MEETING SUMMARY

PARTNERSHIPS, SCIENCE, AND INNOVATION FOR SUSTAINABILITY SOLUTIONS

A SYMPOSIUM

Science and Technology for Sustainability Program
May 16-18, 2012

Achieving the goal of sustainability, meeting human needs while conserving ecosystems, their components, and functions, requires a continuous process of scientific innovation, new integrative knowledge, and collaborative approaches to implementing technologies and policies. It is imperative that the science community collectively assess the state of sustainability, prioritize research needs, understand the needs of decisionmakers and users of the science, and build partnerships in an effort to effectively meet current and future sustainability challenges. To date, there has been no commonly accepted operational framework for how to move forward in addressing sustainability challenges.

To address this need, the National Research Council organized a three-day public symposium at the request of the National Science Foundation (NSF) to better define the issues and forge new collaborations. The symposium featured invited presentations and discussions to showcase federal investments and institutional structures regarding sustainability; identify opportunities to help promote practices that would lead communities toward sustainability; and better communicate the central role of science and innovation in understanding and adopting sustainable practices. The symposium included panels, plenary and breakout sessions addressing a variety of sustainability concepts and discussing examples of successful partnerships, communication and outreach efforts, sustainability metrics, infrastructure and data needs, and international sustainability initiatives. Participants included representatives from federal, state, and local governments, the private sector, academia, nongovernmental organizations, and international bodies involved in sustainability issues.

THE NATIONAL ACADEMIES
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Several themes related to partnerships and advancing the science were voiced by multiple participants:

- The need for research approaches that are problem- and solution-driven and user-inspired. As many participants pointed out, science and technology for sustainability may not be reaching or meeting the needs of decision makers or users of the science, and effective partnerships will be key to bridging this gap. Strategic, durable partnerships between researchers and stakeholders are needed.
- The critical role of involving stakeholders in better defining sustainability challenges. Building the capacity to engage stakeholders is a key opportunity.
- The need to better communicate research results to nonresearch communities.
- The importance of collaborative coproduction and interdisciplinary teams in successful partnerships. The need to integrate sustainability efforts across disciplines and engage stakeholders was repeatedly discussed, as was the need for coordination of government assets and capacity at the regional level.
- The importance of creating efficiencies by building on and linking to existing networks rather than creating new systems.
- The need for a clear vision or set of grand challenges that define the future of sustainability science and drive problem-driven research and development. An assessment of the adequacy of science and technology for sustainability is needed to achieve these goals.
- The importance of demonstration projects with solutions that can overcome barriers to sustainability. Some workshop participants noted that further research is needed to develop place-based approaches and understand knowledge systems, including networks and investments.
- The need to manage the interface between science and policy to advance sustainability. This means actively managing relationships and understanding the context for using adaptive management, some participants noted.

Other opportunities include getting better outcomes from what we already know, managing expectations, and fostering a culture of change, various participants pointed out.

The keynote speakers opened the symposium by describing the significance of the challenges the world faces in developing sustainability solutions. **Pamela Matson** of Stanford University noted needs for new integrative knowledge, technologies, tools, and approaches for linking knowledge to action; for educating leaders and the public; and for strong leadership by corporations, citizens, governments, nonprofits, and universities. Research must be reoriented so that science can better address the needs of decision makers, Dr. Matson said. She also noted the need for a focus on human-environment systems and on solutions to sustainability challenges, as well as for use-inspired fundamental research.

Ralph Cicerone, president of the National Academy of Sciences, stated that all organizations and institutions, including those participating in the symposium, will be essential in the overall human effort to meet sustainability challenges, which will require a sustained commitment to gathering data, evaluating outcomes, and steering a new course. Dr. Cicerone added that sustainability as a concept attracts great interest at all levels of government, from the global to the local level. Many of these governments are trying to develop clear plans for moving forward and structures to assess their own progress in this area. As we continue to define a focus on sustainability, communication and dialogue about these issues in groups similar to those at the symposium will be essential.

John Holdren, director of the White House Office of Science and Technology Policy, described key sustainability challenges and U.S. efforts to address these challenges, including eradicating extreme poverty; defeating preventable diseases; providing the energy our economies need without wrecking the climate our environment needs; adapting to the degree of climate change that can no longer be avoided; managing the intensifying competition for the planet's land, water, and biomass; stemming the toxification of terrestrial ecosystems; and maintaining the productivity and the ecological integrity of the oceans. Barriers to addressing these challenges include finding continued funding for sustainability work under current budget constraints and ensuring that key messages about sustainability are understood.

Subra Suresh, director of the National Science Foundation (NSF), stated that sustainability is analogous to an *in vivo* experiment where the outcome is so critical to our survival that we cannot take chances—it is highly risky, and the experiment is not clearly defined. Sustainability as a concept poses a great intellectual challenge, both for funding and for engaging young people, he said, adding that educating young people about sustainability is going to be key. From the NSF perspective, Dr. Suresh said, sustainability as an organizing principle is enormously helpful in fostering a unified vision for the agency. The Science, Engineering, and

Education for Sustainability (SEES) program, in particular, provides a strong example of an agencywide activity where every office and every directorate at NSF collaborates in both education and research (Figure 1).

