Urban Heat Island

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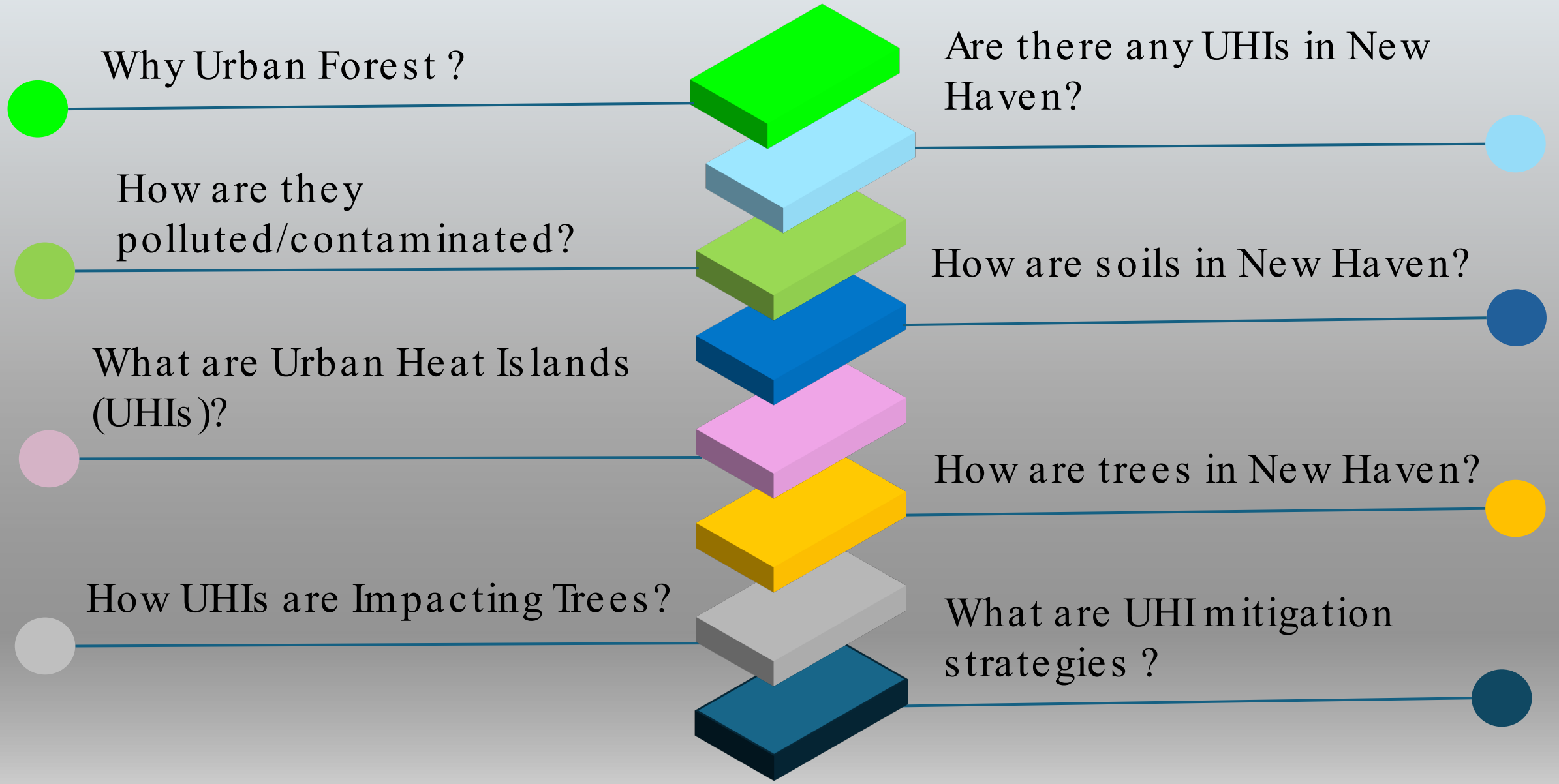
Today's Agenda



Benefits of Urban forests

Social

- Physical activities
- Aesthetics
- Mental health and well being
- Social interaction and sense of community

Environmental

- Carbon storage and Oxygen production
- Runoff and flooding
- Urban Heat Island effect
- Biodiversity conservation
- Improve air quality

Economic

- Home values and income
- Attractive shopping areas and makes them attractive to visitors
- Economic opportunities and green Jobs
- Space for recreation

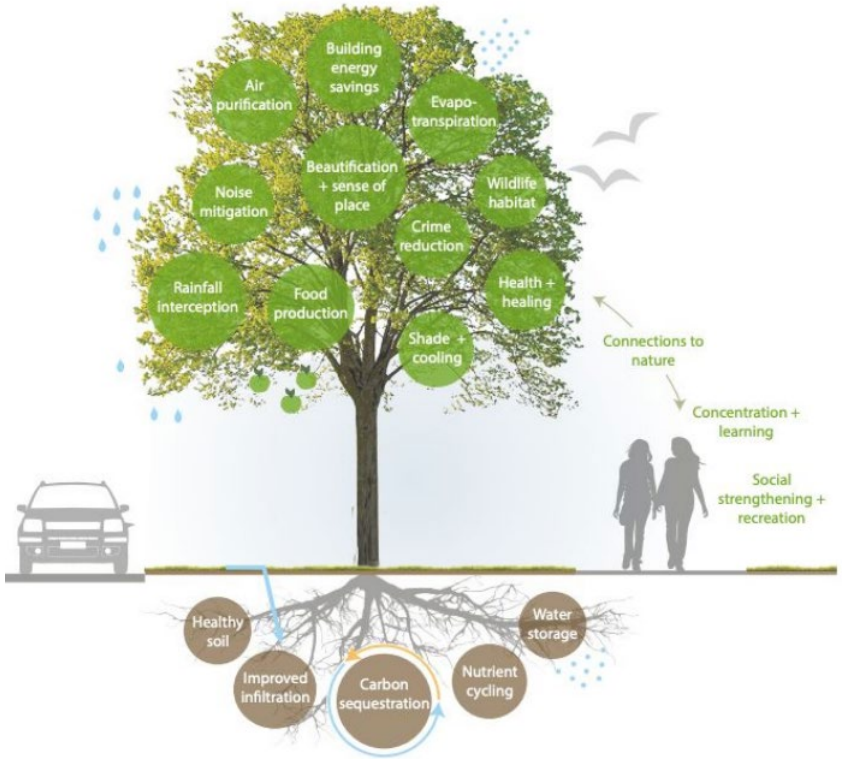
SOCIETAL VALUE OF URBAN FORESTS IN CONNECTICUT

In Connecticut, urban foresters are managing the air purification capacity worth of $120 million, and a carbon stock of $0.5-3 billion

(Nowak et al. 2017, Journal of Forestry 116:2,

Nowak at al. 2014, Environmental Pollution 193)

50% of jobs related to tree planting



Pollutants of Urban Environments

Cigarette Butts

Pollutants of Urban Environments

Oil Spills/ Detergents

(Hydrocarbons)
(Windshield washer fluid)

Pollutants of Urban Environments

Tyre wear particles

Tyre Leachate (6PPD-quinone)

Petroleum based products

Heavy Metals

Pollutants of Urban Environments

Feces and urine
(P and N)

Pathogens

Pollutants of Urban Environments

Grasses and litter

Phosphorus and Nitrogen

Pollutants of Urban Environments

Trash

Metals and their oxides
Micro and Nano Plastics

Pollutants of Urban Environments

Microplastics

Nitrile/latex

Future of Urban forests

Nearly 70% of humanity will live in cities by 2050

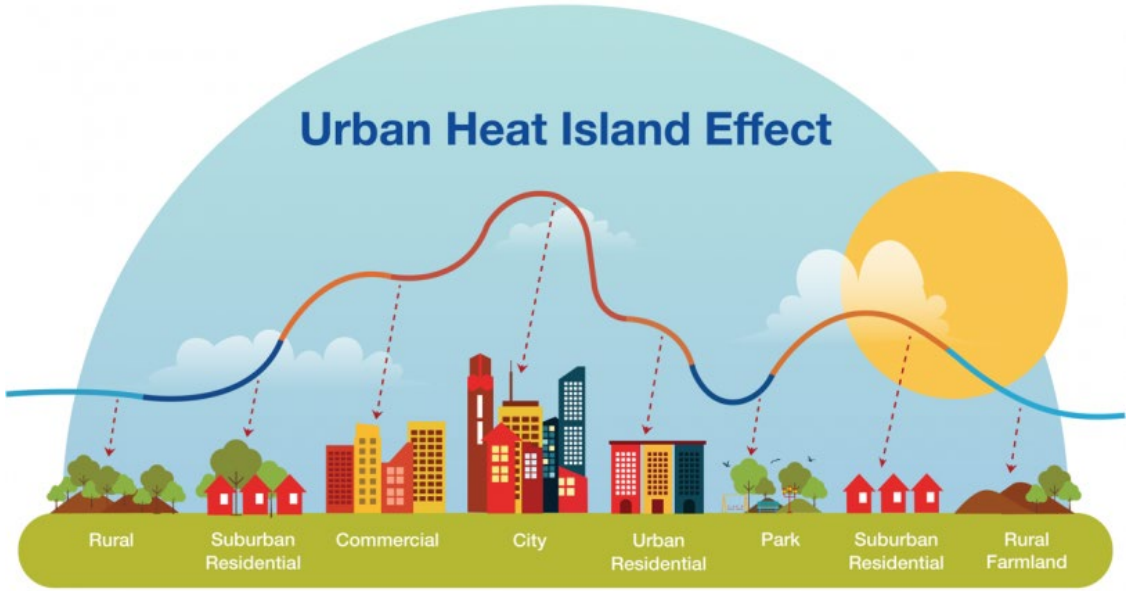
- Deforestation for development

Climate change

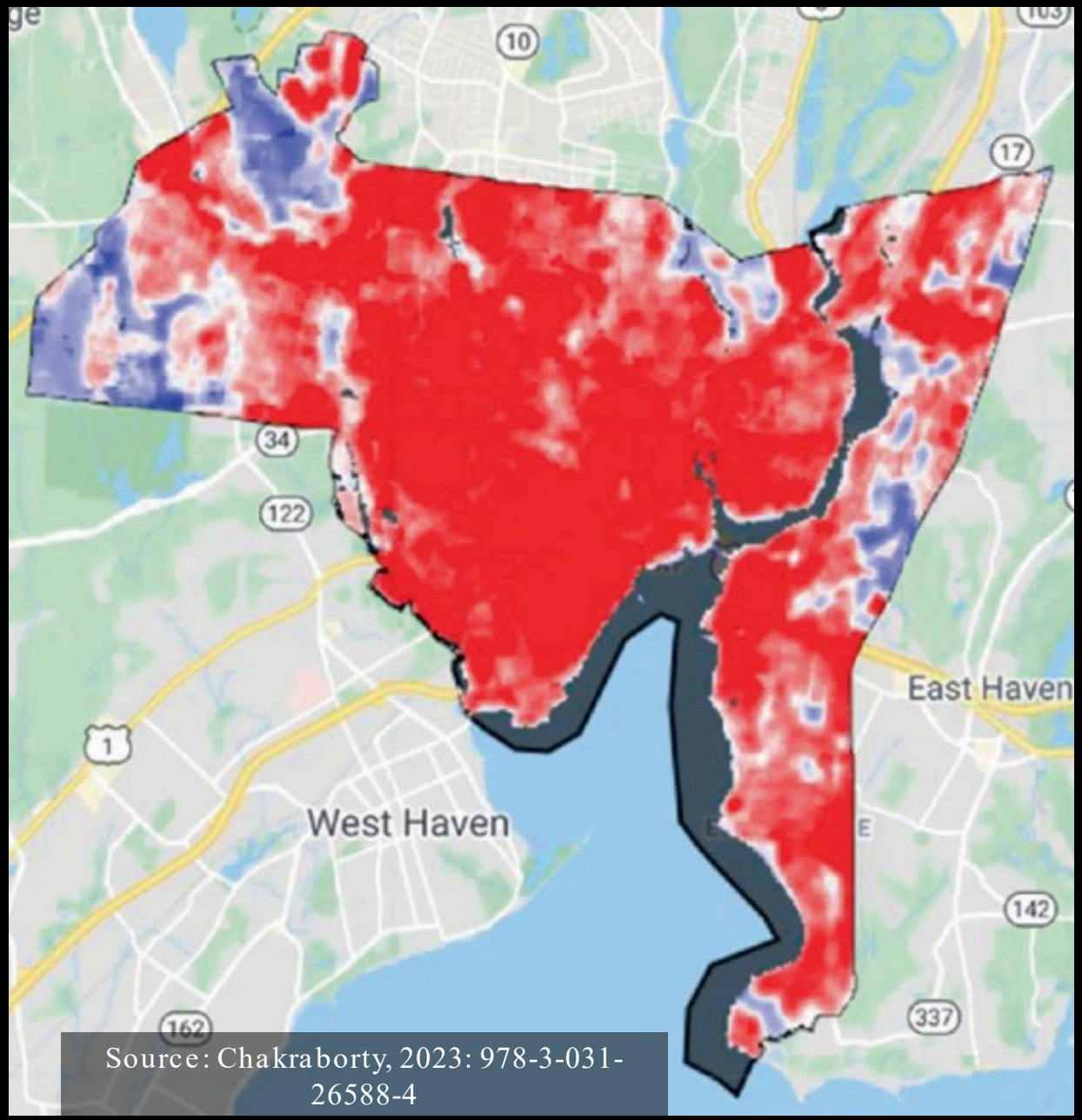
- Lack of proper maintenance
  - (pruning, disease control)
- Pollution (air, soil, water)

Urban Heat Island effect

- Cities experience higher air temperatures than the surrounding countryside.
- On average, cities tend to be 1-7°F warmer during the daytime.
- At night, cities can still be as much as 5°F warmer than the areas around them.



Source: EPA2023



Source: Chakraborty, 2023: 978-3-031-26588-4

Surface Heat Islands

- Man-made surfaces absorb and emit significantly more heat than natural surfaces.

- On a warm day with a temperature of 91°F, conventional roofing materials may be as much as 60°F warmer than surrounding air temperatures.

- Surface heat islands tend to be most intense during the day when the sun is shining.

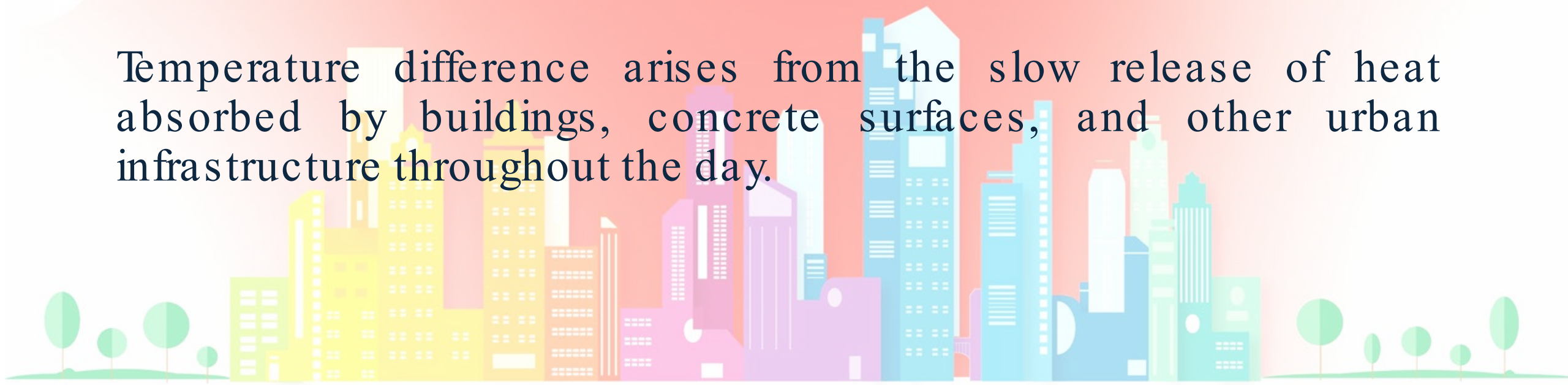
Source: EPA2023

Atmospheric Heat Islands

Warmer air found in urban areas as compared to cooler air in less heavily settled areas.

