Nature Quant

Nature Access and Environmental Justice:

Addressing Nature Access Disparities in the United States

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Introduction

Given the clear connections between nature and health, and the existing inequities in nature access in the U.S., Environmental Justice frameworks must include a measurement for nearby-nature.

A clean and healthy environment is a basic necessity of human life, as are balanced ecosystems, biodiversity, and other elements of nature on which people depend. Indeed, more than 100 constitutions across the world now include a human right to a healthy environment, with those documents serving as a powerful tool to protect the natural world.

The EJ movement promotes environmental, economic, and social justice by recognizing the direct links between economic, environmental, and health issues and demands a safe, clean community and workplace environment for all. A healthy and safe environment is a public good to which every person in the United States has an equal right, both in principle and in law. However, the reality is that American society has distributed nature's benefits—as well as the harms of an industrial society—unequally by race, income, and education status.

Certain environmental injustices related to harmful pollutants, such as the disproportionate concentration of toxic air pollution near communities of color, have been thoroughly demonstrated; but automatically measuring proximity to nature has been more elusive. As discussed below under Nature Access and Environmental Justice, nearby natural elements, like outdoor green spaces, blue spaces, and tree canopy, are unevenly and inequitably distributed. Particularly in communities of color and low-income communities, nature is often out of reach for many families. As the links between exposure to nature and mental and physical health become clear, access to nature must become another central component of the EJ movement.

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One potential reason that access to nature has not been rigorously examined is that technical challenges exist in nature quantification and nature exposure assessment. Additionally, the scientific, medical, and political communities lack consensus around a standard definition or measurement of nature or nature exposure. Finally, at least in the United States, there is limited public promotion or understanding of the health benefits nature exposure can provide.

To address this dilemma, NatureQuant has developed innovative technology tools to quantify the natural elements for any static location or area (yielding a "NatureScore®"). As demonstrated below under Nature Score and Health, NatureScore™ technology shows that beneficial natural elements are not equally distributed across socioeconomic and racial groups. As a result, communities of color and low-income communities are far more likely than other communities to live in a place that is deprived of the benefits of nature, including nearby places that allow them to get outside safely and access clean water, clean air, and diverse wildlife.

The "Urban Century"

Humanity is undergoing a monumental shift, rapidly moving from a largely natural, outdoor existence to life in a more built, urban surrounding. Our current "built environment" is dramatically different from the one we occupied for 99% of human history, as it physically separates us from the natural world. Most people—over half globally, and approximately four in five in the United States—live in urban areas, where nature contact tends to be limited. This means that humans are increasingly disconnected from nature. In short, there is a growing nature deficit. As we have begun systematically studying the impact of this fundamental change, links between declining nature exposure and increasing depression, anxiety, heart disease, and obesity over the last five decades are becoming clear.

A large and growing body of scientific literature demonstrates that contact with nature (broadly defined as green space, parks, forests, bodies of water, etc.) can lead to measurable psychological and physiological health benefits. Natural areas also have been linked to other positive effects, like improved property values, lower pollution, reduced crime rates, strengthened communities, and slowed viral and bacterial disease transmissions. On par with changes in exercise or diet, nature contact offers promise both as prevention and as treatment of many serious diseases. Additionally, potential advantages of nature exposure include low cost (relative to conventional medical interventions), safety, and practicality (not requiring individualized attention from highly trained professionals). Few, if any, medications or other interventions can boast these attributes.

The Science Behind Nature Exposure and Health

Overwhelming evidence in the scientific literature links nature exposure to improvements in physiological and psychological human health. Over 150 observational studies and 100 interventional studies, tracking over 300 million individuals from 20 countries investigating 100 unique health outcomes, have convincingly demonstrated that greater nature exposure results in improvements in health span and longevity.[1] In short, these studies prove that nature exposure can result in a longer, healthier, and even happier life.

HOW DOES NATURE HAVE SUCH A PROFOUND INFLUENCE ON HUMAN HEALTH?

We don't yet have the whole answer, but a number of associations and direct links are becoming clear. Part of the answer is that humans have become more separated from nature than ever before, with a dramatic shift worldwide to more people living in urban environments.[2,3] This shift coincides with increases in the primary causes of death. According to the National Center for Health Statistics, in the United States the primary causes of death include heart and vascular disease, cancer, chronic respiratory disease, cerebrovascular disease (i.e., stroke), Alzheimer's and related dementias, and diabetes. While many of the underlying causes of these diseases are well known (for instance, sedentary lifestyle, poor eating habits, and chronic psychological stress), there are contributing or mediating factors as well, many of which are associated with a lack of nature exposure. Figure 1, below, displays data from a meta-analysis demonstrating the strong relationship between nature exposure (specifically, green space) and improvements in all-cause mortality. A meta-analysis is an evidence-based study with a greater ability to extrapolate outcomes to the greater population than individual studies. What this meta-analysis demonstrates is that, consistently across a number of independent studies collectively investigating over 8 million people, a greater level of greenness surrounding a person's home was associated with a longer life. Importantly, these epidemiological studies control for many potential alternative explanations (such as socio-economic status), definitively demonstrating the health benefits of nature exposure. As displayed in the graph, all studies and the combined data are shifted towards the level of greenness favoring all-cause mortality prevention.