In discussing sustainability, Dr. Suresh added, the intersection of the social, behavioral, and economic sciences with natural sciences and engineering should not be overlooked. NSF is in a unique position to integrate perspectives from those disciplines into the research that emerges from natural sciences, he said. Additionally, NSF supports sustainability work through collaborative international activities; strategic international collaborations are extremely critical because sustainability is neither a national nor a regional effort, he said. These collaborations include the Partnership for International Research and Education (PIRE), which has included sustainability as a central theme, as well as partnerships with the U.S. Agency for International Development that give NSF the ability to fund scientists in other parts of the world. Changes in one part of the world will significantly affect the quality of life in a diametrically opposite part of the world, said Dr. Suresh; we are not isolated in our pursuit of sustainability.

CURRENT STATE OF NSF AND INTERNATIONAL FUNDING FOR SCIENCE, TECHNOLOGY, AND INNOVATION FOR SUSTAINABILITY

Timothy Killeen, formerly of NSF, began the session by noting that rapid, multifaceted global change is upon us, challenging human well-being into the future. Dr. Killeen said that a knowledge base is needed to inform decisions at the local, regional, and global scales. He noted that the SEES program funds interdisciplinary research toward global sustainability, which builds upon NSF's international partnerships such as the Belmont Forum. The forum has a similar research priority—to deliver knowledge needed for action to mitigate and adapt to detrimental environmental change.

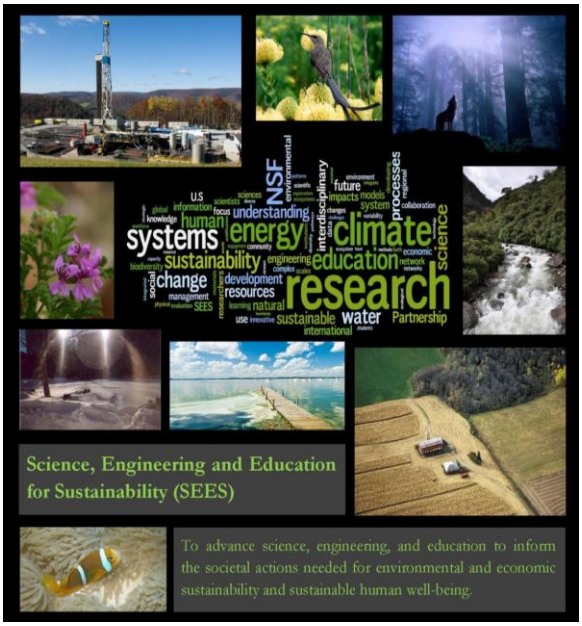

FIGURE 1 National Science Foundation Science, Engineering and Education for Sustainability Program (SEES)
SOURCE: Presentation by Timothy Killeen, NSF, May 16, 2012.

Susannah Scott of the University of California, Santa Barbara, described an international collaborative research program between the United States and several high-profile research groups in China focused on studying catalysis for sustainable energy production. As one of the first cohorts of the PIRE project, this program will combine research training in the United States with the opportunity to conduct experiments and learn new research techniques in China.

Holm Tiessen of the Inter-American Institute for Global Change Research stated that developing sustainability knowledge is a process of combining disciplines, requiring the involvement of stakeholders. Developing solutions will require networking and building the capacity of researchers to ask the right questions—of each other, of users of the science, and across the research network; this requires some relinquishing of authority and acceptance of network transaction costs. Dr. Tiessen added that developing solutions to sustainability challenges is not a linear process but requires flexibility and the ability to monitor action and reaction. He noted that it is important to be aware of the limits between science-based dialogue and advocacy.

Using his work in food sustainability as an example, **John Martin Anderies** of Arizona State University noted that the adaptive capacity of small-scale social-ecological systems is extremely important for sustainable food production. Therefore, it is important to link local governance structures into multi-level governance structures to address sustainability challenges.

F. Stewart Chapin of the University of Alaska, Fairbanks, described key issues from a 2009 NSF-sponsored workshop,[1] which included needing to foster a transition to sustainability, managing synergies and tradeoffs between human well-being and the environment, maximizing resilience and reducing vulnerability in coupled human-environment systems, and monitoring progress toward sustainability in those systems. There is a good fit between the goals and applications of

[1] Toward a Science of Sustainability, Report from Toward a Science of Sustainability Conference. [Online.] Available at: http://www.nsf.gov/mps/dms/documents/SustainabilityWorkshopReport.pdf [Accessed August 6, 2012.]

sustainability and the agencies capable of implementing them, Dr. Chapin said. In particular, there are agencies responsible for sustaining natural capital and ecosystems services and fostering human well-being. Accomplishing these tasks will require adaptive governance, which allows the agency to learn from its management experiences and incorporate those lessons into its management practices. Reaching these goals will also require design and funding for interdisciplinary monitoring rather than monitoring done by a single agency. How best to apply science and technology for sustainability is itself a crucial topic of research that must become an integral part of the field, said Dr. Chapin. Communicating science is also a challenge that requires effective engagement and dialogue between stakeholders, decision makers, and the general public.

