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United States
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Agency

Sustainable and Healthy Communities

STRATEGIC RESEARCH ACTION PLAN 2012-2016

SCIENCE

Office of Research and Development
Sustainable and Healthy Communities

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Sustainable and Healthy Communities

Strategic Research Action Plan 2012 - 2016

U.S. Environmental Protection Agency
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Executive Summary

From its inception in 1970, EPA's mission has been to "protect human health and to safeguard the natural environment—air, water and land—upon which life depends." Early on, EPA established the global benchmark for environmental protection through its implementation—in partnership with state and local governments—of the Clean Air Act, Clean Water Act, Resource Conservation and Recovery Act, Toxic Substances Control Act, and Comprehensive Emergency Response, Control, and Liability Act. For each of these statutes, ORD carried out pioneering environmental research needed to support policies and regulations to protect human health and the environment by protecting the Nation's air, water, land and ecosystems.

Despite these successes, current trends in population and in the use/production of energy, food, and materials have strained our natural resource base and compromised the ability of the environment to respond resiliently to increasing levels of pollution. Human health and essential ecosystem functions have been negatively affected by cumulative exposures to multiple toxic pollutants and a changing physical environment. These impacts also have economic costs, such as increased costs to heat and cool homes; to commute to work or transport goods; to access and treat drinking water; to maintain supplies of raw materials and renewable resources needed for industry, commerce, and food production; and to dispose of wastes. There are societal impacts as well, such as disparities in health risks due to locally impaired air, water, and/or land quality, and due to inadequate access to needed infrastructure, including municipal services, or to natural areas for healthful recreation. Although these trends are evident world-wide, their impacts are experienced most directly by residents of local communities and neighborhoods.

> EPA draws upon the National Environmental Policy Act (NEPA) of 1969 for its operational definition of sustainability: "to create and maintain conditions under which humans and nature can exist in productive harmony, [and] that permit fulfilling the social, economic, and other requirements of present and future generations."

These trends raise the question: How can we meet today's needs without compromising the ability of future generations to meet their needs? More specifically, how can we protect our shared environment—air, water, land, and ecosystems—in ways that are economically viable, beneficial to human health and well-being, and socially just?

Providing the scientific foundation to answer these questions is at the heart of EPA's Sustainable and Healthy Communities research (SHC). The SHC is expressly focused on the growing interest of U.S. communities[1] in sustainable practices.[2] Agency researchers and their partners are working together to better understand the balance among the three pillars of sustainability: the environment, society, and the economy. The transdisciplinary work conducted through SHC will provide decision tools and data that communities need to make strategic decisions for a prosperous and environmentally sustainable future. The SHC research program also conducts

1. SHC defines communities as those people that reside within the jurisdiction of one or more local governments or tribal nations; stakeholders include community decision makers and other groups that share interest in SHC research topics.

2. International City/County Management Association (ICMA), 2010. Sustainability Survey Results. http://icma.org/en/icma/knowledge_network/documents/kn/Document/301646/ICMA_2010_Sustainability_Survey_Results

research to seek more cost-effective means of accomplishing EPA's mission—means that will maximize the benefits of multiple approaches to environmental protection, recognize synergies between protecting human and ecosystem health, and reduce the likelihood that policy decisions will have unintended consequences.

The design of this research program was truly collaborative, as is its implementation. EPA scientists held a series of meetings with internal EPA partners in the policy and regional offices and conducted listening sessions with community officials, tribal representatives, academic experts, and non-profit organizations. These discussions highlighted community and local government approaches for managing their financial and natural resources and for providing services that directly affect their local economies, environment, and the health and well-being of their residents.

These community approaches require decisions about options for how to provide solid waste collection and disposal; maintain and diversify transportation options; develop building codes and zoning for land use planning; and implement shared public/private responsibilities for meeting infrastructure needs, including distribution of water and power. Not only are these decisions the focus of cutting-edge research on sustainability, they are also the same decisions that communities identified as their highest priorities for sustainable practices. Communities repeatedly asked SHC for new ways to better account for the full suite of impacts and outcomes associated with their decisions on how to provide these services.

Problem Statement: Communities make social, economic, and environmental trade-offs in a resource-constrained world. These trade-offs are often not well-characterized in terms of the implications for and interactions among human health, ecosystem services, economic vitality, and social equity. Conventional decision-making often does not adequately characterize these complex interactions.

Vision: The Sustainable and Healthy Communities Research Program (SHC) will inform and empower decision-makers in communities, as well as in federal, state and tribal community-driven programs, to effectively and equitably weigh and integrate human health, socio-economic, environmental, and ecological factors into their decisions in a way that fosters community sustainability.

Working in collaboration with agency partners and community stakeholders, SHC developed a problem statement and vision statement to guide SHC research (see text box); both emphasize the need for methods to integrate and weigh trade-offs inherent in community decision-making. The SHC builds upon EPA's existing community-based programs[3] and extensive use of voluntary practices to achieve human health and environmental goals.[4] In particular, SHC seeks to provide information that will assist decision-makers in implementing innovative actions within communities and tribal programs that can complement EPA, state, and tribal authorities and, in so doing, to achieve shared sustainability goals in more flexible, economically beneficial and effectively synergistic ways. Ongoing communication and feedback is a critical part of the SHC, and will be essential in keeping the program as responsive and rel-

3. See Appendix A for listing of community-based programs that provide technical assistance, training grants, and opportunities to apply for community-based competitive grants.
4. The following are examples of EPA voluntary programs that foster sustainability: http://www.epa.gov/brownfields/areawide_grants.htm, plans for brownfields assessment, cleanup, and reuse; http://www.epa.gov/epawaste/partnerships/sc3/index.htm, Greenscaping for residential and large landscapes; http://www.epa.gov/epawaste/conserve/rrr/greenscapes/index.htm, National award program for smart growth; http://www.epa.gov/smartgrowth/awards/sg_awards_publication_2011.htm, Grants for urban water; http://www.epa.gov/urbanwaters/funding/, Conserving resources and preventing waste generation; http://www.epa.gov/epawaste/partnerships/wastewise/index.htm, EnergyStar; http://www.energystar.gov/

evant as possible to local, EPA policy, and regional needs.

The scope of SHC research is evident in both the national and local priorities it addresses. For example, SHC is the primary source of research support for EPA's Office of Solid Waste and Emergency Response, and Office of Sustainable Communities. It is also the focal point for coordination of research across ORD that contributes to EPA's Office of Children's Health Protection and the Agency's Environmental Justice programs. In addition, because the consequences of decisions affecting air quality, resilience to climate change, availability of energy and water, chemical safety, homeland security, and risk assessment are all ultimately encountered at a local level, SHC integrates aspects of each of ORD's other research programs into the conduct of its work.

To organize this breadth of research, SHC is structured into four interrelated themes having the following objectives:

1. Data and Tools to Support Community Decisions: will use cutting edge technologies to collaboratively develop better data, methods, and indicators, new spatial analyses, and decision tools to assist communities in developing effective approaches to achieve their sustainability goals.

2. Forecasting and Assessing Ecological and Community Health: will develop the information and methods that communities need to assess how the natural and built environment affect the health and well-being of their residents and to identify sound and sustainable management options.

3. Implementing Near-Term Approaches to Sustainable Solutions: will build upon regional and state successes and experience to improve the effectiveness and efficiency of methods and guidance to address existing sources of land and groundwater contamination while while advancing innovative approaches that reduce new sources of contamination and enable the recovery of energy, materials, and nutrients from existing waste streams. This research provides scientific support to EPA program and regional offices and to states and tribes that implement federal requirements and guidelines related to land and groundwater contamination.

4. Integrated Solutions for Sustainable Outcomes: will assess the state of the art for sustainable practices for four high-priority community decision areas with environmental impacts: waste and materials management; infrastructure, including energy and water; transportation options; and planning and zoning for buildings and land use. It will use whole-system modeling to integrate these four areas to better achieve outcomes with multiple benefits and to develop and test methods to estimate the Total Resource Impacts and Outcomes of alternate decisions (TRIO methods).

Introduction

Current trends in population, and in the use/production of energy, food, and materials have strained our natural resources and compromised the ability of the environment to tolerate increasing levels of pollution. Human health and essential ecosystem functions have been negatively affected by cumulative exposures to multiple toxic pollutants and a changing physical environment. This has compromised the ability of the environment to sustain human health and well-being, and threatens our ability to maintain past environmental successes.

According to peer-reviewed estimates, planetary thresholds already have been exceeded for releases of reactive nitrogen into the environment, for loss of plant and animal species (biological diversity), and for climate change.[5] Similarly, we are approaching unsustainable planetary thresholds for ocean acidification, which threatens marine life, and for production of phosphorus, which is essential for agricultural food production.[6] In 2011, it was estimated that the world's populations consumed between 1.25 and 1.5 times the amount of annual global production of biological capacity, meaning that there is a global ecological deficit.[7] Further, as a nation, we face shortages in materials, minerals, and fuels used for industry, national security, transportation, and heating and cooling our homes and businesses[8] ; loss of arable lands for food production through conversion to development [9]; and difficulties in safely siting landfills needed to isolate wastes.[10]

Further, issues of global and local sustainability are linked. Trends are observed globally or regionally, but their impacts are experienced most directly by residents of local communities and neighborhoods. For example, warmer global temperatures and high pollution levels are global in scope, yet they create local ozone concentrations that increase health alerts, and lead to increases in the numbers of people seeking treatment for asthma in (local) hospitals, with attendant costs to communities.[11] [12]Local driving patterns and electricity use contribute not only to pollutants that create those high ozone levels, but also to global patterns of air pollution and climate change. There can be societal impacts as well—such as disparities in health risks due to locally impaired air, water, or land quality; due to inadequate access to needed infrastructure, including municipal services; or to natural areas for healthful recreation.

As more demands are placed on finite resources and ecosystem functions, there are a corresponding opportunities and

5. Rockstrom et al., 2009. Ecology and Society 14 2): 32. Planetary boundaries: exploring the safe operating space for humanity. http://www.ecologyandsociety.org/vol14/1ss2/art32.

6. Rockstrom et al., 2009. Ecology and Society 14 2): 32. Planetary boundaries: exploring the safe operating space for humanity. http://www.ecologyandsociety.org/vol14/1ss2/art32.

7. http://www.footprintnetwork.org/en/index.php/GFN/page/earth_overshoot_day/

8. Moyer, M. 2010. Scientific American. 303, 74-81 (2010). Doi:10.1035/scientificamerican0910-74. http://www.scientificamerican.com/article.cfm?id=how-much-is-left

9. Natural Resources Inventory (NRI), 2007. Between 1982 and 2007, more than 23 million acres of U.S. farmland were converted from farms to developed lands. An estimated 38% of the land converted during this period was prime agricultural land. http://www.farmlandinfo.org/agricultural_statistics/

10. EPA Municipal Solid Waste Landfill Criteria Technical Manual, including siting criteria related to wetlands, floodplains, and active seismic areas. http://www.epa.gov/osw/nonhaz/municipal/landfill/techman/index.htm

11.Takizawa, H. 2011. Impact of air pollution on allergic diseases. Department of Respiratory Medicine, Kyorin Univ. School of Medicine, Tokyo, Japan.

