NatureQuant

NatureScore® Urban Heat Index

A tool to identify and mitigate areas of high urban heat island risk (and socio-economic deprivation) via urban greening.

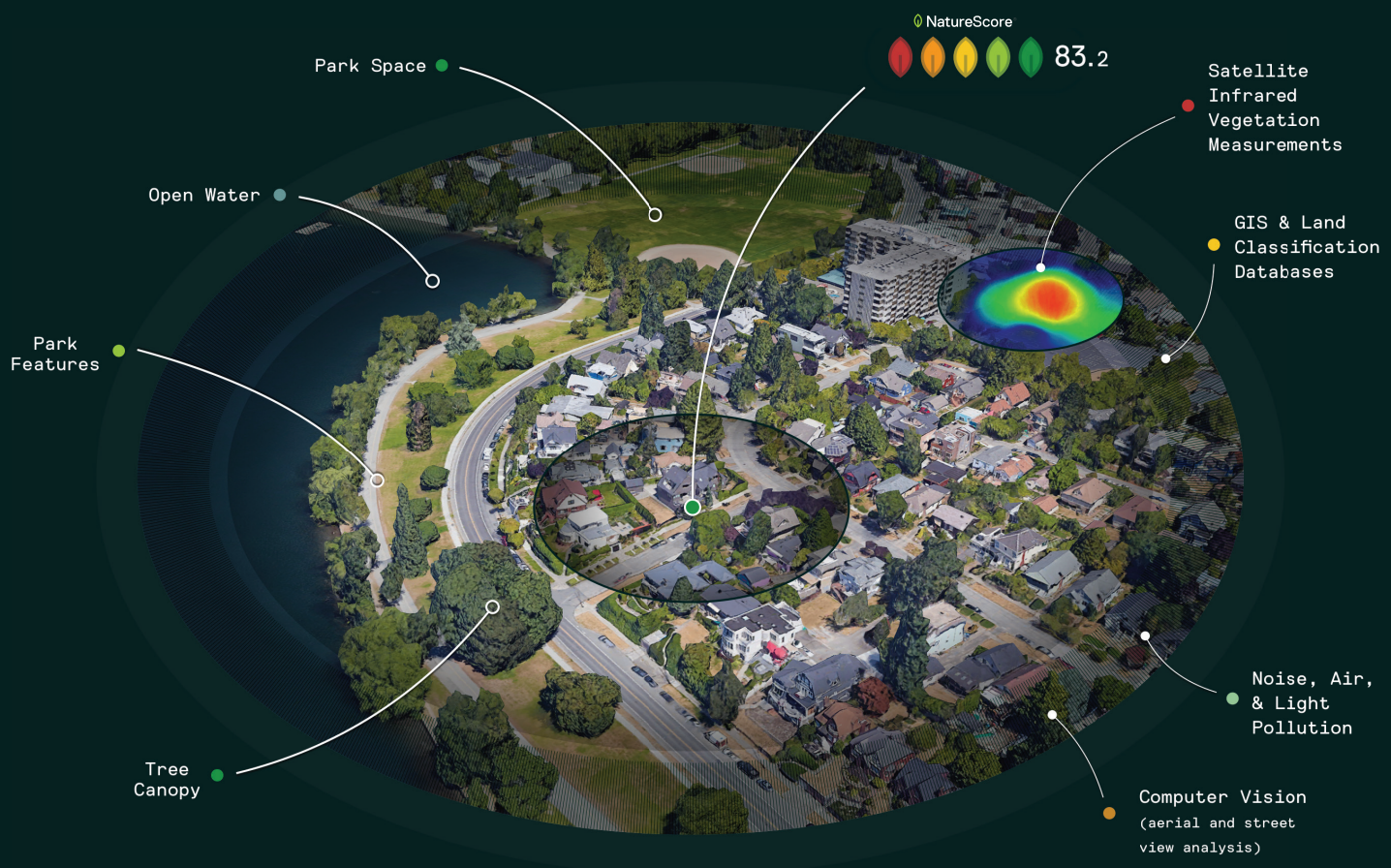