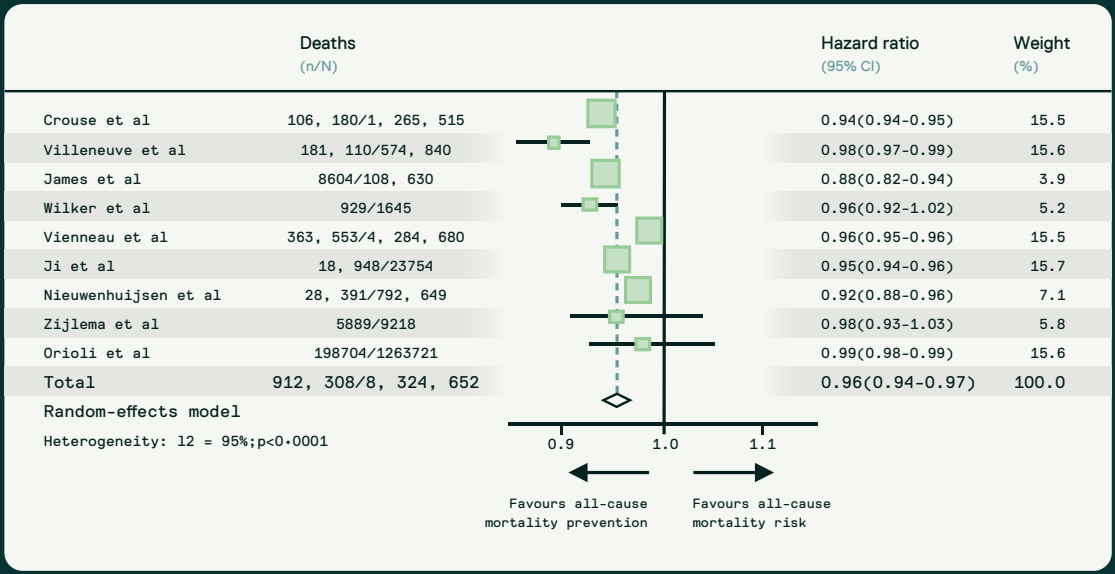


Figure 1. Results from individual studies and a meta-analysis strongly demonstrating the influence of exposure to greenness favors longevity and prevention of all-cause mortality even when many other factors are considered.

The relationships that underpin the health and longevity benefits of nature exposure are complex and multifaceted, and a number of psychophysiological and social pathways have been proposed that generally link the benefits of nature to health, including improved air quality, increased physical activity, more frequent social contacts, and decreased stress.[5]

In an effort to simplify the empirical literature from distinct disciplines, four domains that emphasize different functions of nature have been proposed by Markevych et al (2017)[6]:

1) Environmental Quality, 2) Stress Reduction 3) Physical Activity, and 4) Social Contacts discussed on the following pages, and graphically represented above in Figure 2.

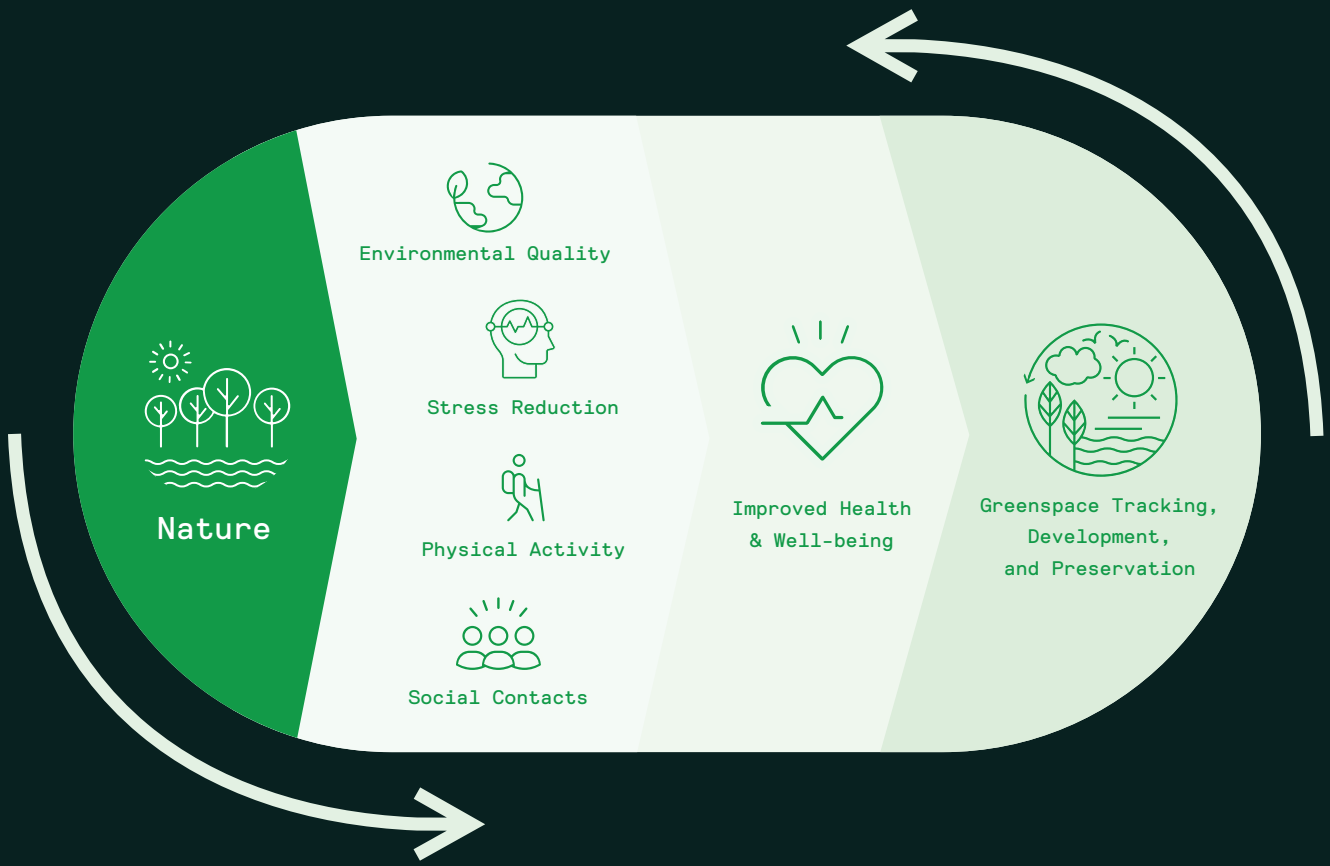


Figure 2

1. ENVIRONMENTAL QUALITY

In this paradigm, Environmental Quality captures the benefits of the urban natural environment through the effects on air quality, noise reduction, reducing urban "heat island effects", lowering building energy costs[7], and improving microbial biodiversity enhancement. In terms of improving microbial biodiversity, use of greenspace in cities increases exposure to a range of micro-organisms, including bacteria, protozoa, and helminths, which are abundant in nature and may be important for the development of the immune system and the regulation of inflammatory responses. This "old friends," hypothesis proposes that lack of exposure to immunoregulatory microorganisms in modern urban societies is resulting in an epidemic of inflammatory disease, as well as psychiatric disorders in which chronic, low-level inflammation is a risk factor. Recent studies indicate that treatment with a specific soil bacterium, Mycobacterium vaccae, may alleviate depression and PTSD[8]. Lastly, nature promotes sustainability through habitats for urban wildlife and reducing flood risk by decreasing impervious surface area[9].