12. Big Air Pollution Impacts on Local Communities: Traffic Corridors Major Contributors to Illness From Childhood Asthma. Science Daily, Nov. 4, 2009

benefits to managing the built environment in ways that reduce environmental, health, and ecosystem impacts, and to manage the natural environment in ways that maximize the benefits and services it provides. Systems-based research can provide insights into actions that communities can take to improve their local environments, reduce their societal and economic costs of pollution, and to improve their health and well-being. However, developing the systems science needed to address these complex issues effectively is usually beyond the capacity and resources of local governments and communities.

SHC worked with EPA Program and Regional Office partners to articulate the problem that communities face with respect to sustainability:

Communities make social, economic, and environmental trade-offs in a resource-constrained world. These trade-offs are often not well-characterized in terms of the implications for and interactions among human health, ecosystem services, economic vitality, and social equity. Conventional decision-making often does not adequately characterize these complex interactions.

SHC also worked collaboratively with communities and community-representative organizations through a variety of venues and formats to identify and understand their most pressing needs related to sustainability (Appendix A). These discussions highlighted community and local government approaches for managing their financial and natural resources and for providing services that directly affect their local economies, environment, and the health and well-being of their residents. These decisions include options for how to provide solid waste collection and disposal; maintain and diversify transportation options; develop building codes and zoning for land use planning, and implement shared public/private responsibilities for meeting infrastructure needs, including distribution of water and power. The most frequently-expressed need was for new ways to better account for the full suite of costs, impacts, and outcomes associated with the diverse actions that communities must consider. Stakeholders and partners also wanted practical ways to predict the likely consequences of their decisions, and ways to measure their results.

Given this widespread agreement on needs, ORD developed the following vision statement for the SHC program:

The Sustainable and Healthy Communities Research Program (SHC) will inform and empower decision-makers in communities, as well as in federal, state, and tribal programs, to effectively and equitably weigh and integrate human health, socio-economic, environmental, and ecological factors into their decisions in a way that fosters community sustainability.

The SHC also engaged with community decision makers in order to better understand their goals, priorities, and constraints. This collaborative approach can help ensure that the information, approaches, and tools developed by SHC will be useful to and used by community decision makers to evaluate their issues, proactively assess their decision alternatives, implement more effective solutions, and track results. SHC's key contribution to community decision-making will be the development of a method to more comprehensively account for the full costs and benefits of community decisions with respect to their effects on sustainable outcomes. SHC calls this method Total Resource Impacts and Outcomes, or TRIO accounting, to reflect its intended scope and its relationship to the three pillars of sustainability: the economy, society, and the environment. TRIO accounting will consider direct and indirect social, economic, and environmental costs and benefits associated with a given set of decision alternatives.

Research Supports EPA Priorities

Statutory and Policy Context

From its inception in 1970, EPA's mission has been to "protect human health and to safeguard the natural environment—air water, and land—upon which life depends." Early on, EPA established the global benchmark for environmental protection through its implementation, in partnership with states, tribes, and local governments, of the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act, the Toxic Substances Control Act, and the Comprehensive Emergency Response, Control, and Liability Act.

For each of the above statutes, the Office of Research and Development carried out pioneering environmental research needed to direct and support regulations that protect the nation's air, water, land, and ecosystems, and therefore, human health and well-being. However, federal action is only one aspect of environmental management. EPA delegates the authority to implement aspects of federal environmental laws to states and local governments, and municipalities have authorities that can address activities and opportunities that federal and state rules do not cover.

Local authorities and actions are essential because communities directly experience the result of ongoing environmental issues. Examples include: lost local revenues due to urban blight associated with Superfund sites; the financial and human costs associated with clean up of leaking underground storage tanks at local gas stations; contamination of groundwater from poorly designed landfills; negative impacts on children's health and performance due to poorly sited schools and inappropriate building materials and operation practices; and combined sewer overflows due to extensive paved areas that increase stormwater runoff and overwhelm the capacity of sewer systems.

EPA's Seven Priorities

Taking action on climate change and improving air quality

Protecting America's water

Cleaning up our communities and advancing sustainable development

Ensuring the safety of chemicals and preventing pollution

EPA's cross-cutting strategies

Expanding the conversation on environmentalism and working for environmental justice and children's health

Strengthening state, tribal, and international partnerships

The SHC research program is designed to help communities implement environmental management in ways that reduce these common, negative impacts, and to increase the benefits that communities can obtain from sustainable practices, such as reducing ambient emissions of air and water pollutants; eliminating indoor exposures to pollutants from building materials, insecticides, or cleaning materials; using natural greenways and waterways to provide recreational areas, and providing green corridors for travel by foot and by bicycle. These actions not only reduce air pollution and facilitate healthful activity, they simultaneously produce co-benefits such as reducing heat island effects, purifying water, and recycling nutrients. SHC methods will be designed to assess the ability of proposed decision alternatives, and their co-benefits,to reduce long-term costs for regulatory compliance.

Municipalities also have unique authorities to make decisions for managing local financial and environmental resources. Their

responsibility to provide community services can directly affect their local economies, environment, and the health and well-being of their residents. These decisions commonly include options for how to provide solid waste collection and disposal, maintain and diversify transportation options; develop building codes and zoning for land use planning, and implement shared public/private responsibilities for meeting infrastructure needs, including distribution of water and power. Communities in listening sessions with SHC identified these service areas as their highest priority for decisions about sustainable practices, and asked for new ways to better account for the full suite of outcomes and impacts associated with decisions for them.

To develop TRIO methods, EPA will build on its long experience related to these service sectors. This experience includes research on indoor air quality as affected by proximity to leaking underground storage tanks or Superfund sites; type of building materials, cleaning products, and ventilation rates; criteria for assessing green building design; quantifying the effects of transportation options on air quality; contributions to RCRA guidance for determining when waste materials can be safely reused; and landscape ecology to identify innovative ways to protect drinking water sources or to meet water quality standards at the watershed scale. This research is not new in terms of EPA's role or expertise; what is new is that SHC will use a systems approach to examine interrelated issues as a whole, across all stressors and effects. SHC's approach to systems science and TRIO methods corresponds to the approach recommended by the National Research Council (NRC) in its August, 2011 report, *Sustainability and the U.S. EPA*. SHC is poised to implement NRC recommendations through innovative and original research that complements, not duplicates, the work of other agencies.

In essence, SHC is based on the premise that the best way to meet the long-term goals of EPA's mission is to help communities find easier ways to meet federal requirements, help the Agency and local governments develop regulations and practices that are less expensive and more socially just and acceptable, and, where possible, provide innovative and effective non-regulatory approaches that simultaneously protect human health, the environment, and advance sustainable practices. New and state-of-the-art tools developed by SHC will help communities proactively assess how their choices advance their sustainability goals. This information, together with communities' more intimate connections with local residents, businesses, and other groups, provides opportunities for communities to pursue effective, state-of-the-art sustainability practices that have cascading benefits. Authority and action at the community level can complement EPA and State authorities and facilitate innovative solutions to complex problems.

EPA Priorities

The SHC research program is unique within EPA due to its explicit, systems-based methods and its community-based focus on addressing sustainability issues within the interplay of environmental, economic, and social factors across the media of air, water, and land. In particular, SHC addresses Goal 3—cleaning up communities and advancing sustainable development—of EPA's *2011-2015 Strategic Plan: Achieving Our Vision:*

"In the area of cleaning up communities, research will allow EPA to identify and apply approaches that better inform and guide environmentally sustainable behavior, protect human health and ecosystems, and provide the products and services needed for mitigation, management, remediation, and long-term stewardship of contaminated sites. It will also provide state, tribal, and local decision makers with the knowledge needed to make smart, systems-based decisions that will inform a balanced approach to their cleanup and development needs."

Both the SHC and EPA Strategic Goal 3 are grounded in the fact that effective and sustainable environmental protection is inextricably linked to long-term human health and quality-of-life, economic opportunity, and community vitality. In addition, research conducted in SHC Theme 2 addresses three cross-cutting EPA priorities for meeting its strategic goals: 1) expanding the conversation on environmentalism, 2) working for environmental justice and children's health, and 3) strengthening state and tribal partnerships. Research conducted in SHC Theme 3 addresses EPA's priority for advancing science, research, and technological innovation.

Program Design

Producing an Integrated Program

ORD has extensive research expertise and experience on which to build the SHC research program. In particular, ORD's expertise in the areas of landscape ecology, remote sensing and modeling, human exposure and health effects assessment, environmental engineering, materials and waste management, and decision science has previously produced many innovative assessment and decision tools.

SHC will use its expertise and experience to conduct transdisciplinary research, which SHC defines as having the following characteristics:

• Focuses on solving complex, real-world issues.

• Uses systems-thinking to "redraw the map" of possible solutions.

• Integrates perspectives from the public sector, private sector, and civil society.

• Emphasizes collaboration in order to transcend the narrow bounds of traditional disciplinary views.

• Creates new knowledge, new theory, and fosters new practical applications that yield outcomes that take advantage of opportunities for multiple benefits.

Collaborating Across Research Programs

All six ORD research programs have as their goal the advancement of sustainability within their respective disciplines and spheres of responsibility: i.e., Sustainable and Healthy Communities; Safe and Sustainable Water Resources; Air, Climate and Energy; Chemical Safety for Sustainability, Homeland Security; and Human Health Risk Assessment.

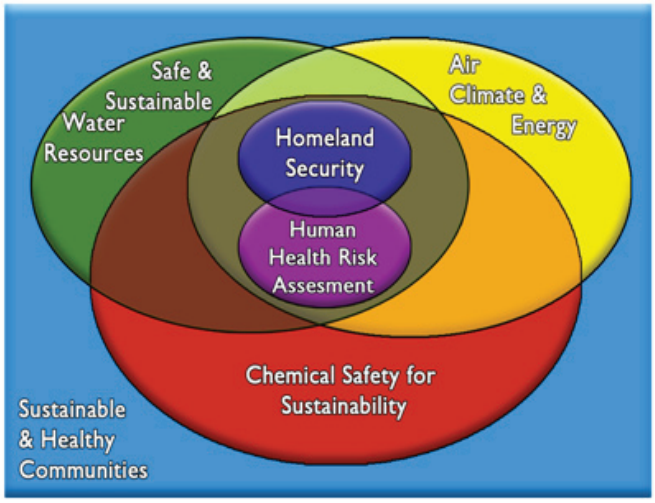

Figure 1. Relationships Among Six ORD Research Programs

Figure 1 illustrates the relationships among ORD's research programs and the resulting opportunities for collaboration and transdisciplinary research. For example, research related to producing chemicals for industry that are inherently safer for humans and the environment will affect opportunities and policies for increasing the safety of water supplies. Similarly, new water saving technologies that reduce water consumption will reduce the amount of energy required to treat and distribute water to homes and businesses, thereby conserving energy and reducing emissions of air pollutants, and reducing the need for extractive energy practices. These relationships – safer chemicals and safer water supplies; less energy use, less air pollution, and less waste – have implications for what communities can choose to do to implement their sustainability goals.

