

Term Project Summary: The Greatness of Green Roofs

Introduction

Modern cities face several sustainability challenges related to climate change, urbanization, and environmental inequity. One of the most pressing is the urban heat island (UHI) effect. The urban heat island effect is an unfortunate consequence of our cities' construction. Because we use so many materials that retain heat, like brick, cement, concrete and asphalt, urban areas are significantly hotter by the end of the day than the surrounding countryside. This heat buildup increases energy consumption for cooling, worsens air quality, and raises health risks, particularly during heatwaves (EPA 2025). As knowledge about these issues increases, finding practical solutions to make urban environments more ecologically sustainable becomes essential. One solution that has gained momentum is green roofs. Green roofs are living vegetation systems that are installed on the rooftops of buildings. Green roofs preserve urban biodiversity, act as carbon sinks, and manage stormwater. These benefits are increasingly critical as cities face more extreme weather events. Green roofs mitigate the UHI effect by shading surfaces and cooling the surrounding air through evapotranspiration (Mihalakakou et al. 2023). The soil level also helps to clean and reduce the amount of storm runoff (DeWeerd 2025). Finally, the vegetative layer cleans the air and acts as a carbon sink (Shahmohammad 2022; Mihalakakou et al. 2023).

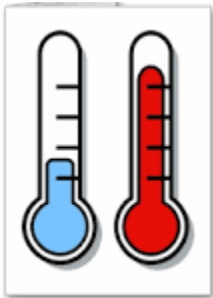
Communities Impacted and Their Needs

The urban heat island effect does not impact all communities equally. Low-income and other historically marginalized neighborhoods often experience higher temperatures and less access to cooling infrastructure. Typically, these areas have fewer trees and green spaces and a higher concentration of heat-absorbing materials. Buildings in these areas also often have older, less energy-efficient roofs and HVAC systems, and residents may have limited financial resources to afford air conditioning or to pay for increased energy bills. These areas also face higher health risks as heat disproportionately affects the elderly, young children, and people with preexisting medical conditions. Despite the benefits, green roofs are underrepresented in lower-income areas due to economic barriers, including high installation and maintenance costs, a lack of policy incentives, and limited awareness of their long-term benefits. Wealthier neighborhoods and commercial districts are far more likely to receive green infrastructure investments, creating an environmental equity gap (Treglia 2022). Expanding green roof adoption in underrepresented communities directly addresses environmental justice goals, ensuring that the benefits of green infrastructure are distributed equitably, not just concentrated in affluent areas. Supporting policies such as subsidies, tax incentives, or community grants can help make green roofs more accessible, helping cities adapt to rising temperatures while improving the quality of life for vulnerable populations.

The Model

The purpose of this model is to demonstrate how green roofs can mitigate urban environmental challenges, including excessive heat, air pollution, and carbon accumulation. The model serves as a visual reminder that green roofs are not just aesthetic features. They are functional systems that improve urban livability and climate resilience. The model translates scientific knowledge into visual and interactive experiences, making complex processes such as insulation, water management, and carbon sequestration more tangible (Figures 1-5). They ensure the audience not only understands the green roofs conceptually but also appreciates their real-world impact, bridging the gap between research and practical comprehension. The organized flow from the problem to a solution, backed by scientific principles and presented creatively, ensures clarity and engages diverse audiences. The goal is to educate people so that they become advocates who recognize the social and environmental benefits that come with green roof designs.

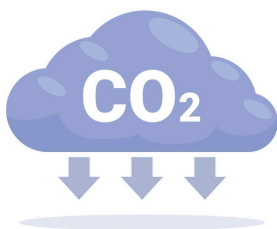
Scientific Concepts Communicated



Heat Transfer and Insulation - This was illustrated with thermometers placed in different locations on the model. Two thermometers on each roof, with the green roof thermometers having the appropriate lower temperatures, both on top of the roof in the ambient air and under the roof, showing the benefit for decreased indoor cooling costs. The science behind the visual was further detailed in the pamphlet. The thermometers reflect a reduction in indoor temperatures of up to 15 °C (27 °F) and a decrease in ambient roof temperatures of up to 32 °C (90 °F) (Mihalakakou 2023, EPA 2025).