CAPA

NatureQuant

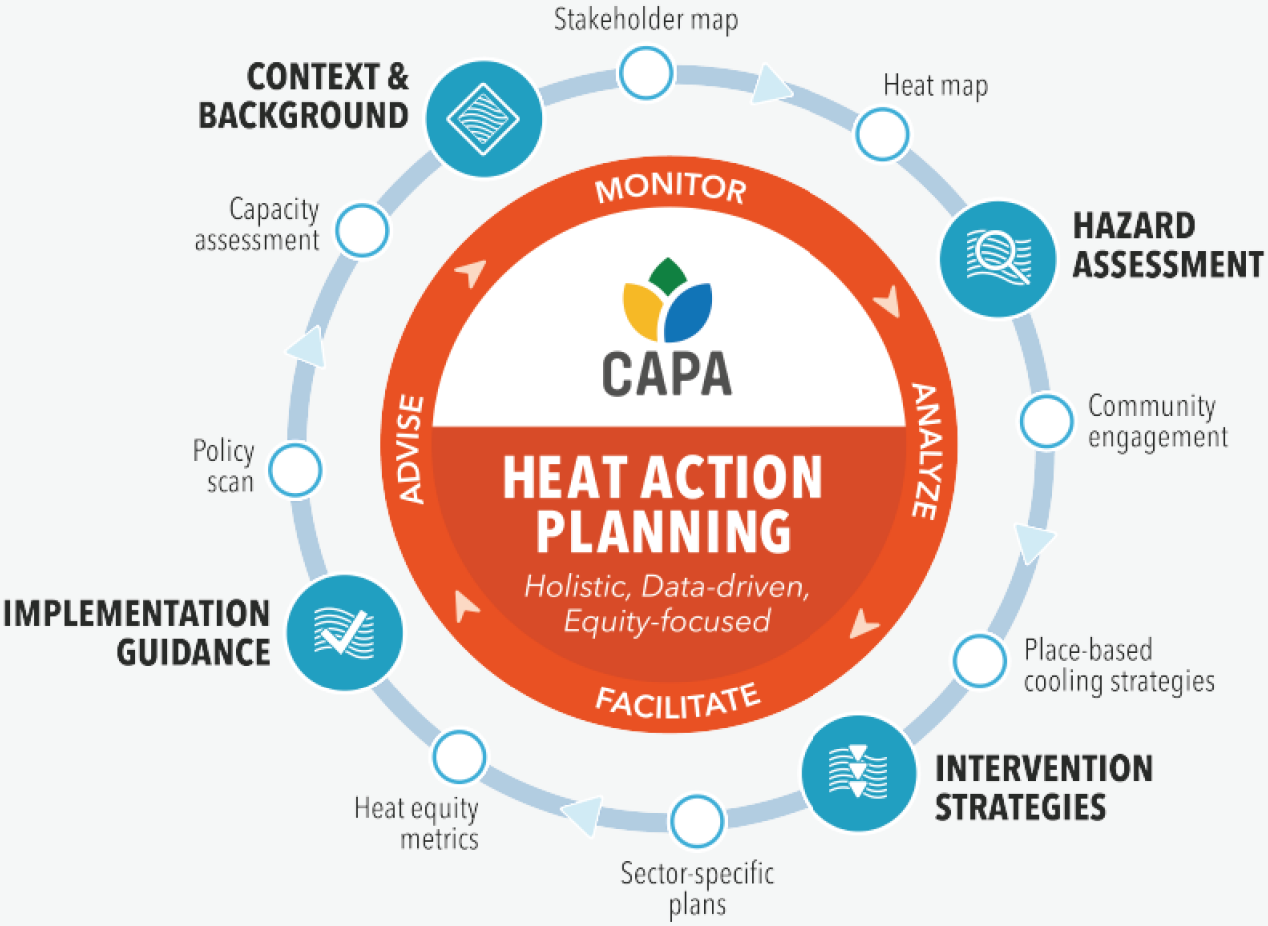
NatureQuant is a technology and research firm developing tools to assess and promote the human health and eco-system benefits of nature.

