U.S. Forest Service and Partners

For more livable cities, researchers study climate up close and personal on the Colorado Front Range

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Imagine standing in a parking lot surrounded by parked cars and black pavement. Then imagine standing in a landscape lush with trees and other vegetation. Regardless of what your weather app says, the parking lot will likely feel warmer. These two microclimates feel different due to interactions between the built environment and the surrounding nature. Pavement and buildings absorb the sun's energy and radiate heat throughout the day. Meanwhile, trees and other vegetation do the opposite; they block incoming radiation and act like natural air conditioners through transpiration.

The urban heat island (UHI) effect describes the tendency for urban areas to be hotter than surrounding rural areas due to the concentration of buildings, pavement, and other infrastructure that absorb and retain heat. It is typically measured using air or surface temperature data across broad spatial scales to quantify the average temperature difference between cities and their outlying areas. However, these large-scale averages don't capture the smaller, human-scale variations in heat—such as the intense warmth radiating off asphalt or the cooling provided by a single shade tree—that shape people's actual experiences of temperature in cities.

Researchers at the Denver Urban Field Station are advancing heat measurement techniques to better capture how people actually experience thermal comfort in urban environments. By measuring heat and thermal comfort of microclimates, researchers can locate within urban areas where exposure to environmental hazards like extreme heat is most significant, who is most at risk, and how communities can reduce risk through active management of urban landscapes. The goal is to identify nature-based solutions to create more livable cities.

Typically, people will go out of their way to avoid exposure to uncomfortable heat and poor air quality, but sometimes, exposure is inevitable. Urban residents reliant on public transportation, for example, must wait at transit stops that often lack shade or other structural or environmental amenities. These effects are especially pronounced for low-income residents, which are typically more reliant on public transportation and more likely to live in neighborhoods with fewer trees or shade structure. Differences in heat exposure translate into unequal risks to the health and well-being of urban residents when temperatures approach extreme highs, as seen in recent summers in Denver and other cities across the U.S. >>

Rocky Mountain Research Station scientists John Frank (left) and George Valentine demonstrate how to assemble the highly portable MaRTa cart, which they engineered to collect microclimate data measures in diverse field settings. USDA Forest Service photo by Natalie Cooper

Researcher Aubrey Benson is seen here with the MaRTa cart hitched to her bike as she set off for field work around residential Fort Collins. Photo by Aubrey Benson

The Denver Urban Field Station (DUFS) is a collaborative research and practice unit of researchers from the U.S. Forest Service, U.S. Geological Survey, the University of British Columbia, and the University of Colorado-Denver. DUFS explores connections between people and nature and the role of vegetation in semi-arid cities, towns, and developing regions. It's also part of a nationwide network of urban field stations that aim to facilitate opportunities to advance knowledge co-production, long-term social-ecological research, and knowledge exchange.

Researchers affiliated with the Denver Urban Field Station collected microclimate data at bus stops around Denver using portable weather stations called Kestrels. They also asked transit riders about thermal comfort during their commutes to understand if extreme heat affects some riders more than others—and how city managers could improve conditions. USDA Forest Service photo by Travis Warziniack

In summer 2023, research teams in Denver and Fort Collins collected data to better understand where and how extreme effects people in cities—and what can be done about it. The Denver research team measured thermal heat and other components of microclimate at bus stops around the city. They paired measurements from globe thermometers with surveys of bus riders during their daily commute. The survey asked about riders' thermal comfort levels and perspectives on bus stop aesthetics. With the micro-meteorological measurements, this information will shed light on how extreme heat might disproportionately affect public transit riders.

The research team in Fort Collins focused on how different types of vegetation and tree canopy cover affect the microclimate around homes. The researchers visited residential yards, which they categorized according to characteristics such as percent tree canopy cover, landscaping type (for example, xeric or mesic), and cardinal directional (north-, south-, east-, or west-facing properties). Accompanying the crew was a mobile weather station called MaRTa, a biometeorological data collection machine on wheels that scientists from the Rocky Mountain Research Station engineered with portability in mind. Results based on MaRTa's measurements will equip agencies and residents to design safer, more comfortable, and more pleasing cityscapes and yards throughout urban areas.

So far, the research team has found that for every ten percent increase in canopy cover, there is a decrease in mean radiant temperature—a metric of thermal comfort at a hyper-local scale—of 1-2 degrees Celsius (33.8-35.6 degrees Fahrenheit). But it is not just about instrumental measurements of heat; the science also shows that people feel more thermally comfortable when they find an environment more aesthetically pleasing and if they can see trees in the landscape.

This research will enable city planners and others to improve urban ecosystems, residential health, and well-being in urban heat islands across the region.

In Fort Collins, University of British Columbia students take microclimate measurements in residential yards with varying amounts and types of vegetation. Photo by Aubrey Benson