TECH + ENGINEERING

Why cities are so hot (and how we can fix it)

Even the Romans noticed that cities are engineered to be heat islands. But that means we can do something about it.

BY ALISSA GREENBERG FRIDAY, APRIL 14, 2023 NOVA NEXT

A pedestrian uses an umbrella to protect herself from the sun during a heatwave in London on July 18, 2022. Image Credit: Bloomberg, Getty Images

You don't have to live in Phoenix, Arizona, to notice that cities are getting hotter, but it helps. Consistently the hottest major metropolitan area in the country, Phoenix spent more than a third of 2022 in triple-digit temperatures. It has also seen a dramatic uptick in heat-related deaths in recent years, with the Maricopa County public health department reporting more than 300 heat-associated deaths in 2021, an increase of 450% from 2014.

"It's a really unfortunate, tragic data point that we find ourselves sharing a lot," David Hondula, director of the city's Office of Heat Response and Mitigation, said in an interview for the NOVA documentary "Weathering the Future." People are often surprised to learn that heat is the leading cause of weather-related death, he said. It "lurks as a background hazard and doesn't always get the attention of hazards like thunderstorms, tornadoes, hurricanes, floods."

Phoenix did not hire Hondula because the planet in general is getting hotter but because cities are the hottest of all. That's due to what's known as the "urban heat island" effect, which refers to the ways that the design and infrastructure of cities tend to make that environment hotter—up to 20 degrees warmer than surrounding rural areas.

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We've known about the urban heat island effect for a long time, even the Romans noticed it. But it's especially important now because of the health risks that come with heat, according Brian Stone, a professor of environmental planning at Georgia Institute of Technology. "Of all the stressors we associate with climate change, heat is the only one that has a physiological threshold that we know will lead to certain death," he told NOVA.

There's a flip side, though. Since "we've basically engineered cities to be hot," he said, "we can reverse engineer them to be cooler."

What creates an urban heat island?

Researchers have pinpointed four main factors that drive the urban heat island effect. First is vegetation, or lack thereof. Trees are often the first thing to go when cities expand. (Take Atlanta, which has lost nearly 80,000 trees to development since 2014.) Cutting down trees creates a double-whammy effect, since they not only offer shade but also soak up heat from their environment. When we cut down urban trees, "we reduce the capacity of the natural system to cool itself through evaporation, much like we cool ourselves through perspiration," Stone said.

Then, the materials we install in place of that lost greenery tend to aggravate the problem further. Mineral-based materials such as asphalt, concrete, shingles, and other roofing have a high "thermal capacity," meaning they absorb a lot of heat during the day and then release it slowly back into the environment as they cool, even well into the night. That's a problem in particular because the atmosphere doesn't actually heat up very much from direct sunlight; instead, it warms more as heat is released from the ground.

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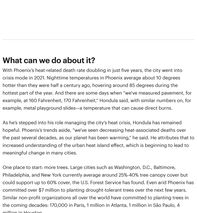


Next, urban morphology, or the three-dimensional structure of a city, also concludes to increasing temperatures, since tall buildings are particularly good at trapping heat between them. And lastly, there's waste heat, another double whammy. The process of consuming energy to do work, by anything from a car engine to a lightbulb to a computer, generates heat as a byproduct. Since cities are where most humans live together, they're also where we consume the most energy for transit, heating and cooling our homes, and the myriad electrified activities of daily life. And the waste heat that escapes into the environment from those activities measurably affects city temperatures.

Urban heat islands and human health

As all of those factors accumulate, the consequences for human health add up, too. Human bodies can handle very hot temperatures briefly but are sensitive to heat over the long term. "It's the warm-nighttime temperatures that cause the health problems," Marshall Shepherd, director of the atmospheric sciences program at the University of Georgia, told NOVA. "And that's where the urban heat island comes in, because that's when it tends to peak"—with all those mineral surfaces re-releasing heat after dark.