NatureQuant has developed “NatureScore®”, which measures the quantity and quality of natural elements for any location using a patent-pending machine learning system. For each location, NatureQuant analyzes and blends various data sets and processed information, including satellite infrared measurements, GIS and land classifications, park data and features, tree canopies, building footprints and heights, impervious surface data, and computer vision elements (aerial and street images).

NatureScore®
Urban Heat Index

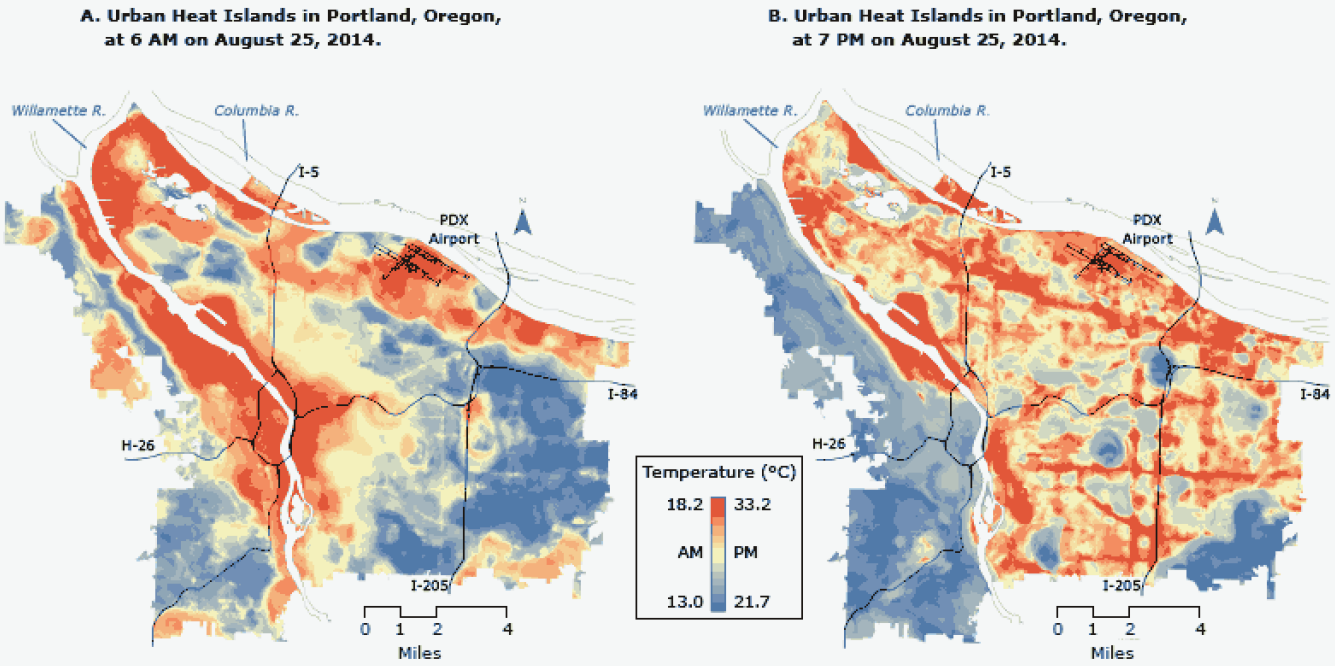


For the NatureScore® Urban Heat Island Index, the considered elements are weighted to create the highest correlation with urban heat islands via a machine learning process.



