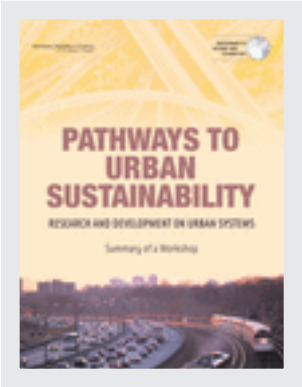

Pathways to Urban Sustainability: Research and Development on Urban Systems: Summary of a Workshop

DETAILS

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PATHWAYS TO URBAN SUSTAINABILITY

RESEARCH AND DEVELOPMENT ON URBAN SYSTEMS

Summary of a Workshop

Committee on the Challenge of Developing Sustainable Urban Systems

Science and Technology for Sustainability Program
Policy and Global Affairs Division

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Preface and Acknowledgments

Transitioning to sustainability will be a collective, adaptive, and uncertain endeavor. In order to identify "problem-driven research" topics critical to sustainability, the National Academies Roundtable on Science and Technology for Sustainability (see Appendix C) has regularly helped organize workshops to convene diverse stakeholders and discuss the role that science and technology can play in addressing these challenges.

In 2007, the National Academies hosted the first Federal Sustainability Research and Development (R&D) Forum, which focused on federal R&D on ecosystem services and biofuels. Based on the success of this initial event and input from various stakeholders, a second forum was organized to again engage federal researchers, this time focusing on urbanization, with the additional goal of engaging leading academic and private researchers to be part of the conversation. The rationale was that metropolitan regions are playing, and will continue to play, an important role in addressing climate change and many other sustainability challenges. The federal government can support these place-based efforts, but sub-national actors will necessarily lead the way in making communities more sustainable.

A committee was appointed by the National Research Council to organize a one-day workshop on September 22, 2009 in Washington, D.C. titled "Transitioning to Sustainability: The Challenge of Developing Sustainable Urban Systems." The committee identified panel topics, invited speakers from throughout the research and development "chain", and developed the agenda. Prior to the workshop, National Academies' staff solicited brief descriptions of notable urban sustainability R&D programs within academia and the federal government (Appendix D).

The workshop was not designed to be a standalone, singular activity, but the beginning of a more sustained conversation between federal agencies, the research enterprise (broadly defined), and decision makers dealing with on-the-ground sustainability challenges in metropolitan regions of the United States. As a new domestic urban agenda begins to unfold in the months and years ahead, it will be critical to learn not only from our own experience but also from the urban experience in other countries and to understand the trends and challenges posed by urbanization on a global scale. We not only live in an urban nation, but we also live in an urban world. That is why the

organizers of this workshop hoped that this event would set the stage for an international workshop on urban systems in 2010. That being said, the agenda was structured in the hopes of using this initial workshop to identify opportunities for deeper collaboration, more effective dissemination, and assessing gaps in our current knowledge of urban systems.

In addition to the planning committee, the workshop benefitted from the input of many federal agency representatives, through phone conversations and e-mails. Jack Kaye and Teresa Fryberger (NASA), Chuck Kent and Danielle Arigoni (EPA), Jerry Dion (DOE), Rich Pouyat and Rob Doudrick (USFS), and several others provided timely feedback leading up to the workshop. The workshop and report could not have come together without the help of many dedicated staff members as well. Pat Koshel and Kathleen McAllister were especially helpful in engaging federal agency representatives, and sharing their experiences from the 2007 Federal Sustainability R&D Forum, precursor to the 2009 workshop summarized in this report.

This summary has been prepared by the rapporteurs as a factual summary of what occurred at the workshop. The planning committee's role was limited to planning and convening the workshop. The statements made in this volume do not necessarily represent positions of the workshop participants, the Roundtable, or the National Academies.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for quality and objectivity. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of this report: Lawrence Baker, University of Minnesota; Nancy Cantor, Syracuse University; Margaret Davidson, National Oceanic and Atmospheric Administration; Bruce Hamilton, National Science Foundation; and Carl Shapiro, U.S. Geological Survey.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the content of the report, nor did they see the final draft before its release. Responsibility for the final content of this report rests entirely with the authors and the institution.

Daniel Schaffer and Derek Vollmer, Rapporteurs

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1

Introduction

More than half of the world's people now live in cities. In the U.S., the figure is 80 percent. Urbanization is viewed as the primary cause of many problems, but also as the primary stage for more sustainable development in the 21st century. Urban environments, both in the U.S. and abroad, spur economic development and allow for an efficient use of resources. But their size and insatiable appetite for growth also mean cities consume resources at prodigious rates, in concentrated areas. This has raised serious concerns about their environmental impacts. Such concerns now vie with those related to public health and economic and social inequities, which have dominated discussions in the past.

It is worthwhile to consider how this trend of increased urbanization, if inevitable, could be made more sustainable. One fundamental shortcoming of urban research and programs is that they sometimes fail to recognize urban areas as *systems*. Current institutions and actors are not accustomed to exploring human-environment interactions, particularly at an urban-scale. The fact is that these issues involve complex interactions, many of which are not yet fully understood. Thus a key challenge for the 21st century is this: How can we develop sustainable urban systems that provide healthy, safe and affordable environments for the growing number of Americans living in cities and their surrounding metropolitan areas?

Organization of the Workshop

An expert planning committee was appointed by the National Research Council to organize a workshop that would explore the landscape of urban sustainability research programs in the United States. On September 22, 2009, the U.S. National Academies' Roundtable on Science and Technology for Sustainability hosted the workshop, and participants examined the research gaps, analytical tools and opportunities for collaboration among R&D programs related to urban sustainability.

While definitions vary widely, for the purposes of this workshop, sustainability referred to the goal of "meeting current human needs while conserving natural life support systems" for future generations (NRC, 1999). When discussing R&D, workshop

participants were asked to focus largely on: activities exploring interactions between human and environmental systems in urban settings, initiatives designed to mitigate the adverse consequences of these interactions, and evaluations of the knowledge generated throughout this process.

The workshop was designed to allow participants to share information about the activities and planning efforts of federal agencies, along with related initiatives by universities, the private sector, nongovernmental groups, state and local agencies, and international organizations (see Appendix A). Information on the workshop, including archived presentations, can be found at the following website: http://sites.nationalacademies.org/PGA/sustainability/urban2009/index.htm.

Participants were encouraged to explore how urban sustainability can move beyond analyses devoted to single disciplines and sectors to systems-level thinking and effective interagency cooperation. To do this, participants examined areas of potential coordination among different R&D programs, with special consideration given to how the efforts of federal agencies can best complement and leverage the efforts of other key stakeholders. This document offers a broad contextual summary of workshop presentations and discussions for distribution to federal agencies, regional organizations, academic institutions, think tanks and other groups engaged in urban research.

The planning committee developed an agenda to address topical concerns that cut across the concerns of individual institutions. These topics were intended to be timely and reflect the interests of a variety of stakeholders. Panelists were encouraged to share their perspectives on a given topic. However, each panel was designed to raise critical issues and provoke discussion that took advantage of the broad experience of the participants.

Many participants remarked that there are promising approaches to working beyond the traditional research silos and institutional barriers, but we still have far to go. Many also stated that we need to accelerate our progress in transcending stovepipes and extending evidence-based knowledge to help urban areas develop more sustainably.

Federal agencies are increasingly collaborating with each other, as well as with regional and state agencies, to address urban challenges. The planning committee hoped the workshop would serve as a platform for fostering even greater collaboration among all parties. Indeed the workshop was designed to provide much-needed space for institutions to explore opportunities for more integrated research on urban systems. Participants at the workshop were particularly eager to examine how the recently established federal Office of Urban Affairs could help support urban systems R&D. This workshop summary identifies some of the critical research gaps and necessary analytical tools that could effectively support decision making.

Defining Sustainability in the Context of Urbanization

As discussions since the Brundtland Commission report (WCED, 1987) have shown, it has been much easier to define sustainability as an intellectual concept (despite its vagueness) than as an operational concept (urban sustainability at the local level may differ substantially from urban sustainability at the national and international levels—as many of the discussions at the workshop indicated). These discussions, not surprisingly, have involved tradeoffs as much as idealism and have recognized that perceptions of sustainability are infused with values and expectations that vary from one society and culture to another—and even among different economic and social groups within a

society. It is here where the research community may be able to play a particularly critical role.

Highlighting this responsibility, Xavier de Souza Briggs, Associate Director of the White Office of Management and Budget, who gave the keynote address at the workshop, called on researchers to help the public better understand and assess the tradeoffs by "identifying a more complete set of long-term drivers of sustainability outcomes, clarifying the stakes, and assessing the policy choices."

It was difficult to separate discussions of urban sustainability from the even wider ranging discussions concerning sustainable development that have been taking place since the early 1970s. The term 'urban' does not lend itself to a precise definition either. In the United States it has become increasingly difficult to determine where urban areas ends and suburban or rural areas begin. The American landscape has become, in a significant (and likely an enduring) sense, a single entity—borderless, yet often sharply separated, amalgam of people and places.

Workshop participants did not set out to uncover a precise definition of a sustainable city. Rather, their discussions emphasized the fluid nature of urban sustainability both as an intellectual concept and a strategic building block for policies designed to improve living and working conditions—for today's citizens and future generations. It was this sense of how difficult it is to make sense of urban parameters in the metropolitan expanses of 21st century America that both guided and constrained conversations at the workshop.

A Role for Research

Many participants, especially those working in academia and government agencies, emphasized the need to apply science not only to understand the key issues shaping urban and suburban growth across the country, but also to devise effective solutions. Members of the Obama administration speaking at the conference expressed uncompromising support for "evidence-based decision making" and the importance that research findings should play in shaping policies. "The Obama administration," Briggs proclaimed, "is dedicated to science."

But as Briggs also remarked, policy makers and researchers (particularly scientists) tend to work in two different worlds, influenced by different demands, expectations, reward systems and constraints. "The research world," Briggs quipped, "is one in which a single person spends 600 days on a really hard problem. The policy world is one in which 600 people spend a single day on a really hard problem."

Other participants noted that researchers and policy makers rarely share the same notion of how much time should be taken and how much information should be gathered and processed before rendering a decision. Researchers work in a world of "insufficient" information; policymakers work in a world of "imperfect" information.

Despite these fundamental differences, many workshop participants made a strong case for nurturing closer ties between policy makers and researchers. For public officials, this means welcoming inputs from the academic community and allowing science-based evidence to drive the discussions and shape the policy options. For the scientific community, this means (among other things) not "being tone deaf," as Briggs described it, "to the people" who are seeking to "build constituencies" for putting "your ideas" into

practice. A key challenge for scientists, he asserted, "is to love science without hating politics."

Scholars and scientists who emphasize the need for additional research, Briggs observed, do so for three reasons. First, they maintain that we simply do not have sufficient information to make effective decisions. As Briggs declared, "not everything we need to do has a richly documented base and a long history of documentation." Second, scholars and scientists agree that research must become more holistic and integrative—that is, there is a need to devise a broader research agenda capable of linking the findings and insights of natural scientists with those of social scientists. For example, it might not be enough to invest greater sums of money in public transportation unless we can devise ways to get people to leave their cars at home and take the bus or train. The latter, in particular, requires more research, measuring such factors as cost, convenience and accessibility, and the relationship between housing, transportation and work locations. And, third, there is a growing consensus that policy makers will need to engage in experimental measures—test cases or field demonstrations—to allow them to distinguish reforms that are likely to succeed from those that are likely to fall short. The work of researchers, he noted, will be essential in both the design and assessment of these demonstrations. This can lead to an adaptive management process in which learning developed through assessment influences future design.

Recurring Themes from the Workshop

Chapters 2-6 of the report summarize the individual panel discussions and breakout group discussions. Each panel and breakout group was designed to discuss a specific subject, such as resilience, but throughout the course of the day there were also several overarching themes that emerged in more than one discussion. These themes were not discussed in any depth, but are nonetheless significant because they reflect some commonalities among different aspects of urban R&D.

Cities as incubators

While many of the presenters were from federal agencies and prominent think tanks and universities, the call for placing the nation's cities on a more sustainable path emphasized the need for place-based solutions and leaned towards bottom-up instead of top-down approaches. Several participants noted that the federal government has started to encourage some of this place-based experimentation, by creating incentives to link housing and transportation planning in urban areas. Other participants pointed out that not all communities will be amenable to, for example, high-density housing and mass transit, but that strengthens the argument for metropolitan areas to examine different approaches to achieving their goals for sustainability. In this regard, they noted that there is an important role for the federal government and research community to facilitate some of these experiments and document the lessons learned.

Integrated research to address complex urban systems

Participants widely expressed their conviction that the United States' problems are multi-dimensional. That means solutions will require multi-dimensional responses that draw on a variety of disciplines and skills, and that ultimately the urban sustainability

agenda will need more than scientific knowledge and research to be successful. The research enterprise in the United States, broadly defined, is not oriented toward this sort of integrated research, as Jonathan Fink, Director of the Global Institute for Sustainability at Arizona State University, noted during his panel discussion (see Figure 1). To remedy this, many participants expressed the need for integrated research networks that include social scientists, natural and physical scientists, engineers, and planners. Partnerships among governments, NGOs, and research institutes will likely be required to facilitate this. As a corollary, integrated research would improve our understanding of the linkages between the built and human environments, the flows of energy, water, and materials, and the opportunities to design more efficient infrastructure with this in mind. As Fink and others noted, funding for urban systems research is not integrated either. There are promising exceptions, such as NSF's two urban LTERs and the proposed Urban Long-Term Research Areas (ULTRA) in cooperation with the U.S. Forest Service. However, these integrated approaches are a relatively recent occurrence and have yet to take hold throughout the U.S. research enterprise.

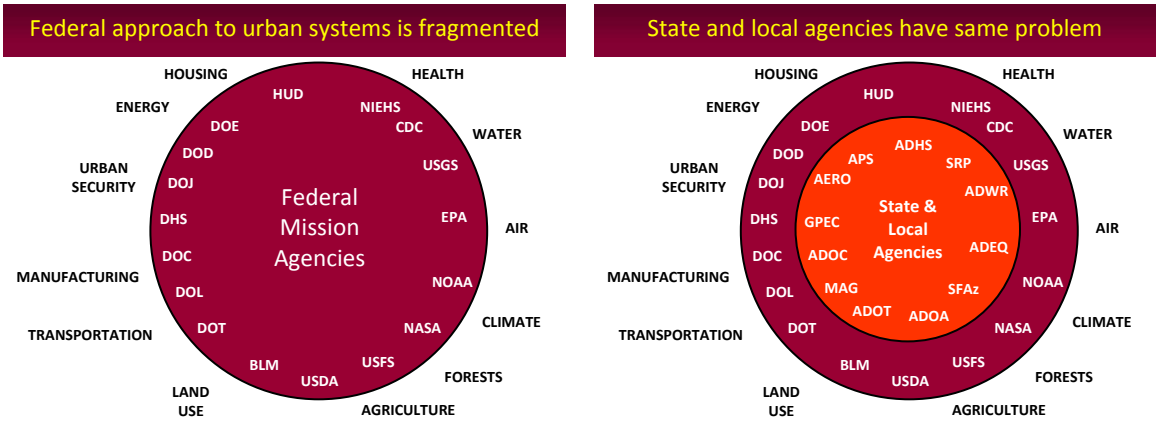

Figure 1 Alignment of federal (left) and state/local (right) agencies with regard to issues important in an urban system. SOURCE: Jonathan Fink, presentation at workshop.

Better, clearer communication on urban sustainability

While many participants lauded the critical role that science and technology could play in this effort, they also emphasized that successfully meeting the challenges of urban sustainability will depend in large part on social, economic and cultural factors that lie far beyond the range of expertise found in the scientific research community. As a result, science would need to be one of many factors integrated into a multi-pronged strategy to advance urban sustainability principles and practices. For these same reasons, scientists would likely play an advisory and not a lead role in the decision-making process.

Several speakers called for a clearinghouse of successes and failures in urban sustainability. This was not a novel idea, but it did reflect the need that decision makers have for information and knowledge on the topic. Some participants countered that a lot

of useful information exists, but it is not easily accessible or translated for the lay public. Thus, they emphasized that there was a need for researchers to give more thought to how they communicate their findings, and an opportunity for more education around sustainable practices, so that the public sees sustainability as in their best interests. This in turn can empower decision makers to implement innovative practices or experiment with a new approach.

2

Developing Livable Urban Areas

The opening panel at the workshop discussed various dimensions of "livable" urban areas—the term has come into use in different federal agencies though participants noted there is no precise definition. Thus, panelists commented on what they viewed as aspects of a "livable" urban area, focusing specifically on research activities that attempt to link public health, environmental management, and urban development goals.

Unsustainable Trends

From a social and political perspective, the key issue driving discussions at the workshop was this: Cities in the United States have been growing in an unsustainable fashion for the past half century—and this trend cannot continue. As Adolfo Carrion, appointed by President Obama as the first Director of the nation's Office of Urban Affairs, noted in his talk: "The United States is becoming more urbanized and the current trend is unsustainable." He went on to caution that: "Our sprawl, the way we continue to spread over the land, the amount of pollution that we create, the inefficiencies that we support, how we have allowed development to take place, doesn't make sense any more."

But knowing that we cannot continue to develop the way we have over the past five decades is not the same as knowing what to do about it. And that is where the discussions become both difficult and complicated. According to Carrion, a critical question is this: "Will we leave future generations a planet and a country that will support human growth and development and sustain our democracy?"

As an urban nation, such a critical question applies directly to America's cities and suburbs, which have grown in ways that are having "a devastating impact on our environment." Carrion advised that we need "to start looking at how we are going to grow our country"—in essence, to begin a "conversation on how we plan to live" in a more sustainable fashion.

This suggests that urban sustainability is more of a process than a goal, and that policies must be adapted to meet the evolving challenges of cities that both policy makers and the public hope to address. There are also economic aspects to the definition and applications of a sustainable city (for example, nothing is sustainable if poverty and

hunger persist [NRC, 1999]; economic insecurity will always trump sustainability); social aspects (sustainability requires a healthy and well educated population as well as security and a collective sense of optimism); and, of course, ecological aspects (much of a nation's wealth is derived from its natural capital and its ability to efficiently conserve, sustain, and use ecosystem services).

There are temporal aspects as well (sustainability takes place in the short- and long-term, and regardless of our efforts to focus on the long term, the short term will almost always take precedence when it comes to political considerations). Indeed politics represents another key aspect of sustainability, especially when considering the concept as a potential instrument for change.

And, finally and perhaps most importantly, there are spatial aspects of urban sustainability. How cities develop—where the roads, houses, parklands, retail stores and factories are built largely determines how sustainable cities are now and will be in the future. The dense populations and economies of scale make cities a potential source of viable solutions to global ecological challenges over the long term. Yet, cities are also daunting parts of the problem in the short and long term.

How we get from here to there—by maximizing the benefits of cities' economies of scale while minimizing their environmental impacts—will be a major challenge in transitioning to urban sustainability. So where does this leave efforts to make sustainability the aim of fundamental reform in urban development? It may, in fact, place us on shaky ground because, as Bruce Jones, Chief Scientist for the Biology at the US Geological Survey (USGS), asserted, "The sustainability agenda can cover almost everything."

The key may lie in turning sustainability from a goal into an effective strategic tool for long-term growth. As Amy Glasmeier, Head of the Department of Urban Studies at the Massachusetts Institute of Technology inquired in her talk: "How do we go about looking at something as grand as sustainability when we are trying to take into account multiple actors, multiple locations, multiple drivers and unexpected events?"

The concept itself is fuzzy and, as the definition of urban sustainability gains sharper focus and acquires the attributes of an operational tool of change, it needs to be considered in the context of many traditional American political and cultural values deeply rooted in idealized notions of individualism and the value of limited, localized government—notions that have gained even greater currency during the post World War II period of suburbanization. While we can change the terminology, as many participants did when they referred to the need to promote "smart growth," the same difficulties will remain. Needless to say, effectively addressing this problem will be far more difficult than assessing the urban situation today. As Briggs advised in his address, "It's not enough to deconstruct the old way. You actually have to build something."

Placing People at the Center

Our understanding of both urban trends and effective policy frameworks for "smart growth" and "urban sustainability" do not, of course, depend solely on research and theory. As many participants at the workshop noted, what is happening on the ground often drives scholarly discussions among researchers, rather than the other way around. Researchers, more often than not, find themselves responding to developments unfolding

on the ground—developments that are beyond their control. They are, in a sense, offering insightful suggestions on how to develop solutions to problems that may develop.

Michael Freedberg, Director of Affordable Housing, Research and Technology at the U.S. Department of Housing and Urban Development (HUD), noted that federal agencies are taking significant steps to work more closely on urban issues. He cited an initiative between HUD, the Environmental Protection Agency (EPA) and the Department of Transportation (DOT) to create a joint agency task force on urban issues that, since January 2009, has been meeting weekly to discuss issues of common concern and, equally important, to devise collective strategies for action.

Freedberg asserted that the "fundamental building blocks" of sustainable urban growth are housing and transportation. "Together, these two critical issues have a decisive influence over the way a community looks, feels and functions." In his view, housing and transportation constitute the elemental ingredients of land use. As a result, they lie at the center of sustainability both as a concept and an operational tool for reform. Build transport and housing at "cross purposes," and you will likely create dysfunctional, unhealthy communities that diminish the quality of life, deny people opportunities and raise household and community costs.

Freedberg cited six specific sustainability or "livability" principles that the multi-agency partnership between HUD, DOT, and EPA believes are destined to shape urban sustainability efforts—both now and in the future. First, efforts to increase sustainability must provide more transportation options. In the U.S.'s automobile-dominated society, that means first and foremost expanding access to public transportation—especially in cities where traffic congestion adversely impacts the economy, local environment, and quality of life (and there are few American cities where this is not the case). As population density increases, public transit options become more viable.

Second, such efforts must promote not only affordable housing but also housing that meets the needs of diverse demographic groups—for example, families of modest incomes, those living alone (more than a quarter of the nation's households are now single person households), the elderly (senior citizens are the most rapidly growing demographic group in the United States.) and minority populations (many cities now have "minority majority" populations).

Third, livability means enhancing economic competitiveness. That necessitates providing greater access to quality education and jobs. As jobs migrated to the suburbs during the second half of the 20th century, many American cities found themselves saddled with declining economies that provided too few jobs for their citizens and too little tax revenues for their municipal coffers. For these cities, economic revitalization is the first principle of sustainability.

Fourth, it calls for supporting neighborhoods that are successfully engaging in sustainable practices and so can serve as models for others. The success of urban sustainability will depend, in part, on effectively conveying information about what works and how successful projects can be adapted to the specific circumstances of other cities.

Fifth, it requires measures that facilitate the coordination of federal policies and that effectively leverage federal investments with other sources of funding. Urban sustainability may have to be "place-based" to succeed, but progress will require the active involvement of the federal government. Washington, D.C., for better and worse, is

the one irreplaceable partner if sustainable urban development is to become a national phenomenon that reaches beyond the local and regional pockets of hope that now exist. We are indeed an urban nation and it will take both individual cities and the entire nation to chart a successful path for urban sustainability.

And sixth, it calls for valuing communities, by investing in healthy, safe, and walkable neighborhoods. Such a goal—the creation, in effect of "walkable cities"—has profound land use implications.