Each of ORD's programs has specific focal areas while maintaining close interrelationship with relevant parts of the other programs. SHC is the focal point for research on community sustainable practices, including waste and materials management. SHC is also the focal

point for research to support cross-cutting topics on children's health, community, health, and environmental justice. In addition, SHC intends to develop ways to integrate research findings from all ORD programs. In Figure 1, this role is illustrated by SHC's location as the program that frames the other six programs.

Developing Partnerships from the Start

SHC scientists were charged with creating a program that would advance community sustainability by providing transdisciplinary research products that are relevant and actionable for decision makers. To do this, SHC researchers engaged early with our traditional EPA Regional Offices, and Program and Policy Office partners (including EPA's Offices of Air and Water; Office of Children's Health Protection; Office of Environmental Justice; Office of Sustainable Communities; and Office of Solid Waste and Emergency Response). SHC researchers held full-day workshops with EPA Program Offices to discuss their community-related regulatory and non-regulatory needs, and to identify important information gaps. In addition, SHC directly engaged with new community stakeholders. Active engagement through a variety of venues and media elicited wide participation from local governments (planning staff or sustainability directors), and from a variety of other participants from universities and other non-governmental organizations (such as ICLEI-Local Governments for Sustainability, the League of Cities, and the Congress for the New Urbanism) (Appendix B). At all sessions, EPA staff explained SHC goals and solicited input about barriers to local sustainability actions and the kinds of information needed to overcome these barriers.

Despite differences in workshop venues and formats, the priorities of stakeholders were surprisingly similar. The most common needs expressed were for:

- Ways to evaluate the full costs and benefits of different communities' actions, so as to inform and enable better decision-making. In particular, stakeholders identified the kinds of decisions for which such an accounting would be useful. These decisions include options for how to provide solid waste collection and disposal; maintain and diversify transportation options; develop building codes and zoning for land use planning; and implement shared public/private responsibilities for meeting infrastructure needs, including distribution of water and power.

- Practical methods and metrics ("yardsticks") with which to measure impacts on environmental, economic, social equity, and interacting conditions; and for use to measure progress toward sustainability,

- Better ways to communicate in order to promote effective programs.

Other high priorities held in common included research on technologies to clean up contaminated sites and tools to manage particular chemicals or waste streams. Environmental justice (the issue of disproportionate impacts on disadvantaged populations) and children's health were recognized as especially critical.

EPA's Office of Sustainable Communities (OSC) is a key internal partner for SHC. The OSC collaborates with other EPA programs; federal agencies; regional, state, and local governments; and a broad array of NGO partners to help communities become stronger, healthier, and more sustainable through smarter growth and green building. OSC partners will advise SHC on their knowledge of local needs, serve as a client for tools or approaches that serve communities, and partner with SHC on research projects. SHC is also working with OSC to participate in the federal Partner-

ship for Sustainable Communities (under a Memorandum of Understanding with EPA, the U.S. Department of Housing and Urban Development, and the U.S. Department of Transportation).

The scope of SHC's transdisciplinary research requires that it must remain innovative throughout its implementation and refinement. To that end, SHC is developing a process for routine, iterative review and feedback from EPA programs, regions, community, and federal partners in order to assure the relevance and utility of SHC products and to identify where strategic cooperation can advance common goals.

In addition, SHC will continue to seek review from independent advisory boards. Early proposals describing the scope and objectives of SHC research were reviewed in June 2011 by a joint panel of the EPA's Science Advisory Board (SAB) and by the Board of Scientific Counselors (BOSC). Both of these independent advisory boards expressed strong support for SHC goals and its community focus. SHC has incorporated their initial comments and suggestions for improvement,[13] and both boards will periodically review SHC progress.

As recommended by the SAB, SHC will also collaborate with other federal and international agencies. SHC has begun two key collaborations: with Department of Defense on site contamination issues, and with the Army's NetZero initiative. Further, SHC's participation in the Office of Science and Technology Policy's Committee on Environment, Natural Resources, and Sustainability Subcommittee on Ecological Systems will serve as the focal point for collaboration with other federal agencies on systems science related to sustainability. SHC's international collaborations include working with the United Nations Environment Programme (UNEP) on interoperability standards, and with Dutch collaborators on urban ecosystem services.

13. The SAB emphasized the need to include social, behavioral, and decision science (including economics) in all ORD research programs. In response, SHC has begun providing seminars by professionals in these disciplines and will pursue additional expertise in these fields through collaborations with university programs and selected hires.

Research Themes and Priority Science Questions

Theme 1: Data and Tools to Support Sustainable Community Decisions

Theme 1 uses decision science, interactive social media, and sustainability assessment methods in order to assist communities in framing their sustainability goals and to develop new tools, indicators, and spatial analyses for community use. This work is carried out in two topic areas: (1) Decision and Information Science, and (2) Assessing Community Sustainability.

Topic 1: Decision and Information Science. SHC scientists will work collaboratively with communities to develop ways to make data, information, and tools more interactive and more accessible to local audiences. Tools will be tailored to community characteristics and will transition from single-issue tools towards an interacting set of modules, using common data sets wherever possible, so that communities can tailor assessments to meet their needs.

Topic 2: Assessing Community Sustainability. SHC scientists will compile and critique existing assessment indicators and tools for their applicability to community issues. They will use consistent "yardsticks," or metrics, to characterize and communicate linkages among human health, well-being, and environmental changes, and to measure progress toward sustainability goals. The National Atlas of Sustainability will provide geographically explicit metrics that characterize ecosystem services and sustainability metrics for the contiguous U.S. and for up to 250 urban areas. Products such as data, tools, and the National Atlas for Sustainability will be accessible through a one-stop web access point, for use by community decision-makers and stakeholders, scientists within other SHC Themes, and other EPA research programs.

Science Questions

The broad science questions that guide Theme 1 research are:

1. How can new information technology be used to enhance ongoing dialogues with communities about their sustainability goals and needs and to facilitate sharing of effective decision tools and community success stories?

2. How can communities be characterized in order to tailor assessment and decision tools to widely shared needs?

3. What are effective methods for framing community decisions about sustainability?

4. What are the best metrics to effectively track and communicate changes and performance?

5. What criteria and standards for future tool development will facilitate collaborative development of decision tools?

6. How can existing tools be modified and linked, including use of service-oriented architecture (sharing of data and a common access point)?

7. What methods for integrating decision tools are capable of incorporating multiple factors for analysis and assessment? What are their current limitations and how can these be overcome?

8. What suite of assessment tools and sustainability metrics are most useful for incorporation into the National Atlas for Sustainabiliy?

9. How can SHC improve accessibility to tools and information across the spectrum of decision-makers and their specific needs?

10. How can new information technology be harnessed to improve delivery of SHC results to communities and to support application of research results?

1st Example Output: Classification of U.S. Communities

The statistical classification of U.S. communities will be used to guide development of decision and assessment tools needed to address widely shared sustainability issues and to enhance transferability of tools to specific types of community needs. The initial classification will be based on characteristics related to biophysical setting (e.g., climate, landform, soils, vegetation), community attributes (local governance, sustainability practices), demographic attributes (e.g., size, growth/decline, density, distribution), and ecosystem service characteristics. The classification will be updated over time to incorporate new data and relevant findings.

Contributing products:

1. Analysis of community decision processes and needs.

2. Refinement of user needs based on input from interactive social media.

3. Iterative input.

2nd Example Output: Beta Version 1 of the National Atlas for Sustainability

Release of the beta Version 1 of the National Atlas for Sustainability will provide communities across the country with a suite of accessible, interactive maps showing indicators of production, demand, and drivers of ecosystem services. Categories of ecosystem services include: clean water for drinking; clean water for recreation and aquatic habitat; adequate water supply; food, fuel and fiber; recreation, cultural and aesthetic amenities; contributions to climate stability; protection from hazardous weather; habitat and the maintenance of biodiversity; and clean air. Metrics will be provided at national, regional, and community scales.

Contributing products:

1. Series of national data sets critical to the calculation of ecosystem services (e.g., soils or crop type).

2. Data summarized by 12-digit hydrologic unit codes (of which there are about 83,000 in the U.S.).

3. Detailed information for at least 150 communities across the nation. Within these communities, a suite of metrics -- such as availability of green space or heat stress caused by the built environment -- will be explored for relationships to vulnerable sectors of the community's residents and for opportunities for mitigation.

3rd Example Output: Interoperable Webtools

This output provides a suite of linked webtools that enables communities to concurrently:

- Access detailed environmental metrics and improved demographic maps (using capabilities from the National Atlas for Sustainability).

- Screen for potential health impacts (using capabilities from the Community-Focused Risk Screening Tool , or C-FERST).

- Develop statistically-based indices that describe vulnerabilities and identify opportunities for mitigation (using capabilities from the Regional Vulnerability Assessment toolkit, or ReVA).

These webtools will be publicly accessible

and seamlessly integrated in order to make it easier for communities to assess how the built and natural environment affects human well-being and to identify targeted opportunities to advance sustainability and to reduce costs associated with mitigation.

Contributing products:

1. Protocols and standards for software interoperability.

2. An analytic Regional Vulnerability Assessment module that uses statistics to provide objective and reliable indices of environmental condition and vulnerability for any combination of spatial data.

3. Direct linkage to the Office of Environmental Information's (OEI) geospatial data platform (GeoPlatform) and Community Analyst for access to the most up-to-date information on environmental and socio-economic patterns and trends across the country.

Theme 1 Outcome:

Communities and stakeholders will be actively engaged and able to collaborate with the EPA and each other for the mutually beneficial exchange of knowledge and resources. They will be better able to articulate challenges, assess proposed solutions, and provide or request specific scientific resources. Communities will be able to select indicators for evaluating the likely implications of decision alternatives and be able to conduct trade-off and synergy analyses.

Theme 1 Impact:

Products created under this theme will help EPA and its partners to better understand the scientific, economic, and social dimensions of community sustainability issues, leading to more effective environmental decision-making. Products will form the foundation for a toolkit of innovative, non-mandatory solutions to complex sustainability problems. Existing and new decision tools will benefit from a wider range of contributing partners, and EPA will become better able to provide tailored decision support to a wide variety of communities, regardless of their geographic location.

Research Themes and Priority Science Questions

Theme 2: Forecasting and Assessing Ecological and Community Health

Research conducted in Theme 2 will develop the information and methods that communities need to assess how the natural and built environment affects the health and well-being of their residents. To accomplish this, Theme 2 conducts foundational research in two major topics: (1) the science of ecosystem services, including their production, use, and benefits, and (2) the science of human health and well-being as influenced by exposures to chemicals or other stressors in homes, schools, or neighborhoods. Theme 2 research will provide information that communities can use to develop management options to mitigate conditions that have adverse effects and to enhance conditions that have positive effects on human health and well being.