2. STRESS REDUCTION

Stress Reduction encompasses the mental and physiological aspects of human health through reduction in stress. Given the links between mental and physical health, the importance of the natural environment on psychological health cannot be over emphasized.[10,11] A number of studies link exposure to the natural environment with mental health benefits through mechanisms such as visibility of urban green spaces for rest and restitution.[12–15] Factors such as improved mood, elevated self-esteem, reduced cognitive fatigue, enhanced attentional capacity and well-being, promoted emotional recovery, and reduced inflammation have all been reported.[12,16]

3. INCREASING PHYSICAL ACTIVITY

Increasing Physical Activity occurs through enjoying accessible, safe, and pleasing places to exercise and experience the natural environment. The benefits of exercise on health are well known and go beyond improvements in typical biomarkers such as reduced blood pressure, improved blood chemistry, and greater strength and endurance.[17] In this context, nature also plays an important role in creating a "culture of health," a culture that supports health improvement by fostering healthy, equitable communities that enable everyone to make healthy lifestyle choices.[18]

4. SOCIAL CONTACTS

Social Contacts describes the benefits of urban natural environments through improved social interactions among people[19] and greater social cohesion.[20] Nature contributes to improved social contacts by building a sense of community, focused on trust, shared norms and values, positive and friendly relationships, and feelings of being accepted and belonging.[21] Residents in neighborhoods with more, and/or higher quality streetscape greenery experience less stress and more social cohesion; in addition, they spend more time on physical activity.[22]

Access and exposure to natural environments impact health and well-being within each of these domains through numerous physiological pathways, including lowering concentrations of cortisol, lowering heart rate and blood pressure, decreasing sympathetic nerve activity, and increasing parasympathetic activity.[23,24] A growing body of evidence suggests this relationship is especially strong for low-income and nature-deprived urban populations.[25,26] Lower exposure to green space in these populations has been associated with a number of lifestyle diseases, such as obesity, Type II diabetes, and osteoporosis, as well as stress-related illnesses, such as depression, heart diseases, and mental fatigue.[22,25]

Importantly, improved health and well-being support the preservation and restoration of nature, allowing for a cycle of health and nature improvements. This comes from the perceived value of the natural environment in cities, pride in community, and improved property values.

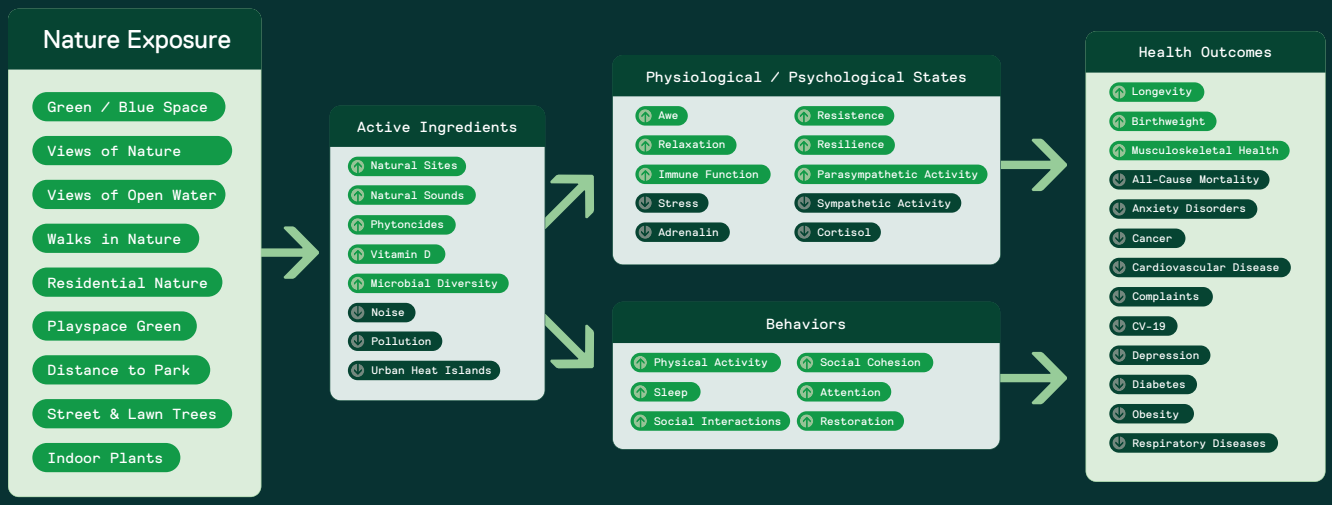


Figure 3

NatureScore® and Health

While it is difficult to untangle the many components that influence a population's health, the analysis below compares NatureScore® by census tract against health statistics for the 500 largest cities in the U.S. The analysis demonstrates a strong association between the presence of nature and health outcomes. Every negative health indicator is inversely associated with observable nature elements (more nature, less disease), while life expectancy is positively correlated (more nature, longer life).

These findings become critically important because, as detailed below, access to nature is not equitably available.

All of these correlations are statistically significant, with confidence intervals exceeding 99.9%.

Pearson Correlation to NatureScore

Based on 29,296 Urban Census Tract Scores, Grouped by State

	Diabetes	Frequent Mental Distress	Frequent Physical Distress	Obesity	Physical Inactivty	Life Expectancy
National Average	-0.18	-0.36	-0.27	-0.25	-0.32	+0.34

NatureScore mesasurements derived from 29,296 census tracts and the 500 largest U.S. cities. U.S. Small-area Life Expectancy Estimates Project (USALEEP):Life Expectancy Estimates File, National Center for Health Statistics. 2010-2017.

