Sustainable Urban Systems:
Predictive, Interconnected, Resilient, and Evolving

Chicago, Illinois

July 16-17, 2019

Research Topics and Key Conclusions

Northwestern University

Argonne NATIONAL LABORATORY

THE UNIVERSITY OF CHICAGO

Center for Urban Resilience and Environmental Sustainability

NSF

Northwestern | CENTER FOR ENGINEERING SUSTAINABILITY AND RESILIENCE

<u>Sustainable Urban Systems: Predictive, Interconnected, Resilient, and Evolving (SUSPIRE)</u>
Executive Summary

On July 16-17, 2019, Northwestern University, Argonne National Laboratory, the University of Chicago, and the Illinois Center for Urban Resilience and Environmental Sustainability hosted SUSPIRE with support from the National Science Foundation (NSF). The workshop delved into 3 broad types of disruptions – climate & natural, technological, and societal – that urban systems face with an emphasis on the Chicago region. Climate change in the Midwest is expected to bring about more frequent and severe air quality events, increasing extreme heat, and heavy rainfall. Technological disruptions include widespread use of autonomous vehicles, increased information availability through sensing, artificial intelligence applied to urban systems, and distributed energy production. Finally, societal disruptions include demographic shifts with urban population growth; changes in the sharing economy, health care, education, and employment patterns; increased social media use; and shifts in power as a result of elections or community actions.

The disruptions were evaluated in half-day sessions with a keynote lecture, panel discussion, and breakout sessions focused on each of 6 integrated urban systems: urban networks; people; urban provisioning; transportation; the natural environment; and the built environment and infrastructure. The final half-day session examined interactions between the 6 urban systems in response to disruptions that result in trade-offs, co-benefits, and indirect effects. SUSPIRE participants closely examined the 3 disruption types and their influence on the 6 integrated urban systems, leading to both a deeper understanding of integrated social-ecological-technological systems within the Chicago region and identification of knowledge gaps that research must address.

This report conveys key themes and conclusions from SUSPIRE to inform a broader research agenda in sustainable urban systems. One key point that emerged from a focus group with community representatives after SUSPIRE is that we need to put community needs first to emphasize their importance. Thus, we prioritized community needs, before moving on to more specific technical themes that emerged from the conference: (1) Collaboration models to get results for communities and increase sustainability of cities; (2) Developing robust and validated techniques to characterize, quantify, and optimize social, natural, and built/economic capital in designing and assessing urban systems; (3) Rethinking equitable development practices for smart sustainable cities; (4) Reimagining public transportation for improved environmental quality and social equity; (5) New approaches to "public" utilities; (6) Changing nature of work/technology-human interface; (7) Comprehensive analysis of GI efficacy, co-benefits and economics; (8) Tracking and management of urban provisioning and networks; and (9) Managing infrastructure through sensors and sensing. The subsection for each theme concludes with research questions that are aligned with the NSF key elements to advance sustainable urban systems.

SUSPIRE brought together a diverse and vibrant group of stakeholders that generated numerous research concepts and resulted in important and new connections that will help transform these concepts into action. Discussions highlighted the role of disruptions in urban systems and their trajectory towards sustainability and resilience. Key themes that emerged were the opportunities to use new data to characterize, design, and understand urban systems; the necessity to consider economic, environmental, and societal factors equally; and the critical importance of engaging community groups from the very beginning in sustainable urban systems research. A major challenge is enabling community groups to benefit directly from research projects. NSF and academic investigators should welcome and expect changes in scope and funding approach if a project evolves based on input from community groups. We also recommend that future grants more explicitly support and reward transfer of expertise via training, sustained connection, and funded exchanges after the research portion of a proposal is concluded.

Dedication

This report is dedicated to Dr. Danielle Kizaire, who was committed to renewable energy, environmental justice, and community development.
We have been inspired by her leadership and the example she set.

Acknowledgements

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1. Introduction

On July 16 and 17, Northwestern University, Argonne National Laboratory, the University of Chicago, and the Illinois Center for Urban Resilience and Environmental Sustainability (CURES) hosted, with support from the National Science Foundation (NSF) and the Northwestern Center for Engineering Sustainability and Resilience, a conference titled "Sustainable Urban Systems: Predictive Integrated Resilient and Evolving," or SUSPIRE.

The workshop delved into three broad types of disruptions that urban systems face with a strong emphasis on the Chicago region. The first of these is climate and natural disruptions prompted by a changing climate, increasing severe weather, and natural disasters. Climate change in the Midwest is expected to bring about more frequent and severe significant air quality events, increasing extreme heat, and heavy rainfall.[1] Accordingly, manifestations of increasingly severe weather in the Chicago region include flooding and reduced air quality. For example, communities in Chicago's South Side and West Side suffer concentrated disadvantage, frequent flooding, and disproportionate air quality impacts.[2–5] Flooding caused over $773M in residential damage in Cook County between 2007-2011, and nearly $2B in total damage across the Chicago metro area between 2007-2014.[2,4] Furthermore, the 2012 Midwestern heat wave and drought caused more than $30B in economic damage, 123 direct deaths, and contributed to considerable long-term morbidity and mortality across most of the central and western U.S.[6]

The second disruption type is technological disruptions such as widespread use of autonomous vehicles,[7] increased information availability through sensing,[8] artificial intelligence applied to urban systems management and characterization, cyber security improvements, real-time monitoring of water quality and water infrastructure, shifting and distributed energy sources,[9] expansion of advanced and distributed manufacturing,[10] and developments in high-performing infrastructure and construction materials.

Finally, societal disruptions include shifts in demographics as the urban population grows, changes in the sharing economy, changes in health care, evolution of employment patterns,[11] changes in education,[12] fast-paced transitions in social media use,[13] modification of policy and regulations to accelerate transition to sustainable technologies,[14] and shifts in power as a result of elections or community-level action.

The three disruptions were evaluated in the context of six integrated urban systems (**Figure 1**) including urban networks; people; urban provisioning of energy, food, water, and goods; transportation; the natural environment and its health; and the built environment and infrastructure. These six areas interact and their evolution in response to disruption will be intertwined resulting in trade-offs, co-benefits, and indirect effects. Yet, not enough is known regarding the interactions among these areas and how improvements in one area may affect another and, indeed, ripple through the entire region and beyond.[15]

At SUSPIRE, participants, closely examined these three disruption types and their influence on the six integrated areas in Figure 1, leading to both a deeper understanding of integrated social-

ecological-technological systems within the Chicago region and identification of knowledge gaps that research must address.
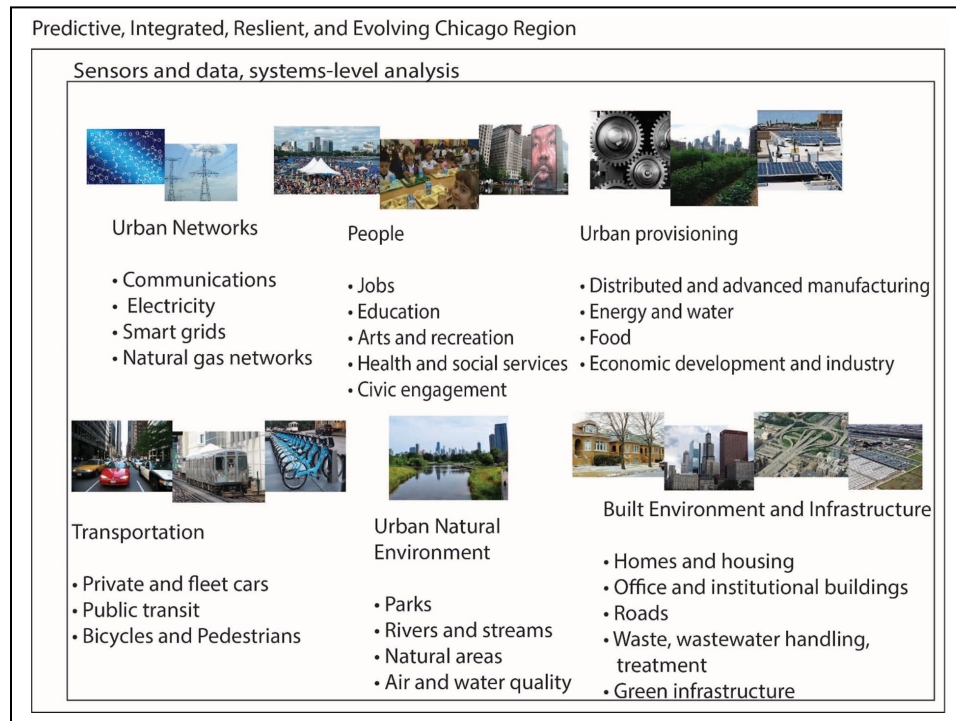
Figure 1. Six urban systems that were considered in the context of climate and natural, technological, and societal disruptions.

The objective of this report is to convey key themes and conclusions that arose from SUSPIRE to inform a broader research agenda in sustainable urban systems. Section 2 provides an overview of the keynote and panel presentations. Section 3 summarizes research questions that arose at SUSPIRE, including a description of the discussion and research questions organized by the six key elements that NSF expects to significantly advance the science of Sustainable Urban Systems. These six elements are provided below in **Table 1**. Section 3 incorporates feedback from members of the organizing and steering committees, breakout facilitators, and a post-workshop focus group comprising representatives of community groups and organizations that work closely with community groups. We provide a summary of attendee feedback in Section 4 and outline key conclusions, recommendations, and next steps in Section 5. Four appendices provide details regarding the conference agenda and attendees.

Table 1. NSF six key elements to advance Sustainable Urban[16]

Element	Description
A. Data and methodological advances	Developing new data and methods to understand current drivers and interactions among natural, human-built, and social systems in urban areas as they impact multiple sustainability outcomes across scales
B. Science advances for sustainability	Developing the science to assess the sustainability outcomes nexus in urban systems, i.e., the co-benefits and trade-offs among multiple human and planetary well-being outcomes across spatial (local to global) and temporal scales.

C. Levers for change in urban systems	Understanding the levers for change in diverse urban systems ("theories of change"), combining:
	    1. A focus on integrative design, technology innovation, and sociotechnical transitions.
	    2. A focus on multi-level actors and governance.

D. Theories of change across city types	Advancing comparative studies, typology studies, and scalability studies to develop a generalizable science of theories of change across diverse city types.
E. Science advances for modeling	Developing the science to model the future of SUS across the three perspectives.
F. Science of knowledge co-production	Developing the science of knowledge co-production among researchers, communities, industry groups, practitioner groups, and governments at multiple levels, leveraging real-world experimentation ongoing in urban areas.

2. Summary of Conference Keynote and Panel Presentations

The conference was divided into four topical sessions: Climate and Natural Disruptions, Technological Disruptions, Societal Disruptions, and a Synthesis session. The following subsections describe the main points raised by the keynote and panel speakers in each of these sessions.

2.1 Climate and Natural Disruptions (Conveners - Katherine Moore Powell, The Field Museum; Scott Collis, Argonne National Laboratory)

Ms. Sarah Murdock, Director of U.S. Climate Resilience and Water Policy at The Nature Conservancy, gave the keynote lecture titled "Investing in Nature Enhances Resilience." She discussed diverse types of green infrastructure (GI) (**Figure 2**) and noted that integrating nature into the urban landscape increases resilience by providing clean water, reducing flooding risk, improving air quality, and mitigating the urban heat island effect – all of which also provide health benefits. When GI is implemented equitably to serve all communities, all residents benefit from clean water, fresh air and the spiritual benefits of nearby nature. Many studies have demonstrated the cost-effectiveness of GI and nature-based solutions. Ms. Murdock concluded her lecture with a discussion of Washington. D.C.'s first-of-its-kind Stormwater Retention Credit (SRC) market. The market reduces the impact of stormwater runoff – the largest growing source of pollution to

the Chesapeake Bay watershed and the fastest growing source of urban water pollution globally. It allows land-constrained developers to meet a portion of their stormwater retention requirements by purchasing SRCs. Credits are generated by stormwater retention projects elsewhere in the city, including green infrastructure projects in under-resourced communities. She also discussed The Nature Conservancy's roles in developing stormwater retention pilot projects and in helping to establish funding the SRC market.

Figure 2. Different types of green infrastructure.

The first panelist was <u>Dr. Jim Angel</u>, State Climatologist emeritus at the Illinois State Water Survey, who was lead author on the Midwest chapter of the National Climate Assessment in 2018. Dr. Angel presented data showing increased temperatures and heavy rain events during the last century and projections for the rest of the 21st Century. The impacts of increased temperatures could be substantial. Chicago could see 4 to 6 days at or above 100°F by mid-century, and 7 to 22 days by late-century, which could lead to an additional 500 to 900 deaths per year by late-century. Also, corn production in the Midwest could drop an estimated 7 to 18% by the end of the century, depending on the scenario. Annual precipitation in the Chicago area is likely to increase by ~10%. Of note, the fraction of total annual precipitation falling in the heaviest 1% of events has increased by more than 40% since 1901, and may increase by a further 40% by the end of the century (**Figure 3**). Dr. Angel noted that increased rainfall intensity has already increased the size of the 100-year, 24-hour storm used by civil engineers when designing systems to handle stormwater.

Observed Change in Total Annual Precipitation Falling in the Heaviest 1% of Events

Projected Change in Total Annual Precipitation Falling in the Heaviest 1% of Events by Late 21st Century

1901–2016

Higher Scenario (RCP8.5)

Change (%)

<0 0-9 10-19 20-29 30-39 40+

Change (%)

<0 0-9 10-19 20-29 30-39 40+
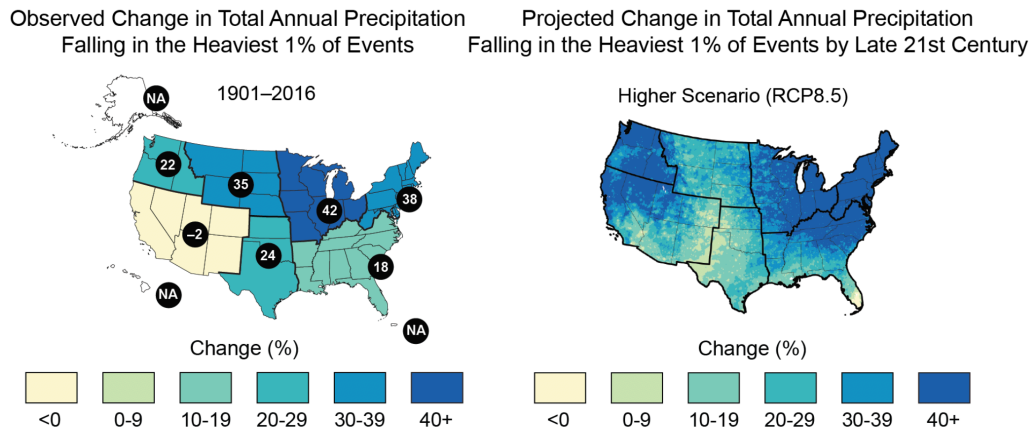
Figure 2-6 National Climate Assessment https://nca2018.globalchange.gov/chapter/2/#fig-2-6

Dr. Jim Angel, SUSPIRE, July 16, Chicago IL

Figure 3. Changes in total annual precipitation falling in the heaviest 1% of events.

Mr. Jason Navota, Director of Planning at the Chicago Metropolitan Agency for Planning (CMAP), discussed CMAP's "On to 2050: Metropolitan Chicago's Comprehensive Regional Plan." The plan focuses on prioritized investments, including in transportation, to target resources to maximize benefits; inclusive economic growth to provide opportunity to all; and resilience to prepare for rapid changes, both known and unknown. Mr. Navota noted that flooding in the Chicago area has been so bad in the past decade that only areas ravaged by hurricanes sustain more damage. Much of the greatest damage has been concentrated in economically disconnected areas in Chicago's South and West Sides (**Figure 4**). Residents in economically disconnected areas have lower incomes, home ownership rates, and education levels, but have higher unemployment rates and spend more time commuting each year.
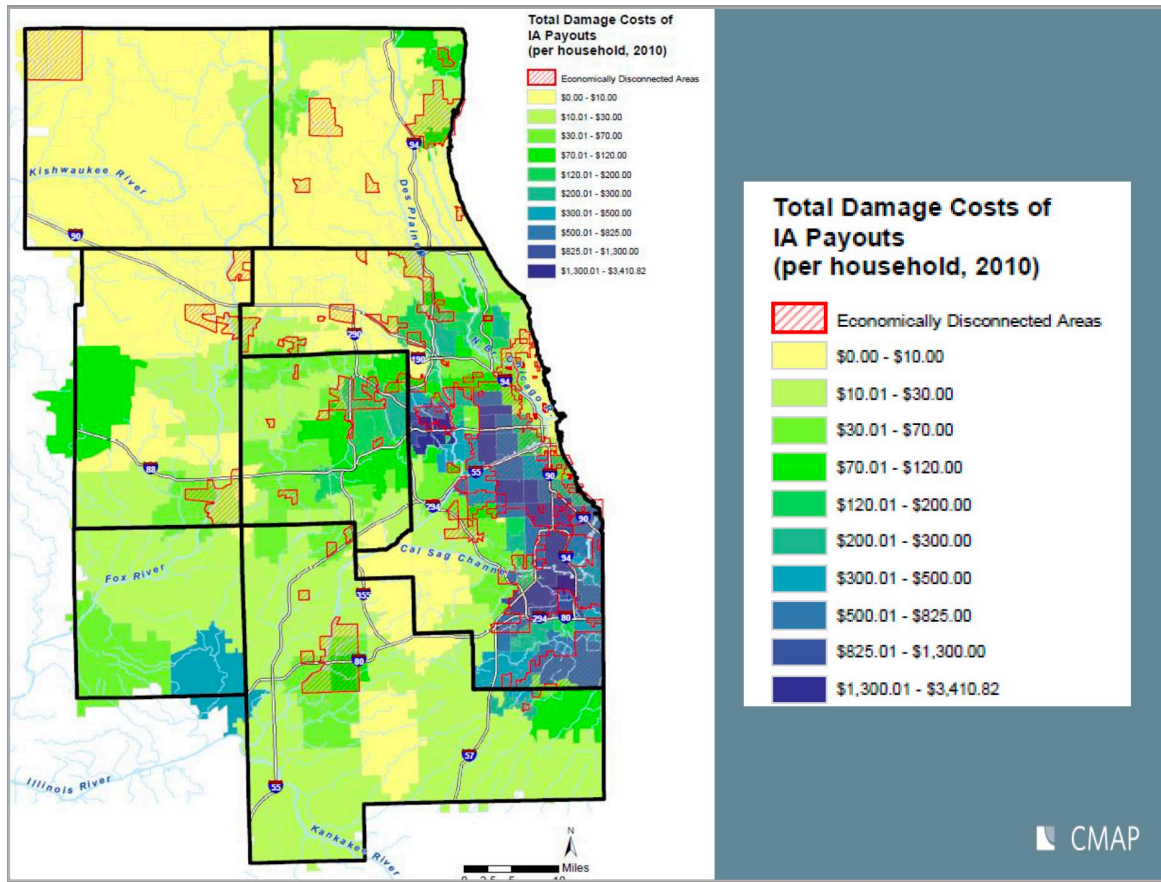
Figure 4. Total damage costs of individual assistance payouts per household in 2010.