Theme 2's ecosystem-focused research will develop methods to quantify ecosystem goods and services—i.e., those ecosystem functions that society depends upon to survive and prosper—like water filtration, nutrient recycling, and mitigation of floods and storm surges. It addresses how to estimate current production of ecosystem goods and services, given the type and condition of ecosystems; how ecosystem services contribute to human health and well-being; and the way in which the production and benefits associated with ecosystem services may be affected under alternative decision scenarios or in response to regional conditions.

Theme 2's human health-focused research will develop better methods to quantify, track, and reduce cumulative risks to public health; to develop a holistic understanding of how children's health may be linked to exposures from before birth through adolescence and impact their health throughout life; and to understand how differences found in community settings – such as location of residence relative to pollution sources; availability of safe, walkable streets; and access to healthful foods – can contribute to good health and well-being or also can result in environmental injustice and disproportionate health risks. Communities can use this information to develop and better implement public health policies and practices, especially for their most vulnerable residents (e.g., infants, children, the elderly, or socio-economically disadvantaged), and to evaluate the effectiveness of interventions designed to improve public health. Although the issues of children's health and environmental justice will be integrated throughout SHC, Theme 2 is the focal point for this research, which is also highly relevant to all ORD research programs.

Science Questions

The broad science questions that guide Theme 2 research are as follows:

> *1. How can more consistency and standardization be brought to the quantification of ecosystem goods and services in ways that facilitate resource conservation through trading, environmental markets, and other policies or incentives?*
>
> *2. What protocols can be developed to improve the ability to value ecosystem services and benefits across different geographic contexts and scales?*
>
> *3. How can the transferability of research*

that quantifies the benefits of ecosystems to society be improved such that these benefits can be routinely factored into community decisions?

4. How can we demonstrate the effectiveness of using ecosystem services in real-world decisions by understanding the relationship to health and environment justice in communities?

5. How can communities become better informed about the sources and levels of pollutants, the nature of cumulative exposures, and the locations of disproportionate impacts? How can they be informed about and taught to use easily accessible web-based tools to develop strategies to mitigate multiple stressors?

6. What chemicals and combinations of chemicals, such as those occurring together in products that children use or are exposed to, pose the greatest risk to children's health and how does exposure and risk vary across specific age groupings?

7. What complex interactions between social, natural and built environmental systems, conditions and policies result in unequal environmental health conditions or disproportionate impacts among diverse disadvantaged population groups, communities, neighborhoods and individuals?

8. How can disadvantaged communities be empowered to better characterize problems and create solutions that ensure equitable distribution of the benefits from community decisions?

1st Example Output: Guidance on Methods to Enhance Children's Health:

This research will contribute to EPA risk assessments, guidance documents, and policies that protect children's health by providing new knowledge about age-specific chemical exposure factors and health metrics; tools for considering how a wide variety of factors (e.g., children's physical activity, psycho-social issues, the condition of school and residential buildings) may interact with chemical exposures to impact children's health and health disparities; and guidance about ways to optimize home, school, and community environments in order to enhance children's healthy development and well-being. This information will improve the scientific basis with which EPA and communities will be able to evaluate and integrate data on exposure, health, and demographics in order to make decisions and take actions that better promote children's health, development, performance and well-being where they live, play and learn. Both in-house and university-based researchers are contributing to this work, including EPA's Children's Environmental Health and Disease Prevention Research Centers that are jointly funded with the National Institute of Environmental Health Sciences.

Contributing products:

1. A peer-reviewed paper that reports study findings that advance the understanding of the dietary sources of human exposure to arsenic.

2. Findings from three major investigations of autism: the Childhood Autism Risk from Genetics and the Environment, (CHARGE), Study; the Markers of Autism Risk in Babies — Learning Early Signs, (MARBLES), Study; and the Early Autism Risk Longitudinal Investigation (EARLI) study.

3. Peer-reviewed papers presenting studies on research results associating prenatal exposure to organophosphate pesticides with IQ deficits in children.

2nd Example Output: Web-based Tools for Environmental Justice

This output will provide user-friendly web-based tools to help communities assess

whether disproportionate health impacts exist in their communities and, if so, to develop risk mitigation strategies that advance environmental justice. One such tool is the prototype Community Cumulative Assessment Tool, or CCAT, which guides users through a step-by-step process to define their assessment objectives, determine its geographic and technical scope, create a partnership database, develop conceptual models, gather information, rank risks, and explore risk mitigation options. With this information, communities can better locate the source of the problems and improve conditions for everyone.

Contributing products:

1. Beta version of CCAT methodology, functional in 2012, with linkage to other tools including C-FERST (Community-Focused Exposure and Risk Screening Tool) and GeoPlatform.

2. Findings of a case study that tests the CCAT in one or more community settings.

3. As a product of EPA's Environmental Justice Plan 2014, demonstration of CCAT use and its effectiveness for characterizing communities at risk for environmental injustice.

3rd Example Output: Standardized Classification for Ecosystem Goods and Services (EGS):

A central scientific problem limiting the reliable and consistent linkage of ecosystem changes to human health and well-being is having a metric with which to compare functions across different geographic settings – e.g., an acre of wetland in one location will not contain the same kinds and amounts of natural functions as an acre of wetland elsewhere. This research will develop standardized metrics for ecosystem goods and services, which can significantly enhance evaluation of how policy choices affect changes in human health and well-being. In addition, it will help to allow "trading" of ecosystem service credits in order to better support mitigation of ecosystem damages through more consistent quantification of ecosystem services that were lost. The product of this research will be the National Ecosystem Goods and Services Classification System (NEGSCS), a searchable online data base.

Contributing products:

1. Published reports from two workshops that bring together practitioners in the quantification and use of ecosystem services to identify a relatively complete, non-duplicative, and human-centric classification of ecosystem services.

2. Standardized reporting units and metrics and indicators that can be used to evaluate current status, trends and sustainability of the Nation's environmental resources as they relate to human needs and well being.

4th Example Output: Searchable Database of Ecosystem Services

EPA scientists are developing or extending production functions for ecosystem services and benefits for numerous areas in the U.S. They are also developing protocols for estimating the value of ecosystem services, including methods to quantify the uncertainty associated with these estimates, understand how scale impacts estimates, and determine the transferability of results from one area to other areas. These production functions are being catalogued so that this information will be easily accessible to EPA, other agencies, NGOs, and anyone interested in considering the ecosystem service trade-offs associated with changes in environmental conditions or decision alternatives. This work will result in a searchable database, the Ecosystem Goods and Services Production Function Library, that provides researchers and those who develop decision-support tools with the best available information about how to estimate the distribution and value of ecosystem services, including how they might change under alternative future scenarios.

Contributing products:

1. Ecosystem service production services developed for clean water provision, clean air provision, carbon storage, nature-based recreation, etc. developed from place-based studies. These production functions will address supply and demand issues (e.g., is the service vulnerable to disruption or loss?, who benefits and what is the worth of ecosystem services?).

2. Standardized classification of ecosystem services linked to human well-being as a basis for better accounting methods.

3. Identification of metrics and indicators of final Goods and Services that can provide consistent measurement and tracking methods.

4. Identification and quantification of public health benefits associated with aquatic ecosystem services.

5. Demonstration of the use of ecosystem services in actual decision-making contexts to elucidate the full suite of trade-offs associated with decision alternatives.

Theme 2 Outcomes

Communities will be able to comparatively evaluate the health and environmental effects of decision alternatives as they relate to the places where they live and work. They will have information with which to assess the contribution of functioning ecosystems to human health and societal well-being, including whether practices and technologies that are less damaging to the environment can contribute to the sustainable provision of ecosystem services over time. They will have better data for addressing issues related to the health of infants and children, community public health, and environmental justice. Communities, regions, and EPA Program Offices will be able to make more sustainable decisions, based on full-cost accounting that includes the impact of alternatives on benefits provided by nature.

Theme 2 Impacts

Products created under this topic will provide federal agencies with consistent, effective, and broadly applicable information on the distribution of ecosystem service benefits, as well as how this distribution changes based on land use, transportation, housing and infrastructure choices, and materials management. This will facilitate conservation as well as public and private investments to support ecosystem services. It will also facilitate the contribution of ecosystem services assessment in their decisions at multiple scales and in different geographies across the country. EPA and communities will have better data regarding factors contributing to disease, as well as the ability of the built and natural environment to enhance health outcomes. They will gain insights about the ways in which livable and walkable cities contribute to public health.

Research Themes and Priority Science Questions

Theme 3: Implementing Near-Term Approaches to Sustainable Solutions

Theme 3 will build upon federal, regional, and state successes and experience to improve the effectiveness and efficiency of methods and guidance to address existing sources of land and groundwater contamination as required under RCRA and Superfund. Theme 3 will also build on RCRA and Superfund policies that encourage use of innovative approaches to reduce new sources of contamination; enable the recovery of energy and material from existing waste streams; and enable brownfields sites to be put to new, economically productive uses that benefit communities.

Theme 3 addresses five main topics: 1) management of contaminated sites, 2) materials and waste management, 3) integrated management of reactive nitrogen, 4) EPA's Report on the Environment and 5) sustainable technologies. Many aspects of Theme 3 directly support EPA's Strategic Goal 3: Cleaning up communities and advancing sustainable development. Theme 3 products also contribute to other parts of SHC and other parts of EPA. For example, findings about waste management technologies will assist in developing options for community waste scenarios to be tested in Theme 4. Findings about sources and ecosystem service impacts related to releases of reactive nitrogen sources will be used by the Air, Climate and Energy (ACE), and Safe and Sustainable Water Resources (SSWR) research programs to develop effective nitrogen management strategies, and also by EPA's Office of Air and Radiation and Office of Water to develop management actions to address the most significant sources and impacts of reactive nitrogen on the environment and human health.

Science Questions

The broad science questions that guide Theme 3 research are as follows:

1. What methods can be developed or applied to assess contaminated sediments and to measure the short-and long-term effectiveness of remediation?

2. How can research findings be used to improve and simplify bioaccumulation models for predicting long-term changes in contaminant accumulation following remediation actions?

3. How can environmental releases from oil spills and leaking underground storage tanks be managed to minimize environmental damage and human exposures?

4. How can contaminated groundwater best be detected, characterized, modeled, and treated to prevent human exposure though contamination of drinking water, especially of ground water resources?

5. How can methods to reduce waste streams using principles of life cycle assessment and sustainable materials management be made more efficient and effective for communities (e.g. separation of waste streams and targeted reuse or minimization steps)?

6. How can research to support decision making at the regional, state, and tribal level be better translated so that it is accessible, useful, and transparent?

7. How can guidelines for the design and operation of disposal facilities be improved to enhance performance, recover energy, and reduce impacts?

8. How can the damaging effects of reactive nitrogen be most efficiently managed? What are the strategic management options that most cost-effectively reduce impacts to highly valued ecosystem services?