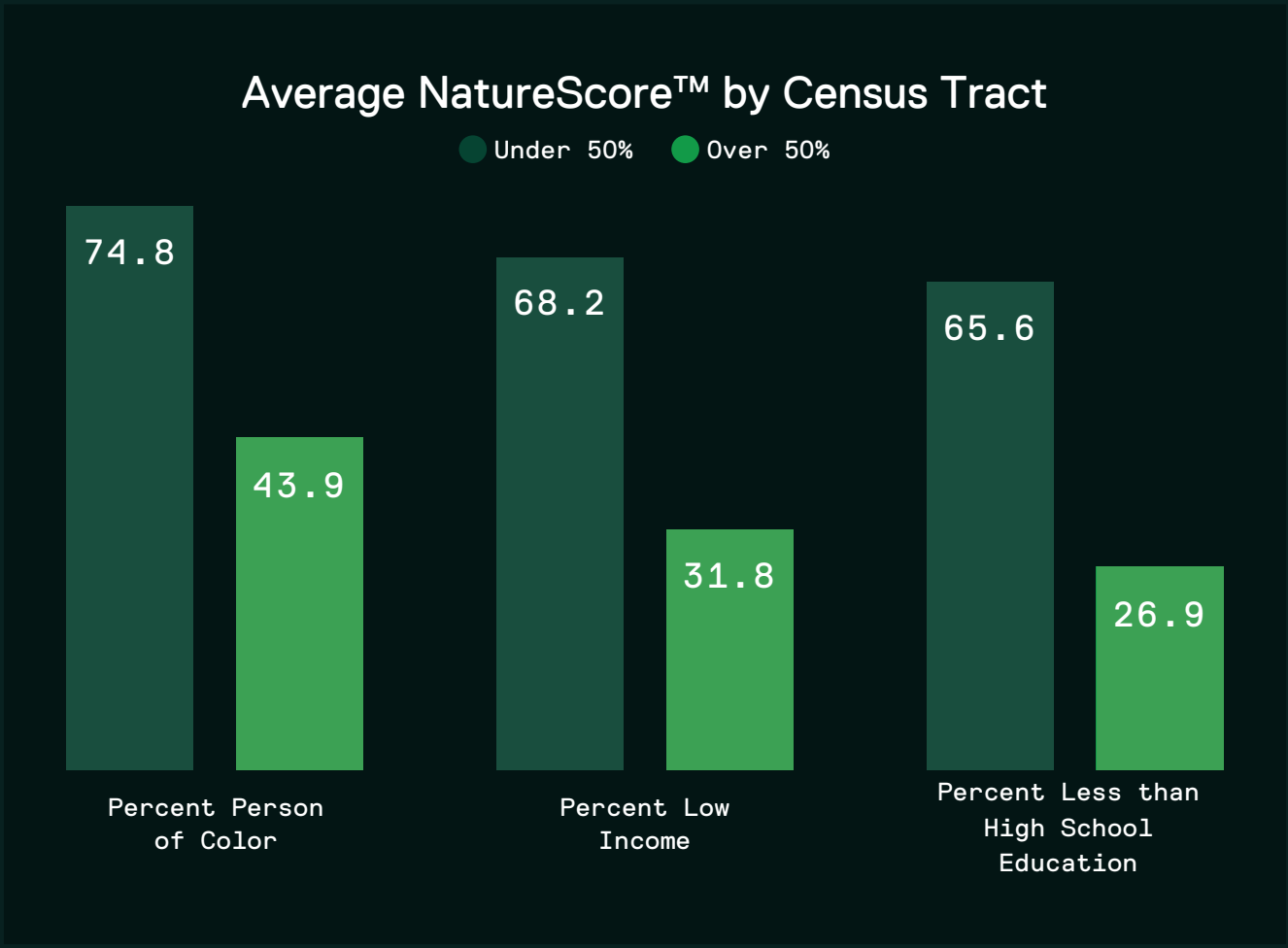
NatureScore®

Illustrative Data Sources. NatureQuant synthesizes numerous data sources to create a "NatureScore®" for any given location. By applying evolving algorithms to an ever-increasing body of health, location, and natural element databases, NatureQuant teases out the critical elements of exposure to optimize the health impacts of the tracking tools.

Nature Access and Environmental Justice

The following analysis examines the distribution of natural elements by neighborhood (as defined by 217,739 census block groups) to help understand the types and extent of disparities in nature access that exist in the United States. Further, this analysis looks at the correlations between NatureScore™ and various EJ Indexes for pollution and disease risks.

This report is intended to supplement, not supplant, the many individual voices and efforts that have been identifying and working to correct existing inequities and injustices. The data helps confirm the scale of racial and economic disparities in nature access. Notably, families of color and/or low income have materially less access to nature than others; in short, these communities are disproportionally nature-deprived.



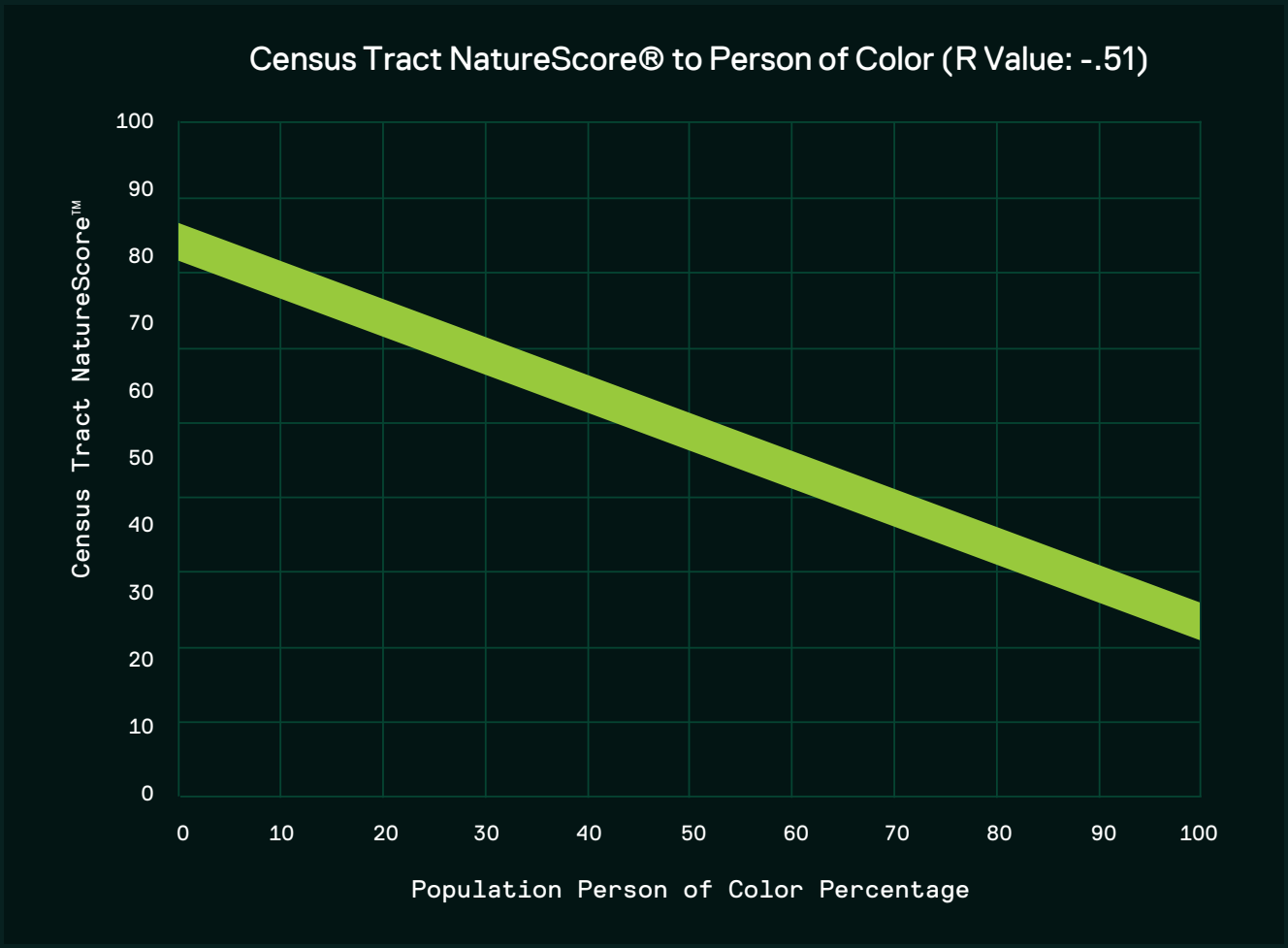
In this analysis we have compared NatureScore® by census tract block to the following demographic indicators, collected from the EPA's EJScreen.