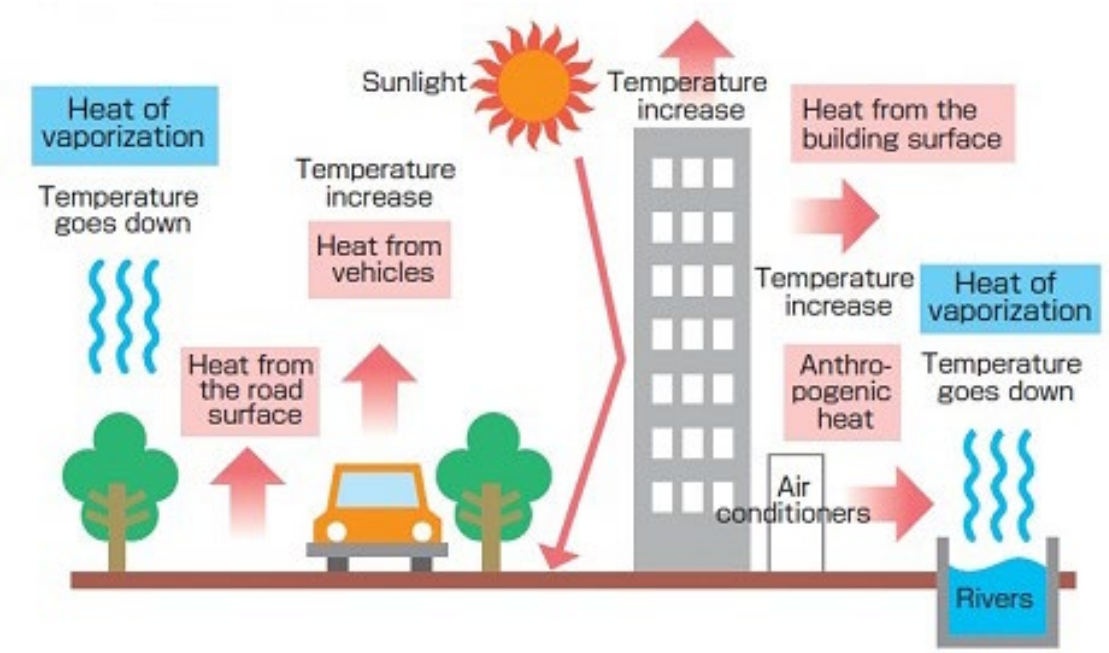
Weaker during the late morning and throughout the daytime hours

Temperature difference arises from the slow release of heat absorbed by buildings, concrete surfaces, and other urban infrastructure throughout the day.



Causes of Urban Heat Island

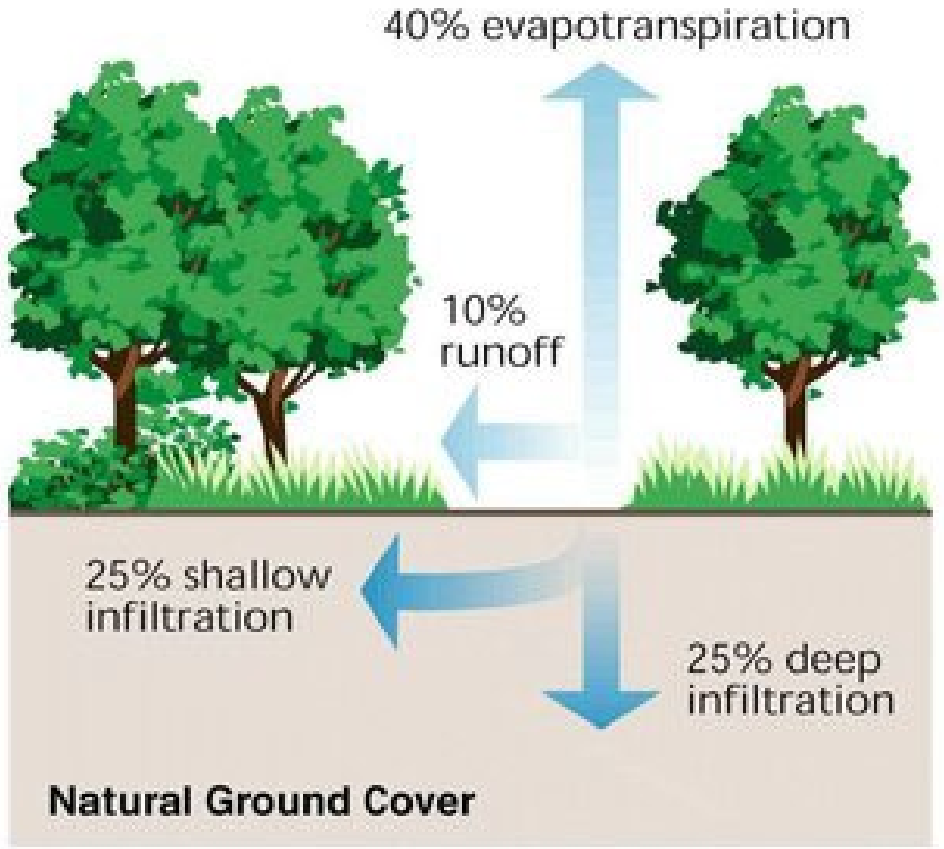
- Building materials absorb sunlight and trap heat through reflections between buildings and street surfaces.
- Building heating/cooling systems further contribute by releasing long-wave radiation.
- Combustion processes from traffic, heating, and industries release additional heat into the urban environment.

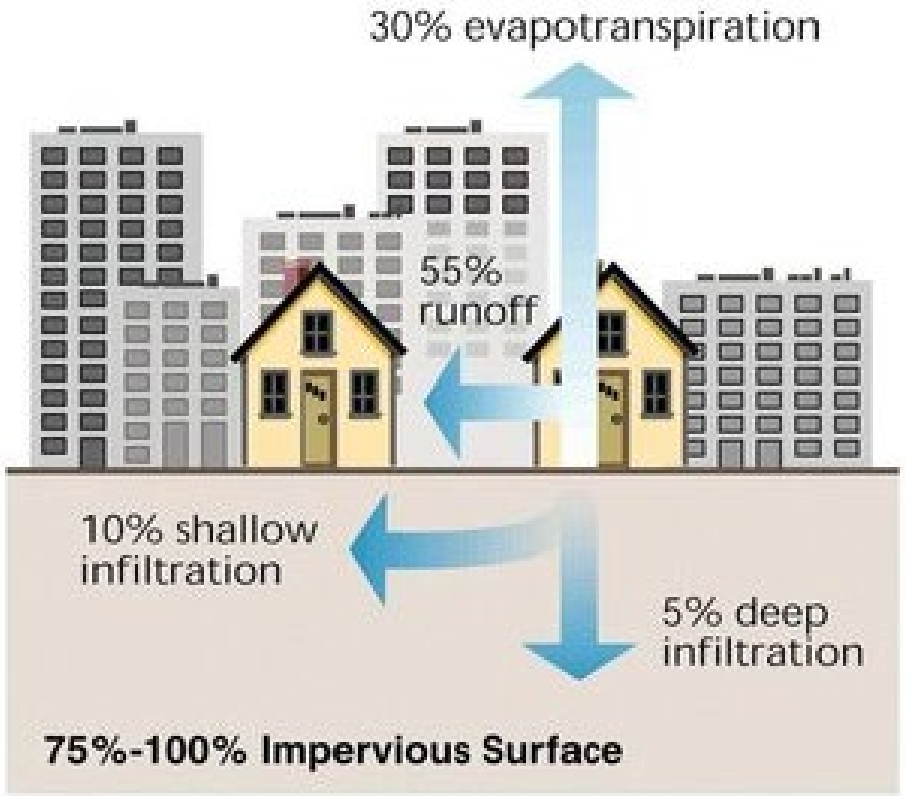


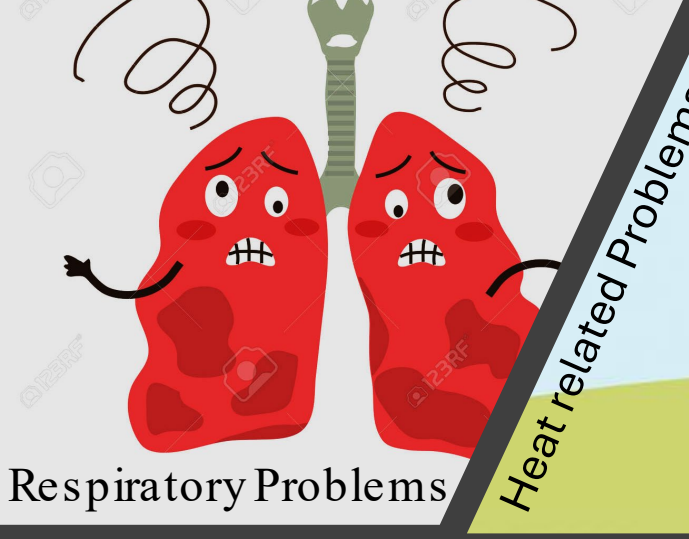
Source: Percival, 2023

Impervious surfaces and Water infiltration

- 75% impervious turns more than half of its precipitation into runoff
- Soils are compacted when covered by impervious surfaces






Respiratory Problems


Heat related Problems


Air Pollution


Smog

- Over 80% of Americans live in urban areas
- A 15-year (2004-2018) study by the CDC found:
  - Over 10,500 heat-related deaths occurred in the United States
  - This translates to an average of 702 deaths per year.

  Heat was directly or indirectly involved in these death


Wildfires

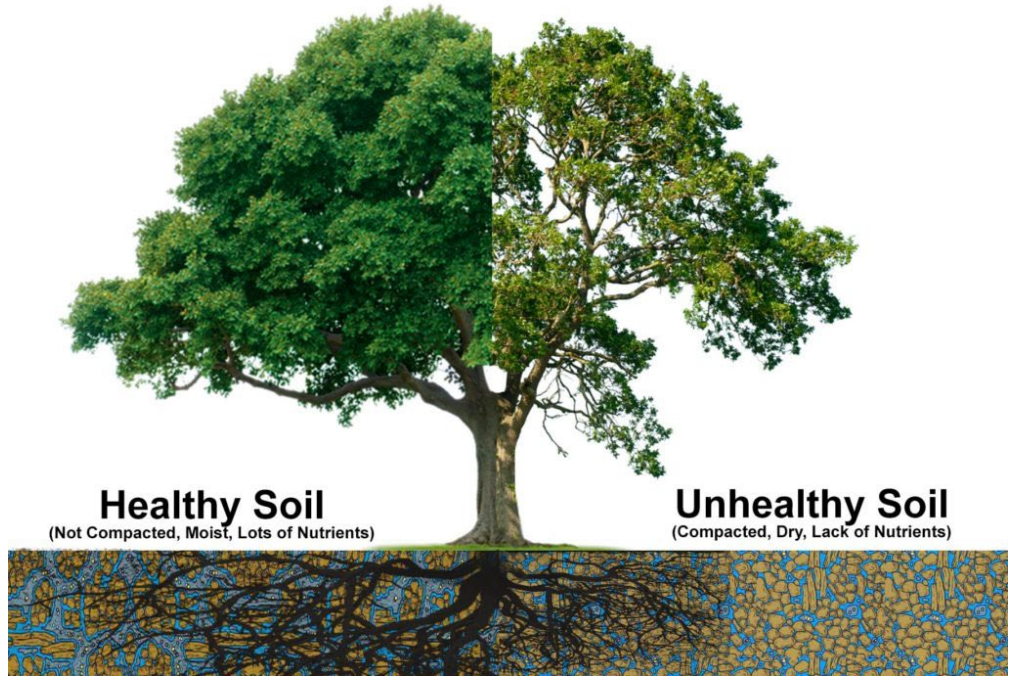
Trees Are Key To Fighting Urban Heat — But Cities Keep Losing Them

Abnormal and prolonged heat stress detrimentally influences tree biology from the cellular to whole-tree scale.

- ❑ Photosynthesis
- ❑ Stomatal conductance
- ❑ Growth
- ❑ Canopy mortality
- ❑ Premature leaf abscission
- ❑ Leaf yellowing and necrosis

All vegetative and reproductive stages are affected by heat stress to varying extents, although ovules are less heat sensitive than pollen.

