Evaluating the Use of Urban Heat Island and Heat Increase Modeling in Land Use and Planning Decision-Making

CLIMAS Investigators: Ladd Keith, Ben McMahan

Additional Investigator: Sarah Meerow (School of Geographical Sciences and Urban Planning, Arizona State University)

Graduate Students: Michael Darren Story, Tess Wagner, and Erika Schmidt (College of Architecture, Planning, and Landscape Architecture)

Key Partners: Josh Pope (Pima Association of Governments)

End Users: Urban planners, landscape architects, urban GIS managers, land developers in New Mexico and Arizona; Pima Association of Governments. New York City, NY, City of Miami, FL; City of Tucson, AZ; City of Seattle, WA; City of Houston, TX; City of Baltimore, MD; City of Detroit, MI; Sonoran Institute; Trust for Public Land; Green Infrastructure / Low Impact Development Working Group; Urban Land Institute; American Planning Association; NOAA Climate Program Office (CPO)

Additional Support: NOAA Climate Program Office Extreme Heat Initiative; University of Arizona – College of Architecture, Planning, and Landscape Architecture and Office of Research, Innovation, and Impact

Project Dates: 2017 – 2021

Summary of Impact

Advancing knowledge of urban heat: This research helped bridge a gap between research, policy, and practice, contributing to a more informed and proactive approach to urban heat governance across the U.S. Research findings advanced knowledge on the topic of urban heat governance, which was a previously under-researched area. Findings have informed discussions on heat-related programs and funding at local to national scales.

Building a network of heat researchers: Connections made through this work led to creation of the Extreme Heat Network, a global community of practice fostering collaboration and knowledge sharing through newsletters, seminars, and outreach.

Informing heat governance and planning efforts: Sustained engagement with communities in the Southwest, and outputs from this work such as updated urban heat island maps, have been used by city and county governments to revise heat planning and governance efforts.

Problem Statement

The impacts of the urban heat island (UHI) and extreme heat events are well documented, including increased public health issues, stresses on urban ecology, and energy usage to mitigate higher temperatures. Increased urban heat is of particular concern to cities in the

Southwest because it counteracts the cooling that otherwise normally occurs at night. While mapping and modeling have become more sophisticated, there is still a gap between the use of heat maps and models to inform urban planning and design strategies to mitigate urban heat.

Research Focus

This research focused on understanding how UHI maps and models could be used for decision-making and planning. The project proceeded in three main phases. The first phase involved evaluating and documenting the use of urban heat maps and models in communities in Arizona and New Mexico and evaluated opportunities to increase their usability. The next phase included a literature review on planning for extreme heat and a survey of U.S. planners on how they plan for extreme heat risk. A third phase built upon the previous literature review and survey and aimed to document the current state of extreme heat governance in the U.S., through five case studies, including Tucson, AZ; Houston, TX; Baltimore, MD; Detroit, MI; and Seattle, WA.

Project Activities

Interviews: Conducted 32 scoping interviews with planners, public health officials, and other decision-makers in AZ and NM local governments about their use of UHI maps, including Tucson, Phoenix, Albuquerque, and Las Cruces. The team also reached out to every incorporated city in Arizona and New Mexico with a population above 40,000 on their current use and knowledge of urban heat maps.

Map development: Created and delivered new UHI maps to the City of Avondale, City of Buckeye, City of Santa Fe, Dona Ana County

Literature review: Conducted a systematic literature review on planning for extreme heat.

Survey: Conducted a nationwide survey of planners (n=98) across the U.S. in communities of diverse sizes and geographies to document current heat planning efforts, information uses, and challenges.

Case studies: Developed case studies on current states of extreme heat governance in the U.S., including Tucson, AZ; Houston, TX; Baltimore, MD; Detroit, MI; and Seattle, WA. Methods included semi-structured interviews with decision-makers and content analysis of local plans for heat mitigation and management strategies.

Heat resilience pilot project: Piloted what would later become the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat with the City of Tucson

Network building: Established an urban heat community of practice, the Extreme Heat Network, with partner cities for them to share their uses and learn from each other.

Project Outputs

Maps:

Urban heat island maps were produced for urban planners and public sector agencies in the City of Avondale, AZ; City of Buckeye, AZ; City of Santa Fe, NM; and Dona Ana County, NM. In 2018-2019, maps were delivered to these partners via online meetings.

Resiliency Planning Interactive Map: The research team provided technical assistance to the Pima Association of Governments for the Tucson metropolitan region's Resiliency Planning Map update, resulting in a new heat severity map and other relevant layers of heat data.

Workshops:

Advancing the Theory and Practice of Urban Heat Resilience: This virtual workshop in 2020 brought together university researchers, leadership representatives from federal agencies (NOAA, USGS, EPA, CDC), non-profits, and stakeholders across the U.S.