Percent People of Color: The percent of individuals in a block group who list their racial status as "a race other than white alone" and/or list ethnicity as "Hispanic or Latino"; thus, all people other than non-Hispanic white-alone individuals are considered a Person of Color. The word "alone" in this case indicates that the person identifies as a single race, not multiracial.

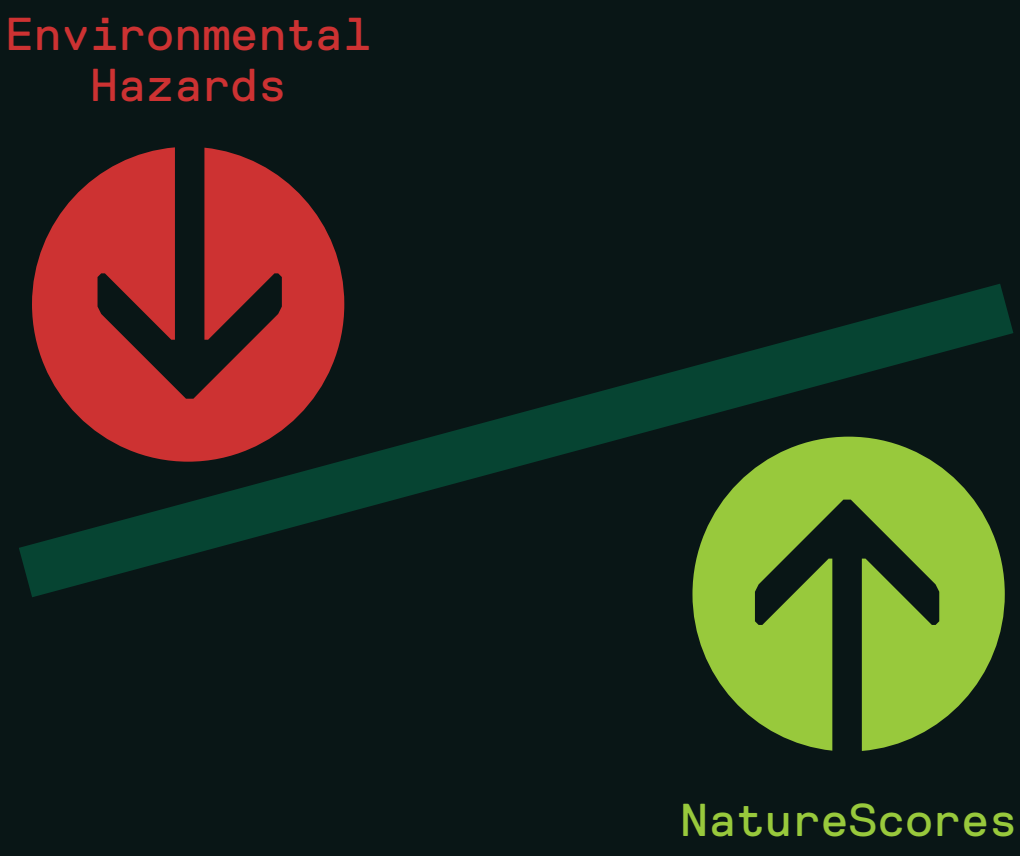
Percent Low-Income: The percent of a block group's population in households where the household income is less than or equal to twice the federal poverty level.

Less than High School Education: Percentage of people age 25 or older in a block group whose education falls short of a high school diploma.

The NatureScore® correlation analysis reveals significant inequities in nature access for marginalized populations. For example, while the national percentage of people of color is 37%, in 66% of the census block groups with a NatureScore™ of 10 or below (nature deprived) the majority of the population were people of color. Across all three demographic metrics we measured, on average, tracts reporting wealthier, whiter, and more highly educated populations had materially higher NatureScores (indicating better access to nature and its protective benefits).



There is a powerful inverse relationship between the presence of nature and the reduction of environmental risks.



Further, we examined the relationship between NatureScores® and various environmental hazards. The results yield a strong negative association across all measures. Put simply, in areas with more nature people generally find better air quality and less environmental risk. Note that all of these correlations are statistically significant with confidence intervals exceeding 99.9%.