Interactions among abiotic factors can stimulate even more complex responses



Source: Percival, 2023

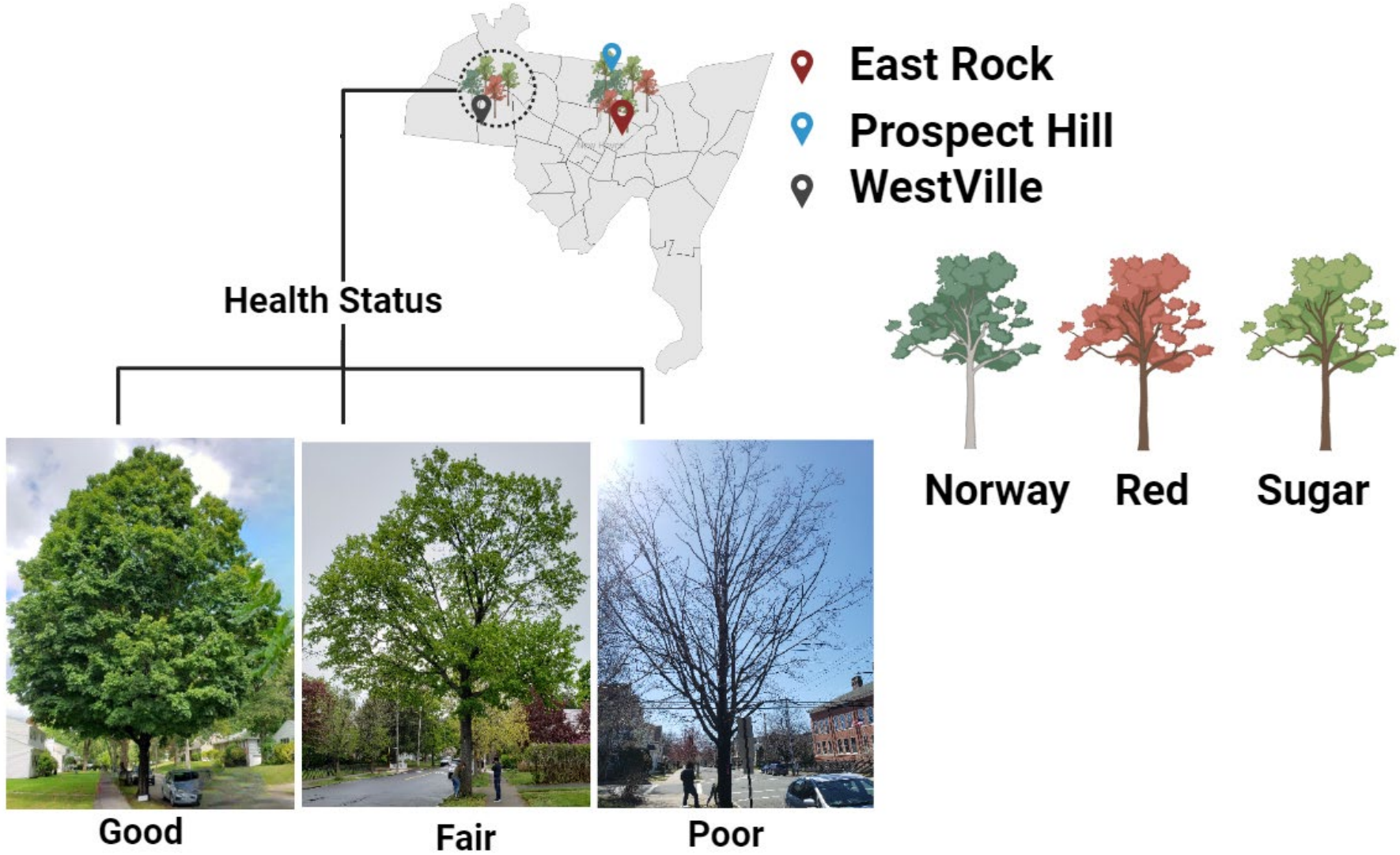
Non-structural Carbohydrates

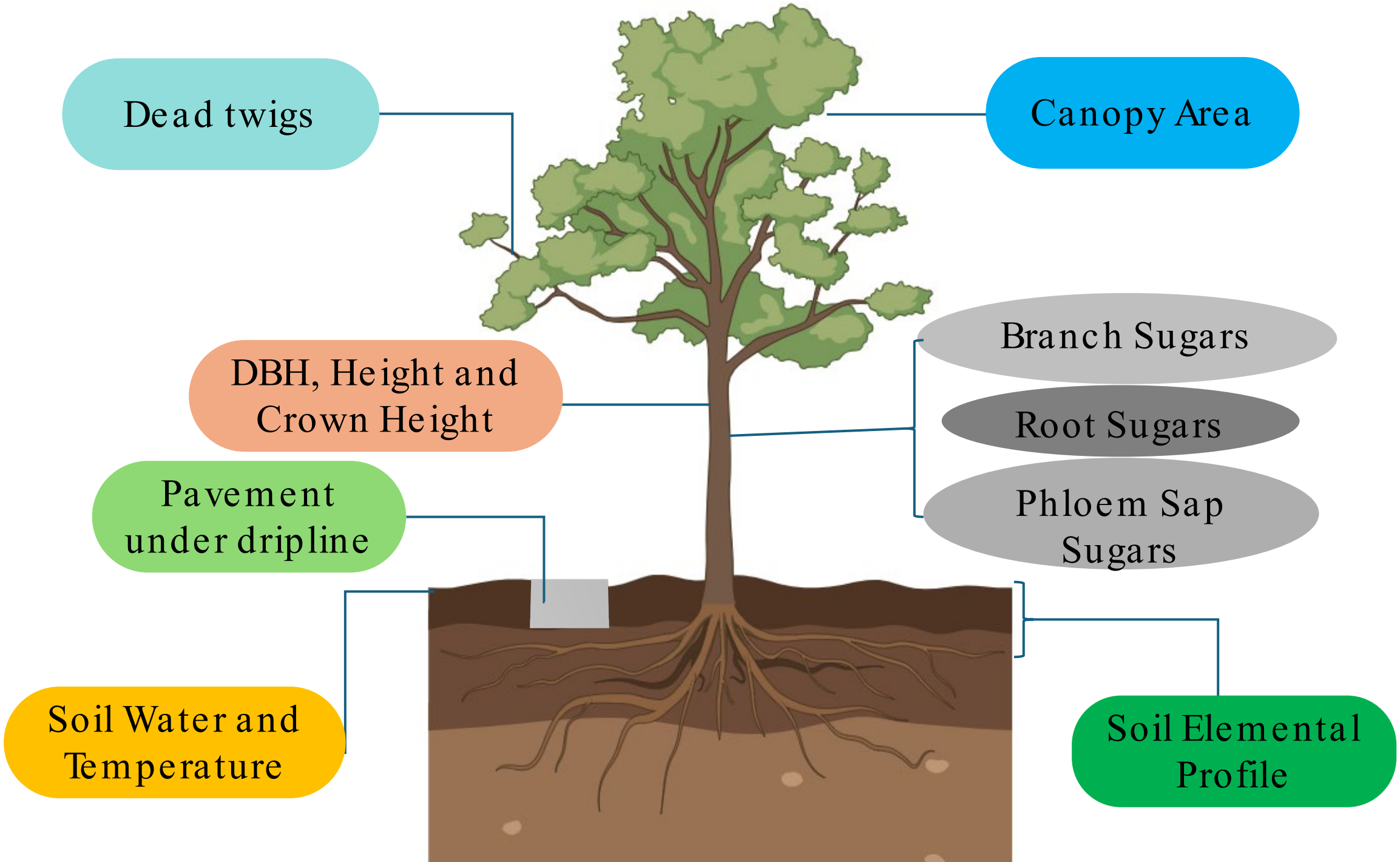
- Non-structural carbohydrates are primarily composed of soluble sugar and starch
- Reflect the carbon supply status of plants and affect the growth and development of plants
    - Plant metabolism (e.g., photosynthesis and respiration)
    - Defense
    - Osmo-protection
    - Transport of carbon and water
    - Export and exchanges with symbionts
- When plants undergo stress, the stored NSCs can be used as a buffer to temporarily supply plants for their growth and metabolism

(Source: Hartmann and Trumbore 2016)

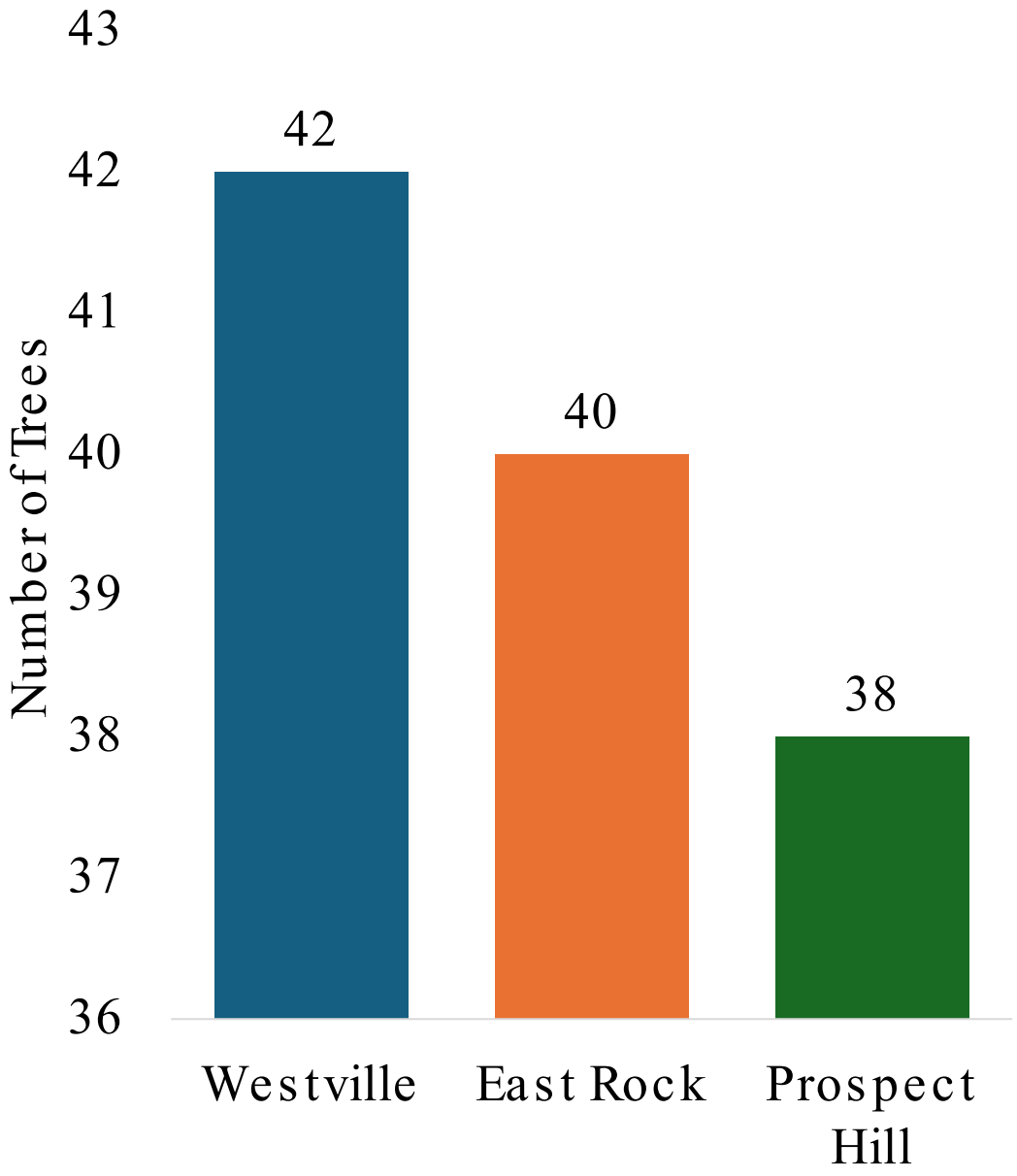
Health condition of maples in New Haven

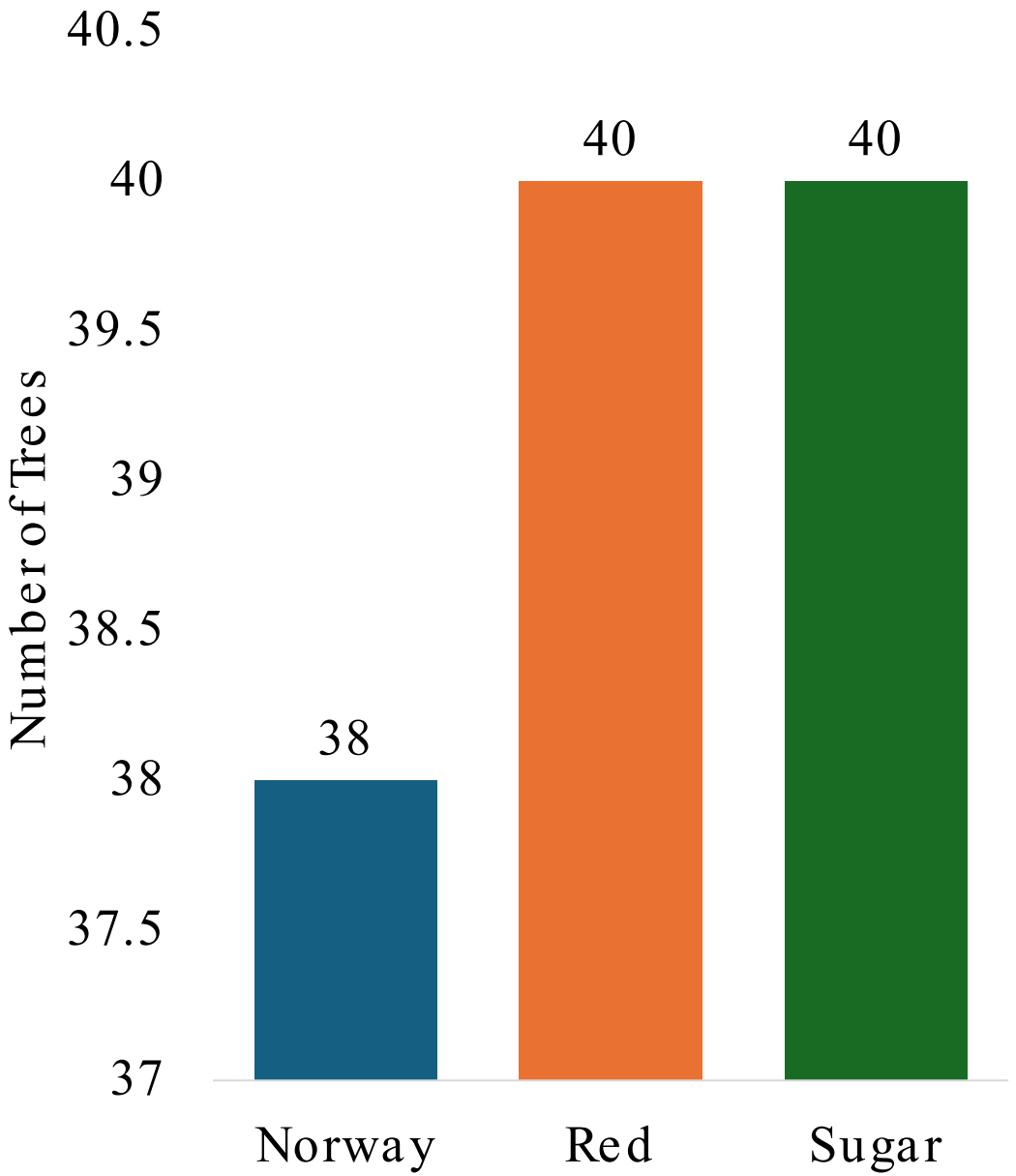
Methodology



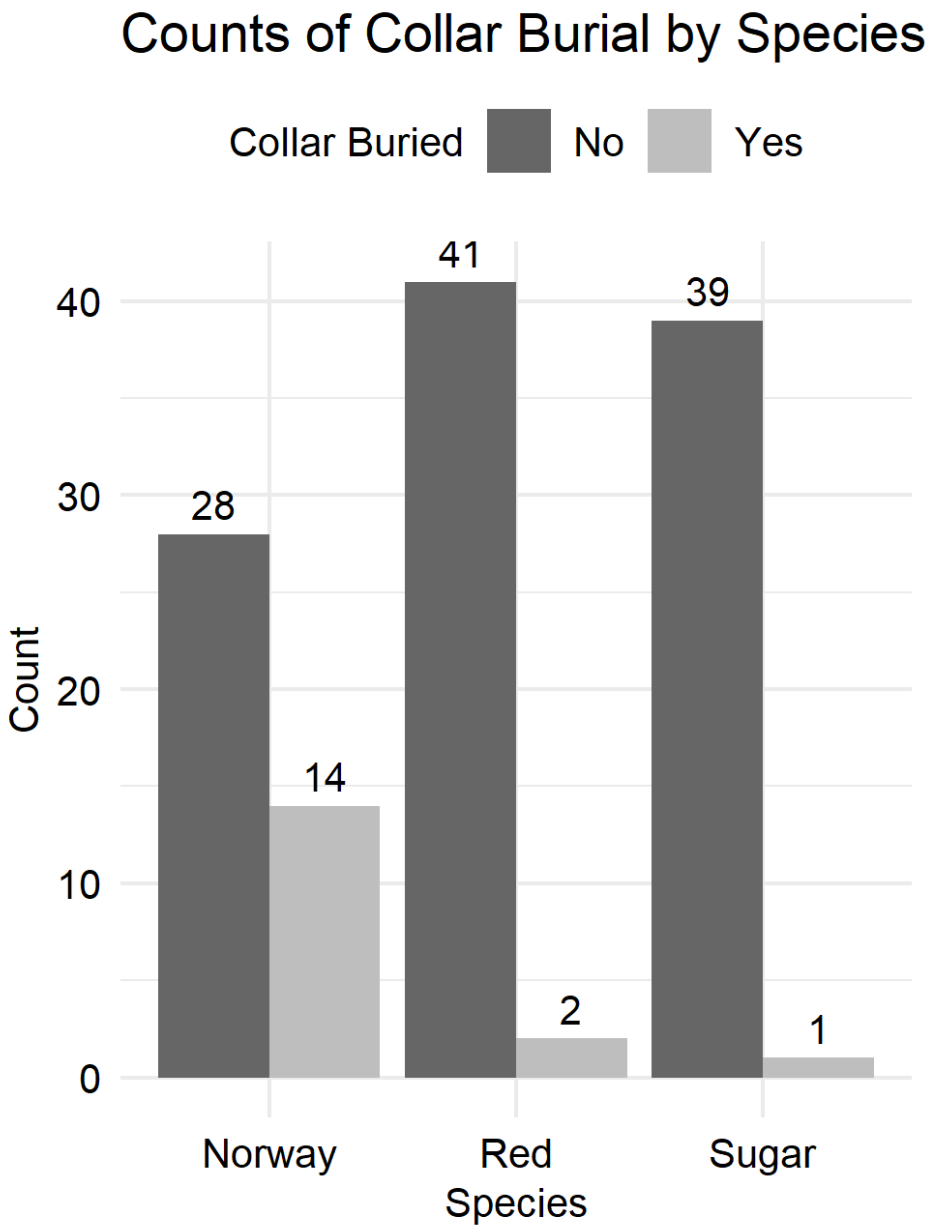

Dead twigs
Canopy Area
DBH, Height and Crown Height
Branch Sugars
Root Sugars
Pavement under dripline
Phloem Sap Sugars
Soil Water and Temperature
Soil Elemental Profile