Ms. Elena Grossman, Program Manager for Building Resilience Against Climate Effects (BRACE) at the University of Illinois at Chicago, presented remarks titled "Climate change and health in Illinois." Ms. Grossman discussed the myriad adverse physical and mental health conditions that will result from increased heat waves, floods and droughts, as well as worsening air quality, associated with climate change (**Figure 5**). Extreme heat is the most deadly climate effect. Ms. Grossman emphasized the importance of building the capacity of public hospitals and noted that focusing on public health is very effective in communicating the importance of climate change. Health departments can play important roles via assessment and surveillance to monitor public health and via policy development to mobilize community partnerships; inform, educate, and empower community members; and enhance emergency preparedness.
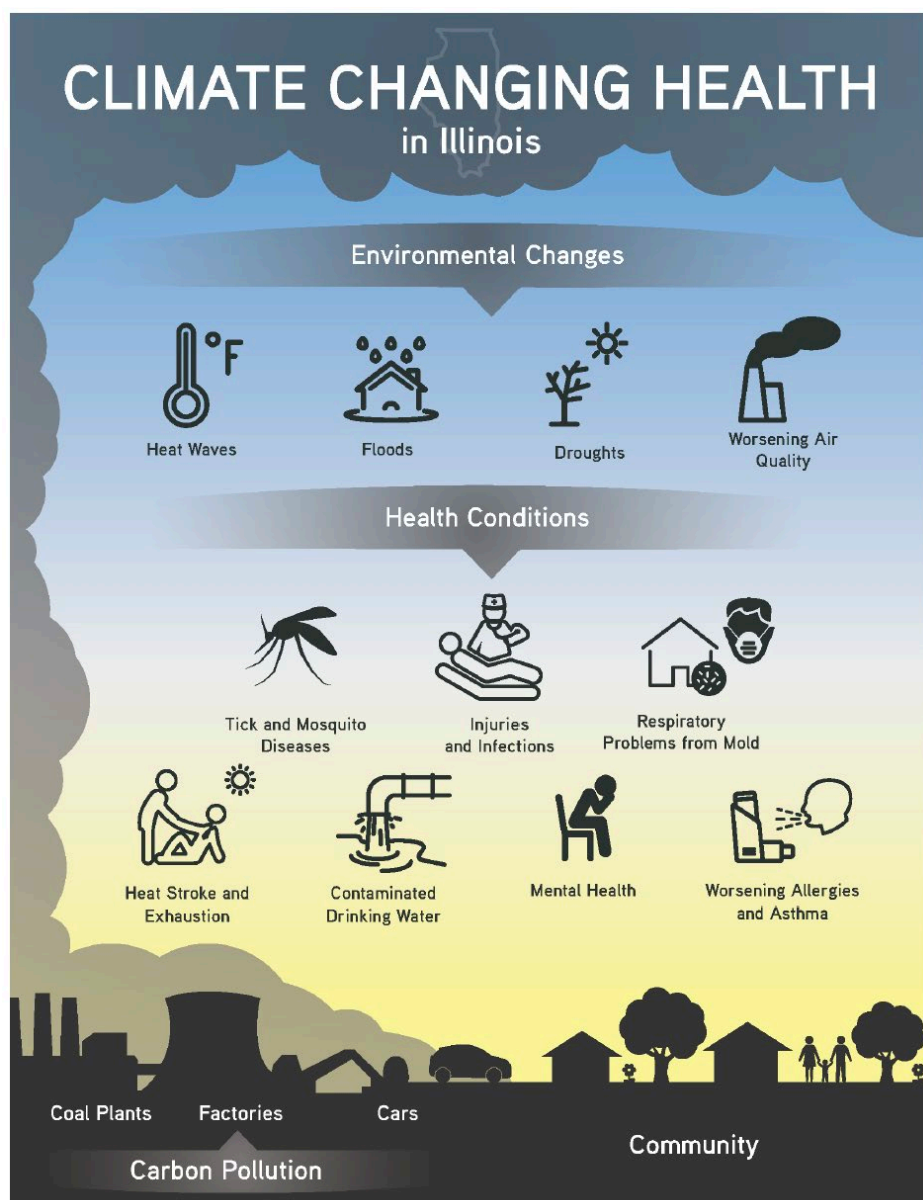
Figure 5. Environmental changes and associated health conditions due to climate change.

The final panelist was Ms. Sarah Coulter, Executive Director at the Calumet Collaborative, which is a nonprofit using sustainable development to transform the Calumet region (southeast Chicago and Cook County in Illinois and the northern part of Indiana along Lake Michigan) through collective action with more than 40 partners from industry; local, state, and federal governments and agencies; and local and national nonprofits. The Calumet region has been subject to extensive industrial development, but still retains natural areas with abundant biodiversity. Ms. Coulter noted that it is important to consider culture along with economy, community and the environment (**Figure 6**). The many brownfields in Chicago and the Calumet region provide opportunities for development, as well as the creation of stormwater parks to alleviate flooding. Ms. Coulter noted

that a translator is often needed between community members and researchers. The 2-person Calumet Collaborative builds relationships, convenes meetings, establishes and grounds shared objectives, brokers information, manages expectations, leads collective efforts to find funding, and hands-off to partners for implementation. A recent project in Cook County near the Indiana border involved working with 3 municipalities, 6 railroads, 3 regional planning agencies, 3 trail advocacy organizations, 1 utility company, and state and federal agencies. During the panel discussion, it was noted that social capital is very important for mitigating the impacts of disasters and that this must be developed in advance. The panel also emphasized the importance of prioritizing infill developments to make use of existing (transportation) infrastructure and of engaging with communities during the design and development stages to offset gentrification pressure.

Figure 6. The four sustainable development focus areas of the Calumet Collaborative.

2.2 Technological Disruptions (Conveners - Douglas Pancoast, Robert Bosch LLC and School of the Art Institute of Chicago; George Wells, Northwestern University)

<u>Dr. Pete Beckman</u>, Co-Director of the Northwestern-Argonne Institute of Science and Engineering (NAISE) and Senior Computer Scientist at Argonne National Laboratory, delivered the keynote lecture in this session, which was titled "Technical Disruptions for Urban Systems." He discussed the proliferation of wireless devices that contribute to the Internet of Things (IoT) especially in the urban environment. He reviewed the many types of sensors and the myriad applications to which they can be applied such as detecting lead in water, which could alleviate issues such as those encountered in Flint, and detection of pollen blooms, which could provide an early alert to asthma sufferers to take preemptive action to limit symptoms.   Furthermore, the IoT in office environments could allow employers to determine time employees spend at their desks, sitting, and using office infrastructure from meeting rooms to coffee pots. IoT can and is being used to gain insight into many other systems including bird migration and detecting forest fires. Overall, wireless sensors can be applied to innumerable technologies and environments to yield voluminous data. Machine learning techniques can enable the interpretation and use of these data to predict future activity or behavior of systems. Dr. Beckman described the ongoing research at Argonne

National Laboratory, Northwestern University, and the University of Chicago to develop the Array of Things (AoT), which exploits new sensor technologies to increase the resolution and types of measurements in urban environments and uses edge computation to support intelligent and autonomous measurement and actions. The AoT is supported by NSF and creates an urban cyberinfrastructure with hundreds of autonomous, remotely programmable devices in partnership with the City of Chicago. In effect, the AoT enables the development of automated observations using computer perception. The AoT measures environmental parameters including ambient, ultraviolet, and infrared light; magnetic field; sound intensity; pressure; and temperature. Air quality data including $PM_{2.5}$, ozone, and NO_2 are measured. Applications of edge computing with AoT-generated data to-date include identifying flooding, characterizing traffic flow, and determining how the public uses public spaces. Sound events are also characterized. A recent user workshop for AoT identified numerous types of data that scientists and policy makers want to collect and analyze with the AoT network (**Figure 7**). Dr. Beckman highlighted the AoT approach
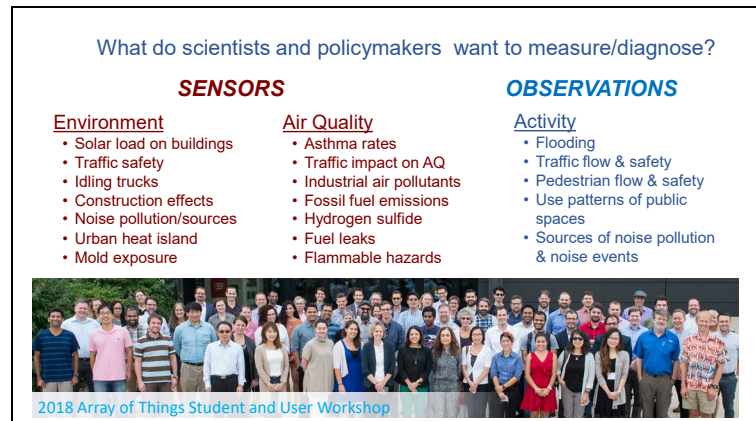
Figure 7. Scientist and policymaker "wish list" for AoT sensor data and insights

of using different sensors (e.g., cameras, microfluidic sensors, light detection and ranging (LIDAR)) gathered into a shared housing compartment called a Waggle Node, which collects data that are handled with parallel edge computing. This enables reduced, compressed data to be used in machine-learning-based approaches to glean new inferences that can then be used to modify how the sensors collect data (e.g., temporally, camera angle). For example, Waggle-Node-generated data can be used to identify how vehicles, bicyclists, and pedestrians interact in intersections of concern. Furthermore, it may be possible through Waggle Nodes to detect surface flooding to alert residents in an area that their neighborhood may be in danger of damaging floods. He summarized how the connected and smart nature of the AoT is feeding an explosion of interest in urban sensing, edge computing, and machine-learning-derived insights into urban systems.

Following Dr. Beckman's presentation, a four-member panel continued the discussion regarding how technology is disrupting urban systems. Mr. Satya Basu, Advanced Insights Analyst and Associate at Perkins+Will, began the discussion with a video highlighting advanced architectural design techniques that enable placement of conceptual buildings in their proposed environments and the possibility to collect data on building occupant experiences through computer vision and machine learning. He concluded with insights into evaluating the connectedness of Perkins+Will employees. Next, Mr. John Edel, Founder of Bubbly Dynamics/The Plant and Owner/Operator of The Plant and the Chicago Sustainable Manufacturing Center that was established in formerly vacant, industrial buildings located in disinvested communities in the Central Manufacturing District of Chicago, described the history of efforts to convert a former Lowe Brothers Paint
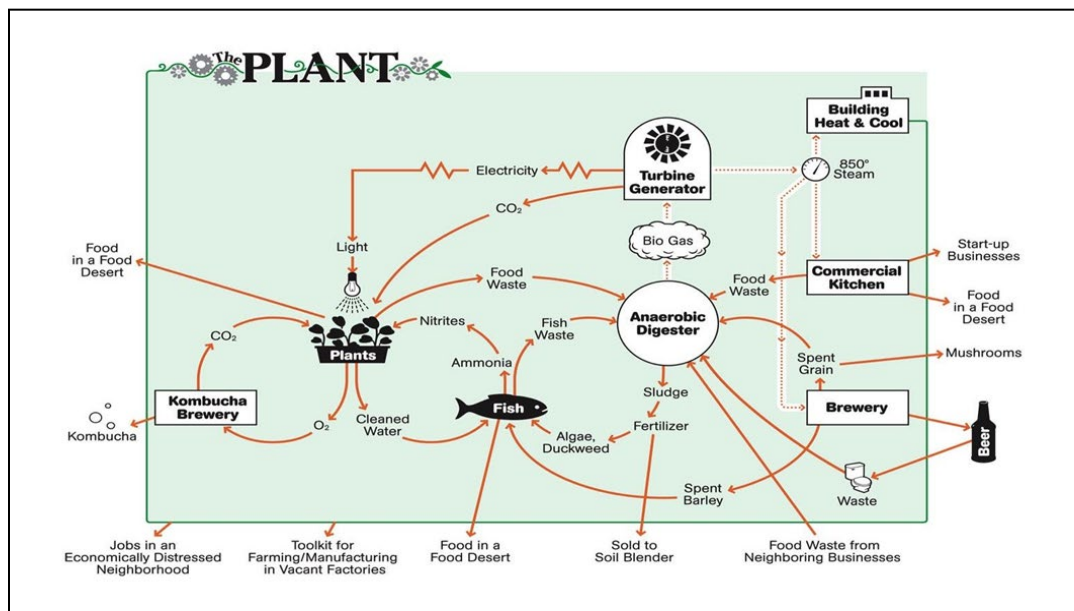
Figure 8. Interconnected food, energy, water systems at the Plant, which provides a sustainable environment for 15 tenants.

warehouse into a space for small and emerging manufacturers, product assemblers, and other businesses committed to sustainability (**Figure 8**). The facility is a model of industrial ecology and includes a green roof and microprocessor-controlled radiator heat and houses 15 tenants. It also has an anaerobic digester and uses the produced biogas to heat and cool the facility. The digesters could produce more gas, but finding an outlet for additional gas has proven challenging and the local utility does not permit sale of power to tenants in the building (which would be approximately 3.5 cents/kWh) but only to the utility, which sells electricity to the tenants of The Plant (at approximately 10.5 cents/kWh). This real-world situation is an example of a barrier to renewable energy that is not immediately apparent.   The Plant is considering only selling/distributing heat, which may be a better fit for the on-the-ground situation. The digester produces sludge that can be used as a soil amendment. The Plant does a good deal of community outreach focusing on small businesses and has a local farmer's market.

Next, Ms. Elizabeth Irvin, Transportation Director at the Center for Neighborhood Technology in Chicago discussed electrification, automation, and shared mobility as three revolutions in urban environments. Ms. Irvin discussed transportation network company (TNC) data considering that most TNC pickups are in the areas of the city along the northern part of Lake Michigan whereas the proportion of those rides that involve a shared ride are concentrated in the South and far West areas of the city. This indicates that in underprivileged areas, where Ms. Irvin pointed out there are also fewer drivers, more TNC users share rides to save costs. These areas are predominantly black and many more black families do not own cars than other families regardless of income (**Figure 9**). However, 45-53% of black and Hispanic Chicagoans without vehicles in their households are below the poverty line. Conversely, 55% of white families without vehicles are 200% above the poverty level. Ms. Irvin proposed several approaches for responding to revolutions in transport in urban environments that would be sustainable, equitable, and affordable. To begin, the three features of urban transport discussed above should be incorporated routinely

into policy discussions. Secondly, goods and people movement are interlinked and should be addressed holistically. Moreover, lower levels of car ownership are generally positive for consumer pocketbooks and environmental quality. Cities should therefore evolve policies that encourage less car ownership, but these policies should not impede access to jobs and other benefits of the city. Finally, the climate and equity impacts of urban transport still need to be better understood and characterized.

