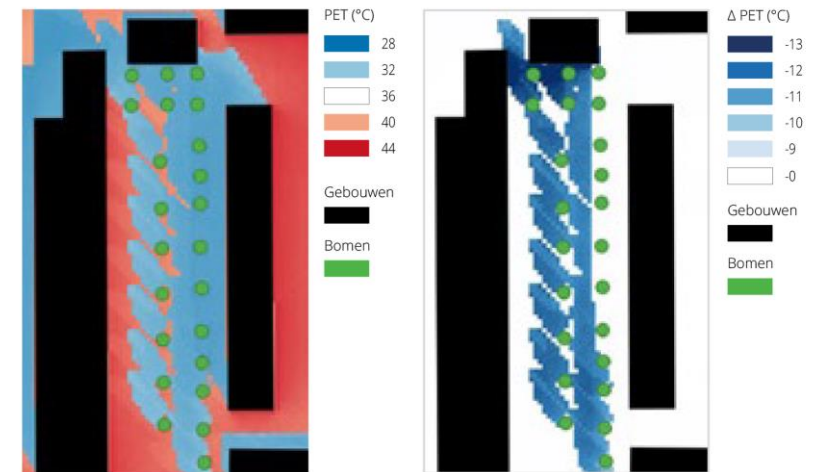
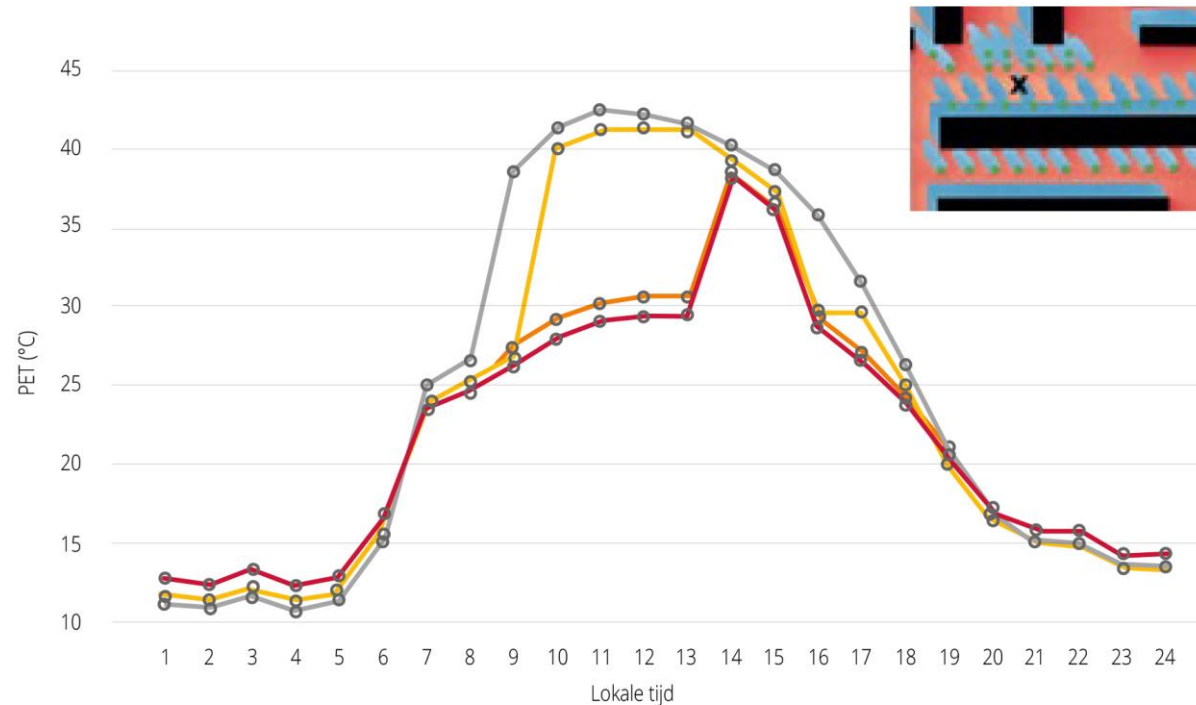
dr. ir. Jeroen Kluck  
dr. ir. Lisette Klok  
dr. ir. Anna Solcerová  
dr. ir. Laura Kleerekoper  
dr. Liesbeth Wilschut  
dr. ir. Cor Jacobs  
ir. Ronald Loeve



in de stad

# MODELLING LOCAL EFFECT ON COMFORT TEMPERATURE (PET)

- ▶ Gray – no tree
- ▶ Yellow – small tree
- ▶ Orange: open canopy, large tree
- ▶ Red: dense canopy, large tree