9. How can the concept of sustainability be made operational for incorporation into EPA's Report on the Environment? What are the best sustainability-related indicators that could be incorporated into future versions of the Report?

10. What incentives can stimulate more sustainable development and environmental protection through the use of innovation and new technology?

1st Example Output: Tools to Assess, Measure, and Monitor Clean-up of Contaminated Sediments.

This output addresses specific programmatic and scientific needs for the Office of Superfund Remediation and Technology Innovation (OSRTI) and the Great Lakes National Program Office (GLNPO, Region 5). It will develop a suite of innovative methods to improve the ability to predict chemical concentrations in fish, shellfish, and birds (i.e., aquatic dependent wildlife) from exposure to contaminated sediments both before and after remedy completion; improve laboratory testing of sediments to assess toxicity and bioaccumulation of chemicals at individual sites; and provide biological, chemical, and geophysical procedures to measure and document the effectiveness of sediment remediation.

Contributing products

1. On-site and laboratory methods to assess the bioavailability of contaminants in sediments.
2. Improved models of food chain bioaccumulation for prediction of long-term changes in fish contaminant concentrations after remediation (e.g., for estimating when levels become safe for human consumption).
3. Tools that more quickly and cheaply detect changes in sediment toxicity and chemical residues in biota and that document success resulting from remediation actions.

2nd Example Output: Capstone Reports on Beneficial Reuse of Material and Energy Recovery from Wastes

This output provides data and tools on ways to optimize the recovery of energy from wastes and to optimize the beneficial reuse of wastes, based upon an assessment of the state-of-the practice. This research will be done in collaboration with states to develop reuse options and with the private sector to assess technologies and processes. This information can identify opportunities to further reduce the volume of waste disposed, conserve natural materials, and reduce net costs while protecting the natural environment in an economically and technically sound manner.

Contributing products

1. Tools that identify methods to maximize energy recovery from wastes.

2. Analysis of improved materials recovery and beneficial use options from wastes.

3rd Example Output: Synthesis document on advanced ground water modeling

This synthesis document describes findings from ground water transport and transformation studies for multiple subsurface contaminants. Ground water has been impacted by multiple contaminants at many contaminated sites located in or near communities across the U.S. Contaminant plumes can affect public and private drinking water supplies and discharge to lakes or rivers. The availability and quality of ground water resources are increasingly important to meeting community needs for water, especially in areas (e.g., the southern U.S.) where urban water growth demand and / or droughts have resulted in shortages

in surface water supplies. This output provides information on how to develop strategies for remediation of multiple contaminants, from multiple sources, within the context of existing and future demands from communities for water.

Contributing products:

1. Development of a multi-agent ground water transport tool.

2. Assessment of the transformation of chlorinated solvents in ground water.

3. Development of a combined ground water model for use in characterizing ground water flow, transformation of organic subsurface contaminants, characterization of source-zones for non-aqueous phase liquids, diffusion of contaminants from low permeability layers, and assessment of natural attenuation of contaminants in the subsurface.

4th Example Output: Sustainable Management of the Nitrogen Cascade

This output provides the scientific basis for the management of reactive nitrogen by identifying strategic and efficient options to reduce its most damaging effects while maintaining the benefits of nitrogen use. When reactive nitrogen is released to the environment it creates a cascade of harmful effects that includes eutrophication of significant ecosystems (e.g., Chesapeake Bay), hypoxia or "dead zones" (Gulf of Mexico, and many others around the world), toxic algal blooms, acid rain, nitrogen saturation in forests, contributions to global warming, and associated human health effects due to contamination of drinking water and air pollution.[14] This output synthesizes existing and new analyses about the sources of nitrogen; its distribution in air, land, and water; and its impacts on valuable ecosystem services. These analyses are tailored to meet national and local needs for information to implement practices, rules, and policies for nitrogen management, as well as to understand the interrelated effects of associated co-pollutants, e.g., phosphorus, sulfur, and mercury.

Contributing products:

1. National-scale maps that describe nitrogen loading to the U.S. from sources including fertilizer, agricultural fixation, air deposition, manure, wastewater, and industry, including estimates of uncertainties associated with these nitrogen loads.

2. A report to inform EPA's review of the National Ambient Air Quality Standards (NAAQS) that provides estimates of critical nitrogen deposition loads, sensitive ecosystems, and connections to ecosystem services.

3. New national scenarios for the Community Multi-scale Air Quality (CMAQ) model based on EPA's new air rules.

4. Report on sustainability and efficiency in nitrogen cycle interventions.

5. Local-scale products, which include N-Sink, a simple geo-spatial tool designed for watershed managers that will enable them to describe sources and sinks of nitrogen within a watershed and a webtool that provides local estimates of nutrient inputs.

14. US EPA Science Advisory Board, Reactive Nitrogen in the U.S.,2011

Theme 3 Outcome

OSWER, the Regions, and states will make better informed decisions, leading to reduced risk, less costly remediation, faster return of property to economic use, and more comprehensive protection of valuable ground water resources. Communities will have more reliable data with which to make decisions for managing solid wastes and materials, safer options for disposal of unavoidable waste, and access to more options for recovery of materials and energy from waste. Decision makers will have spatially explicit information and maps depicting sources and multi-media consequences of reactive nitrogen, allowing them to identify the most critical and efficient intervention points in order to retain benefits received from nitrogen-producing activities while mitigating the damage and cost to valuable ecosystem services. Stakeholders will be able to access the ROE's reliable indicators for air, water, land, human exposure and health, and ecological condition. Innovative technologies will be encouraged through awards to interdisciplinary student teams for their innovations in sustainable technologies and grants to small businesses for their proof-of-concept and pre-commercialization designs for new technologies.

Theme 3 Impact

Products created under this theme will improve assessment and remediation of contaminated soil and ground water, hastening the recovery of damaged ecosystems and enabling safe and productive community redevelopment. EPA guidance on more flexible options for handling waste disposal and materials will increase the availability of beneficial reuse options, permitting increased recovery of energy and materials from waste. A comprehensive analysis of the nitrogen cascade and its effects on valuable ecosystem services will support collaborative research with ORD's ACE and SSWR research programs and inform strategic management options by OAR and OW to reduce negative impacts. A new web-based version of the ROE will allow users to explore, display, and analyze underlying data to better address their specific needs and interests. New generations of entrepreneurs will be trained in real world applications for sustainable technologies, small businesses will have new opportunities to expand and create jobs, and communities will have access to a greater range of technologies and management options.

Research Themes and Priority Science Questions

Theme 4: Integrated Solutions for Sustainable Outcomes

Two significant barriers to effective decision making for community sustainability are (1) the failure or inability to account for unintended impacts of actions, and (2) the failure to account for or take advantage of linkages among issues. Whether due to oversight or lack of information, these omissions impede transparent decision-making. Good sustainable community design —of policies, technologies, and incentives —needs to take into account the linkages among the natural and built environments, human welfare, and ecosystem services. For example, children's health depends on safe buildings, water for human use depends on land use that protects watersheds, transportation routes shape development patterns, and building design determines long-term implications for generation of waste and for managing materials.

Theme 4 will explore systems modeling approaches to account for the linkages among resources and assets managed by a community, with an emphasis on the high-priority decision sectors identified by community stakeholders, i.e., waste and materials management, building codes and zoning for land use planning, transportation options, and provision of infrastructure, including water and energy. Models that account for the stocks and flows of energy, materials, and water can be used by communities to identify opportunities to increase efficiencies and for resource recovery.

Theme 4 will also develop methods and data for Total Resource Impacts and Outcomes (TRIO) accounting of the multiple implications of a given decision alternative, including costs and benefits -- direct and indirect – in terms of economic, environmental, and societal dimensions.

Durham, NC will serve as the first local pilot for developing these modeling and TRIO methods, the proof-of-concept using real world data and conditions. Here, SHC researchers will evaluate the feasibility and benefits of integrating findings from synthesis reports and systems models as well as tools developed in other Themes in order to prototype SHC's TRIO approach for decision-making. Findings from this pilot will be used to refine data inputs, component tools, and the TRIO methodology itself.

Science Questions

The broad science questions that guide Theme 4 research are as follows:

1. Using a life-cycle approach, how can solid wastes be reduced, reused, recycled and disposed or managed in order to conserve land, minimize contamination of land, minimize emissions to air and water, and yield equitable co-benefits throughout a community?

2. What are the full sustainability consequences of any given building or infrastructure entity over the full life cycle of its design, construction, occupancy, renovation, and disposal? How can they be made to have lesser impact, and be more healthful and economical in the long run?

3. How do the types of transportation options (e.g., road density and connectivity, vehicle and fuel technology choices, access to public transportation, options for

commuting by foot or by bicycle) contribute to community health and well being, environmental quality, and economic vitality?

4. What are the intended and unintended consequences of local decisions for land use alternatives and how can this information be used in planning, management, and decision-making by local communities in order to support their sustainability goals?

5. What are the linkages among drivers and outcomes associated with sector-based decisions for: waste and materials management, building codes and zoning for land use planning, transportation options, and provision of infrastructure, including water and energy?

6. What benchmarks can be used to describe the state of the practice for sector-based decisions? What benchmarks can be used to describe the state of the science for sector-based decisions?

7. What measures of environmental quality and community health and well-being best reflect the full costs and benefits of alternative solutions?

8. How can sector-based linkages and analyses of energy, materials, and water flows be included in systems models? How can they be reflected in performance metrics that include economic, environmental, and societal dimensions?

9. What combination of methods to engage stakeholders and tools to support decision making are most useful to local governments and communities?

1st Example Output: Synthesis Reports for Sector-based Decisions

These reports will synthesize available literature and cases studies in order to describe and benchmark the current state of the practice and the state of the science for each sector.[15] This information will provide a common understanding about current states of practice, identify opportunities and information gaps, and suggest "upper-bound" estimates of outcomes from a variety of sustainable practices. These benchmarks can then be incorporated into systems models in order to bracket current and potential future opportunities and to define exploratory model simulations.

Contributing products:

1. Reviews and compilation of individual case studies and literature reviews.

2. Graphic and statistical analyses of findings.

2nd Example Output: Findings Provided by Integrated Model Analyses

Systems models characterize dynamic links between stocks and flows. Multi-agent models characterize the ways in which outcomes are influenced by the interactions of individual preferences/decisions, the implications of municipal or local policies/decisions, and the effects of incentives/constraints associated with state or federal requirements. SHC will use systems models and multi-agent models to explore and characterize the range in outcomes associated with alternative options that communities can choose to implement their sustainablity goals.

Contributing products:

1. Collection of data.
2. Parameterization of the models.
3. Design, implementation, and analysis of multiple model simulations.
4. Creation of a hybrid multi-agent systems model.

15. The NRC report Sustainability and the U.S. EPA, 2012, notes the importance of providing local communities with information about national and international best management practices for sustainability.