Figure 9. Disparities in vehicle ownership by race and income in Chicago.
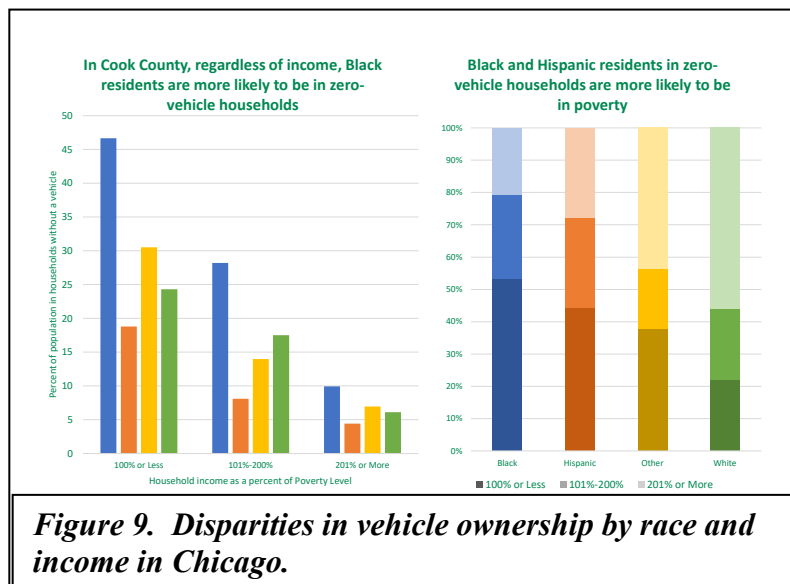
The final panelist in the Technological Disruption session was Ms. Y. Mwende Lefler, Principal Civil Engineer at the Chicago Metropolitan Water Reclamation District of Greater Chicago (MWRD). The MWRD operates seven treatment plants in Cook County serving over 5.3 million people. Over 450 billion gallons are treated annually at MWRD facilities. Ms. Lefler discussed green infrastructure such as permeable pavement and bioswales, along with gray infrastructure approaches to limiting the effect of sewer overflow.

Figure 10. Biogas utilization at the MWRD.

In 2017, MWRD carried out 20 green infrastructure projects with $11.7 million in construction

costs and a design retention capacity of 3.6 million gallons. In 2018, the District selected an additional 20 projects with a capital cost of $9.2 million and a design retention capacity (estimated) of 1.4 million gallons. MWRD finds that green infrastructure helps manage stormwater in concert with gray infrastructure. Alone, green infrastructure would be insufficient. Increasingly, green and gray infrastructure are being integrated on traditional projects like road replacements. Green infrastructure is therefore disrupting water management in urban systems. A second disruption Ms. Lefler covered was recovering energy and nutrients from wastewater. Furthermore, she also discussed production of biogas at MWRD facilities (**Figure 10**) and the opportunity for non-potable effluent water reuse

2.3 Societal Disruptions (Conveners - Megan Kashner, Northwestern University; Michelle Shumate, Northwestern University)

Dr. Susan Popkin, Director of the Urban Institute's HOST Initiative and an Institute Fellow in the Metropolitan Housing and Communities Policy Center, gave a keynote lecture titled "The Social Impact of Chicago's Public Housing Transformation." She discussed the transformation of the Chicago Housing Authority (CHA) from having the worst public housing in the country in the 1990's to the best managed public housing authority in the US today. HUD receivership laid the groundwork for transitioning from high-rises with very poor conditions to mixed-income housing and vouchers. The challenges were daunting because of the vast scale, huge cost, and lack of CHA capacity. Also, many of the current residents didn't want to move from what they considered their homes even though the conditions were terrible; this resulted in forced relocations and disrupted communities. The early stages did not go well, but the outcomes were much better than most observers expected with most residents in better, safer housing and few residents lost to homelessness. This was attributed in large part to the efforts of the Chicago Mayor and the MacArthur Foundation, as well as monitoring by advocates, HUD, and researchers that minimized the impact on families. However, many challenges remain with most residents moving to other poor, African-American neighborhoods. Also, even with better quality of life and services, most of the families are still extremely poor and the

Figure 11. Lessons for policy development.

children still face many challenges. The CHA voucher program has spread to nearly every Chicago community. CHA is acquiring and redeveloping properties, including innovative ideas like co-locating libraries in CHA housing to access additional resources. However, there is pressure from advocates about the long wait times and a push to reopen units at traditional public housing sites. Dr. Popkin briefly discussed HOST's program to engage entire families, with a focus on the challenges in serving children, whose needs vary greatly with age and are difficult to reach after

leaving elementary school. She also noted the unanticipated link between teen hunger and risky behavior. Dr. Popkin ended with the policy lessons shown in **Figure 11**.

Three additional speakers provided introductory remarks before joining Dr. Popkin for the panel discussion. <u>Dr. Andrew Greenlee</u>, Associate Professor of Urban and Regional Planning at the University of Illinois at Urbana-Champaign, gave a presentation titled "Sustaining Urban Mobility Systems."   He emphasized that where you live plays an important role in long-term health, economic and social standing, and that we are sorted into areas with substantial advantages and disadvantages that extend beyond the characteristics of our housing and neighborhoods (**Figure 12**). The poverty rate is highly correlated with the percent of the population that is nonwhite. Despite federal, state, and local innovation, progress is slow such that the percent of African Americans living in communities that are 94-95% black only decreased from 69% to 63% between 1960 and 2011, while the relative income of black households actually decreased from 62% to 50% of that for white households during this period. Chicago has lost more than 25% of its black population since 1980. This is consistent with a large increase in the overall population of people over 16 with high earnings and a decrease for those with low earnings between 2006-2016. Dr. Greenlee concluded by noting that population dynamics continue to evolve with uneven consequences and that exogenous factors are likely to play an increasing influence.
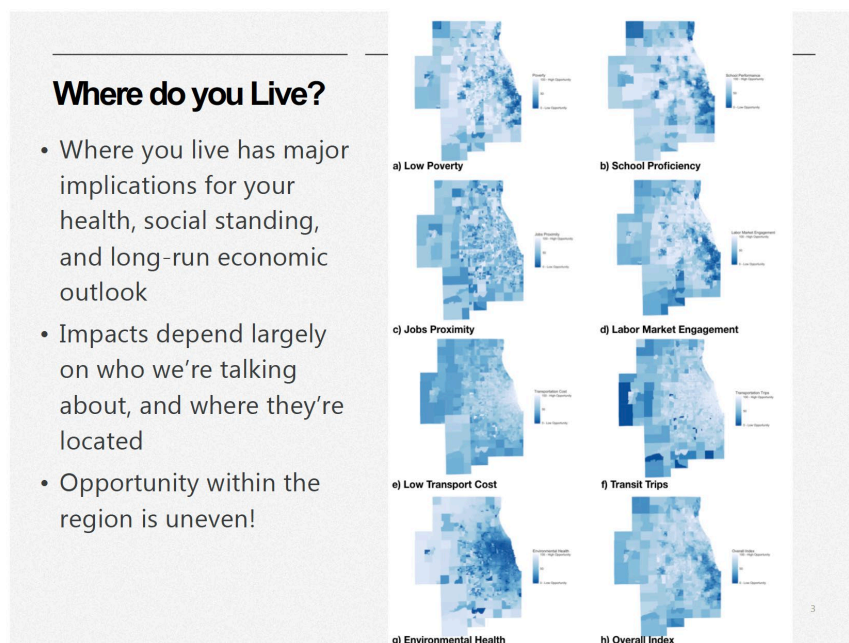
Figure 12. Impact of where you live on your health, social standing and economic outlook.

<u>Ms. Carmita Semaan</u> is Founder and President of the Surge Institute. The institute's inaugural program is The Surge Fellowship – a novel leadership institute for emerging leaders of color in the field of education. Ms. Semaan emphasized that in order to be effective, researchers must work closely with the community. This takes money, time and the belief that the community already has many of the potential resources and experts to solve their problems. Researchers must avoid taking

a "savior" attitude; we have lots to learn from people in the community. It is very important to include education in any solution. She emphasized the need to support entrepreneurs of color to develop businesses for the new economy. There is a need to evaluate how to leverage "access" of funders and investigators to help others develop their own "access". Ms. Semaan noted that it is much easier to evaluate the outcomes of Surge Fellowships on the fellows than to evaluate the follow-on impacts on the educational outcomes of students impacted by the fellows; she encouraged researchers at SUSPIRE to help develop such assessment tools.

The final panelist was Mr. Daniel Ash, Associate Vice President of Community Impact at The Chicago Community Trust (CCT), who has lived in the Woodlawn community for 20 years. The CCT has set a goal of closing the racial wealth gap in Chicago that was described by Dr. Greenlee. Mr. Ash noted that, networks are not sufficient for effective collaboration; there must also be reciprocal trust. People develop trust when they work together on projects. Real proximity requires engagement, not just being close. Mr. Ash highlighted the need to provide better support for community leaders; CCT is setting up a Southland Development organization to support to municipalities with limited resources. CCT will fund neighborhood initiatives and is looking for help from academics in assessing their effectiveness. Mr. Ash also noted that CCT wants to learn more about connections between people and technology.

2.4 Research agenda for developing a sustainable and resilient Chicago region (Conveners – Daniel Kushner, Commonwealth Edison; Demetria Giannisis, Northwestern University)

Mr. William (Bill) Abolt, Vice President at AECOM, gave a keynote lecture to begin the conference session to synthesize the discussions in the three previous sections regarding different types of disruptions and their effect on urban systems. Mr. Abolt described resilience as, "the ability to withstand and recover from chronic stresses and acute shocks" and described his lessons learned from involvement in the 100 Resilient Cities Program which was supported by the Rockefeller Foundation. Chicago, one of the 100 cities, released its resilience plan in 2019.[17] Mr. Abolt posited that for Chicago to be resilient, the city must support strong neighborhoods, build robust infrastructure and prepare its communities for disruptions. Mr. Abolt focused on the case study of ComEd's Community of the Future Project in Bronzeville, a Chicago community, in addition to the City's partnership with local stewards to manage stormwater through installing green infrastructure on vacant lots. He made the critical point that often utility and infrastructure regulation does not value resilience and that the current model is to adopt a wait-and-be-rescued approach in the face of disruptions rather than regulations that promote actively planning and designing for resilience. In fact, one type of disruption that cities are contending with is their struggle to balance budgets that have been historically poorly managed and can lead to under investment in resilient infrastructure and communities. Furthermore, the need to quantify the value of resilience is apparent because if resilience is not valued, companies, cities, and others will not invest in it. Resilience must be quantified holistically, including assessing a rate of return on investment (ROI), to encourage investment. To achieve this outcome, capital and community planning must be formally linked (**Figure 13**). If city departments co-invest in capital programs, broader community goals can be achieved. Mr. Abolt highlighted the need for collaboration among the city, utilities, and other partners to achieve impact, even though such collaboration can

LINK CAPITAL TO MEASURABLE EQUITY IMPACTS
Use established standards to increase transparency and demonstrate progress

AECOM

Percent of Route Traveling through High Asthma Rate Communities

87th... 79% | Madison 75% | 63rd 55% | North 55% | State 55% | 79th 50% | King Drive 50%

Bus Routes with >500,000 Riders per Month
Asthma Rates by Community
Less than 5.0
5.1 - 10.0
10.1 - 15.0
15.1 to 20.7
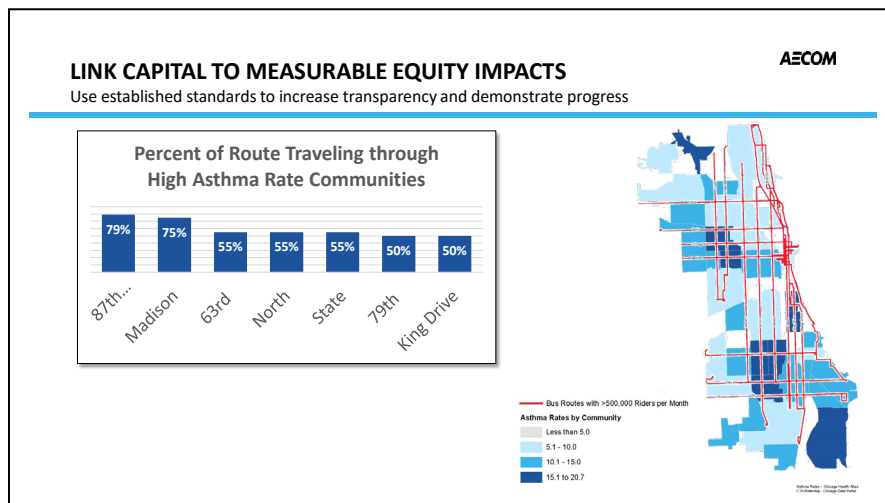
Figure 13. An example of achieving multiple outcomes relevant to city and community goals is planning public transit routes that account for addressing community air quality concerns

be messy. Notably, models for successful multi-stakeholder engagement to achieve multiple outcomes that tie capital planning to community values are limited and must be further developed and documented for replication as one element of moving towards sustainable and resilient urban systems. Furthermore, the ROI for investing in resilience must be quantified and verified. Place-based pilots will be critical to achieving both of these aims. Finally, there is an opportunity for technology like the AoT to move investment forward through tracking performance, operating parameters that effect the best outcomes, and other aspects of projects that are implemented. Such data would facilitate the replication and scaling of effective projects.

The panel discussion was moderated by <u>Mr. Jamie Ponce</u>, Director of Strategic Partnerships with the City Tech Collaborative. <u>Dr. Suzanne Malec-McKenna</u> was the first panelist in this session. She serves as the interim Chief Executive Officer of the Great Lakes St. Lawrence Cities Initiative (GLSLCI) and reflects SUSPIRE's reach beyond the immediate boundaries of the Chicago region. Dr. Malec-McKenna pointed out that Lake Michigan alone touches four states and is part of the local environment for over 10 million people with a regional gross product of over $575 billion. The GLSLCI has a compelling vision that every person, business, community, and ecosystem has the right to access to healthy and safe water, air, land, and food. Dr. Malec-McKenna pointed out that if Chicago embraces environmental justice, the region will prioritize reversing damage to natural and human assets, which will ensure a resilient future. She highlighted some of her experiences on Mayor Lori Lightfoot's transition team, which emphasized equity, diversity and inclusion, transparency, accountability, and transformation. Finally, Dr. Malec-McKenna underlined the collective strength that the group attending SUSPIRE has to develop a research agenda that leads to measurable action leveraging expertise, experience, and effort from stakeholders from many different sectors (**Figure 14**).

Figure 14. Translating a research agenda to measurable action with community engagement.
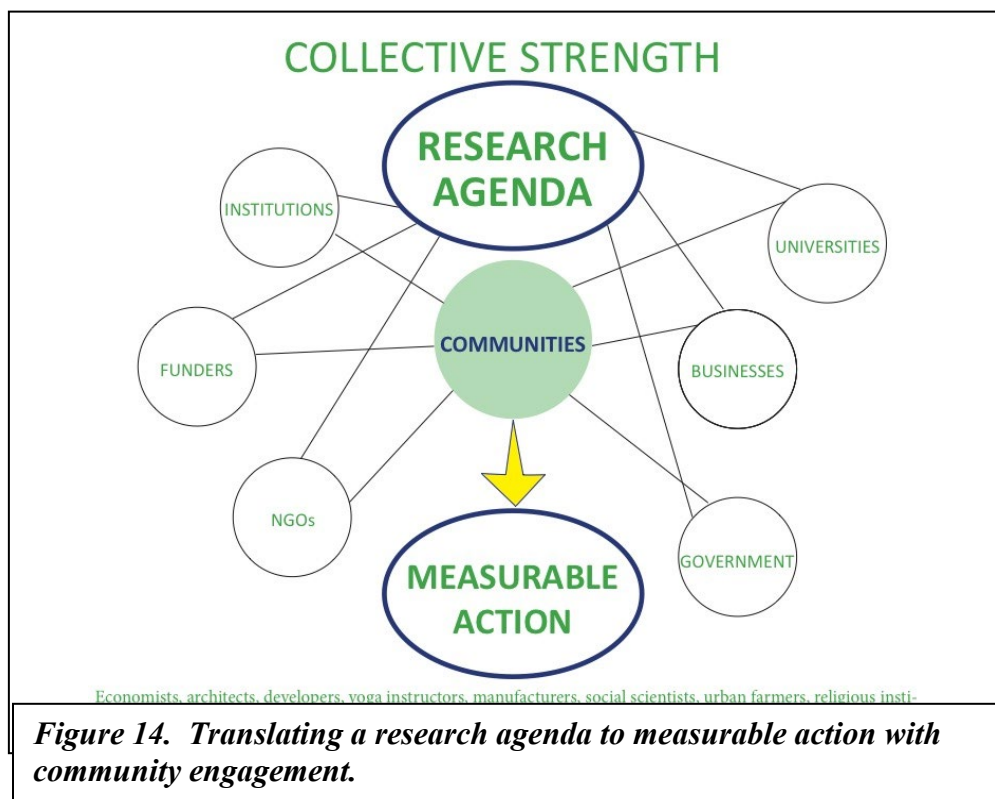
The second panelist was <u>Dr. Aaron Packman</u>, Professor of Civil and Environmental Engineering at Northwestern University. Dr. Packman discussed collaborations to predict and reduce extreme weather impacts in Chicago that leverage a convergent approach. He pointed out that climate change in the Great Lakes region will influence weather, water supply, algal blooms, pathogens in the region, and other urban systems such as shipping. Dr. Packman is using the Waggle nodes discussed in Dr. Beckham's presentation to evaluate flooding and its mitigation through native landscapes in Markham, IL in southern Cook County and green infrastructure in the Chatham community in the South Side of Chicago. These efforts are supporting documentation of the value of urban greenspace in Chicago. An NSF-supported projected called Systems Approaches for Vulnerability Evaluation and Urban Resilience (SAVEUR) is linking long-term monitoring with predictions, planning and design for urban vulnerability and resilience. This project is an example of a combination of climate and natural disruptions with technological disruptions that is highlighting a path towards improved urban resilience (**Figure 15**).
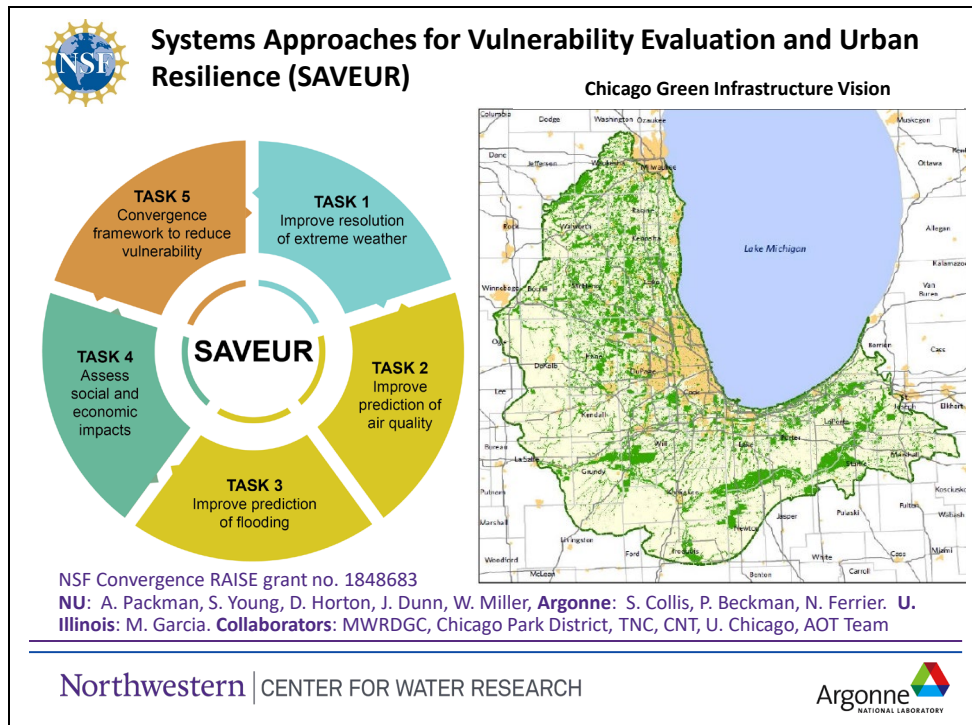
Figure 15. SAVEUR project's approach to using high-resolution data and modeling to predict and reduce the impacts of flooding.