International and National R&D Directions for Science and Technology for Sustainability

Several presenters identified key research directions that should guide international and national efforts to harness science and technology for sustainability. **Chad Gaffield** of the Social Sciences and Humanities Research Council of Canada recommended adopting a people-centered model of sustainability, which identifies human thought and behavior as the source of both the problem and the solution. Secondly, Dr. Gaffield noted that coproduction, codesign, co-execution, and co-application of research is needed and that geopolitically bounded research councils and universities need to adopt a collaborative approach. Although vertical structures are needed, it is important to understand how to cross and connect them in new ways, said Dr. Gaffield.

Nancy Creamer of North Carolina State University added that it is important for NSF to consider funding agriculture as an important component of its science portfolio. It will be necessary to push problem-driven research to the front, using the approaches of foresight and test beds, **Paulo Ferrao** of Technical University of Lisbon said; demonstrations are critical. Technologies, systems, and policies should be developed simultaneously because these are mutually reinforcing, stated Dr. Ferrao. Regarding international research, he added that formal mechanisms could be developed to promote this type of collaboration (Figure 2). **Alan Hurd** of Los Alamos National Laboratory added that countries that invest in sustainability can be more productive if they cofund research with other countries.

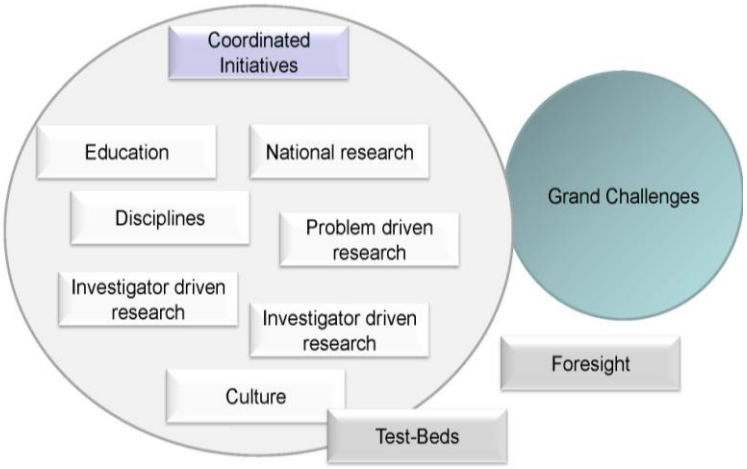

FIGURE 2 New Directions for Science and Technology for Sustainability.
SOURCE: Presentation by Paulo Ferrao, Technical University of Lisbon, May 16, 2012.

CHALLENGES OF LINKING SCIENCE AND TECHNOLOGY FOR SUSTAINABILITY WITH DECISIONMAKING

Effectively linking knowledge to sustainability decision making has been a key area of discussion in the sustainability field. **Amy Glasmeier** of the Massachusetts Institute of Technology introduced a session that explored how knowledge is currently being used for sustainability decision making and key areas where it can be used more effectively. **James Buizer** of the University of Arizona described National Oceanic and Atmospheric Administration's (NOAA) Regional Integrated Sciences and Assessments (RISA) program, which was developed to assist in realigning the nation's climate research. RISA projects typically feature participatory problem framing and problem solving, along with strong stakeholder involvement. Dr. Buizer noted that RISA teams span the boundaries between knowledge and action and require that outputs of basic research be integrated and translated in ways that make the research understandable by the nonresearch community. RISA programs have been an important test bed for learning how to apply the principles of effective decision support to inform decisions about adapting to climate change. Dr. Buizer stated that the program is driven by several operating principles that may be generalizable, such as being problem-defined and solution-driven; able to span the research-to-action barrier; translational; able to build community; and able to develop best practices and evaluation tools.