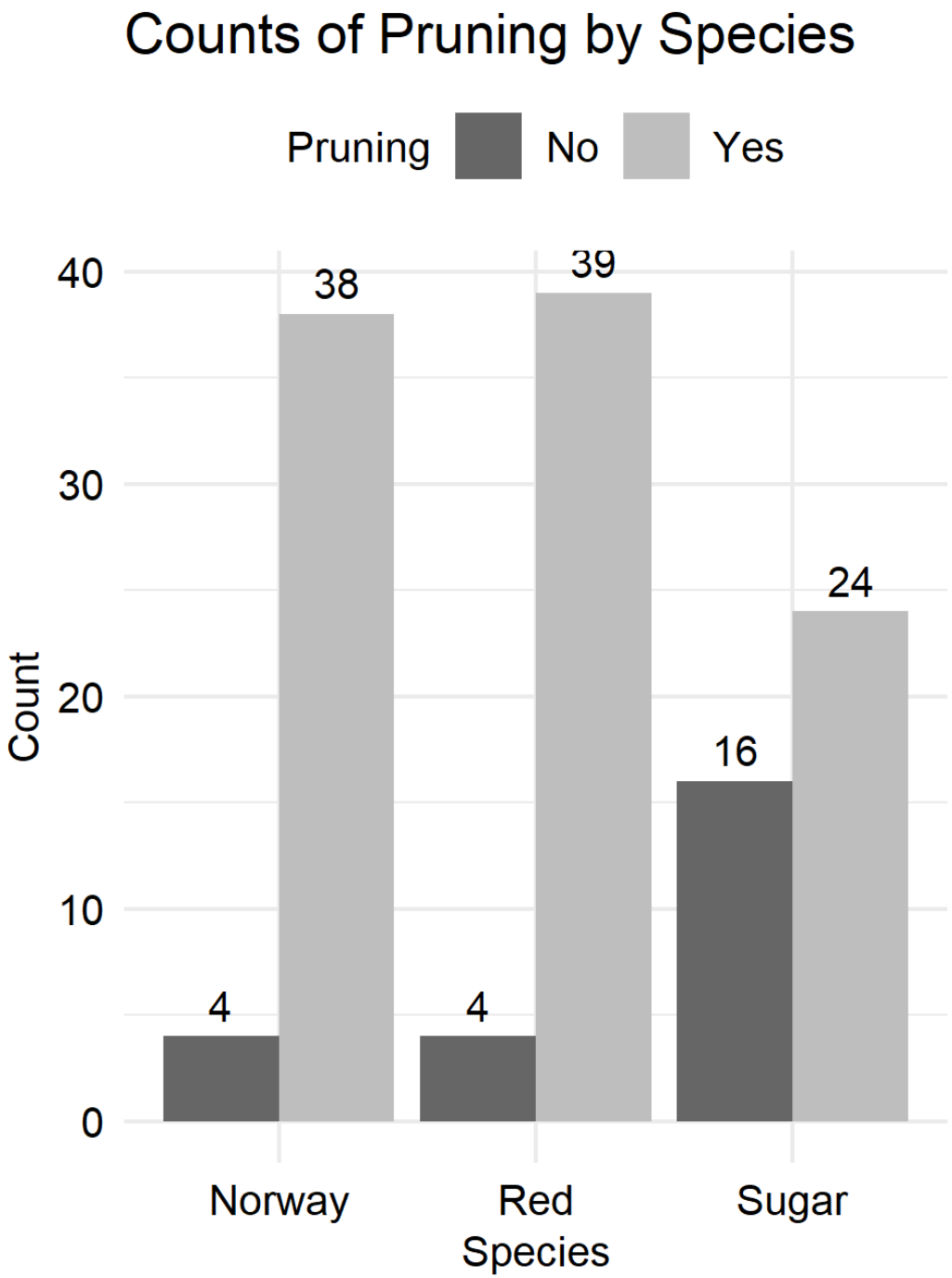
Trees in dataset



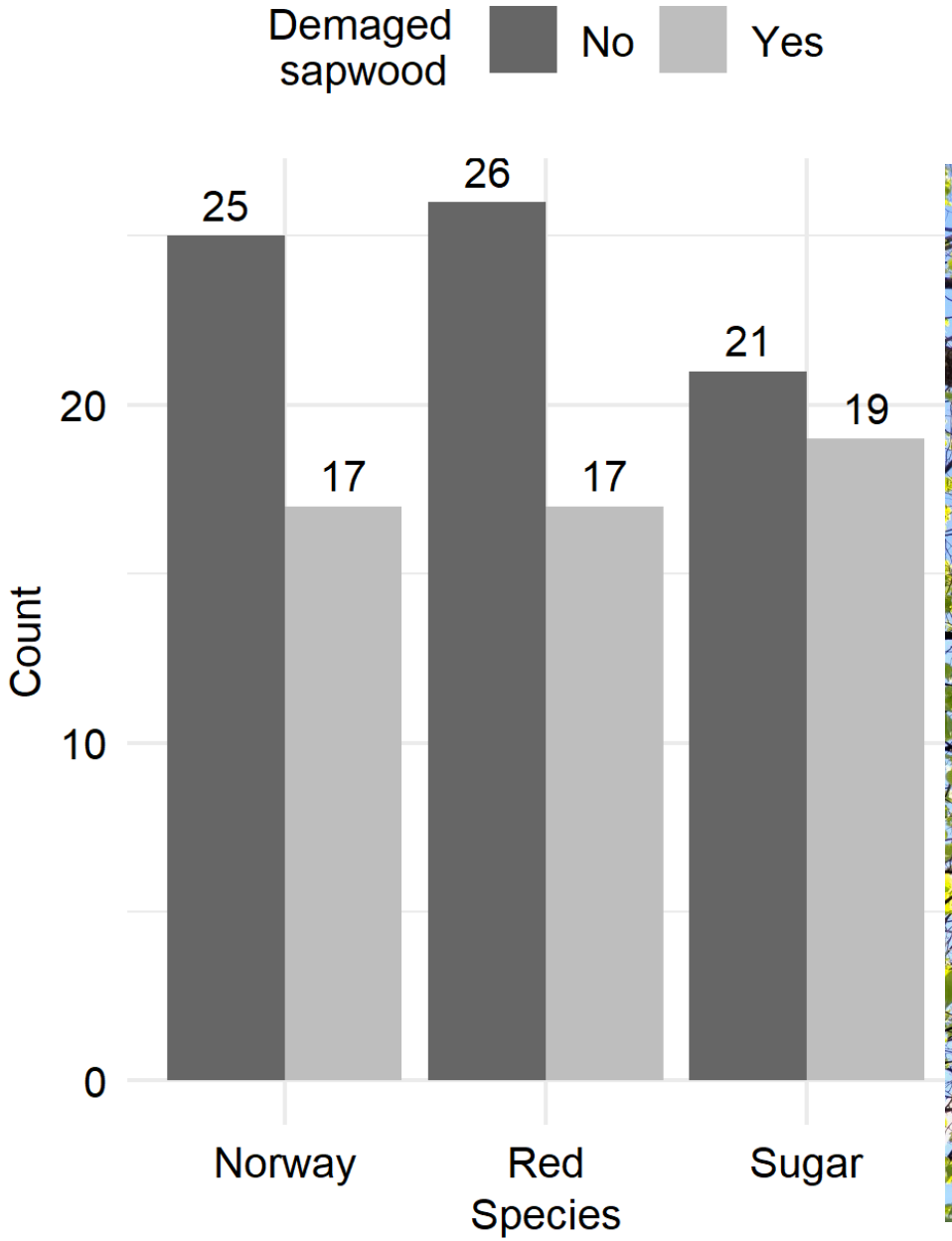


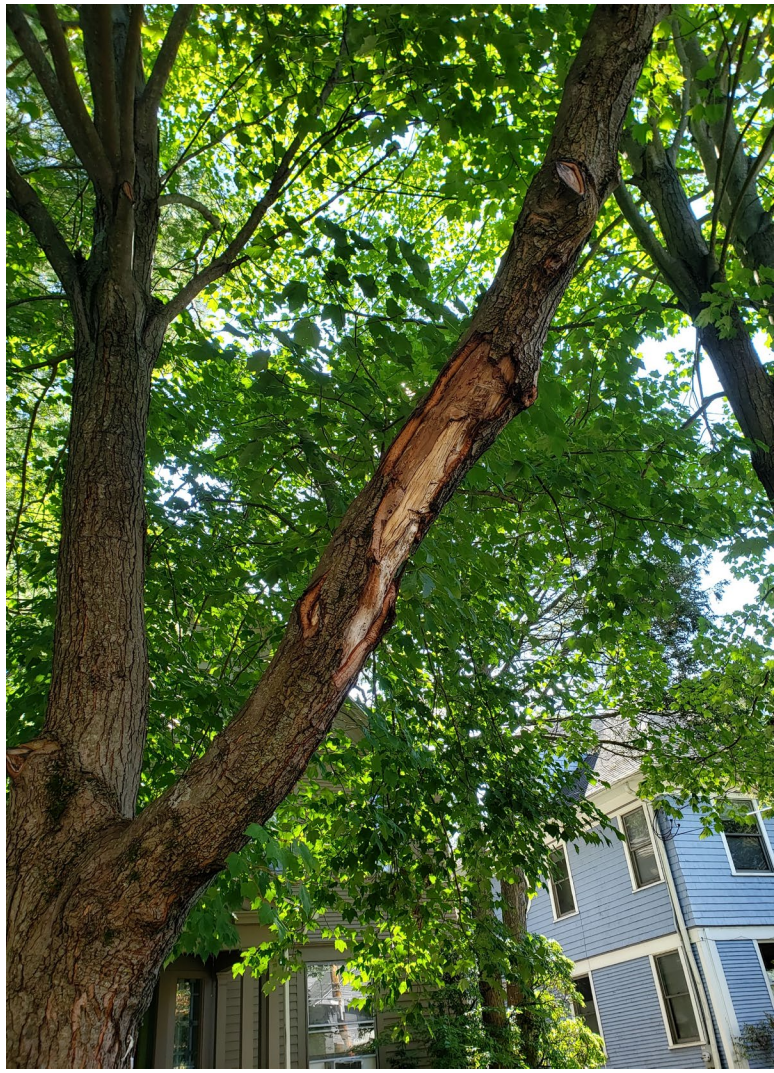
Major stresses to Maples in New Haven




Counts of Pruning by Species
Pruning
No
Yes
40
30
20
10
0
Count
38
39
24
16
4
4
Norway
Red
Sugar
Species