Peer-reviewed Publications:

Hughes, H.B., D.D. Breshears, K.J. Cook, L. Keith, J.R. Burger. 2023. Household energy use response to extreme heat with a biophysical model of temperature regulation: An Arizona case study. PLOS Climate 2(4): e0000110. https://doi.org/10.1371/journal.pclm.0000110

Keith,L., C.J. Gabbe, E. Schmidt. 2023. Urban heat governance: examining the role of urban planning. *Journal of Environmental Policy & Planning* 25(5):642-662. https://doi.org/10.1080/1523908X.2023.2244446

Keith, L., S. Meerow, D.M. Hondula, V.K. Turner, J.C. Arnott. 2021. Deploy heat officers, policies, and metrics. *Nature* 598(7879):29-31. doi.org/10.1038/d41586-021-02677-2

Keith, L., S. Meerow, and T. Wagner. 2020. Planning for extreme heat: a review. *Journal of Extreme Events* 6(03n04): 2050003. DOI: 10.1142/S2345737620500037

Meerow, S., L. Keith. 2021. Planning for extreme heat: A national survey of U.S. planners. *Journal of the American Planning Association* 88(3):319–334. doi.org/10.1080/01944363.2021.1977682

Dissertation:

Keith L. 2019. Assessing Policy Innovation: Climate Action Planning in the U.S. Southwest. PhD Dissertation, University of Arizona.

Reports:

Keith, L. Final Summary Report for NOAA CPO. August 2021.

Keith, L., B. McMahan, T. Wagner. 2019. Urban heat island maps and decision-making. University of Arizona, Climate Assessment for the Southwest (CLIMAS). DOI: 10.13140/RG.2.2.35788.49282

Keith, L., S. Meerow. 2022. Planning for Urban Heat Resilience**.** Planning Advisory Services (PAS) Report 600. American Planning Association.

Keith, L., S. Meerow, P. Berke, J. DeAngelis, L. Jensen, S. Trego, E. Schmidt, S. Smith. 2022. Plan Integration for Resilience Scorecard for Heat: Spatially evaluating networks of plans to mitigate heat. American Planning Association.

Keith, L, S. Meerow, S. Trego, E. Schmidt. 2022. City of Tempe, AZ: Plan Integration for Resilience Scorecard™ (PIRS™) For Heat**.**

Network:

Arizona Extreme Heat Network: This project contributed to development of this online network, now called the Heat Resilience Initiative, an interdisciplinary community of research and practice on the causes, impacts, and strategies to increase resilience to extreme heat. The network has hosted a webinar series and published a monthly newsletter with updates on heat-related opportunities, events, news, and research.

On future partnership:

It's awesome having Ladd as a resource in our region. I look for ways we can work with him and ways in which we can share our work to help further his goals. I know his means are different in that you know it's more policy and that side of things, but the use of this information sparks discussion and new projects.

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Josh Pope, Pima Association of Governments

Op-Eds and Public Media:

Keith, L., A.K. Gerlak. 2021. There's no place in the US safe from the heat. *The Hill,* August 20, 2021.

Keith, L., S. Meerow. 2021. Cities must plan for heat resilience now. Thomson Reuters Foundation. July 5, 2021.

Keith, L., S. Meerow. 2021. Beat Extreme Heat with these 8 Tactics. Planning Magazine. Winter 2021:12-14.

Presentations:

Built Environment Panel at the Surviving Peak Drought and Temperature Workshop. 2018. National Center for Atmospheric Research.

Urban Resilience Lightning Talks & Networking Hour. 2018. Center for Climate Adaptation Science and Solutions.

CLIMAS Research Colloquium. 2019. Climate Assessment for the Southwest.

Arizona Extreme Heat Planning Workshop. 2019. Arizona State University and Maricopa County Department of Public Health.

Urban Dialogue and Masterclass and Member. 2020. Virtual Heat Health Forum. Global Heat Health Information Network (GHHIN).

Evaluating the Use of Urban Heat Island Maps for Extreme Heat Planning. 2020. American Collegiate Schools of Planning Annual Conference.

Heat Risk Project Update to NOAA CPO Heat Risk Team. 2021.

Best Practices for Cross Governmental and Interdisciplinary Collaboration to Advance Heat Governance. 2021. *Southeast Florida Regional Climate Change Compact's Virtual Workshop*

National Perspectives to Local Applications. 2021. *City of Tucson 12th Urban Heat Island Workshop*.

Prioritize and Integrate Heat Planning. 2021. *National Integrated Heat Health Information Systems (NIHHIS) Urban Heat Island Community of Practice Webinar Series.* NOAA.