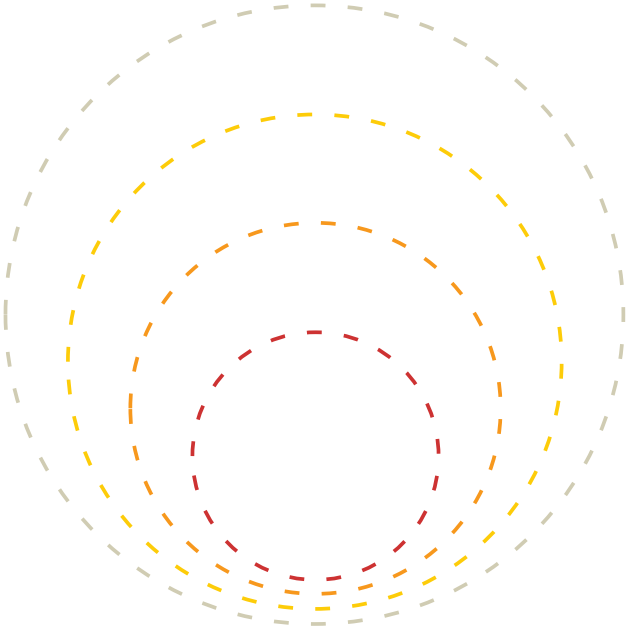
Pearson Correlation to NatureScore

R-Score, Based on 217,739 Census Block Groups

NatureScore™

	↓
Demographic Indicators	
% People of Color	-0.51
% Low-Income	-0.19
% less than high school	-0.25
Air Quality Indicators	
Air Quality Indicators	-0.57
Air Toxics Cancer Risk	-0.26
Air toxics Respiratory Hazard Index	-0.42
Ozone level in Air	-0.23
PM2.5 Level in Air	-0.32
Environmental Hazard Indicators	
Traffic proximity and volume	-0.41
Proximity to National Priorities List (NPL)	-0.16
Proximity to Risk Management Plan	-0.29
Proximity to Treatment Storage	-0.31
EPA Environmental Justice Indices	
EJ Index for Diesel Particulate Matter	-0.38
EJ Index for Air Toxics Cancer Risk	-0.38
EJ Index for Air Toxics Respiratory Hazard	-0.39
EJ Index for Ozone Level in Air	-0.41
EJ Index for PM2.5 Leel in Air	-0.40

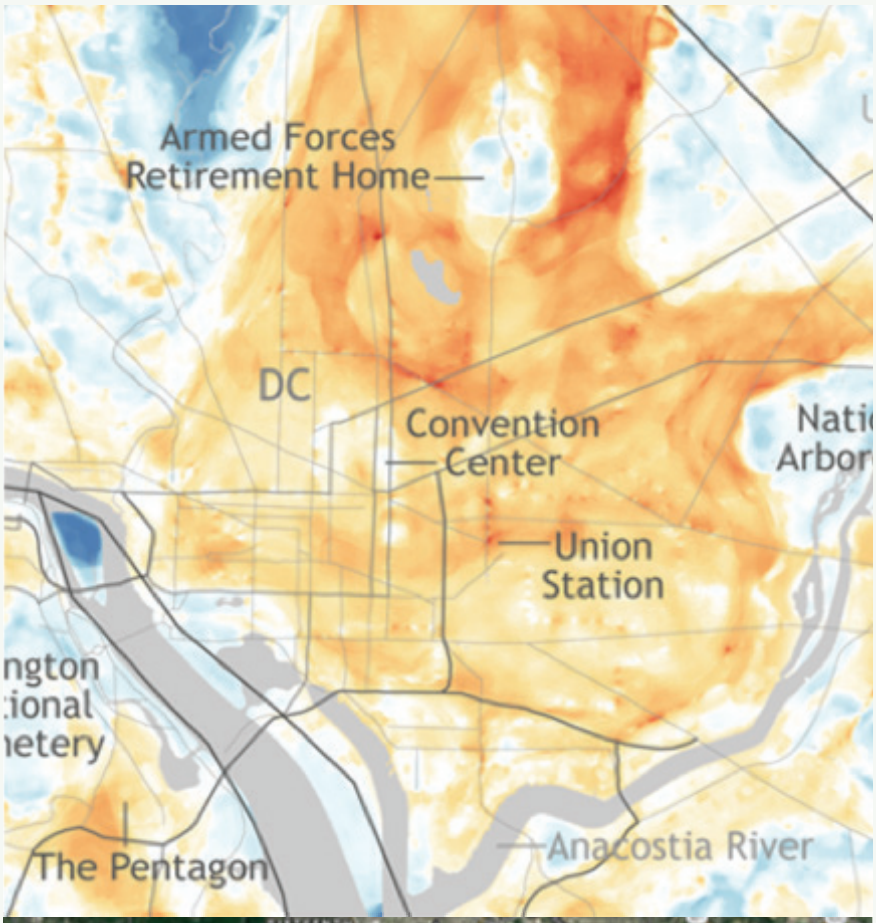
*Data Sourced from EPA EJSCREEN, 3/22/21 (https://www.epa.gov/ejscreen/what-ejscreen)