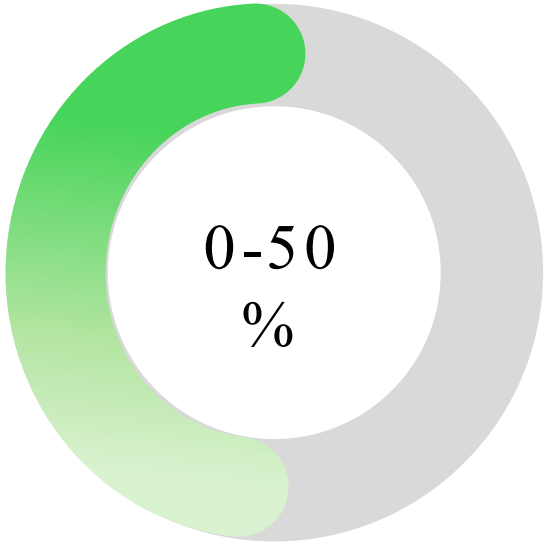
Counts of Sapwood demage by Species

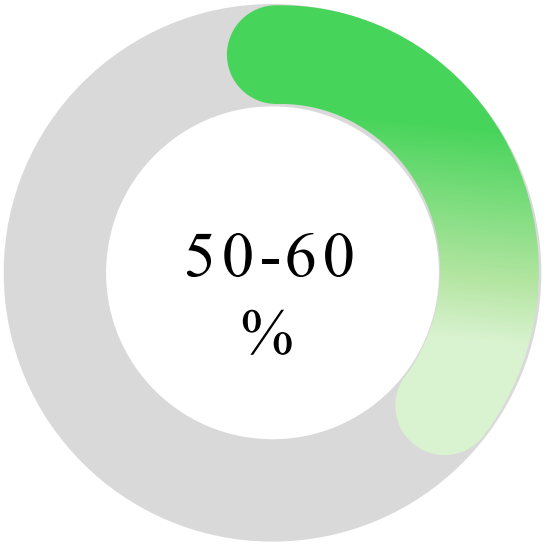


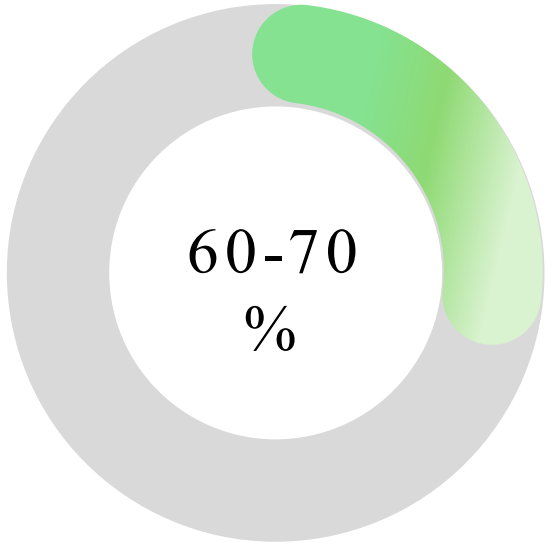


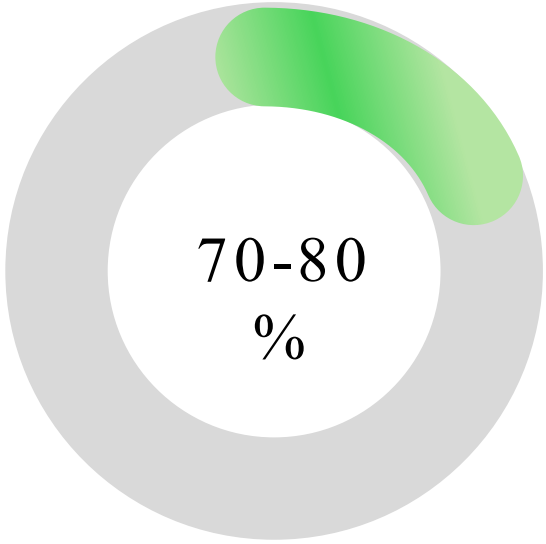
Growth space comparison

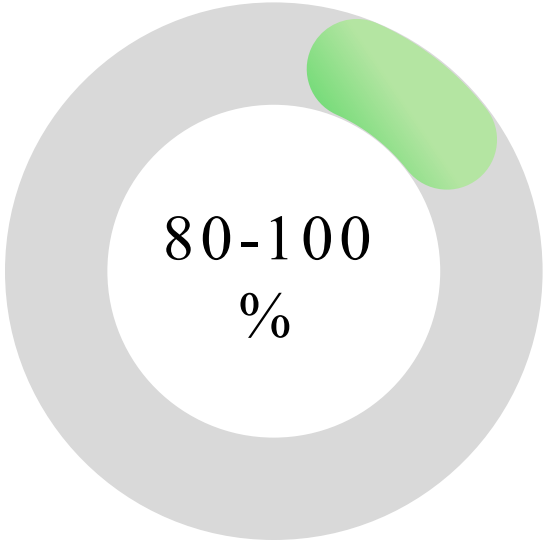
Paved Surfaces and Tree Health


0-50
%

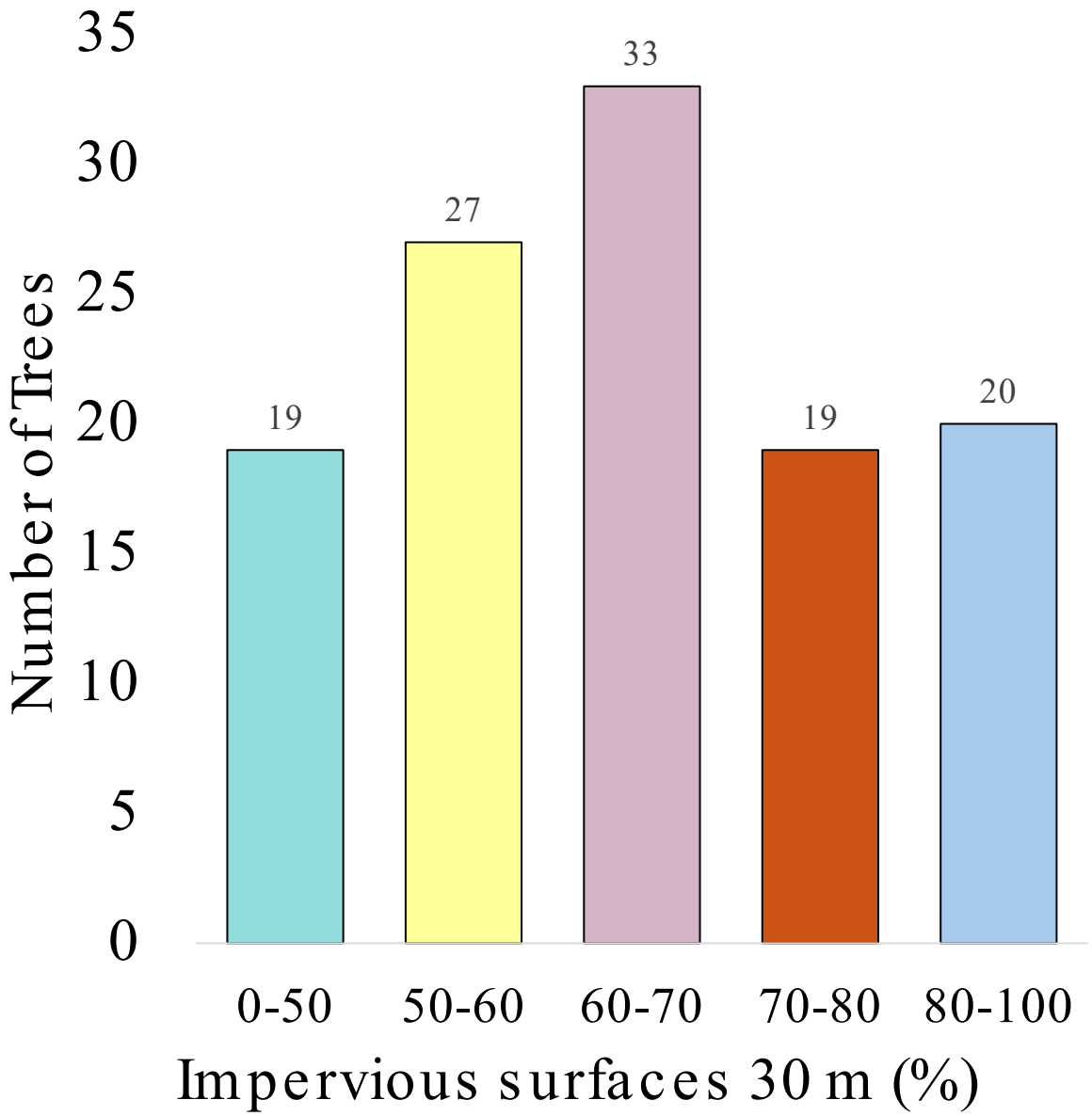

50-60
%

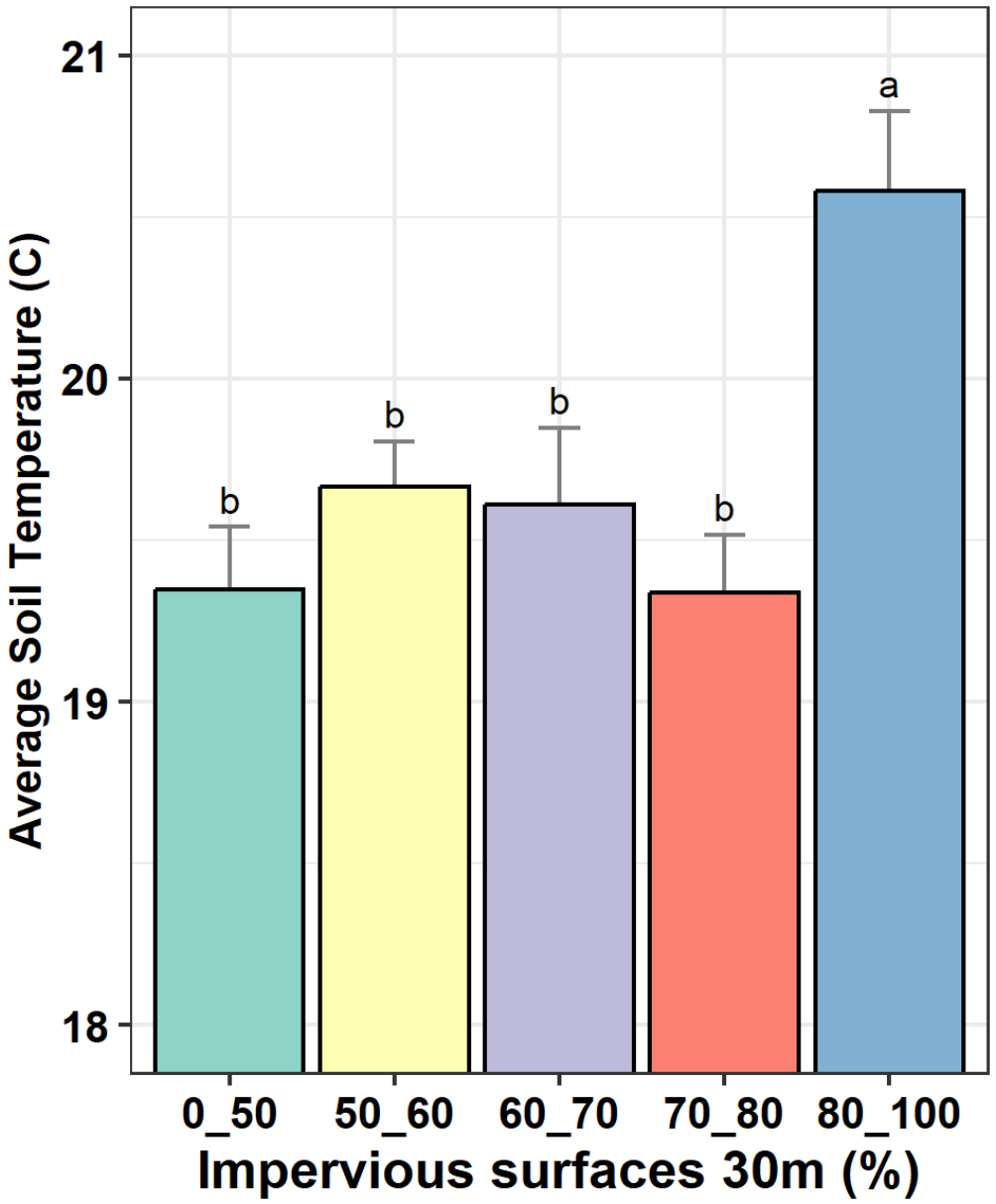

60-70
%

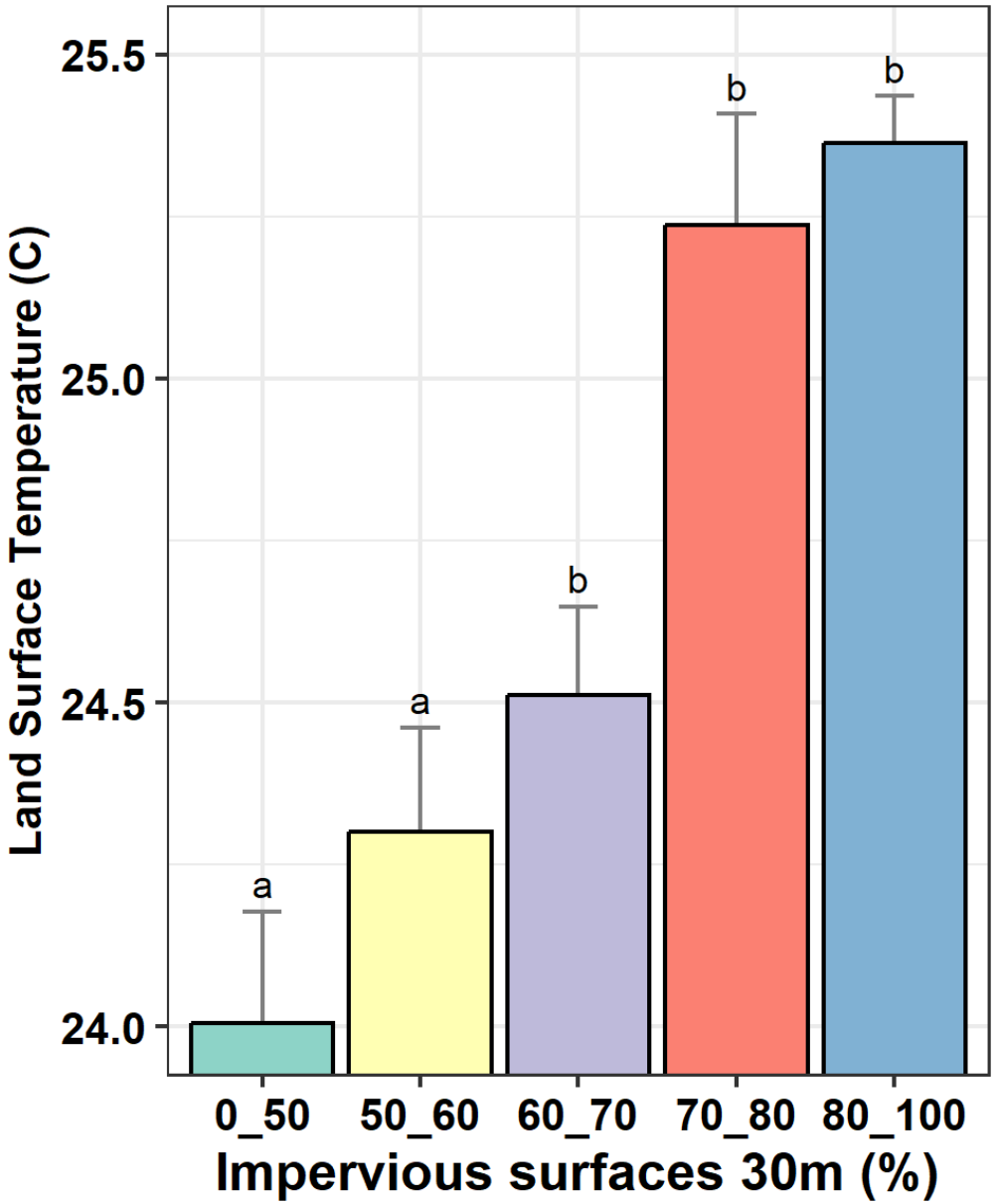

70-80
%

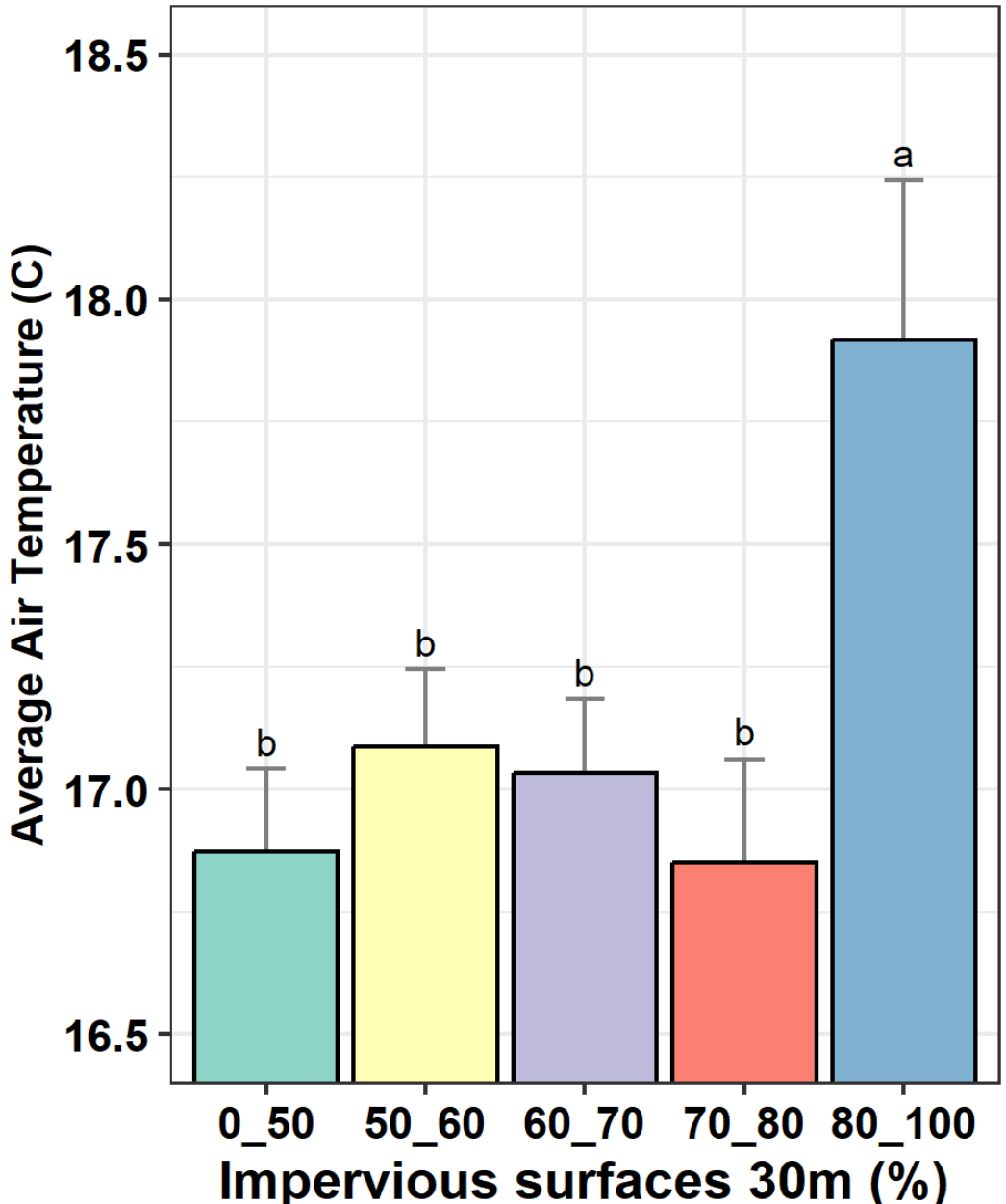

80-100
%

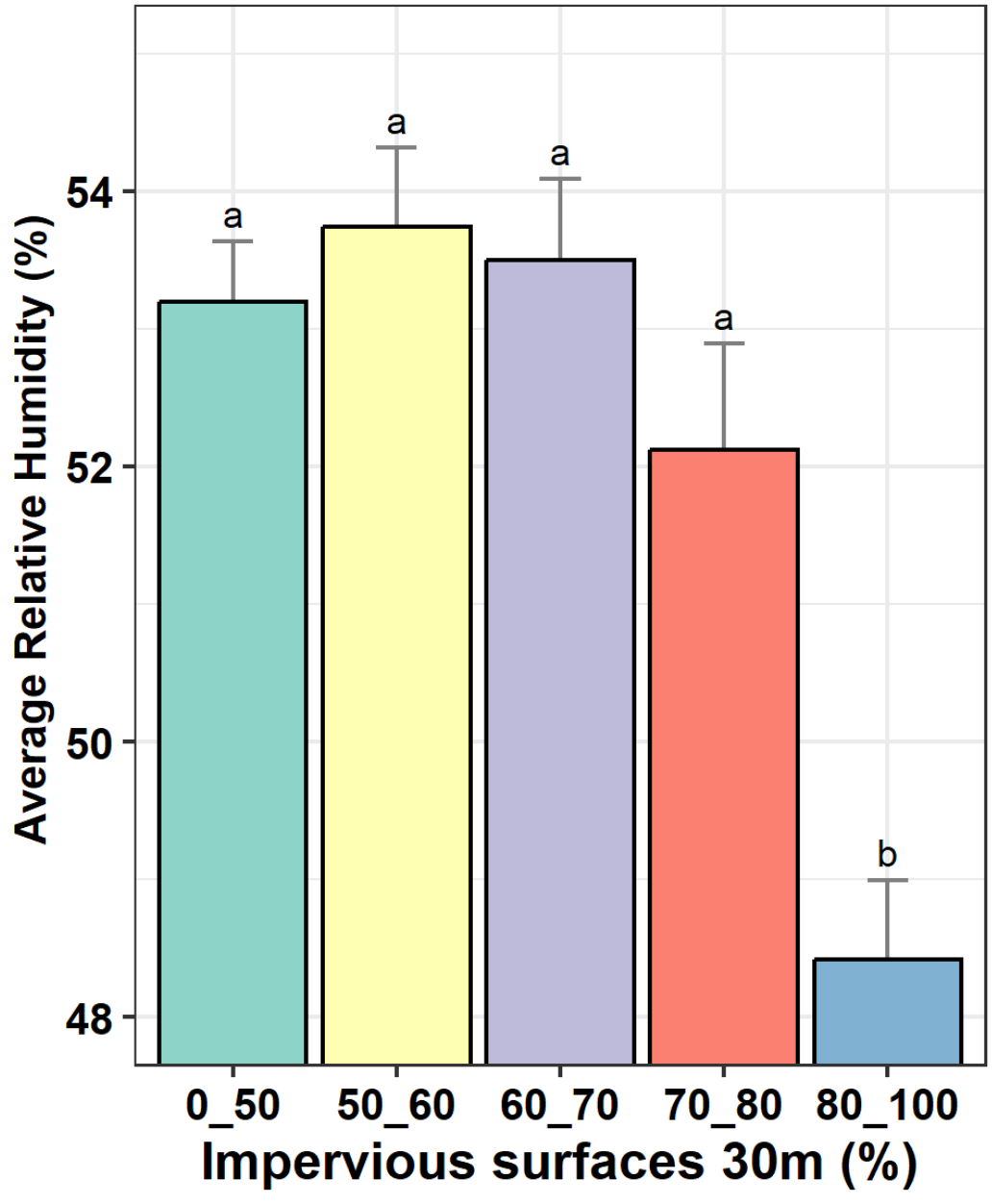
Paved Surface Categories

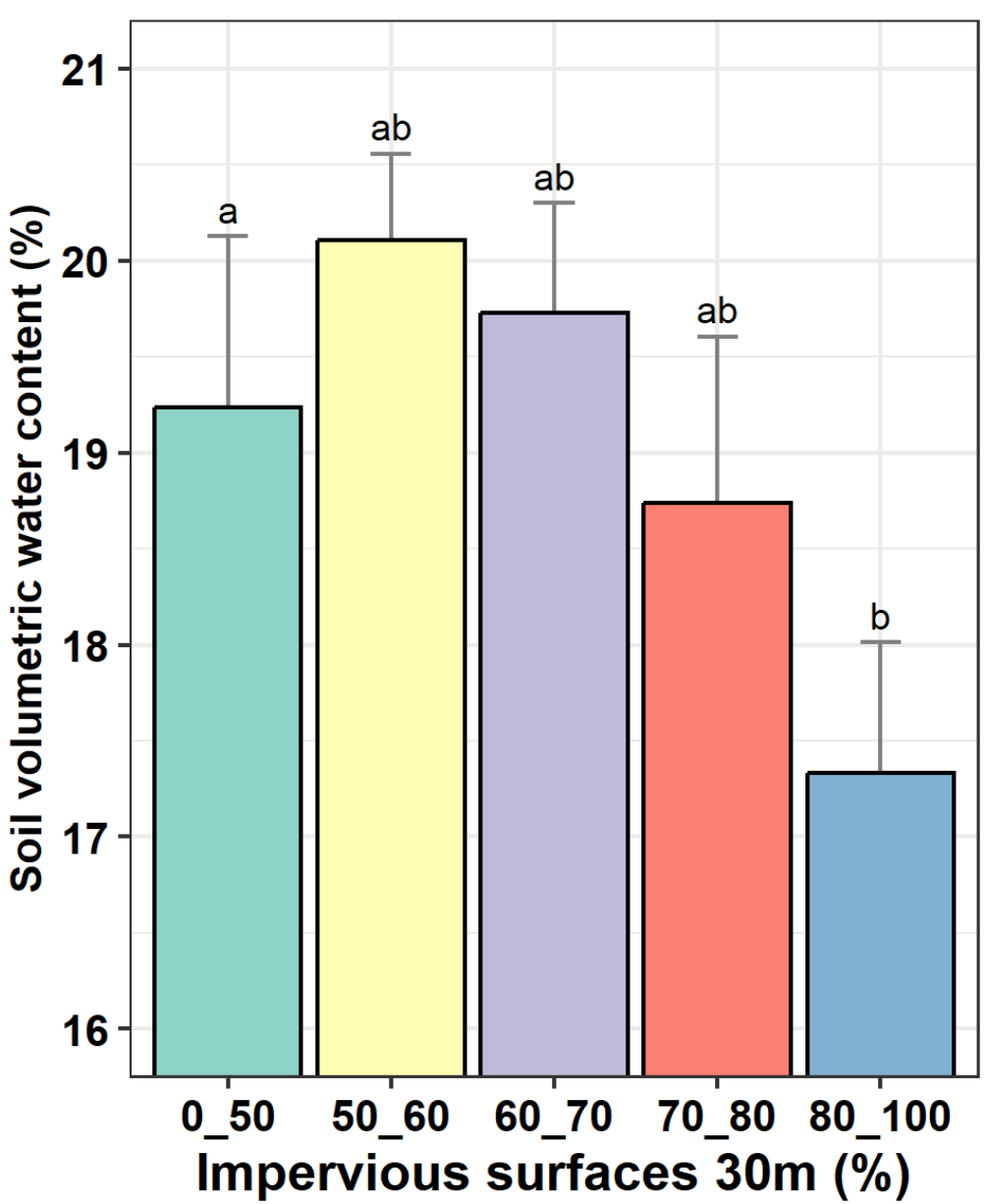


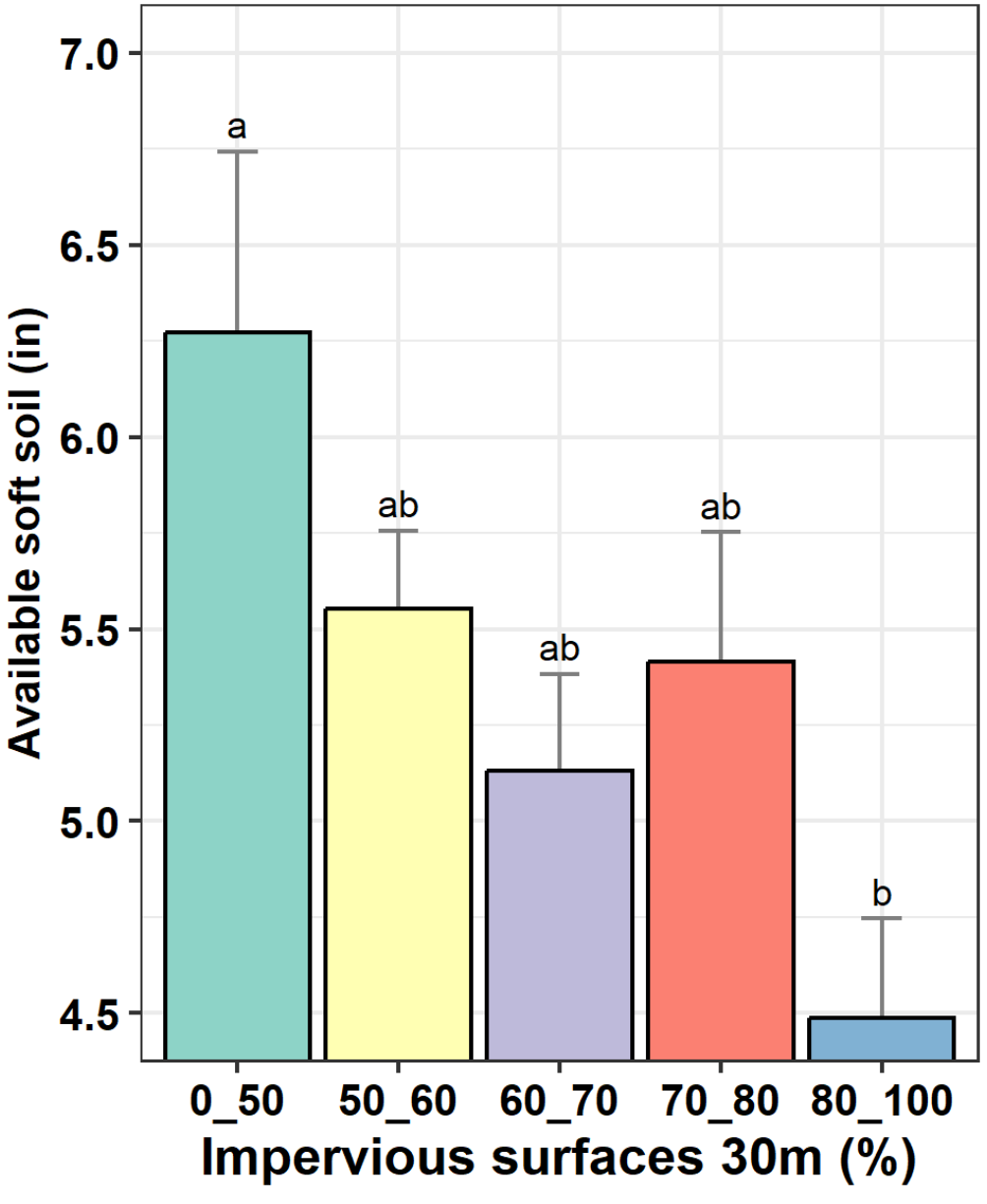

21
20
19
18
Average Soil Temperature (C)
a
b
b
b
b
0_50
50_60