Plan Integration and Governance. 2021. *NOAA Climate and Equity Roundtable: Heat Resilience in the U.S. Southwest.* NOAA.

Extreme Heat and Climate Justice. 2021. *American Collegiate Schools of Planning 2021 Annual Conference*.

Planning for Urban Heat Resilience. 2021. *SGDE Colloquium Series*. University of Arizona, School of Geography, Development and Environment.

Keeping Homes and Cities Cool: Heat Governance. 2021. *Arizona Senior Academy.* Academy Village. Tucson, Arizona.

Creating Cooler Homes and Schools. 2021. *Climate Adaptation Research Symposium 2021.* UCLA Luskin Center for Innovation. Los Angeles, California.

Urban Heat Resilience. 2021. *Wonder at Home*. University of Arizona Foundation.

Addressing Climate Risk through Equitable Community Development. 2021. Federal Reserve Bank of San Francisco.

Framing urban heat governance through five case studies. 2021. *American Collegiate Schools of Planning Annual Conference*. American Collegiate Schools of Planning.

Planning for Urban Heat Resilience. 2022. *SPAN Lecture Series.* Southwest Practitioners Adaptation Network.

Geospatial Online Tools for Public Participation Demonstrations. 2022. *Mapping the Way Ahead: Online Geospatial Tools for Public Participation.* University of Arizona, Udall Center.

Community Perspectives: Roundtable discussion with state and local partners to understand current priorities and challenges in heat resilience planning. 2022. *National Integrated Heat Health Information Systems (NIHHIS) National Meeting.* NIHHIS.

6th Annual Arizona Extreme Heat Planning Workshop. 2022. Arizona Department of Health Services, National Weather Service, Arizona State University, and University of Arizona.

City of Tucson Climate Action and Adaptation Plan. 2022. *Drachman Institute Relaunch.* University of Arizona. Tucson, Arizona.

Planning for Extreme Heat. 2022. *Lifelong Learning in Retirement at the Highlands.* The Highlands at Dove Mountain. Marana, Arizona.

Planning for Extreme Heat & Equity. 2022. *First Annual Symposium*. American Planning Association (APA) Sustainable Communities Division (SCD).

Integrating energy justice with community climate action planning. 2022. *EGU General Assembly 2022*. European Geosciences Union (EGU). Vienna, Austria.

The Effect of Vehicles on Personal Heat Exposure: A Pilot Study. 2022. *Annual Meeting of the Transportation Review Board*. Transportation Review Board. Washington, D.C.

Media Coverage:

Planning for Urban Heat Resilience with Dr. Ladd Keith and Dr. Sarah Meerow. 2022. *America Adapts: The Climate Change Podcast*.

It is Getting Hot in Here – Building Resilience to Address Extreme Heat. 2022. *Mrs. Green's World*.

Urban heat is an invisible threat – resilience against it shouldn't be. 2022. *SmartCitiesWorld*

Equilibrium/Sustainability – Texans cut off. 2022. *The Hill*.

How Cities are Trying to Combat the Nation's Deadliest Weather Risk. 2022. *Route Fifty*.

Equilibrium/Sustainability - Cities need to do more to confront deadly heat: study. 2022. *The Hill*.

Tucson pushes toward climate action goal. 2022. *KOLD News 13*.

City planners have tools to deal with heat. A new survey finds many may not be using them. 2022. *KJZZ – The Show*.

Extreme Heat & Urban Planning. 2021. *Come Rain or Shine Podcast*.

Extreme Heat in the News, Naming Heat Waves, Thermal Equity and more with Dr. Ladd Keith. 2021. *America Adapts: The Climate Change Podcast*.

What's old is new again. 2021. *Hothouse Solutions*.

Will More Cities Hire a Chief Heat Officer? 2021. *NBC LX*.

Facing Our New Climate Reality. 2021. *Dwell Magazine*.

Should air conditioning be a human right? 2021. *Hothouse Solutions*.

South Florida is getting hotter. But planners say there's a data gap in finding solutions. 2021. *WLRN – The Daily*

Extreme, deadly heat in Canada is going to come back, and worse. Will we be ready? 2021. *The Globe and Mail*.

No Safe Place On The Planet From Heat: Extreme Heat Is Becoming National Issue. 2021. *KJZZ – The Show*.

Neighbor wasting water? Is 'water shaming' the answer? 2021. *The Salt Lake Tribune*.

How will cities adapt to extreme heat? 2021. *The Week*.

Protecting yourself during extreme heat. 2021. *KVOA News 4*.

Keeping Homes and Cities Cool in Extreme Heat. 2021. *University of Arizona News*.