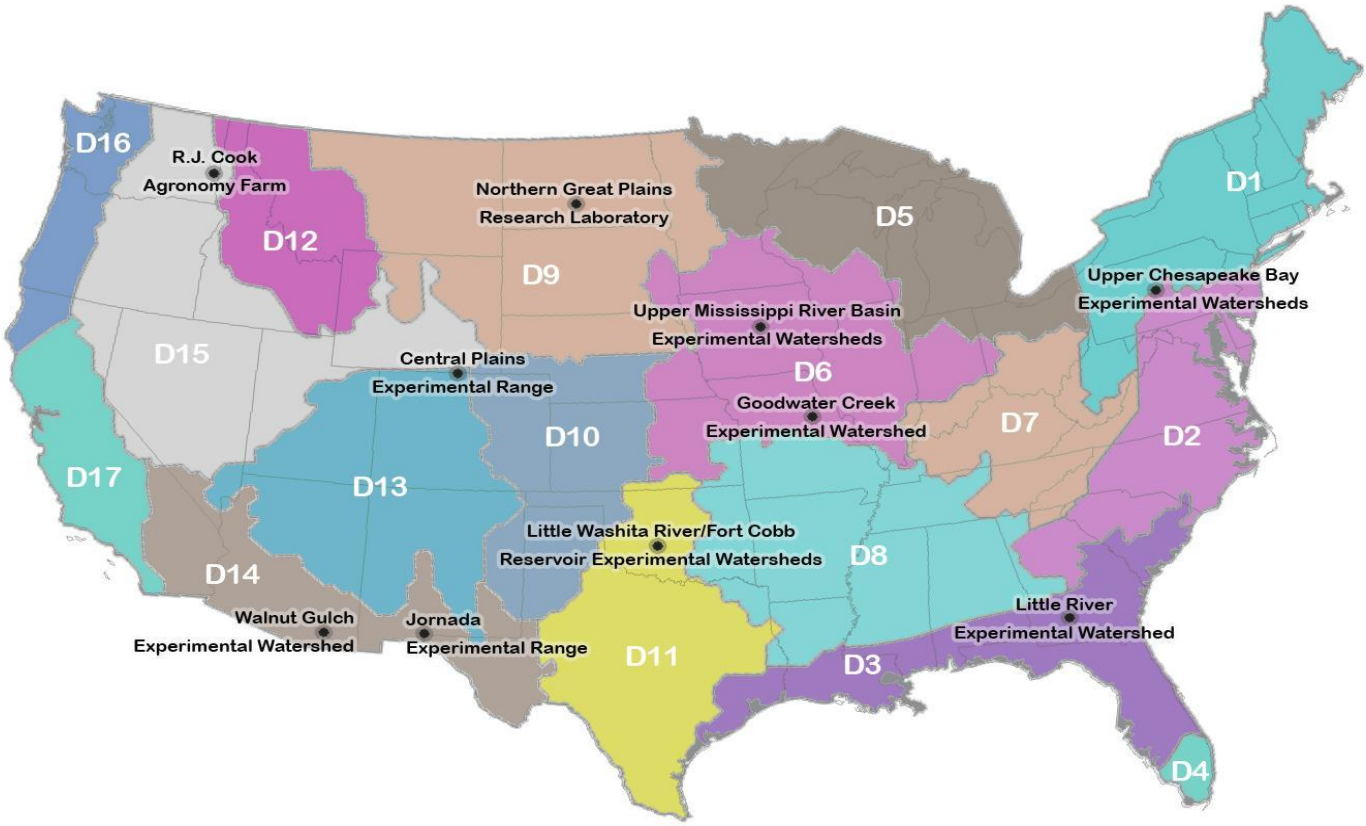

FIGURE 3 USDA's Long-term Agroecosystem Research (LTAR) Network and NSF's National Ecological Observatory Network (NEON) SOURCE: Presentation by Ann Bartuska, USDA, May 16, 2012.

Carlton Hershner of the Virginia Institute of Marine Science echoed the need for problem-defined, user-inspired, and solution-driven sustainability research, adding that use-driven science that is salient, credible and useful, and multidisciplinary should generally be more prevalent in the field. Dr. Hershner stated that one of the major challenges in sustainability is the length of time required for research programs; this can make it difficult to keep the science community, and particularly stakeholders, engaged. Both Dr. Buizer and Dr. Hershner agreed that engaging users from the outset will make research more useable.

Federal Agency Perspectives

Representatives of Federal agencies discussed their experiences in effectively linking knowledge with action. **Ann Bartuska** of the U.S. Department of Agriculture (USDA) described the Forest Service as an example of an agency within USDA that has embedded research into its activities, maintaining an ongoing dialogue between the managers and scientists on how to address emerging problems. Other operations within USDA also have mechanisms to engage others to determine research or high-priority needs; for example, the Agricultural Research Service engages stakeholders every five years to garner input on priorities. Also, USDA's Long Term Agro-Ecological Research (LTAR) sites have been integrated with NSF's National Ecological Observatory Network (NEON) (Figure 3). **Marcia McNutt** of the U.S. Geological Survey (USGS) stated that USGS has already incorporated sustainability into all of the agency's work, as evidenced by its recent reorganization. She added that it helps agencies to collaborate when they have written requirements that force them to do so. Similarly, **Glenn Paulson** of the U.S. Environmental Protection Agency (EPA) added that sustainability is a top priority of the Administrator and that the agency takes action based on the best available evidence.

Jeffrey Marqusee, who directs the tri-agency Strategic Environmental Research and Development Program, explained that the Department of Defense (DOD) has incorporated sustainability in its work in an effort to be more forward thinking, assure the availability of resources, reduce material use, increase efficiency, and ensure the agency's ability to meet its mission in the face of climate change. Sustainability is particularly important for DOD because the agency "is the largest consumer of energy in the world," Dr. Marqusee stated. He added that from DOD's

perspective, linking knowledge to action must involve demonstrations, because agencies typically will not take on risks without some real-world experience. To this end, DOD uses its buildings and lands as test beds for such demonstration projects.

NGO, Foundation, and Academic Perspectives on Linking Knowledge to Action

Lessons learned from the academic and NGO world provide valuable insights about opportunities to link sustainability knowledge to decision making. **Mary Ruckleshaus** of the National Capital Project said that working with partnerships of academics and NGOs to develop decision tools has shown the value of establishing an iterative science-policy process. Other lessons learned have included the need for simple, modular accounting tools and science products that can assist with priority setting, said Dr. Ruckleshaus; experience has also shown that scaling up projects can become easier as demonstration projects illustrate the value of the work. **David Orr** of the Oberlin Project commented that despite the dramatic shifts in science over the past few decades, encompassing the full spectrum of sustainability will require a community organized around renewable energy, policy and law, education, communication, economic revitalization, community mobilization, and agriculture and forestry. To make an impact, there needs to be a change in thinking, paradigms, and beliefs, said Dr. Orr.