Our bodies respond to heat by sweating our heart rate, allowing us to better circulate moisture. That moisture becomes sweat, which we use to cool ourselves down. Most people can handle an elevated heart rate for a few hours a day. But "if you have to elevate your heart rate for 24 hours because it's 85 degrees at night in your home, then you are overly taxing your physiologic capacity to deal with heat," Stone said. Then things start to get dangerous.

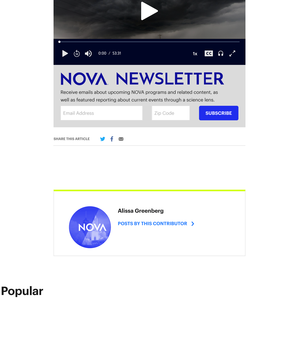
Research shows that it's generally the neighborhoods that can least afford it that get hit the hardest by urban heat. That's in part because of discriminatory urban planning policies like redlining, which ensured that poorer neighborhoods had fewer trees and more industrial development. One recent study found a difference of 7 to 10 degrees between lower and higher income areas of the same cities. In another project, Shepherd and his colleagues compared redlining maps with satellite data tracking heat. The results showed "a clear heat island within the heat island for marginalized groups," he said.

What can we do about it?

With Phoenix's heat-related death rate doubling in just five years, the city went into crisis mode in 2021. Nighttime temperatures in Phoenix average about 10 degrees hotter than they were half a century ago, hovering around 85 degrees during the hottest part of the year. And there are some days when "we've measured pavement, for example, at 160 Fahrenheit, 170 Fahrenheit," Hondula said, with similar numbers on, for example, metal playground slides—a temperature that can cause direct burns.

As he's stepped into his role managing the city's heat crisis, Hondula has remained hopeful. Phoenix's trends aside, "we've seen decreasing heat-associated deaths over the past several decades, as our planet has been warming," he said. He attributes that to increased understanding of the urban heat island effect, which is beginning to lead to meaningful change in many cities.

One place to start: more trees. Large cities such as Washington, D.C., Baltimore, Philadelphia, and New York currently average around 23%–40% tree canopy cover but could support up to 60% cover, the U.S. Forest Service has found. Even and Phoenix has committed over $7 million to planting drought-tolerant trees over the next few years. Similar non-profit organizations all over the world have committed to planting trees in the coming decades: 170,000 in Paris, 1 million in Atlanta, 1 million in São Paulo, 4 million in Houston.



Professor David Sailor (left) and Professor Ni'ckki Osborne Jelks (right) walk through a "cool corridor," where trees have been planted to provide relief from the heat in Phoenix, Arizona. Image courtesy of GBH

But it will take years, maybe decades, for those trees to mature and start making a difference. So Stone also sees great potential in changing the materials we use to build cities. For example, dark-colored slate roof shingles with high thermal capacity might make sense in London, or somewhere else cold and wet, but are much less logical in the southern United States. "We can engineer any color we'd like of roofing material, and so part of what we need is not just a technological change in the way we build, but a cultural shift to be more accepting of lighter, more reflective materials," he said. Other more immediate solutions include materials like Phoenix's cool pavement program, which encourages the use of alternative road materials, as well as the city's work prioritizing shade structures at bus stops or in other places where people must wait for long periods.

The powerful thing about recognizing the heat island effect is recognizing it as a phenomenon within local control. That means it's possible to make progress without waiting for national or international policy change, Stone said. Research shows "we can substantially cool down cities in a relatively quick period of time without major expenditures."

Hondula takes this optimism even further. Even in the context of global warming, he said, efforts to increase tree and other shade cover and promote use of materials with lower thermal capacity mean "we could wind up with a city of the future that's cooler than the one we have today."

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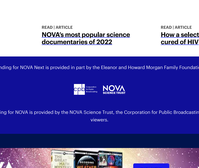

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Funding for NOVA Next is provided in part by the Eleanor and Howard Morgan Family Foundation.

Major funding for NOVA is provided by the NOVA Science Trust, the Corporation for Public Broadcasting, and PBS viewers.