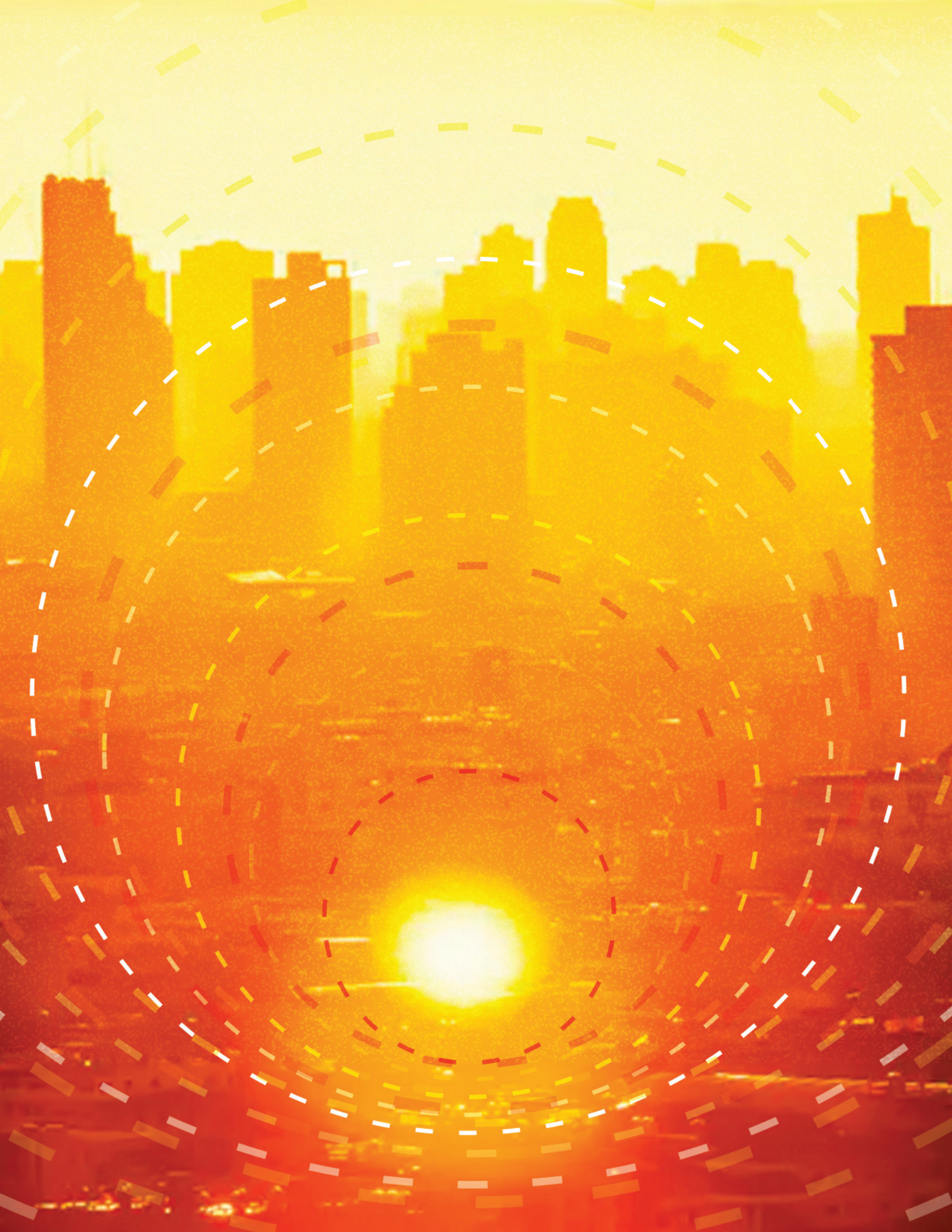
Building Capacity Community to Address Climate Change.

CAPA helps communities plan for an uncertain future with a custom set of products and services to inform decisions that safeguard communities. By characterizing hyperlocal climate risks through data collection campaigns and analytics, co-producing effective solutions, and building capacity to improve decision making, CAPA's offers a holistic and equity-centered approach to improving the public's health. Our flagship and award-winning program, Heat Watch, has delivered high resolution descriptions of extreme heat to over 85 communities across the country, and for nearly a decade CAPA has partnered with US National Oceanic and Atmospheric Administration, The World Bank, and dozens of State, and local public agencies who view CAPA as the authoritative resource for building climate resilience to extreme heat.



