PRELIMINARY DRAFT NOTICE: This Cross-cutting Roadmap, 2016 – 2019 is a preliminary draft. It has not been formally released by the U.S. Environmental Protection Agency (EPA) and should not at this stage be construed to represent Agency policy, nor the final research program.

Environmental Justice Research Roadmap

Cross-cutting Roadmap

Draft, November 6, 2015

Table of Contents

I. Introduction

In 1994, President Clinton issued Executive Order 12898[1] in which he declared that each federal agency must "make achieving environmental justice part of its mission by identifying and addressing…disproportionately high and adverse human health or environmental effects of its programs, policies, and activities." He issued this order in recognition of the racial and economic disparities in the locations of toxic sites and their potential impacts on adjacent communities, disparities that had fueled the birth of the environmental justice movement more than a decade earlier when the civil rights and environmental movements came together to protest the locating of a PCB-hazardous waste site in a predominantly African-American community in North Carolina (Table 1).

The Environmental Justice Research Roadmap describes the interface between environmental justice and science and outlines opportunities that exist in the link between environmental equity and technology. This research has been included in the FY16-19 Strategic Research Action Plans that will guide research in the Office of Research and Development for the next four years.

The EJ Research Roadmap is a key element in the EPA's EJ 2020 Action Agenda: Science Tools Implementation Plan now under development (Table 1). The Roadmap represents a significant body of research, some in progress, some proposed, that recognizes the importance of near-source exposures and the demographics of those exposed. This research asks whether the burden of environmental health risk is evenly distributed across all Americans or whether some communities carry the preponderance of that risk, and why. ORD's inclusion of research to address overburdened groups and communities was accelerated by engagement with advisory groups and the development of a science plan in EPA's Plan EJ 2014 (EPA, 2011) (Table 1).

The science and technology described in this Roadmap is intended to address four essential challenges. 1) Developing decision support tools for identifying and prioritizing concerns, assessing cumulative impacts, and evaluating mitigation options: This includes science and technology to enhance community engagement by translating scientific results into useful information and by giving community stakeholders improved access to environmental science applicable to decision processes such as Health Impact Assessment. This also includes application of ORD research in the implementation of the Agency's Making a Visible Difference in communities program. 2) Improving our understanding of environmental health disparities and developing methods and data for assessing cumulative risks: Filling gaps in scientific understanding of how exposure to chemical stressors in the environment, including multiple, concurrent exposures, interact with societal and economic stressors in the social environment so that these can be appropriately considered in the cumulative assessment of risk and existing conditions in communities. 3) Tribal sustainability and well-being: Developing the science and technology needed to address environmental sustainability and climate adaptation issues for America's Tribes and other indigenous peoples. This includes building capacity to ensure that EPA's national programs are as effective in Indian country as they are throughout the rest of the nation. 4) Climate justice: Research to address the growing recognition that America's poorest communities are also those that are, in many cases, least prepared for potential impacts related to our changing climate such as extreme weather emergencies, drought, heat stress, flooding, and changes in sea level.

[1] Federal Actions to Ensure Environmental Justice in Minority Populations and Low-income Populations (Federal Register, 1994)

This Roadmap also recognizes that gaps still exist in EPA's approach for advancing science to address environmental justice issues. These include: 1) direct community engagement in the development of the Agency's scientific agenda and priorities; 2) assessing outcomes both directly related to the usability of the science and tools developed by EPA and longer term outcomes resulting from voluntary or regulatory actions designed to promote health and reduce environmental inequities; and 3) the need to continue to build scientific and technical capacity in overburdened communities to enhance community capacity to engage meaningfully in the development of environmental rules and other decisions that affect communities.

Background

The mission of the EPA is to protect human health and the environment. The Agency works with urban, rural and economically disadvantaged communities to ensure that everyone—regardless of age, race, economic status or ethnicity—has access to clean water, clean air and the opportunity to live, work, learn, and play in healthy communities[2]. EPA's goal is not only to provide protection for the general population, but to minimize inequities in health risks, environmental quality, and the distribution of ecosystem services (nature's benefits) to overburdened[3] communities.

EPA's environmental justice[4] efforts seek to protect the health and environment of overburdened communities, support these communities to take action to improve their own health and environment, and build partnerships to improve community health and long term well-being[5]. The Agency aims to substantially support and conduct community-engaged research to support improved integrated assessments considering multiple contaminants and life stressors. Ideally, this science integrates social and physical sciences aimed at improving our understanding of environmental and health inequalities in overburdened populations and communities in the United States and taking appropriate actions to eliminate disproportionate impacts [6]. Technological development is focused on enhancing community-stakeholder access to scientific information to inform decision-making with the goal of improving the ability to characterize environmental conditions and identify, assess, and compare available options to reduce potential health and environmental impacts. ORD played a leading role in the development of the Draft Technical Guidance for Assessing EJ in Regulatory Analysis (EPA, 2013a) (Table 1), contributing to guidance on considering EJ when planning a human health risk assessment. Under Plan EJ 2014 (EPA, 2011), EPA committed to continuing to build the strong scientific foundation for supporting environmental justice and conducting disproportionate impact analysis, particularly methods and

[2] Fiscal Year 2014-2018 EPA Strategic Plan (EPA, 2014)

[3] "Overburdened" describes minority, low-income, tribal and indigenous populations or communities in the United States that potentially experience disproportionate environmental harms and risks due to exposures or cumulative impacts or greater vulnerability to environmental hazards. This increased vulnerability may be attributable to an accumulation of both negative and lack of positive environmental, health, economic, or social conditions within these populations or communities, including the inability to meaningfully participate in the decision-making process. (Plan EJ 2014)

[4] EPA defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies."

[5] EJ 2020 Draft Framework

[6] Plan EJ 2014 – Science Tools Development (EPA, 2011)

supporting scientific information to appropriately characterize and assess cumulative impacts. This research has been formally included in the FY16-19 Strategic Research Action Plans that will guide ORD research for the next three years.

The Agency's mandate to pursue environmental justice is rooted in EO 12898, stating that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies and activities on minority populations and low-income populations." EO 12898 contains specific provisions[7] with respect to research related to the health and environment of minority and low income populations, specifically noting the importance of developing the science to assess multiple and cumulative exposures. Table 1 lists additional milestones in the development of EJ programs at the US EPA. EPA's Draft Technical Guidance for Assessing Environmental Justice in Regulatory Analysis (EPA, 2013a) and Guidance on Considering Environmental Justice during Development of Regulatory Actions (EPA, 2015b) contain excellent descriptions of the role of science, impact and risk assessment in regulatory analysis and EPA's regulatory authority with respect to environmental justice.