Discussions concerning sustainability, both during this workshop and in general, have largely focused on issues related to effective resource management and, more specifically, on strategies to ensure the long-term well being (or, in economic terms, the reliability or conservation) of ecosystem services. Yet, it is also true that proponents of sustainability are ultimately interested in creating environments that promote healthier, happier and more productive lives. As Howard Frumkin, Director, National Center for Environment and Health and Agency for Toxic Substances and Disease Registry at the U.S. Centers for Disease Control, declared: Land use decisions have public health implications and that, in turn, makes public health "intrinsic to sustainability."

This effort, moreover, has implications for all other components of sustainability. Frumkin noted that unless the United States finds a way to rein in escalating health-care costs, all other aspects of the sustainability agenda will be starved for a lack of funds. Health considerations are important, Frumkin asserted, not merely because a healthy population is a fundamental goal of sustainability, but also because policies that make public health a priority offer an effective way "to put sustainable principles into practice." They do so, he contended, by "placing people at the center of sustainability."

Like Carrion and Briggs, Frumkin observed that we have created "car-culture landscapes," especially in our suburbs, and this has adversely impacted the nation's health. Build it right, Frumkin seemed to be saying, and we will become a healthier nation. As one example, Frumkin cited the construction of Hubbard Lake Elementary School in Hubbard Lake, Michigan, on a 35-acre site more than seven miles from the home of the nearest student. The school's motto, he wryly noted, is "outstanding in its field."

Obviously, no child can walk to school there—a situation that is mirrored in low-density and sparsely-populated communities across the United States. Every child in Hubbard Lake must instead travel to and from school in motor transport. This not only increases fuel consumption and raises air pollution levels, it also means less interaction with the environment and less social exchange with classmates before and after school hours. Taking his call for "walkable" schools one step farther, Frumkin cited recent statistics indicating that the 5 percent reduction in driving that accompanied the spike in gas prices in the summer 2008 led to a 20 percent reduction in auto-related fatalities (Sivak, 2008). A less-car oriented society, he noted, would be a safer society.

Cities as a Focal Point for Research

Echoing a growing number of researchers, Nancy Grimm, Co-Director of the Arizona-Phoenix Long-Term Ecological Research Project and Professor of Ecology at the School of Life Sciences at Arizona State University, contended that cities are "extremely open ecosystems" that "interact with other ecosystems both near and far"—comments that paralleled those of Bartuska. Solutions to the nation's urban problems, she

emphasized, lie in "allowing ecosystems to do the work rather than opting for technological solutions." Furthermore, she observed that "cookie cutter" responses will not succeed. What are needed are policy adaptations on a city-by-city basis.

Efforts to enhance urban sustainability, she added, will require place-based solutions because every city is somewhat different in both its makeup and the problems that it faces. Grimm cited climate studies in Phoenix indicating that night time temperatures in the center city are 5 degrees Centigrade (C) higher on average than 100 years ago. That compares to 1 degree C higher in the adjacent region. Moreover, the number of days in downtown Phoenix in which temperatures have exceeded 38 degrees C (100 degrees Fahrenheit) has doubled in the past 50 years ago. Even more revealing from a place-based perspective, average summer temperatures in downtown Phoenix are often 5 degrees C warmer than the less densely populated surrounding areas.

While all cities are experiencing the effects of climate change, the desert city of Phoenix shows a trend towards warmer temperatures in its own unique way: Overall temperatures are rising faster and differences in temperatures between the city and suburbs are growing more extreme than in many other places.

Yet, the experience of Phoenix, despite its uniqueness, holds lessons for all cities. Climate change is increasing average global temperatures. The U.N.'s Intergovernmental Panel on Climate Change (IPCC, 2007) estimates that temperatures have risen 0.6 degrees C over the past four decades and it projects that temperatures could rise another 1.1 to 6.4 degrees C by the end of this century. But, as Grimm showed, city centers, where the nation's poorest people often live, are already experiencing a heat island effect, which increases some of the risks (e.g., higher incidences of ozone formation and heat-related illnesses) posed by climate change.

Rising temperatures and heat-related stress, she said, "varies dramatically from neighborhood to neighborhood in Phoenix." In fact, Phoenix has placed-based micro-climates. And, like so many other urban attributes, the impact and risk of these micro-climates are closely associated with such factors as family income, population density, race, ethnicity and age. There are, in short, "high heat areas" just as there are "high crime areas," she observed. This example showcases the spatial dimensions and complexity underlying discussions of sustainability.

Several participants noted that in our globalized economy, rural environments are often as dramatically impacted by urban growth as the urban environments themselves. As Ann Bartuska, acting Under Secretary for Natural Resources ad Environment at the U.S. Department of Agriculture's (USDA) Forest Service, observed: "It goes without saying that America's cities, and more broadly cities around the world, do not exist in isolation. Constant exchange takes place between the urban core, which is often the focal point of the analysis, and the urban periphery, which often allows the city to grow and, in fact, serves as a primary source of its sustainability."

As Glasmeier noted, "Urban sustainability requires an examination of the distributive consequences of urbanization." She went on to caution that unless urban sustainability starts from such a perspective, it will fail to address this critical question: "What quality of life or way of living is being obtained or preserved?" The fact is that what may be sustainable over the short term and at the micro-level may not be so over the long term and at the macro-level.

This presents a compelling challenge for those engaged in efforts to create long-term, comprehensive solutions designed to reverse the unsustainable patterns of growth that America's cities have experienced over the past five decades. What incentives can be created to encourage sustainable behavior? Conversely, how can we ask those living in impoverished conditions today not to seek to replicate the lifestyles of those living in more upscale, "greener" neighborhoods, thus placing even greater stress on fragile and finite ecosystem services? Under such circumstances, should researchers—and particularly scientists—assume advocacy roles, or is it their job to simply present the data and facts and to leave it at that, especially when the data and facts indicate that there is no clear cut strategy for addressing the competing problems that are being faced?

The truth is that science can help address this dilemma, but it simply cannot begin to resolve problems of choice, circumstance and lifestyle. That's because the challenges involving the temporal and spatial aspects of sustainability (which is where the broad, often abstract, principles of sustainability are turned into concrete measures) are ultimately political and social issues, and not scientific ones—unless, of course, nature intervenes to transform time-bound and place-based challenges into existential risks that necessitate a truly global response.

3

Resilience and Adaptation

The second panel of the workshop was asked to discuss the key environmental threats and opportunities communities face. Climate change is one obvious challenge over the longer term, but in the near term communities will continue to face natural disasters and related environmental challenges, the impacts of which can be catastrophic. Panelists focused their remarks on notable research efforts into environmental impact reduction, resilient infrastructure, and adaptation measures.

From Recovery to Resiliency

For Glen Daigger, Senior Vice President and Chief Technology Officer, CH2M Hill, Inc., the key term is not “sustainability” but “resiliency.” "What will it take," he asked, "to create resilient cities?" This is no small matter, as the devastation inflicted on New Orleans in the wake of Hurricane Katrina tragically showed.

Walter Peacock, Professor of Urban Planning and Landscape Architecture and Urban Planning and Director of the Hazard Reduction and Recovery Center at Texas A&M University, noted that U.S. coastal areas, which are home to half of the nation's population (more specifically, 50 percent of all Americans live within 50 miles of an ocean coastline), are at risk to storm surges and rising sea levels due to climate change. "We need science-based information," he observed, "to help us assess the extent of the risk and to develop effective strategies” both to mitigate and adapt to the likely impacts.

Pointing to Howard C. Kunreuther's (2009) book, *At War With the Weather*, Peacock asserted that "we are in an age of new catastrophes." We may think of "hurricanes, tornadoes, land slides and earthquakes as acute events that strike only rarely," Peacock said. But in truth, mega-catastrophes have become "chronic challenges" that must be addressed in much the same way we have addressed and planned for inevitable increases in traffic or demand for housing. He also noted that our lack of foresight in planning for and responding to natural disasters makes them “man-made catastrophes.”

Peacock observed that between 1950 and 2000, coastal areas in the United States grew in population by more than 100 percent while the rest of the country grew by 75

percent. Consequently, coastal areas have experienced enormous increases in housing and infrastructure. As he lamented: "Katrina was a horrific event. Yet, the $85 billion in property losses and damages spoke as much to a human miscalculation as it did to a natural disaster." We have developed in places where we should not have and we have paid a steep price as a result, he warned.

Peacock cited the coastal hazard planning tool kit developed for the Texas coast as an example of how 'visualization tools' could be used to convey valuable information to citizens and policy makers alike that could help make urban communities more resilient.

The tool kit, which was funded by the Texas Sea Grant Program, the National Oceanic and Atmospheric Administration (NOAA) and the Texas General Land Office, has helped shed light on the development difficulties likely to be faced by policy makers and the public residing along the rapidly developing Texas coastline. The challenge is how to make room for this growth without undermining the coastline's ecology and the irreplaceable ecological services that it provides.

Perhaps most importantly, the tool kit can be used to help policy makers and the public plan for natural disasters in areas that are prime targets for devastating hurricanes in the short term and relentless sea-level rise in the long term. In such regions as these, efforts to build more resilient communities should be of the highest priority.

Peacock, however, was not optimistic that things were about to change for the better. He noted that historically a predictable series of responses have followed on the heels of natural disasters in the United States. These responses, which have become all too familiar, have more to do with poor decision making than with inadequate technology or even insufficient information.

The emergency response, he stated, begins with an outpouring of heartfelt concern backed by a profusion of resources to aid in the recovery. Yet, from the start, the response is uneven, with wealthier, more politically astute segments of society invariably receiving more assistance. Equally disturbing, as the impact of the disaster fades into memory, old patterns of development return. As a result, many of the same risks and vulnerabilities recur. And, when disaster strikes again (as it inevitably will), the cycle of deadly destruction, generosity and willful forgetfulness plays out once more.

How can a sustainable path to development take hold, Peacock asked, when we continue to repeat the same mistakes? What we really need to do, he asserted, is to focus not on recovery but on "reducing vulnerability and enhancing resilience." He went on to note that the half-hearted solutions put in place during the recovery tend to be technological and/or "brick and mortar" fixes—for example, sea walls and dikes—and that long-term solutions—for example, prohibiting development in high-risk areas—are invariably eclipsed by short-term economic considerations. He regretted that "environmental preservation and restoration were rarely high on the agenda of the reconstruction projects that follow in the wake of a natural disaster."

A solution to this vicious cycle, Peacock maintained, lies in focusing on resiliency and vulnerability—that is, concentrating on preventative measures. In Florida, for example, only 19 percent of the people live in coastal communities that engage in comprehensive planning. Even more worrisome, less than 30 percent of the state's coastal residents live in communities where floodplain and storm-water management are integral parts of the political decision making process when it comes to development. "Let's face

it," Peacock lamented, "powerful economic interests win, especially at the local level, because land use and local economic development issues are what drive the economy."

Echoing the observations made by Peacock, Keelin Kuipers, Manager of the Coastal Storms Program at NOAA, also pointed to a sophisticated 'visualization tool' that her organization, in partnership with the USGS and Delaware Department of Natural Resources, has devised to help policy makers "see the future contours of the coastline" in and near Wilmington, Delaware, based on past and current patterns of development. More specifically, the tool has been designed to help officials better understand the impact that climate-change-induced sea-level rise could have on the city's economy and ecology.

Kuipers contended that this is more than a tool used for the protection of the natural environment (important as that is). It is also a tool that lets policy makers and planners determine where infrastructure should be built so that it can remain out of harm's way during a hurricane or storm surge. It is, in effect, a tool designed to help create an investment strategy for more sustainable growth.

NOAA and the USGS, Kuipers stated, have forged a partnership with the Chamber of Commerce in Mobile, Alabama. The goal is to "provide critical information that is credible and science-based but, at the same time, can highlight significant gaps in knowledge."

Like other participants, Kuipers proclaimed that coastal communities in the United States face a unique set of challenges because of the enormous investments that have been made in infrastructure and the high risks this infrastructure faces due to storms and rising sea levels. The challenge is to provide these communities with science-based information and services that can help them "make better decisions."

As one example, Kuiper spoke about how public officials in Wilmington, Delaware, would like to build a new wastewater treatment facility. But they would also like to know whether the facility would be there 100 years from now—or whether it would it be swept away by storms or flooding. The research conducted by NOAA and its partners, Kuipers said, could help them make a wise investment decision that would retain its value over the long term.

At a more general level, Kuiper cited two critical problems that researchers and public officials must contend with when advancing science-based responses to the risks posed by natural hazards such as hurricanes and storm surges. First, she noted that the "benefits derived from redevelopment" in the aftermath of a natural disaster often accrue locally, while the costs of redevelopment "are borne by the nation." And second, she observed that we do not yet have a sufficient understanding of the "cultural perceptions and attitudes" that come into play at the regional, state and local levels" in discussions of adaptation and resilience. Greater understanding of this type of "people-in-place" information, Kuipers believed, might make it easier to formulate successful strategies for coastal management that would help promote "good decision making" and ultimately sustainable growth.

Managing Tradeoffs

Denice Wardrop, Assistant Director, Institute of Energy and Environment at Penn State University, pointed to the "25-year-old experiment in sustainability" in the Chesapeake Bay as a possible model for others to follow. She noted that the progress the

project has been able to achieve has rested on framing discussions on questions of ecosystem services—the Bay's ability (or lack of ability) to provide recreation, seafood, commerce and biodiversity—to area residents, and on what would be lost if they allowed the Bay to continue to be exploited beyond the ecosystem's limits of resiliency and recovery. Wardrop noted that ecosystem services have aided discussions of sustainability "by providing a way for people to talk about tradeoffs."

Recreating a pristine environment, she said, was not possible, but developing a strategy based on tradeoffs and short-term sacrifices to attain long-term benefits was. Historically, discussions had focused on the level of resources that could be extracted—that is, on the "eco-demand-side" of the equation. Today, discussions are more likely to focus on the level of resources that must remain in place to ensure a healthy ecosystem into the future—that is, on the "eco-supply side" of the equation.

For all of its detailed analyses, broad-based discussions and comprehensive policy actions involved in the Chesapeake Bay initiative, a change in mindset may have been its greatest achievement: that is, its success in transforming the drivers of policy from one based on the notion of unlimited resources to one based on a firm conviction that we live in a region (and a world) of limited resources. That means we cannot have it all now, but must instead think in terms of tradeoffs and what ought to be protected and conserved for the future. Find the right balance for managing competition between land, water and biodiversity, she seemed to be saying, "and we will have begun to map a proper course for sustainability."

Sophisticated computerized tools, Wardrop said in comments that closely tracked those of Peacock and Kuipers, are now available to accurately project what the ecosystem tradeoffs will be when pursuing specific land use policies. But she quickly added that "there has often been a mismatch between the scale at which we describe the ecosystem benefits when pursuing these measures and the scale at which we describe the socio-economic benefits."

Put another way, we have yet to develop an analytical tool that can consistently illustrate how "smart" ecosystem management will render short-term impacts for social well being. "What we forget as scientists," she cautioned, "is to talk to people at a scale that is meaningful for them."

Wardrop raised an even more general challenge for the scientific community when she asserted that "scientists must learn to separate *interesting* problems from *meaningful* problems," if they hope to play a key role in devising a more sustainable future. She observed that scientists are often encouraged to develop their own research agendas and find their own disciplinary niche. Moreover, they are inherently curious about the natural world around them and "find everything interesting." As a result, we should not be surprised to discover that many scientists have difficulty tailoring their research agendas to problems that have been defined by others, particularly if "the others" are not part of the scientific community.

As a result, she urged scientists concerned about sustainability issues to focus on this critical question: "What is the science that will change decision making?"

Wardrop seemed to be suggesting that scientists seeking to address the issues of sustainability, including urban sustainability, would be wise to turn to the emerging subdiscipline of sustainability science (Clark, 2007) and be willing to frame their research agendas around questions that are posed by those who are not members of the

scientific community—that is, to allow their research to be "demand driven." She concluded by noting that this is largely the path that scientists studying the Chesapeake Bay have taken over the past several decades with encouraging results.

Translating Knowledge into Action

Bill Werkheiser, Eastern Regional Director at the U.S. Geological Survey (USGS), concentrated his remarks on his agency's efforts to analyze and respond to the risks posed by such natural hazards as coastal storms, droughts, floods, landslides, volcanoes and wild fires. He emphasized the importance of the USGS's recent initiatives to unite research in the natural sciences with research in the social sciences so as to inform effective evidence-based strategies for mitigating and responding to such catastrophes.

Specifically, Werkheiser pointed to a multi-agency, multi-disciplinary project in southern California dedicated to earthquake preparedness—the "great shakeout," as it was called. The region that served as the site of the project lies on the infamous 1,100-kilometre (800-mile) San Andreas fault, which runs through an area in southern California that is home to more than 5 million people.

The project not only involved 25 percent of the region's population but also enlisted the services of some 300 professionals, including seismologists, public health specialists, economists, sociologists and even writers and art designers. The latter prepared messages that could be easily understood by the public and that would capture its attention. For example, instructions for reacting to an earthquake were reduced to this: "drop, cover and hold on."

As Werkheiser explained, project organizers wanted to alter the "mindset" of the people living on the fault line from the prevailing passive attitude of "we live here and accept earthquakes as inevitable," to an attitude of informed resolve: "we live here and want to prepare for earthquakes, because we *know* they *will* occur."

In the parlance of the scientific community, the USGS hoped the project would help shift discussions from a focus on "vulnerability" to a focus on "resilience" —to transform residents' fatalism that "we can't do much about earthquakes" to a conviction that "though we can't prevent earthquakes, we can mitigate their impacts."

Scientists working for federal agencies, Werkheiser contended, could make significant contributions to this proactive strategy. For example, using sophisticated modeling techniques, they could forecast the ground motion that would accompany an earthquake of a given magnitude in a given location. They could then project the damage likely to be caused by the earthquake. The goal would be to identify critical vulnerabilities and then propose solutions that would enable communities to prepare and respond to the risk.

In the past, Werkheiser said the USGS would "go deep into the science." Now, the agency tries to "focus on relevance and on devising strategies that allow communities to avoid or absorb the shock created by a natural disaster and ultimately to build resilience" that enables them to face the future—however uncertain it might be—with confidence.

He cited the catastrophe in New Orleans in the aftermath of Katrina as providing an important lesson for federal departments and, more generally, state and national risk management agencies. "Scientists had accurately predicted that a tragedy would take

place some time in the future." They had even "developed scenarios that turned out to project almost exactly what happened there." Indeed the scenarios pinpointed the city streets that would suffer the greatest damage and loss of life.

But this knowledge, he said, was kept within a small cadre of experts and not shared with the larger population. "People in New Orleans," he observed, "didn't know how vulnerable they were." What good is scientific information, he asked, if it cannot be put to use to save lives and protect property?

As a result of this experience, USGS now wants to ensure that critical information concerning risk does not remain closeted among experts. Instead, it wants to widely share this information with policy makers and the public. "What we had in New Orleans," Werkheiser stressed, "was a communications, not scientific, problem." And, he and his agency do not want poor communications to obscure good science in the future.

Denise Stephenson Hawk, an environmental and educational consultant and Chairperson of the Atlanta-based Stephenson Group, concurred with Werkheiser, in noting that "we need to make sure that scientific data and information are used by the people" to help them make informed decisions on critical issues.

She added that data and information, particularly information that can help break down the disciplinary silos that have characterized and constrained problem-solving research (especially in universities and government agencies), must drive research efforts in the future. Scientific data, she observed, also is essential for establishing baselines against which changes in resource use can be measured over time. The gathering of data is essential, Stephenson Hawk noted. Nevertheless, like Werkheiser, she emphasized that science-based sustainable development will ultimately depend on moving scientific data and information beyond scientific circles to the larger policy community and lay public.

4

Models, Metrics, and Future Scenarios

The third panel was organized to address some of the challenges associated with measuring change within an urban area, as it relates to sustainability. Panelists discussed some ways that urban change can be modeled into the future, how human and environmental outcomes can be measured, and what information is most useful or needed in assessing outcomes.

The City as a Unit of Analysis

Jonathan Fink, Vice President for Research and Economic Affairs and Director of the Global Institute for Sustainability at Arizona State University, claimed that cities offer an excellent place to study sustainability issues. If you focus on individuals, he said, investigations might prove to be "too slow and broadly dispersed." If you focus on nations, he contended, "political barriers may stand in the way." Cities, in contrast, are at the "intermediate scale and therefore may prove to be just the right size both for studies and pilot projects devoted to sustainability. Urban environments, he added, offer an additional bonus for researchers and practitioners wanting to understand what works and what does not. Simply put, "they are places where things are being done."

The focus on cities—and how to make them more sustainable—raises another critical issue, according to Fink: How can we develop a strategy that allows for a more coordinated flow of information? Progress on this front would enable us to move from detailed examinations of critical problems in specific cities to a broad analysis of sustainable urban development, based on "lessons in city living" from across the nation. The challenge would be to extract broad evidence-based lessons from the particular experience of individual cities. This would require input from a wide range of experts in the natural and social sciences as well as from policy makers and representatives of nongovernmental organizations. The approach would not only be cross disciplinary in nature but would also foster partnerships, helping to blunt the sharp distinctions that have historically existed between scholars and practitioners.

Fink cited the efforts of the Central Arizona Phoenix Long-Term Ecological Resiliency Programe, an initiative funded by the National Science Foundation (NSF),

which has examined the impact that the rapid growth of Phoenix's metropolitan area has had on urban ecosystems. He observed that the initiative, which is comparable to the Baltimore ecological resiliency project, has built excellent models for projecting trends in water, air, transport and land use. Yet, he cautioned, it has been less successful in integrating the data and insights into a fully drawn portrait of the future of the city. Universities, he observed, are not the only institutions handcuffed by traditional silos of information. Government agencies often find themselves constrained by similar circumstances.

The Phoenix project is part of a larger effort by the NSF to fund long-term ecological research (LTER). But as Fink noted, only two of LTER's 26 projects have taken place in urban environments: in Phoenix and Baltimore.

Clearly, the NSF's ecological research agenda does not place the same weight on built environments as it does on natural environments (although because of demographic trends, several LTER projects have seen exurbs and suburbs encroach on their study areas). Nevertheless, farmland, forests and parks have traditionally been considered a more integral part of the environment than cities.

This will have to change if urban sustainability is to become a major aspect of ecological research in federal agencies. As the USDA's Bartuska noted, there may be more to the concept of 'eco-cities' than the current perceptions of the 'steel, glass and cement' would suggest. She noted that of the 193 million acres of forest managed by the federal government, 80 million acres are located in urban areas. That's more than 40% of the total.

Fink also pointed to the recently launched Global Cities Indicators Facility project, located at the University of Toronto and funded by the World Bank. The project is designed to encourage cities worldwide to collect "the same kind of data in the same way" and to "place their data all in one place." The ultimate objective is to facilitate access to urban research on global urban issues in ways that make comparisons easier to discuss and analyze.

It is a worthy goal, Fink said, that could go a long way to helping establish base lines that will be crucial for assessing trends in urban sustainability. Indeed research-based evidence, many participants noted, represents our best hope for changing minds and changing policies.

Between 1973 and 1998, Atlanta's 13 county metropolitan regions witnessed the destruction of an estimated 55 acres of forest each day, resulting in a cumulative loss of 280,000 acres of vegetation during a quarter century of unprecedented growth. As Dale Quattrochi, a Geographer and Senior Research Scientist, Earth Science Office at the National Aeronautic and Space Administration (NASA), described it: One of America's premier Southern cities experienced a period of suburban "slash and burn."

As was the case in Phoenix, explosive population growth and the associated construction frenzy in Atlanta fueled an urban heat island effect in which temperatures in the city and even some suburbs far exceeded temperatures in the open areas lying at the periphery.