Intro on CAPA and Air Temp Data

Central to the distinct advantage that CAPA offers for advancing solutions is the ability to transcend conventional approaches that use course and incomplete satellite-derived descriptions of urban heat. CAPA's unique approach improves the quality and quantity of heat data through the collection of hundreds of thousands of air temperature measurements, which are used to create high [spatial and temporal] resolution and accurate descriptions of urban heat. Air temperatures are more relevant to advancing nature-based solutions and public health interventions, since they offer a rich picture about the locations, duration, and magnitude of exposure to extreme heat. The resulting data provides a first step to developing risk profiles and developing solutions, such as green space and tree canopy planning.



Urban Heat Islands and Green Infrastructure

Extreme heat events affect the most vulnerable human populations and are a lethal health hazard to urban dwellers globally. In the United States, extreme heat causes more deaths annually than all other weather events and natural hazards combined.

Urban Heat Islands occur when cities replace natural land cover with dense concentrations of pavement, buildings, and other impervious surfaces that absorb and retain heat.

A lack of natural elements and concentrated buildings can provide an excellent predictor of where Urban Heat Islands may occur. The areas with the least vegetation cover are generally the hottest. While it is now increasingly understood that nearby nature bestows powerful health benefits, the mitigation of Urban Heat Islands is another reason for individuals, governments, non-profits, and businesses to track and monitor equitable urban nature infrastructure. More broadly, inequities in nature proximity

Trees, green roofs, and vegetation can reduce Urban Heat Island effects by shading building surfaces, deflecting radiation from the sun, and releasing moisture into the atmosphere.

This effect increases energy costs (e.g., for air conditioning by an estimated $200/year), air pollution, and heat-related illness and mortality. Relatedly, climate change will likely lead to more frequent, more severe, and longer heatwaves during summer months. Extreme heat events often affect our most vulnerable populations first; indeed, heat-related mortality rates for the elderly and socio-economically disadvantaged have increased markedly in the last decade.

are particularly concerning because nature is not an amenity but a necessary public health component. In the places where human activities in the United States have destroyed the most nature, fewer trees filter the air; fewer wetlands and marshes clean the water and protect communities from floods; fewer parks offer children a place to play and adults to unwind; and fewer public spaces invite all people to forge a strong community and build solidarity.

The NatureScore® Urban Heat Index (UHI)

One potential reason that nature infrastructure has not been broadly examined as a tool to mitigate Urban Heat Islands (or for public health broadly) is that technical challenges exist in nature quantification and impact forecasting. To address this dilemma, NatureQuant and CAPA Strategies have developed the NatureScore Heat Index.

The NatureScore Heat Index was trained by combining CAPA's ground-level measurements of air temperatures throughout major cities in the U.S. with industry leading nature and built element location intelligence. This big data and machine learning approach provides unique insight into what combination of built and natural elements yield higher heat risks. And more importantly, how to mitigate those risks. Additionally, neighborhood level socio-economic deprivation factors are considered to ensure help is provided to the most vulnerable communities.

The NatureScore Heat Index is a scalable tool that can provide a turn-key solution to identify and combat UHI's for any urban environment on the planet via green infrastructure.

The NatureScore Heat Index will allow researchers, non-profits, municipal agency staff, ESG investors, and others to effectively combat urban heat islands in neighborhoods that are both nature deprived and have socioeconomic disadvantages (low income, low education, low employment, poor housing, etc.).