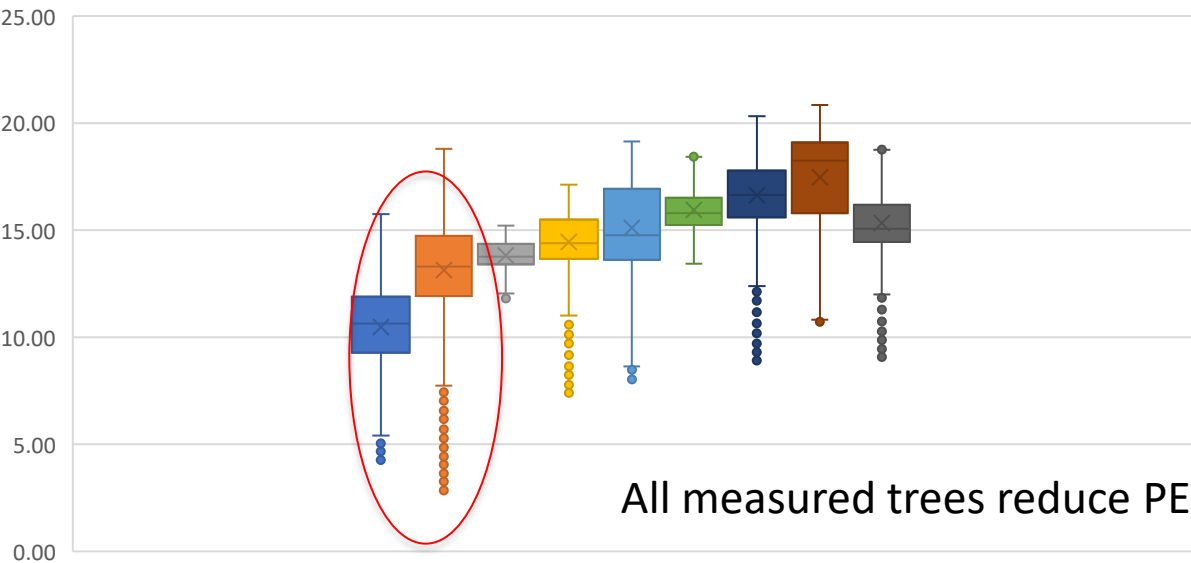


Figuur 3.9 De gevoelstemperatuur (links) en het verkoelende effect van bomen (rechts) in een van noord naar georiënteerde straat.

# MEASUREMENTS EFFECT CROWN DENSITY ON PET

PET reduction versus crown density – 3 days measurements

- 3\_Acacia (0-30%)
- 7\_JapanseSierkers (20-40%)
- 10a\_Linde (40-60%)
- 1\_Paardenkastanje (80-100%)
- 4\_Paardenkastanje (80-100%)
- 9\_Paardenkastanje (80-100%)
- 5\_Haagbeuk (80-100%)
- 6\_Haagbeuk (80-100%)
- 6\_HaagbeukSchaduwrand (80-100%)



All measured trees reduce PET by 10 degrees




Acacia



Kastanje



 Amsterdam University  
of Applied Sciences

100 pages with interventions measured

- Trees
- Shelter canopies
- Green walls
- Water features
- Cool surfaces

# Cool Towns Intervention Catalogue

Gideon Spanjar, Debbie Bartlett, Sába Schramkó,  
Jeroen Kluck, Luc van Zandbrink and Dante Föllmi

Proven solutions to  
mitigate heat stress  
at street-level

# Single lime tree on a town square, Merelbeke, Belgium

## Single tree

|      |                       |
|------|-----------------------|
| Date | 23 June 2020          |
| Time | 13:00                 |
| dPET | 14,7 °C PET reduction |