EPA's Fiscal Year 2014-2018 EPA Strategic Plan (EPA, 2014a) "recognizes (that) environmental justice, children's health, and sustainable development are all at the intersection of people and place. These goals are not mutually exclusive. Throughout all our work to achieve more livable communities, EPA is committed to ensuring we focus on children's health and environmental justice." The EPA Strategic Plan also captures EPA long-standing commitment to strengthen human health and environmental protection in Indian County and increase tribal capacity to establish and implement environmental programs. Environmental justice, disadvantaged communities, and tribal issues are explicitly addressed in four of the EPA's five media and enforcement-based strategic goals and two of its cross-Agency strategies; research needs for these goals are addressed across ORD's six National Research Programs. In recognition of this, ORD has identified environmental justice as a cross-cutting research area.
Problem formulation statement: The goal of ORD research addressing Environmental Justice is to strengthen the scientific foundation for actions at the agency, state, tribal, local and community levels to address environmental and health inequalities in overburdened populations and communities. This goal will be reached through the use of fundamental and community-based research approaches and the development of scientific understanding, guidance, decision tools and scientific information to help support decision-making[8]. ORD will focus on the following areas: environmental health disparities and cumulative risk and impact including chemical risk assessment for emerging contaminants, multiple contaminants, and non-chemical stressors; tribal science; and development of decision support tools and the application of citizen science to insure meaningful community engagement. ORD has also initiated research into climate justice.

Purpose

The purpose of the EJ Research Roadmap is to highlight the role of EPA science in addressing EJ and provide an inventory and analysis of EJ-related research included in ORD's six National Research

[7] Section 1-103 and Section 3-3 of the Executive Order outline goals for research, data collection and analysis specific to environmental justice.

[8] 2014 Plan EJ 2014 Progress Report (EPA, 2014b)

Programs. This Roadmap describes current research and identifies research gaps and addresses strategic directions at EPA.

It serves to communicate to EPA's Program and Regional Office Partners as well as to our external stakeholders (e.g., State and local agencies, tribal organizations, public health and community groups) how ORD is integrating EJ-related scientific research across ORD's national research programs. ORD research has and will continue to play an important role in supporting EPA rulemaking and policy decisions that can reduce environmental health disparities in communities. Research findings will provide the Agency, state and local governments, and other community stakeholders with the most recent and best scientific information that will inform decisions to improve environmental equity with respect to public health and environmental quality. Research results will be applied to providing protection from significant risks to health and well-being where people live, work, learn, and play. Environmental equity also includes ensuring access for all people to nature's benefits that promote health and well-being such as those afforded by, e.g. access to green space, urban tree arbors, clean water, and features of the environment that provide natural hazard mitigation, and the reduction of environmental exposures and accompanying health impacts (e.g., vegetative barriers around roadways).

The research included in the EJ Roadmap is not from an independent research program; it draws upon the Strategic Research Action Plans of ORD's National Research Programs and will serve to inform further research directions for these programs through its identification of research gaps. The research included in the EJ Roadmap promotes sustainable, healthy communities by providing state-of-the-science information, tools, and decision processes that can characterize and lead to mitigation of environmental and health inequities. The Roadmap also emphasizes research efforts that support engaging and working with community stakeholders to reduce disproportionate environmental exposures and health impacts, and ultimately promoting equitable access to sustainable and healthy environments for all.

This roadmap was developed by ORD staff in consultation with staff from EPA regional and program offices, including the Office of Environmental Justice. It is responsive to recommendations on the planning and implementation of research addressing environmental justice concerns received from key advisory committees including ORD's Board of Scientific Counselors (2015), National Environmental Justice Advisory Council (NEJAC, 2014), and the National Advisory Council on Environmental Policy and Technology (NACEPT, 2012). Additional input includes the Children's Health Protection Advisory Committee (CHPAC, 2013), and in national strategies such as Healthy People 2020 (DHHS, 2010).

Section 3-3 of EO12898 emphasizes the inclusion of at-risk populations in environmental health research, the identification of multiple and cumulative exposures, and the engagement of overburdened groups in the development and design of research affecting their communities. Recent guidance from NEJAC and CHPAC includes recommendations for research on the social determinants of disease and how psychosocial stressors in over-burdened communities may modify sensitivity to the effects of pollution, resulting in health disparities. This guidance is emphasized in Healthy People 2020 (DHHS, 2010), the 10-year national health agenda for the American population developed by DHHS and 8 other Federal Agencies. Healthy People 2020 has set the elimination of health disparities and achieving health equity as top national priorities. The focus on health equity calls for addressing the determinants of health that put particular groups within the general population at potential disproportionate risk. Understanding the role and contribution of the environment to health

disparities allows for the development of policies and interventions that provide primary prevention, and contributes to the improvement of resiliency at the individual and community levels. NEJAC also recommended that EPA characterize and identify or map communities that are potentially vulnerable to the impacts of climate change (e.g., based on geographic and demographic vulnerability) and analyze and measure socioeconomic, racial or ethnic disparities associated with different adaptation and mitigation options. NACEPT's recommendations focus on technologies for detection and assessment, communications, and remediation solutions. All of these guidance documents, advisory reports, and strategic plans emphasize the importance of community engagement and meaningful involvement in addressing environmental health and well-being[9].

[9] The World Health Organization defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1948). " ORD's Sustainable and Healthy Communities research program emphasizes this in its Strategic Research Action Plan (StRAP): Well-being is defined broadly and includes human health and safety, continued access to the benefits provided by eco-system services, and economic security and resilience, now and in the future. This definition is central to SHC's working definition of sustainability: SHC's StRAP defines sustainability as the long term well-being that emerges from a resilient economy existing within a healthy society dependent on an intact, functioning environment.

Table 1. Key events in the development of Environmental Justice programs at US EPA

