The Effects of Mitigation Technologies on Urban Heat Islands

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Introduction

The Urban Heat Island effect is a rapidly growing, widely spread, phenomenon sweeping and slowly destroying our nation. An Urban Heat Island is when "Urban areas that have microclimates that are different than the climates of their surrounding rural areas." (Price, 2015).

Urban Heat Islands are contributing to climate change with the higher temperatures cities put out from vehicles, large buildings, factories, air conditioners, and dark building materials (i.e. concrete and asphalt) which absorb the energy from the sun and add warmth to their surroundings.

This paper will describe the effects of Urban Heat Islands and discuss different mitigation technologies that could help slow or reverse the pace of this quickly growing epidemic.

Literary Synthesis

"An urban heat island is a metropolitan area which is significantly warmer than its surroundings." (UCAR, 2011)

Urban Heat Islands form in metropolitan areas "as vegetation is replaced by asphalt and concrete for roads, buildings, and other structures necessary to accommodate growing populations in an urban setting." (UCAR, 2011).

The reason that metropolitan areas are more susceptible to the Urban Heat effect is as "European and North American cities suggest that areas with denser and taller buildings will more rapidly develop heat islands." (UCAR, 2011). However, the achature described is needed for growing populations in cities, as well as places like college campuses, which house many people in a small area. "Urban areas cover less than 3% of the earth's surface, however, they are

responsible for an estimated 71% of global energy-related carbon emissions." (Battisti, A., et. al, 2018).

This information does not mean rural areas are safe from the Urban Heat Effect. Although it is true "that the heat island effect is more common in metropolitan areas over more rural areas, due to the differences in temperature during calm, clear evenings. As rural areas cool off faster at night than cities, which retain much of the heat stored in roads, buildings, and other structures that absorb—rather than reflect—the sun's heat, causing temperatures to rise." (UCAR, 2011), rural areas are still susceptible to the Urban Heat effect. College campuses are an example of how more rural places, i.e. Farmville, can become susceptible to the Urban Heat effect than they might be without those campuses.

This phenomenon has caused researchers to study, research, and purpose a way to decrease and try to reverse the effect that have caused Urban Heat Islands through different Mitigation Technologies. One major mitigation technology that has been shown to reduce the heat effect is an adaption of roofs to be more eco friendly, and not just a giant slab of concrete collecting heat energy.

One roof adaptation used to decrease thermal temperatures is the use of cooling roofs. Cooling roofs are "a roof that has been designed to reflect more sunlight and absorb less heat than a standard roof." (US Department of Energy, 2019) "When cool roofs are considered, the analysis of the existing data shows that the expected depression rate of the average urban ambient temperature varies between 0.1 and 0.33 K per 0.1 increase of the roofs albedo with a mean value close to 0.2 K." (Santamouris, 2014). Another roof adaptation studied is the use of green roofs, "ideal for urban buildings with flat or shallow-pit roofs, and can include anything

from basic plant cover to a garden" (US Department of Energy, 2019),and how "they may reduce the average ambient temperature between 0.3 and 3 K." (Santamouris, 2014).

The research done on both cooling roofs and green roofs show how they are very effective in heat island reduction, as they provide both direct and ambient cooling effects. In addition, it has been found that green roofs improve air quality by absorbing pollutants from the air and providing more shade. Cooling roofs are particularly effective as they "can be made of white vinyl, an inherently reflective material, which would reflect the heat of the sun instead of absorbing it." (Levinson, Ronnen M. et.al, 2017).

Although green and cool roofs are extremely effective methods of mitigation it seems that lighter colored building materials are the easiest to implement into the current urban setting as they seem to be less costly to impose into metropolitan areas and would change thermal temperatures drastically. "Build green infrastructure improvements into regular street upgrades and capital improvement projects to ensure continued investment in heat-reducing practices throughout your community." (Rosenzweig, C., et al, 2006).

Simply by using a lighter color material to build streets and buildings we could reduce thermal energy levels by a large amount. Streets and sidewalks are constantly replaced with the same dark, energy absorbing asphalt and concrete when, "solar reflective "cool" pavements stay cooler in the sun than traditional pavements. Pavement reflectance can be enhanced by using reflective aggregate, a reflective or clear binder, or a reflective surface coating." (Levinson, Ronnen M. et.al, 2017).

Another simple mitigation technique would be the implementation of increased vegetation in Urban areas. Decreased vegetation is very important to the development of Urban

Heat Islands as "The displacement of trees and vegetation minimizes the natural cooling effects of shading and evaporation from the soil and leaves." (UCAR, 2011). Vegetation is often heavily decreased and disposed of in metropolitan areas in order to increase the space to build more energy consuming buildings and streets. However, an increase in vegetation around metropolitan areas in a previous study showed that "At the regional scale, that vegetation patch size had a direct effect on reducing the LST (Land surface temperature) of the green space. At a local scale, the analysis of the relationship between vegetation on urban green spaces and LST along a gradient of urbanization showed that green spaces with more vegetation tends to reduce LST. The results showed that largest green spaces were between 1.5 and 2.8 °C cooler than the surrounding built. In order to mitigate the UHI effect in cities, larger green spaces appear to be a possible solution." (Gioia, et.al. 2014), proving that increased vegetation could only benefit urban setting as help to reduce and reverse the effects of Urban Heat Islands.

Method

In order to further research the effectiveness of certain Mitigation Technologies, I plan to go to small metropolitan areas that are more rural and their heavily rural surroundings (i.e. Longwoods Campus and Farmville), medium metropolitan areas and their more rural surroundings (i.e. Greenville, South Carolina), and large metropolitan areas and their more rural surroundings (i.e. Washington D.C., Virginia and Maryland or New York City, New York) and record and analyze the difference in temperatures from the urban areas to the more rural areas within the same geographic locations.

After concluding that there is a significant temperature difference between the two settings, which geographically should be the same, I will pick certain parts of each city and each

surrounding area and implement different mitigation techniques. For example I would implement cooling roofs in one section, green roofs in another, lighter concrete and reflective building materials in another, and increased vegetation in another. After a period of time in which the mitigation techniques have time to make an effect, I will document average temperature change in that part of the city before and after the implementation and compare the results to the other sections in order to find the most effective mitigation techniques and if they change for the level of heat effect that the area is under.

After analysing and comparing temperature dropping effectiveness in each location, and cost to implement these techniques at a large scale, I will publish my findings and launch a campaign in order to convince cities to change to the outcome technology in order to decrease the rise of Urban Heat Islands in our country.

Conclusion

The majority of publications on Urban Heat Islands agree that something must be done about this widespread phenomenon in order to decrease the rise of thermal energy temperatures being caused by overpopulated urban areas with large energy consuming buildings and roads. Mitigation techniques such as repopulating trees and vegetation, cool and green roofs, cool pavements and many other simple fixes could aid urban areas with large increases in temperatures from the heat effect in slowing or decreasing their temperature rise. In my research I plan to find the most easily implementable and costly mitigation technology to reduce the widespread growth of the Urban Heat Effect. The research and implementation of these mitigation technologies could help save climate change from going past the point of no return.

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