Healthy Urban Environments (HUE) Initiative
Arizona State University

Project Update: Third Year, Fourth Quarter, 2022
Date of Report: April 30, 2022

Project Overview

As outlined in the Healthy Urban Environments (HUE) Initiative proposal, ASU has launched HUE as a solutions-focused research, policy and technology incubator to rapidly develop, test and deploy heat-mitigation and air-quality improvement strategies and technologies. This will be accomplished through four project components: 1) research, solutions and innovation incubator; 2) communication, networking and solutions hub; 3) implementation and evaluation of new insight in real-world contexts; and 4) public, workforce and management education and capacity building. The schedule for delivery of each component as proposed is shown below; we will report on progress for each of these components separately in the following pages.

Project Summary: April 30, 2022

During the fourth quarter, the Healthy Urban Environments initiative continued to focus on implementation of solutions and institutionalization of approaches for improving local thermal comfort and reducing air pollution exposure, which in turn support continued economic advancement in the Phoenix region. Highlights of this quarterly report:

- A research project that quantifies the air quality benefits for adoption of electric vehicles (EVs) and seeks solutions to make EV adoption feasible in low-income communities.

- A collaboration between HUE and the City of Phoenix to develop a toolkit to prioritize tree planting and shade in communities most impacted by extreme heat.

- Continued collaboration between HUE and Paideia Academy in South Phoenix to quantify the impact of HUE-led redesign of outdoor play space to make the environment more thermally comfortable and to mitigate air pollution exposure.

- A new effort focused on commercial product development to make asphalt roofs more energy efficient and promote local job creation.

1. Research, Solutions and Innovation Incubator

Overview:
ASU will develop a research, solutions and innovation incubator to test novel heat and air pollution mitigation technologies; deploy field demonstration projects to quantify the heat and air quality mitigation effectiveness; and modeling projects to simulate the impact of heat and air quality mitigation approaches.

April 30, 2022 Status:

Transportation is a major source of urban and regional air pollution in the United States, impairing air quality with tailpipe emissions such as ozone precursors and particulate matter. Since electric vehicles (EVs) do not have a tailpipe, they are widely seen as a key technology for reducing local air pollution. Yet while the potential air quality benefits of EVs are *qualitatively* recognized, there is relatively little research that *quantitatively* estimates the air quality impacts of EVs. For example, a recent review article on air pollution found only seven studies globally that investigated how EV adoption could affect ground-level ozone. Estimating local air quality impacts is challenging, because it depends on a variety of technical and environmental factors, including season, driving patterns, vehicles replaced, and proximity to power plants. Nevertheless, it is critically important for policymakers to have a sense of how air quality would be improved by EV adoption, and furthermore to know how to tailor policies for the largest benefit. This is especially relevant in Maricopa County, given that Phoenix is among the most polluted areas in the U.S.

In this project, HUE researchers analyze the impact of EV adoption scenarios on air pollutants in Maricopa County. We particularly focus on air quality impacts for low-income and minority communities, which are disproportionately burdened due to their proximity to highways and industrial zones. EVs may have mixed effects for these communities; on the one hand, emissions will be reduced near high traffic roads and distribution centers, but on the other hand, emissions may be increased near coal or natural gas power plants, which also tend to be sited near vulnerable communities. Examining these effects requires an integrated analysis of traffic flows, marginal emissions from power generation, and spatial patterns of urban socioeconomic and demographic characteristics. In addition, it requires the development of various scenarios for EV adoption and charging.

This project will conduct the following components in our analysis:

First, we will provide a macro perspective by modeling how regional EV adoption will affect emissions in vulnerable communities. Using traffic flow models and an electricity dispatch model, we will generate spatial emissions profiles for different scenarios of EV adoption between 0 and 50 percent. Emissions from electricity production will be sensitive to the timing of EV charging, existing loads, and the lowest cost generator at a given time. Differences in emissions from transportation will use per mile emissions factors of ozone and particulates precursors (NOx, SOx, PM2.5, NH3, and VOCs) for EVs and the vehicles they would displace. Different scenarios will be compared as the difference from a no-EV scenario. The impacts on different communities will then be evaluated to understand who benefits and who is harmed in each scenario via exposure to pollution associated with the emissions in these scenarios.