The final panelist in this session was <u>Dr. Danielle Kizaire</u>, the Co-Founder of Bronzeville Urban Development (BUD). This organization has a mission to, "educate and revitalize under-resourced urban populations by leveraging community assets, including human capital, real property, and natural resources…," BUD has worked with the Illinois Institute of Technology and ComEd on the GenR8 Community Energy Project to promote community-owned and/or operated energy through a microgrid. BUD seeks to promote renewable energy and provide education and employment, while addressing environmental justice issues. They are considering installing solar panels on over 1,000 units of moderate- to low-income housing that enable combined heat and power and have battery storage. Dr. Kizaire pointed out that, through community involvement, the ability to modify Chicago's energy economy would cause ripple effects for all ComEd ratepayers. Overall, this approach would contribute to electric utility resilience with microgrids reducing central utility construction costs (**Figure 16**). Franchise agreement approaches would need to be evaluated and adopted including permission for the utility to re-create the urban electric grid and the associated costs would be repaid through local infrastructure improvements. Overall, the city and utilities would become partners with jobs created in the management of microgrids. Utility rates would be fair and equitable based on building resilience into the electricity supply. Dr. Kizaire advocated for community involvement during the planning, implementation, and evaluation stages of installing solar energy.

ENERGY DEMOCRACY IMPLEMENTATION
Facilities perspective – control and ownership

Comprehensive Microgrids for thermal and electric end users
Reduce electric consumption before installing PV microgrids
Efficiency in structure and site utilization
  • Building re-use rather than tear downs
  • Owner control of energy generation
  • Local energy storage, bigger UPS (uninterruptable power supply)
Renewable Energy within the building (Net Zero)
  • Midwest Climate – Combined Heat and Power
  • Implement all possible thermal energy capture and use
  • Air to air, geothermal, solar thermal, building envelope
  • Transition to renewables over time
  • Approach Net Zero buildings and sites first
Partner with Local Electric Utility
Facility owners can provide means to implement distributed generation

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Figure 16. Benefits and considerations in the implementation of microgrids.

3. Highlighted research questions arising from SUSPIRE

This section synthesizes the discussions at SUSPIRE regarding climate and natural, technological, and societal disruptions and their intersections. The discussions have been grouped into nine major themes that emerged from the SUSPIRE breakout sessions. The subsection for each theme concludes with research questions aligned with the NSF key elements to advance SUS presented in Table 1. One key point that emerged from our focus group with community representatives after SUSPIRE was that we need to put community needs first to emphasize their importance. Based on this input, we have structured the themes by prioritizing community needs at the forefront, before moving on to more specific technical themes identified from the conference.

3.1 Collaboration models to get results for communities and increase sustainability of cities

What society has been doing in underserved communities for the last 50 years hasn't worked. Researchers need to consider new models that include community groups as an integral partner from the beginning. People and organizations in this space aspire to cross-sector collaboration, meaningful community engagement, and inclusion…but it's always far harder than it appears. New advances are needed for when and how to engage community groups, how to approach and co-develop projects, and developing a framework for bringing resources to the community. It is important to ask "why" to engage community groups, as well as "how" to engage them. It is also important to develop and value processes, as well as projects.

Long-term relationships build trust and have the potential to reduce "research fatigue" among highly researched community groups.[18]   Researchers and community groups need to work together throughout the course of a project with frequent check-ins, rather than a post-result check-in that may reveal the overall project was not impactful or meaningful to the community. Competing priorities of community groups, industry, and city government can result in unfavorable outcomes for communities. All parties, including elected officials and the financial community, need to be at the table as decisions are made about development and community evolution.

To be effective, researchers and policy makers must work closely with the community and engage with people to understand their needs and desires BEFORE asking for their help. It is very helpful for scientists to spend time and attend activities in the community to better understand the community's dynamics and challenges. What are community members looking for in jobs and other potential benefits? Understanding community perceptions is just as important as other types of data. For example, it is important to discuss perceptions around access and safety before designing new parks. Researchers can benefit from the knowledge and experiences of community members in many subject areas. Capacity building is mutual and equal between community groups, researchers, and research organizations. The community must be an equal partner to ensure that community needs and desires are addressed to make the project a success. One should develop rules of engagement that all can agree to as an outcome of community discussions. It is important to formalize the collaboration and define what each group will get out of the collaboration. Set clear expectations in advance (e.g., legal agreements, IP protection). Researchers must be trained in how to work with community groups as equal partners.[18]

Researchers should go to the affected communities and work directly with the relevant community stakeholders on specific, tangible, local issues. It is important to recognize that communities already have many good ideas and experts to solve their problems, but often lack key resources to implement their ideas on a large scale. Researchers should learn from people in the community and build on and elevate what exists within the community. Rather than starting big new programs and collaborations from scratch, it may be much more effective to support (and expand from) existing programs that need help developing capacity. This requires knowledge of the assets in an area and what is being done in the community. Providing access to money and other resources by the community is essential for success. Community members should be recruited and paid for their time conducting research and should have priority for jobs that result from the research. Education and training programs should be included in any solution. One effective approach is to train key community members and then have them train other community members (training the trainer). Another effective approach is to support entrepreneurs of color to develop businesses for the new economy. Research is needed to evaluate how to leverage "access" of funders and researchers to help entrepreneurs in the community develop their own access. It is important to measure or evaluate success – including community culture and social and environmental equity, along with economics and the environment. Networking with other communities can greatly increase impact. Sharing data and information to increase cooperation may avoid having to repeat the same research, data collection, and surveys. However, networks are not enough for effective collaboration; there must also be reciprocal trust developed by working together on projects.

It is a major challenge to develop connections between community organizations with specific needs/interests and multidisciplinary research teams that have the relevant expertise and interests. One approach to building project partnerships is to work with collaborative organizations that have long-term relationships and credibility with community organizations, as well as direct knowledge of their needs. Another option is to work with existing vetted connection platforms, such as the American Geophysical Union's Thriving Earth Exchange.[19]

However, a more directed approach will likely be necessary to assemble multi-disciplinary teams of researchers and connect them with government agencies and policy makers. A potentially effective approach to building impactful projects is to provide financial support for groups to develop ideas – e.g., selected based on a 2-page description – that would compete for full funding with long-term support for implementation and maintenance. All attendees get to hear each other's pitch to the funders, so there is good potential for other collaborative projects to be generated among the groups that don't receive full funding. One recommendation from SUSPIRE was to hold follow-on workshops with researchers, community members, policy makers and funders designed to result in pilot projects. The first part of each workshop would be designed to assemble multi-sector and multi-disciplinary teams interested in particular topics. During the second part of each workshop, the teams would begin to develop concrete projects and forge partnerships. This encourages workshop participants to think through tangible solutions. The workshops could also provide ideas for collaborative grant application support and/or crowdfunding projects.

Element	Research questions
B. Science advances for sustainability	Can we identify co-benefits and pursue joint funding from organizations, including industry, with complementary goals? Can we develop an holistic assessment of ROI that takes co-benefits into account?
C. Levers for change in urban systems	What is the impact of civic engagement, taking action, increasing political consciousness/mobilization within communities on engagement with researchers and project success?
D. Theories of change across city types	How can we effectively scale successful projects developed in one community across many communities? This will require developing trust between and among different communities, research teams, and policy makers.
F. Science of knowledge co-production	How can we ensure that community participation in designing and co-producing new projects and developments directly benefits the community? How do you empower individuals in a community to take responsibility for developing and implementing actions to benefit their community? How do you build and sustain a grass roots platform to connect the community with experts? Who would be able to do this? What is the overlap between vulnerable communities and those we can reach with our current networks? How to expand the networks? How do effective collaborations with researchers differ between community organizations and communities? Consider differences in organization focus, strategy (top down vs. bottom up), willingness, and funding. How can society provide the funding needed for implementation and maintenance of promising projects developed through NSF-funded research?

3.2 Developing robust and validated techniques to characterize, quantify, and optimize social, natural, and built/economic capital in designing and assessing urban systems

In general, decision making in urban planning is guided by cost, opportunity, and in some cases, environmental outcomes. The methods civil engineers use to establish built capital, the costs of developing new infrastructure or maintaining existing infrastructure, are well-established. In addition, the fields of environmental economics and multiple engineering disciplines have built methods to characterize the economic value of natural systems and ecosystem services, termed natural capital. The quantification of natural capital, however, remains an active research field.[20] Methods to evaluate and build social capital into decision making and policy lag behind economic and environmental considerations, particularly in the engineering domain. Social capital remains difficult to define and quantify.[21] Ideally, built, natural, and social capital of different urban systems scenarios should be put on an equal footing with well-defined methods of taking each into account when making decisions about urban systems' design and management. Before realizing this ideal, methods for quantifying natural and social capital as well as how natural, social, and built capital interact and affect each other requires additional research.

In urban systems, open research questions around quantifying natural capital include accounting for multiple benefits of green infrastructure (e.g., air quality, water quality, mental and physical health) and the influence of healthy soils on urban agriculture and water quality. In Chicago a flagship natural capital research question is valuing the Great Lakes from their role as a freshwater resource to the mental health benefits accrued from their natural beauty and recreational value.

At SUSPIRE, the importance of quantifying social capital in decision making across urban systems was a common theme. Participants also inquired how different urban systems influence social capital. The influence of disasters on social capital was of particular importance to attendees. One research question could be how to predict and design mitigation strategies using engineering approaches to limit the influence of disasters on social capital.

One point of discussion was how to develop methods that measure human connections in smart city research that uses sensors, social media data, and other data sources such that social capital has a robust, data-driven basis. Yet, social capital depends on more than an individual's network including on the quality of the relationships in that network and, notably, the trust that exists in the network. The flow of information through this network is another key element of social capital. News deserts (e.g., due to the loss of local newspapers) and disruption to standard news outlets can have an influence on social capital that is poorly understood. Finally, weak social networks complicate building and developing resident leaders, who are critical for advancing the development of sustainable urban systems to realize built, natural, and social capital benefits across the city and region. Methods to quantify these and other key characteristics of social networks and translate these findings into social capital estimates are needed. Also, leveraging ethnographic techniques to qualitatively understand people's lived experiences would complement quantitative estimates and provide data that would otherwise not be gathered.

As methods to characterize natural and social capital improve, it will be important to devise decision-making methods that optimize all three types of capital, which is a very difficult task that requires extensive research and piloting. One need is for more practical and applied research on how social, natural, and built environment challenges overlap, spill over and cause challenges elsewhere in an urban system. Existing theories of cascading failures are not adequately designed to guide interventions because they are not grounded in how communities reason and behave, which are influenced by social capital. There is an opportunity to explore helplessness, mobilization, intersectionality and other motivational and community-based theories and methods to understand how systems cause vulnerability and how to untangle and intervene effectively through increased built, natural, and social capital. More field experimental methods are needed to study how systems work in practice, have worked historically, and/or how they work in natural experiments to see how interventions strengthen or weaken built, natural, and social capital. There is an opportunity to direct resources to research teams that examine multi-sector vulnerabilities and work with communities to examine how they unfold and how to break destructive patterns.

Key Element	Research questions
A. Data and methodological advances	What new methods can be developed to characterize social capital, especially tapping data from sensors and social media?
	How can we build upon existing methods to quantify natural capital with a focus on urban systems?
B. Science advances for sustainability	How do social, natural, and built capital interact and how can each be taken into account when designing and evaluating urban systems?
C. Levers for change in urban systems	What role does social capital play in driving change in urban systems?
F. Science of knowledge co-production	What are effective ways for multiple disciplines (e.g., anthropology, public health, science, engineering) to collaborate with community groups in building understanding of natural and social capital and the interplay among the three types of capital (including built)?

3.3 Rethinking equitable development practices for smart sustainable cities

It is important at the outset to acknowledge disruptions (e.g., zoning, access to transportation, etc.) that have already occurred to create systematic inequities, racial inequities in particular, and develop plans with intentionality in order to avoid actions that perpetuate these inequities. Many urban communities, including Chicago, have a number of underserved communities with empty buildings and vacant lots resulting from a population exodus driven by a lack of economic opportunities and gang violence. Many of these communities have transportation infrastructure that would make them very attractive to young professionals eager to move into the city if they were redeveloped with improved amenities. It is very difficult to bring healthy communities to life in underserved areas, while keeping them affordable to live in for the current residents and also accessible to previously displaced residents who would like to return. This is especially difficult if most of the housing is owned by investors, rather than the residents. One major challenge is created by developers who come in from outside the community and redevelop without consulting the current residents. One way to address this challenge is to build leadership for community-driven development. However, due to limited resources, community-driven development often occurs incrementally – one or several properties at a time. This allows speculators to swoop in relatively early in the process to purchase and develop the remaining properties in a manner that forces out and/or excludes lower-income residents.

The research community needs to examine how we can "green" and make communities more resilient without gentrification. One option may be to use zoning or rent control to prevent outside developers from purchasing large numbers of properties without developing a plan for community input and the creation of affordable housing. Zoning policy is challenging to change, but other mechanisms, such as community development agreements, exist that can inform and encourage structures or approaches to development that can safeguard and/or benefit the community, such as installation of air quality monitors and green space that meets community expectations and needs. Communities that develop a menu of at-the-ready project ideas for inclusion in community benefits

agreements before developers come in could have an advantage in working with developers to advance their community's objectives for development and sustainability, rather than having to react to a developer's perception of community needs or benefits in a process that can breed mistrust and contention and retard or prevent the necessary progress. It is very important to include elected officials and the financial community. Project leaders should also consider engaging researchers from business schools to address financial aspects, including effective rules for designating TIF districts.

Another option may include providing additional resources for community-driven development from tax incentives, socially responsible investment funds or community lending institutions and/or by collaborating with the Chicago Housing Authority resident relocation programs and/or the Chicago Public Library to develop housing for low-income residents. We need to better understand the economic impact of current housing policies (e.g., setting aside affordable housing units). A longitudinal study on residents in co-op vs. non co-op housing would provide valuable information. It is also worth exploring the potential impact of high-earning corporations, especially those located in newly developing areas, to provide a certain amount of affordable housing for their employees in the same areas as their office (e.g., subsidized downtown housing for new employees). It may be possible to decrease development costs by adopting modular construction and other advanced manufacturing approaches. Case studies from other cities on what has worked and not worked would provide valuable perspective. Researchers also need to identify the best qualitative and quantitative measures for success.

Resources to support equitable development may also be derived from integrating into a project locally-controlled income-generating components, such as renewable energy production (see Section 3.6 on new approaches to public utilities) or urban agriculture. Another attractive option is the development of a local circular economy, such as The Plant in Chicago, wherein conventional waste streams from one process are re-purposed as inputs for another. This creates a circular, closed-loop model of material reuse and yields revenue from diverse inter-connected businesses that also provide jobs in the community. There is potential to develop and implement zoning that intentionally promotes (re)connecting greenspaces to form resilient corridors. Homeowners, community groups and researchers could be engaged to provide information on enhancing connectivity. Working with homeowners and community groups could provide a new business model for construction companies with skills to incorporate green offerings and green infrastructure for possible stormwater retention credits.

Researchers need to understand how to most effectively engage incoming and current residents in redeveloping communities to assess their needs and distribute resources. Research is needed on developing cultural adaptation and awareness between the groups of residents and how communities can plan ahead and intervene proactively to smooth the transition and decrease conflicts. This will include acknowledging the existence of systemic racism and developing approaches to deconstruct this through policy and cultural exchanges. It is also important to effectively address race and gender issues as they relate to pay, workplace culture, and associated mental/ emotional health issues for people from different cultures. Possible approaches to develop awareness include participatory art and music events. Strategically improving community safety may also facilitate cross-cultural engagement.