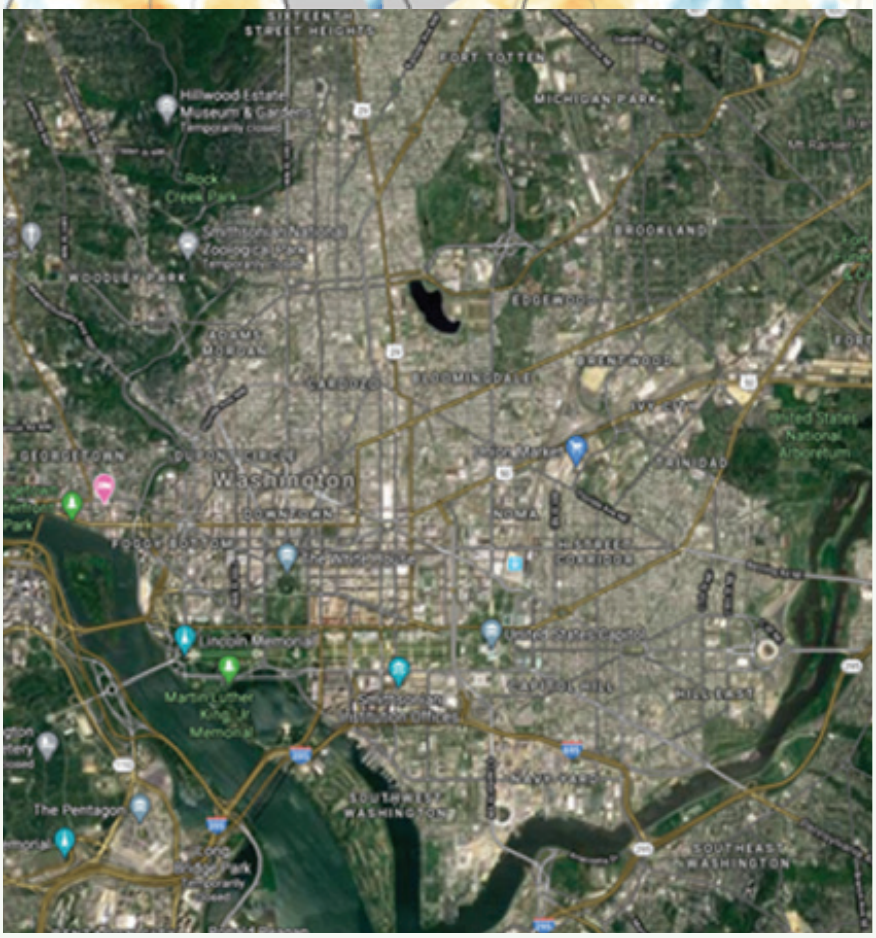


Nature and Urban Heat Islands

Urban Heat Islands occur when cities replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. This effect increases energy costs (e.g., for air conditioning), 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 have increased markedly in the last decade. Trees, green roofs, and vegetation can help reduce Urban Heat Island effects by shading building surfaces, deflecting radiation from the sun, and releasing moisture into the atmosphere.

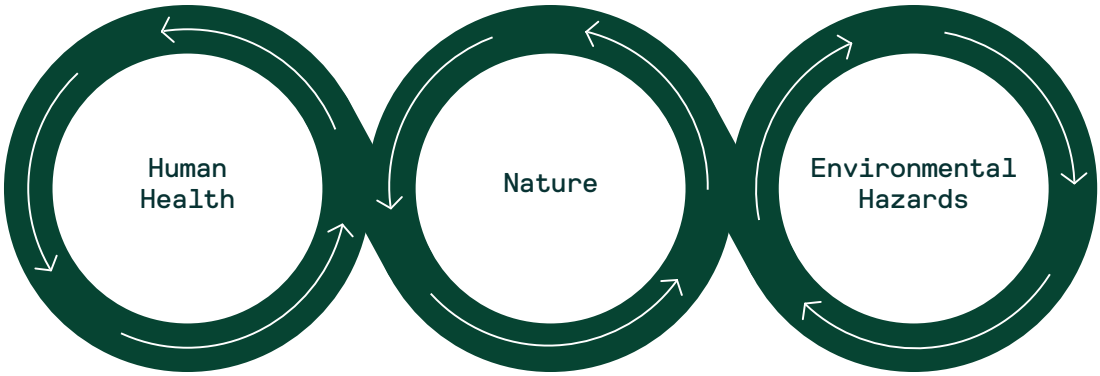
As the image below shows, a lack of natural elements can provide an excellent predictor of where Urban Heat Islands may occur. Note that the areas with the least vegetation cover are generally the hottest; red areas are hotter while blue areas are cooler.





NatureQuant analyzed data from 4,165 census tracts using the CalEPA Urban Heat Island Index and found that the NatureScore™ by census tract predicted the prevalence of Urban Heat Islands. In coastal cities with consistent coastal winds, the correlations were weaker (R: 0.22), but for inland cities, a stronger connection was found (R: 0.38). While many factors influence the existence of an Urban Heat Island, NatureScore® can provide a helpful proxy.

While it is now understood that nearby nature bestows powerful health benefits, the mitigation of Urban Heat Islands is another reason for individuals, city planners, and businesses to track and monitor nature.



Nature Access is a Health Infrastructure Tool and Human Right

Inequities in nature access are particularly concerning because nature is not an amenity but a necessity for everyone's health and well-being. In the places where human activities in the United States have destroyed the most nature, fewer trees filter the air and provide shade on a hot day; 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.

Most existing models, like the EPA EJSCREEN or CalEnviroScreen, do an excellent job of matching sensitive populations and environmental hazards (like pollution); but they largely ignore the direct and clear benefits that proximity to nature can provide.

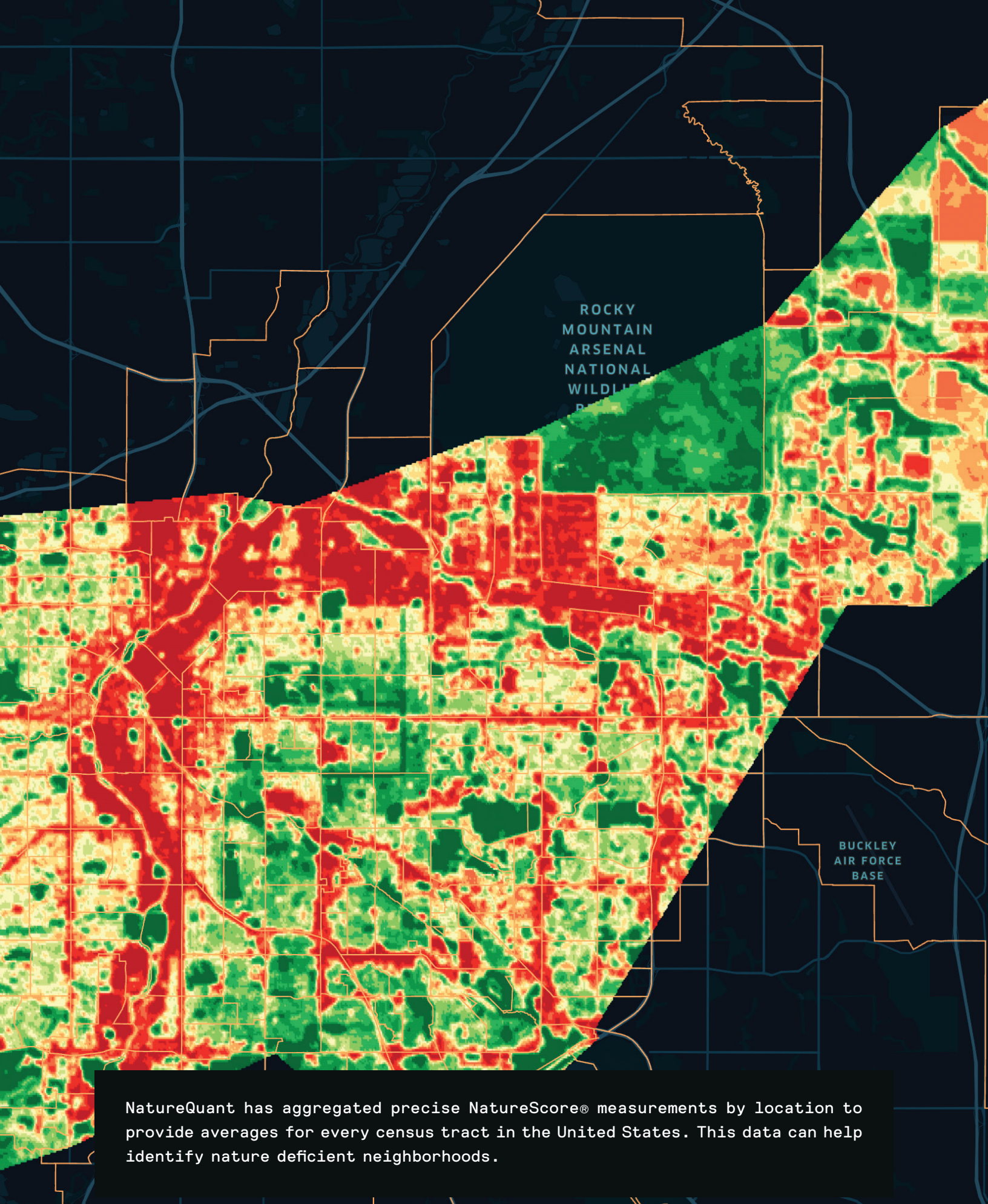
> Given the clear connections between nature and health, most Environmental Justice frameworks must include a measurement for nearby-nature (like the NatureScore®).