Water Retention - The sponge was used intentionally to illustrate how green roofs can both store and clean rainwater. This also intuitively translates the idea that a thicker roof layer will store and clean more stormwater. The water droplets that are located on the side of the roof represent run off and direct viewers to the water droplets on the pamphlet. The water droplet on the green roof will have 97.5% printed on it to reflect that green roofs capture about 97.5% of microplastic particles during a light rainfall event (DeWeerd 2025).



Photosynthesis, Carbon Sequestration, and Air Filtration
The carbon dioxide molecules were made with arrows that demonstrate that CO₂ is absorbed by plant material on the green roof side and is

emitted out into the atmosphere on the conventional side to illustrate how green roofs also act as carbon sinks. The carbon dioxide icons directed viewers to look at the section in the pamphlet that discusses carbon sequestration and air filtration.

How does my model improve awareness?

My model of a green roof brings attention to the sustainability challenges caused by the urban heat island effect and environmental inequality in cities. By visually showing how vegetation, soil, and roof layers work together to cool the air, filter pollution, and store carbon, the model makes the science behind climate resilience easy to understand. The contrast between a traditional bare roof and a green roof highlights how green infrastructure reduces surface temperatures and improves air quality, benefits that are especially important in low-income urban areas, which often experience higher heat exposure and have fewer green spaces. By making these processes visible, the model encourages viewers to see green roofs not only as a tool for energy efficiency and sustainability but also as a means to promote environmental justice and enhance the quality of life for communities most affected by rising temperatures.

The target audience for my green roof model is students, educators, and community members in urban areas affected by the heat island effect, as the model helps them understand how green roofs can improve air quality, lower temperatures, and promote environmental equity, with the hope that this understanding will then translate into action. The best location for this model would be a public space frequented by urban dwellers, such as a subway station. This setting allows a wide and diverse audience to interact with the model, including people who may not otherwise encounter this type of environmental education. By placing the model in a high-traffic transit hub, it has the potential to spark curiosity, increase awareness about climate challenges, and even shift public perceptions about sustainable design and environmental justice.

Works Cited

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Visuals



Figure 1: Models and pamphlet



Figure 2: Close up of the two models showing the different ways the concepts were conveyed. Note the CO₂ molecules with arrows, the red and blue thermometers, the sponge layer and the water droplets. The butterfly was also added to illustrate that green roofs provide needed habitat.



Figure 3: The interior view of models.



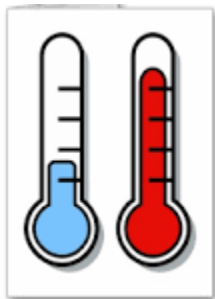
Figure 4: Exterior view of models.



Figure 5: Models with pamphlet.

Written Information provided in Pamphlet

Heat Transfer and Insulation



The urban heat island effect is an unfortunate consequence of our cities' construction. Because we use so many materials that retain heat, like brick, cement, concrete and asphalt, urban areas are significantly hotter by the end of the day than the surrounding countryside. According to the EPA this can cause city temperatures to be as much as 22°F (12°C) warmer than surrounding areas (EPA 2025). Luckily, green roofs can help mitigate this in two ways:

- 1) Reflecting more heat from vegetation than is reflected off impermeable surfaces like concrete and cement. This prevents heat from entering the building and decreases cooling costs.
- 2) Cooling the air further through evapotranspiration, which is the release of water vapor into the air through plant stomata.

The results are impressive. Studies show a decrease in indoor temperatures of up to 15 °C (27 °F) and a decrease in ambient roof temperatures of up to 90 °F (32 °C) versus the conventional rooftops (Mihalakakou 2023, EPA 2025). A more detailed explanation can be found below.

Vegetation shades rooftops and cools the surrounding air through evapotranspiration, reducing the heat island effect. The layers of a green roof block sunlight from reaching the underlying roof membrane, reducing the heat transmitted into buildings or re-emitted into the atmosphere. Evapotranspiration adds to the cooling effect. Plants absorb water through their roots and emit it through their leaves through transpiration. Evaporation then absorbs heat energy from the air to convert water to a gas. Jointly these processes are referred to as evapotranspiration. Reduced surface temperatures help buildings stay cooler because less heat flows into the building decreasing the need for indoor cooling. Lower green roof air temperatures help to reduce the UHI effect. Studies indicate that green roofs reduce roof surface temperatures by 30–40°F (16–22°C) compared to conventional roofs (Mihalakakou 2023).