It would be very helpful to develop a predictive model for population growth and movements within the city and region. Models of people moving in vs. out of a community could include analysis of changing resource requirements (housing, utilities, etc.). It would also be valuable to integrate the distribution of pollution and green spaces across the area as a way to estimate the (physical, mental, and emotional) health effects of population changes across the region, as well as the localized effects of industry, highways, and railways. One could also engage community members in developing models to create a shared responsibility.

Element	Research questions
A. Data and methodological advances	How do we "green" and make our communities more resilient without gentrification?
B. Science advances for sustainability	What actions and policies build strong social networks in communities with changing demographics?
	How can integrating locally-controlled, income-generating components (e.g., renewable energy production, sustainable industry, urban agriculture) into a project provide additional resources to increase the pace and scale of community-driven development?
C. Levers for change in urban systems	What zoning and other policies are most effective for decreasing segregation and gentrification that forces current residents out of their homes and communities?
	Can we develop and implement zoning that intentionally (re)connects greenspaces to form resilient corridors?
E. Science advances for modeling	How can we develop a predictive model for population growth and movements within the city? What scenarios of urban development can we simulate?
F. Science of knowledge co-production	What amenities are most valued by communities in different neighborhoods within a city?
	How can researchers work with communities to develop a menu of at-the-ready project ideas for inclusion in community benefits agreements that effectively advance the community's objectives for development and sustainability?
	How to most effectively engage with the incoming and resident communities to assess their needs and distribute resources? What is the best way to develop cultural exchanges and awareness between communities?

3.4 Reimagining public transportation for improved environmental quality and social equity

Climate change and public transportation are interlinked, notably because of demographic changes including Chicago's possible role as a destination for those leaving communities elsewhere that have been adversely affected by climate change. It is widely agreed that reducing vehicle miles traveled in commuting and other types of trips through wider use of public transit (increased

ridership, increased service options, longer and more far-reaching routes) improves air quality and reduces greenhouse gas (GHG) emissions. Yet, public transit may have increasing demands placed upon it as the effects of climate change are more widely felt and Chicago's population grows. Furthermore, a healthy economy with high employment, which is a characteristic of sustainable urban systems, translates into additional commuters and increased congestion on the roads which can be alleviated through increased use of public transit.[22] Simultaneously, public transit may face challenges posed by more frequent severe weather, which in Chicago includes intense thunderstorms that lead to flooding, extremely cold weather, and heat waves. These effects could make public transit less reliable leaving commuters with no transportation options and possibly result in some people turning to their cars, which are unaffected by phenomena such as rails bending in the heat or cessation of service upon a power outage or flooded tracks. Additionally, commuters may prefer to travel the last mile of their journey in the coolness or warmth and dryness of their vehicles, rather than walking through increasingly inclement weather. Another option for the last mile is ride share companies. Fee-based ride share activities can be part of enhancing public transit. The fee structure applied to rideshares could be more tailored to avoid negatively influencing those who are riding with others and overall, ride sharing policies should be investigated to move towards on-road vehicle reduction while increasing access to underserved areas. In addition, there is a complex link between public transit and active transit[23] with each type of transit requiring unique infrastructure (e.g., well-lit walkways, bike lanes in the case of active transit). Active transit plays a key role in last-mile travel. Moreover, it brings public health benefits. How climate change will affect active transit and how active and public transit interactions will evolve with climate change remain unknown, limiting the ability of cities to plan for transit that addresses public health, climate change, air quality, and economic drivers. Overall, in the coming decades, if commuters turn away from public transit and active transit, the population increases, and employment is strong, more cars could clog highways and local streets.

Furthermore, to offer its full potential, public transit, and infrastructure for active transit, must offer equitable service, reaching communities that are currently underserved or inequitably served, and should improve its regional links to the suburbs and beyond. New opportunities present a chance to reimagine public and active transit and move towards an urban region with fewer vehicles on the road, equitable service, and low environmental impact. These include the use of sensors and social-media-derived data to interlink public transit timing and traffic flow, including potentially changing pricing on public transit tickets and tolls to modify behavior and render public transit more cost effective. Secondly, through the use of social media data and other sources, there is new opportunity to advance the field of transportation psychology to inform understanding of how people decide which way they will get to work. Certainly, it is important to assess a rider's experience before, during, and after riding public transit. Research into how transit availability and usage influences mental health, including by way of providing high quality and reliable commuting options, could also inform public transportation planning and policy. Overall, considerations of how public and active transit could reduce urban sprawl or limit its effects through reliable and efficient service to job centers should be factored into decision making regarding urban planning and techniques to combat air pollution and GHG emissions from commuting in concert with the demographic shifts described elsewhere in this report. Finally, opportunities to make public transit more inclusive through linking it with ride shares, autonomous vehicles, and active transit infrastructure present ways to improve the deficient service that is observed in disadvantaged communities.

Key Element	Research questions
A. Data and methodological advances	Based on sensor data, social media postings, and surveys, how do commuters decide how and when they will travel to work?
	Where do those with limited mobility outside of public transit go when transit is closed or delayed?
B. Science advances for sustainability	How does weather influence use of public transport and how does use of public transport influence climate (e.g., air quality)?
	How is the design of public transport routes and usage incentives linked to access to employment?
	What are the social, environmental, and cost benefits and/or drawbacks to an urban system with no cars?
	What are the environmental and economic tradeoffs between building more roads (e.g., land-use change, use of concrete) versus more rail lines, more bike-friendly options in the Chicago region?
C. Levers for change in urban systems	As the climate, demographics, and employment landscapes change in Chicago, how will this influence use of public transport and what policies and engineering and design strategies can increase public transport use in the coming decades?
F. Science of knowledge co-production	What are the most impactful ways developers, community groups, employers, and local and regional government can collaborate and share information to lead to increased use of public transit taking into account reducing transportation costs and commuting time for residents in addition to local environmental impacts (e.g., air quality effects on near-roadway homes and schools)?

3.5 New approaches to "public" utilities

Decentralized, smart energy production, such as the development of locally controlled renewable energy microgrids, has the potential to increase grid resilience and bring cost savings to residents. Research is needed to develop a series of case studies in different types of communities and locations that show what it takes and looks like to transition to a decentralized grid that communities can use for reference when developing their own microgrid. What are reasonable prospects for conversion of brownfields to solar energy farms? It will be important to include education and social learning when engaging residents, and to ensure that people not trained in technical/ professional/ technological skills are treated in an equitable manner during policy discussions.

Decentralized energy production will force us to rethink the concept of a public utility. Research is needed to understand how communities organize and adapt to a new utility concept. It will be important to ensure equitable distribution of services (e.g., electric vehicle infrastructure) across neighborhoods and understand how improvements to off-grid infrastructure will impact "left behind" ratepayers. The regulatory environment will have a major effect on the scope and speed of microgrid development. Research is needed to better understand how different types of

regulations hinder or support microgrid development, self-generation, and grid resilience. It is important to evaluate the prospects for and potential benefits of public-private partnerships, as well as an appropriate ROI for investors. Researchers and practitioners also need to understand the long-term impacts on financing (e.g., tax breaks), ownership, and responsibility for and coordination of maintenance.

It is essential to better understand how grid vulnerability and stability are impacted by distributed power production and energy storage by multiple actors. Research is needed to understand how cybersecurity risks scale with the number of new "smart" components. Is this proportional or does it increase more than proportionally due to multiple interactions? It is important to understand the risks of connecting less sophisticated small producers, who may provide a "back door" for hacking to disable the grid, and how can this be prevented. New devices should be designed in a manner that facilitates periodic upgrading (including cybersecurity), as well as facilitate reuse and recycling of components. Electric vehicles (EVs) pose both challenges and opportunities for developing stable grids, particularly with the growing renewable energy sector. Research is needed to better understand the potential role, benefits, and tradeoffs of EVs as integrated grid infrastructure in the form of energy storage in their batteries.

Systems must be designed to be more resilient during emergencies and minimize disparities in restoring service after outages. Researchers need to develop energy distribution models to predict impacts of different disruptions. Is it possible to develop methods to identify "signatures" that predict different types of imminent grid instability and develop automated procedures to maintain stability in an equitable way? For example, how to decide who has power reduced first and how this varies depending on the situation? What will be the impacts of new technology, innovation and the availability of data to make real-time decisions as power demand and production change? It will be important to develop more pilot projects paired with modeling to speed implementation and provide motivation for politicians to invest their support.

Increased periods of drought and depletion of groundwater in addition to loss of water from aging infrastructure will make it important to develop effective regional (across city and state boundaries) planning and cooperation on fresh water supplies. This will also require coordination between public and private water suppliers. One largely unexploited source of fresh water is treated wastewater. Rainwater harvesting also provides an opportunity for reducing groundwater consumption. Researchers need to analyze what it would take to make water reuse viable in a water-rich urban system such as Chicago. It will be essential to involve community organizations, state legislators, municipal governments, water reclamation districts, and environmental groups to consider what new regulations will be needed.

Element	Research questions
A. Data and methodological advances	How do communities organize and adapt to a new utility concept? How can we rethink the concept of a public utility?
	How have large utilities elsewhere adapted to decentralized and renewable energy?
B. Science advances for sustainability	How do cybersecurity risks increase as the number of "smart" components increases in a micro-grid? Is this proportional or does it increase more than proportionally due to multiple interactions?
	What are the potential role, benefits, and tradeoffs of using EV batteries as integrated grid infrastructure in the form of energy storage?
	Can we develop methods to identify and detect system "signatures" that predict different types of imminent grid instability and develop automated procedures to maintain stability in an equitable way?
C. Levers for change in urban systems	How do different types of regulations hinder vs. support grid resilience?
	How can we develop effective regional (across city and state boundaries) planning and cooperation on water supplies among public and private water utilities? What is the impact of privatizing public water utilities?
F. Science of knowledge co-production	How can we ensure that people not trained in technical/professional/ technological skills are treated in an equitable manner during policy discussions?
	What are the prospects for and potential benefits of public-private partnerships? What is an appropriate ROI for outside investors?

3.6 Changing nature of work/technology-human interface

The Chicago area is facing a number of challenges in growing and sustaining its workforce[24] and does not ensure equitable opportunity for all residents.[11] Some limitations to improved participation in the regional economy include limited access to public transit and other forms of transportation that do not equitably serve all city regions, limited access to information technologies, and limited opportunities for learning new skills that might allow a transition from employment in a fading economic sector to a growing sector.

New approaches to anticipating and preparing Chicago's workforce for the changing nature of work are needed. Research topics in this area could include the following: characterizing the role of automation in creating jobs in a region with the employer profile of Chicago, development of methods to assimilate workers into growing industries through technology training, developing technology to connect workers to short-term jobs while addressing social security and tax requirements, and developing technology and managerial approaches to enable increased remote work – especially for the disabled population, those with limited transportation, and caregivers with time constraints such as only being able to work during the hours their children are in school.

As the work environment continues to evolve in response to economic and technology factors, it is critical to identify those who may be vulnerable to loss of employment or problems with job acquisition. With this understanding, efforts to design solutions to bring these workers into economic sectors that provide upward mobility through effective training programs, efforts to keep capital in communities, and efforts to engage youth in particular in employment will be more effective. Overall, measurement of the influence of these efforts on employment and associated social and environmental (e.g., through reduced or increased commuting, emissions from manufacturing facilities) is critical to advancing understanding of sustainable urban systems.

Element	Research questions
C. Levers for change in urban systems	Who is most vulnerable to changes in the human/technology interface in the workplace and how can governments and community groups implement programs to bolster their competitiveness and engagement/enjoyment at work?
F. Science of knowledge co-production	How can governments, community groups, and researchers design real-world experiments that can reveal effective pathways to increased employment and reduced income inequality in all Chicago regions?

3.7 Comprehensive analysis of GI efficacy, co-benefits and economics

Climate change is expected to increase the frequency of intense rain events and extended heat waves in the Chicago region and many other parts of the US.[1] Flooding in the Chicago area has been so bad over the past decade[2,4] that only places ravaged by hurricanes have sustained more flooding damage. Green infrastructure (GI) and other nature-based solutions have been proposed to mitigate the realized and predicted increases in flooding and urban heat islands associated with climate change.[25,26] However, many issues remain to be resolved.

While specific measures of stormwater mitigation performance can be tested against projected future precipitation patterns, there also needs to be a comprehensive evaluation of the efficacy and economic benefits associated with the wide range of co-benefits or ecosystem services (urban heat island mitigation, improved air quality, increased wildlife habitat and biodiversity, improved water quality, improved aesthetics, health benefits, human stress reduction, etc.).[27] Research is also needed to better understand how stormwater mitigation and co-benefits of different types of GI evolve over time under different monitoring and management scenarios. Improved models are needed to inform GI placement and predict GI outcomes. Researchers also need to develop a valuation and cost-benefit analysis for green infrastructure, as well as develop an inventory of different types of green infrastructure in scales required to understand the broad impacts.

It is important to prevent flooding, but also retain the ability to capture rainwater to prepare for droughts (e.g., by recharging ground water). Research is needed to understand how different types of GI systems behave in a "feast or famine" cycle of heavy rains followed by drought, as well as which plants are best suited for this. One option is to reconfigure city parks and forest preserves to better retain stormwater. However, estimating the benefits of such approaches requires better

understanding of the stormwater retention capacity of native and restored environments. The many brownfields and vacant properties in Chicago provide opportunities for development, as well as the creation of stormwater parks to alleviate flooding. However, many of these sites are contaminated by heavy metals or chemicals that can be released into the environment by flooding. It will be important to evaluate the potential for different types of GI and plants to take up heavy metals and support microbes capable of breaking down hazardous chemicals.

Research is needed to determine what types of green infrastructure will be most effective in mitigating the effects of heat waves. What is the optimal location of trees and other green spaces for health benefits? How far do the benefits extend as a function of green space size? What species of trees, plants, etc. are most effective for different types of green infrastructure? What are the impacts of different plants and combinations on decreasing temperature, volatile organic carbon (VOC) release, particulate removal, biodiversity, health, recreation, etc.? Can researchers and practitioners design a systems-level infrastructure for 'livability'?

Finally, it will be important to develop and evaluate different funding mechanisms for green infrastructure. Researchers and practitioners need to understand community preferences and willingness-to-pay for different types of GI or open space. What factors are most important in green space use and willingness-to-pay? Can we use behavioral economic understanding to address these issues? What types of education programs are most effective? Questions around a market-based approach and stormwater credit trading to increase and provide funding for GI must be resolved.

Element	Research questions
A. Data and methodological advances	What mixture of green and gray infrastructure will be most effective in decreasing flooding and improving water quality in a "feast or famine" cycle of heavy rains followed by drought?
	How best can green infrastructure be effectively monitored and managed for sustainable urban water management?
	How can/should parks and forest preserves be integrated with other types of green infrastructure for stormwater management?
B. Science advances for sustainability	What is the potential of green infrastructure for remediation of hazardous materials (lead, PCBs, chemicals) released into the environment by flooding of brownfields and landfills?
C. Levers for change in urban systems	What are community willingness-to-pay measures for green space and associated co-benefits? What factors are most important in green space use and willingness-to-pay?
	What are the most effective funding mechanisms for green infrastructure?
E. Science advances for modeling	How can we develop improved models to inform green infrastructure placement, predict outcomes (urban heat islands, air quality, flooding, biodiversity, etc.), and estimate cost-benefit ratios for different types of GI?
F. Science of knowledge co-production	What types of green infrastructure do communities desire? What types of education programs are most effective for acceptance of green infrastructure?

3.8 Tracking and management of urban provisioning and networks

The concept of urban metabolism[28,29] is used to characterize flows into, within, and from urban systems. With an understanding of urban metabolism, systems can be modified to lessen costs, environmental, and social impacts of urban systems at a local, regional, national, and even international level. Furthermore, residents and policy makers within a city may be interested in making decisions regarding their purchases and other choices based on the source of goods and services. Better tracking systems are required to increase the utility of urban metabolism studies to community groups and governments.

Tracking energy, water, goods, and materials flows within and outside of an urban system is currently difficult. Emerging blockchain technologies, particularly those that are less energy intensive such as the Proof of Stake approach,[30] offer an opportunity to track a food item from farm-to-table. Advantages of this approach include supporting small farmers, reducing food waste, and informing consumers about the origins of their food and associated farming practices that could shift behaviors towards more sustainable food choices.[30,31] Chicago could serve as a testbed for blockchain-based food source tracking to understand how the city influences agriculture in its immediate region and beyond, as well as the city's susceptibility to climate, technological, or societal influences that could disrupt the food supply. Furthermore, such tracking could be used to support urban agriculture and small-scale organic farmers within and outside of Chicago's borders, thereby enhancing economic opportunity for these producers. Finally, food origin can

influence public health given differences in farming practices and nutritional content. Can we understand how food origin influences public health and how to reduce the effect of food deserts?

Moreover, the tracking of energy is even more difficult than of food. Local utility providers offer consumers the opportunity to purchase solely renewable energy, but as the electricity distribution systems mixes electrons from all sources, fossil and renewable, it is currently impossible to know the source of a home or company's electricity. Can technologies be developed that would enable consumers to trace energy to know it is renewable and even to know it came from a job-scarce region where unemployed residents are trained to work in the renewable energy sector?