Second, we will examine scenarios in which EV adoption occurs specifically in low-income and predominantly minority communities. This will build leverage our research currently underway that surveys low-income households on EV preferences and barriers and examines factors in providing EV charging in multi-family units (Parker). We can use these studies to identify Census blocks most likely to have the demographic and urban built environment features favorable for EV adoption. We will couple this with demographic data from the Census and the EPA EJ Screen to have a full characterization of communities across Maricopa County. We will then model the impact of a reduction in cold-start emissions due to EV adoption in these Census blocks as compared to a uniform adoption of EVs across Maricopa. This will provide policy makers with an understanding of the value of targeting EV adoption for these communities.

Third, we will identify neighborhoods most impacted by pollution due to truck traffic for distribution centers and evaluate the impact of electrification of delivery vans originating from and delivering to those distribution centers. These two will be evaluated separately as the delivery van electrification is more feasible in the near term.

This research will produce several types of knowledge outcomes – including estimates of emissions reductions, tools for data visualization, and models that can be applied for further analyses – to support local and regional air quality policymaking. We will share findings with the community through two major pathways. First, we will leverage our existing connections with Arizona Thrives, the Sustainable Cities Network, and the ASU-SRP strategic partnership to conduct outreach and presentations for community stakeholders. This project will generate data visualizations, including maps of spatial differences in pollutants under different scenarios and low-income census tracts with favorable characteristics for EV adoption, that will be highly useful for cities to use in their own policy and program development. We will make these data visualizations available online for cities to explore and utilize.

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2. Communication, Networking and Solutions Hub

Overview:
Arizona State University (ASU) will convene workshops to share mitigation approaches, initiate new inquiries to expand on urban heat and air quality improvement strategies, and provide summative reports on relevant community strategies for interventions for urban heat and air quality.

April 30, 2022 Status:

Increasing urban tree coverage and shade availability is a focal point of many municipal plans in Maricopa County. This project will build a next-generation, publicly accessible, customizable decision support tool for guiding equitable tree and shade investments. The Tree Equity Score Analyzer for Maricopa County (TESA-MC) will be a community-shaped web map and modeling environment that integrates a wide suite of data, modeling, and information technology resources available from Arizona State University, American Forests, municipalities, and other partners.

Tree and shade initiatives address the region's heat and air quality challenges through multiple causal pathways. Most immediately, trees and engineered shade significantly lower the mean radiant temperature (MRT) experienced by people outdoors, which reduces health risks associated with heat exposure and increases thermal comfort. Trees can also reduce daytime air temperatures through modification of the near surface energy balance, and in some cases, directly reduce ambient concentrations of certain air pollutants. Regional air quality improvements can be realized as a co-benefit of tree and shade initiatives if more residents shift their transportation mode away from single-rider vehicle trips and toward public transit. Municipal tree and shade investments are accelerating in Maricopa County. Notably, the City of Phoenix added $1.5M to its operating budget in 2021 for a new Cool Corridors program that will add 1,800 trees each year along highly used walking routes. Phoenix is also planning to spend approximately $5M in tree planting and engineered shade investments as part of its 2022 American Rescue Plan Act allocation. All municipalities will have the opportunity to integrate tree and shade components into projects funded by the federal Infrastructure Investment and Jobs Act, including the Healthy Streets Program.