The Nature Quantification Solution:

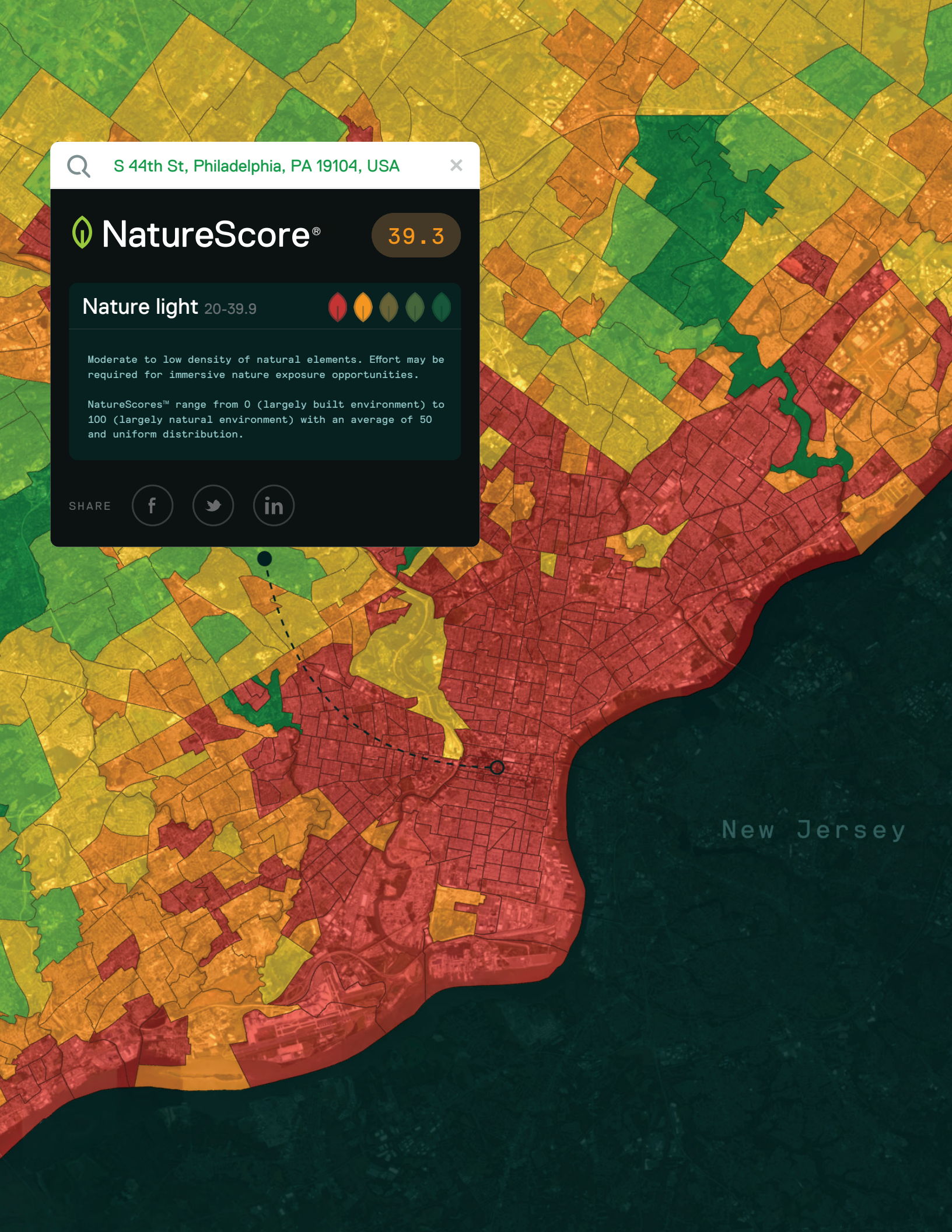
NatureScore®

NatureScore® measures the amount and quality of natural elements for any location using a patent-pending system. For each physical address, NatureQuant analyzes and blends various data sets and processed information within a given radius, including satellite infrared measurements, GIS and land classifications, park data and features, tree canopies, air, noise, and light pollutions, and computer vision elements (aerial and street images).

The considered elements are weighted to create the highest correlation with the predictive health impacts of given natural elements via a machine learning process. Note that certain "natural" elements that have not demonstrated positive health correlations, like sand or rock, therefore do not contribute to a high NatureScore like live vegetation.



NatureQuant has aggregated precise NatureScore® measurements by location to provide averages for every census tract in the United States. This data can help identify nature deficient neighborhoods.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NatureScore®
39.3
Nature light 20-39.9
Moderate to low density of natural elements. Effort may be required for immersive nature exposure opportunities.
NatureScores™ range from 0 (largely built environment) to 100 (largely natural environment) with an average of 50 and uniform distribution.
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