Furthermore, better information about urban provisioning and networks could lead to improved community-centered design that enables communities to have their provisioning needs met from nearby sources, identify who benefits from urban consumption of materials and energy, and improve equity and justice associated with urban provisioning patterns.

Finally, such tracking of urban provisioning and networks is critical to gain insights for the potential of a circular economy. With understanding of demand for and provisioning of goods and energy, the optimal scale for resource recovery (energy, water, nutrients) from wastewater and municipal solid waste within the urban boundary will become more apparent. In addition, demand for by-products of waste flows would be illuminated and insights into the conditions for viability of water reuse in urban systems and the full potential of urban agriculture to help a city or a neighborhood meet needs for fresh produce would emerge.

Overall, with efforts to track and manage urban provisioning and networks, determining the priorities of stakeholders from individual residents to corporations and governments will help researchers provide insights with data that already exist and build methods to collect and interpret data that is not currently available.

Element	Research questions
A. Data and methodological advances	What data regarding the supply chains of goods and energy consumed within Chicago would be of use to those looking to enhance the city's sustainability, social well-being, and opportunities for a circular economy? Is it feasible to use blockchain to track these supply chains? What other tracking methods can be developed to provide useful information? Can we understand how food origin influences public health and how to reduce the effect of food deserts?
B. Science advances for sustainability	How do Chicago's consumption patterns influence the region, the nation, and the world from environmental and social perspectives? Can technologies be developed that would enable consumers to trace energy to know it is renewable and even to know it came from a job-scarce region where unemployed residents are trained to work in the renewable energy sector?
E. Science advances for modeling	How can *tracking data* be used to parameterize models of urban systems or to validate them? How can improved information from supply chain data for Chicago improve circular economy models and identify ways to reuse energy, nutrients, and water to achieve multiple sustainability outcomes?
F. Science of knowledge co-production	What are the priorities of stakeholders from individual residents to corporations and governments regarding developing data to track urban provisioning and networks and how would they use these data to improve multiple sustainability outcomes?

3.9 Managing infrastructure through sensors and sensing

Urban infrastructure encompasses roads, bridges, highways, public transportation tracks and stations, wastewater collection and treatment plants, water distribution systems, and green infrastructure among other elements of the built environment. It is widely known that existing infrastructure in the United States is aged, deteriorating, and in need of significant investment.[32] This state of infrastructure poses two high-level themes for sustainable urban systems research: monitoring and maintenance of existing infrastructure to ensure adequate performance and design of new infrastructure to meet the challenges of sustainable urban systems. Two themes arose at SUSPIRE for rising to these challenges. The first theme was the role of materials science in developing new infrastructure for urban systems able to withstand significant temperature and moisture variations that will accompany a changing climate. For example, with more frequent and severe rainfall in the Chicago area, infrastructure may be submerged frequently and should be designed to maintain structure and performance through these conditions, as well as more frequent and extended cold snaps and heat waves.

The second theme was the use of sensors to monitor and improve the performance of both aging and new infrastructure. Sensors can detect vibrations and other characteristics of infrastructure and can give early warning of potential failure in the case of aging infrastructure. Or, in the case of existing infrastructure that influences the behavior of dynamic systems, such as storm water

management, sensors can be added to improve performance. An example was given at SUSPIRE of St. Louis, which uses sensor data to direct flow among storm water reservoirs based on how close each reservoir is to capacity and the levels of stress for the various treatment plants. An example was also raised of using multi-platform sensor data at public transportation stations (e.g., from phones, radar, CCTV) to make commutes more pleasant through adjusting platform conditions and transportation timing.

In the case of new infrastructure, sensors can be incorporated to give data-based performance insights beginning from installation. For example, sensors monitoring green infrastructure performance aid in quantification of its benefits (economic, environmental, and social) to guide design and use of green infrastructure elsewhere

Broader use of sensors and making the resulting data open source with privacy protection in place can result in making sustainable infrastructure more scalable within one community and beyond community borders. How to release sensor data without compromising privacy or intellectual property is an open research question that must continually be addressed as new types of sensor data and new locations of sensor data gathering come on-line.

Element	Research questions
A. Data and methodological advances	How are weather conditions and infrastructure performance interrelated?
	What types of data are most useful in informing infrastructure design, placement, and use?
B. Science advances for sustainability	How can sensor data be used in methods that evaluate the cost and environmental effects of infrastructure, such as life cycle costing and assessment?
C. Levers for change in urban systems	What can infrastructure-embedded sensors tell us about sociotechnical transitions that drive how people use infrastructure, thereby informing future infrastructure design?
E. Science advances for modeling	How can sensor data be used to parameterize and validate sustainable urban system models?
F. Science of knowledge co-production	What types of sensor data and in what form are most useful to those who co-produce knowledge?
	How can sensor data privacy concerns be addressed and mitigated?

4. Attendee feedback about SUSPIRE

Forty-seven people, representing 1/3 of SUSPIRE attendees, completed the post-workshop survey. Everyone reported learning something new and meaningful interactions (**Figure 17**). Example comments include
"SUSPIRE was extremely beneficial for learning how to connect different systems and approach problems from different lenses."

Figure 17. Presenters, panelists, and participants at SUSPIRE.

"There are interesting possibilities for integrating sensors, complex systems modeling (ABM), and stakeholders to address critical urban issues."

"Useful info on green infrastructure, new insights about the societal disruptions on urban systems."

"Better sense of what data some organizations have, don't have, or might easily have if prodded."

"This was an amazing learning experience for me. As a non-scientist, most of my information about the environment and climate change comes from the media. The quality of data was a breath of fresh air."

"I learned how different sectors approach issues within a city. There are some issues regarding organizations working in silos and often not addressing the needs of a community in a sustainable way."

"I learned much more specific concerns and needs for legislation, regulation, engineering code requirements related to issues that I study as a researcher but do not always study deeply in terms of implementation."

"The most effective solution to climate change and sustainable urban living needs to be a systems wide approach. … The challenge is moving any one of the large institutions is an arduous process

- getting "everyone" moving in the same direction around common benchmarks is an immense challenge."

Several attendees commented on the diversity of ideas and people at SUSPIRE including comments such as
"The many discussions around equity added a huge amount of nuance to what I would have thought were just technical problems needing technical solutions. For instance, when people go off grid, potentially increasing utility costs for everyone else."
"The session on the second morning was excellent on issues of social equity, public housing, and resident services."
"One challenge is connecting technical research and development with people who own the problem and must live with the solutions."
"I was also thrilled to see so much emphasis on equity and community."
However, one person pointed out the need to expand the participants and to place greater emphasis on diversity and inclusion. "I was disappointed at what I would call the structural lack of conversations around racial equity, racial justice and the lack of inclusivity of community-based organizations, particularly ones focused on environmental justice and community organizing. ... My frustration is that the black and brown communities that will be most impacted by climate change in the region were not at the table. Yes, the room was diverse in terms of race, but diversity is not the same as inclusion and is not the same as centering racial equity and justice in an approach to dealing with the impacts of climate change."

A major goal of SUSPIRE was to facilitate connections between attendees from the different sectors of academic and national lab research (41%), community organizations (21%), cities and regional governments (17%), large NGOs (11%), and industry (10%). We maximized the opportunity to make new connections by assigning proportional numbers of attendees from each of these sectors to each of the breakouts and by redistributing attendees for each of the four breakouts. Almost 90% of attendees reported making at least 3 new connections, with 40% making more than 5 new connections. Many attendees appreciated the chance to connect with people outside their discipline with comments such as
"The breakouts were productive for generating ideas, but also for making connections."
"It was fantastic to meet so many people from different disciplines and perspectives who all have the same goal in mind: sustainable urban systems."
"Very diverse group, it was great networking and connecting with people outside my field."
"We need more events such as this that drag us out of our silos and get social scientists talking with engineers and biomedical/public health people. We also need to be pulled out of our institutional silos (academia, government, non-profits) to generate new ideas. SUSPIRE was a great place to start."
"It was wonderful to connect with people who are doing complementary research and communicate about ways to build on, share, or avoid replicating research efforts. Connecting with community organizations additionally helped bridge some of the gap between academia and the broader community and discuss ways to make research more approachable and applicable."
"From an industrial background, I was able to develop contacts both with government representatives and universities that will support future research projects as well as the implementation of technologies that could make communities more sustainable and resilient."
"I met several people who are interested in talking about possibilities of working together."

"Attendees and panelists were extremely kind and willing to connect after the conference. I look forward to following up with my connections over the rest of the year."

5. Conclusions, Recommendations, and Next Steps

Discussions at SUSPIRE highlighted the role of disruptions in urban systems and their trajectory towards sustainability and resilience. Key themes that emerged were the opportunities to use new data to characterize, design, and understand urban systems; the necessity to consider economic, environmental, and societal factors equally; and the critical importance of engaging community groups from the very beginning in sustainable urban systems research.

As discussed above, to be effective, researchers and policy makers must work closely with community groups as integral partners throughout urban sustainability projects. A major challenge is enabling community groups to benefit directly from research projects. NSF has been giving more attention to broader impacts and to the community impacts of research. Still, there is a need to valorize or generate better rewards for the effective application of research findings in communities. For example, research plans often include recommended actions for government or policy such as legislation suggestions. However, rarely is there effective support for the financial and administrative burden including pilots and testing, information sessions, meetings across municipalities to learn approaches, etc. Neglecting the implementation costs greatly decreases the likelihood that a project will be successful. For funded projects, NSF and investigators should welcome and expect changes in project scope and funding approach if a project evolves based on input from community groups. Another approach to increase the effectiveness of research with community groups would be a requirement from NSF that investigators allocate a substantial fraction of the budget for research and implementation by community groups. Also, there is a huge skill gap between sectors, agencies, cities and between academia and practitioners. We recommend that future grants more explicitly support and reward transfer of expertise via training, sustained connection and funded exchanges after the research portion of a proposal is concluded. If NSF is not able to cover such costs, it should strongly consider partnering with relevant government agencies, such as HUD, or foundations on joint calls for collaborative proposals.

One recommendation from SUSPIRE was to hold follow-on workshops with researchers, community members, policy makers and funders designed to result in pilot projects to address near-term actions that could move the Chicago region towards sustainability and resilience. The first part of each workshop would be designed to assemble multi-sector and multi-disciplinary teams interested in particular topics. During the second part of each workshop, the teams would begin to develop concrete projects, forge partnerships and begin to think through tangible solutions. The workshops, which we plan to convene every 1-2 years, could also provide ideas for collaborative grant application support and/or crowdfunding projects.

SUSPIRE brought together a vibrant group of stakeholders that generated numerous research concepts and resulted in important and new connections that will help transform these concepts into action.

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Appendix 1. Agenda

This appendix contains the conferecne program with agenda and speaker descriptions.

Tuesday, July 16

REGISTRATION

8:00–8:30 a.m.   Registration; Coffee and breakfast

WELCOMING REMARKS

8:30–9:00 a.m.   **Welcome & conference goals**

SESSION 1

Climate and natural disruptions

9:00–9:05 a.m.   **Conveners** - Katherine Moore Powell, The Field Museum; Scott Collis, Argonne National Laboratory

9:05–9:45 a.m.   **Keynote Lecture:** - Sarah Murdock, Director, US Climate Resilience and Water Policy at The Nature Conservancy

9:45–11 a.m.   **Session 1: Panel Discussion**

Panelists - James Angel, Former State Climatologist for Illinois;
Sarah Coulter, Calumet Collaborative;
Elena Grossman, University of Illinois at Chicago;
Jason Navota, Chicago Metropolitan Agency for Planning

BREAKOUT SESSION #1

11:00–12:30 p.m.   Breakout sessions on six diverse urban systems followed by reports back to the conference. Breakout room assignments for all participants will be available on the SUSPIRE Event2Mobile App

LUNCH

12:30–1:45 p.m.   Networking Lunch in Ryan Family Atrium

Tuesday, July 16

SESSION 2:

Technological disruptions

1:45–1:50 p.m. **Conveners** Douglas Pancoast, Robert Bosch LLC and School of the Art Institute of Chicago; George Wells, Northwestern University

1:50–2:30 p.m. **Keynote Lecture:** - Pete Beckman, Senior Computer Scientist, Argonne National Laboratory

2:30–3:45 p.m. **Session 2: Panel Discussion**

Panelists - Satya Basu, Perkins+Will;
John Edel, The Plant, Bubbly Dynamics;
Elizabeth Irvin, Center for Neighborhood Technology;
Mwende Lefler, Metropolitan Water Reclamation District of Greater Chicago

BREAKOUT SESSION #2

3:45–5:00 p.m. Breakout sessions on six diverse urban systems followed by reports back to the conference. Breakout room assignments for all participants will be available on the SUSPIRE Event2Mobile App

RECEPTION

5:30–7:00 p.m. Networking Reception – Ryan Family Atrium

Wednesday, July 17

8:00–8:30 a.m.   Registration; Coffee and breakfast

WELCOMING REMARKS

8:30–9:00 a.m.   Welcome & conference goals for day 2

SESSION 3

Societal disruptions

8:45–8:50 a.m.   **Conveners** - Megan Kashner, Northwestern University;
Michelle Shumate, Northwestern University

8:50–9:30 a.m.   **Keynote Lecture:** - Susan Popkin, Institute Fellow and Director of the
Housing Opportunities and Services Together (HOST) Initiative at The
Urban Institute

9:45–11 a.m.   **Session 3: Panel Discussion**

Panelists - Daniel Ash, Chicago Community Trust;
Andrew Greenlee, University of Illinois at Urbana-Champaign;
Carmita Semaan, Surge Institute

BREAKOUT SESSION #3

10:45–12:15 p.m.   Breakout sessions on six diverse urban systems followed by reports
back to the conference. Breakout room assignments for all
participants will be available on the SUSPIRE Event2Mobile App

LUNCH

12:15–1:35 p.m.   Networking Lunch in Ryan Family Atrium

Wednesday, July 17

SESSION 4:

Research agenda for developing a sustainable & resilient Chicago region

1:45–1:50 p.m.   **Conveners** Daniel Kushner, Commonwealth Edison; Demetria Giannisis, Northwestern University

1:50–2:30 p.m.   **Keynote Lecture:** - William Abolt, Vice President, Energy at AECOM

2:30–3:45 p.m.   **Session 4: Panel Discussion**

Panel Facilitator – Jamie Ponce, City Tech Collaborative

Panelists - Danielle Kizaire, Bronzeville Urban Development; Suzanne Malec-McKenna, Great Lakes St. Lawrence Cities Initiative; Aaron Packman, Northwestern University

BREAKOUT SESSION #4

3:45–4:15 p.m.   Breakout sessions on six diverse urban systems followed by reports back to the conference. Breakout room assignments for all participants will be available on the SUSPIRE Event2Mobile App

Closing Remarks

3:45–4:15 p.m.   Closing remarks and plans for follow-up

3:45–4:15 p.m.   Departure

Featured Speakers

Sarah Murdock
Director, US Climate Resilience and Water Policy at The Nature Conservancy

Protecting and Investing in Nature Enhances Resilience

Increased disruptions to, degradation of and disconnection from our natural world is undermining the resilience of our communities. Climate change is exacerbating many of the impacts communities currently experience in the form of growing heat, increased flooding caused by intense rain events, increased drought and threats from catastrophic wildfire. When living in the urban environment, it is easy to forget the essential services that nature provides to humans that support our existence; clean water, clean air, lands to grow food and habitat to allow fish and animals to survive and prosper. If we work with nature and not against it, we can help restore nature's ability to deliver these services. Resilient urban communities occur when the environmental, economic and social systems are all healthy. They can withstand shocks and rebound to continue to support its population. We must be deliberate in planning for and making investments in communities to ensure resilience is strengthened. Some examples of innovative ways urban areas investing in nature are found in Philadelphia and D.C.

Biography: Ms. Murdock serves as the Director of U.S. Climate Resilience and Water Policy at The Nature Conservancy. Her 30-year career has spanned work in the public, private and now nonprofit sector on environmental and energy policy. Currently, she manages the development and implementation of the Conservancy's climate resilience and water related policy positions with a focus on disaster risk reduction policy. Prior to working at the Nature Conservancy, she served as a consultant working with environmental and energy clients. Prior to being a consultant, she served on the staff of United States Senator John F. Kerry of Massachusetts concentrating on environmental and energy policy. She holds a B.A. in environmental science from Colby College and a M.A. in urban and environmental policy from Tufts University. While in college she spent a semester participating in the Sea Education Association program during which she spent six weeks sailing on a 100-foot schooner. She is married, a mother to a teenage son, loves all active and inactive outdoor activities, and resides in Scituate, MA.

Peter Beckman
Senior Computer Scientist, Argonne National Laboratory

Technical Disruptions for Urban Systems

The number of network-connected devices (sensors, actuators, instruments, computers, and data stores) now substantially exceeds the number of humans on this planet. Predictions are that by 2020, 200 billion things that sense, think, and act will be connected to a planet-spanning network of computers. Combined with the astonishing explosion of machine learning technologies that have given us autonomous vehicles and predictive analytics, our urban systems will be disrupted. This presentation will explore the technological disruptions headed our way as well as some of the opportunities and risks to our cities.