Year	Event	Content
1982	Warren County, NC Landfill for PCBs	Linking of environmental and civil rights movements, resulting in civil disobedience action drawing attention to environmental racism. Over 550 protesters were arrested.
1987	Report by Commission for Racial Justice United Church of Christ	Toxic Wastes and Race in the United States: A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Wastes Sites: Recognized racial and economic disparities in hazardous waste siting.
1990	Report by EPA Environmental Equity Workgroup	Reducing Risk in all Communities (1992) recognized that environmental risks are often greater for low-income and minority communities
1992	Formation of EPA Office of Environmental Equity / Justice	EPA's Office of Environmental Equity was established in November 1992. Its name was changed to the Office of Environmental Justice in 1994.
1993	Formation of National Environmental Justice Advisory Council (NEJAC)	The National Environmental Justice Advisory Council is a federal advisory committee to EPA provides advice and recommendations about broad, cross-cutting issues related to environmental justice, from all stakeholders involved in the environmental justice dialogue.
1994	Issuing of Presidential Executive Order (E.O.) 12898 Federal Actions To Address Environmental Justice in Minority Populations	EO 12898 focused Federal attention on environmental and human health conditions in minority communities and low-income with the intention of achieving environmental justice. It established the expectation that federal agencies use existing regulatory statutes to address EJ, including the Civil Rights Act of 1964 and the National Environmental Policy Act (NEPA) of 1969.
1999	NAS report on Toward Environmental Justice: Research, Education, and Health Policy Needs	Institute of Medicine report on Environmental Justice made strong recommendations to improve the science base, involve the affected population, and communicate the findings to all stakeholders.
2004	EPA: Toolkit for Assessing Potential Allegations of Environmental Injustice	This toolkit provided a conceptual and substantive framework for understanding the Agency's environmental justice program. It presented a systematic approach with reference tools and indicators that could be used to assess and respond to potential allegations of environmental injustice or to prevent injustices from occurring. The Toolkit includes the Guzy memo (2000) that described the EPA statutory and regulatory authorities under which environmental justice issues may be addressed in permitting.
2010	EPA Symposium on the Science of Disproportionate Environmental Health Impacts	Science from inside and outside US EPA to address environmental justice including indicators, indices, cumulative assessment, and information access tools.
2013	EPA publishes Draft Technical Guidance for Assessing Environmental Justice in Regulatory Analysis	This draft document provides technical guidance to help analysts evaluate potential EJ concerns associated with EPA regulatory actions. It is based on currently available, scientifically-appropriate risk assessment and regulatory analysis methods.
2014	Development of EPA Plan 2014 EJ	Strategy and implementation plans to protect the environment and health in overburdened communities; empower communities to take action to improve their health and environment; and establish partnerships with local, state, tribal and federal organizations to achieve healthy and sustainable communities.
2014	EPA FY2014-2018 EPA Strategic Plan	EPA's EJ-related research, along with the activities of the other EPA offices, support the Administrator's commitment to ensuring that all communities have the same degree of protection from environmental and health hazards.
2014	NEJAC recommendations for research	NEJAC released a report titled Recommendations for Integrating Environmental Justice into the EPA's Research Enterprise.
2015	EPA final Guidance on Considering Environmental Justice during Development of Regulatory Actions	EPA's guide for determining when environmental justice should be considered during the Action Development process when developing regulations. This includes strategies and techniques for meaningful involvement and screening level assessments to identify potential EJ concerns.
2015	Active development of EPA Plan 2020 EJ	EJ 2020 will build on the foundation established through EPA's Plan EJ 2014, and expand that work through commitments that will continue through the next five years. As we work to get input and finalize EJ 2020, we will continue to implement EJ priorities across our programs.

II. Research Scope

Expanded Problem Statement and Key Research Topics

In June 1992, the EPA issued its first report, Reducing Risk in All Communities (EPA, 1992), followed by others (Table 1), that recognized that environmental risks are often greater for low-income and minority communities.[10] The impacts on citizens in these communities are influenced not only by differential exposures due to close proximity to sources of harmful chemicals or toxicants, but also by non-chemical stressors. Communities may suffer from inadequate physical and economic infrastructures, such as poor housing, lack of transportation, healthy foods, limited access to natural amenities such as green spaces or parks, medical care and inadequate water systems. Exposures to multiple environmental contaminants and non-chemical stressors may combine to induce adverse impacts on health or result in greater cumulative impacts.

This research roadmap will consider the following science challenges:

1. **Developing decision support tools for identifying and prioritizing concerns, assessing cumulative impacts, and evaluating mitigation options.** Development of decision support tools and science, including citizen science, to ensure meaningful engagement and acknowledge community ownership or investment in the process of research, data collection, and development of solutions. This research and development is used in problem formulation and scoping, for screening level assessments, and to improve information access, evaluate options, and inform decision-making. The Agency's implementation of its Making a Visible Difference program has provided an opportunity for broad ORD participation in community-engaged projects.
2. **Improving our understanding of environmental health disparities and developing methods and data for assessing cumulative risks.** Research to understand and reduce health risks and mitigate the incidence and prevalence of environmental health disparities in overburdened communities. This includes scientific understanding and supporting metrics to support the consideration cumulative risk of multiple contaminants and non-chemical or community stressors (Figure 2) in risk assessments.
3. **Tribal sustainability and well-being**. Science to support the use of traditional ecological knowledge (TEK), facilitate the characterization and mitigation of environmental conditions that place heritage diets and other cultural practices at risk, and support the environmental health and well-being of tribal nations.
4. **Climate justice**. Characterize community-scale vulnerability and resilience factors and cumulative risk of health disparities resulting from environmental stressors such as extreme weather conditions, drought, flooding, or other results of changes in precipitation, heat stress, sea level rise, changes in natural benefits (eco-system services).

The EJ Research Roadmap contains research on impact assessment and screening level tools as well as cumulative risk assessment. Cumulative impact and cumulative risk assessments are distinguished by such factors as the amount and quality of data available, the level of scientific rigor and quantitation

[10] http://www.epa.gov/environmentaljustice/basics/ejbackground.html

required, and whether the application is for non-regulatory or regulatory purposes (EPA, 2013a). The importance of the distinction between cumulative impacts and risks was noted by the National Academy of Sciences in its landmark report, *Science and Decisions: Advancing Risk Assessment* (NAS, 2009). Cumulative impact assessments use a range of qualitative and quantitative information to characterize a problem or establish priorities for action by local, state, tribal or national decision makers. These types of assessments, which include Health Impact Assessments (HIA), are of particular value for advancing policies to promote the health and well-being of overburdened communities. Cumulative risk assessments, by contrast, are typically more analytically complex, quantitative assessments of the combined risk to health or the environment from multiple stressors. Decisions made at the federal level for the establishment of standards for environmental contaminants, for example, would require these more rigorous types of assessments. Due the special data and methodological requirements of cumulative risk assessments, this approach is less applicable than cumulative impact assessments to local decision making at the current time, though a CRA could provide needed information to inform one or more objectives of a structured decision process like an HIA.

The research and development described in this Roadmap can be applied to analyses that provide useful information about how policy options under consideration might affect distribution of risks across population groups of concern and communities. Cumulative impact and risk assessment, along with life cycle assessment of chemicals and materials, acquisition of data on critical health stressors and promoters in the built, natural, and social environments, and differential exposures and outcomes are all part of science-informed environmental decision-making and policy (Figure 1). This is an iterative process that starts with effective planning and scoping, which in turn drives subsequent steps of problem formulation, data acquisition, modeling and analysis, and effective translation and communication to assess the implications of decisions (NRC, 2012). The iterative nature of this process means that assessments and approaches will necessarily be fit for the purpose of the decision at hand, considering the context and use of the final results (EPA, 2013a).