MONSOON 2021: Hiking in heat can have deadly repercussions in southern Arizona. 2021. *KOLD News 13*.

Urban Planners Looking to Standardize Heat Maps. 2019. KJZZ - Arizona Science Desk.

For Desert Dwellers, A Life in Balance. 2018. UA Research, Discovery and Innovation.

Hot Weather Forecast Warms Up Urban Planning Research. 2018. Arizona Public Media.

Selected Scientific Findings:

Lack of heat planning in literature: Findings from a systematic literature review on extreme heat planning research suggest that most studies focus on heat mapping and modeling, with fewer studies examining extreme heat planning and governance processes.

Heat is not adequately included in city planning: In the communities in the urban heat governance case studies, city plans did not adequately consider the impacts of extreme heat or include sufficient strategies to mitigate those impacts.

Separation of planners from heat governance: Planners have been siloed in heat governance with limited input into heat governance in their communities, or the policies, regulations, and actions aimed at addressing heat-related challenges.

Use of urban heat maps: Partner cities and counties indicated they want to use urban heat island maps to inform the conservation of natural and agricultural lands, prioritize shade interventions along trails and street corridors, and reduce the amount of parking lots.

Need for heat governance work: Heat governance is less mature than structures, processes, and actors for other climate risks, such as wildfire, flooding, and sea level rise.

Leveraged Funding:

Supporting this project:

- NOAA – Regional Integrated Sciences and Assessments Program: Urban heat and health interventions and evidence gaps ($40,000)
- NOAA – Plan Integration for Resilience Scorecard for Heat (PIRS™) ($147,474)

Supporting new initiatives beyond this project:

- U.S. Department of Transportation and the National Institute for Transportation & Communities ($75,000)
- U.S. Department of Transportation and the National Institute for Transportation & Communities ($5,000)
- Robert Wood Johnson Foundation ($584,886)
- City of Tucson and Buro Happold ($13,013)

Societal Impacts by Category

Conceptual:

- A nationwide survey of planners established baseline knowledge on the rapidly emerging topic of urban heat governance in the U.S. This work was cited by the Urban Institute in their Centering Equity to Address Extreme Heat report.

- This project informed federal discussions about developing and funding heat and health programs, including discussions about NIHHIS - National Integrated Heat Health Information System.
- Several media outlets reported on research findings from this project and the need for better extreme heat planning and governance in the U.S.
- The definition of heat governance conceptualized in a paper from this project is displayed in a call-out box for the NOAA/NIHHIS Maturity Model for Heat Governance.

Connectivity:

- The Extreme Heat Network (now the Heat Resilience Initiative) launched through this project is a community of research and practice that sends out a monthly newsletter, organizes seminar series, and has worked to expand heat networking globally.
- Ladd Keith has served in advisory roles for the New York City Mayor's Office of Resiliency and the Urban Design Forum. Keith also has served as an expert reviewer for the Urban Land Institute's report *Scorched: Extreme heat and real estate*.
- Long-standing partnerships were established with heat-related researchers at Arizona State University.

On university partnership:

From a public sector perspective, it was good working with {CLIMAS]. Ladd helped add some formality to the partnership, which helped my leadership feel more comfortable. I was very upfront with Ladd about how my leadership is anxious about us saying, "It's getting hotter here, and your efforts aren't cooling anything over here." So, working with the university and us being able to point to a collaboration on that was helpful. Ladd was quick to point out that no one else was doing this work, so there's not a lot [of other research] to compare this to.

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Josh Pope, Pima Association of Governments

- Ladd Keith's 2022 appointment on the Global Heat Health Information Network's (GHHIN) Management Committee is a direct result of CLIMAS, and the NOAA partnerships built through this project.

Capacity Building:

- Ladd Keith finished his dissertation work on assessing climate action planning in the U.S. Southwest in 2019 and has since launched an impactful research career, as an Associate Professor in the College of Architecture, Planning and Landscape Architecture at the University of Arizona.
- Graduate students received training on qualitative interview techniques and coding analysis through this project. Erika Schmidt presented research findings at the Climate Prediction Applications Science Workshop.
- New York City's Office of Resiliency used results from this research to acquire grant funding to implement urban heat mitigation strategies.

Instrumental:

- Preliminary results were reported to NOAA's Climate Program Office and informed development of a new national funding opportunity for five communities to monitor, understand, and respond to local heat risk.
- Provided information utilized in the ULI Scorched: Extreme Heat & Real Estate report.
- Trust for Public Land served as an informal project advisor. They used findings from the project to inform data use guides they produce.
- The Pima Association of Governments revised their resiliency planning map from a green infrastructure-focused map. Using technical assistance from this CLIMAS project, they now have a layer for heat impacts and cooling centers on their Resiliency Planning Maps.