Biography: Pete Beckman is the co-director of the Northwestern University/Argonne Institute for Science and Engineering and a recognized global expert in high-end computing systems. During the past 25 years, his research has been focused on software and architectures for large-scale parallel and distributed computing systems. For the DOE's Exascale Computing Project Pete leads the Argo team focused on low-level system software used by the operating system. He is the founder and leader of the Waggle project for smart sensors and edge computing that is used by the Array of Things project. Pete also coordinates the collaborative technical research activities in extreme-scale computing between the US Department of Energy and Japan's ministry of education, science, and technology and helps lead the BDEC (Big Data and Extreme Computing) series of international workshops. Pete received his Ph.D in computer science from Indiana University.

Susan Popkin
Institute Fellow and Director of the Housing Opportunities and Services Together (HOST) Initiative at The Urban Institute

Protecting and Investing in Nature Enhances Resilience The Social Impact of Chicago's Public Housing Transformation. For more than 40 years, Chicago's enormous public housing high-rises dominated the city's poorest African-American neighborhoods, bringing crime and drug trafficking and blighting the lives of the families that lived in them. But 20 years ago, the City of Chicago began a remarkable odyssey that would help the Chicago Housing Authority (CHA) evolve from the most dysfunctional public landlord in America to the ordinary city bureaucracy it is today. The CHA's Plan for Transformation originally called for demolishing all 11 of the agency's notorious high-rise family developments; over time, the Plan has expanded to include all but a few of the agency's properties. There is no question that its transformation has changed the face of the city—and that it has profoundly changed the lives of the thousands of families who lived in these developments. My research focuses on how CHA families have fared, the challenges that remain, and the implications of Chicago's experience for the national public housing crisis.

Biography: Susan J. Popkin Ph.D. is both Director of The Urban Institute's HOST Initiative and an Institute Fellow in the Metropolitan Housing and Communities Policy Center. A nationally-recognized expert on public and assisted housing policy, Dr. Popkin directs a research program that uses community engagement and community-based participatory approaches to explore new strategies for improving outcomes for families, and in conducting evaluations of complex community-based interventions. Dr. Popkin is the author of No Simple Solutions: Transforming Public Housing in Chicago; co-author of the award-winning Moving To Opportunity: The Story of an American Experiment to Fight Ghetto Poverty; lead author for the book The Hidden War: Crime and the Tragedy of Public Housing in Chicago; and is co-author of Public Housing Transformation: The Legacy of Segregation.

William Abolt
Vice President, Energy at AECOM

Biography: Bill Abolt, LEED AP, is a Vice President at AECOM and leads its Smart Energy Practice in the Americas, focusing on energy, sustainability and resilient urban infrastructure. He has 31 years' experience managing complex environmental, energy, water and public issues and programs to develop and implement smart city solutions. He has extensive experience with alignment of grants, incentives and other third-party resources with project and enterprise-wide budgeting, planning and sustainability goals. His experience includes recent and ongoing work in Berkeley, Boston, Chicago and Detroit.
Previously, Bill served as Environment Commissioner, Director of the Office of Budget and Management and Chief of Management, Office of the Mayor, for the City of Chicago, where he was responsible for developing Chicago's strategy to become one of the greenest cities in the nation.

Jim Angel
Former State Climatologist for Illinois

Dr. Jim Angel has been a climatologist at the Illinois State Water Survey for 34 years, including 20 years as State Climatologist. He has worked on a wide variety of climate issues impacting Illinois including droughts, floods, heat waves, and winter storms. His two areas of expertise are the impacts of climate on agriculture and on heavy precipitation. His most recent work has been the update of Bulletin 70, the rainfall frequency atlas, and was the lead author on the Midwest Chapter of the National Climate Assessment.

Daniel Ash
Chicago Community Trust

Daniel O. Ash is Associate Vice President of Community Impact at The Chicago Community Trust. Ash previously served as the Trust's Chief Marketing Officer from 2013 to 2019. Prior to joining the Trust, Ash spent 10 years as vice president at Chicago Public Media, production home of WBEZ/91.5FM (Chicago's primary NPR station), This American Life, Sound Opinions, Wait Wait...Don't Tell Me and Vocalo.org. In this senior management role, Ash was responsible for the organization's two largest revenue categories—corporate sponsorship and individual giving—and led double-digit growth during his tenure. Additionally, he oversaw marketing and strategic partnership. He was a key voice in shaping Chicago Public Media's overall strategic focus.

Ash's professional career has been focused on developing and using marketing and communication tools to advance social causes. He has worked exclusively in the nonprofit sector on issues including poverty, adolescent health and HIV/AIDS care and prevention. The early stage of Ash's professional career included leadership roles at Sergeant Shriver National Center on Poverty Law, Chicago Department of Public Health, Center for Family Policy and Practice and the Illinois Caucus for Adolescent Health.

Ash earned a M.P.P. from the Harris School of Public Policy at the University of Chicago, and a B.A. in Economics from Oberlin College. He also completed a Woodrow Wilson Fellowship at Princeton University. He is married to Sarah Karp, education reporter at WBEZ; and they have three sons: Devonte (21), Josiah (18) and Zion (14).

Satya Basu
Perkins+Will

Satya Basu is an Advanced Insights Analyst in the Perkins+Will i/o lab. Satya is a designer, strategist and technologist who utilizes his diverse background to respond to design challenges with inventive problem-solving. He holds a Bachelor's degree in philosophy and social thought from the University of Chicago and an M.Arch from the School of the Art Institute of Chicago. Satya began his practice by designing residential interiors to meet the challenges of Manhattan rental apartments and has shifted scales since then to design everything from furniture to urban-scale interventions. His focus at Perkins+Will is the research and development of next-generation tools and technologies.

Sarah Coulter
Calumet Collaborative

As the executive director Sarah has led the evolution of the Millennium Reserve partnership into the present-day Calumet Collaborative, engaging multiple stakeholders and setting a course to capitalize on the region's assets and remove barriers through collective action. The Calumet Collaborative is a nonprofit organization that works to bring stakeholders from Illinois and Indiana together to leverage funding, expertise and other opportunities for transformative sustainable development in the Calumet region. Sarah has more than twelve years of experience in economic development and community building through sustainable practices and principles including three years as south suburban Village of Park Forest's sustainability coordinator. She led Park Forest's effort to become the second STAR Communities Certified community in Illinois and 30th (and smallest) certified community in the US and Canada. Sarah is a LEED AP and has a background in green real estate/building. She played a key role in bringing green fields to Chicagoland's Multiple Listing Service (MLS) and on the City of Chicago's Energy Disclosure Ordinance that connects energy usage data with the home buying consumer. Sarah served as the Residential Green Building Committee Advocate for the US Green Building Council Illinois Chapter and on the State and Local Government Committee. She is a graduate of The Evergreen State College in Olympia, WA and has a number of green real estate designations and additional coursework in sustainable design

John Edel
The Plant, Bubbly Dynamics

John Edel is both an eco and social entrepreneur. His most recent endeavor, The Plant, is a project combining adaptive industrial reuse, waste recovery, smart building technologies, and aquaponics to create the nation's first vertical farm and food-business incubator. Located in a former meatpacking facility in Chicago's historic Stockyards, The Plant is home to 24 businesses whose inputs and outputs are woven together as a living laboratory for the circular economy. John also is the owner and developer of the Chicago Sustainable Manufacturing Center, an affordable, energy-efficient space for small and emerging manufacturers, product assemblers, and other businesses committed to sustainability. As General Contractor, Edel took the facility from a burnt-out shell to 100% occupancy while using a mixture of waste-stream recycled materials and leading-edge technology to make the building exceptionally energy efficient and pleasantly non-toxic. The renovation was assisted by a core group of volunteers and by bartering with suppliers, tenants and scrappers. The building's green roof is a photo of Edel's daughter Zoe rendered in 9,600 sedum plants, each of which is a pixel in her image.

Andrew Greenlee
University of Illinois at Urbana-Champaign

Andrew J. Greenlee Ph.D. is an Associate Professor in the Department of Urban and Regional Planning at the University of Illinois at Urbana-Champaign. Dr. Greenlee's research lies at the intersection of housing policy, poverty, and social equity within cities and regions. His current research examines neighborhood and metropolitan opportunity structures through residential mobility processes. Greenlee's other ongoing research examines the influence of governance on spatial outcomes for public and subsidized housing participants, and the dynamics of neighborhood change driven by urban renewal processes and public housing transformation. As an expert in housing policy, Greenlee has testified before the U.N. Special Rapporteur on Housing, and has provided technical assistance to fair housing advocates, states, and local governments. Greenlee received a B.A. from Grinnell College, a M.S. in Urban and Regional Planning from University of Iowa, and a Ph.D. in Urban Planning and Policy from University of Illinois at Chicago.

Elena Grossman
University of Illinois at Chicago

Elena Grossman is the Program Director for the Building Resilience Against Climate Effects in Illinois (BRACE-Illinois) Project. BRACE-Illinois is a partnership between the University of Illinois at Chicago School of Public Health and the Illinois Department of Public Health to help prepare Illinois for the health effects from climate change. In her capacity as program director, she develops education and training tools on climate change and health; facilitates the strategic process for local health departments to address climate change; develops and manages the evaluation plan for BRACE-Illinois; researches the relationships between climate change and health as well as intervention and communication strategies to address them; and collaborates in developing and writing state reports on climate change and health. Elena holds a BA in Spanish and International Relations from Franklin & Marshall College, and an MPH in Community Health Sciences from The University of Illinois at Chicago with a concentration in global health.

Elizabeth Irvin
Center for Neighborhood Technology

As CNT's Transportation Director, Elizabeth advocates for diverse mobility options that improve the equity, affordability, and sustainability of our transportation system. Before joining CNT in 2019, Elizabeth worked at the Chicago Metropolitan Agency for Planning on evaluating the land use, environmental, and equity impacts of transportation projects, and developing strategies to harness emerging transportation technologies for the region's long-range plan. She previously worked on regional and national transportation and environmental policy at the Union of Concerned Scientists and the Sierra Club. Elizabeth has a Master of City Planning from the Massachusetts Institute of Technology and a Bachelor of Arts in English and Music from Williams College.

Danielle Kizaire
Bronzeville Urban Development

Upon retiring from social work and medical education consulting, Dr. Kizaire renewed her interest that began on Earth Day, 1970. She studied with V.P. Al Gore to become a Climate Leader. She began studies of environmental building practices and design at the Chicago Center for Green Technology. One thing became evident: sustainability included economic stability. This led to Dr. Kizaire completing a course at the Copenhagen Business School through the Department of Corporate Responsibility concentrating on social enterprise development and followed by a course of study with Jeffery Sachs on Sustainable Economic Development. These endeavors culminated in the establishment of Bronzeville Urban Development, NFP, an organization she co-founded with her husband, Charles Sutton. The organization is dedicated to bringing healthy communities to life, starting with Bronzeville. Currently, the organization is striving to create locally controlled renewable energy projects and dedicating efforts to promoting energy democracy.

Mwende Lefler
Metropolitan Water Reclamation District of Greater Chicago

Mwende Lefler began her career with the Metropolitan Water Reclamation District of Greater Chicago in 2007. She has served in the process design group which evaluates, plans, designs, bids, and supports post-award construction work for capital improvement projects at the district's seven water reclamation plants. She has also worked extensively with the district's phosphorus task force which implemented mainstream phosphorus removal and sidestream recovery at one of the world's largest water reclamation plants. Previous to joining the district, she worked in environmental engineering consulting and graduated with a B.S. in civil engineering from Duke University and a master's in environmental engineering from Northwestern University.

Suzanne Malec-McKenna
Interim CEO, Great Lakes St. Lawrence Cities Initiative

Suzanne Malec-McKenna is the Interim CEO of the Great Lakes St. Lawrence Cities Initiative (GLSLCI). The organization's membership is comprised of Mayors on both the Canada and U.S. sides of the Great Lakes and St. Lawrence Seaway. GLSLCI focuses on policy, local solutions and advocacy for key issues impacting local government agencies and their constituents. Current priority issues include: invasive species and the Asian Carp barrier; shoreline and community climate resiliency; microplastics; and agricultural solutions to addressing nutrient loading. For the past two years prior to joining GLSLCI, Suzanne worked on the transition team for new Chicago Mayor Lori Lightfoot, led collaboration building for ConTextos and consulted on sustainability issues. Prior gigs include serving as Executive Director of Chicago Wilderness where she where she led strategies and actions to advance its conservation mission for the alliance, made up of two hundred conservation organizations in the business, government, nonprofit, and institutional sectors. Additionally, Suzanne served as Assistant Commissioner, Deputy Commissioner and Commissioner of the Chicago Department of Environment for seventeen years, leading efforts in Natural Resources and Water Quality, Brownfields restoration, Energy and Sustainable Business, Permitting and Enforcement, green buildings, and environmental communications and education. She was responsible for management of the City's Climate Action Plan, which coordinated nearly 40 agencies to carry out robust mitigation and adaptation efforts. Suzanne holds a Bachelor's degree from University of Illinois, Urbana-Champaign, and Master's and Doctoral degrees from Northwestern University.

Jason Navota
Chicago Metropolitan Agency for Planning

Jason Navota, Director of Planning at the Chicago Metropolitan Agency for Planning, is a thought and practice leader with 20 years of public and private sector urban and environmental planning and policy experience. Jason leads the agency's sustainability and resilience efforts, as well as policy and planning initiatives within the area of environment and land use planning. He also oversees the agency's Local Technical Assistance program, in which CMAP provides planning and policy assistance to the Chicago region's local governments. Jason also has experience working as a planning consultant, in education, and working in the field in a variety of settings. Jason attended the University of Illinois and the University of Michigan.

Aaron Packman
Northwestern University

Aaron Packman is the Director of the Center for Water Research and Professor of Civil and Environmental Engineering at Northwestern University. Dr. Packman is an internationally recognized expert in water resources, surface-ground water interactions, and biological and biogeochemical processes in aquatic systems. His current research focuses on water systems dynamics, contamination risks, and microbial growth and transmission in natural and engineered water systems. Dr. Packman's research team is working to solve a variety of problems, including nutrient pollution, urban flooding, ecosystem degradation & restoration, and waterborne disease transmission. Packman has received numerous awards and honors, including a Fulbright Distinguished Chair in Hydrology and Hydraulic Engineering, the Huber Research Prize from the American Society of Civil Engineers, and research Career Awards from the National Science Foundation and National Institutes of Health. He received a B.S. in Mechanical Engineering from Washington University in St. Louis, and an M.S. and Ph.D. in Environmental Engineering and Science from the California Institute of Technology.

Jamie Ponce
City Tech Collaborative

As Director of Strategic Partnerships with the City Tech Collaborative, Jamie works to drive breakthrough solutions to critical city challenges using technology, data analytics, and collaboration. He previously served as Director of Innovation with the Environmental Law & Policy Center, a public interest and environmental advocacy group focused on clean energy, transportation, air, and water throughout the US Midwest. From 2012-16, Jamie was the Chicago Director of Energy and Climate Innovation with the C40 Cities Climate Leadership Group, where he led initiatives on energy efficiency, sustainable development, food, and climate in the office of Chicago Mayor Rahm Emanuel and across a network of global megacities.

Prior to these roles, Jamie spent 10 years with global management consulting firm A.T. Kearney, specializing in corporate strategy, economic development, and resource efficiency. These efforts –including work with the Rocky Mountain Institute, Africare, the Environmental Defense Fund, and the Packard Foundation – address some of the planet's most pressing challenges through solutions that span industries, sectors, and ideologies. Jamie holds a bachelor's degree from Indiana University, a Master in Public Administration from the Harvard Kennedy School, and an MBA from Harvard Business School.

Carmita Semaan
Surge Institute

Carmita Semaan's career began in corporate America; however corporate could not contain her desire to lead high-impact initiatives benefitting urban youth and transforming urban communities – so she blazed a trail within the nonprofit sector. Carmita's commitment to empowering our country's most underserved youth led to a decade of executive service, driving results for visionary leaders including Alma Powell, Gen. Colin Powell and former US Secretary of Education Arne Duncan. In 2014, Carmita founded the Surge Institute and its signature program, the Surge Fellowship, which was designed to identify and elevate emerging leaders of color and empower them to change the landscape of education by providing a unique leadership development experience. Carmita holds an MBA from Northwestern University's Kellogg School of Management, and a BS in Chemical Engineering from the University of Michigan. She serves on the Board of Directors for the Academy for Urban School Leadership, Marwen, and America's Promise Alliance. Carmita received the Chicago Business Journal's 2016 Woman of Influence award.

Appendix 2. Attendee List and Statistics

SUSPIRE attendees numbered 150 and came from diverse groups (Figure A1). Furthermore, according to a post-conference survey, many attendees formed new connections (Figure A2).
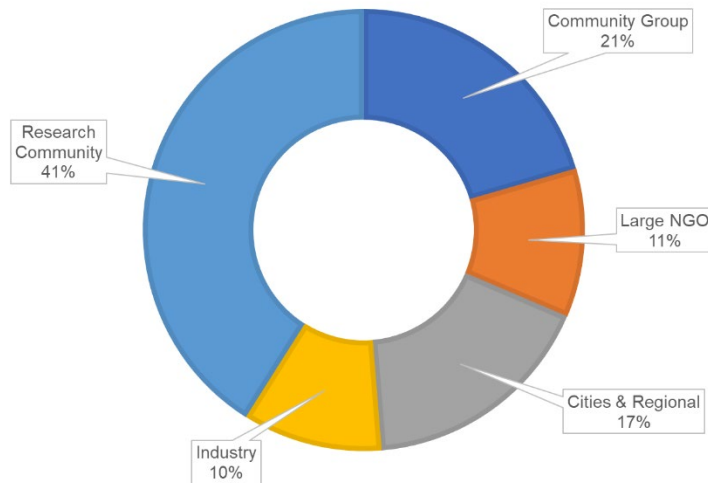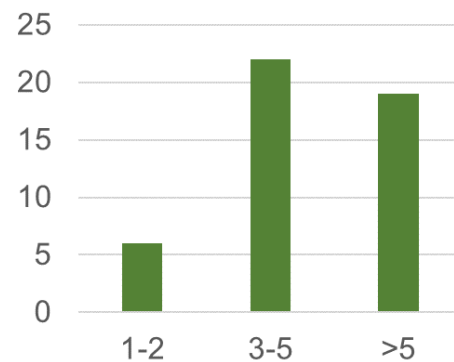

Figure A1. Percent of attendees from different groups.