## Intervention characteristics

|             |                      |
|-------------|----------------------|
| Species     | <i>Tilia cordata</i> |
| Height      | 8 m                  |
| Crown Ø     | 2 m                  |
| Orientation | na                   |
| Ground      | Cobble stone         |
| Condition   | Healthy              |
| Shape       | Oval                 |

|              | PET (°C)                     | T <sub>air</sub> (°C) | T <sub>g</sub> (°C) | MRT (°C) | Wind (m/s) | RH (%) |
|--------------|------------------------------|-----------------------|---------------------|----------|------------|--------|
| Intervention | <b>28,8</b>                  | 24,6                  | 29,1                | 41,8     | 1,6        | 44,6   |
| Reference    | <b>43,5</b>                  | 24,7                  | 39,8                | 72,6     | 1,4        | 45,3   |
| Difference   | <b>-14,7</b>                 | -0,1                  | -10,7               | -30,8    | 0,2        | -0,7   |
| Int. grade   | Moderate Heat Stress         |                       |                     |          |            |        |
| Ref. grade   | Extreme heat stress: Level 1 |                       |                     |          |            |        |



# Group of beech trees in a community courtyard, Eeklo, Belgium

## Group of trees



|      |                       |
|------|-----------------------|
| Date | 14 June 2021          |
| Time | 14:42                 |
| dPET | 19,9 °C PET reduction |

## Intervention characteristics

|             |                        |
|-------------|------------------------|
| Species     | <i>Fagus spp</i>       |
| Height      | 10 m                   |
| Crown Ø     | 10 m                   |
| Orientation | na                     |
| Ground      | Grass / Asphalt (ref.) |
| Condition   | Healthy                |
| Shape       | Domed                  |

|              | PET (°C)                     | T <sub>air</sub> (°C) | T <sub>g</sub> (°C) | MRT (°C) | Wind (m/s) | RH (%) |
|--------------|------------------------------|-----------------------|---------------------|----------|------------|--------|
| Intervention | 27,3                         | 26,9                  | 27,8                | 29,5     | 0,8        | 35,9   |
| Reference    | 47,2                         | 29,6                  | 45,4                | 63,9     | 0,5        | 34,0   |
| Difference   | -19,9                        | -2,7                  | -17,6               | -34,4    | 0,3        | 1,9    |
| Int. grade   | Slight heat stress           |                       |                     |          |            |        |
| Ref. grade   | Extreme heat stress: Level 2 |                       |                     |          |            |        |



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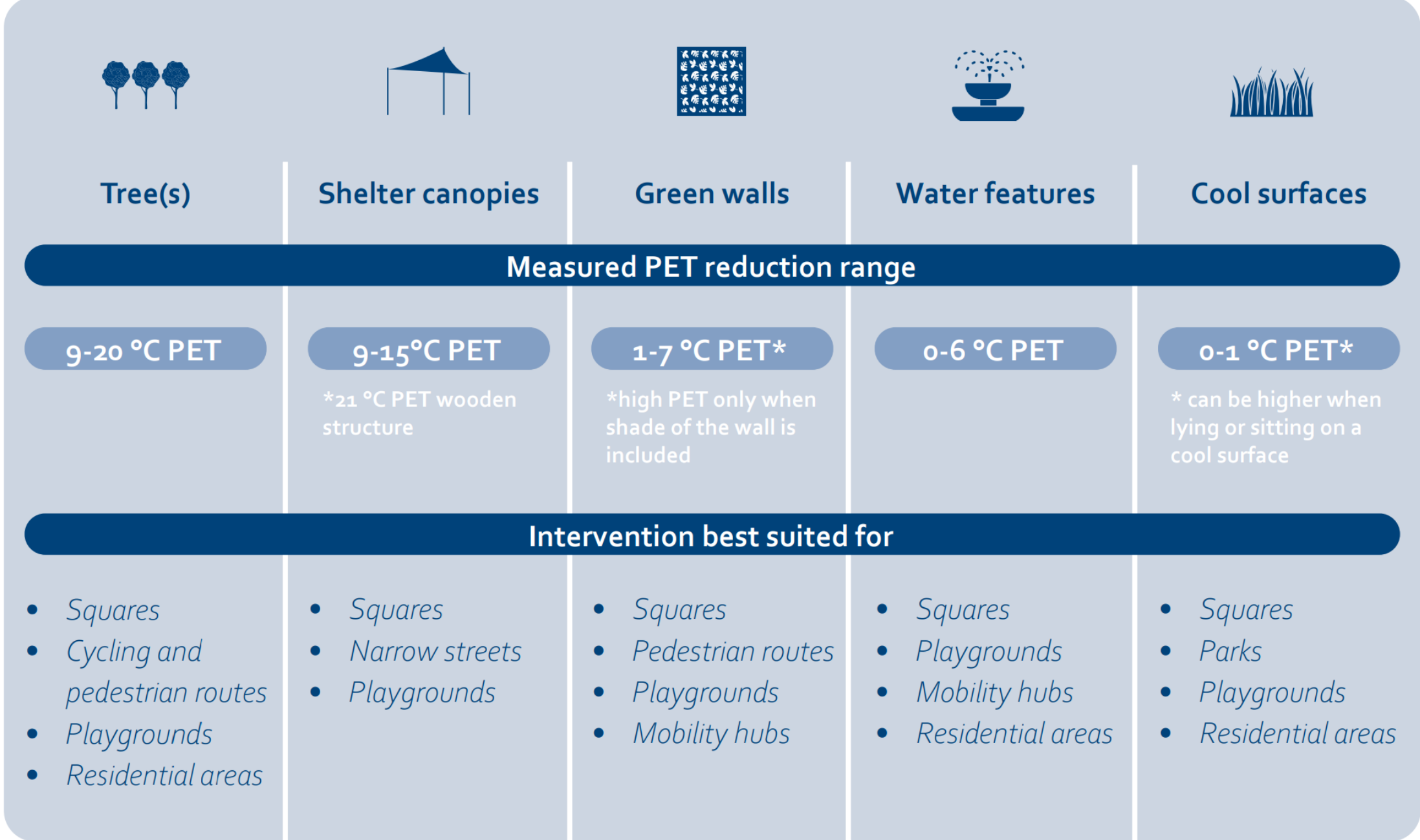