60_70
70_80
80_100
Impervious surfaces 30m (%)


25.5
25.0
24.5
24.0
Land Surface Temperature (C)
a
a
b
b
b
0_50
50_60
60_70
70_80
80_100
Impervious surfaces 30m (%)

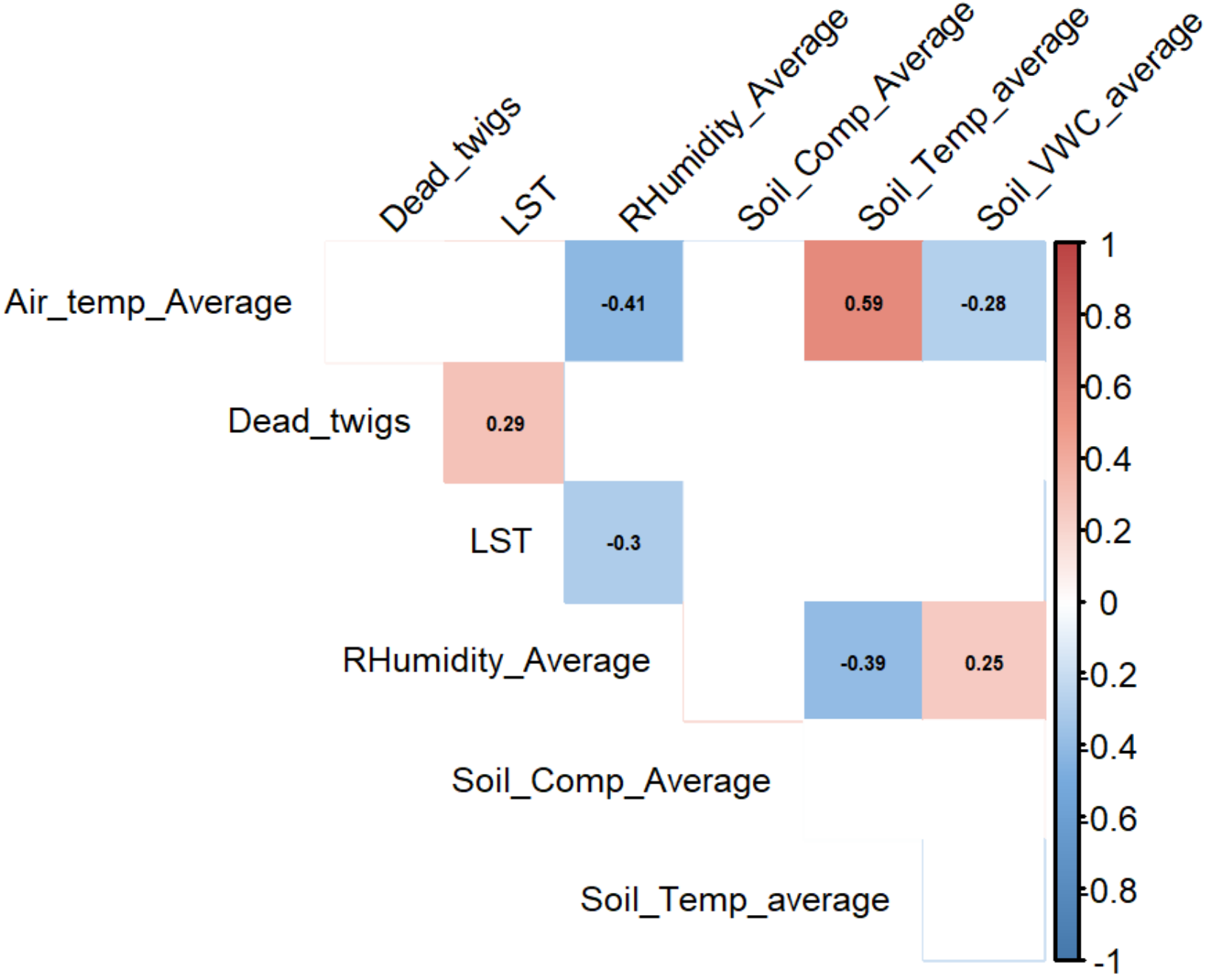

Average Air Temperature (C)
18.5
18.0
17.5
17.0
16.5
b
b
b
b
a
0_50
50_60
60_70
70_80
80_100
Impervious surfaces 30m (%)


Average Relative Humidity (%)
54
52
50
48
a
a
a
a
b
0_50
50_60
60_70
70_80
80_100
Impervious surfaces 30m (%)

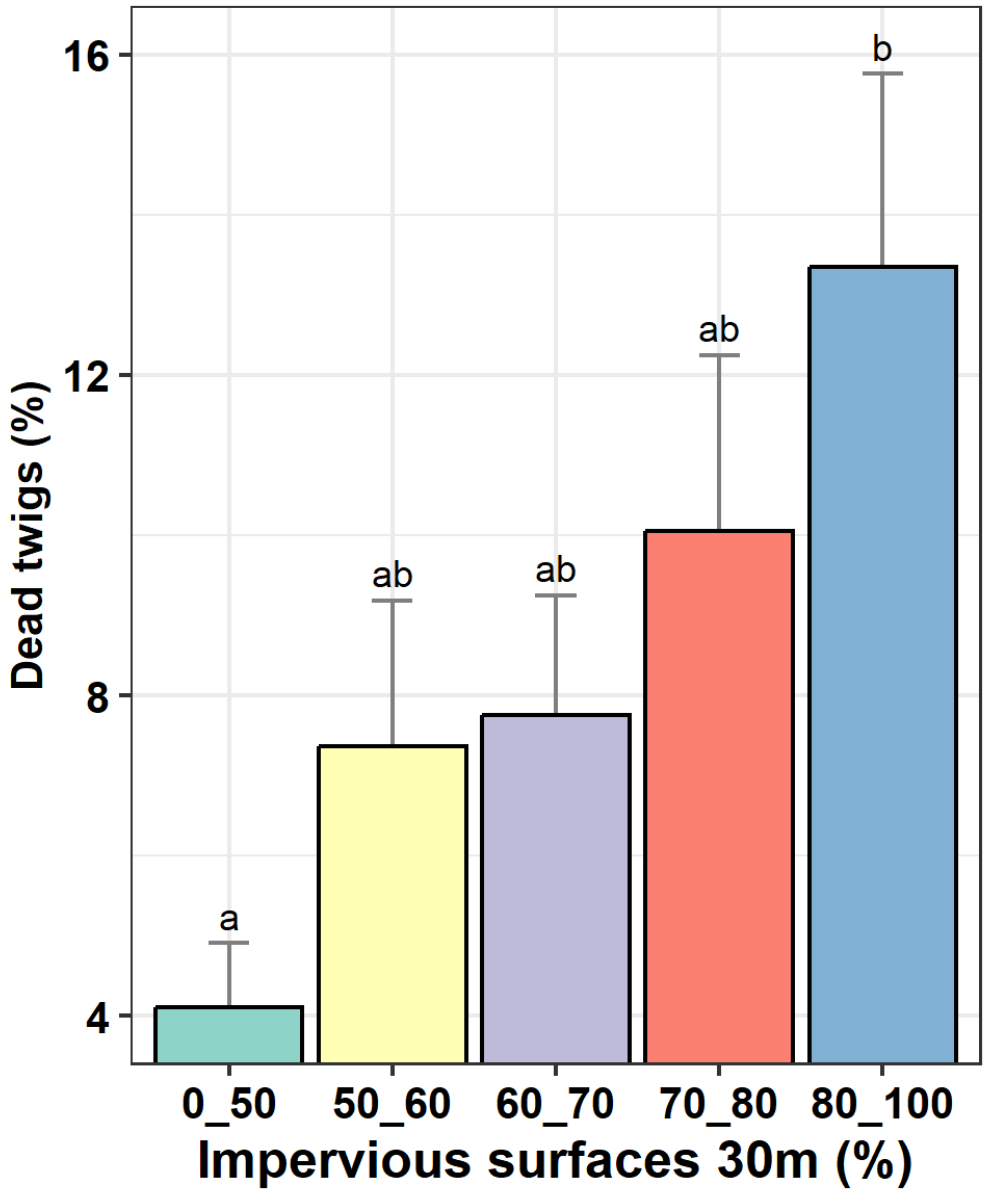

Soil volumetric water content (%)
21
20
19
18
17
16
a
ab
ab
ab
b
0_50
50_60
60_70
70_80
80_100
Impervious surfaces 30m (%)


Available soft soil (in)
7.0
6.5
6.0
5.5
5.0
4.5
a
ab
ab
ab
b
0_50
50_60
60_70
70_80
80_100
Impervious surfaces 30m (%)