"We all know that cities are hot; nothing new here," Quattrochi said. But we may not be fully aware of how hot they stay once the sun sets. Detailed weather surveys indicate that two to three hours after sunset summer time temperatures in the center of Atlanta often remain 3 to 10 degrees F higher than in the outlying districts. Simply put,

the heat that builds up during the day is released much more slowly at day's end in places where cement covers much of the landscape and open space is in short supply.

Such “urban hot spots” are uncomfortable, unpleasant and less livable places that most people might prefer to avoid. But what is less well known, according to Quattrochi, are the increased public health hazards posed by the urban heat island effect. As he explains, higher temperatures accelerate the formation of ground level ozone (smog) as precursors (volatile organize compounds and nitrous oxides) combine photochemically in the lower atmosphere.

Quattrochi suggested that relatively inexpensive measures could ease temperatures, most notably the replacement of heat-absorbing, blacktop tar roofs (where temperatures can reach 175 degrees F on hot summer days) with light-colored roofs that reflect sunlight. Planting more trees would also help. Quattrochi cited the work of TreesAltanta, which hopes to plant 1 to 2 million trees in the city over the next two decades, as an excellent example of urban sustainability at work.

Indeed TreesAtlanta is a project that reinforces the three principles behind the concept of urban sustainability: There's an economic dimension (it creates jobs), a social dimension (it upgrades the appearance of the city and increases its appeal), and an ecological dimension (it aids in efforts to enhance the environment and improve the habitat).

Both policy makers and the public speak of the need to better understand urban ecosystems. Yet, examples of urban models and scenarios that shed light on this issue remain relatively few in number. That is why participants at the workshop were particularly eager to hear Steward T.A. Pickett, a Plant Ecologist and Distinguished Scientists at the Cary Institute of Ecosystem Studies, speak about the ongoing efforts of the Baltimore Ecosystem Study of Long-Term Ecological Research (LTER) Program, funded by the National Science Foundation (NSF).

The project, Pickett noted, focuses on "the structure and process of Baltimore's urban ecosystems," and how the city’s inhabitants have chosen "to use these systems." The initiative is comprised of several inter-related goals, some that seem within reach in the near term and others that are likely to take some time to fulfill.

These goals, Pickett said, include doubling the city's tree canopy, creating ample, well-maintained public recreational space that can be easily accessed (especially by poor citizens), protecting Baltimore’s ecology and biodiversity, and establishing the city as a national leader in sustainable food systems.

The vision that drives these goals is based on a desire to create a better life for the people of Baltimore while conserving and protecting the city's ecology and biodiversity —that is, the goal is to turn Baltimore into a model for sustainable urban growth.

"We rely on watershed measurements to gauge our progress," explained Pickett. "That means we invest both a great deal of time and money assessing the water quality of our streams, the biochemistry of the soil and levels of atmospheric pollutants." The staff also integrates large amounts of economic and social data into their analyses—detailed information about the city's demography and economy, transportation systems and construction sites, health services and recreational facilities, and many other factors. Not a single trend is too big or too small. Indeed no mega-trend or minor detail goes unnoticed. Borrowing a term used by hydrologists, Pickett called this "synoptic

sampling"—an effort to present a broad picture of resource use and development trends in Baltimore based on a relentless pursuit of facts and figures.

But Pickett also maintained that this has not been a top-down approach led by public officials and government bureaucrats. Part of the process has included an ongoing dialogue with the citizens of Baltimore to determine what they hope the project will achieve in making the city a better place to live. He estimated that 1,000 of the city's residents have participated directly in this exchange and that many more have heard about it from friends and in the media.

Collecting and Analyzing Data

"Fear and greed" motivate my commercial clients, said Thomas Parris, Vice President and Director of Sustainability Programs at ISCIENCES LLC. "Should we expect anything more or less from those asked to respond to ecological challenges?" A broader understanding of thresholds is one of the keys to urban sustainability, Parris said. "Cities," he went on to note, "are highly engineered environments," and it is important to think of them in terms of what they require in order to function well—both now and in the future.

If the demands placed on a city's requirements exceed the supply of resources that are available to meet them, the city will be placed at risk. That is why, according to Parris, we need to study not only population and economic trends, but also energy and water use, the prospects for technological advances and the possible impact of climate change. Each of these factors, and many more, will impact the requirements placed on an urban environment by increasing the demand for ecological services. Technological advances, in turn, would enhance the efficiency of the delivery systems (thus extending the use of these services).

Adding to the complexity, Parris asserted, is the rising number of unusual events that are impacting cities—including unprecedented annual variations in rainfall, withering heat spells, intensive storms and flash floods.

Other speakers, including Peacock and Kuipers, had made the same observation, but Parris added a new twist to the discussion. Because we are dealing with rare events, he said, we have been unable to observe a sufficient number of them to draw insightful conclusions on how they might affect urban environments. Nor have we been able to project the long-term impact they are likely to have on urban sustainability. Hinting at the same challenges raised by Peacock, Parris plaintively inquired whether these rare events will become commonplace and, if so, what does that mean for our cities?

"We do financial, economic and even estate planning," Parris wryly observed, but we "don't do spatial planning," and for this reason it is extremely difficult to devise an effective strategy for sustainable urban growth.

Jennifer Wolch, Dean, College of Environmental Design and William W. Wurster Professor of City and Regional Planning at the University of California, Berkeley, expanded on Parris's observations by suggesting that we need to develop more integrated models for cities that are capable of providing “multi-sector, cross-over and real-time analysis of events.”

While not discounting the importance of data, Wolch echoed the concerns of some of her colleagues when she questioned whether more precise large-scale models would serve as the basis of better decision making. "No one wants to make decisions in

the dark," she asserted. But she wondered if the quest for more high-powered, large-scale models ran the risk of becoming "cul-de-sacs into which researchers happily go, running their regression analyses, while the rest of the world goes on without them." Most models, she also advised, “don’t capture some of the most critical aspects of sustainability” that “reach beyond any particular metropolis and connect to global production and consumption networks.”

To counteract these shortfalls, Wolch contended that large-scale models needed to be theory-driven, multiple-scaled and, most importantly, based on high-quality data and state-of-the-art technology. Such urban models exist, she said, but they are too few in number. She lauded the efforts in Phoenix and Baltimore but maintained that such initiatives needed to be replicated elsewhere not only for the sake of other cities but also to build a complete portrait of trends in urban sustainability across the country.

She also cited a smaller scale initiative in Southern California that was using a GIS planning tool to provide integrated analyses of trends in habitat and watershed conservation and parks and open space. The goal has been to determine whether the use of selected parcels of parkland could deliver multiple (and mutually reinforcing) benefits —both for local residents (particularly the poor) and fauna and flora species preservation. In other words, could the GIS planning tool help policy makers select new swatches of parkland that would maximize the payoff for people and the environment?

In addition, Wolch observed that none of this technology, data collection and analysis comes cheap, and that it is unrealistic to believe that it can be successfully put in place and maintained without government involvement at all levels.

Nongovernmental organizations, she acknowledged, are gaining increasing expertise in using sophisticated data and analyses when engaging both policy makers and the public in discussions on critical urban issues. But government remains the most important player, not only because of the resources it has at its disposal to assemble and utilize data, but also because the information and analysis that is derived from these data bases and models generally constitutes a public good.

Nevertheless, she regretted that governments have rarely displayed the stamina and commitment for long-term data-collection projects and, as a result, virtually none of these projects has been open-ended. "At some point," she observed, "they become 'legacy initiatives' of interest to planners and historians, but of limited value to policy makers simply because they tell a story of the past" instead of shedding light on the present and future.

Finally, Wolch noted that high-quality data and analysis could help us better understand the factors that drive high-performance communities.

"Each city is different," she said, "and big cities even have very different micro-environments within their borders." That makes measuring sustainability a difficult task because there are so many matrices involved." Yet, at the same time, she added that we all know of examples of success both at the neighborhood and city-wide levels. What we need to do, according to Wolch, is to examine "what accounts for these successful experiences" and what can be done to replicate them.

In other words, we need `'to understand what works, to be able to build models capable of assessing alternative scenarios, and to find ways to make cities more resilient" based on high-quality information. This will require integrated data on "energy, health, food habits, consumption, buying habits and ecosystem services." She concluded her

remarks by adding that we need this data not just for one or two cities "but for many cities" if we hope to devise a comprehensive strategy for sustainable urban growth that cities and suburbs across the country find of use.

Computer-generated tools, in fact, have vastly expanded the level of detail and refinement available for researchers studying the city and countryside. “These are the best of times for geographers,” declared Glasmeier. “We can analyze data at multiple scales over distinct time periods. We can integrate satellite data. We can integrate microbial data. We can put sensors inside people and have them walk around. We have enormous capacity to track people.”

“The critical question,” Glasmeier said, is this: “Do we really have the tools to analyze” all of this data? Participants raised similar questions. Will this vast treasure trove of data allow the public and policy makers (or even researchers) to see the problem more clearly and to make better decisions? Are we confusing ever larger amounts of data and information with in(fore)sight and innovation? Are there limits to what additional data and information can do in the absence of comprehensive blueprints for growth at the local, regional and national levels—a blueprint that is truly sustainable? In short, what do we need more of: additional information or a better plan? Or, as Glasmeier observed: “We are good at measurement. We are much less effective at long-term monitoring. As a result, “how do we know where we want to be?” In other words, do we run the risk of being lost in a mountain of data?

5

Moving R&D into Practice

The fourth and final panel was designed to present the end-users' perspective as a way of moving towards more user-defined research, a key ingredient to sustainability (NRC, 1999). Panelists included mayors, urban planners, and membership organizations that facilitate the flow of information to decision makers. To conclude the workshop, participants were encouraged to explore opportunities to both broaden the impact of place-based R&D and disseminate promising practices more efficiently.

Transitioning to More Sustainable Practices

From the rarefied air that often characterizes discussions about urban planning theories and models, Jeremy Harris, a biologist by training who served as Mayor of Honolulu from 1994 to 2004, brought the conversation back down to places where Americans live and work, when he proclaimed that: "The infrastructure in our cities is falling apart." At the same time, "America's suburbs must acknowledge the adverse consequences of decades of sprawl." Today, Harris added, a growing number of cities, including his own, must also confront the consequences of global warming and the threats that storms and rising sea levels pose to their future well being. Reiterating a fundamental theme of the workshop, he warned that "we haven't built our cities in a sustainable way," and we can no longer afford to wait to change our ways.

Harris spoke about several modest measures that Honolulu has taken to reduce its ecological footprint. For example, it has built a wastewater treatment plant that relies on membrane bioreactor technology to improve water quality in a more ecologically sound way; it has turned to ocean thermal conversion techniques to generate irrigated water through condensates; and it has designed a series of bus rapid transit routes, modeled after the successful program begun in Curitiba, Brazil, to promote public transportation. To reduce development-related environmental impacts, Honolulu has also begun micro-tunneling when laying sewer lines and has mounted photovoltaic cells on its street posts to power the city's lights.

Harris is proud of the efforts that his city has made – and rightfully so. But he candidly admitted that these are small, discreet steps, which will merely curb, but not

reverse, the city's unsustainable patterns of development. "We need a systems approach," he asserted. Otherwise, we will be straight jacketed into "solving our problems one at a time." And, when problems are as inter-related as they are today, solving them one at a time likely means not solving them at all.

"We are in the mess we are in," Harris contended, "because in the past our economic behavior, including our urban economic behavior, was not honest." According to Harris, we simply failed to account "for the value of ecological services" and exploited these services as if they were free and would last forever.

This is a lament often heard among scholars and scientists but rarely expressed with such directness by elected officials. Harris acknowledged that we will not be able to alter our patterns of behavior in a day, but that we can focus our attention on issues that can make a difference – paying greater attention, for example, to developing renewable energies that meet the demands of the marketplace, increasing the recycling and reuse of materials, easing traffic by relying more on mass transit, and improving our waste management techniques.

Most urban officials operate in a chronic state of "crisis management," he proclaimed, and you cannot expect them to take a long-term approach to urgent matters. Not surprisingly, then, urban officials often turn to the research community to help shed light on consequential matters that are continually unfolding over long periods. Researchers, however, must rise to the occasion and present their findings in ways that policy makers can understand and, more importantly, use. He asked whether it might be possible to draw on the experience of USDA's agricultural extension service to create an urban extension service where (this time drawing on the experience of the medical research community) "translational research" would take place in ways that would move ideas and insights from the classroom and computer laboratories to America's homes and communities.

John Frece, Director of the Environmental Protection Agency's (EPA) Smart Growth Division, concurred with Harris's "think big, act small" approach. "It is important," he noted, “to align resources, regulations and legislation with urban sustainability principles" if we hope to make progress. He also maintained that such smaller measures as "tree plantings, electric buses and longer lasting and more energy-efficient light bulbs, while they may not seem "earth-shattering," do point us in the right direction and that the cumulative effect can make a difference.

To this "small may be valuable" to-do list, Frece added the recent announcement by HUD to allow mixed-income and multi-family housing to be built on brownfield sites (in truth, this represents an initiative of a larger dimension). With the help of other government agencies, both at the federal and state level and including the EPA, undesirable sites that had been abandoned because of high pollution levels can now be cleaned up and turned into areas where citizens can hope to lead better lives. Both people and the environment will benefit from this measure that will encourage more densely populated growth in places that are already built up.

The manner in which we have developed our land and constructed our cities has placed significant restrictions on our ability to adapt to the resource and energy demands of the present (development patterns are, in this sense, legacy costs we cannot avoid and must learn to deal with). At the same time, how we choose to develop virgin land in the future will impact the country’s overall energy and resource budgets (existing cities can

become more resource and energy efficient, but if suburbs and exurbs continue to grow, overall levels of energy and resource consumption will continue to increase). As Frece put it, “more brownfield redevelopment” will lead to less “greenfield development.”

He also suggested that it would be helpful to devise strategies for measuring small things such as the number of houses located within 15-minute radius of a bus stop or train station, or the percentage of low-income houses built within two miles of an employment center. Such indicators, while modest in their dimensions, could prove essential in determining whether a community—and a city—are moving in a sustainable direction. The message is clear: taking small steps – just as long as they are in the right direction—can be an effective way to create a more sustainable urban future.

Connecting with Political Will

Between 1950 and 1973, Dana Williams, the Mayor of Park City, Utah, recalled, "his town was listed on the national registry of ghost towns." Park City, in short, once a thriving silver mining town, had gone bust. Then, in the 1960s, "the city received a federal grant to build ski runs" as a way of giving renewed life to its moribund economy.

Park City quickly emerged as a captivating winter resort and, in 2002, it became an internationally renowned winter wonderland when it hosted the Olympic games. In many respects, Williams noted, this town of just 7,500 residents, with vacation homes owned by the "rich and famous," is a "poster place" for sustainability concerns. "Our entire economy," he said, "is based on the weather and disposable income." If climate change transforms the weather in ways that adversely affect the winter snow pack, the core of Park City's economy will be damaged—perhaps irreparably.

Park City has the resources—and the economic motivation—to pursue sustainability initiatives, which includes efforts to promote greater energy efficiency and an expansion of open space. Yet Williams observed that crafting and using the right language to argue the case for reform has been crucial to the city's success. For example, he remarked, the city's concern for the potential impact of climate change went nowhere in the legislative corridors of the state capital until "we started talking about the need for energy independence." This created appealing images of a more self-reliant people, which resonated with the strong sense of patriotism among his constituents. In a similar way, discussions concerning the need for open space become more palatable in other parts of Utah, including the state capital, when the talk shifted from “land conservation” to “range protection.”

That is why Williams pleaded with the researchers in the audience to "get the word out about your findings in ways that people can understand and appreciate." Indeed he claimed that this advice, however "simple it may sound," could be "more important than anything else you do" in seeking to lay a strong scientific foundation for sustainable growth. Briggs had made a similar point in his talk when he spoke about the need for comprehensive planning to serve as a tool for “liberating people” by “popularizing concepts that have been locked up in the science or planning professions.” The goal is to have “people grasp the concepts and put them into practice in their daily lives.”

"America's mayors are innovative," proclaimed Harriet Tregoning, Director, District of Columbia Office of Planning. "Cities," as a result, "often serve as testing grounds" for new ideas and new technologies. And, while Tregoning acknowledged that the problems faced by American cities have been persistent—rising poverty rates,

shrinking tax bases, crumbling infrastructures, crime, poor schools, the list is long – she also believed that the solutions have been evident, although rarely enacted upon, for some time.

We may not know how to address every problem but even when knowledge is lacking, we often know enough about the challenge—and possible solutions—to devise a response that can be assessed for its effectiveness. In other words, Tregoning maintained that, in many cases, we can begin to tackle a problem with pilot projects and then check the results before deciding whether to broaden the scale of the activity.

What has been lacking in efforts to move urban sustainability efforts forward, however, are two indispensable ingredients for success: financial resources and political will. And while urban problems are national in scope, Tregoning was quick to add that each city will need to devise its own distinctive answers to the problems it faces. "Cities," she cautioned, "cannot compete as generic places."

Tregoning pointed to recent developments in Washington, D.C. to shed light on how to build a more sustainable urban future. The capitol city she spoke about was not the seat of power for the world's most powerful nation (D.C.'s federal zone), but the capitol city of neighborhoods – low- and moderate-income residential areas, industrial zones that await redevelopment, transportation corridors that enable residents to get to-and-from work, and commercial districts where people shop, go to restaurants and see movies.

For Tregoning, neighborhood improvement initiatives, however halting and fragile, give hope of a better future and serve as examples of how we might be able to chart our way out of the endless swathes of urban decay and suburban sprawl that have been the twin hallmarks of the United States' unsustainable growth patterns for the past half century.

The areas lining the banks of the Anacostia River in the southeastern quadrant of Washington, D.C. have been home to some of the city's most blighted neighborhoods, and the river carries the dubious distinction of being one of the nation's most polluted. Yet, today, three new neighborhoods are rising from the squalor on brownfield sites that had long been abandoned as industrial wastelands.

Tregoning readily acknowledged that no matter how crucial housing may be to a city's well being, housing alone will not ensure a sustainable future. Echoing the earlier comments of Freedberg, she affirmed that transportation is also a key element. She went on to note that Washington, D.C. may have some advantages when it comes to urban transportation networks in the 21st century. For example, she stated that household transportation costs in the capitol city consume 9% of family income, while nationally the figure is l9%.

This means rising fuel prices may not have directly impacted D.C. residents as much as those in other cities and suburbs across the nation, at least in terms of household transportation expenditures. It also suggests that D.C. residents have options (namely, access to an efficient public transportation system) that others may not. Indeed during the last six months of 2008, when the economic recession was at its worst, residents in Washington, D.C. were selling off their cars at the rate of 4,000 a month. In the nation's capital, automobiles can become a luxury in tough times. In America's car-dependent suburbs, on the other hand, an automobile (and likely two or three) has remained a necessity.

Tregoning ended her talk by emphasizing the need to "walk the walk" and "bike the bike" to sustainability. She noted that the Washington D.C.'s bike-sharing program would soon be expanding its fleet from 100 to 3,200 bikes. She also mentioned Washington, D.C.'s recent transportation survey, which was designed to determine people's transportation preferences.

She pointed out that the findings of the survey confirmed the prevailing notion that little things can mean a lot. For example, the survey suggested that people would be willing to increase their daily walk to work or to a transit hub from one-quarter to one-half of a mile if there were storefront windows to gaze at along the way. In short, if the walk could be made more interesting, people would be glad to walk longer distances.

6

R&D Gaps and Opportunities

To conclude the workshop, participants divided themselves into three groups to explore cross-cutting aspects of urban systems R&D: decision-support tools and knowledge transfer, technology development, and research on and evaluation of promising practices. The results of these breakout discussions were reported back in plenary and are summarized in this chapter.

Decision-support and Knowledge Transfer

Participants in this group were asked to discuss ways of generating knowledge that is useful to urban decision makers, and to suggest ways to assure that this knowledge could be put into practice. Several of the issues that participants raised in this discussion echoed the themes of a 2006 NRC workshop on "Linking Knowledge with Action" (NRC, 2006b). Specifically, many participants emphasized the importance of engaging potential end-users up front in designing research agendas. This not only helps researchers investigate the problems that decision makers face, but it also helps with the "pull" mechanism so that the knowledge has a waiting audience. Some participants noted that this is an important function for boundary organizations—institutions that are accountable to the scientific community and end-users, and can specialize in translating knowledge into formats so that it is more readily absorbed and locally accessible.

Some knowledge has economic value (e.g., spatial data, or household energy consumption). These are areas where the private sector, through consultancies, information technology companies, and others, are engaging. Still, some knowledge has public but not direct economic value. A few participants suggested that these are areas where universities could be engaged, though incentives do not often exist to do so. One suggested remedy is to utilize an extension model with urban universities. Urban extension programs could also provide a mechanism to distribute seed funding for innovative programs in a given urban area—participants noted that large funding agencies (governments and foundations) are not always well-suited to support small-scale, experimental projects.

Other participants emphasized that knowledge is necessary but not sufficient to support sustainable urban development. They pointed out that there is built-in resistance within an urban system, whether it is cultural, institutional, or economic. Many participants stressed that economics cannot be overlooked. Insufficient local revenues are a major reason that new ideas and approaches do not get implemented in cities. Some participants countered that economic research itself must improve, to better account for the lifecycle costs and external (especially public health) costs of unsustainable urban development.

Technology Development

The group discussing technological development was asked to consider specific technologies with implications for sustainability. The group also discussed incentives for and barriers to innovation. One recurring theme was the importance of distributed and integrated infrastructure. Most U.S. urban areas are characterized by large, centralized nodes for critical infrastructure such as power and water. However, there appear to be major opportunities for urban areas to adopt decentralized, smaller-scale technologies, ranging from small renewable power generators to neighborhood water treatment facilities. Distributed infrastructure would add flexibility and resilience, and could also be scaled to meet the needs of shifting populations. Moreover, there are opportunities to integrate some of these traditionally separate systems and make efficient use of the interactions among water, wastewater, power, transportation, telecommunications, and the environment (NRC, 2009).

Viewing the city as a natural system is helpful in this regard. At an individual technology level, biomimicry research can be applied to make technologies more efficient based on natural processes, such as passive heating and cooling in buildings. Participants also noted that industrial ecology principles can be applied to make an urban area less wasteful, and as participants had suggested throughout the day, there is a need for additional data to better understand these resource flows and monitor them in real time. This presents two additional needs: knowledge/data management tools for cities as they attempt to integrate information from different sectors, and low-cost monitoring technologies and sensors that would facilitate real-time information and rapid detection of problems. Some participants pointed out that these are areas in which private industry is now devoting more attention, particularly in the context of the "smart grid" paradigm for modernizing electric utilities.

Urban areas are full of manufactured products and materials that, once past their useful life, are considered waste. However, one participant suggested that cities could be thought of as "above-ground mines" if societies would be willing to invest in repurposing or harvesting valuable materials for reuse. Recycling programs have expanded throughout the country in the past decade, and so a next step might be to investigate approaches to recycling larger, durable goods (e.g., hard plastics or construction materials). In addition, many urban areas in the United States are suffering from outdated and crumbling infrastructure. If this infrastructure is replaced instead of continually repaired, there is an opportunity to transition to new materials that are either more durable or at least more resilient and adaptable to environmental stress.

Some participants emphasized that water issues, which have been fundamental to urban development for centuries, tend to be overlooked as energy, transportation, and

climate change issues garner more attention. However, others insisted that the fundamental role that water plays in urban systems has not diminished, and in some urbanized regions scarcity has become a potential limiting factor in future development. Thus a sharper focus on systems for water delivery, consumption, and treatment may be warranted.