A significant challenge facing public sector entities and their partners in implementing tree and shade initiatives is selecting the locations that are most responsive to community need while balancing other quality of life and public safety considerations (e.g., roadway visibility, utility reliability). A history of under- and disinvestment in certain neighborhoods, combined with zoning and development practices that have been insufficiently attentive to heat-health and thermal comfort, has created significant inequities in access to cool spaces and shade across Maricopa County. Municipalities are actively working to change this multidecadal trajectory; equity and climate justice figure into climate action plans of Tempe and Phoenix, among others. Along the same lines, the Phoenix City Council signed a Tree Equity Pledge with American Forests in April 2021, committing to ensure adequate access to urban trees throughout the city.

Cities and their partners are using a wide variety of tools to support decision-making regarding tree and shade investments. Maps of current tree canopy cover, land surface temperature, and demographic variables such as poverty and racial identity frequently appear in planning documents and workshops. More sophisticated products are also in use in selected settings, including a HUE-supported Cool Corridor Prioritization tool in the City of Phoenix that incorporates state-of-the-art estimates for MRT and pedestrian exposure. All cities in the County have access to the American Forests Tree Equity Map (Figure 1), which combines environmental and social indicators for every neighborhood into a 0-100 score, accessible on a publicly-friendly interactive web map with easy filtering and layering capabilities.

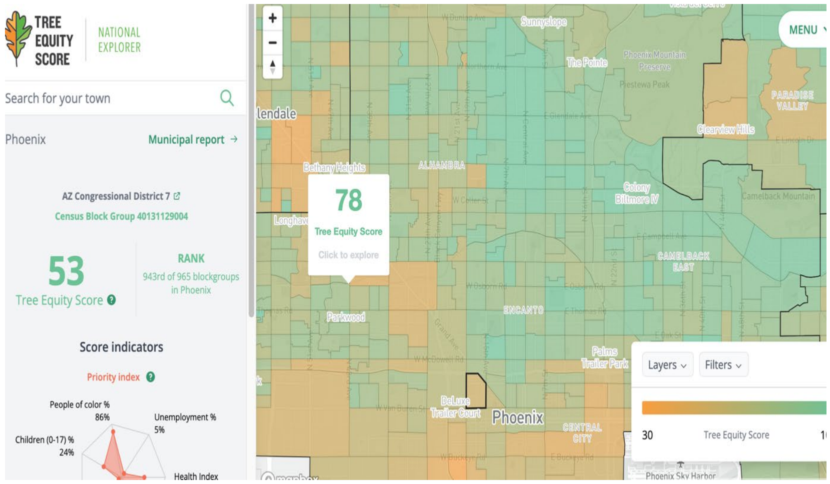

Fig 1 – Sample screenshot from American Forests Tree Equity Score Map, accessible online at treeequityscore.org.

Despite the significant progress made in developing tools to support tree and shade decision-making in recent years, major shortcomings persist. Most tools (1) are available at coarser spatial scales than those at which decisions are made; (2) do not explicitly incorporate information about shade coverage; (3) use proxy measures for thermal conditions including land surface or air temperature; (4) do not have reasonably recent information about tree points, canopy, or health; (5) are unfamiliar or inaccessible to community members and community-based organizations. Our proposal is to build TESA-MC in collaboration with American Forests and a network of local municipalities and non-profit organizations. TESA-MC will be a new publicly-accessible web-based platform for deliberation and decision-making around tree and shade investments in Maricopa County that overcomes the limitations of previous tools.

Our partnership with American Forests not only introduces additional data resources and technical capabilities, but also creates a conduit for extending the impact of ASU innovation and HUE investment.

The primary deliverable from this project will be a publicly-accessible web tool (TESA-MC) that integrates a wide suite of data resources to enable unprecedented and customized exploration, querying, and scenario evaluation. American Forests has previously developed a TESA for Rhode Island (Figure 2) and is currently developing one for Richmond, VA. This is aligned with HUE's mission of serving as a resource hub and solution center for local communities.

Fig 2 – Sample screenshot from American Forests Tree Equity Score Analyzer for Rhode Island showing improved spatial resolution of tree canopy. This level of resolution will be developed for Maricopa County under this effort.