Correlation Plot for Climatic Data



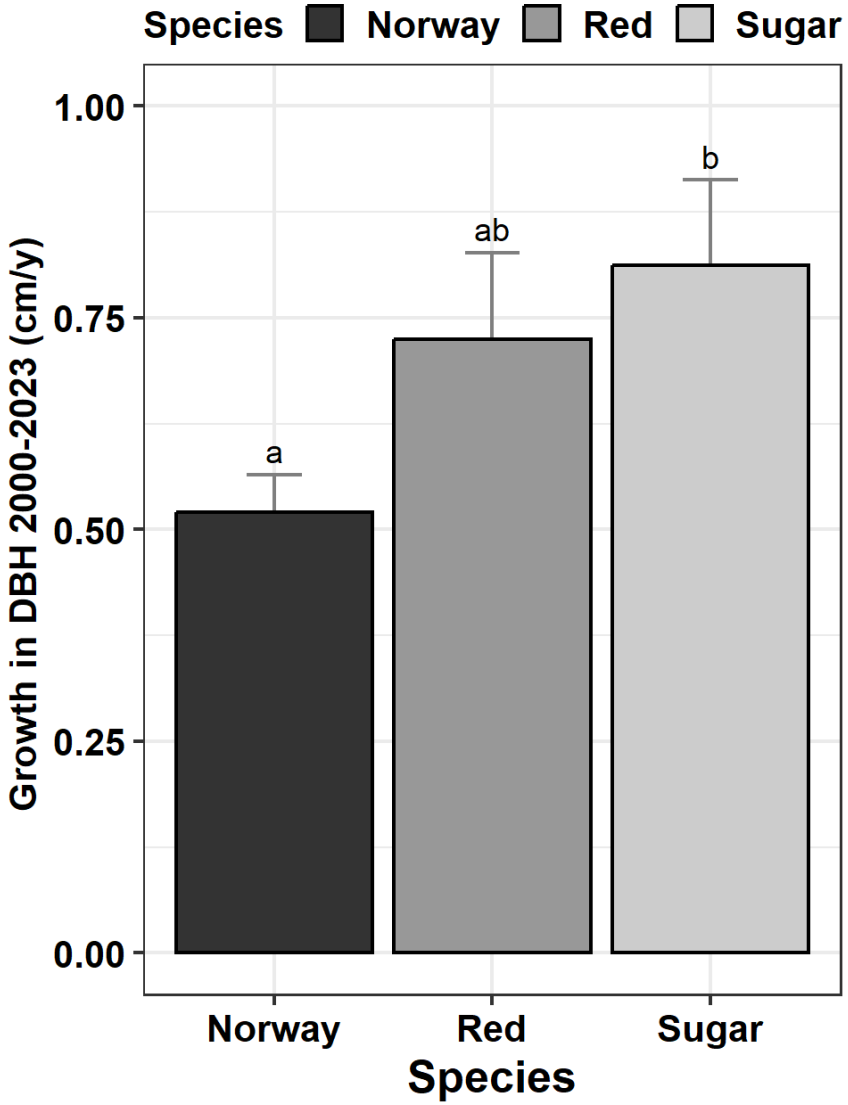
Impervious surfaces and Tree Canopy

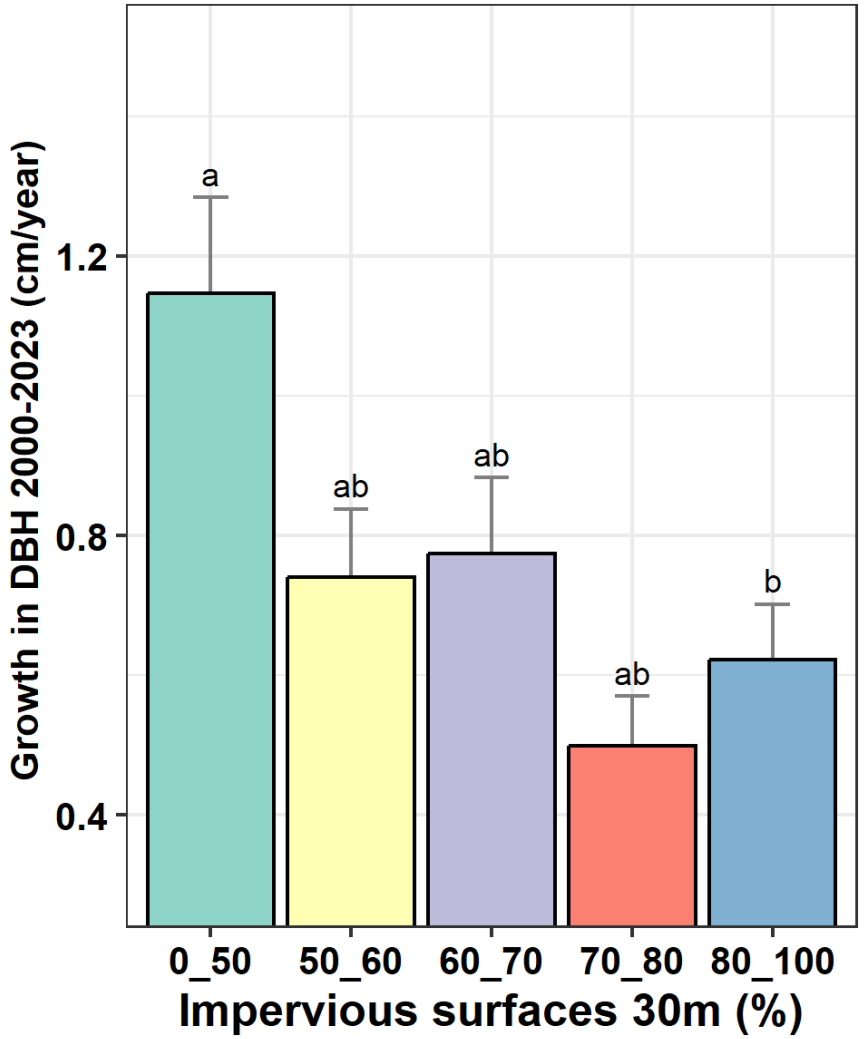


Paved trees and their canopies

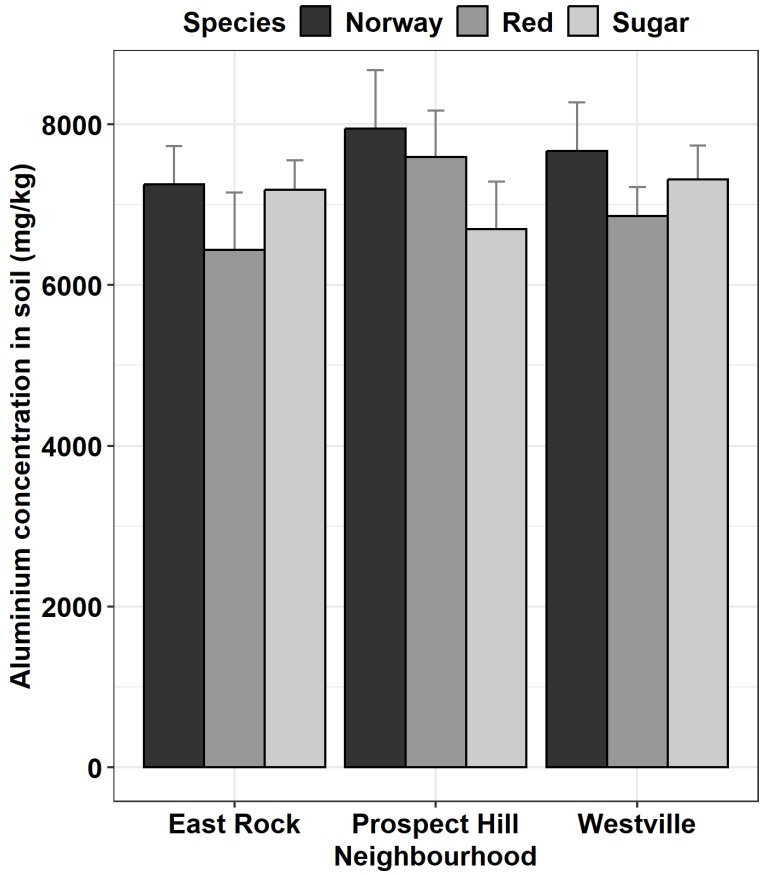



Change in Diameter

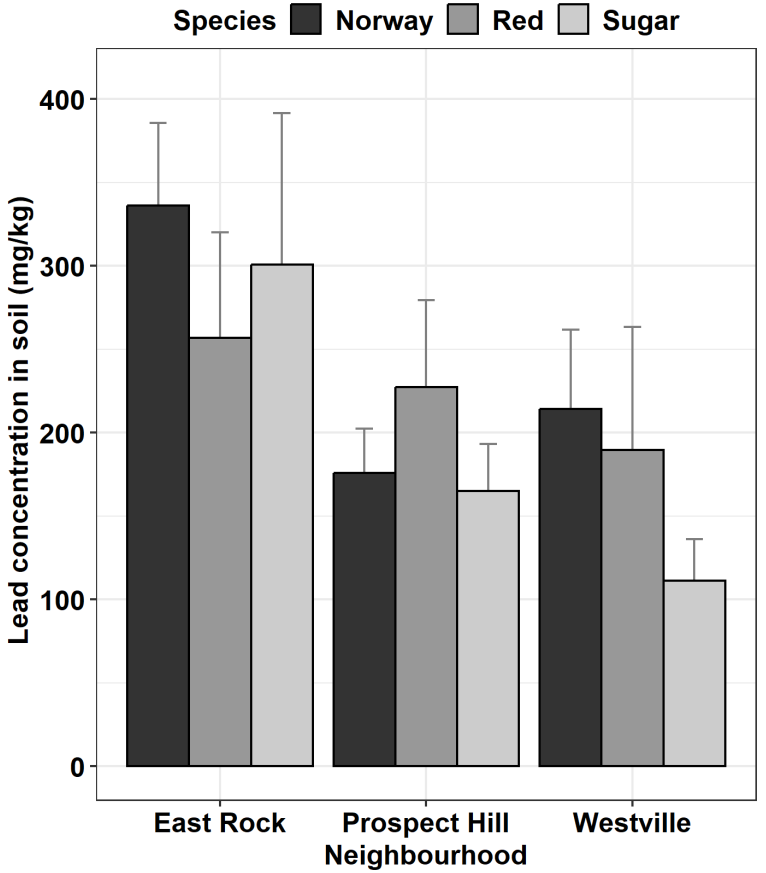




Elemental Concentration in Urban Soils

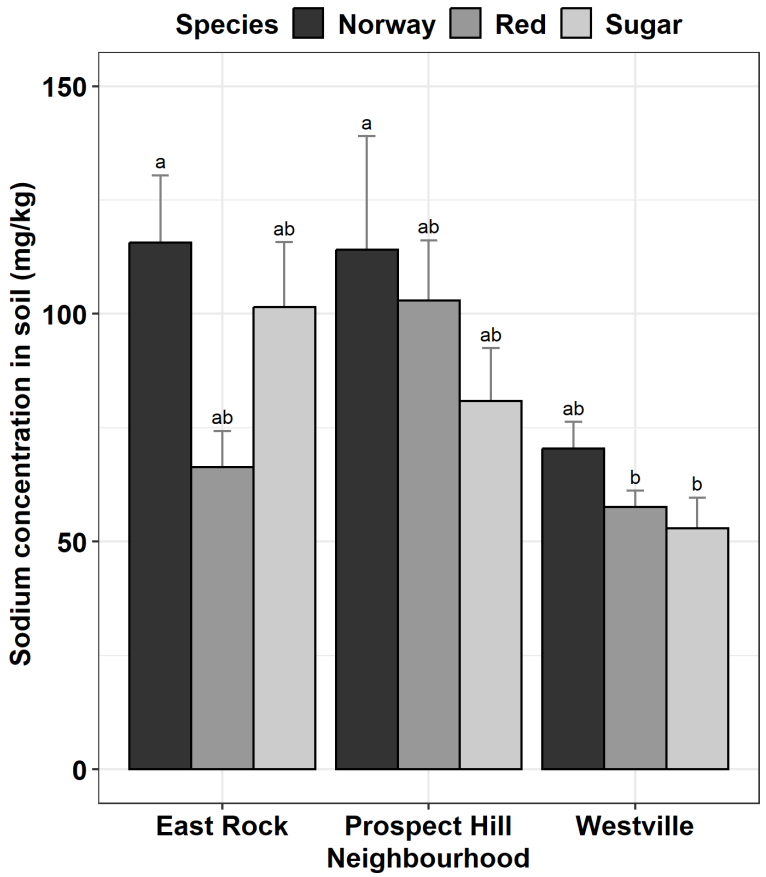


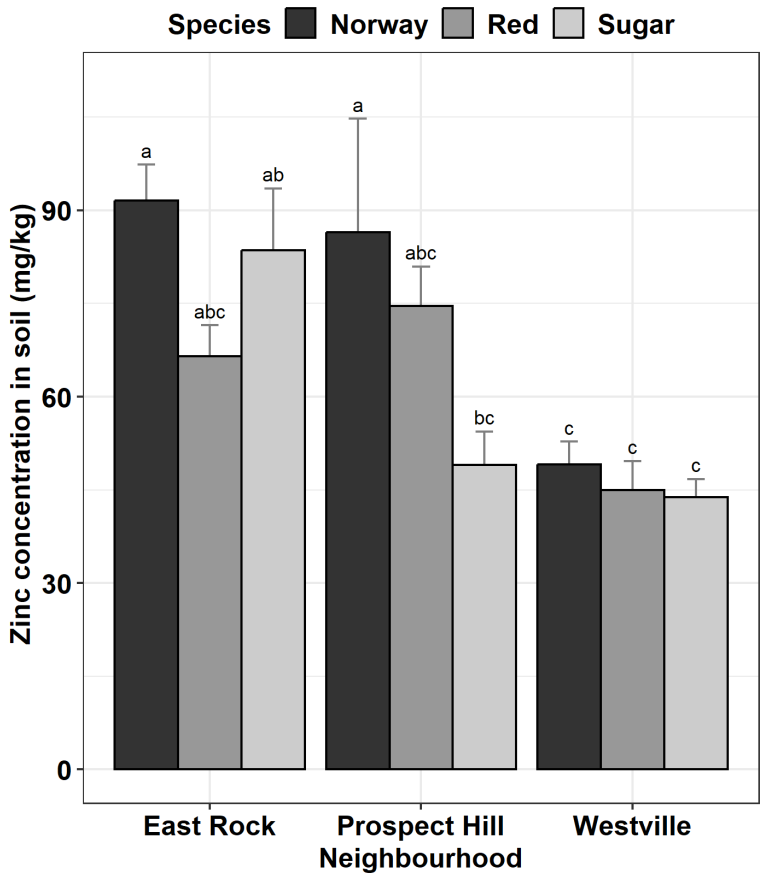
EPAbaseline 8500 mg/Kg



EPAbaseline 5 mg/Kg

Elemental Concentration in Urban Soils

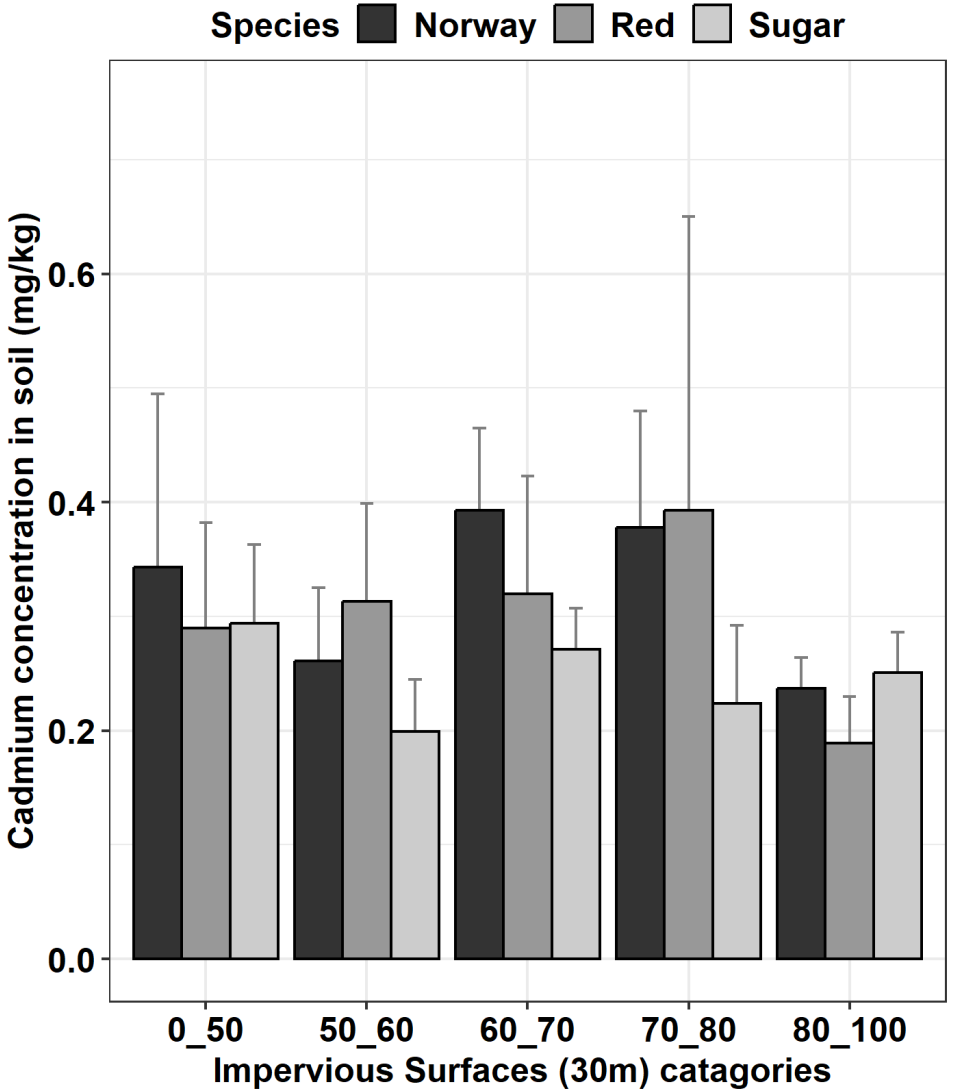




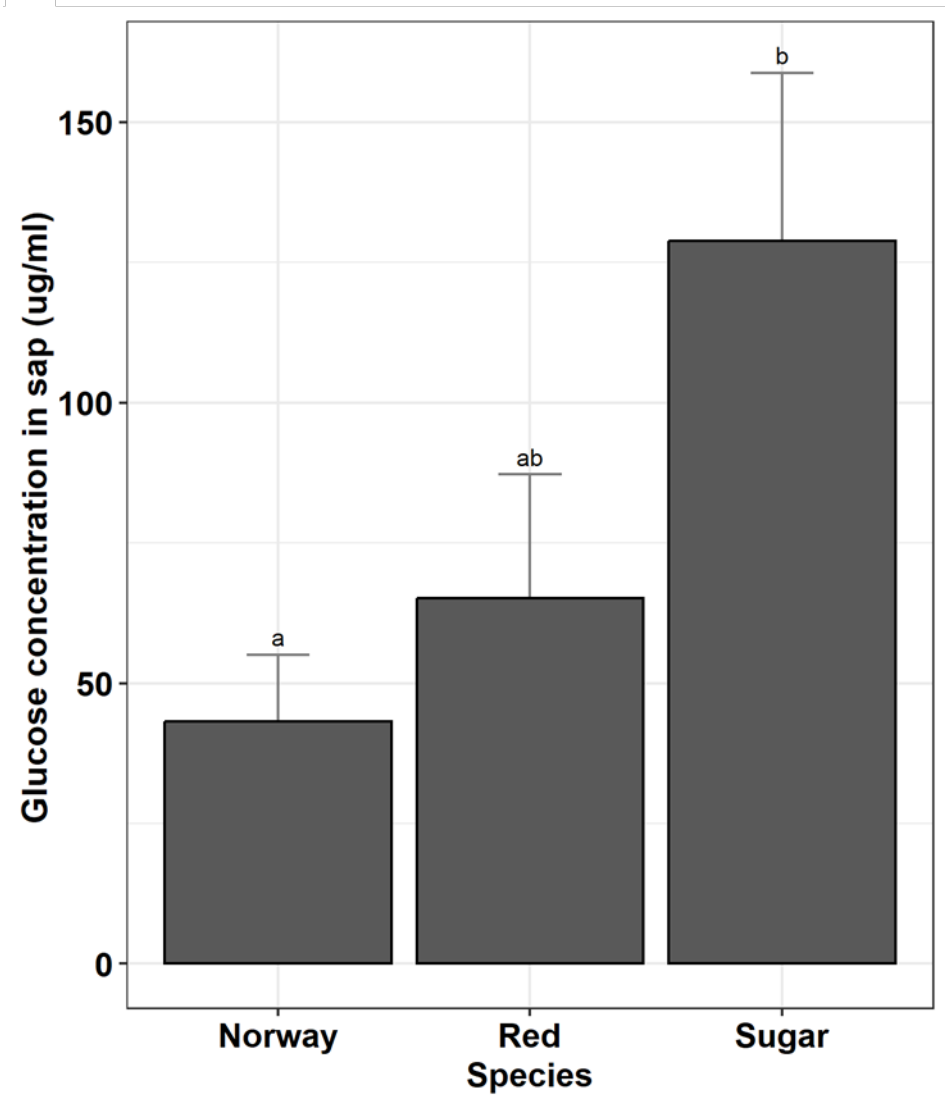
EPA standard 40 mg/Kg

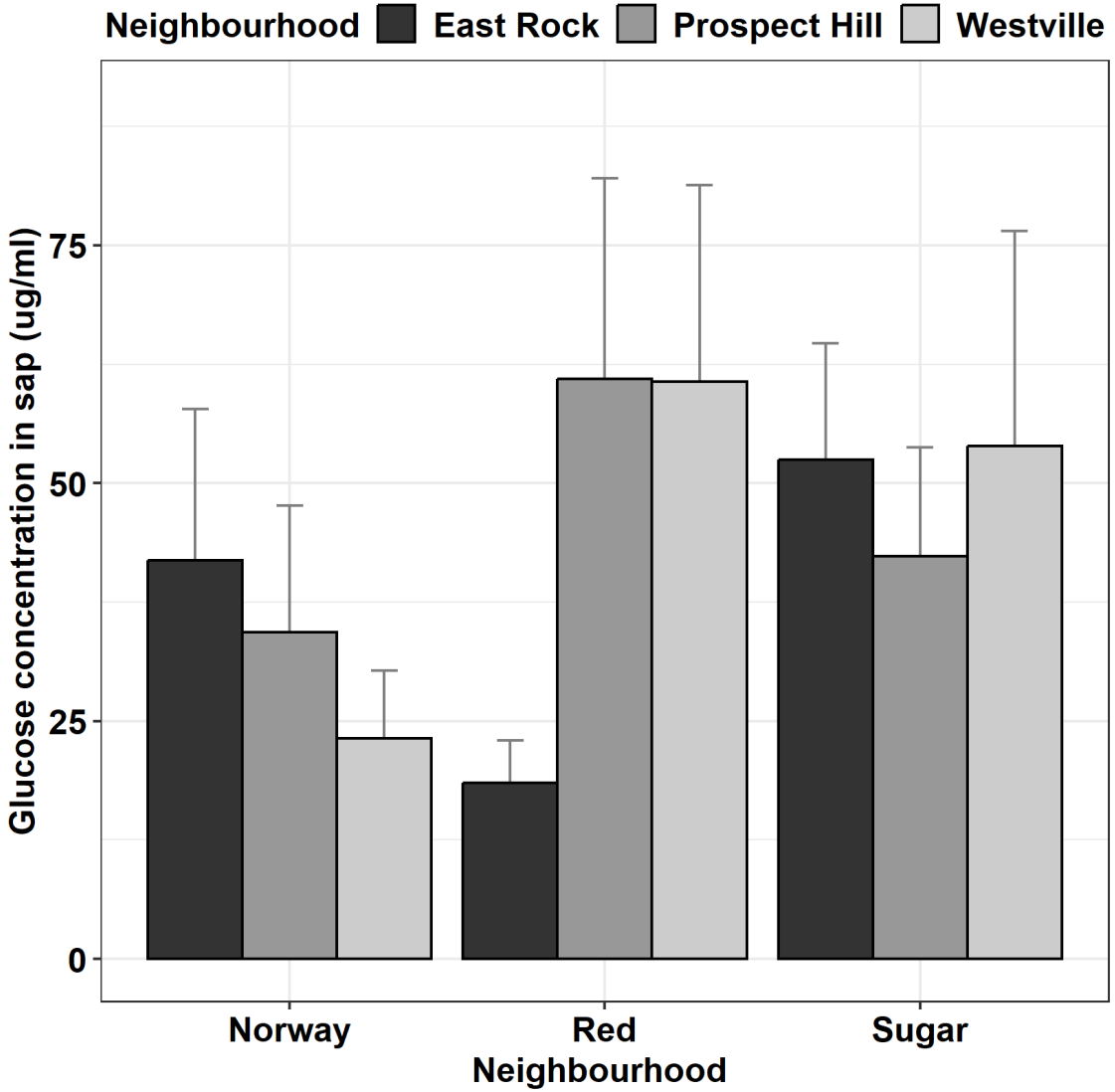
Impervious surfaces and metals

- There was no statistical difference in elemental content and paved surfaces