Reflecting the need, raised by other participants earlier in the day, to engage the public on issues of urban sustainability, several participants remarked that communication methods could be better utilized. This would include social media, which many local governments now use, but also sophisticated visualization tools that allow residents and decision makers to see what a new park would look like, for example. Participants pointed out early examples where visualization tools had a major impact, including time-series data on urban sprawl and remote sensing images of urban heat islands.

To complement technological development, several participants emphasized that science-based standards were needed to guide this innovation, such as public health standards for wastewater treatment alternatives. On a related point, existing codes and standards likely need to be reviewed and revised so they are not an impediment to more sustainable approaches. One example cited was the Clean Water Act, which can be a barrier to innovation—cities must devote substantial resources to meeting standards which have not been substantially updated since 1987.

Looking ahead, several participants noted that these possible paradigm shifts in urban development and management will also necessitate changes in the workforce. This may not be a limiting factor, but it is still an important consideration because governments will have to invest in appropriate education and training programs, so that the workforce is equipped to manage a more flexible, integrated, and dynamic urban system.

Research and Evaluation

Participants in this group were asked to discuss major interdisciplinary research gaps and, more specifically, the opportunities for evaluating urban sustainability projects and programs. This group pointed out that more consideration must be given to the time and resources required to maintain data and information systems in this field. Participants throughout the day had suggested that a clearinghouse of best practices is sorely lacking, but such a clearinghouse would require long-term support and maintenance, especially if it is to be a dynamic database. Some participants suggested that the research community should consider how much data are "enough," since there are costs associated with compiling and analyzing all of this data, not all of which ares directly relevant to decision makers' needs.

Urban areas could also benefit from an evaluation template, some participants suggested, or a common set of guidelines and objective measures/indicators that would: A) assess progress in meeting sustainability objectives, B) help cities invest in measuring the right things, and C) transfer across locales, so that researchers (and perhaps state/federal agencies) could evaluate performance across regions. The Carbon Disclosure Project was offered as an analog—the UK-based organization has grown to become the largest database for corporate climate change reporting. One decision maker in the group suggested that it would be useful to consider tiers of performance or compliance, akin to

the Leadership in Energy and Environmental Design (LEED) certification system for buildings, which has four tiers of compliance (Certified, Silver, Gold, Platinum). A baseline could include the (generally) inexpensive interventions that all urban areas could be investing in now, and ascending tiers could help put communities on a path toward sustainability. Overall, participants emphasized the need for objective evaluations if this knowledge from the field is going to be mined and made useful to a broader community.

On the subject of best practices, many participants noted that existing databases are generally sector-specific (e.g., water and sanitation) and thus are not focused holistically on urban systems. Moreover, evaluations of technologies may be viewed as incomplete if they do not include an objective evaluation of how the technology is successfully integrated into a community, in other words, an assessment of what works and why. In recent years, more and more communities purport to be sustainable, though there are not widely agreed-upon metrics to substantiate these claims. Many participants suggested that measurement protocols with flexibility built in for regional variation would be a valuable contribution from the research community. Some participants suggested that an open, web-based platform could provide a forum to share experiences and experiment results globally, at modest cost. As other participants noted, such user-supported approaches may not be rigorous enough for some applications, but it would at least provide an initial venue for place-based research and knowledge to be exchanged

Finally, spurred in part by the last panel discussion on decision makers' needs, a few participants remarked that more research was needed to understand the incentives that can foster change in an urban area. Local budgets may not allow for major expenditures with long-term payoff, so participants wondered aloud if this can be overcome through lifecycle costing, or better communication with citizens. Participants identified three primary motivations for urban areas to pursue sustainability objectives: economics, ethics, and competitiveness. Some participants suggested that competitiveness may in fact be the strongest motivation, since metropolitan regions (and communities within a metropolitan region) do in fact compete with one another. Put another way, one participant inquired how "keeping up with the Joneses" and behavioral research more generally is being factored into the urban sustainability research agenda.

Closing Remarks

To conclude the workshop, participants discussed various ways to move a sustainable urban systems research agenda forward. At present, there is no federal office or agency that can oversee the range of research going on, and because the research community itself is still fragmented, it is difficult to identify all potential research gaps. Many participants noted that not everyone uses the terms "urban sustainability" or "urban systems" but there are elements of it implicit in the approach that federal agencies, the White House, and others are taking. From a federal perspective, one participant suggested that it might be useful for the new White House Office of Urban Affairs and the Office of Science and Technology Policy to jointly discuss how urban sustainability, however they collectively define it, could be made a priority, and then issue a directive to mission agencies to advance urban sustainability through the lens of their particular agencies. Finally, some participants noted that the research community knows how to do evaluations, and so it might be beneficial to direct future research funding into projects which help objectively evaluate progress towards urban sustainability.

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APPENDIXES

Appendix A

WORKSHOP AGENDA
Transitioning to Sustainability:
The Challenge of Developing Sustainable Urban Systems

The National Academies' Second Sustainability R&D Forum

September 23, 2009
The National Academy of Sciences, Lecture Room
2100 C St. NW, Washington, D.C.

OBJECTIVES

- Share information about ongoing activities and strategic planning efforts, with an eye towards strengthening cross-agency, cross-sectoral partnerships
- Explore how federal agency efforts can complement/leverage the efforts of other key stakeholders
- Identify critical research gaps and needed analytical tools

8:30 AM **Welcome and Goals of the Forum**
Tom Graedel, Clifton R. Musser Professor of Industrial Ecology, Yale University

8:50 AM **Keynote Address**
Xavier de Souza Briggs, Associate Director for General Government Programs, Office of Management and Budget

9:20 AM **Panel: Developing Livable Urban Areas**
Moderator: Ann Bartuska, Acting Under Secretary for Natural Resources and Environment, U.S. Department of Agriculture

This panel will consider the various dimensions of "livable" urban areas, and will comment on R&D that attempts to link public health, environmental management, and urban development goals

- Michael Freedberg, Director, Division of Housing Technology Research, Office of Policy Development and Research, U.S. Department of Housing and Urban Development
- Howie Frumkin, Director, National Center for Environmental Health, U.S. Centers for Disease Control
- Amy Glasmeier, Head of Department of Urban Studies and Planning, Massachusetts Institute of Technology
- Nancy Grimm, Co-Director, Central Arizona-Phoenix Long-Term Ecological Research Project

10:00 AM Audience Q&A

10:10 AM Break

10:30 AM **Panel: Resilience and Adaptation**
Moderator: Glen Daigger, Senior Vice President and Chief Technology Officer, CH2M Hill, Inc.

This panel will address the key environmental threats communities face and will discuss R&D on environmental impact reduction, resilient infrastructure, and adaptation measures

- Keelin Kuipers, Coastal Storms Program Manager, National Oceanic and Atmospheric Administration
- Walter Peacock, Professor and Director, Hazard Reduction and Recovery Center, Department of Landscape Architecture and Urban Planning, Texas A&M University
- Denice Wardrop, Assistant Director, Institutes of Energy and Environment, Penn State University
- William Werkheiser, Eastern Region Director, U.S. Geological Survey

11:10 AM Audience Q&A

11:20 AM **Panel: Models, Metrics, and Future Scenarios**
Moderator: Denise Stephenson Hawk, The Stephenson Group

This panel will focus on how urban change is modeled, how human and environmental outcomes can be measured, and what information is most useful (or needed) in assessing outcomes

- Jon Fink, Director, Global Institute for Sustainability, Arizona State University
- Thomas Parris, Vice President and Director of Sustainability Programs, ISCIENCES LLC
- Steward Pickett, Director, Baltimore Ecosystem Long-Term Ecological Research Program
- Dale Quattrochi, Senior Research Scientist, Earth Science Office, National Aeronautic and Space Administration
- Jennifer Wolch, Dean, College of Environmental Design, University of California, Berkeley

12:00 PM Audience Q&A

12:10 PM **Luncheon Keynote**
Adolfo Carrion, Director, White House Office of Urban Policy

1:00 PM **Panel: Moving Urban R&D into Practice**
Moderator: Jeremy Harris, former Mayor of Honolulu

This panel will present the end-users' perspective and will explore opportunities to both broaden the impact of place-based R&D and disseminate promising practices more efficiently

- □ James Davenport, Project Manager, National Association of Counties
- □ John Frece, Director, Office of Smart Growth, EPA
- □ Harriet Tregoning, Director, District of Columbia Office of Planning
- □ Dana Williams, Mayor, Park City, Utah

1:45 PM R&D Gaps and Opportunities (Small Group Discussions)

- □ **Tools and Knowledge Transfer**
- □ **Technology Development**
- □ **Research and Evaluation**

3:30 PM Break

4:00 PM Feedback from Group Rapporteurs

4:45 PM Closing Comments

5:00 PM CONCLUDE

Appendix B

REGISTERED PARTICIPANTS LIST

Transitioning to Sustainability: The Challenge of Developing Sustainable Urban Systems
The National Academies' Second Sustainability R&D Forum

The National Academy of Sciences
2100 C St. NW
Washington, D.C.
September 23, 2009

Danielle Arigoni
U.S. Environmental Protection Agency

Jill Auburn
U.S. Department of Agriculture

Larry Baker
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The World Bank

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National Association of Counties

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Olivia Ferriter
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Samuel Figuli
HydroGeoLogic, Inc

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Paul Sparks
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Planning Commission, Upper Dublin Township

Richard Wright
National Institute of Standards and Technology

Marcela Zeballos
Association of American Geographers

Appendix C

The Roundtable on Science and Technology for Sustainability was established by the National Academies in 2002 to provide a forum for sharing views, information, and analyses related to harnessing science and technology for sustainability. Members of the Roundtable include senior decision makers from government, industry, academia, and non-profit organizations who deal with issues of sustainable development, and who are in a position to mobilize new strategies for sustainability. Through its activities, the Roundtable identifies new ways in which science and technology can contribute to sustainability. The Roundtable does not make formal recommendations or produce official reports, but it is anticipated that all members will take good ideas back to their institutions to be acted upon.

The goal of the Roundtable is to mobilize, encourage, and use scientific knowledge and technology to help achieve sustainability goals and to support the implementation of sustainability practices. Three overarching principles are used to guide the Roundtable's work in support of this goal. First, the Roundtable focuses on strategic needs and opportunities for science and technology to contribute to the transition toward sustainability. Second, the Roundtable focuses on issues for which progress requires cooperation among multiple sectors, including academia, government (at all levels), business, nongovernmental organizations, and international institutions. Third, the Roundtable focuses on activities where scientific knowledge and technology can help to advance practices that contribute directly to sustainability goals, in addition to identifying priorities for research and development (R&D) inspired by sustainability challenges.

ROUNDTABLE ON SCIENCE AND TECHNOLOGY FOR SUSTAINABILITY[#]

Thomas Graedel (Co-Chair), Clifton R. Musser Professor of Industrial Ecology, Yale University
Emmy Simmons (Co-Chair), Former Assistant Administrator for Economic Growth, Agriculture, and Trade, USAID
Matt Arnold, Partner, PricewaterhouseCoopers
Ann M. Bartuska, Acting Deputy Under Secretary for Natural Resources and Environment, U.S. Department of Agriculture*
Arden Bement, Director, National Science Foundation*
Michael Bertolucci, President, Interface Research Corporation
Nancy Cantor, President and Chancellor, Syracuse University
John Carberry, Former Director of Environmental Technology, DuPont
Leslie Carothers, President, Environmental Law Institute
William Clark, Harvey Brooks Professor of International Science, Public Policy, and Human Development, Harvard University
Glen T. Daigger, Senior Vice President and Chief Technology Officer, CH2M HILL
Patricia Dehmer, Acting Director, Office of Science, U.S. Department of Energy*
Sam Dryden, Managing Director, Wolfensohn & Company
Nina Fedoroff, Science and Technology Advisor to the U.S. Secretary of State, U.S. State Department*

Marco Ferroni, Executive Director, Syngenta Foundation for Sustainable Agriculture
Mohamed H. A. Hassan, Executive Director, The Academy of Sciences for the Developing World (TWAS)
Neil C. Hawkins, Vice President of Sustainability, The Dow Chemical Company
Geoffrey Heal, Garrett Professor of Public Policy and Business Responsibility, Graduate School of Business, Columbia University
Catherine (Katie) Hunt, Corporate Sustainability Director, Rohm and Haas Company
Lek Kadeli, Acting Assistant Administrator, Office of Research and Development, US Environmental Protection Agency*
Jack Kaye, Associate Director, Research of the Earth Science Division, National Aeronautics and Space Administration*
Gerald Keusch, Assistant Provost of the Medical Campus and Associate Dean, School of Public Health, Boston University
Suzette Kimball, Acting Director, U.S. Geological Survey*
Kai Lee, Conservation & Science Program, Packard Foundation
Thomas E. Lovejoy, Biodiversity Chair, The H. John Heinz III Center for Science, Economics, and the Environment
Pamela Matson, Dean of the School of Earth Sciences and Goldman Professor of Environmental Studies, Department of Geological and Environmental Sciences, Stanford University
J. Todd Mitchell, Chairman, Board of Directors, Houston Advanced Research Center
M. Granger Morgan, Professor and Head, Department of Engineering and Public Policy, Carnegie Mellon University
Prabhu Pingali, Head, Agricultural Policy and Statistics, Agriculture Development Division, Bill and Melinda Gates Foundation
Per Pinstrup-Andersen, H.E. Babcock Professor of Food, Nutrition and Public Policy, Nutritional Sciences, Professor, Applied Economics and Management, Cornell University
Christopher Portier, Associate Director, National Institute for Environmental Health Sciences (NIEHS)
Harold Schmitz, Chief Science Officer, Mars Inc.
Robert Stephens, International Chair, Multi-State Working Group on Environmental Performance
Denise Stephenson Hawk, Chair, The Stephenson Group, LLC
Dennis Treacy, Vice President, Environmental and Corporate Affairs, Smithfield Foods
Vaughan Turekian, Chief International Officer, The American Association for the Advancement of Science*

STAFF

Marina Moses, Director, Science and Technology for Sustainability Program
Pat Koshel, Senior Program Officer
Derek Vollmer, Program Officer
Kathleen McAllister, Research Associate
Emi Kameyama, Senior Program Assistant

[#]*membership as of September 2009*
**denotes ex-officio member*

Appendix D

Notable Examples of Urban Sustainability R&D Programs

TITLE OF PROJECT OR PROGRAM: Smart Growth Program Research
(*http://www.epa.gov/dced/publications.htm#tools*)

AGENCY: US EPA

PROJECT/PROGRAM DESCRIPTION:
Ongoing research is being conducted to estimate and quantify the benefits of compact, mixed-use development for reducing VMT and associated environmental/climate impacts. A number of research projects are underway:

1. Location efficiency tool—This effort will create a location efficiency score at the census block group level that will reflect the location's density, walkability, distance to jobs and transit, as well as access to transportation alternatives. It will be produced in the form of a tool that communities can use to evaluate how a location performs relative to its region, state, or the nation, and to evaluate the impact of potential policy changes.
2. Mixed-use development evaluation method—This effort, developed in partnership with the Institute for Transportation Engineers, will lead to a spreadsheet tool that generates trip reduction estimates associated with a proposed project. Input factors include project characteristics (design, density, etc.,) as well as location (walkability, regional distance to job centers, etc.,). The results will likely be published in the ITE Trip Generation Handbook, enabling policy makers to more accurately reflect the trip generation reductions associated with mixed-use, compact developments.
3. Carbon assessment tool—This effort will support local governments to estimate the GHG reductions associated with proposed developments. The spreadsheet tool will consider emissions associated with construction, operations and maintenance, and transportation connections.
4. Evaluation of Infill Development as a Greenhouse Gas Reduction Strategy—This effort will use case studies to estimate the cost effectiveness of GHG-reduction strategies achievable through TOD and infill projects. It will consider the total public investment in a range of projects, calculate the anticipated (or realized) GHG reductions resulting, and illustrate a range of costs for each strategy, and which dimensions of particular strategies are most effective in dollars of net public expenditure per ton of emissions avoided .
5. Energy consumption white paper—This effort will quantify the energy consumption with residential buildings, considering both their construction (conventional or green certified, single-family or multi-family, attached or detached), as well as their location (low-density suburban locations or transit-rich urban locations).

A more recent, completed effort evaluated the residential construction trends in urban centers, noting that center cities were gaining share of total development activity faster than suburban areas, even despite the market slow-down ("Residential Construction Trends in America's Metropolitan Regions" was published in January 2009).

RESULTS, OUTCOMES OR IMPACTS TO DATE:
Effort #3 above is in beta testing; the others are still in development.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
Effort #2 above is an effort done in partnership with the Institute for Transportation Engineers; many of the others will likely involve local or regional government partners in their testing and roll-out (specific communities yet to be determined)

PROJECT PERIOD:
#1 – Phase 1 will be completed in December 2009
#2 – Will be completed by spring 2010
#3 – In beta testing now; will be completed by early 2010
#4 – Will be completed in early 2010
#5 – Will be completed by December 2009

FUNDING LEVELS (CURRENT OR PROPOSED):

#1 – Roughly $40,000
#2 – Roughly $100,000
#3 – Roughly $250,000 over two year period
#4 – Roughly $150,000
#5 – Roughly $15,000

TITLE OF PROJECT OR PROGRAM:
"Boston Metropolitan Area ULTRA: Exploring past, current and future socio-ecological dynamics in a founding city"
(*http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0948857*)

AGENCY/INSTITUTION: National Science Foundation with USDA Forest Service

PROJECT/PROGRAM DESCRIPTION: Over the next 50 years, U.S. cities will double in population and land area, creating a pressing need for science to inform sustainable growth. While considerable advances have been made in the ecological study of cities, many research challenges remain. A particular need is for greater understanding of the complex responses of ecological systems to changing human policies and activities and responses of humans to these changes. As one of the nation's mature founding cities, Boston has been evolving for almost 400 years, but the metropolitan region is projected to grow in population by 5.5 percent and lose 140,000 acres of open space to residential subdivisions by 2030. This two-year project launches an interdisciplinary long-term research program for the Boston Metropolitan Area (BMA ULTRA) that will provide a national model of sound science in service of the common ecological good of urban communities and their surrounding regions. Through an innovative partnership between the City of Boston, the non-profit Urban Ecology Institute, and 7 academic institutions, the research program will address three main areas: (a) the primary historical and social drivers of local and regional changes in land use; (b) the complex linkages between social conditions (e.g., wealth, social capital, land-use policies), biophysical processes (e.g., resources for animal populations, or hydrological flows), and social-and-ecological outcomes (e.g., people's attachment to place, or an area's biodiversity); and (c) future conditions for people and the environment in greater Boston under different scenarios. Land use changes of focus include urban greening at local scales and suburbanization and urban infill at broader scales. Urban greening, such as tree planting, community gardening, and riparian restoration, represents a significant, though understudied avenue for feedback between human actions, ecosystem changes, and new human energy in response. The project treats citizen-driven greening projects as opportunistic experiments, with testable predictions regarding consequences for people and the environment. From this perspective, urban greening can be placed in the context of broader scale processes, such as suburbanization and urban infill. Partnership with two extensive non-profit networks will facilitate active involvement of citizens and decision makers in field studies as well as synthesis of data from ongoing research. Their involvement in turn facilitates study of feedbacks from information to knowledge to action and ecosystem response. A series of scenario building workshops will examine alternative spatial patterns for locating development, forest cover and plantings under the Mayor's 100,000 trees initiative. Scenarios will also address the potential impacts of climate change. Stakeholders and scientists will collaborate on defining the goals, policies and assumptions for the scenarios. Maps and images of scenarios will be used in transmitting and translating project findings. In addition to directly supporting undergraduate, graduate and postgraduate education, BMA ULTRA leverages programs serving over 2000 middle and high school students annually, approximately 90 percent from underserved communities.

A central recent advance in urban ecology has been the recognition that human actions strongly influence ecological patterns and that these human actions are themselves conditioned by values, lifestyle, experiences, social group, and institutional forces. Research supported by BMA ULTRA will deepen and extend these theoretical insights by focusing explicitly on a diverse set of socioeconomic drivers that are changing the forest cover and composition of the Boston Metropolitan Area. The program's focus on urban greening as a form of urban land use-land cover change creates opportunities for new insight into feedback loops between humans and the environment. Hitherto, greening has been viewed as a set of practices rather than as an integral component of an urban system. Through the use of scenarios, the program begins to make a more thorough integration of urban ecological theory and the science of climate change. Strong academic-civic partnerships together with the diverse composition of the metropolitan area, its historic nature, and the progressive state of regional development make greater Boston an ideal setting for testing urban ecological theories and developing new insights for application nationwide.

RESULTS, OUTCOMES OR IMPACTS TO DATE: No results yet; funding begins January 2010

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): Partners include the non-profit Urban Ecology Institute based in Boston, MA as well as the City of Boston, Massachusetts Dept of Conservation and Recreation, and the USDA Forest Service.

PROJECT PERIOD: January 2010-July 2012

FUNDING LEVELS (CURRENT OR PROPOSED): Current NSF funding = $300,000; current UMass additional funds = $141,848

TITLE OF PROJECT OR PROGRAM: Central Arizona Phoenix Long Term Ecological Research Program (CAP LTER—*http://caplter.asu.edu*)

AGENCY: NSF

PROJECT/PROGRAM DESCRIPTION: Multi-decadal, multidisciplinary investigation of the impact of Metro Phoenix on the underlying desert ecosystem and the constraints provided by that ecosystem on the growth and development of the city.

RESULTS, OUTCOMES OR IMPACTS TO DATE: Part of the significance of CAP LTER (and its sister program, the Baltimore Ecosystem Study) to the NRC workshop is that it provides a focal point for an expanding and expansive view of how urban systems work. At ASU, CAP LTER became the basis for a broad research and teaching agenda related to cities, which in turn led to the creation of our Global Institute of Sustainability and degree-granting School of Sustainability. It spawned two $3M IGERT (Integrated Graduate Education and Research Traineeship) grants from NSF to develop graduate training programs in urban ecology. It also became the foundation for us to partner with a number of federal and state agencies, including NASA ("100 Cities" remote sensing program), EPA ("National Center of Excellence" dealing with the urban heat island), CDC (funding to examine the health effects of urban heat), and others. The heat island work also received financial support from more than a dozen companies involved with urban systems, like cement manufacturer CEMEX, and remote sensing tool manufacturer Raytheon.

One recommendation is that NSF's LTER program (which also funds 26 non-urban centers) be expanded to include more cities. One way to do that is by supporting additional urban LTERs. A faster and cheaper way would be to provide supplemental funding to existing non-urban LTERs (most of which are run by universities located in major cities like Minneapolis, Boston, and Albuquerque) so they could add staff (perhaps one per LTER site) to coordinate interdisciplinary studies of the urban systems where the universities are located. These could then be networked together to form a national network of urban environmental research programs.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): Current and past: NASA, EPA, Center for Disease Control, Arizona Department of Environmental Quality, Arizona Department of Water Resources, Maricopa Association of Governments, Maricopa County Department of Public Health.

Proposed: USDA through ULTRA; Department of Justice to look at urban crime data; NASA proposal on aircraft-based urban remote sensing currently being prepared by Ames Research Center, Goddard Space Flight Center and ASU (with other partners) at $10M/year for 3 years.

PROJECT PERIOD: 1997-indefinite future (CAP LTER)

FUNDING LEVELS (CURRENT OR PROPOSED): NSF: approximately $1M/year, indefinitely for CAP LTER. NASA 100 Cities (now completed) received $350K; EPA National Center of Excellence ($100K); consortium of corporations supporting National Center of Excellence ($400K). State agencies (approximately $50-150K for each, total around $250K).