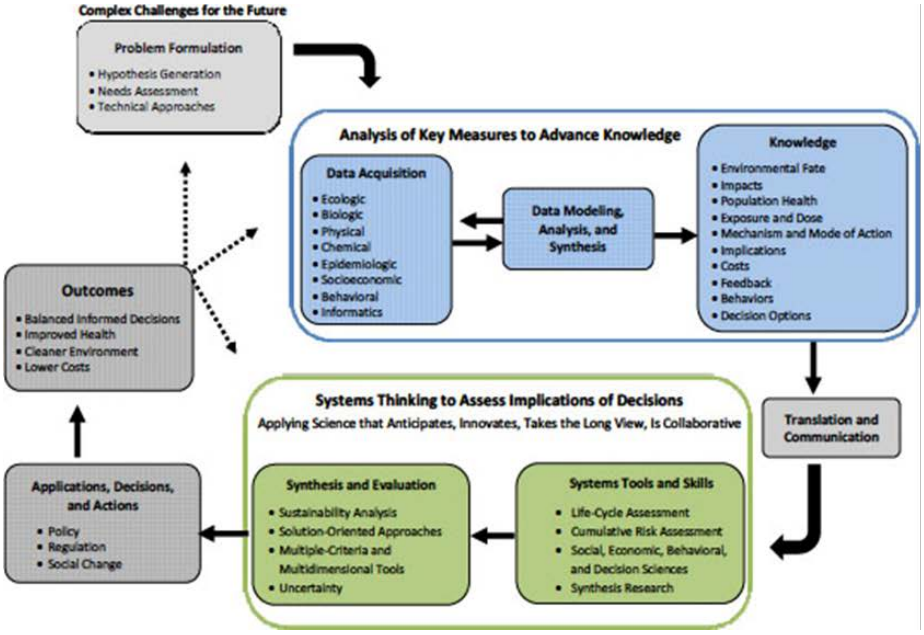

Figure 1. Framework for enhanced science for environmental protection describes the iterative process of science-informed environmental decision-making and policy (NRC, 2012)

The science challenges in this roadmap are not mutually exclusive because they all contain components that address aspects of a systems approach to environmental justice, itself a systemic problem, providing support for decisions made at the local through national levels. In recognition of these interleaved challenges and the potential utility of qualitative, semi-quantitative, or quantitative approaches to address environmental justice, the EJ Research Roadmap addresses the following key questions. These are mapped onto ORD's research projects in Appendix A, Table A-1.

1) 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?
2) How can overburdened communities be empowered to better characterize problems linked to the environment and create solutions that ensure equitable distribution of the benefits from community decisions?
3) How can indicator approaches assist in better understanding the interrelationships between social determinants of health, other non-chemical stressors, chemical agents and the natural environment – with particular emphasis on place-based contexts and potential for decision-making?
4) What are the key social determinants related to vulnerability and environmental public health for high priority public health outcomes such as poor birth outcomes, cognitive deficits, cardiovascular disease, obesity, diabetes, asthma?
5) What interactions between environmental exposures and social, natural, and built environmental systems, conditions, and policies result in unequal adverse environmental health conditions among diverse overburdened populations groups, tribes, communities, neighborhoods, and individuals? How can this understanding be applied to cumulative assessment?
6) What causal links can be made between chemical and non-chemical stressors and potential biological adverse outcome pathways and mechanisms such as epigenetics for the purposes of cumulative risk assessment and the identification of risk mitigation strategies?
7) How can community-engaged research be used by EPA to understand cumulative exposures and risks, health disparities, and explore scenario-specific case studies to explore implementation of cumulative risk assessment?
8) How can traditional ecological knowledge and ecosystem goods and services be used in tribal-specific assessments and other actions to support tribal sustainability?
9) What are the key factors in the social, natural, and built environments that result in vulnerability or resilience to stressors associated with climate change? How do these interact with contaminated sites or other community environmental hazards? How can this understanding contribute to greater community preparedness?

We note that there are a wide spectrum of contaminated sites across the nation, many of which are located in or near overburdened communities and which may have disproportionate impacts on those communities. ORD works closely with the Office of Land and Emergency Management and EPA's Regional Offices to develop remediation technologies that will benefit these communities, but a discussion of this research has not been included in this document. Please refer to the Sustainable and Healthy Communities Strategic Research Action Plan (EPA, 2015c) for more details on research on remediation of contaminated sites.

Developing decision support tools for identifying and prioritizing concerns, assessing cumulative impacts, and evaluating mitigation options.

EPA recognizes that research to serve communities will have greatest impact when it addresses problems formulated at the community stakeholder level, and, when possible, it is conducted through participative and collaborative studies. This transdisciplinary approach to research is rooted in Community Based Participatory Research (CBPR). It builds on community expertise and places the focus on the end user of that science while providing opportunities for the community to build capacity. These opportunities help to ensure meaningful engagement in the process of research, data collection, and development of solutions and acknowledge community ownership of or investment into that process.

Research addressing this challenge includes the continued evolution of development of decision processes such as Health Impact Assessment (HIA) and other structured decision approaches allow for translation of scientific information into objectives that are meaningful to community members and technical experts alike. These approaches incorporate community's values into the decision process and ideally allow science to be considered together with other factors, such as job creation, demographics, environmental quality, and land use or transportation issues in decisions that affect communities. For EPA, this research and research process is designed to increase community engagement and ensure that EPA provides access to the best science available and facilitates its application to decision making and generating solutions for overburdened communities.

Research under this challenge also includes the development and application of tools that provide access to relevant community-scale data and mapping or other visualization tools. It also includes screening level assessment tools that can potentially be used to evaluate different decision scenarios. Finally, this research topic includes citizen science, including environmental monitoring and GIS mapping. In 2015, EPA charged NACEPT to comment on strategic directions for using citizen science (EPA, 2015a). In this charge, EPA notes that "Citizen Science advances environmental protection by helping communities understand local problems and collect quality data that can be used to advocate for or solve environmental and health issues." The White House Office of Science and Technology Policy recently issued a memorandum that directs agencies to take specific actions to advance citizen science and crowdsourcing, emphasizing public participation and making it easy for people to find out about and join in these projects. Additionally, fulfilling a commitment made in the 2013 Open Government National Action Plan, the U.S. government is releasing the first-ever Federal Crowdsourcing and Citizen Science Toolkit to help Federal agencies design, carry out, and manage citizen science and crowdsourcing projects. The incorporation of citizen science, especially which uses the new generation of environmental monitoring tools, into CBPR is an exciting new research area for ORD.

Improving our understanding of environmental health disparities and developing methods and data for assessing cumulative risks.