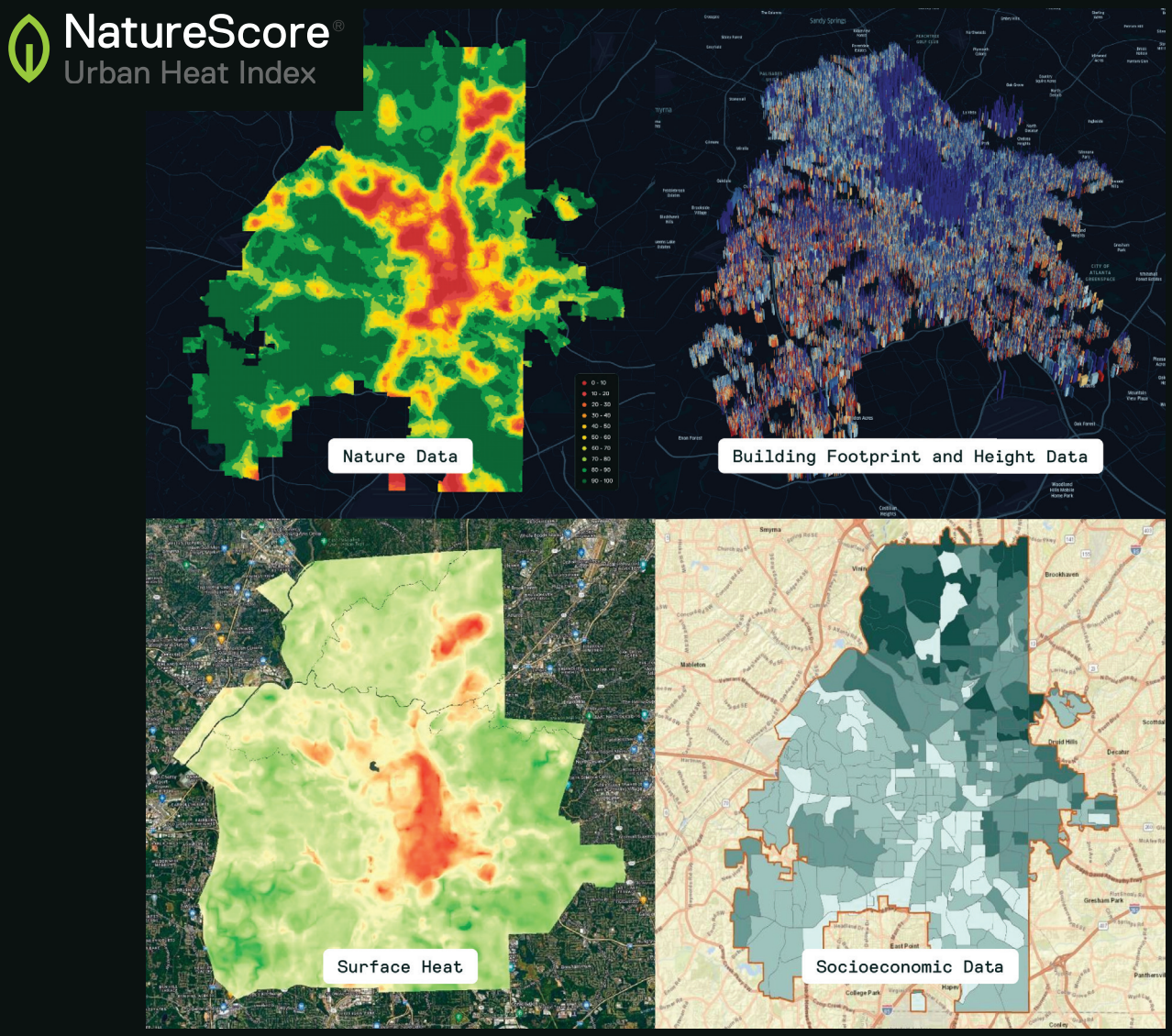
The NatureScore Heat Index combines NatureScores® trained to combat urban heat islands via ground-based air temperatures measures with the Area Deprivation Index (ADI).

The urban heat 'surface' for US cities is created through a peer-reviewed machine learning data analysis model that integrates land cover information with in-situ measurements of air temperatures. The model has been tested across all US climate zones, resulting in upwards of 99% accuracy for describing air temperatures at 2m heights throughout the day and night, and evening within a 10m grid cell.

NatureScores capture numerous measures of natural and built elements (bio-mass, impervious surfaces, building footprints and heights, bodies of water, densities of highways, etc.). The weighting of elements is derived from a machine learning process optimized to predict urban heat islands. The result is a uniquely powerful tool for identifying and combating urban heat at scale.