TITLE OF PROJECT OR PROGRAM: Weatherization Assistance Program (*http://www1.eere.energy.gov/wip/wap.html*)

AGENCY: Department of Energy, Office of Energy Efficiency and Renewable Energy

PROJECT/PROGRAM DESCRIPTION: The overall goal of the Weatherization Assistance Program is to reduce the burden of energy prices on the disadvantaged. The Weatherization Assistance Program's weatherization services are cost-effective energy efficiency measures for existing residential and multifamily housing with low-income residents. Under this definition, it includes a wide variety of energy efficiency measures that encompass the building envelope, its heating and cooling systems, its electrical system, and electricity consuming appliances. In other words, the full range of energy efficiency measures in buildings that apply to all homes and apartment buildings is included in weatherization technologies.

RESULTS, OUTCOMES OR IMPACTS TO DATE: During the past 32 years, the U.S. Department of Energy's (DOE) Weatherization Assistance Program has provided weatherization services to more than 6.2 million low-income families. For every $1 invested, weatherization returns $2.73 in benefits. These include $1.65 in energy-related benefits and $1.07 in other benefits such as reducing pollution, unemployment, and adverse health concerns.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): DOE provides funding and technical guidance to the states, but the states run their own programs and set rules for issues such as eligibility. They also select service providers, which are usually nonprofit agencies that serve families in their communities, and review their performance for quality. Together, this group of more than 900 agencies makes up a nationwide weatherization network.

PROJECT PERIOD: This is an ongoing program since 1976.

FUNDING LEVELS (CURRENT OR PROPOSED): In Fiscal Year 2009, $250 million dollars were appropriated by Congress, which was in addition to Recovery Act funding of $5 billion. The average expenditure limit is $6,500 per home.

TITLE OF PROJECT OR PROGRAM: Building Technologies Program (*http://www1.eere.energy.gov/buildings/*)

AGENCY: Department of Energy, Office of Energy Efficiency and Renewable Energy

PROJECT/PROGRAM DESCRIPTION: Building Technologies Program

The Building Technologies Program (BTP) funds research and technology development to reduce commercial and residential building energy use. The program is working to achieve the goal of net-zero energy buildings, which produce as much energy as they consume.

To achieve the goal of net-zero energy buildings, the Building Technologies Program supports research and development of innovative new technologies and better building practices. The program is divided into three interrelated strategic areas designed to overcome technical and market barriers: Research and Development, Equipment Standards and Analysis, and Technology Validation and Market Introduction.

The BTP's funding is organized in five key program areas. Each of these areas contains projects and programs addressing one or more of the strategic elements:

Research and Development

- Residential Integration—reduce energy loads by 70-80 percent and integrate renewable technologies in new construction to create marketable net-zero energy homes in the five major U.S. climate zones at net-zero financed cost to home buyers; to increase homeowner energy savings by supporting energy efficient retrofits and new homes while raising consumer awareness of the benefits of increased health, safety, and durability of energy efficiency.
- Commercial Integration— to partner with major companies that design, build or operate large fleets of buildings and that commit to exemplary energy performance in selected new and existing commercial buildings; invest in commercial building technology solutions, design approaches and tools to enable net-zero energy performance.
- Emerging Technologies —to accelerate building technology RD&D through R&D projects to advance lighting, HVAC, water heating, solar heating and cooling, thermal envelope, and window technologies, via national laboratory as well as with the private sector to develop more efficient technologies contributing to 70 percent energy savings in new construction and deep retrofit in existing homes and commercial buildings.

Technology Validation and Market Introduction

- DOE-EPA Energy Star - a joint undertaking with DOE, EPA, and the private sector to promote energy efficient products designated by the Energy Star label, used to alert the consumer to the energy savings offered by such products.

- Building Codes—working with other government agencies, state and local jurisdictions, national code organizations, and industry to promote stronger building energy codes and help states adopt, implement, and enforce those codes.

Equipment Standards and Analysis

- Residential Appliances —develops test procedures and sets efficiency standards for residential lighting, equipment and appliances.
- Commercial Equipment Standards —develops test procedures and sets efficiency standards for commercial lighting and equipment.

RESULTS, OUTCOMES OR IMPACTS TO DATE:

BTP's Recent Accomplishments:

- Residential:
  - Completed research and best practices for 30 percent energy savings in all climates, and 40 percent savings in Marine and Hot/Mixed-Dry, research ongoing.
  - In response to the DOE Builders Challenge 345 builder partners have labeled more than 1000 homes with 30 percent greater energy performance while meeting stringent quality criteria
- Commercial:
  - Launched the Net-Zero Energy Commercial Building Initiative
  - Launched Retailer Energy Alliance, Commercial Real Estate Energy Alliance, and Hospital Energy Alliance
- Emerging Technologies:
  - SSL prototype cool white LED that delivers world record 107 lm/W.
  - Commercialization of dynamic insulation, cellulose with doped phase change material
  - General Electric Hybrid Water Heater announced that will meet new Energy Star Advanced Water Heater Specification; development assisted under a Cooperative Research and Development Agreement with DOE's Oak Ridge National Laboratory.
- Building Codes:
  - 2009 International Energy Conservation Code will improve new home energy efficiency by 15 percent over 2006 edition.
- ENERGY STAR:
  - Market penetration for the main DOE products-windows, refrigerators, dishwashers, and CFLs. CFLs market profile shows that there are 4.3 Billion residential sockets, of which 0.5 Billion are filled with CFLs.

PERFORMERS/OTHER PARTNERS: Working with other federal and state agencies, and industry representatives from a variety of business sectors to achieve the goal of marketable net-zero energy buildings.

PROJECT PERIOD: The strategic goal is to create technologies and design approaches that lead to marketable zero energy homes by 2020 and zero energy commercial

buildings by 2025. Goals for retrofit of existing homes and commercial buildings are being formulated.

FUNDING LEVELS (CURRENT OR PROPOSED): Fiscal Year (FY) 2009- $140 million + $346 million of Recovery Act Funds. FY2010- Proposed $237 million. The chart below shows the break-out of funds for the five key programs.

TITLE OF PROJECT OR PROGRAM: CDC's Climate Change and Health Program (http://www.cdc.gov/climatechange/)

AGENCY: Centers for Disease Control and Prevention

PROJECT/PROGRAM DESCRIPTION: As the nation's public health agency, CDC is uniquely poised to lead efforts to anticipate, prevent and respond to the broad range of effects on the health of Americans and the nation's public health infrastructure. CDC's expertise and programs in environmental health, infectious disease, and other fields form the foundation of public health efforts in preparedness for climate change. In FY2009, Congress appropriated $7.5 million for CDC to formally establish its Climate Change and Health Program. The Program is addressing five broad areas:

1. Expanding the climate change research foundation: Seventeen intramural research awards have been awarded competitively, amounting to nearly $3 million. Additionally, approximately seven extramural research grants will be awarded.

2. Developing partnerships: The focus is to develop innovative partnerships to better understand predicted health outcomes and to ensure cooperation between diverse stakeholders.

3. Enhancing climate change capacity at state and local health departments: CDC is supporting state and local health departments through pilot programs run by ASTHO and NACCHO. Five states have received $90,000 each, and six local jurisdictions will receive $50,000 each to conduct needs assessments and develop strategic plans to address weaknesses and bolster climate change capacity.

4. Promoting workforce development: Projects include funding post doctoral work and dissertation awards in climate change and health, developing web-based training, and a global workshop on climate change.

5. Communicating health-related aspects of climate change: This aspect supports evidence-based communication strategies.

RESULTS, OUTCOMES OR IMPACTS TO DATE:

1. Expanding the climate change research foundation: When funding intramural research projects, CDC implemented a two-pronged approach by supplementing existing projects and funding new projects.

- The Climate Change Program provided resources to add a climate change component to existing CDC projects. This approach builds climate change capacity by leveraging infrastructure established at CDC and improving sustainability of projects.
- New projects were conceptualized as multi-year projects. Initially funding one-year of the project allows CDC to evaluate the projects for long-term feasibility, sustainability, cost effectiveness, and broader application at the conclusion of the first year. This evaluation will inform decisions regarding funding for years two and three of each projects.

2. Developing partnerships: Conducted a series of six workshops with diverse stakeholders to clarify the public health priorities, impact, and future research needs for the public health response to the effects of climate change.

3. Enhancing climate change capacity at state and local health departments: At the conclusion of the currently funded one-year pilot projects, CDC, ASTHO, and NACCHO will evaluate these projects to inform future development of climate change programs in state, territorial, city, and county health departments.

4. Promoting workforce development: Developed web-based training for coaches and secondary school educators to identify and prevent heat-related illness in student athletes.

5. Communicating health-related aspects of climate change: Developed a comprehensive communications campaigns for coordinated public health response to extreme heat events.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):

Government

- U.S. Global Change Research Program
- U.S. Environmental Protection Agency
- U.S. Geological Survey
- U.S. NASA
- U.S. NOAA's National Weather Service; National Climatic Data Center
- 5 state health departments (MN, CA, FL, NH, MA)
- 3 cities (Baltimore, Detroit, Austin)
- 6 county health departments (Travis Co, TX; Mercer Co, IL; Orange Co, FL; Thurston Co, WA; Hennepin Co, MN; Imperial Co, CA)

Nongovernmental

- National Association of County and City Health Officials
- Alaska Native Tribal Health Consortium
- American Meteorological Society
- American Public Health Association
- American Water Works Association
- Associations of Schools of Public Health
- Association of State and Territorial Health Officials
- International Society for Disease Surveillance
- National Hispanic Environmental Council
- AARP
- National Network of Public Health Institutes
- Physicians for Social Responsibility
- West Harlem Environmental Action, Inc
- Council of State and Territorial Epidemiologists

International Indian Council of Medical Research
- European Centre for Disease Prevention and Control
- Health Canada
- Public Health Agency of Canada
- Intergovernmental Panel on Climate Change
- World Bank
- Pan American Health Organization
- World Health Organization

Academic
- Arizona State University
- Emory University School of Public Health
- Colombia University
- University of Michigan School of Public Health
- Center of Excellence in Climate Change Communication Research, George Mason University

PROJECT PERIOD: Ongoing

FUNDING LEVELS (CURRENT OR PROPOSED): FY2009 $7.5 million

TITLE OF PROJECT OR PROGRAM:
Healthy Community Design Initiative, National Center for Environmental Health (*http://www.cdc.gov/healthyplaces/*)

AGENCY:
Centers for Disease Control and Prevention, Atlanta

PROJECT/PROGRAM DESCRIPTION:
The Healthy Community Design Initiative establishes an evidence base that describes the relationship between health and the design of the built environment, directs a program that builds capacity and facilitates efforts to achieve outcomes in the built environment that improve public health, and works to instill a practice of decision-making among leaders and other stakeholders that ensures that health impact is considered in all projects and policies that affect the built environment. Key activities include developing and promoting the use of health impact assessment by decision makers; strengthening partnerships with organizations within and outside of the health sector that work with transportation, land-use planning, and other areas that impact health; developing surveillance systems that track built environment-related indicators and health impacts; conducting research and evaluation to define the health outcomes and populations affected by transportation systems, land-use, and greenspace; and developing communications strategies to raise awareness of healthy community design issues.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
HCDI has written or supported numerous publications on topics such as documenting the amount of walking associated with use of public transit, creating a model curriculum for a course on health and built environment, inventorying health impact assessments completed in the United States, and developing a workplace walkability audit tool. HCDI staff have given dozens of presentations to international, national, state, and local audiences that have raised awareness of the links between health and the built environment. Anecdotal evidence suggests that decision makers have been influenced by HCDI's projects, publications and presentations to consider health in their decisions.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
HCDI partners include the US Environmental Protection Agency, US Department of Transportation, American Planning Association, Association of State and Territorial Health Officials, National Association of County and City Health Officials, Association of Schools of Public Health, National Environmental Health Association, Institute of Medicine, Safe Routes to School National Partnership, Trust for Public Land, Robert Wood Johnson Foundation, The Prevention Institute, Local Government Commission, Congress for New Urbanism, the US Green Building Council, and schools of planning and of public health at various universities.

PROJECT PERIOD: Ongoing

FUNDING LEVELS (CURRENT OR PROPOSED):
Approximately $1,500,000 per year

TITLE OF PROJECT OR PROGRAM:
Healthy Communities Program, National Center for Chronic Disease Prevention and Health Promotion (*http://198.246.98.21/healthycommunitiesprogram/index.htm*)

AGENCY:
Centers for Disease Control and Prevention, Atlanta

PROJECT/PROGRAM DESCRIPTION:
CDC's Healthy Communities Program supports local communities in implementing evidence-based interventions and policy, systems, and environmental changes to achieve the critical local changes necessary to prevent chronic diseases and their risk factors. The program mobilizes community leadership and resources to bring change to the places and organizations that touch people's lives every day—at work sites, schools, community centers, and health care settings—to stem the growth of chronic disease.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
Local communities funded through the Healthy Communities Program have produced positive results, including reducing obesity through community-based interventions, reducing chronic disease risk factors and health care costs; creating healthier school environments; implementing clean indoor air ordinances; and reducing blood sugar levels among diabetes patients. Specific positive results for the program include the following:

- The percentage of adult smokers who were advised to quit by a health care provider increased from 63 percent to 71 percent during 2004-2006
- The percentage of adults with diabetes who reported having a foot exam in the past year increased from 71 percent to 77 percent during 2004-2006.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
CDC funds 14 communities (via 5-year cooperative agreements) through the ***Strategic Alliance for Health*** (SAH) program. SAH communities represent a mix of urban, rural, and tribal communities funded through state and local health departments and tribes. CDC also funds ***ACHIEVE*** communities (Action Communities for Health, Innovation, and EnVironmental changE). CDC provides funds to selected national organizations, which provide technical support and funds to selected communities (approximately 40 new communities per year). CDC collaborates with five national partner organizations to extend the reach and impact of the program: National Association of County and City Health Officials, the National Association of Chronic Disease Directors, the National Recreation and Park Association, and the YMCA of the USA

PROJECT PERIOD:
Ongoing

FUNDING LEVELS (Average awards per year):

SAH communities—State coordinated small cities and rural areas - $900,000; Large cities/urban communities - $600,000; Tribes —$400,000. National Organizations under ACHIEVE: $875,000.

TITLE OF PROJECT OR PROGRAM: Decision Center for a Desert City (DCDC) (*http://dcdc.asu.edu*).

AGENCY: NSF

PROJECT/PROGRAM DESCRIPTION: As the largest of five academic projects funded by NSF's Decision Making Under Uncertainty program, DCDC charged ASU to work with private and public water providers, local utilities, and state and federal agencies to develop tools to help water managers evaluate future water needs in the face of uncertainty due to population growth, drought, climate change, land-use change, and the urban heat island effect.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
DCDC builds tools, mostly implemented in ASU's Decision Theater (*http://dt.asu.edu*), to help decision makers and the public understand the implications of specific policy choices related to water use. The tools are designed to help non-experts and experts better understand in a very interactive way the future implications of current policy choices. Widely used models like MODFLOW and PowerSim form the basis for the visualization tools, like WaterSim (*http://watersim.asu.edu*).

The relevance of DCDC to the NRC workshop is that computer-based models alone are insufficient to affect policy. Public officials needs convenient ways to see alternative futures. They also need to have input into research agendas carried out by universities. The original DCDC research proposal to NSF was developed with considerable input from local, regional and state stakeholders.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
Arizona Department of Water Resources, Bureau of Reclamation, Salt River Project, over a dozen other private and public water providers.

PROJECT PERIOD: 2005-2010 (renewal proposal submitted for another five years).

FUNDING LEVELS (CURRENT OR PROPOSED): $7.5M to date from NSF

TITLE OF PROJECT OR PROGRAM: Workshop on Southeast Regional Planning & Sustainability (SERPS)
(*http://www.serdp-estcp.org/workshops/serps/*)

AGENCY: DoD - Office of the Secretary – the Sustainable Ranges Initiative (SRI), the Strategic Environmental Research and Development Program (SERDP), and the Environmental Technology Security Technology Certification Program (ESTCP).

PROJECT/PROGRAM DESCRIPTION: Given the tremendous economic and population growth taking place in the Southeast U.S.—along with the fact that many DoD bases are located in this region – the Southeast represents a major challenge and opportunity for sustainability planning. At the same time many academics and other stakeholders in the Southeast and around the country are undertaking—or could potentially undertake—various types of analysis and research (science, policy, and community-based) that could benefit DoD's broader sustainability efforts and be directly applied to current regional initiatives. The Sustainable Ranges Initiative (SRI) recently completed a project, funded by the DoD Legacy Program, to begin better engagement with the academic community on sustainable planning issues. This included the SRI hosting a day-long brainstorming session with a small group of academics in Atlanta in April, 2006.

As a key pilot effort of the SRI, DoD has joined with other Federal agencies and state governments of five Southeast coastal states (North Carolina, South Carolina, Florida, Georgia, and Alabama) to form the Southeast Regional Partnership for Planning and Sustainability (SERPPAS). SERPPAS is working to promote improved regional, state and local coordination and to better manage, sustain and enhance natural, economic and human resources as well as national defense. In particular, SERPPAS is identifying shared issues to be addressed in the region and is developing several focused collaborative projects.

Given the growing significance of the SRI overall and its interest in the Southeast in particular – and the value that can be added by enhanced research and further linkages with the academic community and others—the SRI and SERDP/ESTCP jointly sponsored a multi-day workshop to take place April 25-27, 2007. The workshop, held in Atlanta, provided a forum of about 75 participants, including not only DoD representatives and academics but also outside stakeholders representing a cross-section of groups and interests. The goals of the workshop were to:

- To identify the high-priority issues of shared concern between the military, academia, and other key stakeholders related to sustaining military training land, regional planning, and compatible land use in the Southeast.

- To explore collaborative approaches— particularly ones that engage the academic and research community —that can build on existing efforts and help address these high-priority issues.

RESULTS, OUTCOMES OR IMPACTS TO DATE: To identify shared issues of concern among the military and stakeholders as well as potential collaborative approaches to meet those concerns, the workshop was divided into five Breakout Groups — Military, Forests, Agriculture, Land Corridors, and Built Environment. A Final Report integrates the main recommendations from these Breakout Groups, and divides those recommendations into areas of policy, research, and outreach. It calls for increased DoD collaborative efforts with researchers and other stakeholders to meet the sustainability challenges of the Southeast, and identifies a number of promising areas offering opportunity for future progress. The report also includes the Breakout Reports from each of the five Breakout Groups.

The Final Report provides a suggested roadmap as the military further pursues changes in sustainability policy, research, and outreach. From fostering a new generation of military sustainability professionals to creating living laboratories for universities to engage in cutting-edge conservation research, the proposed solutions offer myriad opportunities for shifting the current thought and behavior patterns of business as usual to more sustainable approaches.

For more information about the workshop and Final Report, see *http://www.serdp-estcp.org/workshops/serps/*

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): DoD —SRI, SERDP/ESTCP, US Army Southern Regional Environmental Coordinator, US Army IMCOM Southeast, US Marine Corps, Installations East, American Farmland Trust , USDA Forest Service, University of Virginia, University of North Carolina at Chapel Hill, University of Maryland, Clemson University, North Carolina State University, Georgia Institute of Technology, Texas A&M University

PROJECT PERIOD: June 2006 – December 2007

FUNDING LEVELS (CURRENT OR PROPOSED): $200,000

TITLE OF PROJECT OR PROGRAM: Sustainability Assessment of a Military Installation: A Template for Developing a Mission Sustainability Framework, Goals, Metrics and Reporting System
(*http://www.serdp.org/Research/upload/SustainAssessMili.pdf*)

AGENCY: Department of Defense - Strategic Environmental Research and Development Program (SERDP)

PROJECT/PROGRAM DESCRIPTION: The sustainable management of U.S. military bases is a matter of increasing priority. Effective management of all the relevant aspects of long-term stability, reliability, and resilience of operations requires a comprehensive framework as well as appropriate management metrics and reporting systems to highlight emerging issues and systemic problems. The primacy of the mission to the U.S. military, together with the complexity of base operations and their relationships with the surrounding environment and community, means that simple adaptation of existing sustainability metrics and management frameworks would not produce an adequate set of tools. A tailored approach is required. To fill this gap, the Strategic Environmental Research and Development Program (SERDP) worked in collaboration with sustainability experts and military personnel, to develop a suitable Mission Sustainability Framework (MSF) and set of sustainability metrics that could be adapted to virtually any military installation across the United States.

Naval Base Ventura County (NBVC) in southern California was selected as the prototype and reference location for the research and development (R&D) process. Highly representative of U.S. military bases in general, NBVC consists of 73 commands, in two separate locations (Pt. Mugu and Port Hueneme) housed in 1,500 buildings. NBVC exists to fulfill three main functions: training, mobilization, and testing. NBVC operates an airfield as well as a seaport. It has base housing and deploying units. It also serves many commands not directly associated with these three functions. This diversity of functions ensured that the MSF and metrics would be robust across different types of military bases.

RESULTS, OUTCOMES OR IMPACTS TO DATE: The key results of this project include the development of: (1) is a framework on which to build a comprehensive sustainability metrics system for U.S. military installations, (2) the Issues and Elements of management and measurement interest, (3) Conceptual Examples of sustainability metrics in each MSF category, and (4) a Conceptual Design Sketch for a sustainability reporting system, which can be further developed to work in harmony with other metric reporting systems now in use or development.

Next steps in that process should include: (1) moving beyond the Conceptual Metrics to define specific sustainability metrics for each of the Issues and Elements based on available data for an installation; (2) validating and adjusting those metrics through a data assessment process and in dialogue with expected end-users; and (3) constructing an actual sustainability reporting system (document and digital versions), using all available and relevant data, for trial use in real-time base sustainability management.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):

SERDP, NBVC, AtKisson Associates, and HydroGeoLogic, Inc.

PROJECT PERIOD: January 2006 – September 2009

FUNDING LEVELS (CURRENT OR PROPOSED): $300,000

TITLE OF PROGRAM: Urban Forestry Research and Development (*http://www.fs.fed.us/research/*)

AGENCY: U.S. Forest Service

PROJECT/PROGRAM DESCRIPTION:

Forest Service R&D supports several centers for urban forestry research. These include centers in Chicago, IL (social sciences); Davis and Riverside, CA (urban forestry, social science, and recreation); Gainesville, FL and Athens, GA (urban-wildland interface, recreation); Baltimore, MD (urban ecosystems), and New York City and Syracuse, NY (urban forest function and restoration). The Syracuse and Chicago centers have been conducting urban forestry research since the mid-1970s. Comprehensive research projects have taken place in Dayton, OH, Oakland, CA, Chicago, IL, New York, NY, Sacramento, CA, Baltimore, MD, Atlanta, GA, and several other cities. In addition to the urban focused research centers, the Northern Research Station initiated the Urban Natural Resources Institute (UNRI), which conducts research training workshops and informational web-casts.

Projects include research for the development of urban forestry management and planning tools such as iTree, long-term ecological research of urban ecosystems (Baltimore Ecosystem Study, ULTRAex grants), interdisciplinary studies (e.g., Watershed 263 in Baltimore, Calumet Initiative in Chicago), urban greening and woodland restoration (New York City PlaNYC), wildfire in the urban-wildland interface (Florida), and benefits and costs of urban forests.

Much of the Forest Service Urban R&D is applied by the State and Private Forestry (S&PF) Urban and Community Forestry field staff. In addition, we receive advice on research and technology transfer from the National Urban and Community Forestry Advisory Council (NUCFAC), a 15 member board appointed by the Secretary of Agriculture.