EPA research will help understand and identify ways to prevent health disparities resulting from environmental conditions and pollution in overburdened populations and communities. This includes developing science and approaches to assess cumulative risk from exposure to chemical and non-chemical stressors. It also includes promotion of health and well-being through consideration of the built and natural environments, including access to nature's benefits (ecosystem services).

Previous research has focused primarily on disproportionate exposure to chemicals and their associated adverse health effects. There is, however, a need to expand this area to understand how social determinants of health, that is, the conditions in which people are born, grow, live, work, and age, together with environmental pollutants and/or poor environmental quality, can contribute to inequities in health and well-being (Figures 2 and 3). Social determinants of health include such factors as access to affordable healthy food, potable water, green space, safe housing, clean air and supportive social networks (CHPAC, 2014; EPA, 2013a; deFur et al., 2007). Within the context of social determinants of health, environmental determinants, comprising natural, built, and social environments, stand out as critical for reducing and preventing health disparities because they are amenable to intervention and prevention strategies. Thus, environmental influences are not limited to physical, chemical, or biological agents and natural amenities, but also include social and economic stressors, institutional processes and resiliency factors. Since environmental stressors often occur together, a key need is to understand how they act in combination with one another, as well as how they combine with non-environmental stressors. Research is needed to understand the contributing factors and the potential impact that they have on communities and individuals such that it may be factored into decisions.

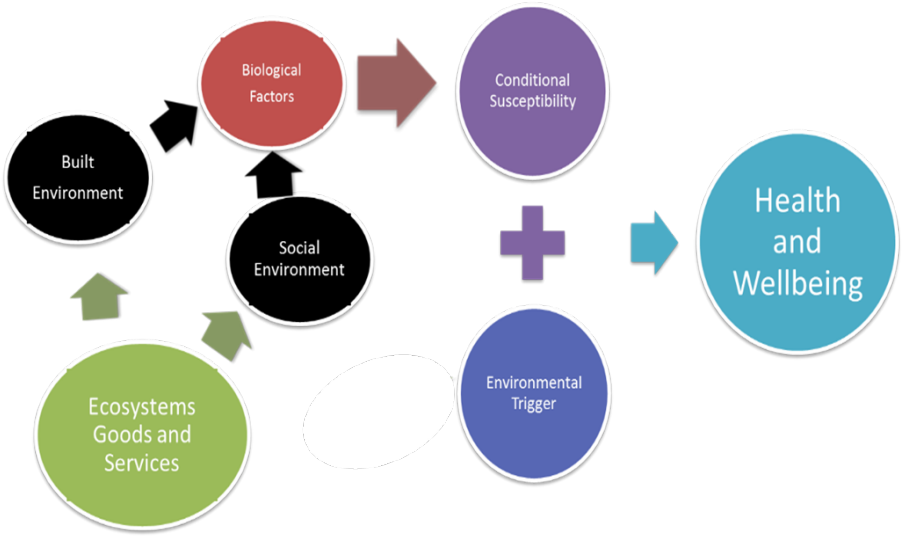

Figure 2. The natural, built, and social environments interact with biological factors and exposures to environmental pollutants to affect health and well-being.

Improved health and well-being are the critical endpoints for this research. Health impacts documented to show disparities in the incidence and severity of disease between socioeconomic and racial or ethnic groups include adverse birth outcomes, cognitive deficits, growth and metabolism (obesity, diabetes, high blood pressure, cardiovascular disease), and respiratory health (asthma)[11]. Well-being is defined broadly and includes human health and safety, continued access to the benefits provided by eco-system services, and economic security and resilience, now and in the future[12].

[11] E.g., Morello-Frosch, et al 2011. Understanding the cumulative impacts of inequalities in environmental health: Implications for policy. Health Affairs 30(5):879-887.

[12] This definition is included in the ORD's Sustainable and Health Communities Research Program Strategic Research Action Plan FY16-19

Under this science challenge, a main emphasis is understanding the interactions between biological, social, spatial and environmental factors and how they contribute to disproportionate risk. To this end, laboratory and community-based studies are designed to evaluate the extent to which these various factors contribute to disproportionate risks and health disparities in overburdened communities. This research is prerequisite to understanding the causal bases of adverse effects due to cumulative exposures for informed and effective EPA and community-based decisions and interventions. ORD's Human Health Risk Assessment research program (HHRA) has made its goal to move beyond traditional risk assessment methods to integrate and evaluate impacts of chemical and non-chemical stressors on the environment and human health (Figure 3). Reaching this goal will be aided by making causal links between the non-chemical stressors on the left of this figure and the realization of adverse health effects through biological pathways on the right.

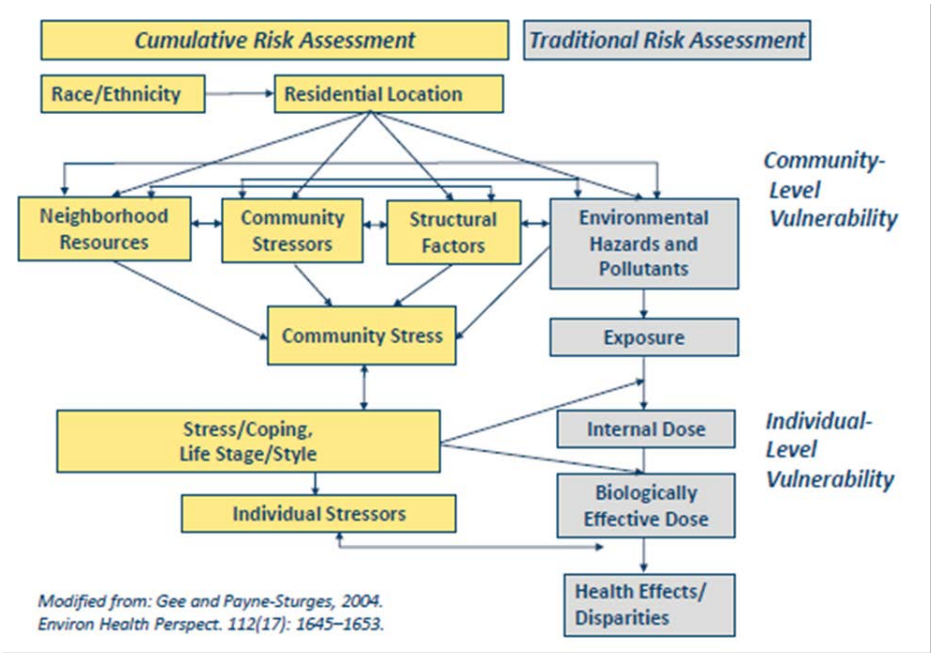

Figure 3. Conceptual map of the interaction between traditional risk assessment, focused on biological and adverse outcome pathways emphasized by the CSS research program, and community-scale contributors to cumulative risk assessment needed to address environmental health disparities.