3rd Example Output: Total Resource Impacts and Outcomes

TRIO is a method under development by SHC for evaluating the outcomes of community decisions across the three dimensions of sustainability: societal, economic, and environmental. A transdisciplinary team of health scientists, ecologists, economists, and policy partners will evaluate or develop indicators (see also Theme 1) that reflect the response of those sustainability dimensions to decisions made within the SHC decision-sectors. The TRIO approach uses systems models to estimate the full range of costs, benefits, impacts, and outcomes for a given decision; the relative weights of the indicators can be varied to reflect community preferences and needs. TRIO will be tested in the Durham proof-of-concept project; ultimately the TRIO tool will be available as a web-based model for more widepread application to community sustainability decisions.

Contributing products:

1. Indicators and metrics and web-based community assessment tools from Theme 1.

2. Information about links between ecosystem services, the built environment and human health and well-being from Theme 1.

3. Findings regarding waste and materials management from Theme 3.

4th Example Output: SHC Pilot – Durham, North Carolina.

The complex and dynamic nature of decision evaluation and sustainable design processes argue against developing approaches only in theory. For this reason, Theme 4 includes a proof-of-concept project in a real community, Durham NC, where results can be immediately and practically applied to community issues while providing feedback on the method and on needs for further research. This project will engage the community to identify priority decisions, apply the TRIO method to those decision alternatives, evaluate the full impacts of alternative decisions and cascading effects that can result, and design a municipal decision process that can increase efficiencies, decrease costs, and prevent environmental and community health impacts. Durham will benefit by having some of their relevant decisions comprehensively evaluated in a transparent fashion. SHC will benefit by having immediate feedback on research products, to improve the TRIO method and inform future efforts. The Durham proof-of-concept study will: 1) address high priority areas identified by the community; 2) collaboratively identify the interconnections among issues and opportunities to concurrently advance the multiple goals as identified by multiple parties; and 3) analyze scenarios that link Durham-specific issues to TRIO methods.

Contributing products:

1. Synthesis reports.

2. Findings from use of systems models for characterizing options and outcomes.

Theme 4 Outcomes

Community decision makers and stakeholders will be able to: 1) identify linkages among issues, resulting in greater opportunities for more effective and economical decisions; 2) concurrently evaluate opportunities for multiple sectors and stakeholders to achieve mutually desirable goals; 3) assess a broad range of impacts, outcomes, costs and benefits of decisions, including the ability to consider impacts on the environment and community health in similar terms.

Theme 4 Impacts

Communities will have greater flexibility in developing sustainable practices for materials and waste management, transportation alternatives, and the built and natural environment. Durham will benefit from results of the pilot project that tests new multi-agent, multi-

media tools for their ability to identify potential synergistic outcomes associated with an array of sustainability practices. This information will contribute to community discussions – in Durham and in future site-specific sustainability studies -- about options for crafting their preferred sustainability policies, including selection of desired performance metrics, ways to more comprehensively account for impacts and outcomes, and the design of incentive programs. This research will also assist the Agency in implementing the Livability Principles developed with its Federal partners in Sustainable Communities (DOT and HUD).

Conclusion

Each community is unique with respect to policy context, resources, constraints, and culture, but the issues of sustainability are common to all – a clean environment, a robust, resilient economy, and concern for their resident's health and well-being. The goal of the SHC research program is to provide communities the information they need to transform their expressed interest in sustainability into integrated actions that can yield greater returns than current piecemeal approaches. To accomplish this, SHC will develop and use a whole-systems approach to assess opportunities for achieving multiple benefits through integrated sustainability practices.

The new methods and tools developed by SHC will enable EPA regions, states, tribes, and communities to implement their respective responsibilities with far greater ability to proactively assess how their choices affect progress in meeting their respective sustainability goals. This information, together with communities' more intimate connections with local residents, businesses, and other groups, provides opportunities for communities to pursue effective, state-of-the-art actions that have cascading benefits. There is also great interest from communities, around the country and the world, in using more sustainable practices to provide a full range of services. These conditions present both a receptive audience for SHC products and a trove of information about early experiences on which to build and refine a scientific program with immediate applicability to community needs. Supported by tools and information developed by SHC, communities can be empowered to better manage, and individuals or organizations to better understand, how their activities promote progress toward a sustainable future. As benefits accrue for individual communities, and as lessons spread, more and more sustainable communities will add up to a more sustainable nation and planet.

Appendix A
EPA Community Based Programs

	PROGRAM NAME AND OFFICE
OAR	Community -Based Childhood Asthma Program (OAR)
	EPA School Monitoring Initiative (OAR)
	Local Climate and Energy Program (Climate Showcase Communities) (OAR)
OCSPP	Community-Based Lead Grant Program (OCSPP) (funding ended in 2009)
	Economy, Energy, and Environment (E3) Initiative (OCSPP)
	Tribal Lead Grant Program (OCSPP) (funding ended in 2009)
OECA	EJ Showcase Community (OECA)
	EJ Small Grants Program (OECA)
OITA	Indian Environmental General Assistance Program (OITA)
OP	Smart Growth (OP)
OSWER	Brownfield Sustainability Pilots (funded 2008)
	Brownfields and Land Revitalization Technical Support Centers (OSWER)
	Brownfields Assessment, Cleanup, and RLF Grants (including Browfields Area-wide Planning Pilots) (OSWER)
	Brownfields Training, Research, and Technical Assistance Grants (OSWER)
	Environmental Workforce Development and Job Training Grants (OSWER) see brownfields in orange
	Partnership for Sustainable Communities Brownfield Pilots (2010) (OSWER)
	RE-Powering America's Land (OSWER)
	Superfund Technical Assistance Grants (TAG) (OSWER)
	Superfund Job Training Initiative (OSWER)
	Superfund Redevelopment Initiative (OSWER)
	Targeted Brownfields Assessments (OSWER)
	Technical Assistance Services for Communities Program (TASC) (OSWER)
	Technical Assistance to Brownfields (TAB) Communities (OSWER)
OW	Community Action for Renewed Environment (CARE) (OW)
	Five Star Restoration Grants Program (OW)
	Lead in Schools Programs (OW)
	Stormwater/SSO/CSO permits (OW)
	Urban Waters Initiative (OW)

Appendix B: Summary of SHC Stakeholder Engagement Activities

Program Stakeholders:

EPA Partners Meetings: Participants at two workshop-style meetings included representatives from EPA's Offices of Air & Radiation, Chemical Safety & Pollution Prevention, Children's Health, Environmental Justice, International & Tribal Affairs, Solid Waste & Emergency Response, Sustainable Communities, and Water, and representatives from Regions 1, 2, 4, 7, and 10. In addition, many more informal meetings and conference calls were held with these Offices and all EPA Regions during design of the SHC research program development. Staff from these Offices and Regions served on workgroups for selected themes and topics.

Participants per Session Types:

Regional Listening Sessions: 103 community representatives participated from 7 different communities in 5 EPA Regions.

Durham Pilot Outreach Meeting: 27 Durham representatives, including an elected official, two local NGOs, a representative of ICLEI and city and county government agencies.

Community Outreach Webinars: 157 attendees from 36 states representing 12 universities, 16 state-level planning departments, 20 county- and city-level planning departments, 25 tribes, as well as many community-oriented and non-governmental organizations across the country participated in these webinars.

Key Community Leaders Workshop: 1 ½ day workshop with 20 non-EPA participants from 3 universities, six communities, several city sustainability offices, and 6 national non-governmental organizations.

Non-governmental Participants:

Advantage West
Appalachian Sustainable Agriculture Project
Asheville City Schools Foundation
Asheville Design Center
Association of Spokane Realtors
AZ State University
Boston Environment and Energy
Center for Resilient Cities
Clean Energy Durham
Community Colleges of Spokane
Congress for the New Urbanism
Duke's Nicholas Institute
Eastern Washington University
Economic Opportunity Council Weed and Seed

Eno River Association
Green Opportunities
Green Team
Hand Made in America
Health Impact Project
ICLEI USA
Impact Capital
Martin Luther King Community Health Center
Midwest Environmental Advocates
Midwest Quality Water
National League of Cities, Director of Sustainability Program
Newsday
Nicholas Institute
RTI, International
Scientific Consulting Group, Inc.
Sixteenth Street Community Health Center
SNAP- Significant New Alternatives Policy
Sweet Water Trust
Transition Milwaukee
UNC-Chapel Hill Finance Center
University of North Carolina at Asheville
University of North Carolina at Chapel Hill
University of Wisconsin-Milwaukee
University of Wisconsin-Milwaukee Geography and Urban Planning
University of Wisconsin-Milwaukee School of Freshwater Research
University of Wisconsin-Milwaukee Urban Planning
Washington State University
Waste Reduction Partners
Western North Carolina Alliance
Woodbine – AmeriCorps
Woodbine Main Street
Woodbine Municipal Lighting and Power
Wyandanch Community Development Corporation
As well as teachers, farmers, legislators, engineers, and other citizens

Appendix C: Acronyms and Definitions in the Context of SHC's Strategic Plan

BOSC	Board of Scientific Counselors
CCR	Coal Combustion Residue
C-FERST	Community-Focused Exposure Risk Screening Tool
DOT	U.S. Department of Transportation
EGSPF	Ecosystem Goods and Services Production Function
EJ	Environmental Justice
EPA	Environmental Protection Agency (or "the Agency")
FEGS	Final Ecosystem Goods and Services
HUD	U.S. Housing and Urban Development
ICLEI	International Council for Local Environmental Initiatives
LC	EPA Labs/Centers
MSW	Municipal Solid Waste
N	Nitrogen
NEGSCS	National Ecosystem Goods and Services Classification System
NGO	Non-governmental Organization
NIMHD	National Institute on Minority Health Disparities
NPL	EPA's National Priorities List
NRP	National Research Program
OEI	Office of Environmental Information
ORD	Office of Research and Development (in EPA)
OSC	EPA's Office of Sustainable Communities
OSWER	EPA's Office of Solid Waste and Emergency Response
OW	EPA's Office of Water
P3	EPA's People, Prosperity and the Planet Program
RAP	Research Action Plan
RCRA	Resource Conservation and Recovery Act
ReVA	Regional Vulnerability Assessment
RO	EPA Regional Office
ROE	EPA's Report on the Environment
SAB	Science Advisory Board
SHC	Sustainable and Healthy Communities
SHCRP	Sustainable and Healthy Communities Research Program
SSWR	EPA's Safe and Sustainable Water Resources
T-FERST	Tribal-Focused Exposure Risk Screening Tool
TRIO	Total Resource Impacts and Outcomes
VOC	Volatile Organic Compound

Definitions

Bioaccumulation: the bodily accumulation of chemicals that are ingested, but not eliminated.

Cumulative exposure: exposures to chemicals from many sources that, may not be significant individually, but which add up or accumulate to a possibly significant level.

Decision science: study and methods related to issues important to making decisions, like identification of values (what's important to society), evaluation of uncertainties and risk in given decisions, etc.