RESULTS, OUTCOMES OR IMPACTS TO DATE:

i-Tree Suite of Management Tools and Web Interface that features the Urban Forest Effect Model (UFORE) and Street Tree Resource Tool for Urban Forest Managers (STRATUM). Forest Service R&D and S&PF Urban and Community Staffs have worked with private sector partners to implement i-Tree decision computer programs in hundreds of cities nation-wide. For example, Mayor Bloomberg, New York City, recently expanded the city forestry budget to increase tree cover in an effort to improve air quality, storm water runoff and other benefits.

Baltimore Ecosystem Study Long Term Ecological Research (LTER) Site

- Urban watershed studies (salinity of surface waters, post-drought response of urbanized watersheds, and elevated surface water temperature)

- Urban stream ecology (the "hydrologic drought" syndrome and "curb subsidy" of organic matter and contaminants)
- A spatial predictive model of heavy metal contamination of soils
- Carbon sequestration in urban ecosystems (mechanistic models to estimate above and belowground carbon sequestration)
- First permanent eddy covariance flux tower located in an urban landscape
- Urban Tree Canopy assessment and tree planting goals
- Community revitalization through watershed restoration

Chicago

- Climate Project (development of UFORE model, cost-benefit analyses, urban heat island)
- Aesthetic quality and public acceptance of land management
- Urban natural resource stewardship
- Wildland-Urban Interface (WUI, first status report of urban-wildland interface in the USA)

New York City

- Urban-Rural Gradient Ecology (URGE) project (pioneered use of urbanization gradients to study urban environmental effects on forests)
- Ecological reforestation of vacant urban land
- Living Memorial Project (Memorial to victims of September 11 terrorist attack)
- Urban Forestry Field Station (a collaborative with Department of Parks and Recreation to establish facility for urban ecological restoration research and management)

California

- Urban atmospheric pollution and effects on adjacent forested ecosystems
- Development of passive air monitoring systems
- Cost-benefit analysis of green infrastructure
- Tree benefits (carbon calculator, stormwater runoff, energy conservation)

Florida

- Developed a dichotomous key for resource managers and homeowners to categorize ornamental shrubs by flammability characteristics
- Urban growth effects on coastal plain ecosystems
- Establishment and implementation of an urban forest strike team to assist local governments with damages to the urban forest by catastrophic storms

Resources Planning Act Assessment 2000 (First national assessment of urban forest ecosystems)

PERFORMERS/OTHER PARTNERS (FEDERAL, STATE, & LOCAL):

The urban forestry research program has too many partners to list. Some critical partnerships include, National Science Foundation (LTER, ULTRAex), other federal agencies (USGS and NRCS), academic institutions (SUNY-CESF, UC Los Angeles, UC-Davis, UM Baltimore County, U Illinois, U Vermont, Columbia U, U Florida, to name a few), non-profits (American Forests, Cary Institute of Ecosystem Studies, and others), and the private sector (Davey Tree).

PROGRAM PERIOD: 1975 to present

FUNDING LEVELS (CURRENT OR PROPOSED): $5.45 million fiscal 2009

TITLE OF PROJECT OR PROGRAM: Global City Indicators Program (http://www.cityindicators.org/)

AGENCY: Global City Indicators Facility, University of Toronto, Canada

PROJECT/PROGRAM DESCRIPTION: The Global City Indicators Program was established by the World Bank and is designed to help cities monitor performance and quality of life by providing a framework to facilitate consistent and comparative collection of city indicators. The Program includes a set of indicators that are standardized, consistent, and comparable over time and across cities. This standardization enhances the ability of cities to observe trends and to facilitate comparisons with other cities. The Program recognizes the urgent need for a single comprehensive system for measuring and monitoring city performance and urban quality of life that would:

- Enable elected officials, city managers, and the public to monitor the performance of cities over time;
- Facilitate comparisons across cities and over time; and
- Provide enhanced government accountability demanded by policy makers and the public.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
The Program was piloted with nine cities and membership is growing with over 50 cities since recent launch; creation and development of GCIF website; hosting international workshop on Metropolitan Governance; review and Technical Workshop for analysis of first round pilot city indicators; preparation of reports and publications; establishment of offices at the GCIF headquarters based at the University of Toronto; creation of advisory council and governing board.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):

Institutional partners: World Bank, UN-HABITAT, Center for Research and Urban Innovation (Dubai), CAI-Asia, ICLEI, ICMA, Metropolis, League of Cities of the Philippines, Cities Alliance; Federation of Canadian Municipalities

Private Partners: IBM, IBI Group, Zerofootprint, Design & Development International

PROJECT PERIOD: 2008-2012

FUNDING LEVELS (CURRENT OR PROPOSED):
Current funding: World Bank $1.2 million
Proposed funding: Ministry of Research and Innovation, Ontario Government $4 million

TITLE OF PROJECT OR PROGRAM: FEMA RVII: LONG-TERM COMMUNITY RECOVERY,
OVERVIEW OF SUPPORT OF SUSTAINABLE (GREEN) ACTIVITIES IN GREENSBURG, KS AND IOWA
(*http://www.fema.gov/media/2008/greensburg_1yr/index.shtm*)

FEMA's ESF#14 Long-Term Community Recovery (LTCR) team helped support sustainable (green) initiatives for the Greensburg, KS tornado (DR-1699-KS) and Iowa flooding (DR-1763-IA).

Greensburg

- Discussions involving sustainable (green) rebuilding began the night after the tornado when the Mayor and the Regional Administrator discussed the concept while sheltering in the courthouse basement during a second round of severe storms in the community.
- The ESF#14 LTCR program provided a framework for the community to explore the elements and nuances of sustainable (green) rebuilding.
    - Organized community meeting for citizens to discuss issues, needs, and a post-disaster vision. These discussions would pave the way path for sustainability as a integral part of Greensburg's future.
    - Organized a "Community Conversation" where 20 facilitated groups of citizens simultaneously discussed issues related to Greensburg's future. Green rebuilding was a prominent theme throughout the conversations.
    - Hosted and coordinated community rebuilding fair. Architects and resources specific to green rebuilding were among the educational opportunities at this fair.
    - Hosted a two-day Design Workshop to review ideas and develop design concepts. Architects, planners and other technical specialists participated side by side with residents to design and plan the community. Sustainable design was a prominent theme during the workshop.
    - Co-Hosted a second rebuilding fair with USDA that also provided resources for citizens and governmental leadership to explore sustainable (green) rebuilding.
    - Convened the Public Square where citizens could organize discussions, explore issues and develop community leadership.
    - Mission Assignments to DOE and EPA to provide subject matter expertise to support sustainable (green) rebuilding.
    - Provided office space to Integrated Building and Construction Solutions where classes and one-on-one green rebuilding strategies were available. Provided venue for demonstration display of rebuilding best practices.
    - Develop a ***Long-Term Community Recovery Plan*** that provides the framework for project implementation.

- An entire section dedicated to exploring specific green rebuilding strategies
- Explored green opportunities in nearly every project and program in the plan.

Inventory of Greensburg Green Rebuilding Projects

Long-Term Community Recovery Plan	**Provided the framework for additional planning (such as the Sustainable Comprehensive Plan) as well as provided guidance for residential and infrastructure projects and programs to use sustainable development to redefine the community**
Sustainable Comprehensive Plan	Explored green strategies for the entire community
Downtown Master Plan	Explored green strategies for downtown design and development
Kiowa County Courthouse Renovation	Designed and certified as LEED Gold
Sun Chips Business Incubator	Designed and certified as LEED Platinum
Community Arts Center	Designed and Certified LEED Platinum
BTI John Deere Dealership	1st LEED Platinum JD Dealership
Shank Motors	1st Green GM Dealership
Residential	Wide variety of projects exploring different strategies for rebuilding
Wind Farm	
Greensburg City Hall	Designed as LEED Platinum
Kiowa County Memorial Hospital	Designed as LEED Platinum
Greensburg Schools	Designed as LEED Platinum

Iowa Flooding
Intro
Each plan explored strategies for green rebuilding based on the level that the community was interested in going green. Below is an inventory of project and programs that explored green rebuilding in each community plan or report.

- Cedar Falls/Waterloo (Cedar River Initiative)
  - Smart Growth Implementation Assistance program (SGIA)
    - To identify critical corridors which can absorb new development. It will include a charrette/workshop for visualizing the redeveloped corridors.
    - Evaluates local codes policies and applicable state/federal programs (such as HMGP) to identify barriers and opportunities for support infill, better redevelopment and economic growth.
    - Includes a public open house of the benefits of smart growth approaches.
- Cedar Rapids
  - Smart Growth Audit
    - Cedar Rapids is looking at developing policies to support sustainable building practices
    - LTCR Coordinated communication with EPA-SGIA and staff which helped identify processes Cedar Rapids Community Development Dept. could use to enhance and better implement Smart Growth principals. The Smart Growth Audit was identified as way to implement these concepts.
    - Drafted a Smart Growth Audit as a primer for Cedar Rapids
    - Developed initial implementation action steps.
  - Co-Generation Feasibility Study
    - Project background and summary and status organized for the *Long-Term Community Recovery Report*
    - Assisted the scoping of this project further for presentation to the Inter-agency Coordination Team (IACT)
    - A number of agencies agreed to continue to discuss this project further (current status unknown)
    - Developed initial implementation action steps.
  - Comprehensive Energy Plan
    - Project background and summary and status organized for the *Long-Term Community Recovery Report*
    - Assisted the scoping of this project further for presentation to the Inter-agency Coordination Team (IACT) where members identified Department of Energy as a possible partner for the project.
    - Developed initial implementation action steps.
  - Green Building Workshop
    - LTCR used project specific experience to provide detailed background information/sample of another Green Building Program including the ordinance

establishing the program, and checklists for staff, Planning Commission and City Council.
- Developed initial implementation action steps.

- Smart Growth Implementation Assistance (SGIA)
  - Project is to continue smart growth audit activities by reviewing development codes, policies and practices.
  - Help identify barriers to implementing smart growth initiatives
  - Establish and prioritize short and long-term smart growth opportunities.
  - Services available through FEMA ESF#14 Mission Assignment.
  - Site visit scheduled for September 9-10
  - Workshop is planned as part of the September site visit

- Coralville
  - SGIA
    - Visioning exercise
    - Review of development codes and standards to encourage smart growth
    - Identify funding opportunities for smart growth initiatives.
- Iowa City
  - Wastewater Treatment Plant Consolidation
    - Scoping of project for *the Long-Term Community Recovery Strategy*
  - SGIA
    - Visioning for the redevelopment of the South Gilbert Street Commercial Corridor
- New Hartford
  - SGIA
    - To find solutions to storm water management issues
  - Expand City Limits (alternatives to floodplain location)
    - Scoping of project for *the Long-Term Community Recovery Plan*
  - Improve Stormwater Drainage System
    - Scoping of project for *the Long-Term Community Recovery Plan*
- Oakville
  - Community Rebuilding/Relocation Strategies
    - Scoping of project for *the Long-Term Community Recovery Plan*
  - Construct Duplex Infill Housing
    - Scoping of project for *the Long-Term Community Recovery Plan*
  - Adaptive Reuse of Old Oakville School

        - Scoping of project for *the Long-Term Community Recovery Plan*
    - Palo
        - Center City and Future Growth Strategy
            - Scoping of project for *the Long-Term Community Recovery Strategy*
        - Iowa's Living Roadways Community Visioning Program Implementation
            - Scoping of project for *the Long-Term Community Recovery Strategy*
    - Parkersburg
        - Relocate Ballfields Outside Beaver Creek Floodplain
            - Scoping of project for *the Long-Term Community Recovery Report*
    - Waverly
        - Identify Infill Opportunities
            - Scoping of project for *the Long-Term Community Recovery Strategy*
        - Remove and Construct Housing Outside the Floodplain
            - Scoping of project for *the Long-Term Community Recovery Strategy*
- Inter-agency Coordination Team (IACT)
    - Provides a venue for projects that need multiple partners or may have some implementation barrier to be discussed between multiple state and federal agencies
- Mission Assignment and Interagency Agreement to EPA for SGIA
    - Five communities selected to receive technical assistance for smart growth initiatives.
    - Includes potential workshops, audit of codes and land development regulations, development of green infrastructure strategies and more.

TITLE OF PROJECT OR PROGRAM: Research Program of the Chicago Wilderness Science Team (*http://www.chicagowilderness.org/initiatives.php*)

AGENCY/INSTITUTION: Several institutions and agencies that are part of the Chicago Wilderness Alliance

PROJECT/PROGRAM DESCRIPTION: Socio-ecological research designed to provide a scientific foundation for the management, conservation and restoration of biodiversity and the delivery of ecosystem services in the greater Chicago metropolitan area

RESULTS, OUTCOMES OR IMPACTS TO DATE: Building of a diverse research team that is now initiating several projects. The three major projects are listed below.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):

Note: The numbers in parentheses refer to participation in the three research projects listed below.

Chicago Department of the Environment (3)
DePaul University (1, 2, 3)
Field Museum (2, 3)
Lincoln Park Zoo (3)
Loyola University (3)
Purdue University (3)
University of Illinois at Chicago (1, 2, 3)
University of Illinois at Urbana-Champaign (2)
US Forest Service (2, 3)

PROJECT PERIOD: See below

FUNDING LEVELS (CURRENT OR PROPOSED): See below

PROJECTS:

(1) 2009-2011 —Gaylord and Dorothy Donnelley Foundation ($236,000): "Chicago Wilderness land management research program: Building upon the foundations"

(2) 2009-2013 —National Science Foundation (DEB-BE-0909451) ($1,474,491): "CNH: Collaborative Research: Coupled natural-human systems in the Chicago Wilderness: Evaluating the biodiversity and social outcomes of different models of restoration planning"

(3) PENDING (2009-2011) —National Science Foundation (0948484) ($299,920): "ULTRA-Ex: Connecting the social and ecological sciences with planners, managers, and the public: Building a broad foundation for the Chicago Region ULTRA"

TITLE OF PROJECT OR PROGRAM: National Park Service's Center for Urban Ecology (*http://www.nps.gov/cue/*)

AGENCY: National Park Service (NPS)

PROJECT/PROGRAM DESCRIPTION: The Center for Urban Ecology's mission is to provide scientific guidance, technical assistance and education for the preservation, conservation and enhancement of park resources within urbanizing landscapes. Established in 1985, the Center for Urban Ecology (CUE) identifies and responds to the natural resource needs of NPS's National Capital Region parks, located in the greater Washington, D.C. metropolitan area. The CUE staff focuses on urban ecology within the matrix of the region's nationally significant natural and cultural resources. Through science, service, and partnerships, CUE assists managers in understanding, protecting, and restoring natural resources for future generations. An interdisciplinary staff of 12 provides technical assistance on many aspects of natural resources and management. Due to the diversity of landscapes found in the National Capital Region parks, resource managers identify science and management issues based on individual park needs.

RESULTS, OUTCOMES OR IMPACTS TO DATE: NPS draws on Research Learning Centers, Cooperative Ecosystem Studies Units, and Inventory and Monitoring Networks to provide ecological science for managing natural areas of the national parks. In 1998, Congress authorized and directed NPS to assure that management of the national parks is enhanced by the availability and use of a broad program of science.

The Chesapeake Watershed Cooperative Ecosystem Studies Unit, of which NPS is a partner, has promoted stewardship and integrated ecosystem management of natural and cultural resources within the Chesapeake Watershed since 2001 through collaborative research, technical assistance, and education. The Chesapeake Watershed is home to more than 3,600 species and over 15 million people, all competing for resources and space within the 64,000 square mile region. Twelve university/research institutions and six federal agencies comprise the Chesapeake Watershed Cooperative Ecosystem Studies Unit. These partners work together to provide leadership in watershed science and stewardship.

The National Capital Region Network, responsible for inventory and monitoring, has monitored vital signs in 11 National Capital Region parks since 2001. Vital signs monitoring informs managers of the condition of water, air, geologic resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Knowing the condition of natural resources in national parks is fundamental to managing park resources in a manner that "preserves, unimpaired, the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations."

The Urban Ecology Research Learning Alliance is an alliance of 15 parks in the region and 16 formal and 5 informal (research and education) partnerships. Since 2002, the Urban Ecology Research Learning Alliance has facilitated research in all parks within the

National Capital Region by following a goal of increasing research on the natural and cultural resources in the National Capital Region and communicating new information about its parks. The Alliance is the point of communication for scientific research and inventory and monitoring information to parks' staff and the public. Alliance projects provide opportunities for education and interpretation of the region's natural resources. The Urban Ecology Research Learning Alliance's interdisciplinary research projects have developed through partnerships with various researchers, agencies and institutions, as well as the Chesapeake Watershed Cooperative Ecosystem Studies Unit. Additionally, 43 students have participated in diverse research and education projects facilitated by the Alliance. In FY08, the Urban Ecology Research Learning Alliance began implementing a comprehensive Urban Ecology Science and Education Program to promote science and resource management focused internships and fellowships in the National Capital Region's parks.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): Research opportunities may include student, volunteer, and interpretive components. Projects are funded through the Urban Ecology Research Learning Alliance, the Chesapeake Watershed Cooperative Ecosystem Studies Unit, and the National Capital Region Network.

PROJECT PERIOD: NA

FUNDING LEVELS (CURRENT): $3,125,000 (CUE Budget)

TITLE OF PROJECT OR PROGRAM: Water Quality Assessment (NAWQA) Program (*http://water.usgs.gov/nawqa/*)

AGENCY: U.S. Geological Survey (USGS)

PROJECT/PROGRAM DESCRIPTION: *A major emphasis of the NAWQA program is to understand the relationship between urban land use and water quality. Specifically, the goal is to describe biological, chemical, and physical characteristics of urban water resources over time, and relate those characteristics to natural processes and human activities that control the movement and quality of water within and among urban watersheds. The intended outcome is an improved scientific basis for decision makers to protect urban waters in varying geographic and environmental settings across the Nation, and to manage and prioritize competing demands, such as for safe drinking water, aquatic ecosystem health, native and endangered species preservation, and recreation in urban areas. NAWQA does not address urban issues with one network. The program uses a collection of networks and studies that are each designed with specific questions, that together help to accomplish the overall goal.*

RESULTS, OUTCOMES OR IMPACTS TO DATE: [1]

National Topical Studies

- *Effects of Urbanization on Stream Ecosystems (EUSE) a*ddresses the magnitude and pattern of response in stream hydrology, habitat, water chemistry, and biological communities as watersheds are urbanized in 11 metropolitan areas.
- *Transport of Anthropogenic and Natural Contaminants to Public Supply Wells (TANC)* provides local and regional-scale vulnerability assessments of public supply wells affected by contamination from multiple sources, including urban.
- *Mercury in Stream Ecosystems* addresses the questions of what are the concentrations of mercury in water, sediment, and fish; and how do biological, chemical, and other environmental characteristics govern the methylation, transport, and bioaccumulation of mercury in undeveloped and urban streams in 3 metropolitan areas.

National- and Regional-Scale Assessments

- *Pesticides* in urban streams (water, bed sediment, fish tissue) and shallow ground water.
- *Nutrients* in urban streams and shallow ground water.
- *Volatile organic compounds (VOCs)* in urban streams and shallow ground water.
- *Trace elements* in bed sediments, fish tissue, and ground water in urbanized areas.

[1] (See *http://co.water.usgs.gov/nawqa/urbanPortal/*)

- Ecology sampling studies that assess health of fish, invertebrate, algal communities, and riparian habitat.

Special Studies

- *Parking Lot Sealcoats: A Major Source of Polycyclic Aromatic Hydrocarbons (PAHs) in Urban and Suburban Environments* is a collaborative study with the City of Austin, Texas.
- *Contaminant Trends in Lake Sediments (CTLS)* uses sediment-core analyses to evaluate trends over time of persistent urban contaminants, such as trace elements, DDT, PCBs, chlordane, and PAHs in reservoirs and lakes in 42 metropolitan areas.
- All USGS NAWQA Publications Dealing with Urban Areas (see urbanization link): *http://water.usgs.gov/nawqa/bib/*

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):

- U.S. Environmental Protection Agency, Office of Water, Office of Pesticide Programs, Superfund
- Center for Watershed Protection
- Source Water Collaborative
- Duke University
- City of Austin, Texas
- Association of State Drinking Water Administrators

PROJECT PERIOD: 2001-2012

FUNDING LEVELS (CURRENT): $5 million (estimated NAWQA urban component) in Federal Fiscal Year 2009

TITLE OF PROJECT OR PROGRAM: Impact of urbanization on nitrogen biogeochemistry in xeric ecosystems (*http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0918457&WT.z_pims_id=13690*)

AGENCY/INSTITUTION: NSF

PROJECT/PROGRAM DESCRIPTION: The overall objective of this new, three-year project is to understand how urbanization of desert ecosystems influences nitrogen cycling processes, especially those associated with stormwater. We ask three primary questions: 1) How does urbanization affect the processes controlling delivery of nitrate from upland to lowland parts of the desert landscape? 2) What are the dominant nitrate sources in arid urban watersheds? 3) How does the substrate type of washes, through which stormwater flows, modulate the removal or transformation of nitrate? Our results will help to inform better design of stormwater conveyance systems to enhance ecosystem services besides flood containment.

RESULTS, OUTCOMES OR IMPACTS TO DATE:

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): The project is a collaborative effort between ecologists, hydrologists, and stable-isotope biogeochemists at the University of Arizona, Arizona State University (including the CAP LTER), and Purdue University. Community partners include the cities of Tucson, Phoenix, Tempe, Glendale, Scottsdale, and Mesa, and the USGS and the Arizona Department of Environmental Quality.

PROJECT PERIOD: September 2009-August 2012

FUNDING LEVELS (CURRENT OR PROPOSED): Combined total of $876,000

TITLE OF PROJECT OR PROGRAM: Effects of urban atmospheric pollution on desert ecosystems

AGENCY/INSTITUTION: NSF

PROJECT/PROGRAM DESCRIPTION: This effort has been supported by a 3-year NSF grant and is currently under consideration for renewal. The objectives are to explore the potential for urban pollutants, especially inorganic nitrogen, organic carbon, and ozone to alter ecosystem functioning in unmanaged desert sites both within and downwind from cities. These chemical stressors also are considered in concert with other urban effects, such as recreational use and urban heat island. The research team has included atmospheric chemists, ecosystem scientists, ecohydrologists, and ecosystem modelers.

RESULTS, OUTCOMES OR IMPACTS TO DATE: Although impacts of urban pollution are well known for mesic biomes, this research to date has shown that desert ecosystems are relatively resistant to the effects of urban air pollutants.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): The project is a collaborative, multidisciplinary effort centered at Arizona State University, with co-investigators at The Pennsylvania State University and in private consulting, and closely aligned with the CAP LTER at Arizona State University. Community partners include private, city, county, and state parks and USDA Forest Service and Bureau of Land Management lands in the Phoenix metro area.

PROJECT PERIOD: April 2005-March 2009; renewal proposed for March 2010-February 2013

FUNDING LEVELS (CURRENT OR PROPOSED): Funds received total ~$750,000; renewal request for $855,000.

TITLE OF PROJECT OR PROGRAM: A Workshop on the Concept of a National Hazard Vulnerability and Resiliency Observatory (*http://www.nehrp.gov/pdf/RAVON.pdf*)

AGENCY: National Science Foundation (Infrastructure management and extreme events and decision risk and management programs) and United States Geological Survey.