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**Figure 36:** Heat stress mitigation achieved by the five intervention types, based on CoolTowns measurements conducted between 2019-2022.

# WHAT IF NO (UNDERGROUND) SPACE FOR TREES

- ▶ Street Pergola
  - ▶ Temporary
  - ▶ Beautiful
  - ▶ Attractive
  - ▶ Effective

| Pergola  |  |
|---|--|
| Date  | 6 September 2021   |
| Time  | 15:25  |
| dPET  | 8,6 °C PET reduction   |
| Intervention characteristics  |  |
| Species   | <i>Fallopia baldschuanica</i> or <i>Polygonum baldschuanicum</i> |
| Height  | 3 m  |
| Shade size  | 300 m <sup>2</sup>   |
| Ground  | Concrete paving slabs / Crushed brick (ref.)                     |
| Material  | Wood pergola structure   |
| Transparency  | 75%  |



|              | PET (°C)             | T <sub>air</sub> (°C) | T <sub>g</sub> (°C) | MRT (°C) | Wind (m/s) | RH (%) |
|--------------|----------------------|-----------------------|---------------------|----------|------------|--------|
| Intervention | 25,7                 | 23,3                  | 26,4                | 35,4     | 1,6        | 56,9   |
| Reference    | 34,3                 | 25,3                  | 33,1                | 45,3     | 0,7        | 52,2   |
| Difference   | -8,6                 | -2,0                  | -6,7                | -9,9     | 0,9        | 4,7    |
| Int. grade   | Slight heat stress   |                       |                     |          |            |        |
| Ref. grade   | Moderate heat stress |                       |                     |          |            |        |

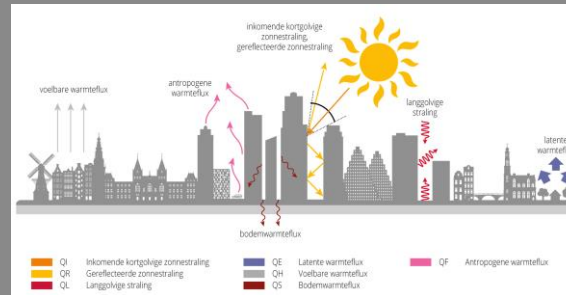


Measurements conducted by *Coste*



# TEMPERATURE REDUCTION

## Air temperature



25% green roof + 30% more trees and parks :  
(Kleerekoper et al., 2018)