- Maximum element concentration was observed in 60-70 and 70-80% pavement categories

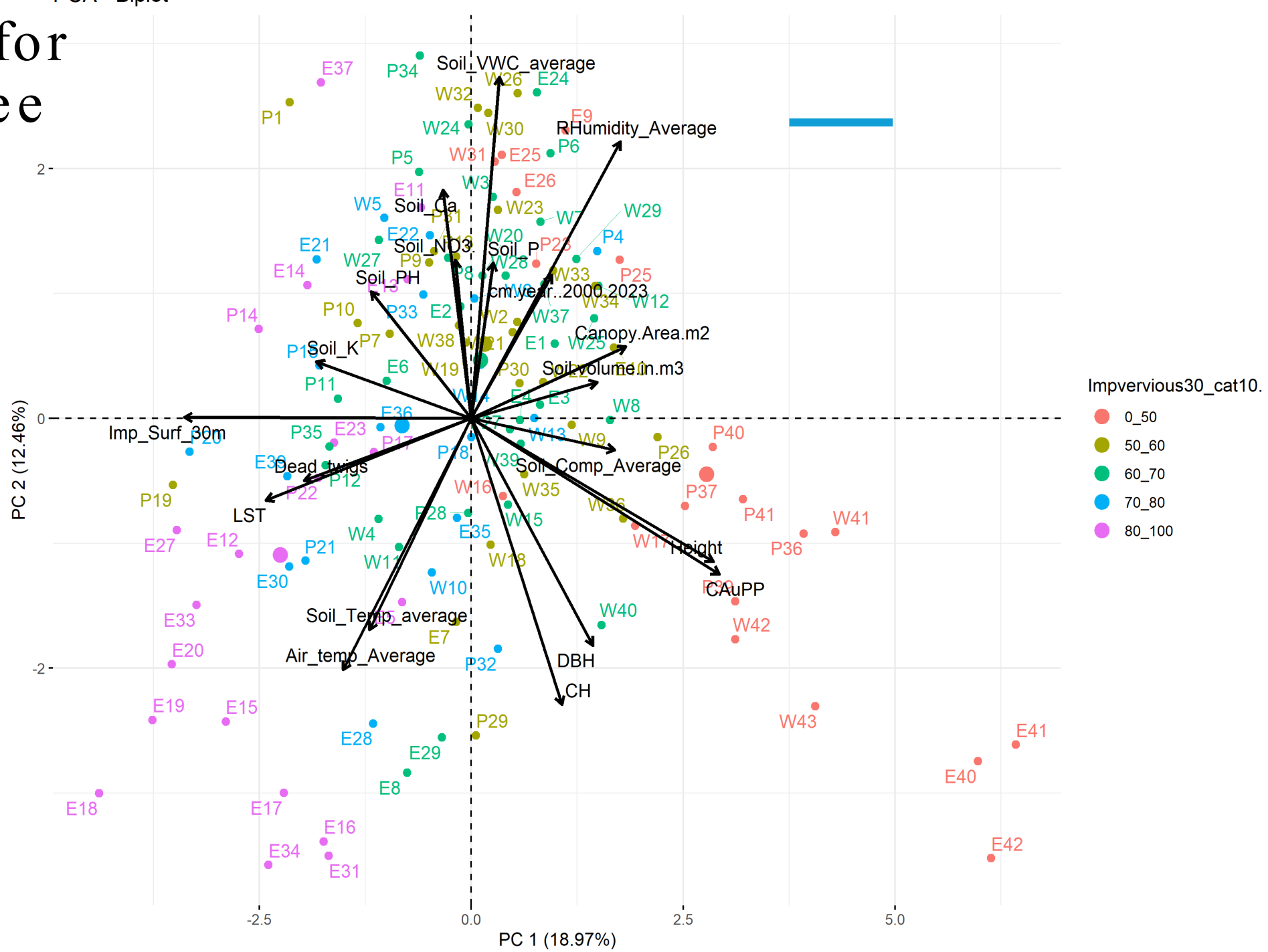


Free glucose content in phloem sap

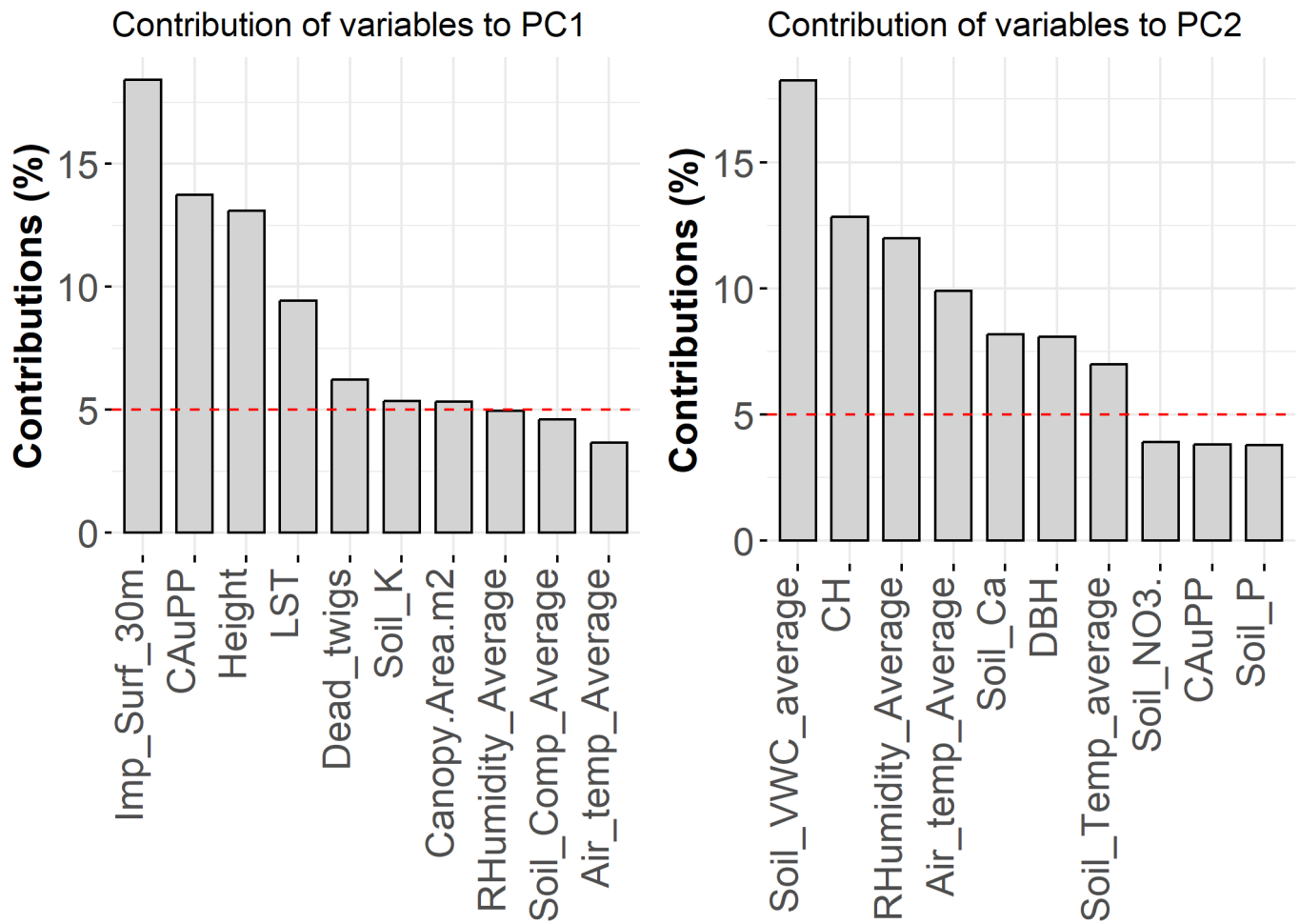




PCA Biplot for climatic, tree and soil parameters



Contribution of traits to first two PCs

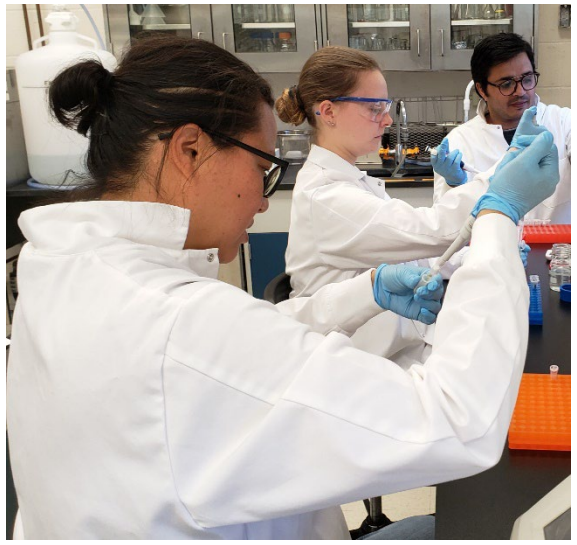


Keeping Cool

1. **Plant a Tree**
   Right tree for right place
2. **Increase Park Land**
3. **Green roof and walls**
4. **Cool Pavements**
   Cool pavements could reduce the frequency of heatwaves by 41% across all US urban areas.

Acknowledgements



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- Collaboration: Dr. Nubia Zuverza, Dr. Leigh Whittinghill, Soil Testing Lab at CAES, Annie Mixsell (City of New Haven), URI
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Thank You