Hypoxia: Refers to the conditions of 'low-or no-dissolved oxygen in water; hypoxia conditions kill fish and other aquatic life.

Economic multiplier: a factor which can define how money spent at local businesses will result in more local financial benefits than money spent at non-locally owned businesses.

Ecosystem: the system of living things which function together in a given place with a particular geology and climate, for example, a coastal marsh wetland.

Ecosystem goods: natural resources provided by ecosystems, like timber or fish.

Ecosystem services: the natural functions of ecosystems which are useful for humans, for example, the functions which support agriculture, like pollination or the decomposition of organic matter into soil.

Ecosystem goods and services benefit functions: a numerical characterization of the value to humans of nature's functions and services.

Environmental Justice: protection of historically disadvantaged populations or communities from environmental impacts greater than those on the general population.

Eutrophication: refers to the over-fertilization of lakes, rivers, or coast waters, leading to over-growth of aquatic plants, algal blooms, and conditions unpleasant or unsafe for people or fish and other aquatic animals.

Holistic: relating to a whole system, rather than analysis or treatment of parts.

Index: a number or symbol, developed from a series of observations or measures and used to indicate or describe a subject of interest.

Indicator: a measure used to describe a particular state or relationship, which may, or may not, be a direct measure of that state or relationship.

Indices: plural of index.

Iterative: doing something repeatedly, learning and improving each time

Media: In this program, media (the plural of medium) has meanings in two different contexts: one, the air, land and water, so called because each is a medium that carries pollution; two, electronic methods of carrying data or information, as in cell phones or radio.

Metric: a standardized unit of measure.

Mitigation: actions taken to prevent, lessen or solve problems.

Modeling: using mathematics and an understanding of the ways a system works to describe or predict state, outcomes or events.

Monofills: landfills that contain one specific material.

Remediation: to bring a contaminated site or resource back to a safe and usable state.

Remote sensing: the use of aerial photography, satellite imagery, or other means to collect data or information from a distance.

Risk: the probability of adverse effects.

Scale: the relative degree of detail on a geographic data set, according to the amount of area covered and size of the units of data.

Scenario: experimental representation of “what if?”.

Spatial: having to do with the character of space, here used to describe data that is geographic.

Systems thinking: evaluating an issue from the perspective of the whole system of interacting parts, rather than evaluation of separate parts.

TMDLs: Total Maximum Daily Loads of pollutants to water bodies; these loads are set to maintain water quality.

Urban heat island: the retention of heat by urban concrete and pavement during the day, creating warmer conditions than for green space.

Summary Tables of Outputs and Outcomes

Communities face social, economic, and environmental trade-offs in a resource-constrained world. These trade-offs are often not well-characterized in terms of the implications and interactions between human health, ecosystem services, economic vitality, and social equity. Conventional decision-making often does not adequately characterize these complex interactions.

Theme 1. Data and Tools to Support Sustainable Community Decisions

Topic 1. 1 Decision and Information Science

Outcomes: Outputs created under this theme will help EPA and its partners to better understand the scientific, economic, and social dimensions of community sustainability issues, leading to more effective environmental decision-making. Products will form the foundation for a toolkit of innovative, non-mandatory solutions to complex sustainability problems. Existing and in-progress decision tools will benefit from a wider range of contributing partners, and become better able to meet the needs of more communities. Communities and stakeholders will be actively engaged in ongoing sustainability planning, using innovative new tools including social media. They will be able to collaborate with the EPA and each other for the mutually beneficial exchange of knowledge and resources. They will be better able to articulate challenges, assess proposed solutions, and provide or request specific scientific resources. EPA will increase its ability to support all communities and stakeholders in their sustainability goals, fostering participatory problem solving, empowerment, and buy-in.

Framing Sustainable Decisions and Enhancing Collaboration	
Outputs	**Output Year**
Community typologies to guide future community selection for collaborative research and tool development	FY2013
Collection of tools and processes for community decision analysis	FY2014
Compilation of best practices for community and stakeholder engagement	FY2014
Information Science, Innovation, and Evolved Stakeholder involvement	
Service-oriented architecture to facilitate interoperability among SHC tools and accessibility to assessment and full cost accounting tools	FY2013-2016
Mechanisms -- and facilitation thereof -- to allow external improvements to and maintenance of SHC tools	FY2013

Communication and Community Engagement	
Outputs	**Output Year**
The Communication and Community Engagement Plan will describe the activities, processes and timeline where ORD will collaborate with EPA, HUD, and DOT community based programs and our partners including universities to systematically and more effectively identify community issues, develop and deliver science products, and develop networks for building capacity in communities to empower communities for better decision-making.	FY2012
Topic 1. 2 Assessing Community Sustainability	
Outcome: Outputs created in this theme area will form the foundation for a toolkit of innovative, non-mandatory solutions to varied and complex sustainability problems. Existing and in-progress decision, assessment and evaluation tools will benefit a wide range of partners and stakeholders and help EPA better meet the needs of a wide variety of communities. Communities and stakeholders can actively engage in the use of these innovative new and existing tools. Communities will be able to better articulate their challenges, assess their needs and proposed solutions, and describe the scientific tools they are using as well as those they need provided or developed. EPA will increase its ability to support as many communities and stakeholders as possible in their sustainability goals, fostering participatory problem solving without having to work solely community-by-community.	
Existing and New Tools (models, methods, frameworks, etc)	
Inventory of relevant community sustainability tools and peer review evaluation of effectiveness and accessibility of existing tools	FY2012
Modified existing tools, support data for external tools, new tools, and interoperable modules that address community decision needs and meet SHCRP goals for improved accessibility and efficiency	FY2015
Providing Indicators and Indices to Assess, Track, and Inform Community Sustainability	
Updated guidance document and inventory of available sustainability and performance indicators in a searchable database; Prototype completion of web tool for searching database	FY2013
Publically available EQI (years 2000-2005) data set with user's guide so communities can extract the data and use for their own study questions.	FY2012
Updated EQI data inventory for expanded geographic areas	FY2014

National Atlas for Sustainability	
Outputs	**Output Year**
Full public release of Version 2 of the Atlas with additional national, regional, and community data, additional functionality, and overall improvements based on results of new research and feedback from users of Version 1	FY2013
Annual releases of Atlas with additional functionality and data; ecosystems services data and sustainability data related to the built environment	FY2014 FY2015 FY2016

Theme 2. Forecasting and Assessing Ecological and Community Health

Topic 2. 1 Quantifying Production and Valuation of Ecosystem Goods and Services for Sustainable Communities	
Outcomes: Outputs created under this topic will provide federal agencies with consistent, effective, and broadly applicable information on the distribution of ecosystem service benefits, as well as how this distribution changes based on land use, transportation, housing and infrastructure choices, and materials management. This will facilitate conservation as well as public and private investments to support ecosystem services. It will also facilitate the contribution of ecosystem services assessment to decisions at multiple scales and in different geographies across the country. Communities, regions, and the nation will be able to make more sustainable decisions, based on full-cost accounting that includes the impact of alternatives on benefits provided by nature. EPA will improve standards and guidelines for incorporating economic valuation into mitigation efforts.	
Standardized Classification and Indicators for Ecosystem Goods and Services	
Outputs	**Output Year**
A National Ecosystem Goods and Services Classification System (NEGSCS) and identification of metrics and indicators of the biophysical features needed to support that system	FY2013
Ecosystems Goods and Services(EGS) Production and Benefit Function	
An accessible compilation of existing ecological production functions and benefit functions (models relating management options to changes in the timing, spatial distribution and quantity of a variety of ecological endpoints, and the social benefits of ecological goods and services derived from those ecological endpoints), with an assessment of critical missing data	FY2014
Methods for estimating the transferability of ecological production, ecosystem goods and service production, and benefit functions across landscapes, and regions and to unmonitored locations	FY2015
Guidance on how integrated ecosystem goods and services system models can help inform market decisions (e.g., how to estimate credits for markets)	FY2016
Community-based EGS Research for Representative Communities	
Incorporation of EGS production and benefit functions in specific decision-making contexts and forecast of intended and unintended consequences of different decision options	FY2014
Models and useable decision support tools that incorporate social, economic and environmental information for alternative decision scenario analysis	FY2014
Models for estimating social, economic, and environmental sustainability of past decisions and future decision options	FY2015
Evaluation of different modeling and decision support tools for application to different decision contexts and different scales	FY2016
Place based and Thematic EGS Research	
A synthesis of recent ORD research on the calculation of ecological production functions and benefit functions for multiple ecosystem services, providing a preliminary compilation of data to model how changes in ecosystems affect social welfare	FY2013
An accessible compilation of existing ecological production functions and benefit functions (models relating management options to changes in the timing, spatial distribution and quantity of a variety of ecological endpoints, and the social benefits of ecological goods and services derived from those ecological endpoints), with an assessment of critical missing data	FY2014

Outputs	Output Year
A methodology for generating ecosystem goods and services production functions (models relating changes in ecological endpoints to changes in the production of valued ecosystem goods and services)	FY2014
ReServe Regional EGS	
Topic 2. 2 Improving Human Health and Well-being for Community Sustainability	
Outcomes: EPA will have better data regarding factors contributing to disease, as well as the ability of the built and natural environment to enhance health outcomes. The research will provide insight into the contribution of livable and walkable cities to public health. EPA and communities will be able to holistically assess community health and well-being, as they relate to the environment where people live and work. They will have better data for addressing issues related to the health of infants and children, community public health, and environmental justice	
Enhancing Community Public Health	
Identification of the most prevalent environmental public health conditions in communities resulting in disparities in health and well-being between communities or populations for use in targeting and prioritizing research and generation of risk management methods	FY2014
Identification of environmental and health-related factors, including chemical and non-chemical stressors and their impact on vulnerable populations, related to high-priority sectors identified by communities	FY2014
Integrated methods, measurements, and models to characterize effects of key environmental factors on public health, and application of these to quantify, track, and reduce cumulative health risks related to both chemical and non-chemical stressors	FY2016
User-friendly tools for improving and increasing the quality and accessibility of diverse, reliable, integrated information and data, and to evaluate the implications (positive and negative) of alternative management decisions to inform local environmental health decisions that promote public health and well-being with the long-term goal of better accounting for their social, economic, and environmental costs and benefits.	FY2016
Results, best practices, and transferable approaches derived from community-based participatory case studies to address emerging and ongoing health concerns in community settings	FY2016
Enhancing Children's Health	
Sustainable community solutions to prevent/reduce children's health disparities and optimize child-specific settings (home, day care, school, recreational [land, water]) and community practices	FY2016
Mitigation/intervention strategies and data to evaluate success in community settings	FY2016
Securing and Sustaining Environmental Justice	
Workshop and synthesis papers for EPA and EJ stakeholder groups on the interactions of environmental, social, behavioral, and biological factors / policies as they relate to health disparities	FY2011-FY2016
A successful approach for incorporating community knowledge into the development of tools and the application of qualitative approaches and social science methods into cumulative impact assessments. A web-based user-friendly tool to conduct community-based cumulative impacts assessments that include step-through process for problem identification, partnership building, inventory of community stressors and ranking.	FY2011-FY2014