Tribal sustainability and well-being:

EPA has a trust responsibility with respect to native tribes, and the tribes have sovereign rights to develop environmental implementation plans. Historical events have adversely changed the environments and traditional food sources specific to many Tribal populations (American Indians and Alaska natives), and have negatively impacted Tribal cultural practices and health. For example, environmental degradation and displacement of Tribes from traditional lands have led to the elimination of heritage diets affecting health, well-being, and social cohesion. Impaired features of Tribal environments are not supporting previously sustainable and healthy diets and lifestyles. These changes, combined with social stressors, may have contributed to increased incidences of asthma, diabetes, high cholesterol, and obesity in many Tribal communities. Tribal communities may also be

more vulnerable and disproportionately impacted by climate change, especially when it disrupts the ability to depend on surrounding ecosystems for food sources, cultural practices, and unique lifestyles. This is a notable issue for native Alaskans who face the need to move whole communities because of sea level rise and defrosting of the tundra. Tribes need evidence-based data and tools to help them identify and anticipate potential environmental problems that may result from changes in their environments and societies.

ORD plays an important role as co-chair of the EPA's Tribal Science Council. This role recognizes ORD's responsibility and ensures that Tribal science priorities have a direct voice in ORD research planning and implementation. ORD research to build tribal sustainability is focused on: the use of traditional ecological knowledge and development and training in assessment and restoration for proper functioning conditions for restoration and maintenance of tribal lands and waterways; adaptation by tribes to the impacts of climate change; tribal health issues including indoor air quality, asthma, and use of indoor cookstoves; collaborative development of decision support and environmental information access tools. This research is consistent with the principles included in the EPA Policy on Environmental Justice for Working with Federally Recognized Tribes and Indigenous Peoples (EPA, 2014c).

Climate Justice: Climate change-related cumulative health risks are expected to be disproportionately greater for disproportionately impacted communities, in part due to differential proximity and exposures to chemical sources and flood zones. EPA's Climate Adaptation Plan includes focusing on "the most vulnerable people and places." EPA's Policy Statement on Climate Change Adaptation includes the need to "focus on incorporating consideration of environmental justice into the design and evaluation of adaptation strategies." NEJAC recommendations to EPA on Conducting Research on Potential Disproportionate Impacts of Climate Change Effects, Mitigation and Adaptation include conducting research (tools, indicators, maps) to identify the most climate vulnerable communities to inform climate adaptation and emergency response strategies. Specifically, NEJAC recommended EPA characterize and identify or map communities that are vulnerable to climate change (e.g., based on geographic and demographic vulnerability) and analyze and measure socioeconomic, racial or ethnic disparities associated with different adaptation and mitigation options.

EPA research will focus on identifying key factors and interrelationships between social determinants of health, other non-chemical stressors, and chemical agents with respect to climate change-related impacts for vulnerable populations. EPA has proposed the development of climate vulnerability and community resilience indices as metrics for use in identifying and mapping locations at high risk from stressors such as sea level rise, extreme weather conditions, heat stress, wildfires, changes in precipitation patterns leading to drought and/or flooding, impacts on communities with contaminated sites and brownfields, and impacts particular to tribal communities.

III. Cross-cutting ORD Research

Current and Planned ORD Research

This section summarizes ORD's current and planned research activities as they aligned with the four EJ Science Challenge Topics described in the previous section. These research activities are implemented by ORD's National Research Programs (NRPs) according to their respective Strategic Research Action Plans (StRAPs). Each activity addresses NRP-specific outputs and at the same time contributes to addresses the EJ Roadmap core research areas.

The NRP with key responsibility for each of the activities is provided below:

- ACE = Air, Climate and Energy Research
- CSS = Chemical Safety for Sustainability Research
- HHRA = Human Health Risk Assessment Research
- HSRP = Homeland Security Research Program
- SHC = Sustainable and Health Communities Research
- SSWR = Safe and Sustainable Water Resources Research

Table 2 provides a high-level overview of the distribution of environmental justice research across ORD's six National Research Programs. Appendix Tables A-1 and A-2 summarize ORD EJ research on a project by project basis and provide more detail on environmental justice research funded through ORD's Science to Achieve Results (STAR) program.

Table 2. Relative contribution of ORD's National Research programs to ORD's Environmental Justice Research activities. More checkmarks indicate a relatively larger contribution to research in a particular science challenge area.

EJ Science Challenge	National Research Program					
	Air, Climate, and Energy	Chemical Safety and Sustainability	Homeland Security Research Program	Human Health Risk Assessment	Safe and Sustainable Waters	Sustainable and Healthy Communities
Decision Support and Community Engagement	✓ ✓		✓	✓	✓	✓ ✓ ✓
Health Disparities and Cumulative Risk	✓ ✓	✓		✓ ✓ ✓		✓ ✓ ✓
Tribal Science	✓					✓ ✓
Climate Justice	✓ ✓		✓		✓	✓ ✓

Decision support, citizen science, and community engagement

This research area includes tools to provide access to scientific information to communities and tribes in a context that increases community engagement in defining, prioritizing, and solving environmental quality, exposure, and health issues. These decision support tools and resources are expert systems that allow community and tribal stakeholders inside and outside the EPA to gain access to high quality science pertinent to their location and issues, visualize features of the built and natural environment through publically accessible Geographic Information System tools, and identify potential pollution sources or modeled exposure concentrations and risks for some environmental pollutants. They also provide use cases, tutorials, and step-by-step processes for addressing community-level environmental issues. The tools highlighted here are not a comprehensive list – for example, others under development include decision-support tools to help community stakeholders identify options associated with Green Infrastructure. A more comprehensive table, the SHC Usable Tool List, provides more examples of tools that can assist all communities. SHC is also working on interactive tools to help potential users of these tools sort through the many options available, depending on the issues they are addressing.

A) The Agency's Cross-Agency Strategies include "Make a Visible Difference in Communities," which is a high priority for the Administrator, and one which the Agency launched with boots-on-the-ground actions. The Action Plan for that strategy includes four action items: 1) focused and coordinated agency action to assist selected communities; 2) an online Community Resource Network to ease access to resources and share lessons learned; 3) assistance to communities on monitoring data, especially for enforcement; and 4) design and deliver an online tool to help communities find solutions to problems, starting with the Green Infrastructure Wizard.