The ADI is based on a measure created by the Health Resources & Services Administration (HRSA) over three decades ago, and has since been refined, adapted, and validated to the Census Block Group neighborhood level by Amy Kind, MD, PhD and her research team at the University of Wisconsin-Madison. It includes factors for the domains of income, education, employment, and housing quality.

Through a big-data and machine learning approach, the NatureScore Heat Index is uniquely able to both predict areas of urban heat island risk and identify the most effective nature based interventions.

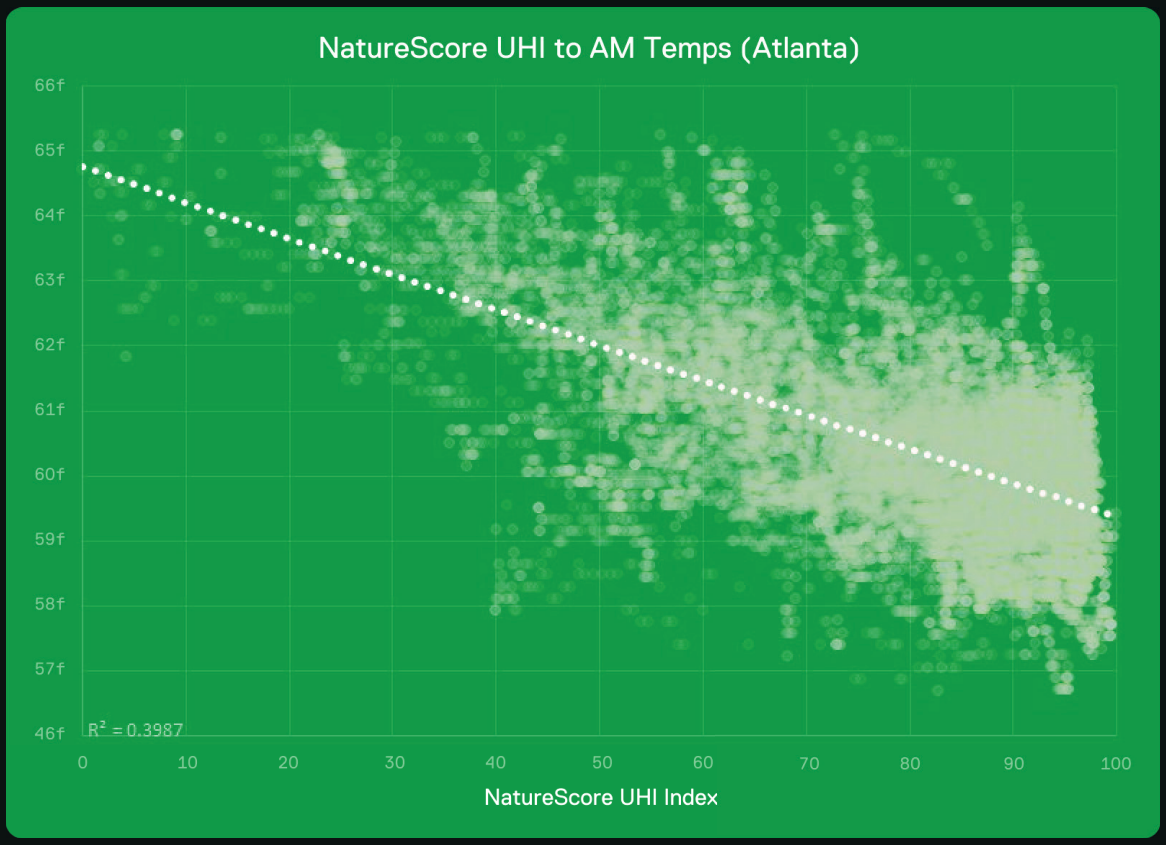


Illustrative Elements in NatureScore Heat Index

What do NatureScore® Urban Heat Index scores mean?