PROJECT/PROGRAM DESCRIPTION: This project will conduct a workshop of leading natural hazards and disaster researchers to address the creation of a National Hazard Vulnerability and Resiliency Observatory Network. The focus of this observatory network will be vulnerability and resiliency as they relate to natural and technological hazards and disasters, not deliberate or willful acts of terrorism.

There is a need for concerted research efforts to reduce our nation's vulnerabilities to natural disasters and to enhance resiliency. This workshop will take the initial steps toward the development of a national framework for interdisciplinary comparative research on natural hazard vulnerability and resiliency that should be undertaken through a national observatory network. This framework will identify the core research themes and more specific research questions related to hazard vulnerability and resiliency. The workshop will also identify critical data that should be collected and organized in order to enhance and facilitate research efforts for understanding and monitoring vulnerability and resiliency. The overall structure of the observatory network and location of research sites will also be addressed.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
A workshop was held in June 2008, and researchers throughout the United States and Canada attended. That workshop developed the concept of a Resiliency and Vulnerability Observatory Network (RAVON) as a necessary and fundamentally important complement to the existing national observatories such as the National Center for Ecological Analysis and Synthesis (NCEAS); the Long Term Ecological Research Network (LTER,); and the National Environmental Observatory Network (NEON), that would directly address the human and social structures and dynamics of our nation’s urban systems that are driving anthropomorphic environmental changes. Vulnerability research now increasingly includes not simply hazard exposure and the physical characteristics of hazard agents themselves, but also social factors that are now also seen as critical dimensions in vulnerability analysis and assessment. Even more recently, disaster resilience has emerged as a critical focus area demanding, not simply the modeling of how complex social systems resist, rebound and respond to disaster, but also a broader ecological perspective, placing social systems in interaction with bio-physical systems to better assess changing vulnerabilities and ultimately resilience. The emergence of vulnerability and resilience science in the hazards field has brought into even sharper focus the once chronic, but now acute limitations of current approaches to hazards research. RAVON offers the possibility of transforming the nature of research on natural hazard vulnerability and disaster resiliency so critical for establishing sustainable urban systems. It provides a mechanism for dramatically altering the nature of the resiliency and vulnerability science by providing the opportunities to develop

comprehensive long term data sets on urban systems in multiple locations that will make possible temporal and comparative investigations that researchers will never be able to undertake given normal funding opportunities and structures.

A summary document was produced entitled, Toward a Resiliency and Vulnerability Observatory Network: RAVON. Copies of the report can be obtained as the following website location: *http://archone.tamu.edu/hrrc/Publications/researchreports/RAVON.pdf*

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
This project was jointly funded by the Unites States Geological Survey and the National Science Foundation.

PROJECT PERIOD: August 2008-2010

FUNDING LEVELS (CURRENT OR PROPOSED): $83,000

TITLE OF PROJECT OR PROGRAM: Twin Cities Household Ecosystem Project (*http://www.tchep.umn.edu/*)

AGENCY/INSTITUTION: NSF

PROJECT/PROGRAM DESCRIPTION (Proposal abstract): Humans are increasingly living in urban ecosystems. Cities cover only 1-2 percent of the earth's surface, but they are important hotspots of biogeochemical cycling because they concentrate the consumption of food and energy that are produced beyond their boundaries. Thus, cities are largely unsustainable, requiring large imports of fossil fuels, food and water. Furthermore, cities are important sources of greenhouse gas emissions and other pollutants resulting from fossil fuel combustion and waste generation that lead to nutrient loading downwind and downstream. Yet, little is known about the socio-ecological coupling between human behavioral factors and biogeochemical cycles. The long-term goal of the proposed research is to advance understanding of integrated human-biophysical interactions in urban ecosystems towards improved knowledge and management of urban biogeochemical cycles. **Specifically, this research seeks to understand the coupling between household biogeochemical fluxes and socioeconomic factors along an urban to exurban gradient in the Minneapolis-St. Paul (Twin Cities) metropolitan region, Minnesota.** The project focuses on household consumption because it contributes substantially to urban biogeochemical cycling and because it is potentially flexible and therefore amenable to reduction in response to changes in factors that influence household choices.

As part of the ongoing **Twin Cities Household Ecosystem Project (TCHEP)**, a social survey of households (3100 respondents) was conducted along an urban-to-exurban gradient (from 6 to 1,200 houses/km^2); landscape characteristics were surveyed for a subset of households. Survey-generated data about key behaviors that influence biogeochemical fluxes (e.g., driving, air travel, diet, pets, lawn care) are used as input to a Household Flux Calculator (HFC, developed with earlier funds) to generate total and component carbon (C), nitrogen (N) and phosphorus (P) fluxes for each household. The survey also gathered demographic data and linked behaviors with household attitudes, norms, and perceived control, all Theory of Planned Behavior factors. The proposed research aims to (**1) use the TCHEP database to examine how socioeconomic and biophysical factors influence household decisions and, thus, the fluxes of C, N, and P through households along a gradient of housing density; (2) determine the effect of consumption and pollution production by single family homes on fluxes of C, N, and P at the scale of the urban study region; and (3) examine how behaviors can be influenced through social networks to change consumption choices and, therefore, elemental fluxes.** Thus, the study will establish a **feedback loop** between **household choices, elemental fluxes and back to household choices.** Elucidating the nature of such socio-environmental coupling should stimulate novel approaches to making cities more sustainable, reducing urban pollution, and reducing urban contributions to climate change.

This study has **intellectual merit** in that it will integrate human choice into an overall model of urban biogeochemistry. The study will quantify the effect of behavioral flexibility (and its underlying behavioral controls) on elemental fluxes through households. Understanding of the coupling between human behavior and biogeochemistry will transform our approach to reducing pollution through identification

of behavioral changes that reduce pollutant sources. The study will achieve **broader impacts** through extensive educational training of numerous undergraduate, graduate and post-doctoral trainees; development of an interactive web page for non-scientists in collaboration with the Science Museum of Minnesota's *Earth Buzz* web project; use of the HFC model as a teaching tool in undergraduate courses taught by project co-PIs; and **global dissemination** of the TCHEP survey tool, the TCHEP database, and the HFC tool through the world-wide web (via the Cedar Creek LTER website). In addition, project outcomes can be directly applied to developing a new paradigm for pollution control, a paradigm based on source reduction, information feedback loops to guide adaptive management, and greater citizen involvement.

RESULTS, OUTCOMES OR IMPACTS TO DATE: We designed and implemented a mail survey of single-family, owner-occupied, detached homes along an urban-exurban gradient. This poster focuses on the methodologies of the TCHEP survey and the contributions to an integrating Household Flux Calculator that estimates element fluxes associated with home energy use, air and car travel, diet, pets, paper and plastics, and vegetation. Our conceptual boundary for a household included the physical property of each household plus all personal transportation by household occupants. Using a modified Dillman method, we sent mail surveys to randomly selected homes in the sample frame and received approximately 3,000 responses, supporting generalizable findings; 2,000 of these respondents provided access to their energy records. We then conducted a field survey of vegetation at 400 randomly chosen respondent households. A key conclusion is that the unique TCHEP methodology, a hybrid approach that includes a mail survey, permission to access utility records, ground-based sampling, and readily available GIS data, can be used to estimate C, N, and P fluxes for large numbers of households. The simultaneous collection of demographic characteristics and behavioral attributes has allowed us to examine relationships between elemental fluxes and consumption behaviors in these households.

A key hypothesis is that most component fluxes (e.g., transportation) would be highly skewed. Results to date suggest that skewness follows the order airline > household energy > human food. The first major papers will be generated over the next six months.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): None

PROJECT PERIOD: Refunded, September 1, 2009 to August 31, 2012.

FUNDING LEVELS (CURRENT OR PROPOSED): $1.5 million

TITLE OF PROJECT OR PROGRAM: Sustainability in a Changing Climate (*http://web.mit.edu/dusp/epp/music/wwd/projects/index.html*)

ORGANIZATIONS: Massachusetts Institute of Technology and the U.S. Geological Survey

PROJECT/PROGRAM DESCRIPTION:
Over the course of the program's research we will compare city pairs in different environments and cultures, which will include developing countries, to develop robust strategies and methods to achieve sustainability. Our research includes the use of role-play games to provide a "safe harbor" to explore planning options to achieve sustainable and resilient cites; one such project was conducted with the state of Maryland as part of their Coast Smart program. (Visit *http://scienceimpact.mit.edu* for the full range of MUSIC activities.) Our goal is to change practice through the development and implementation of new methods and tools.

Urban sustainability research and development undertaken by the MIT-USGS Science Impact Collaborative* (MUSIC) is organized under an activity called Communities and Climate Change. The underlying premise of this R&D is that collective action, at all scales and levels of governance and society, is needed to address the impacts of climate change to achieve sustainable communities and ecosystems. We ask the question: Do institutions need to be realigned in a way that fosters collective decisions made in the common interest and for the common good? Through case study research, we will examine how climate change effects strain the current institutional, legal, regulatory, and planning tools available, which evolved in a stable climate and with the assumption that climate would remain stable. That's no longer true. Current decision making processes and institutions are not adequate to deal with changing climate. Our research will consider if this assertion is valid. Through action research, we will develop and test alternative strategies, institutional arrangements, methods, and tools that include joint fact-finding, collaborative adaptive management, collaborative modeling, scientific and technological (engineering) applications, GIS, and scenario future planning to achieve sustainability in a changing climate. Cities are complex adaptive systems. They are dynamic, open and connected systems, which implies that social, ecological and economic elements of cities are interrelated, and are influenced in a complex way by diverse external factors. Moreover, the urban environment cannot be decoupled from the natural environment, they are interdependent; we have been taught this lesson many times—Hurricane Katrina is only one example—but have yet to learn it. Planning for cities and metropolitan complexes needs to be done within the context of natural processes and changing climate. Secure and healthy communities and towns are dependent upon healthy, functioning ecosystems. And, like ecosystems, to be sustainable cities need to be resilient so that they can adapt to inevitable surprises. To design cities to be resilient we need to analyze their vulnerabilities. Three fundamental questions of our research are: How does climate change influence the vulnerability of a city as a system

* MUSIC is a partnership between the Massachusetts Institute of Technology and the U.S. Geological Survey. It is a component of the Environmental Policy and Planning Group, which is a subgroup in MIT's Department of Urban Studies and Planning.

and how can interventions (adaptive strategies) be developed in order to reduce this vulnerability? Can adaptive strategies and collaborative governance help to make cities more resilient to climate change? How can we manage and make collective decisions across multi-jurisdictions and scales?

RESULTS, OUTCOMES OR IMPACTS TO DATE:
We have completed a study of Somerville, Massachusetts where we developed methods and tools to manage water drainage in a changing climate, and will do a comparative study in Aurora, Colorado— a different geographic, climatic, and ecological setting. We start a five-year program of action research and development September 2009 by looking at Rotterdam, the Netherlands and Ft. Lauderdale, Florida.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):

Communities and Climate Change is an interdisciplinary effort among urban planners, landscape ecologists, landscape architects, social scientists, natural scientists, and engineers; collaborating institutions include the Dutch applied science organization, TNO, the Dutch bureau for Environmental Assessment, the University of Amsterdam, the French environmental organization, Cemagref, the non-profit organization, Batelle, and the U.S. Geological Survey.

PROJECT PERIOD: 5 year program beginning in September 2009.

FUNDING LEVELS (CURRENT OR PROPOSED): N/A

TITLE OF PROJECT OR PROGRAM: The Evolving Morphology of Metropolitan Regions *(http://www.reeis.usda.gov/web/crisprojectpages/210442.html*)

AGENCY/INSTITUTION: University of California at Davis, Department of Environmental Design, Landscape Architecture Program

PROJECT/PROGRAM DESCRIPTION:
This ongoing project analyzes the historical growth and current built landscape patterns of urban regions, using GIS, historical maps from the Library of Congress and other sites, Google Earth, and local data. An initial phase of the project compared urban growth and morphologies of six U.S. regions: Boston, Atlanta, Minneapolis/St. Paul, Albuquerque, Las Vegas, and Portland OR. Results were published as "The Evolution of Built Landscapes in Metropolitan Regions." 2008. *Journal of Planning Education and Research*. 27 (4) 400-416. This article received an Honorable Mention for the Chester Rapkin Award honoring best article of the year in this publication.

A second phase of the project is analyzing the Sacramento metropolitan region in greater detail, mapping urban growth at 10 year increments, and comparing environmental characteristics of different built form types using CityGreen software. This phase of the project will be completed in late 2009/early 2010.

Additional phases of the project may compare development of U.S. metropolitan areas with others internationally.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
The most dramatic finding so far is the rapid growth of rural sprawl (lot sizes between 1 and 5 acres) in the 1980-2010 timeframe. This type of form accounted for 57 percent of land area developed in the six sample cities during this time period.

A second finding was the effectiveness of the Portland urban growth boundary in reducing rural sprawl, when the Oregon portion of that region is compared with the Washington state portion, and with other metropolitan areas.

A more general finding is the rapid proliferation of built landscape types in recent decades, and the increasing fragmentation of form within U.S. metropolitan regions. The lack of connection between different development types has profound implications for motor vehicle use and related emissions. New Urbanist-style development found in some regions represents an attempt to counteract this trend, but so far accounts for a very small percentage of the land area developed. More proactive public sector regulation of large-scale development patterns appears necessary to counteract fragementation.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): None

PROJECT PERIOD: 2005-ongoing

FUNDING LEVELS (CURRENT OR PROPOSED): $25,000 in UCD funds

TITLE OF PROJECT OR PROGRAM:
Double Exposures: Socio-ecological Vulnerabilities in the Miami-Dade Urban Region, submitted and recommended for funding to the NSF Urban Long-Term Research Area Exploratory Awards (ULTRA-Ex) program.
(*http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0948988&WT.z_pims_id=503283*)

AGENCY/INSTITUTION: Florida International University

PROJECT/PROGRAM DESCRIPTION:

The greater Miami urban area is characterized by a unique and paradoxical set of conditions and forces: a global commerce center, where assets are vulnerable to catastrophic coastal disasters; an affluent city with among the highest rates of poverty in the nation; a de-vegetated city situated between and dependent upon unique and protected natural environments; a city that receives significant rainfall, but whose freshwater supply is critically vulnerable to climatic change. What unites these strengths and vulnerabilities is their shared dependence on the interaction between local and global drivers. We will use the two-year ULTRA-Ex award to ask: How do global biophysical and socio-economic drivers interact with local processes to determine the socio-ecological structure and dynamics of cities? In addressing this question we conceptualize urban Miami as uniquely vulnerable to the double exposure of economic globalization and climate change, while recognizing the linkages, feedbacks and synergies between the transformative processes of global environmental change and economic globalization as they impact local communities.

The project will convene three themed working groups —1) Coastal Vulnerabilities, 2) Urban Land Stewardship, and 3) Freshwater Sustainability—that will include researchers, educators, community stakeholders, and state and local government agencies. Each group will describe the spatial distribution of populations and resources; derive a conceptual model of the controls on population/resource vulnerability to climate change and globalization; and identify spatial and statistical relationships among resources and vulnerabilities, providing a template for future empirical validation. Working group products will include peer-reviewed articles; white papers for policy makers and community partners; educational products including course modules and dissertation research; and various technical products including GIS databases, algorithms, and interactive maps.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
South Florida Water Management District, Miami-Dade County Department of Environmental Management, Miami-Dade County Climate Change Task Force, Miami-Dade County Water and Sewer Department, Miami-Dade School System, Everglades Foundation (NGO), U.S. Forest Service, Fairchild Tropical Botanic Garden

PROJECT PERIOD: Two years, beginning January 2010

FUNDING LEVELS (CURRENT OR PROPOSED): $299,000

TITLE OF PROJECT OR PROGRAM:
Earth Science and Applied Sciences Programs
(*http://geo.arc.nasa.gov/index.html*)
(*http://appliedsciences.nasa.gov/*)

AGENCY:
National Aeronautics and Space Administration

PROJECT/PROGRAM DESCRIPTION:
Although NASA has no official program dedicated to research on urban systems or urban sustainability, the NASA Earth Science Research and Analysis (R&A) and Applied Sciences (AS) programs have offered proposal calls related to urban analysis via the Research Opportunities in Space and Earth Sciences (ROSES) process. In the NASA R&A program (http://nasascience.nasa.gov/earth-science), urban systems and urban sustainability are addressed through the Land Cover and Land Use Change program. Additionally, urban sustainability research is also approached through the R&A's focus areas on Carbon Cycle & Ecosystems and Climate Variability and Change. Perhaps a more pertinent avenue for research on urban systems and sustainability is provided by the NASA AS program. The AS program (http://nasascience.nasa.gov/earth-science/applied-sciences) has 7 focus areas: Agriculture, Air Quality, Ecological Forecasting, Natural Disasters, Public Health, Water Resources, and Weather. Outside of agriculture and weather, the remaining 5 focus areas all have direct or indirect applications to urban systems and sustainability. In particular, the air quality and public health national applications areas have proposals funded that relate to urban areas, urban decision making and urban sustainability.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
Studies completed as part of the AS program have related to the urban heat island effect (UHI) and its impact on air quality. These studies have looked at the relationship of urban areas, the UHI, and air quality impacts as associated with $PM_{2.5}$ (particulate matter <2.5 microns); e.g., whether the UHI causes an increase in $PM_{2.5}$ over urban areas. Ongoing studies are analyzing the public health impacts of $PM_{2.5}$ and how cities exacerbate air quality and health impacts. Other studies have assessed how NASA satellite data can be used to quantify land surface temperatures over urban areas as they affect development of the UHI. It has been observed that city size and UHI development are directly related, which is of serious concern given that the number of "megacities" — those urban areas with 10 million or more inhabitants - will increase to over 20 by 2025. Additionally, NASA Earth science data have been incorporated into urban growth modeling scenarios to illustrate both how urban areas have expanded in the last 20-30 years, and how cities will grow given modeled input data to predict urban sprawl in the future.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
The NASA AS program in particular, has focused on bringing in partners at the national, state, and local level to illustrate how policy and decision makers can utilize NASA satellite data within a decision making framework. Partnerships at the federal level are

varied including, USGS, EPA, NOAA, and the Centers for Disease Control and Prevention (CDC). State partnerships are even more wide-ranging, with the AS program working with state planning offices, state offices of public health, state emergency management agencies, and host of other intra-state agencies and offices. Numerous local partnerships are also part of the AS program's collaborative network, all of which are related in some way to local decision making offices and agencies where it has been demonstrated, or is in the process of being demonstrated, that NASA Earth science satellite data can be an integral part of the decision making, risk management, public health, and overall public infrastructure process.

PROJECT PERIOD:
Funding for urban systems and sustainability work is conducted via the ROSES proposal process. Calls for proposals that have direct relevance to these areas are currently listed, or will be listed, on the NSPIRES web site at http://nspires.nasaprs.com/external/.

FUNDING LEVELS (CURRENT OR PROPOSED):
Current and proposed funding levels for are provided by the NASA Earth Science and Applications Programs as listed on the NSPIRES web site.

TITLE OF PROJECT OR PROGRAM: Greater Everglades Ecosystem Decision Support System (South Florida Ecosystem Portfolio Model, "EPM") (*http://pubs.usgs.gov/sir/2009/5181/*)

AGENCY: USGS

PROJECT/PROGRAM DESCRIPTION: Land-use and preservation/restoration decisions have significant, but highly uncertain impacts on habitat quality and connectivity, water quality and quantity, flow patterns, and other aspects of ecosystem health in the Greater Everglades Ecosystem. In land use decision making these impacts are often considered at the scale of individual proposed land-use changes. Thus, impacts related to the cumulative regional impacts of multiple land-use changes are often ignored. This project designed and implemented a regional land-use use decision support system as a web-enabled GIS-based set of models and visualization tools. The South Florida Ecosystem Portfolio Model (EPM) compares proposed regional land use patterns (at the scale of Miami-Dade County) in terms of relevant ecological, economic, and social criteria that combine information about probable outcomes (potential land use consequences), as well as value judgments (preferences) elicited from users. Based on on-going meetings and interviews with stakeholders and potential tool users, we focus on three dimensions of land use/cover-related anthropocentric value: ecosystem services (or ecological value), market land price, and indicators of community quality-of-life.

RESULTS, OUTCOMES OR IMPACTS TO DATE: The ecological value and market land price components (suite of models) have been implemented and the community quality-of-life component is currently being designed for later implementation. The EPM prototype is now available online (*http://lcat.usgs.gov/sflorida/sflorida.html*; password protected: user = sflorida; password = alligator). The EPM is being tested by USGS with the Everglades and Biscayne National Parks using real-world proposed land-use change test cases in Miami-Dade County. Model results should support the responses that the Park Service provides in its role as stakeholder in regional land-use planning. The results of the methodologies used for test cases will be used to improve the EPM and will be published. The South Florida EPM approach has been extended to two other applications: (1) the Puget Sound EPM, a set of models that relate upland land-use change and nearshore human modifications (e.g., beach armoring) to changes in nearshore ecosystem goods and services; and (2) the Santa Cruz EPM, in support of the "Predicting Environmental Consequences of Urban Development on the US-Mexico Border" project.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): South Florida EPM: Everglades and Biscayne National Parks. U.S. Fish and Wildlife Service, Vero Beach. Puget Sound EPM: U.S Army Corps of Engineers, the Washington Department of Fish and Wildlife, and the U.S .Environmental Protection Agency (USEPA); Santa Cruz Watershed EPM: USEPA and other partners to be determined.

PROJECT PERIOD: 2005 - 2010

FUNDING LEVELS (CURRENT OR PROPOSED): $410,000

TITLE OF PROJECT OR PROGRAM: The Land Use Portfolio Model (LUPM) - Risk Assessment and Analysis for Natural Hazards (Geographic Analysis and Monitoring) (*http://geography.wr.usgs.gov/science/lupm.html*)

AGENCY: US Geological Survey

PROJECT/PROGRAM DESCRIPTION: Natural hazards, including floods, fires, and earthquake-triggered hazards such as strong ground-shaking, landslides and liquefaction, pose a significant threat to public safety and economic health worldwide. This project focuses on applying economic and geographic tools to the study of natural-hazard risk and on developing decision support systems (DSS) for evaluating potential public policies for mitigating that risk. The underlying goal is to facilitate the use of USGS and other earth-science information to develop tools to aid communities in reducing their vulnerability to natural hazards. This involves integrating many kinds of data, such as natural science, geography, and socioeconomic, and developing methods using a DSS for translating the information into socially relevant forms. Furthermore, this project aims to understand the reasons behind, and research ways to reduce, the gap in the availability of natural-hazard DSS that estimate damage, loss, and risk, and the use of such tools by natural-hazards decision makers.

The Land Use Portfolio Model (LUPM) and GIS-based DSS were developed as tools to support natural-hazards risk analysis, and are designed to help decision makers analyze risk-reduction policies. The LUPM is a geospatial scenario-based tool that incorporates hazard-event uncertainties, asset values at risk, conditional-damage probabilities, and mitigation costs, to estimate loss, risk, and return on investment for different mitigation strategies. Current objectives include performing a comprehensive risk analysis demonstration for earthquake hazards for mobile homes in southern California; using simulation modeling as an alternate method for estimating LUPM model uncertainties and risk curves; designing a study to demonstrate how FEMA's HAZUS-MH loss-estimation tool can be linked with the LUPM to improve natural-hazard decision making; and developing a tool to link the LUPM and HAZUS-MH software.