   The most visible "MVD" action is the first, where each Region selected a handful of communities that were "environmentally overburdened, underserved and economically distressed". As such, environmental justice (EJ) has been built into the MVD effort from the start. The essence of this action item is for Agency Regions and National Programs to coordinate their resources where they are badly needed, to synergistic effect, working to address real community problems and improving lives and conditions. For example, in Newport News, VA, ORD, with Region III, is evaluating the cumulative risk of port-related emissions on the disadvantaged communities who live nearby, which will help target solutions. In Alexandria/Pineville, LA, ORD is working with Regional staff to evaluate the health implications of creosote plants on nearby neighborhoods, and look for sustainable materials solutions. **Appendix B** describes ORD engagement in 16 of the current MVD projects

   Serving MVD communities serves the EPA as well. Focus and teamwork in communities demonstrates how coordination by easily-siloed programs can achieve more holistically-effective outcomes. For ORD, there is the added advantage of real-world testing and feedback for ORD tools. With the integration of ORD staff and tools into these efforts, local capacity limitations can be overcome. As such, success is more likely, barriers can be identified and the toolmakers can better craft tools and "how-to" materials so they are most useful and easily usable for communities across the country.

B) The Community-Focused Exposure and Risk Screening Tool (C-FERST) and Tribal-Focused Environmental Risk and Sustainability Tool (Tribal-FERST): C-FERST and T-FERST are web-based decision support tools that are designed to help communities and tribes, respectively, to use their limited resources to identify, prioritize and manage their environmental public health issues. In Portland, OR and Tacoma, WA, for example, a *beta*-test version of C-FERST has been used in conjunction with local community colleges and community groups to increase community engagement in overburdened communities. C-FERST has become the core of a broader effort to leverage other resources and convene partners to identify issues, assess conditions, and address these issues. Communities can map their neighborhoods, add data from EPA databases on the locations of contaminated sites, combined sewer overflows, toxic release inventory sites and other locations of interest, add demographic data drawn from the census, and add geo-coded data for local community features such as markets providing fresh food. In addition, ORD is working to develop a module within C-FERST to allow it be used to expedite the information gathering and organizing of Health Impact Assessments.

T-FERST is being developed together with tribal partners to address tribal specific needs for information access, assessment, mapping, and considering potential solutions. The United Southern and Eastern Tribes (USET) developed a step by step roadmap that includes the use of traditional ecological knowledge and will incorporate approaches to habitat restoration like Proper Functioning Conditions, described in the Tribal Sustainability and Well-being section. USET is also engaging the Alaskan indigenous tribes for more input into this tool. T-FERST is also developing an Open Waters module that will provide historical and current water quality data to assess impaired or improved water quality for reservation water management efforts. SHC Project 2.62

C) The Community Cumulative Assessment Tool (CCAT): CCAT is designed to guide community groups through the challenging aspects of cumulative risk assessment in a participatory process with a specific focus on environmental justice. CCAT has built a ten step process for local cumulative risk assessment and prioritization of potential solutions. It is based on EPA's Framework for Cumulative Risk Assessment and collaborations with EPA's Community Action for Renewed Environment program (CARE, www.epa.gov/care), Regions, and communities, with critical input from EJ stakeholder groups. The CCAT step-by-step methodology incorporates community-specific and other data into a structured decision-making approach to identify stressors and prioritize solutions. CCAT addresses multiple stressors, as well as susceptibility and vulnerability factors. It combines decision analysis and risk assessment to identify, evaluate, rank, and prioritize stressors and solutions. A beta-test version of CCAT is currently being used in a number of communities to evaluate its utility in different contexts. In Newark NJ, CCAT is part of a collaboration with Region 2 and a local community corporation to develop and include citizen science measurements into assessment of multiple stressors and potential solutions and outcomes. In Chicago, IL, CCAT is being used in collaboration with Region 5, University of Illinois, and a CARE partnership to develop best practices and risk reduction related to EJ and Superfund considerations. CCAT is also being used in conjunction with C-LINE, described below, in near-road and near-port contexts. CCAT will become part of C-FERST to provide decision support structure in the context of community assessment guidance. CCAT has been SHC Project 2.62

D) Health Impact Assessment (HIA): HIA is a structured decision process that uses a combination of procedures, methods, and tools to evaluate the potential effect on the health of the population and the distribution of those effects within the population of a proposed project or policy. The WHO identified four core values of HIA that are consistent with goals of environmental justice:

- Democracy: HIAs should be participatory, involving stakeholders, build collaborations between health and other sectors
- Equity: Reduction of social disparities in health as a central concern in policy making
- Sustainability: Identify both short-term and long-term health impacts of a policy
- Ethical use of evidence: Should be as rigorous as possible, using both quantitative and qualitative evidence, drawing on different scientific disciplines.

Stakeholder and community engagement are a critical component of HIA so that those impacted by the decision have a voice in the process. Research translation, defined as the transfer of knowledge to community members and stakeholders about the relationship between determinants of health and health outcomes is another overarching goal of the HIA process.

ORD research will produce an HIA Resource and Tool Compilation that will be a free, publicly-accessible compilation of tools and resources that can be utilized by HIA practitioners at all levels of experience to guide them through the HIA process. The Compilation will be designed to provide an extensive list of resources that apply to the HIA process itself and the themes present throughout the process, such as equity and community participation, as well as tools that can be used in data collection and analysis. ORD will also be working with EPA's Regions to increase capacity to assess the impacts of federal, regional, state and local decisions on public health.

ORD/SHC has worked with EPA's Regions and municipal and community groups on two HIA's that addressed environmental justice issues, one in Springfield , MA and the other in the Proctor Creek neighborhood in Atlanta, GA. This latter effort will be expanded to consider the establishment of an incentive based approach to increase green infrastructure (GI) within the Proctor Creek Watershed. Proctor Creek is one of the most impaired water bodies in the area. The communities of Proctor Creek experience overlapping concerns including flooding, derelict and abandoned properties, crime, and lack of economic opportunity. The assessment will support identification of the best locations for GI that maximize public health benefits across environmental, social and economic determinants of health and where physical properties are best suited for GI. SSWR is providing extensive soil analysis within the watershed to contribute to the assessment. Region 4 continues to be a key collaborator. SHC Project 2.62; SSWR Project 5.02

SHC will be working with EPA's Office of Federal Activities (OFA) to promote the use of HIA as part of EPA's NEPA/Section 309 reviews as a way to enhance human health considerations in the NEPA process due to its ability to:

- Provide the lead agencies, stakeholders and communities with information on the potential health effects of a proposed action and its alternatives, through the broad consideration of impacts to health and health determinants;

- Identify potential disproportionate human health and/or environmental effects of a proposed action and its alternatives on minority populations, low-income populations, and children and develop recommendations to address those effects;
- Develop recommendations to improve a proposed action and its alternatives and/or mitigate against potential negative health impacts before the action is implemented.