The NatureScore Heat Index provides a single score from 1 (low priority) to 10 (high priority) by census block or single point. A block with a ranking of 1 indicates the lowest level of heat risk (both in terms of a lack of nature and socioeconomic vulnerabilities) while a NatureScore Heat Index of 10 indicates the highest level of heat risk and disadvantage.

Neighborhoods with high NatureScore Heat Index scores should be prioritized for green infrastructure development, one of the most affordable and effective ways to mitigate heat risk. All NatureScore Heat Index scores are city relative, meaning each neighborhood is compared only to the subject city, not nationwide. Further, a ranking of lowest to highest priority neighborhoods by city are delivered.



Notes & References

NatureScore® Heat Index is derived from an equal weighting of the NatureScore™ and the Health Resources and Service Administration's Area Deprivation Index, delivered by census tract.

It is calculated as follows:

"NS": NatureScore for Census Tract (high score indicates more nature)

"ADI": Area Deprivation for Census Tract (high score indicates more deprivation)

"NatureScore Heat Index": NatureScore® Heat Index (high score indicates a high priority neighborhood)

In Decile Rank from 1-10: [NatureScore UHI=((100-NS)+ADI)/2]

NatureScore® UHI Data Elements

NatureScore® UHI has been developed by examining the following data. In many cases, NatureQuant has also developed a cross-referencing process to correct various data sources for edge cases, or other scenarios where an element (e.g. water, sand or an artificial turf field) is not correctly measured as "nature", due to the technique used to capture the data.

- Computer Vision of Aerial/Street Images
- NDVI processed satellite imagery
  - NatureQuant has a proprietary process for correcting and enhancing this data in relation to elements of nature.
- NDWI processed satellite imagery: measures water
- Parks GIS data
- Park features
  - NatureQuant examines various park amenities (playgrounds/sport courts/etc.).
  - Park quality ratings are included from public platforms (Yelp/Foursquare/Google
- Reviews/etc).
- Natural/nature features GIS data
- GIS and land classification databases
- Human Modification (HM) Model (Theobald et. al. 2016)
- AQI: air quality monitoring
- Noise pollution
- Light pollution
- UV exposure (watt-hours per square meter)
- Impervious surface data
- Road density
- Tree canopy data
- Water quality data (select areas)
- Tree BioMass and Species Identification (select areas)
- Light Detection and Ranging (LIDAR) (select areas)
- In Development: Tassled Cap Values Data Structures
- In Development: Global Biodiversity Information Facility (Order/Family/Genus/Species Data)

Area Deprivation Index Data Elements

The ADI is a validated, factor-based deprivation index which uses 17 poverty, education, housing and employment indicators drawn from US Census data to create a measure of socioeconomic context for a particular census-based region. The ADI has previously been used to document a number of socioeconomic-health associations, including the direct relationship between area deprivation and all-cause, cardiovascular, cancer and childhood mortality, and between area deprivation and cervical cancer prevalence.

The ADI uses 17 US Census variables in its construction. The US Census variables are as follows:

- Percent of population aged >= 25 years with >= 9 years of education
- Percent of population aged >= 25 years with >= a high school diploma
- Percent of employed persons >= 16 years of age in white-collar occupations
- Median family income
- Income disparity (Defined by Singh as the log of 100 * the ratio of the number of households with <$10,000 in income to the number of households with $50,000 or more in income.) (25)

- Median home value
- Median gross rent
- Median monthly mortgage
- Percent owner-occupied housing units (home ownership rate)
- Percent of civilian labor force population >= 16 years of age unemployed (unemployment rate)
- Percent of families below the poverty level
- Percent of population below 150% of the poverty threshold
- Percent of single-parent households with children <= 18 years of age
- Percent of households without a motor vehicle
- Percent of households without a telephone
- Percent of occupied housing units without complete plumbing
- Percent of households with more than one person per room (crowding)

These 17 indicators are weighted using factor score coefficients to deliver appropriate weightings for the most influential elements.

More detail is available here:
https://www.ncbi.nlm.nih.gov/labs/pmc/articles/PMC4251560/

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