Past and present case studies include earthquake-triggered liquefaction in Watsonville, California; flooding in Squamish, British Columbia, Canada; earthquake hazards in Memphis, Tennessee; earthquake-triggered landslides in Ventura County, California; and earthquake hazards in the San Francisco Bay Area. The software that was developed to calculate the LUPM equations is designed to work within ArcGIS desktop applications. Two versions of the LUPM software (LUPM version 1.0) include an ArcGIS tool extension and an ArcGIS Model Builder tool accessible through ArcGIS Toolbox.

RESULTS, OUTCOMES OR IMPACTS TO DATE:

USGS and the Geological Survey of Canada (GSC) scientists collaborated to apply the LUPM to natural-hazards risk-reduction decisions in Squamish, British Columbia, Canada. Squamish, a coastal community located about 40 miles north of Vancouver, will be the gateway to the 2010 Winter Olympics in Whistler, and is predicted to face rapid

population growth over the next 25 years. The LUPM was used to run scenarios to analyze the sensitivity of risk results to decision parameters. A hypothetical analysis of the cost-effectiveness of two mitigation strategies illustrated risk-return trade-offs between the two options. A GSC-USGS workshop presenting GIS analyses and LUPM results to Squamish community planners raised awareness and educated planners about how to integrate the risk of natural hazards into the planning process and the potential benefits of incorporating science into planning decisions.

The USGS collaborated with the City of Memphis and Shelby County, Tennessee, to develop a prototype web-based LUPM tool to evaluate alternative earthquake risk mitigation strategies. The DSS is intended to provide: (1) quantitative policy analysis of construction standards for earthquake risk mitigation for commercial and public property over long planning periods by estimating the expected return on investment for a proposed level of safety, and (2) estimates of the net benefits (losses avoided less mitigation costs) of alternative building standards. Work is ongoing to program the benefit-cost equations, integrate them with loss estimates, and design a prototype graphical user interface. An initial design for the map viewer, with hypothetical data input and run-output screens, was completed and will be followed by testing, refinements, and eventual transfer to cooperators. (Hearn et. al, expected in 2009)

Completed publications (not including abstracts or conference proceedings papers) include:

Dinitz, L., Champion, R., Wein, A., Ng, P., and Bernknopf, R., 2009, Assessing natural-hazards risks with GIS, *in* Thomas, C., and Humenik-Sappington, N., eds., GIS for Decision Support and Public Policy Making: Redlands, CA, ESRI Press, pp. 106-111.

Dinitz, L.B., 2008, Applying the Land Use Portfolio Model to estimate natural-hazard loss and risk; a hypothetical demonstration for Ventura County, California: U.S. Geological Survey Open-File Report 2008-1309, 12 p. [http://pubs.usgs.gov/of/2008/1309/].

Champion, R.C., 2008, A Bernoulli formulation of the Land Use Portfolio Model: U.S. Geological Survey Open File Report 2008-1310.

Bernknopf, R., Rabinovici, S.J., Wood, N., and Dinitz, L., 2006: The influence of hazard models on GIS-based regional risk assessments and mitigation policies, in *International Journal of Risk Assessment and Management*, Vol. 6, Nos. 4/5/6, pp. 369-387.

Bernknopf, Richard L., Dinitz, Laura B., Rabinovici, Sharyl J.M., and Evans, Alexander M., 2001, "A Portfolio Approach to Evaluating Natural Hazard Mitigation Policies: An Application to Lateral-Spread Ground Failure in Coastal California," in *International Geology Review*. Vol. 43, pp. 424-440.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): City of Palm Springs, California; Geological Survey of Canada; and City of Memphis, Tennessee.

PROJECT PERIOD: FY2005 through FY2010

FUNDING LEVELS (CURRENT): $392,000

TITLE OF PROJECT: Risk and Vulnerability to Natural Hazards (*http://geography.wr.usgs.gov/science/vulnerability.html*)

AGENCY: Department of Interior, U.S. Geological Survey

PROJECT DESCRIPTION: A core element of the USGS mission is to provide reliable scientific information to minimize loss of life and property from natural disasters. Minimizing the impact of future disasters requires an understanding of natural hazards and of societal vulnerability to these threats. Although there is considerable attention paid to characterizing natural hazards, officials and the public need assistance, in the form of model development and case study assessments, to better understand their vulnerability. The primary research objectives are to (1) develop conceptual models of societal vulnerability to natural hazards, (2) develop geospatial metrics of vulnerability for the various sudden-onset and chronic hazards that threaten the Nation, and (3) collaborate with local officials and the general public to incorporate non-spatial aspects of adaptive capacity into vulnerability assessments. Geographic research focuses on the use of midresolution satellite imagery, geographic-information-system (GIS) tools, collaborative processes, dasymetric mapping, factor analysis, and systems analysis in characterizing community vulnerability. To maximize the use of research results by practitioners, the project is organized around the following hazard-specific themes:

1) Tsunamis, with specific attention to those generated by a Cascadia subduction zone earthquake in the Pacific Northwest;
2) Coastal storms and climate change, with a focus on climate-change-enhanced coastal hazards in the Pacific Northwest (e.g., erosion, flooding) and on the Gulf coast of Florida (e.g., hurricane storm surge);
3) Volcano hazards in the Pacific Northwest (e.g., Mount Rainier, Mount Hood), with specific attention to lahars;
4) Earthquake hazards in the Pacific Northwest (e.g., Tacoma Fault and South Whidbey Island Fault in Washington)

Research for each hazard and study area includes some level of GIS analyses of land-use/land-cover patterns and community assets, statistical analyses to develop comparative indices of exposure and sensitivity, and collaborative processes (e.g., focus groups, workshops) to examine system resilience. Partnerships have been developed with local and State emergency management agencies to ensure research results are well-grounded in practitioner needs.

RESULTS, OUTCOMES OR IMPACTS TO DATE:

Results: A quantitative method that integrates GIS software and statistical methods was developed to assess and compare community exposure and sensitivity to natural hazards. State-level assessments of variations in community exposure and sensitivity to tsunamis were completed for Hawaii, Oregon, and Washington (all published as USGS Scientific Investigations Report and coupled with supporting Excel databases). Each report summarizes the amount and percentage of developed land, residents, employees, tourists, dependent populations, critical facilities, and parcel values in tsunami-hazard zone of

each community. A similar USGS report (currently in press) summarizes variations in community exposure to lahar hazards associated with Mount Rainier, Washington. A method using midresolution satellite imagery was developed to approximate variations in community vulnerability to tsunamis. A method to integrate factor analysis and geospatial analysis was developed to model variations in demographic sensitivity to potential tsunamis along the Oregon coast. Public workshops have been held in Oregon and Florida to examine community sensitivity, adaptive capacity and post-disaster recovery. Articles summarizing these efforts have been published in *Natural Hazards Review*, *Applied Geography*, *Coastal Management*, *Natural Hazards*, *International Journal of Mass Emergencies and Disasters*, and *Journal of Volcanology and Geothermal Research*. Chapters in textbooks (one on volcano-hydrologic hazards and another on community adaptation to climate-change-enhanced coastal hazards) have been written to discuss societal vulnerability to natural hazards. Manuscripts currently in preparation focus on (1) the influence of climate change on increasing community vulnerability to hurricane-storm-surge hazards in west-central Florida, (2) the use of collaborative process to document stakeholder perspectives for adapting to climate-change-enhanced coastal hazards, and (3) inclusion of vulnerability metrics in the USGS National Volcano Early Warning System (NVEWS).

Results from the various research efforts demonstrate that social vulnerability to natural hazards manifests itself differently throughout a community or region and that certain areas are likely to suffer disproportionately due to differences in pre-event socioeconomic conditions and other demographic attributes. Significant results include (1) distinctions of community vulnerability based on city size, (2) the identification of several dependent-population and public-venue facilities in hazard zones that were previously ignored in regional emergency planning, (3) strong correlations between the relative percentage of land and community assets in tsunami-hazard zones but no correlation between the absolute amount of assets and land, and (4) development of population metrics to characterize societal vulnerability.

Impact of Results: The State-level assessments of community vulnerability to tsunamis are definitive works on the subject and are the only assessments of their kind in the world. Emergency managers (city, county, and State) have responded very favorably to the reports. Memorandums of agreement to conduct further collaborative vulnerability assessment research have been developed with several county and State governments. Invited briefings have been done for directors of county and State emergency management departments, county and regional hazard organizations, and participants in regional functional exercises. Media (e.g., newspaper, radio, and Internet) have recognized the work. Tsunami results have been incorporated into the hazard mitigation plans for the State of Hawaii and the State of Washington. The PI was appointed to a National Research Council committee on tsunami preparedness. Local, State, and foreign governments have invited the PI to train them on vulnerability-assessment and risk-communication techniques. A research colleague from Penn State was asked to present results of our Florida work at a NATO-sponsored workshop on community adaptation to climate change.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):

- USGS personnel: Principal Investigator is Nathan Wood (USGS research geographer). Other project personnel include Amy Mathie, Rachel Sleeter, and Chris Soulard
- Research partners: University of South Carolina, Pennsylvania State University, Oregon State University, Oregon Dept. of Geology and Mineral Industries, USGS Earthquake Hazards Program, USGS Volcano Hazards Program, USGS Coastal and Marine Geology Program
- Practitioner and Outreach partners: State of Washington Emergency Management, Hawaii State Civil Defense, Oregon Sea Grant, Clackamas County (OR) Emergency Management

PROJECT PERIOD: October 1, 2003 to September 30, 2013

FUNDING LEVELS (CURRENT): $301,500

TITLE OF PROJECT OR PROGRAM: Multiple Hazards Demonstration Project: The Shakeout Scenario for Southern California - Economic Consequences (*http://pubs.usgs.gov/of/2008/1150/*)

AGENCY: U.S. Geological Survey

PROJECT/PROGRAM DESCRIPTION:
The question is not if but when southern California will be hit by a major earthquake - one so damaging that it will permanently change lives and livelihoods in the region. How severe the changes will be depends on the actions that individuals, schools, businesses, organizations, communities, and governments take to get ready. To help prepare for this event, scientists of the U.S. Geological Survey (USGS) have changed the way that earthquake scenarios are done, uniting a multidisciplinary team that spans an unprecedented number of specialties.

The 'what if?' earthquake modeled in the ShakeOut Scenario is a magnitude 7.8 on the southern San Andreas Fault. The hypothetical earthquake was developed by considering the amount of stored strain on that part of the fault with the greatest likelihood of imminent rupture for a large earthquake. From this, seismologists and computer scientists modeled the ground shaking that would occur in this earthquake. Engineers and others used the shaking to estimate earthquake damage to buildings, roads, pipelines, and other infrastructure. From these damages, social scientists projected casualties, emergency response, and the impact of the scenario earthquake on southern California's economy and society.

The next phase of the Multi Hazards Demonstration Project will focus on a flooding and landslide scenario throughout California.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
By examining the consequences of one hypothetical earthquake and the dynamic interactions among elements of our physical infrastructure and economic and social systems, the ShakeOut Scenario is helping to identify potential points of failure and places where relatively small efforts or investments *before* the next earthquake could yield tremendous benefit *after* the earthquake (Perry and others, 2008).

In addition, the ShakeOut Scenario found that previous efforts to reduce losses through mitigation before the event have been successful. There are more actions and policies that could be undertaken at the individual and community levels to further reduce losses. For instance, actions to improve the resiliency of water delivery systems would reduce the loss from business interruption, as well as reduce the risk of catastrophic conflagrations. At an individual and business level, actions to secure non-structural items in buildings and retrofitting existing structures will greatly reduce individual risk. Planning and preparedness can improve personal and business resiliency (Jones and others, 2008).

Addressing the five major areas of loss identified could provide benefits in possible future disasters. The five major areas of loss include:

Older buildings built to earlier standards.
Non-structural elements and building contents that are generally unregulated.
Infrastructure crossing the San Andreas Fault.
Business interruption from damaged infrastructure, especially water systems.
Fire following the earthquake.

Publications:

The ShakeOut Earthquake Scenario—A Story That Southern Californians Are Writing, 2008. U.S. Geological Survey Circular 1324, California Geological Survey Special Report 207, version 1.0

By Suzanne Perry, Dale Cox, Lucile Jones, Richard Bernknopf, James Goltz, Kenneth Hudnut, Dennis Mileti, Daniel Ponti, Keith Porter, Michael Reichle, Hope Seligson, Kimberley Shoaf, Jerry Treiman, and Anne Wein

The ShakeOut Scenario, 2008. U.S. Geological Survey Open File Report 2008-1150 California Geological Survey Preliminary Report 25, version 1.0.

By Lucile M. Jones, Richard Bernknopf, Dale Cox, James Goltz, Kenneth Hudnut, Dennis Mileti, Suzanne Perry, Daniel Ponti, Keith Porter, Michael Reichle, Hope Seligson, Kimberley Shoaf, Jerry Treiman, and Anne Wein

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): Partners include the Bureau of Labor Statistics, Caltrans, Southern California Association of Governments, City of Torrance, City of Palm Springs, San Pedro Ports, SoCalfirst (banking consortium), CA Trucking Association, Metropolitan Transit Authority, Southern California Gas Company, and the Water districts including MWD, LADPW,

PROJECT PERIOD: May 2007 to May 2010

FUNDING LEVELS (CURRENT): $360,000

TITLE OF PROJECT OR PROGRAM: The Water Environment of Cities (workshop) (*http://www.springer.com/environment/environmental+management/book/978-0-387-84890-7*)

AGENCY/INSTITUTION: NSF

PROJECT/PROGRAM DESCRIPTION (Project summary of proposal): The proposed workshop *The Water Environment of Cities: Adapting to Change* was an important step in the evolution of a holistic, interdisciplinary approach for managing the urban water environment that recognizes water as a core organizing concept for urban design. The proposed workshop will be the culmination of a book project, *The Water Environment of Cities* and a prolegomenon for future efforts to better understand and manage the urban water environment. Workshop participants (chapter authors, plus a small number of others) have expertise in surface and groundwater hydrology, civil and environmental engineering, environmental policy, urban planning, law, geomorphology, and recreation management. The main target audience for the book is graduate students across the many disciplines involved in water resources. Key themes for the proposed workshop and the book are: (1) water scarcity, (2) multiple uses of water, (3) water management institutions, (4) formation on new knowledge, (5) sustainability, and (6) resilience.

Outcomes from the workshop will include a workshop report, a synthesis chapter for the book and at least one journal article. The workshop report will focus on the process used in the workshop and key results. The synthesis chapter will be written in a didactic fashion to tie topical chapters of the book together. The journal article will be more heavily referenced, more theoretical in nature, more speculative, and will conclude with an "agenda for the future."

Managing the water environment of the world's burgeoning urban population is one of the critical needs for humanity. The broad impact of this workshop will be to create a more holistic, integrated concept of urban water management. One of the key ways this broader impact will be achieved is by integrating these concepts directly into graduate water resources education, using the resulting book, *The Water Environment of Cities*, as a teaching text for the next generation of water resources practitioners and scholars. Diffusion of these ideas will occur quickly because most of the participants in the workshop/book project teach courses in water resources.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
1. Baker, L (editor). 2009. The Water Environment of Cities. Springer Scientific, Lowell, MA.

2. The Water Environment of Cities: Adapting to Change. 2009. Workshop held at the Riverwood Inn, Otswego, Minnesota, January 16-18, 2008. NSF Project CBET 0739952

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL): None

PROJECT PERIOD: Completed in 2008

FUNDING LEVELS (CURRENT OR PROPOSED): $45,000

TITLE OF PROJECT OR PROGRAM: Opposition to Green Economy Investments: Where and Why is it Emerging?

AGENCY/INSTITUTION:
Cornell University, Department of City and Regional Planning

PROJECT/PROGRAM DESCRIPTION:
Everyone can agree on the need to build a "green" economy when it is *your* community that is targeted for a wind farm, a bio-fuel processing plant, new transmission lines, or new regulations to promote energy efficiency, however, problems occur and opposition begins to arise. This research/action project responds to a clear need to understand: (1) how different types of communities respond to alternative energy investments and (2) what happens "on the ground" when projects are proposed and realized. This project has two goals. The first is to provide local policy makers with the information they need regarding the potential impact of alternative energy investments, both positive and negative. The second is to develop knowledge about "real" alternative energy investments and their impact on communities. One premise of this project is that not all investments labeled "green" are good for the environment or the community. Another is that local policy makers face substantial uncertainties in making decisions about what is best for their community. This project will develop information that aids their decision-making about green investments in the city or community, presenting what is known about both the upside and downside of these investments. It will also provide state and national policy makers with knowledge about the sources of community opposition to alternative energy investments. The project results will be presented in a series of policy briefs aimed at local officials and via a Web site*: www.GREEENCHOICES.cornell.edu*. The initial project research will focus on controversies affecting New York State cities and communities but resources and good practice examples will be drawn from national sources.

RESULTS, OUTCOMES OR IMPACTS TO DATE:
Initial research has led to the development of a Web site *www.GREENCHOICES.cornell.edu* and a policy report assessing the methods used in evaluating the local economic impact of ethanol plants.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
The research is supported by a small grant through The U.S. Department of Agriculture program that provides seed money research support to faculty in land grant Universities.

PROJECT PERIOD:
The initial one-year grant ends October 1, 2009. A second small grant will support some continued website development.

FUNDING LEVELS (CURRENT OR PROPOSED):
($20,000 - $28,000)

TITLE OF PROJECT OR PROGRAM
Eliminating Barriers to Transit-Oriented Development
(*http://policy.rutgers.edu/vtc/tod/documents/FHWA-NJ-2010-002%20Eliminating%20Barriers%20to%20Transit-Oriented%20Development.pdf*)

AGENCY/INSTITUTION
New Jersey Dept. of Transportation
Daniel Chatman, PI

PROJECT/PROGRAM DESCRIPTION
The research in this project centers on answering the question, "What are the barriers to housing projects approval near transit (TOD— which is considered a necessary element in sustainability planning) in New Jersey?"

RESULTS, OUTCOMES OR IMPACTS TO DATE
Project is on-going. Researchers have finished gathering data from households near transit, barriers to TOD, and observing parking practices. Professor Chatman is now synthesizing the information in a report.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL)
N/A

PROJECT PERIOD
This research project started in 2007 and will be finished in December 2009.

FUNDING LEVELS (CURRENT OR PROPOSED)
$164, 000 (current)

TITLE OF PROJECT OR PROGRAM
EFRI-RESIN: Assessing and Managing Cascading Failure Vulnerabilities of Complex, Interdependent, Interactive, Adaptive Human-based Infrastructure Systems
(*http://nsf.gov/awardsearch/showAward.do?AwardNumber=0835989&WT.z_pims_id=503431*)

AGENCY/INSTITUTION
National Science Foundation (NSF) under EFGRI Grant No. 0836047.
Principal Investigator: Robert Bea (Engineering)
Co-Principal Investigator: Karlene Roberts (Haas Business School)
Co-Principal Investigator: John Radke (LAEP-DCRP, College Environmental Design)

PROJECT/PROGRAM DESCRIPTION
Assessing and Managing Failure Vulnerabilities of Infrastructure Systems: Resilience and Sustainability of the California Sacramento Delta Region Interconnected Critical Infrastructure Systems
Our regional focus studies the California Sacramento—San Joaquin Delta flood protection, water distribution, and power supply systems. These systems are embedded in a complex and sensitive ecosystem that co-exists with other important ICISs such as communications, transportation, and emergency services. The ultimate goal of this research is to learn how to improve the resiliency and sustainability of ICISs while maintaining other vital performance characteristics such as serviceability, safety, durability, and compatibility.

RESULTS, OUTCOMES OR IMPACTS TO DATE
This research includes a collaborative interdisciplinary research team to create, validate, and apply new Risk Assessment and Management (RAM) methods to assess and improve the design, operation, and maintenance of interdependent complex infrastructure systems (ICISs).

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL):
Howard Foster, Ian Mitroff

PROJECT PERIOD
N/A

FUNDING LEVELS (CURRENT OR PROPOSED)
Award amount to date: $1,999,964

TITLE OF PROJECT OR PROGRAM
Impact of Global Warming on California's Urban Forests

AGENCY/INSTITUTION
Department of Environmental Science, Policy, and Management UC Berkeley
Department of Landscape Architecture and Environmental Planning UC Berkeley
Joseph McBride, PI

PROJECT/PROGRAM DESCRIPTION
Global climate change presents a critical challenge to sustainability of trees in cities throughout the United States and in other parts of the world. Many commonly planted urban tree species will no longer be able to survive as the climate becomes warmer and drier. The research proposed in this study will investigate changes in the composition of California's urban forests in response to global warming. Surveys of urban forest managers across climate zones, surveys of arborists at regional conferences, and measurements of chlorophyll fluorescence will be used to project the fitness of common urban trees for changing climates. The three sources of information will be combined to produce lists of trees suitable for cities in different parts of California as the climate becomes warmer. Lists will also be generated of trees not expected to survive the warming of cities in the state. These lists will be used to advise arborists, landscape architects, and urban forest managers on probable future response of urban tree species to climate change. California presents an unusual opportunity for this study because of its extensive range in temperature zones, recently developed models predicting climate change on a regional level, and an active community of arborists and urban foresters. Results from the study will have direct application to states neighboring California and the methods developed will be useful in conducting similar studies in other regions. The objectives of this project are to determine how tree species in California's urban forests will be affected by global warming and the implications of global warming for urban forest planning and management. The study will contribute to the knowledge of the urban forest's response to global warming and will inform arborists, landscape architects, and urban forest managers about appropriate species for future urban forests in California. The study will also add to our basic knowledge of how tree species from different parts of the world respond to increasing leaf temperatures.

RESULTS, OUTCOMES OR IMPACTS TO DATE
The expected outcomes will be lists of trees appropriate to the future climates of various cities in California and species that are not expected to survive increasing urban temperatures.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL)
N/A

PROJECT PERIOD 2009-2012

FUNDING LEVELS (CURRENT OR PROPOSED)

"Urban forest composition, structure, and function in the world's biomes" Farrand Fund for Research in Urban Forestry - $20,000 (2008 to 2010)

"Plant succession in the grasslands of Mt. Tamalpais State Park" California Department of Parks and Recreation - $97,000 (2007 to 2010)

TITLE OF PROJECT OR PROGRAM
Shrinking Urban Transportation's Environmental Footprint Evidence on Built Environments and Travel from 370 U.S. Urbanized Areas
(*http://www.envplan.com/abstract.cgi?id=a4236*)

AGENCY/INSTITUTION
National Science Foundation
Robert Cervero, PI

PROJECT/PROGRAM DESCRIPTION
Concerns over rising fuel prices and greenhouse gas emissions have prompted research into the influences of built environments on travel, notably vehicle miles of travel (VMT). Based on data from 370 U.S. urbanized areas and using structural equation modeling, population densities are shown to be strongly and positively associated with VMT per capita, however this effect is moderated by the traffic-inducing effects of denser urban settings having denser road networks and better local-retail accessibility. Accessibility to basic employment has comparatively modest effects as do size of urbanized area and rail transit supplies and usage. Still, urban planning and city design should be part of any strategic effort to reduce the urban transportation sector's environmental footprint.

RESULTS, OUTCOMES OR IMPACTS TO DATE
The results demonstrate that higher densities are not sufficient, by themselves, to substantially lower transportation-related VMT and GHG emissions, and need to be supplemented by attention to road and community design and regional planning – such as jobs-housing balance and mixed-use integration—to leverage significant impacts.

PERFORMERS/OTHER PARTNERS (FEDERAL, STATES, OR LOCAL)
Robert Cervero, PI

PROJECT PERIOD
July 2007 to June 2009

FUNDING LEVELS (CURRENT OR PROPOSED)
$150,000