Water Retention



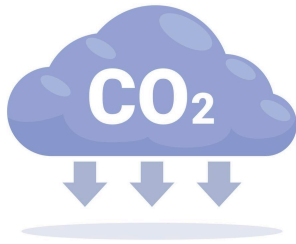
Each storm dumps billions of gallons on cities, and when it has nowhere to go, stormwater pours off of buildings and flows through the city. This causes a huge range of harms like increased pollution, erosion or infrastructure, and the spread of disease. Green roofs help to slow the release of rainwater while also cleaning the water before it is released. Instead of letting water run off surfaces, green roofs grab it and hang on tight. In doing so, they prevent chemicals and diseases from entering our streets and waterways, and reduce erosion. A more detailed explanation of the process can be found

below.

Green roofs function like sponges, storing rainfall in soil and plant matter and releasing it slowly over time. This helps to reduce the volume and rate of stormwater runoff, which is increasingly important as urban areas face more frequent and severe storms due to climate change. By absorbing and temporarily holding precipitation, green roofs decrease the burden on stormwater systems and reduce the risk of flooding. In addition, they filter pollutants like microplastics from rainwater, improving the quality of water that eventually reaches rivers and streams. As the water drains through the layers of vegetation, particulates are retained in the

substrate, preventing them from entering storm drains. The thickness and composition of the soil layer directly influence the efficiency of particle capture. Slower flow, from thicker substrates, allows more time for pollutants to settle, enhancing filtration (DeWeerd 2025). Researchers have found that green roofs are able to capture about 97.5% of the microplastic particles during a light rainfall event (DeWeerd 2025). As cities continue to grow and climate-related rainfall events intensify, green roofs offer a practical, nature-based solution to these pressing stormwater management challenges.