Outputs	Output Year
New tools and approaches for cumulative impact assessments to integrate non-chemical stressors. Synthesis papers on methods for examining combined effects of social and physical exposures on health.	FY2011-FY2016
User-friendly and accessible tools and technical guidance for conducting disproportionate risk analysis needed to ensure environmental equity	FY2011-FY2016

Theme 3. Near-term Approaches for Sustainable Solutions

Topic 3. 1 Contaminated Sites	
Outcomes: Outputs created under this theme will improve assessment, response, and remediation of ground water contaminants, sediment contaminants, vapor intrusion, fuel spills, and oil spills. Better response and remediation tools will hasten the recovery of damaged ecosystems and the return of wildlife populations, as well as supporting community redevelopment. OSWER, the Regions, and states will make better informed decisions on remediation and response to contamination. This will directly lead to reduced risk, less costly remediation and faster return of property to economic use. Communities benefit economically from losing the stigma associated with contaminated sites, and from the high quality redevelopment which accompanies site clean-up	
Contaminated Sediments	
Outputs	**Output Year**
Biological procedures to measure/document remedy effectiveness.	FY2014 & FY2015
Standardized procedures for passive samplers	FY2015 & FY16
Standardized procedures for use of passive samplers for incorporating chemical bioavailability and flux measurements into site assessments	FY2015 & FY16
Improved ability to predict chemical concentrations in fish, shellfish, and birds (e.g., aquatic dependent wildlife) from exposures to contaminated sediments prior to and after remedy completion.	F20Y15
Improved laboratory sediment testing methods for assessment of toxicity and bioaccumulation at individual sites.	FY2014 & FY2016
Innovative Approaches to Support the Measurement and Assessment of Vapor Intrusion into Homes/Buildings from Contaminated Sites	
Scientific reviews of pending guidance document dealing with the vapor intrusion issues based on results from vapor intrusion task	FY2013
Simple, efficient, and rapid methods to determine the potential for vapor intrusion into the home and other buildings	FY2013
Assessment of the practical approaches to measure and monitor vapor intrusion from the source to the building	FY2015

Science and Engineering for Restoring Contaminated Land	
Outputs	**Output Year**
Toxicological information to inform the risk assessment of asbestos-contaminated communities	FY2014
Synthesis report of toxicology studies from the Libby Action Plan.	FY2013
Environmental Releases of Oil and Fuels: Preparedness, Response, and Recovery	
Modeling method and assessment of how natural in-situ biodegradation affects the potential for petroleum vapors from leaking underground gasoline storage tanks to enter homes and buildings.	FY2013
Assessment and Management of Contaminated Ground Water to Protect Human Health and Ecosystem Services	
Results published in peer-reviewed journal articles in order to address information gaps that currently limit the use of innovative in-situ technologies to stabilize and/or remove metals and organics from the subsurface. This information will improve understanding of the performance of permeable reactive barrier walls for metal stabilization, will inform engineering design guides for in-situ oxidization of organics, and describe methods to monitor to confirm natural attenuation of metals.	FY2015
Software, journal articles and EPA reports provide improved knowledge on transport of organic contaminants, including impacts of biodegradation, back-diffusion into permeable strata, dissolution from DNAPLs, and modeling. This work provides scientific knowledge previously unavailable (solvent biodegradation and back-diffusion) as well as improved engineering assessment of monitored natural attenuation and flux-based site assessment. Taken together this work compiles existing information and new knowledge to give the most scientifically advanced approach to organic contaminant transport.	FY2016
Topic 3. 2 Materials Management and Sustainable Technologies	
Outcomes: Outputs created under this topic will enable EPA to provide definitive guidance and more flexible options for handling waste disposal and materials. They will increase the availability of beneficial reuse options, permitting increased recovery of energy and materials from waste. Communities will have more reliable data with which to make decisions for managing solid wastes and materials. They will be able to find safer options for disposal of unavoidable waste, and have access to more options for recovery of materials and energy from waste.	
Tools to Assist States in Developing Beneficial Use Determinations for Wastes	
Comprehensive Report on State-of-the-Practice for Beneficial Use of Materials	FY2013
Modeling tools and databases to help decision makers manage waste utilization more sustainably A prototype science-driven user-friendly decision analysis toolset will be delivered for use by national, regional, and local decision-makers.	FY2014
Assessment of the state-of-the-practice in the beneficial reuse of materials to minimize waste disposal Collaboration with the States to assist in developing reuse options and with the private sectors in assessing technologies/processes	FY2015
Tools and Approaches to Recover Energy from Wastes	
Report on State of the Practice on Bioreactor Landfills	FY2013
Evaluation of Enhanced Energy Recovery Technologies from Waste Organics	FY2015

Outputs	Output Year
Construction and Demolition	
Assessment of sustainable management approaches for construction and demolition wastes, and working with industry to assess C&D materials flow and optimizing recoverable materials	FY2015
Coal Combustion Residue Research CCR - Regulatory	
Analyses and data sets for use in assessing materials reuse options, including coal combustion materials as aggregate in concrete.	FY2012
Topic 3. 3 Integrated Management of Reactive Nitrogen	
Outcomes: Outputs under this topic will contribute to a comprehensive analysis of the nitrogen cascade and its effects on the environment. This will contribute to more informed assessments and identification of the most critical and efficient intervention points. Decision makers will have spatially explicit information and maps depicting sources and multi-media effects of reactive nitrogen. This will allow them to increase the benefits from nitrogen-producing activities while mitigating the costs.	
Informing Sustainable Decisions about Nitrogen	
Maps and information about uncertainties associated with nitrogen loading to the US. This includes fertilizer, agricultural fixation, deposition, manure, wastewater and industrial N sources. Also database and website relating N loads to lake ecosystem services in the northeast and a tool for examining nitrogen sinks and sources within the landscape that can inform local management.	FY2012
Report on Sustainability and efficiency in the nitrogen cycle: Interventions to benefit human well-being and ecosystems. Tools for nitrogen management at the local scale. An integrated scalable framework of response relationships between N loads and the ecosystem goods and service production, human health and well-being, and economic benefits functions.	FY2013
Topic 3. 4 EPA's Report on the Environment	
Outcomes: The ROE, developed through a collaborative Agency-wide effort, is the EPA's most complete and reliable source of information on the status of the environment and trends over time. The ROE tracks indicators for air, water, land, human exposure and health, and ecological condition providing scientifically sound, timely data to the public as well as EPA programs as they prepare strategic plans and measure their programs' successes. A new web-based version of the ROE will allow users to access underlying data and display graphics, using these tools for expanded understanding and analysis. Stakeholders will be able to access reliable environmental information based on updates to 85 existing environmental indicators, along with several new sustainability indicators. They will use new ROE enhancements to explore, display, and analyze underlying data to better address their specific needs and interests.	
EPA's Report on the Environment	
Fully web-hosted eROE2012--A dynamic website interface featuring interactive, customizable graphics and mapping capability; a systems-level conceptual framework with a sustainability focus showing linkages among indicators; a new thematic area on Sustainability/Sustainable development, with relevant national-level sustainability indicators; fully updated indicators; new and revised indicators reflecting new data, knowledge and/or changing programmatic needs; updated graphics displaying quantified statistical uncertainty information where possible and appropriate	FY2012
Fully revised and updated web-hosted eROE2016	FY2016
Topic 3. 5 Innovation and Technology to Foster Sustainability	
Innovation and Technology to Foster Sustainability	

Outputs	Output Year
Completed real-world research projects designed by teams of college students to provide sustainable environmental designs or technologies for local communities and small business ideas. Graduates with greater experience in sustainability thinking going into environmental science, engineering, business, biology and policy fields.	Annual
Make available to communities innovative water treatment, residuals management, and monitoring technologies for drinking water and wastewater systems. EPA and the Small Business Administration are leveraging with national and international water and water research organizations, Wright Brothers Institute, Air Force Research Laboratory, Green Umbrella (Cincinnati), Artemis Top 50, Imagine H2O, to develop and commercialize systems that enhance community sustainability.	FY2015

Theme 4. Integrated Solutions for Sustainable Outcomes

Topic 4.1 Community Decision Sector Analysis	
Outcomes: The research produced under this topic will provide EPA and communities with greater flexibility in developing sustainable practices for materials/waste management, transportation alternatives, and the built and natural environment. This will enable communities to achieve multiple objectives under complex constraints. The research will also assist the Agency in implementing the Livability Principles developed with its Federal partners in Sustainable Communities (DOT and HUD). Communities will be able to analyze the full costs and benefits of decisions, allowing them to consider impacts on the environment and community health in similar terms. Community decision makers will be more transparent in their choices, and better stewards of community resources.	
Buildings and Infrastructure	
Outputs	**Output Year**
Synthesis report on existing tools and state of the practice for Community decisions in the buildings and infrastructure sector	FY2013
Land Use Planning: Natural and Built Environment	
Synthesis report on existing tools and state of the practice for Community decisions about land-use planning for the built and natural environment	FY2013
Transportation	
Synthesis report on existing tools and state of the practice for Community decisions in the transportation sector	FY2013
Spatial tool for evaluating air quality impacts of alternative transportation designs for input into community health and environmental assessments	FY2013
Waste and Materials Management	
Synthesis report on existing tools and state of the practice for Community decisions about waste and materials management	FY2013

Guidance and tools for communities, States and industry to reduce energy and water consumed in managing materials while reducing costs, synthesis and critical evaluation of materials management issues and multimedia assessment.	FY2015
Topic 4. 2 Integrated Approaches to Sustain the Built and Natural Environment and the Communities they Support	
Outcomes: The outputs developed under this theme will improve analysis of linkages between community sectors, enhancing community sustainability. At the Regional level, analysis of linkages can be used to support planning and permitting activities, resulting in more collaborative and sustainable solutions. The Durham pilot project will test new multi-agent, multi-media tools for their ability to achieve the greatest possible synergistic outcomes from sustainability practices. Results will contribute to EPA guidance documents and incentive programs, as well as future site-specific sustainability programs. Community decision makers will be better able to evaluate opportunities for multiple sectors and stakeholders to achieve mutually desirable goals. Communities will be able to identify linkages among issues, resulting in greater effectiveness and increased economic efficiency.	
Outputs	**Output Year**
Methods to support Total Resource Impacts and Outcomes (TRIO) Accounting	
Synthesis of literature and existing case studies that summarizes the science and practical application of various methodologies for “triple-bottom-line accounting.”	FY2013
Collaborative Proof-of-concept: Durham NC	
Issues linkage map that demonstrates to stakeholders and decision makers the interconnections among issues and identifies opportunities to concurrently advance the goals of multiple interests and /or parties.	FY2013
Topic 4. 3 STAR Fellowships	
Fellowships	
Completed fellowships contribute toward a workforce ready to innovate and implement transdisciplinary approaches to a more sustainable future.	Annual