TESA-MC will leverage the overall information technology architecture developed for those jurisdictions while integrating the significant data and modeling assets that are uniquely available for Maricopa County from ASU and HUE research. Envisioned functionality for TESA-MC that extends beyond the scope of current tools includes:

- Identification of all pedestrian corridors within each jurisdiction in Maricopa County that do not meet shade targets in the MAG Active Transportation Plan Toolbox
- Realistic two-dimensional simulation of tree planting in eligible areas (e.g., public right of way) and calculation of anticipated changes in shade coverage and tree equity scores
- Automated recommendations and comparisons for tree planting or shade structure projects to meet user-defined goals and specifications within a given area
- Cost-benefit analysis for user-specified tree and shade scenarios

One of the major technical advances in this project will be the development of high-resolution shade and MRT maps for the entire County and incorporation of those data elements into an interactive public tool. Previous HUE-supported field experiments quantified the benefits of natural and engineered shade to reduce outdoor heat exposure. While those observations can inform place-based decisions on shade infrastructure (e.g., should a specific bus stop be shaded by a bus shelter or tree), results cannot be extrapolated to all locations that may be of interest to TESA-MC users without modeling. This project scales up shade solutions that have been previously tested with MaRTy to the Phoenix metropolitan area. We will use the SOLWEIG model to calculate shade and MRT distributions in the region for typical summer days at 1-m resolution.

3. Implementation and Evaluation of New Insights in Real World Context

Overview:
ASU will test new solutions developed as part of HUE; conduct surveys and in-depth interviews with community members; and enable Technology Transfer and Intellectual Property licensing on all projects sponsored by HUE.

April 30, 2022 Status:

There is immense potential for a paradigm shift in the way we think about, design, and utilize outdoor play areas. The design and siting of contemporary school and childcare playspaces enhance the risk of heat and air pollution hazards, which can be lessened through place-based bioclimatic design. Yet minimal, if any, research has quantified the impact of schoolyard transformations to nature-based playspaces on localized (microscale) environmental exposure reductions, and synthesized these microscale data with related physical data (e.g., in-situ, drone, satellite, built environment). Since the start of HUE, our team has been involved in a deep collaboration with Paideia Academy in South Phoenix; working to design heat and air pollution mitigation approaches in to the physical infrastructure of the school; collecting microscale data to be the first to ever quantify long-term environmental changes based on a schoolyard re-naturalization; linking health, physical activity, behavior, school-based gardens, and education to local environmental conditions.

However, there is a growing challenge in working with such a high volume of historical and real-time data in ways to ensure they are used to their fullest potential. The richness and amount of environmental data collected can be enhanced through novel data science methods, encompassing data organization, cleaning, aggregation, and manipulation to perform advanced data analysis and visualizations for different user groups. In the last year, our team has noticed a gap in resources and abilities to synthesize the millions of data points we have collected at Paideia Academies for use in conjunction with related physical data types listed above, while increasing its potential future use alongside health data.

As part of our long-term commitment and collaboration with Paideia, focused on implementing solutions in a real-world environment, the current effort of HUE researchers includes:

1. Working with a data scientist to maintain and enhance our growing database of environmental data; work to process the data into unique data visualizations and maps for the school; work will entail data organization, cleaning, aggregation, and manipulation and long-term documentation for sharing.
2. Create methods, metadata, and processes for other parks or schools to follow for similar data collection; and
3. Continue to systematically monitor and document environmental changes that are being measured (air pollution, weather, noise)

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4. Public, Workforce, and Management Education and Capacity Building

Overview:
ASU will enable capacity through development and implementation of workshops aimed at stakeholders and community members; create online modules to be integrated into existing ASU outreach programs; and develop material for new workforce training programs.

April 30, 2022 Status:

Over 75% of North America housing has roof shingles, and 90% of those roofs are made with asphalt fiberglass material. Asphalt roofs are also considered one of the least energy efficient roofing materials. This is because they absorb and conduct heat from the sun to attics. As a result, consumer's demand for energy efficient roofs is greatly rising (Figure 3).