Photosynthesis, Carbon Sequestration, and Air Filtration

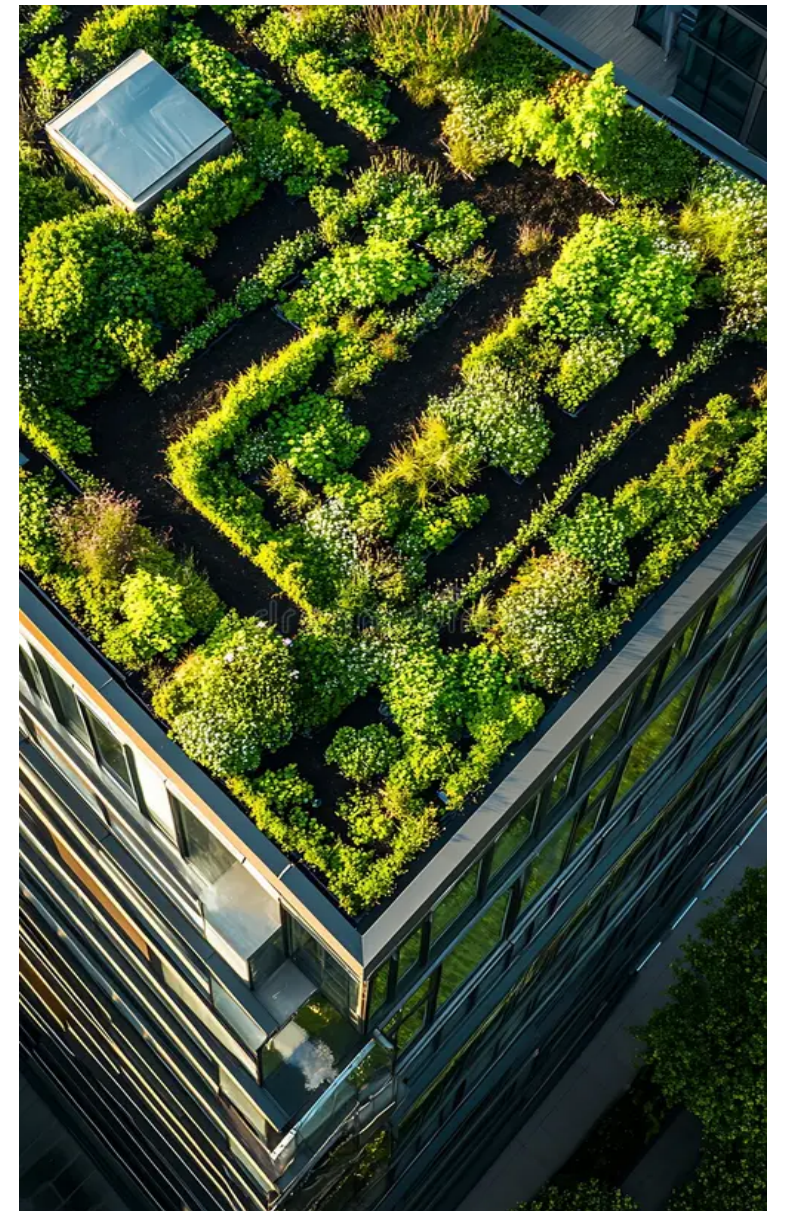


Green roofs improve air quality. In order to survive, plants need to absorb carbon dioxide and emit oxygen through the process of photosynthesis. By absorbing CO₂ green roofs decrease the amount of greenhouse gases in the atmosphere. The cumulative effect across multiple rooftops in a city can be significant, contributing to reduced urban carbon footprints and healthier living environments for residents (Mihalakakou, G., et al 2023). In addition to carbon sequestration, the plants filter airborne pollutants which improves the quality of the surrounding air. Plants absorb gaseous pollutants and fix these compounds with their roots or metabolize them into healthier molecules for the other organisms in our cities (Shahmohammad, M et al. 2022). A more detailed explanation of the process can be found below.

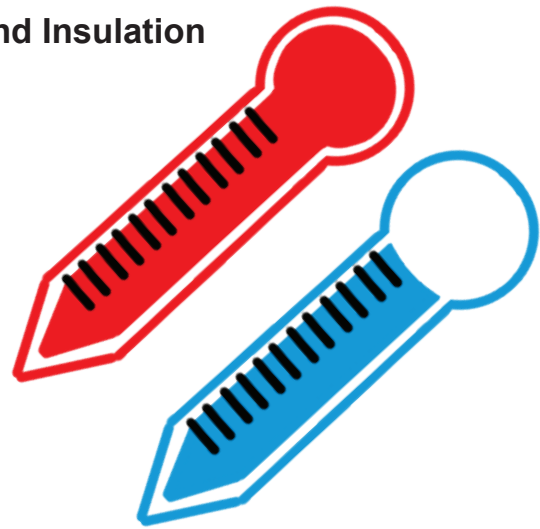
Plants convert carbon dioxide into oxygen and organic matter through photosynthesis, functioning as urban carbon sinks. This helps to offset the increased greenhouse gas emissions in urban areas (Mihalakakou, G., et al 2023). In addition to carbon sequestration, the plants filter airborne pollutants which improves the quality of the surrounding air. Plant surfaces act as physical barriers that intercept airborne particulate matter, including dust, soot, and microplastics, removing them from the air and preventing them from being inhaled by humans. (Shahmohammad, M et al. 2022).



The Greatness of Green Roofs



Heat Transfer and Insulation

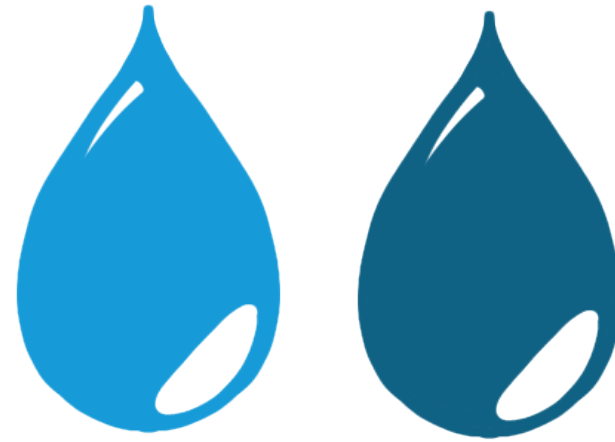


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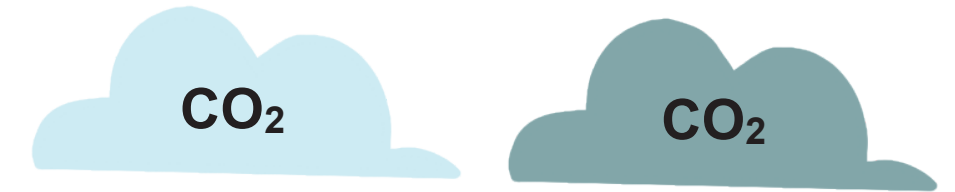
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