Up to 2 °C daytime  
And 1 °C 'night time

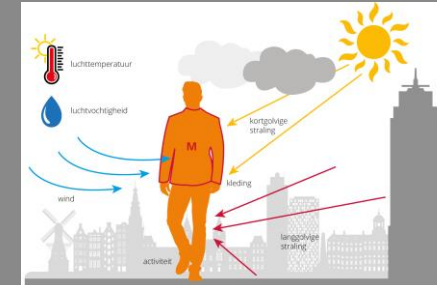
Water: large lake  
(Theeuwes et al., 2013)

Up to 1,5 °C

Increase green with 10 %  
(Steenekveld et al., 2011;  
Heusinkveld et al., 2014)

Up to 0,5 °C

## Comfort temperature (PET)



Shadow of trees (and buildings)  
(Klok et al., 2019)

12 to 22 °C

Gras (Klok et al., 2019)

Up to 4 °C

Small water bodies  
(Jacobs et al., 2020)

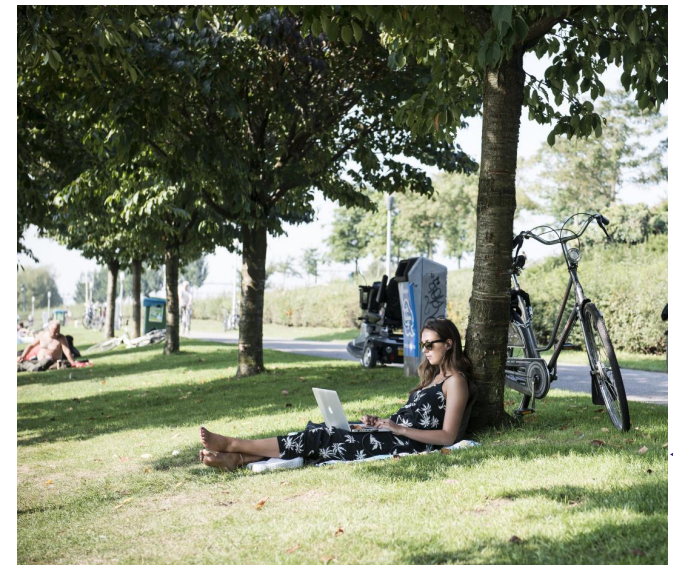
Up to 1,5 °C

Shadow (trees)  
(Heusinkveld et al., 2011; 2014)

~15 °C

# CONCLUSION

- ▶ Shadow is effective
- ▶ Most important: Size canopy and number of trees!
  - ▶ Note in NL 30%-40% shadow on pedestrian routes
- ▶ Less important: permeability
  
- ▶ → healthy trees → tree pit! or in green.
  
- ▶ Important for choices
  - ▶ Biodiversity
  - ▶ Draught resistance
  - ▶ Aesthetics
  - ▶ Pollen





# VOORBEELD STEDELIJK BOUWBLOK



# THANK YOU FOR YOUR ATTENTION

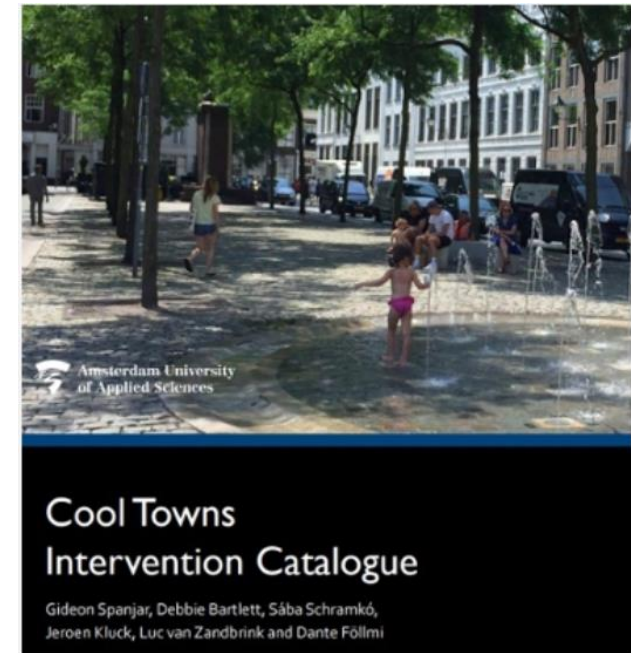
- ▶ [J.kluck@hva.nl](mailto:J.kluck@hva.nl)
- ▶ +31639357868
- ▶ [www.hva.nl/klimaatbestendigestad](http://www.hva.nl/klimaatbestendigestad)



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