A Meta-analysis on the Cooling Effect of Green Roofs

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Background

The urban heat island effect (UHI) is a pressing issue in cities, especially in face of a rapidly urbanizing world

Green roofs are an increasingly common solution to mitigate the impacts of UHI[1]

It's known that it reduces energy costs and retains moisture compared to traditional roofs[2]

Gap in current research of full scope of ecosystem services, such as cooling, provided by green roofs

Lack of comparative analysis of external cooling effects on experimental green roofs vs. regular roofs

Two types of green roofs : Intensive (>15cm) vs. extensive (<15cm) green roofs

Objectives

What is the cooling effect of green roofs around the world?

Where would they be most beneficial at reducing UHI?

Methods

Published, peer-reviewed articles on experimental green roofs from the last 10 years were collected from three academic databases

Screened for temperature data, green roof and control roof (traditional rooftops) properties such as: Vegetation type, roof area, substrate depth, height above roof at which sensor recorded temperature

Engineering Village	Clarivate Web of Science	Elsevier Scopus
574	648	475

1697 studies

removing duplicates

726 studies

screening for above criteria

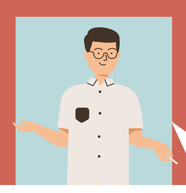
29 studies

To calculate the cooling effect of a green roof, this formula was used for each study:

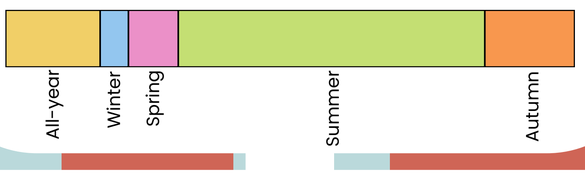
$$\Delta T = T_{control\ roof} - T_{green\ roof}$$

Temperature data was extracted from figures and graphs using WebPlotDigitizer [3]

Results & Discussion



Distribution of Datasets in Collected Studies by Season



Four primary climate regions, with over half the datasets recorded during the summer (56 of 102 datasets)

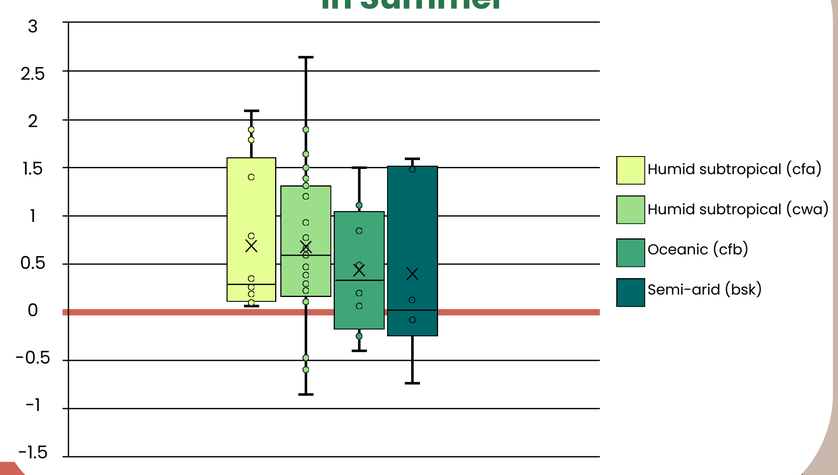
Green roofs around the world exhibit a **cooling effect (0.73°C)**, however further statistical modelling must be done

Large variation, specifically in Humid subtropical cwa

Warming effect, particularly in Oceanic region (ex: Western Europe)

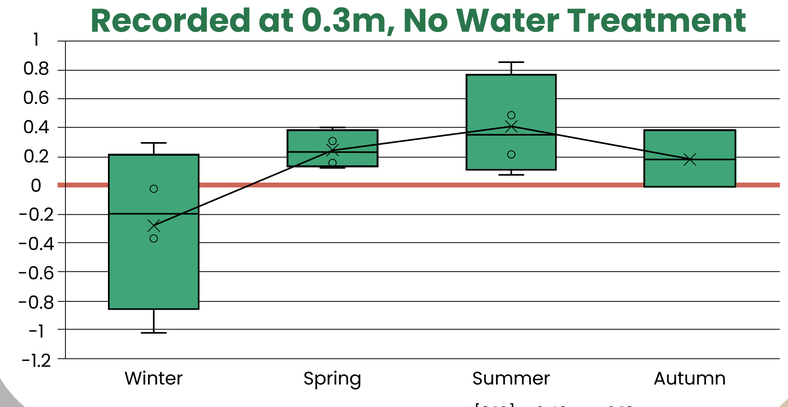
Trend of **higher cooling effect** in warmer climates (summer)

Temperature Difference by Climate Region in Summer



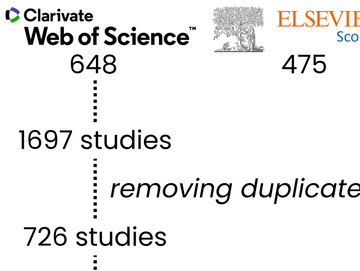
F[5,49] = 9.94, p = 1.3 x 10^-6

Temperature Difference in Oceanic (cfb), Recorded at 0.3m, No Water Treatment



F[3,10] = 2.43, p = 0.13

Implications



Experimental green roofs exhibit a cooling effect, although very small (<1 °C)

One roof is not the solution to mitigating UHI, however, informs ecosystem services at a larger scale

Currently building a statistical model to determine what properties most influence cooling on green roofs based on these studies

Gap in literature on cooling effect of experimental green roofs, particularly in Canada

References:

(1) Santamouris, M. (2014). Cooling the cities – a review of reflective and green roof mitigation technologies to fight Heat Island and improve comfort in urban environments. Solar Energy, 103, 682–703. https://doi.org/10.1016/j.solener.2012.07.003

(2) Costanzo, V., Evola, G., & Marletta, L. (2016). Energy savings in buildings or UHI mitigation? comparison between green roofs and cool roofs. Energy and Buildings, 114, 247–255. https://doi.org/10.1016/j.enbuild.2015.04.053

(3) Roghati, A. (2015). Version (4.0). WebPlotDigitizer. Retrieved from https://apps.automeris.io/wpd4/.