From an Academic perspective, **Anu Ramaswami**, University of Colorado, Denver, discussed her work on urban sustainability issues, particularly through partnerships with the city of Denver to develop ways to better measure and report greenhouse gas emissions associated with the city's activities.

Peter Kareiva of the Nature Conservancy noted that the concept of sustainability is widely accepted; however, operationalizing and developing measures of sustainability remain key challenges. The scientific community needs to reach consensus on metrics for sustainability, said Dr. Karieva. In the private sector, he said, corporations have developed sustainability measures based on their carbon footprint. He added that we need to move beyond carbon counting to a richer vision of sustainability that is more fully integrated. Current thinking about sustainability tends to be framed as a "balance sheet" of decisions, where the focus should be on the probability of collapse or tipping points. Sustainability metrics should incorporate the concept of a "tipping point" or "the probability of collapse in the next ten years," stated Dr. Karieva. **Barry Gold** of the Moore Foundation said that foundations are moving toward incorporating sustainability concepts but are looking for guidance in terms of sustainability principles and ways to operationalize ecosystems services. He added that the NGO and business communities need to be considered more when designing messages or communicating scientific information to decision makers.

Andrew Rosenberg of Conservation International remarked that more consistent language is needed to inform policymakers about sustainability issues in a coherent way. While it is commonly thought that policymakers lag in their understanding of science issues, this is a misconception; policymakers are often out in front of an issue and are waiting for advice. The largest need is finding a way to engage scientists across a broader set of issues, not just individual issues. Similarly, **Angela Ledford Anderson** of the Union of Concerned Scientists said that science still has high credibility with the public. Linking science and technology for sustainability with decision making requires making the information accessible and communicating it in such a way that it is useful to many audiences, she stated.

Corporate Perspective

The corporate sector is often cited as embracing sustainability as an organizing principle, but it still struggles with how to bring science–particularly basic science—into the business equation, stated **Neil Hawkins** of Dow Chemical Company. Dr. Hawkins described Dow's long-term efforts to incorporate sustainability into its work, including developing specific long-term plans and goals, and supporting training, fellowships, and research, including collaborative research with universities and with NGOs such as The Nature Conservancy. From the food and agricultural sector's perspective, **Harold Schmitz** of Mars Inc. noted that the current state of science in food and agricultural areas is thin, largely near-term oriented, and driven by markets. Unless federal agencies such as NSF, National Institutes of Health (NIH), and USDA make a concerted and intentional investment in these areas, activity to further the science is likely to be limited. He added that several factors are critical in furthering science in the food and agriculture sectors, including developing explicit strategies for both precompetitive research and for the next generation of scientists that revolves around convergence thinking.

Jason Busch, Executive Director of the Oregon Wave Energy Trust (OWET), described the work of this public-private partnership, which is funded by the state and has direct ties to industry. OWET provides an example of a partnership that works closely with the university system, the federal laboratories, and the various state, local and federal agencies.

Linking Knowledge to Action—What Works and What Doesn't: Synthesis of Scholarly Research

William Clark, **Granger Morgan**, and **Rajesh Gupta** provided a synthesis of scholarly research on linking sustainability knowledge to action. Dr. Clark, of Harvard University, identified three overarching barriers that have limited the potential of research in the sustainability field. The first is mutual incomprehension between scientists and decision makers; addressing this challenge will require moving away from pipeline models of technology transfer and promoting more collaborative production of trusted knowledge by stakeholders. There is also a need for individuals and organizations to play boundary-spanning roles, facilitating communication across a variety of "cultural" boundaries (e.g., scientist-farmer). The second barrier is fragmentation of the knowledge system, Dr. Clark said. To address this fragmentation, systems integration will be needed, along with incentives to encourage research to address the "missing" parts. These changes will require a more realistic understanding of the central role of use-inspired research. The final barrier is inflexibility; there are significant institutional incentives to hide failures rather than document them. To address this there need to be safe spaces for scientists to work and innovate. Successful agents of change find what the Office of Naval Research calls places to hide it from the admirals, or safe environments where research can be conducted without fear of having to document failure.

Granger Morgan of Carnegie Mellon University provided an overview of the literature on decision making under uncertainty, public perceptions, and public engagement. Dr. Morgan discussed the use of formal quantitative expert elicitation in addressing uncertainty, noting that this process is important but difficult to do well.

Qualitative expressions mean different things to different people and to the same people in different circumstances; quantitative assessments can be easy only if large amounts of data are available. Dr. Morgan discussed limitations in the use of scenarios and integrated assessment models and the development of mental models and studies of public understanding of issues like climate change. Finally, he noted that there are many strategies and tools available on fostering public engagement, including several that he has been developing, such as a Web tool for the International Risk Governance Council, to help people in their review of this literature.

Rajesh Gupta of the University of California, San Diego, stated that sustainability as a subject is changing the nature of the institution in which the research is done. The university is becoming a natural place for society's expression of what it wants to become, said Dr. Gupta, noting that his laboratory is experimenting with energy efficiency initiatives, particularly in buildings. He discussed computer applications currently being developed at UCSD to achieve a hundredfold reduction of energy use in buildings, taking into account human behavior, the physical operations of buildings, and other factors. The university is proposing now to build a test bed energy efficiency facility.

