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back into the area. There are a lot of surfaces that we need in an urban area that are absorbing the sun's rays," Wasiutynski said.

There can be as much as a 15- to 20-degree difference in cool parts of the city, such as Forest Park, or neighborhoods that are shaded with a denser tree canopy, such as Irvington or Eastmoreland, on a hot day.

"Portland has some pretty significant urban heat island effects," said Bob Sallinger, the Audubon Society of Portland's conservation director. Sallinger notes that Portland ranks fourth in the country with the most extreme urban island heat effects, which is supported by research conducted by Climate Central.

"Portland has a reputation as a green city, but the green is not equitably distributed. To some degree, it does correlate with the amount of wealth and poverty that is in a neighborhood."

The map Shandas created detailed that correlation for the first time by overlaying the map of temperature readings with maps showing the environmental assets — such as tree canopy and bioswales — with demographic statistics such as the poverty rate, population density, the presence of racial and ethnic minorities, and the number of people who speak English as a second or third language, the number of people under age 18 and over age 65, and the number of people whose highest education is a high school diploma versus a college degree.

The connection between urban heat islands and the traditional signs of poverty and disadvantage is not an exact correlation, but one that still surprised Shandas.

"Urban heat islands," he said, "completely overlap in many ways with those communities that have the least resources."

Pointing to the harmful health effects of hotter weather, Sallinger said, "Those neighborhoods are going to suffer the most because you have higher poverty, (and they are) the least equipped to respond well."

Heat waves, in addition to causing heat stroke and dehydration, can aggravate health conditions such as asthma and other

cardiovascular illnesses and even cause people with already vulnerable health, such as seniors, to have strokes or heart attacks. Certain medications can reduce a person's ability to cope with heat.

Communities that are considered isolated, such as people who live alone, seniors who are often confined to their homes and seldom travel, and homeless people who live outside are at the highest risk for heat-related illness, as well as people who don't own air conditioners or who live in places where they can't easily cool off.

"It all comes together in a perfect storm," Sallinger said. "If you're (poor) and you're in an area that is covered with pavement and cement, doesn't have trees, doesn't have natural areas, doesn't have a local swimming pool ... it just makes those communities more vulnerable."

Since the map of urban heat islands was launched, city planners and environmentalists have been using the map to pinpoint places throughout Portland that need the most work to reduce urban heat island effect.

Kaitlin Lovell, the manager of the science integration division of the Bureau of Environmental Services, said the map and the way it overlays with demographic data have heavily influenced the city's tree-planting program.

"It was finally understanding how it all layered together," Lovell said. "It was a much more visual explanation of how we were already approaching our work."

Research by David Sailor, a former Portland State University professor who worked with Shandas, has done research showing that Portland's tree canopy cover is the most important factor that determines whether an area is cooler or hotter. A neighborhood with a high number of mature trees and a thicker canopy cover can cool an area by a several degrees, at least.

During the 2015-16 fiscal year, BES' Tree Program planted 3,437 trees, 504 of which were planted in east Portland and 563 in north Portland.

Trees and a robust urban canopy, Sallinger and Lovell said, is probably the

most effective tool that can be used to reduce urban heat island effect. But it can take decades for a tree to mature — so there is pressure to plant now.

"Our thinking is that the climate warms and that we have more of these intense heat waves throughout the summer, we're really going to need these trees 20 years from now in order to keep our communities livable," Wasiutynski said.

Rockwood, a neighborhood that straddles Portland and Gresham, is the poorest census tract in all of Oregon. According to the city of Gresham, the neighborhood has a canopy cover of approximately 15 percent, well below the city average of 28 percent.

In July, the city — partnering with the East Multnomah County Soil and Water District, Friends of Trees, Depave, the county, and Mt. Hood Community College — conducted an inventory of the trees already growing in Rockwood, as well as places where trees could be planted. The city will begin planting trees in the neighborhood this fall.

Other ways to reduce the temperatures produced by urban heat islands include installing eco-roofs, depaving portions of parking lots and other asphalt surfaces, and even painting roofs, streets and parking lots white so that the sun's rays are deflected and the amount of heat that is absorbed into the surface decreases.

Lovell said the bureau builds bioswales or plants street trees principally for the benefits in managing the city's stormwater in particular blocks or pieces of a neighborhood. Because of the map, Lovell said, the bureau can see that "the next block over also has a need for street trees because of urban heat islands" and extend the tree-planting and stormwater work slightly further to also address urban heat islands.

"It's one of those additional layers we (now) consider," she said. "It really helps us maximize opportunities to reduce urban heat island."

Eric Rosewall, the executive director of

the non-profit Depave, which removes pavement and asphalt to install gardens and other green infrastructure, said there are ways to reduce urban heat island effect without removing, for instance, an entire parking lot.

"A better way to impact urban heat islands is to find places to insert trees so that you can expand the forest and shade the pavement," he said. "There are a lot of creative strategies ... to keep some of that

hard infrastructure but use it creatively and adaptively.

It's an urban environment. There are going to be a lot of compromises."

Shandas is beginning to study how the height of buildings can cool local temperatures. Taller

buildings provide shade, producing an effect he calls "urban canyon effect." He concludes that there are five main factors that can determine whether an area is an urban heat island: building height, the density of buildings in an area, the amount of pavement and blacktop versus tree canopy, and the height of the tree.

"Each neighborhood will have a mix of all these things," he said, and he advocates for identifying solutions that are particular to each urban heat island. "Which strategy and mix of these strategies lowers that daytime temperature?"

Portland and Multnomah County's work to reduce urban heat islands, however, will be only a small part of the effort to mitigate climate change. Lovell said there is a constant push and pull in any conversation about climate change: reducing carbon dioxide and other greenhouse gas emissions to stop climate change and reducing climate change's impacts on human health and the environment.

"We can't stop (climate change) at a local level," Lovell said. "These are efforts to build in urban resiliency to weather climate change."

URBAN HEAT ISLANDS

See the Portland area map created by Vivek Shandas at climatecope.org

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