Urban Heat Islands & Climate Change

Executive Summary

Urban heat islands are regions that experience higher temperatures than surrounding areas, primarily due to the concentration of buildings, roads and other structures that absorb and re-emit heat. As climate change leads to higher temperatures, urban heat values are likely to increase. In Missouri, high summer temperatures and high humidity are exacerbated in urban areas, where temperatures can be 2 to 10 degrees hotter than their surroundings. This can increase overall energy use and lead to dangerous conditions for those without access to air conditioning or other ways to stay cool (e.g., green roofs, weatherproof buildings). Scientific research indicates that green infrastructure, including cool pavement, tree canopies and park space within urban areas, is an effective way to offset urban heat island effects.

Science Highlights

- Urban heat islands are caused by reduced vegetation cover in urban areas.
- Increased urban heat is a consequence of development and climate change.
- The health and economic consequences of extreme heat disproportionately impact low-income households, people with chronic health problems, older adults and kids.
- EPA recommends green infrastructure to moderate urban heat islands, such as increasing the urban tree canopy and building green roofs.

Limitations

- In hot and humid areas like Missouri, vegetation that dissipates heat through evaporation can increase humidity and counteract the benefits of increased evaporative cooling on the hottest nights. There is not enough information to determine the optimal level of vegetation to reduce heat in humid areas.

Research Background

Urban heat islands

Urban heat islands are regions within a city that experience higher temperatures than surrounding areas. The phenomenon of urban heat islands was first noticed more than a century ago. Areas with high concentrations of roads and dark buildings are hotter than areas with grass and trees, because built infrastructure absorbs more heat. Even after sunset, urban areas retain some of this heat, so more populated areas tend to be warmer at night than surrounding rural areas. Warmer temperatures in urban areas might provide some relief during

This community science note was prepared by the Missouri Local Science Engagement Network (LSEN), a partnership between MOST Policy Initiative and the American Association for the Advancement of Science (AAAS) aimed to elevate science in policy conversations in Missouri. For more information, contact Harold Draper- h.m.draper@att.net or MOST- info@mostpolicyinitiative.org. This was prepared on 10/12/21.

winter; however, during the summer, more extreme conditions from urban heat islands increase human discomfort and electricity use.[1,2]

The dominant contributor to urban heat island is the urban-rural difference in vegetation cover.[1-3] Urban areas reflect more radiation but store more energy, leading to cooling effects in daytime. The stored energy is subsequently released at night and contributes to the nighttime urban heat island effect. As urban areas expand, the heat island effect is enhanced. Less soil moisture and vegetative cover contributes to the intensity of the urban heat island. In contrast, rural areas have more vegetation that can dissipate heat through evaporation. However, this can increase humidity, which also increases the urban heat island intensity in humid areas is larger because of denser vegetation and more evapotranspiration in rural areas.[4]

When vegetation is replaced with built infrastructure, the cooling effect of evaporation and transpiration from plants no longer takes place. In a rural landscape, a portion of solar radiation is spent evaporating water, not on raising air temperatures. Plants perform this function through evapotranspiration, drawing moisture from the ground and evaporating it, thus cooling the surrounding air.[1,4]

Heat islands and climate change

As extreme temperatures become more common, existing urban heat islands are expected to get more extreme.[1] For places that have hot summers like Missouri, extreme heat poses serious health risks, including heat-related fatalities.[5] These problems disproportionately affect low-income and minoritized populations, who may not have adequate air conditioning to cool temperatures in their residence.[5,6] Additionally, low-income areas are more likely to have higher population density, less vegetation and less green infrastructure.[3]

Researchers have investigated whether the observed temperature rises that were being attributed to climate change were actually due to the urban heat island effects, which could increase due to urbanization worldwide. Though heat island effects may confound temperature measurements over time, research indicates that the heat island effect is not responsible for observed increases in average temperatures over time. Moreover, such temperature increases have been observed in rural and remote areas without a heat island effect, such as the Arctic and ocean surfaces.[7,8]

Mitigating strategies

It has been well understood for years that urban green spaces and increases in tree canopy (green infrastructure) are important mitigation options for urban heat islands. However, in Missouri, evapotranspiration leads to elevated humidity levels, which tends to counteract benefits from evaporative cooling. Even with increased humidity, there are benefits to having a tree canopy to block the sun.[1,3, 5,9]

To address urban heat island effects, EPA suggests planting of shade trees, along with installation of green roots to lower surface and air temperatures and reduce the energy needed to cool buildings.[2,10] In addition, smart growth strategies that mix land uses, promote compact building design, increase parkland, and promote walkable neighborhoods are suggested. Because vulnerable populations are most susceptible to the negative health and economic consequences of extreme heat, policy solutions may also consider program designs that are accessible to renters, adults with limited mobility and people experiencing homelessness.[11] For example, some cities provide grants or low-interest loans to encourage green improvements, while other areas subsidize cool roof installations in public buildings (e.g., affordable housing, schools, shelters).

References

1. Mohajerani, A., Bakaric, J., & Jeffrey-Bailey, T. (2017). The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete. *Journal of environmental management*, *197*, 522-538. https://doi.org/10.1016/j.jenvman.2017.03.095.
2. United States Environmental Protection Agency. (2021, October 1). Learn about heat islands. Retrieved from: https://www.epa.gov/heatislands/learn-about-heat-islands.
3. Hass, A. L., Ellis, K.N., Mason, C.R., Hathaway, J.M., Howe, D.A. (2016). Heat and humidity in the city: Neighborhood heat index variability in a mid-sized city in the Southeastern United States. *International Journal of Environmental Research and Public Health*, *13*, 117. https://doi.org/10.3390/ijerph13010117.
4. Li, D., Liao, W., Rigden, A.J., Liu, X., Wang, D., Malyshev, S., and Shevliakova, E. (2019). Urban heat island: Aerodynamics or imperviousness? *Science Advances*, *5*, eaau4299. https://doi.org/10.1126/sciadv.aau4299.
5. Heaviside, C., Macintyre, H., & Vardoulakis, S. (2017). The Urban Heat Island: Implications for Health in a Changing Environment. Current environmental health reports, 4(3), 296–305. https://doi.org/10.1007/s40572-017-0150-3.
6. Hsu, A., Sheriff, G., Chakraborty, T., & Manya, D. (2021). Disproportionate exposure to urban heat island intensity across major US cities. Nature communications, 12(1), 1-11. https://doi.org/10.1038/s41467-021-22799-5.
7. Hausfather, Z., Menne, M.J., Williams, C.N., Masters, T., Broberg, R., Jones, D. (2013). Quantifying the effect of urbanization on U.S. Historical Climatology Network temperature records. Journal of Geophysical Research: Atmosphere, 118, 481-494. https://doi.org/10.1029/2013JD018509.
8. Parker, D. E. (2010). Urban heat island effects on estimates of observed climate change. Wiley Interdisciplinary Reviews Climate Change, 1, 123-133. https://doi.org/10.1002/wcc.21.
9. Venter, Z. S., Chakraborty, T., and Lee, X. (2021). Crowdsourced air temperatures contrast satellite measures of the urban heat island and its mechanisms. Science Advances, 7, eabb9569. https://doi.org/10.1126/sciadv.abb9569.
10. United States Environmental Protection Agency. (2021, October 1). Climate Change and Heat Islands. Retrieved from https://www.epa.gov/heatislands/climate-change-and-heat-islands.
11. United States Environmental Protection Agency. (2021, October 1). Heat Islands & Equity. Retrieved from https://www.epa.gov/heatislands/heat-islands-and-equity.