Six out of the 14 National Academy of Engineering grand challenges for engineering[2] are related to computing, and NSF has a big role to play in this, Dr. Gupta said; universities and their chairs look to NSF for the source of inspiration, for identification of the problems, and for the means to solve them.

OPPORTUNITIES FOR SCIENCE AND TECHNOLOGY FOR SUSTAINABILITY AND FOR MAKING IT HELPFUL TO DECISION MAKING

Several breakout groups were tasked with identifying key science and technology needs, as well as opportunities and challenges related to several areas: data needs for sustainability; tools and methodologies; energy, hazards, and climate change; food, water, and habitation; and education and workforce needs. Table 1 includes a summary of these discussions.

Opportunities and Needs for Science and Technology for Sustainability

Kathy Jacobs of the White House Office of Science and Technology Policy identified several opportunities to move the field forward. In particular, Ms. Jacobs stated that managing the interface

[2] The 14 grand challenges include: make solar energy economical; provide energy from fusion; develop carbon sequestration methods; manage the nitrogen cycle; provide access to clean water; restore and improve urban infrastructure; advance health informatics; engineer better medicines; reverse-engineer the brain; prevent nuclear terror; secure cyberspace; enhance virtual reality; advance personalized learning; and engineer the tools of scientific discovery. National Academy of Engineering. 2012. Grand Challenges for Engineering. [Online.] Available: http://www.engineeringchallenges.org/ [Accessed August 7, 2012.]

TABLE 1 - KEY SUSTAINABILITY CHALLENGES AND OPPORTUNITIES DISCUSSED DURING BREAKOUT SESSIONS

	CHALLENGES	OPPORTUNITIES
TOOLS AND METHODS		
Data Needs for Sustainability	• Data are easier to collect than convert into useful information • Costs to develop and maintain data over the long term • Sustainability data comes from highly coupled system, compositionality is important in monitoring and analysis • Privacy and security of the data while making it available and accessible	• Improved sustainability through better data-base decisions • Human-centered benefits: situation awareness for machine and human monitoring • Development and validation of models and ability to create new theories • Repurposing old data and combining disparate data sets • Innovations in new and open infrastructure services (industry, government, universities)
Tools/Methodology for Sustainability Analyses and Linking to Decision Making	• Context and values are critical • Importance of integration and synthesis across tools/three pillars and from data that inform through to decisionmaking	• Interoperability of data • Importance of screening tools; the need to get early buy-in from the communities • Uncertainties, i.e., problems versus opportunities; we do not need full information to make decisions
CRITICAL SUSTAINABILITY ISSUES		
Energy, Hazards, and Climate Change	• Assessing actions to be taken today vs. long-term changes necessary for transforming policy infrastructure and center structures	• Need for policies to facilitate incentives for both small and large-scale infrastructural and institutional changes • Need to couple decision and social science with the technological systems and the environmental risk
Food, Water, and Habitation	• Need for communication strategies	• Need for funding for fundamental, use-driven research • Collaboration across existing institutions needed (e.g., NSF, USDA, NIH)
INSTITUTIONAL ISSUES		

University and Science and Technology for Sustainability/Educational and Workforce Approaches for Sustainability	• What are the core problem-solving skills of a sustainability student? Is there a core, and how is it defined?
	• How do we measure learning? What are skills that we are imparting?
	• Tension: sustainability as a standalone vs. spread throughout curriculum
	  ○ Lack of data about job market
	  ○ Engineering (problem solving)/Science (advanced knowledge rather than solving problems)
		• Collaboration
		• Learning networks – how to bring together information on what is being learned?
		• Professional masters – how to fund this?
		• Student demand for programs is increasing
		• International collaboration

between science and policy is a critical tool for sustainability, and it requires actively managing relationships and understanding the context for using adaptive management. Other key opportunities include getting better outcomes from what we already know, managing expectations, fostering a culture of change, asking the right questions, and building the capacity to engage stakeholders. Building on and linking to existing networks rather than creating new systems can create efficiencies, Ms. Jacobs noted, adding that the convening function is critical in supporting these networks. Finally, coordinating government assets and capacity at the regional level will be essential. **Dietmar Kueltz** of the University of California, Davis, added that the concept of resilience in the context of sustainability and global change is important for many reasons, but in particular, it illustrates the lengthy timeframe needed when considering sustainable actions.

This timeframe is critical to consider in developing appropriate metrics, he said. **Diana Liverman** of the University of Arizona added that rigorous metrics of success are needed; the lack of baseline data is a predominant concern. Dr. Liverman also said that if more researchers focused on educating about what they do or the "sustainability basics," this might improve their prospects for funding. For example, sustainability research is currently being conducted to ensure water, food, and energy security, and these are all areas that the public is interested in and should know about. Dr. Liverman added that making sustainability a high key issue at the international level should be a priority; conversely, there is also a need to evaluate what international action means for demands on science and technology for sustainability.

John Wingfield stated that standards are needed, as well as a national network to develop a consensus on standards, including how data should be made accessible to PIs and their students. This is linked to another significant challenge, the management of large datasets, including how data are stored and how data management will be funded. Dr. Wingfield added that there is enormous potential for research in synthetic biology, a field that will significantly impact the future of agriculture and provide new sources of fuel, vaccines, pharmaceuticals, and biomaterials. Finally, Dr. Wingfield noted that it will be crucial to strengthen the pipeline for STEM education to ensure that the best talent is being cultivated.