Fig 3 – Thermal image of an attic underneath asphalt shingles showing the heat that raises energy consumption to cool indoor spaces

Asphalt shingles typically age / dry out from the heat, making them brittle. In hot summer seasons, the aging mechanism is increased due to longer and higher temperature exposures; these temperatures can be up to 40 to 50 degrees F higher than air temperatures. An estimated 11 million tons of waste is produced annually in the U.S, due to shingles replacement. The life span of asphalt shingles ranges between 15 to 20 years.

There is a need to better tackle the energy storage inside homes and buildings. By making the asphalt shingles less temperature susceptible, this would help address the thermal storage problem, durability, reduced shingles cracking, and provide better heat mitigation overall.

The insulation mechanism proposed in this study refers to the addition of encapsulated aerogel product, called Aerogel Modified Bituminous material (aMBx); it was developed recently at Arizona State University. The aMBx is an asphalt coated granules with excellent thermal resistance properties (particles range from 0.1 to 3mm, density ranging from 0.32 to 0.38 g/cm^3, thermal conductivity from 0.15 to 0.20 W/m ^{o}K). They have been proven effective in providing thermal insulation and increased durability for asphalt binders and mixtures (Figure 4).

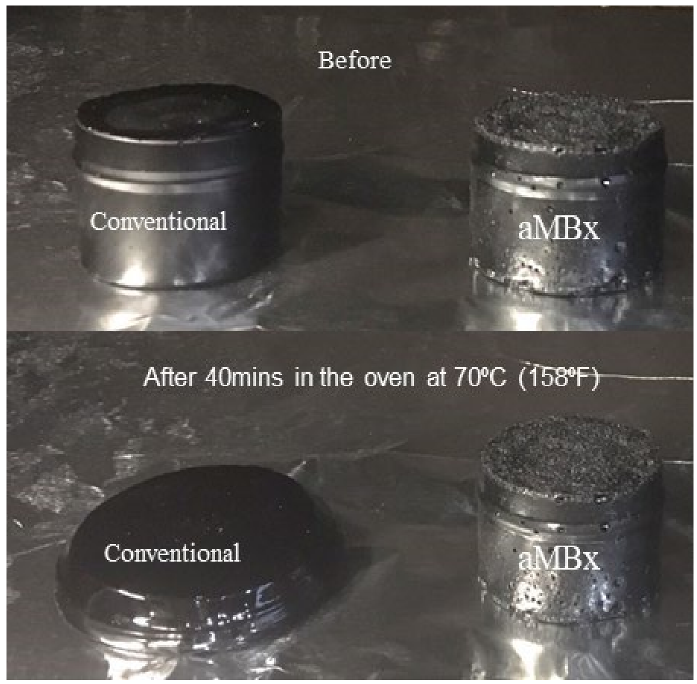

Fig 4 – Preliminary data showing the heat resistance capacity of aerogel modified asphalt materials

To spur a new industry in Phoenix responding to the need for heat resistant building materials, HUE researchers will:

1) Develop a method to successfully incorporate aMBx into the roofing shingle mastic. Develop understanding on the modified material composition, workability, consistency and production temperatures. It is anticipated to evaluate 2 to 3 dosages of aMBx. This task will focus on determining the proper mixture design, production temperatures and viscosities of the modified asphalt binders.
2) Perform laboratory tests to evaluate thermal properties and durability for conventional and aMBx modified asphalt shingles. Tests such as thermal conductivity, specific heat capacity and thermal expansion and contraction

will be conducted.

3) Use the data from Tasks 1 and 2 to model heat reduction and energy use in typical residential homes.

HUE researchers have interest in this research and material development project from GAF Material Corporation in the Phoenix area to help spur economic development and job creation to fulfill the HUE mission.