Figure A2. Number of new connections post-conference survey respondents made at SUSPIRE.

Sustainable Urban Systems: Predictive, Interconnected, Resilient, and Evolving (SUSPIRE) Registration List

First Name:	Last Name:	Organization:	Job Title:
Narjes	Abbasabadi	Illinois Institute of Technology	Adjunct Professor
Bill	Abolt	AECOM	Vice President
Anna	Ahn	Univeristy of Illinois at Chicago/Field Museum	Student
Dana	Al-Qadi	AECOM	Engineer
Dean	Alonistiotis	MWRD	Chief of Staff
Vernard	Alsberry	Village of Hazel Crest IL	Mayor
Jim	Angel	University of Illinois	Former State Climatologist
Candice	Archie	Urban Juncture	Community Garden Lead
Daniel	Ash	The Chicago Community Trust	Associate Vice President of Community Impact
Mehdi	Ashayeri	Illinois Institute of Technology	PhD Candidate
Rahman	Azari	Illinois Institute of Technology	Assistant Professor
Satya	Basu	Perkins and Will	Advanced Insights Analyst
Julianne	Beck	Northwestern University - Institute for Sustainability and Energy at Northwestern (ISEN)	Assistant Director of Marketing and Communications
Pete	Beckman	Argonne National Laboratory	Co-Director, NAISE
Stephanie	Bohr	Lincoln Park Zoo	Director, Community Innovation & Collaboration
Beth	Bond	Bosch	Head of City Development
Eric	Boria	UIC	Student
Elisa	Borowski	Northwestern University	PhD Candidate
Joe	Bozeman III	University of Illinois at Chicago	Ph.D. Candidate
Charlie	Branda	Art on Sedgwick	Founder & Executive Director
Kristin	Brock	Chicago Park District	Outdoor & Environmental Education Manager
Kevin	Burns	City of Geneva / Metropolitan Mayors Caucus Envrironment Committee Chair	Mayor
Scott	Collis	Argonne National Laboratory	Atmospheric Scientist
Sarah	Coulter	Calumet Collaborative	Executive Director
Irene	Crisologo	Northwestern University - Department of Earth and Environmental Sciences	Research Scholar
Kate	Cummings	Center for Humans and Nature	Editor, Questions for a Resilient Future
Abigail	Derby Lewis	The Field Museum	Conservation Tools Program Director
Isabella	Downes	CMAP	Urban Planning Intern
Jennifer	Dunn	Northwestern University	Assoc Dir, Center for Eng. Sustainab. & Resilience
Vidushi	Dwivedi	Northwestern University - Institute for Sustainability and Energy at Northwestern (ISEN)	Research Specialist
Jane	Eagleton	Great Lakes and St. lawrence Cities Initiatives	Events and Operations Manager

First Name:	Last Name:	Organization:	Job Title:
Margaret	Eaglin	Chicago Department of Public Health	Senior Epidemiologist
John	Edel	Bubbly Dynamics, LLC/The Plant	Founder
Josh	Ellis	Metropolitan Planning Council	Metropolitan Planning Council
Christine	Esposito	Terracom / Ex.Change Project	President
McKenna	Farmer	Black & Veatch	Water Technology Group Intern
Cory	Foster	ComEd	External Affairs Manager
Eliza	Fournier	Chicago Botanic Garden	Program Director, Windy City Harvest
Jordan	Francisco	Greenest Region Corps (AmeriCorps)	Sustainability Advisor
Matt	Freer	Chicago Park District	Assistant Director
Steven	Frenkel	Current	Executive Director
Margaret	Frisbie	Friends of the Chicago River	Friends of the Chicago River
Lainet	Garcia Rivera	The Nature Conservancy	Wisconsin Cities Conservation Fellow
Sarah	Gatzke	The Nature Conservancy	Wisconsin Director of Resource Sustainability
Franklin	Gay	Chicago Center for Youth Violence Prevention	Executive Director
Viviana	Pellon	Advocates for Urban Agriculture	Technical Assistance Manager
Melody	Geraci	Active Transportation Alliance	Deputy Executive Director
Demetria	Giannisis	Northwestern University - Institute for Sustainability and Energy at Northwestern (ISEN)	Managing Director
Meagan	Gibeson	Chicago Metropolitan Agency for Planning	Peters Fellow
Rory	Gilchrist	Gensler Architecture, Design and Planning	Design Strategist
Karl	Gnaedinger	The Nature Conservancy	Indian Boundary Prairies Site Manager
Andrew	Greenlee	University of Illinois at Urbana-Champaign	Associate Professor
Elena	Grossman	UIC SPH	BRACE-Illinois Program Manager
Bruce	Hamilton	NSF	Program Director
Jeff	Henderson	Northwestern University - Institute for Sustainability and Energy at Northwestern (ISEN)	Associate Director
Liliana	Hernandez Gonzalez	Northwestern University	Graduate Student
Josiah	Hester	Northwestern University	Assistant Professor
Ashley	Hodges	Calumet Collaborative	Program & Communications Manager
Daniel	Horton	Northwestern University - Department of Earth & Planetary Sciences	Assistant Professor
Teresa	Horton	Northwestern University	Associate Professor of Research
John	Hummel	Argonne National Laboratory	Lead for Integrated Resiliency Analyses
Kristin	Ihnchak	Chicago Metropolitan Agency for Plannin (CMAP)	Principal Planner
Elizabeth	Irvin	Center for Neighborhood Technology	Transportation Director
Kumar	Jensen	City of Evanston	Chief Sustainability and Resilience Officer
Gabriela	Juarez-Dominguez	OPEN Center for the Arts	Operations Manage

First Name:	Last Name:	Organization:	Job Title:
Chloe	Kang	Northwestern University	Senior Associate Director, Foundation Relations
Susan	Kaplan	Northwestern University - Feinberg School of Medicine	Adjunct Assistant Professor, Preventive Medicine
Megan	Kashner	Northwestern University - Kellogg School of Management	Kellogg School of Management at Northwestern University
Cria	Kay	Lincoln Park Zoo	Coordinator for the Urban Wildlife Information New
Frances	Kelly	AECOM	Summer Intern - Water
Piyush	Khairnar	Illinois Institute of Technology	PhD Student
Angela	Kim	UN Environment, Mayor's Fund for Los Angeles	SDGs and Environment Statistics Intern, SDG Data A
Danielle	Kizaire	Bronzeville Urban Development	Bronzeville Urban Development
Samuel	Kling	Chicago Council on Global Affairs	Fellow, Global Cities
Jennifer	Kunde	Northwestern University	Executive Director, Government Relations
Daniel	Kushner	ComEd	Principal Business Analyst
Warren	Lavey	University of Illinois	Adjunct Professor
Yvonne Mwende	Lefler	MWRD	Principal Civil Engineer
John	Legge	The Nature Conservancy	Chicago Conservation Director
Liza	Lehrer	Lincoln Park Zoo - Urban Wildlife Institute	Assistant Director
Sarah	Levesque	Compass at Northwestern	Sustainability Manager
Yi-Pin	Lin	National Taiwan University	Associate Professor
Nancy	Loeb	Northwestern University - Pritzker School of Law	Director, Environmental Advocacy Clinic
Mario	Longoni	The Field Museum	Urban Anthropology Manager
Denise	Lopez	Northwestern University	Research Assistant
Omar	Magana	Open Center For the Arts, Chicago	Executive Director, Founder
Edith	Makra	Metropolitan Mayors Caucus	Environment Director
Suzanne	Malec-McKenna	Great Lakes St. Lawrences Cities Initiative	Interim CEO
Raed	Mansour	City of Chicago Department of Public Health	Director of Innovation
Justin	Marquez	Marin Clean Energy (MCE)	Community Equity, Diversity and Inclusion Manage
Sudip	Mazumder	University of Illinois Chicago	Professor
Megan	McConnell	Northwestern University	Research Development Specialist
Joshua-Paul	Miles	Northwestern Univeristy	PhD Student
William (Bill)	Miller	Northwestern University	Director, Ctr for Eng. Sustainability & Resilience
Arseniy	Minasov	Northwestern University	Research Coordinator
Jake	Miner	AECOM	intern
Nicole	Mormando	AECOM	intern
Anastasia	Montgomery	Northwestern University	PhD Student
Katherine	Moore Powell	The Field Museum	Climate Change Ecologist
Ralph	Muehleisen	Argonne National Laboratory	Principal Building Scientist

First Name:	Last Name:	Organization:	Job Title:
Sarah	Murdock	The Nature Conservancy	The Nature Conservancy
Ron	Nahser	DePaul University	Director, Urban Sustainable Management P:rogrfams
Jason	Navota	Chicago Metropolitan Agency for Planning	Director
Carter	O"Brien	Keller Science Action Center	Sustainability Officer
Jonathan	Ozik	Argonne National Laboratory	Computational Scientist
Aaron	Packman	Northwestern University	Professor
Cora	Pancoast	Northwestern University	Student
Douglas	Pancoast	Bosch	Research and Development, Urban Mobility
Emalee	Pearsson	Chicago Center for Youth Prevention, University of Chicago	Research & Implementation Associate
Barbara	Peterson	CLOCC, Lurie Children's Hospital	Health Educator
Colin	Phillips	Northwestern University	Postdoctoral Fellow
Graham	Pickren	Roosevelt University/Field Museum	Asst. Prof of Sustainability Studies
Jamie	Ponce	City Tech Collaborative	Director of Strategic Partnerships
Susan	Popkin	The Urban Institute	Institute Fellow
Mark	Potosnak	DePaul University	Associate Professor
Elham	Ramyar	Northwestern Univeristy	Research Assistant PhD Student
Emily	Reynoso	Cristo Rey Jesuit Highschool	Student
Vivien	Rivera	Northwestern University	Ph.D. Candidate
Joel	Rogers	University of Wisconsin-Madison	Sewell-Bascom Professor of Law, Political Science, Public Affairs, an
Amy	Rogin	Climate Change Research Group Northwestern	Undergraduate Researcher
Karen	Roothaan	Trees R Beautiful	Coordinator
Ruth	Rosas	CLOCC	Community Programs Coordinator
Ann	Rosen	Canadian Consulate General	Trade Commissioner
Howard	Rosing	DePaul University	Executive Director, Steans Center
Rajesh	Sankaran	Argonne National Laboratory	Assistant Computer Scientist
Jordan	Schnell	Northwestern University -Department of Earth and Planetary Sciences	Postdoctoral Research Fellow
Joseph	Schofer	Northwestern University	Professor
Carmita	Semaan	The Surge Institute	Founder and President
Libby	Shafer	Christy Weber Farm & Garden	Plant Receiving Assistant
Ashish	Sharma	UIUC	Illinois Research Climatologist
Michelle	Shumate	Nothwestern University	Professor
Leah	Siskind	Uptake	Director of Uptake.org
Kathleen	Skoller	Forest Immersion, LLC	Certified Nature & Foret Therapy Guide
Amanda	Stathopoulos	Northwestern University	Assistant Professor Transportation systems
Lucas	Stephens	Environmental Law and Policy Center	Senior Research Analyst

First Name:	Last Name:	Organization:	Job Title:
Eli	Suzukovich	The Field Museum and Northwestern Center for Native American and Indigenous Research	Adjunct Anthropologist
Gavin	Taves	Chicago Housing Authority	Development Associate
Anthony	Tindall	Forest Preserve of Cook County	Policy Manager and Chair of Sustainability
William	Towns	Northwestern University - Kellogg School of Management	Adjunct Lecturer of Social Impact
Elif	Ulger	AECOM	Civil Engineering Intern
Jacqui	Ulrich	Forest Preserves of Cook County	Deputy - Conservation & Experiential Programming
Lauren	Umek	Chicago Park District	Project Manager
Tricia	Van Eck	6018North	Director
Vidya	Venkataramanan	Northwestern University	Postdoctoral Fellow
Ella	Weber	University of Minnesota	Graduate Student
Lucy	Weidner	Northwestern University	Research Assistant
Simone	Weil	CMAP	Principal for Policy and Programming
George	Wells	Northwestern University	Assistant Professor
Mark	Werwath	Northwestern University	Director of MEM programs
Debra	Williams	The Nature Conservancy	Indian Boundary Prairies Community Outreach Coordinator
Marlie	Wilson	Chicago Food Policy Action Council	Good Food Purchasing Project Manager
Kyra	Woods	Sierra Club	Clean Energy Organizer
Alyson	Wright	The City of Evanston	Sustainable Business Fellow
Donald	Wuebbles	University of Illinois	Professor
Moira	Zellner	University of Illinois at Chicago	Associate Professor
Liuxi (Calvin)	Zhang	ComEd	Manager, Smart Grid and Innovation

Appendix 3. Chairs and Organizers

William M. Miller, Professor, Chemical and Biological Engineering and Director, Center for Engineering Sustainability and Resilience (CESR), Northwestern University

Jennifer B. Dunn, Research Associate Professor, Chemical and Biological Engineering, Northwestern University, and Director of Research, Northwestern-Argonne Institute of Science and Engineering (NAISE), Associate Director of CESR

Peter H. Beckman, Senior Computer Scientist, Argonne National Laboratory, and Co-Director, NAISE

Charles E. Catlett, Director, Urban Center for Computation and Data (UrbanCCD), University of Chicago

Steering Committee

William Abolt, Vice President, AECOM

Habibul Ahsan, Dean, Population and Precision Health, University of Chicago

Brenna Berman, Executive Director, City Tech Collaborative

Kimberly Gray, Professor and Chair, Civil and Environmental Engineering, Northwestern University

Danielle Kizaire, Vice President, Bronzeville Urban Development (BUD)

Ralph Muehleisen, Principal Building Scientist, Argonne National Laboratory

Joseph Schofer, Professor, Civil and Environmental Engineering, Northwestern University

Karen Weigert, Vice President Business Strategy and Regional Operations, Slipstream

Donald Wuebbles, Professor, Atmospheric Sciences and Director, Center for Urban Resilience and Environmental Sustainability, University of Illinois, Urbana-Champaign

Organizing Committee

Amy Ando, Professor, Agricultural and Consumer Economics, University of Illinois, Urbana-Champaign

Scott Collis, Atmospheric Scientist, Argonne National Laboratory

Monique Cook-Bey, Chief Programs Officer, Chicago Youth Programs

Josh Ellis, Vice President, Metropolitan Planning Council

Christine Esposito, President and Chief Connections Officer, Terracom and The Ex.Change Project

Angie Fyfe, Executive Director, ICLEI USA

Demetria Giannisis, Sr. Director Operations & Outreach, Institute for Sustainability and Energy at Northwestern (ISEN), Northwestern University

Daniel Horton, Assistant Professor, Earth and Planetary Sciences, Northwestern University

Megan Kashner, Clinical Assistant Professor & Director of Social Impact, Kellogg Public-Private Initiative, Kellogg School of Management, Northwestern University

Daniel Kushner, Principal Business Analyst, Smart Grid and Technology, Commonwealth Edison

Lorena Lopez, Community Engagement Specialist, The Field Museum

Edith Makra, Director of Environmental Initiatives, Metropolitan Mayors Caucus

Iñigo Manglano-Ovalle, Professor of Art Theory and Practice, Northwestern University

Jason Navota, Director of Planning, Chicago Metropolitan Agency for Planning (CMAP)

Douglas Pancoast, Head of R&D for Urban Mobility, Robert Bosch LLC; Associate Professor, School of the Art Institute of Chicago

Katherine Moore Powell, Climate Change Ecologist, The Field Museum
Michelle Shumate, Professor, Communication Studies, Northwestern University
Amanda Stathopoulos, Assistant Professor, Civil and Environmental Engineering, Northwestern University
George Wells, Assistant Professor, Civil and Environmental Engineering, Northwestern University
Liuxi (Calvin) Zhang, Manager, Emerging Technology, Commonwealth Edison

Appendix 4. Breakout discussion facilitators and scribes

Facilitators
Scott Collis, Argonne National Laboratory
Sarah Gatzke, The Nature Conservancy in Wisconsin
Josiah Hester, Northwestern University
Dan Horton, Northwestern University
Terry Horton, Northwestern University
Daniel Kushner, Commonwealth Edison
Katherine Moore Powell, The Field Museum
Jason Navota, Chicago Metropolitan Agency for Planning
Colin Phillips, Northwestern University
Graham Pickren, Roosevelt University
Raj Sankaran, Argonne National Laboratory
Michelle Shumate, Northwestern University
Vidya Venkataramanan, Northwestern University
Mark Werwath, Northwestern University
Moira Zellner, University of Illinois at Chicago

Scribes
Anna Ahn, University of Illinois at Chicago and Field Museum Intern
Eric Boria, University of Illinois at Chicago
Elisa Borowski, Northwestern University
Joe Bozeman, University of Illinois at Chicago
Irene Crisologo, Northwestern University
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