CREATING PARTNERSHIPS FOR SUSTAINABILITY

Several keynote speakers provided insights about the importance of partnerships in promoting sustainability best practices.

Undersecretary of State **Robert Hormats** observed that there are many effective organizations--such as the World Bank, International Monetary Fund, and the World Trade Organization—that were not designed to address the kinds of issues society and the world are grappling with today. These organizations were largely established before the emergence of the Internet and in a period when nation states and borders meant something.

Today, however, borders have less significance, and more collaboration takes place across these borders, Dr. Hormats said. He noted that virtually every problem we face today cannot be dealt with by just one or two or five or ten countries. Developing solutions to these global issues—such as pandemics and challenges related to agriculture, water, and energy—requires the collaboration of many countries and a much greater emphasis on innovation in science and technology. Today's institutions were not designed with this type of collaboration in mind.

Science and technology are at the center of sustainability, but their role is changing, Dr. Hormats said. The focus is shifting from information technology to areas such as energy and agricultural technology, and there needs to be an environment that fosters creative innovation in these areas. He added that a greater emphasis is needed on science in diplomacy; the ability of the U.S. to lead in any area depends on a strong and robust scientific community, vibrant innovation, and support for a strong educational system to get more people engaged.

Alex Dehgan of USAID added that the value of science and technology cannot be underestimated. He described his agency's efforts to launch a program on "grand challenges" in the developing world. Because the next century will belong to the developing world, he said, these grand challenges provide opportunities to harness the power of global efforts in interconnectedness. USAID has created partnerships to foster the creativity that the developing world has demonstrated in terms of world-class solutions to some of these grand challenges, Dr. Dehgan said, stressing that science, technology, and engineering are at the core of development. USAID is partnering with other federal science agencies and other organizations to increase the availability of data for the development of foresight analyses, as well as to

develop tools for addressing grand challenges.

Some key issues for the agency include identifying tools for powering agriculture and fostering open-source approaches to development. The latter priority was inspired by the Indian government's initiatives to develop drugs through open-source collaborations involving more than 50 countries. Ultimately the goal is to develop a funding stream that encourages people to use collaborative approaches throughout the research process—from doing the research to writing up the publications—that will foster this interconnectedness.

Understanding Local, Federal, and International Partnerships

Successful research partnerships at the local, federal, and international levels provide examples of lessons learned in linking knowledge to action and demonstrate how federal agencies and others can collaborate despite their varying missions and goals.

Sally Ericsson of the Office of Management and Budget (OMB) stated that partnerships are critical to advancing sustainability throughout the federal government in order to protect and restore our nation's natural resources. She described some ongoing federal partnerships, including the Partnership for Sustainable Communities, in which EPA, the U.S. Department of Housing and Urban Development (HUD), and the U.S. Department of Transportation (DOT) collaborate with the goal of providing homes in livable communities, transportation options that reduce greenhouse gas emissions and other air pollution, and vibrant and healthy communities. One particular achievement of this partnership is the redevelopment of the Fairmount Corridor in Boston, where DOT is supporting an upgraded infrastructure by refurbishing and building transit stations; HUD is building new affordable homes near the stations; and EPA is helping to clean up nearby Brownfields. Going forward, HUD, DOT, and EPA will continue to work on this partnership, providing technical assistance and tools and sharing milestones of their success to encourage other communities to take a similar approach.

Ms. Ericsson described several other federal agency partnerships, including the America's Great Outdoors initiative; the National Fish Habitat partnership; and the National Oceans Policy, among others. She added that for agencies with common goals, targeting limited resources is especially important. A challenge facing all who care about sustainability is ensuring that the behavior of the agencies is changing, so that the new, collaborative approaches to problem solving last. OMB is to continuing to focus its efforts on developing interagency collaboration with common goals, outcomes, and metrics.

Prabhu Pingali of the Gates Foundation stated that sustainable small holder food production systems should be a key area of focus for the sustainability field. The scope of rural poverty issues cannot be underestimated and will require targeted efforts to improve agricultural productivity, he said. The complexity of the agricultural yield gap is clear; new technologies, knowledge, and markets are needed, but partnerships are also necessary to close the gap. The challenge will be to promote sustainable agricultural intensification while minimizing environmental and social costs. The Gates Foundation is heavily involved in work supporting research in sustainable intensification through partnerships with other entities, including federal and international agencies, NGOs, and the private sector.

Deborah Swackhamer of the University of Minnesota discussed the work of a National Research Council committee tasked with identifying the linkages among areas such as energy, water, health, and biodiversity that are critical to promoting and encouraging long-term sustainability within the federal regulatory framework. Dr. Swackhamer described the committee's approach to its task and noted that many of the themes discussed during the symposium would be critical to the committee's work.

Federal Agency Perspectives on Creating Partnerships

Several federal agencies reflected on the challenges and opportunities for partnerships for sustainability. **Cora Marrett** of NSF introduced the session, noting that we need to move beyond recognizing our common interests in sustainability to building on complementarities and synergies. Dr. Marrett added that it is problematic if NSF is unable to make connections between what the agency supports in terms of science and technology for sustainability and the contributions this research makes towards solving key problems facing the nation. NSF will be working to understand the kinds of partnerships necessary to do this type of "connecting" and, as a follow up to the symposium, the agency will be thinking about what can be learned from the discussions that will have implications for what the NSF does in partnership with others.

Jane Lubchenco of the National Oceanic and Atmospheric Administration stated that the agency's thinking about sustainability has evolved

considerably over the last 10 years, including their thinking about the scale of sustainability, which is not just global but operates at many different spatial and temporal scales. There is now more focus on the deep interdisciplinary connections that are required to understand what sustainability means and how to convert knowledge to action. This new focus is not just limited to incorporating social sciences into the discussion but to understanding behaviors that drive actions and having the problems be codefined from the outset by multiple perspectives. A corollary to this, Dr. Lubchenco added, is the key role of involving not just scientists, but the users of the information in defining the problem, the knowledge needed, and the solutions. Another element in this theme is a focus on ecosystem services as an integrator and a linkage between humans and the ecosystems of which they are a part. This new lens of ecosystem services—which is embodied in the Millennium Ecosystem Assessment and now the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services framework—is very appropriate.

Similarly, the role of science is evolving, Dr. Lubchenco said. Historically, science was seen as a process solely conducted by scientists with the product delivered to society. Recently there has been a move to include users of the science throughout the process, including defining the problem, designing the research, and implementing actions. This type of use-inspired science should be emphasized, said Dr. Lubchenco; partnerships are key to this process, and transboundary organizations are needed to bridge the gap. She added that we need not just think tanks, but do tanks. There is a desperate need for knowledge for action, so that as scientists we can make better use of the knowledge we currently have and create more of what we need.

Partnerships are not a sign of failure; rather, agencies are doing things through partnerships that could not have been done in the past. Partnerships arise through situation-specific recognition of the mutual benefits of working together by those in power to assign resources and rewards, said **Paul Anastas** of Yale University. The National Science and Technology Council's Committee on Environment, Natural Resources, and Sustainability, which Dr. Anastas previously co-chaired, focused on ways to develop collaborations and partnerships among federal agencies. Identifying ways to bridge the missions of the agencies was tremendously difficult for the committee, Anastas said. He noted that operationalizing partnerships for sustainability is crucial to advancing knowledge-action networks. He added that to achieve sustainability there is a need for metrics and incentives but cautioned about the zeal for quantification: Not everything that can be counted counts, and not everything that counts can be counted. Moving forward, developing conceptual frameworks for sustainability will be critical. Dr. Anastas added that if we are going to enable the types of disruptive innovations that will be required to move to a sustainable trajectory, it may be necessary to develop frameworks in order to design tomorrow to be different from today.

Jonathan Powers of the Council on Environmental Quality discussed the Administration's sustainability efforts, including Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance, which requires federal agencies to set sustainability goals. He also discussed other related federal initiatives, such as those to improve energy efficiency.

CONCLUDING REMARKS

Dr. Granger Morgan stated that many of the ideas discussed during the meeting were too abstract and should be put in more concrete terms—for example, developing a specific list of priority areas for the field. For those areas, he proposed clean energy systems; diverse and healthy ecosystems; strategies to make the world safe; preservation and protection of arctic systems; and

NEXT STEPS

William Clark of Harvard University proposed the following key priorities for short-term and long-term activities to foster partnerships and linkages. Short term actions include continuing to deepen ongoing work to identify critical knowledge gaps in S&T for sustainability; developing partnerships between NSF and mission agencies to support fuller range of "use-inspired basic research"; and partnering with organizations that have already identified sustainability goals to link to action. Research is also needed on the role of boundary organizations that bridge science and policy and boundary processes, such as joint fact finding, in furthering partnerships in the field. Longer-term activities include identifying priority sustainability goals and outcomes through an inclusive process and designing potential strategies to meet those goals, including S&T needs to support the strategies. Regarding partnership development, there is a need to identify clear responsibilities for end-to-end integration and organize monitoring, evaluation and feedback necessary for adaptive learning and management. Funding will need to be mobilized and coordinated.

the development and implementation of strategies to address vulnerabilities to extreme events. Dr. Clark responded that to move the field forward there needs to be a combination of investment in new technologies and in the underlying science that will support these activities. Dr. Morgan closed the symposium by highlighting two points: Sustainability is a field in which there is an unresolved tension between the abstract and the concrete; concrete issues are needed to engage people, identify and solve problems, and provide the collective support to address pressing global challenges in energy transformation, agriculture, extreme events, and other areas. Second, he noted that partnerships arise and are successful because people enjoy working together on problems they really care about.

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The National Academies' Science and Technology for Sustainability Program (STS) in the division of Policy and Global Affairs was established to encourage the use of science and technology to achieve long-term sustainable development. The goal of the STS program is to contribute to sustainable improvements in human well-being by creating and strengthening the strategic connections between scientific research, technological development, and decision-making. The program concentrates on activities that are cross-cutting in nature and require expertise from multiple disciplines; important both in the United States and internationally; and effectively addressed via cooperation among multiples sectors, including academia, government, industry, and non-governmental organizations (NGOs).

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