SHC Project 2.62, 4.61

E) EnviroAtlas: EnviroAtlas is a collection of interactive tools and resources that allows users to explore the many benefits people receive from nature, often referred to as ecosystem services. Though critically important to human well-being, ecosystem services are often overlooked. Using EnviroAtlas, many types of users can access, view, and analyze diverse information to better understand how various decisions can affect an array of ecological and human health outcomes. It also allows users to display demographic information together with information on natural amenities. The EnviroAtlas includes Use Cases as examples to help new users of the tool. One of these demonstrates use of the EnviroAtlas for analysis and planning of an urban tree arbor, bringing in demographic layers that might be considered if equitable distribution or access to natural amenities is a community goal. Another Use Case shows population numbers in an urban near road environment and the adequacy of vegetative buffers to reduce potential near-source exposures. This kind of analysis is highlighted to be used for the planning of transportation corridors and placement of green spaces and other natural amenities.

The EnviroAtlas includes a module called the Eco-Health Browser. This Browser is an easy-to-use interface for a curated database that describes connections between access to natural amenities and health conditions of concern to many communities. For example, users can make links between low birthweight or cardiovascular disease and the provision of ecosystem services providing clean air, clean water, recreation and physical activity, and engagement with nature. One could also start with features of Urban Ecosystems and learn about the relationships between these and physical and mental health. Ultimately, this information can be used in decision-making about, e.g., the siting of roads, the preservation or development of greenspace. It could be easily incorporated into processes like Health Impact Assessments as supporting data for community objectives.

The EnviroAtlas is described further is the section on Climate Justice. SHC Project 1.62.

F) C-LINE, C-PORT: Transportation (including roadway traffic, ports, and airports) is a critical feature of the nation's economy. Ports, for example, may be considered multi-modal transportation facilities as they typically have truck and rail yard facilities for the shipment of goods to and from the port. Multiple air pollutant species such as carbon monoxide (CO), oxides of nitrogen (NO, NO_2, NO_X), particulate matter (PM_{10}, $PM_{2.5}$), black carbon (BC), and a number of air toxics can be emitted from these multi-modal facilities, affecting communities near the port as well as along freight movement corridors.

C-LINE and C-PORT are screening level models designed to help communities explore the potential improvements to air quality and exposures due to voluntary or mandatory programs. These tools predict concentrations of multiple criteria (NAAQS) as well as hazardous air pollutants (of key mobile source air toxics) at fine spatial scales in the near-source environment. Screening-level air quality modeling is a useful tool for examining what-if scenarios of changes in emission volume, such as those due to changes in traffic counts, fleet mix, or speed, or changes in traffic, ports, and airports emissions due to equipment or vehicles. EPA's Guidance on Considering EJ during the Development of Regulatory Actions (Table 1) encourages the use of screening-level analysis when feasible to identify opportunities to identify and address potential EJ concerns.

C-LINE was used in a collaboration between ORD and EPA Region 4 to examine the potential impact of port expansion on air quality. As freight volume increases in Region 4 ports, communities near the port and along goods movement corridors may experience increased local-scale air pollution due to increased traffic. C-LINE was used to consider the entire transportation network. In Newport News, VA, a community that contains commercial port operations, highways, and multiple industrial facilities, C-LINE was used to quickly compare different roadway pollution scenarios to help to identify areas for further research. Draft versions of these tools are currently being applied in selected case studies in conjunction with CCAT and citizen science approaches in the Ironbound District and Port of Newark, NJ, and will be used in an integrated assessment project on Sustainable Port Communities. SCH Projects 2.62, 4.61; ACE Projects AIMS-1, PEP-1.

G) Citizen Science: Community engagement in environmental decisions that affect members of the community is enhanced in a community that collects its own data on, e.g, air quality, traffic, potential pollution sources such as auto body shops, or locations for access to fresh healthy food. Collection of data by community members allows communities to participate in the research and development process, to evaluate baseline conditions, and to evaluate changes in environmental conditions after actions are taken to mitigate exposures to environmental pollutants. The C-FERST, T-FERST, and EnviroAtlas tools described above allow communities to upload local data to maps provided by those tools. For example, Region 10 has used C-FERST as a community engagement tool in two communities. For these communities, the presence of Superfund sites was the point of entry for the Region but was not the basis for the use of the tool; C-FERST is acting to help facilitate interactions between community groups and local community colleges to address the many other environmental health issues in these communities.

Those local data remain the property of the communities; none of those data are saved by government computing systems. These decision support tools are or will be available to the public for free on the internet for their use in learning more about issues identified by their communities, mapping sensitive sites or locations of concern, and considering risk management or risk mitigation alternatives. SHC Projects 1.62, 2.62.

EPA has developed an Air Sensor Toolbox for Citizen Scientists and developed Community Air Monitoring Training videos to help build community capacity for environmental monitoring. The videos are based on face-to-face Community Air Monitoring Training that provided individuals from community action groups and tribes across the nation an opportunity to consider their own citizen science air monitoring projects in the context of

hands-on training and small group discussions with experts in the field of citizen science. ORD and EPA Region 2 piloted community use of air sensor technologies in collaboration with the Ironbound Community Corporation (ICC) in Newark, NJ. These efforts include both the sensor technologies and tools to examine the data collected against the backdrop of community maps. The ICC and EPA see Citizen Science projects that connect local residents to air quality data as a way to make public health a priority in communities and to build the capacity for communities to advocate for health-protective policies at the local, state, and federal levels. ORD research also includes developing methods for low cost sensor evaluations so that performance standards can be set to allow more credible use of these sensors for citizen science applications and to describe the sensors' capabilities and limitations. ORD has also developed technology to help reduce technical barriers to analyzing air quality data with its Real-time Geospatial Data Viewer (RETIGO). RETIGO, together with mobile sensors and potential new sensor technologies, begins to address NACEPT's recommendation to provide robust real-time data that can be applied to fenceline and myriad community applications. RETIGO can serve as a data analysis platform, as an interim data processor, or as an interoperable module with C-FERST or EnviroAtlas to address community air quality issues. ACE Project EM-3.

H) ORD notes that EJSCREEN has been developed by the EPA as a tool that highlights locations for further review as a starting point for engagement, evaluation, and /or enforcement efforts. EJSCREEN, C-FERST, and ORD's EnviroAtlas all draw from EPA's Geoplatform and have some of the same capacities for displaying community-scale information. EPA, state and local agencies, and communities might use these tools together or in sequence, e.g., to first identifying overburdened or other candidate communities with EJSCREEN, then follow up by using C-FERST, T-FERST, CCAT, and EnviroAtlas or the other tools listed above to engage communities to provide more detailed information and walk through the provided step-by-step guides for community assessments and generation and evaluation of potential solutions. ORD is working with EJSCREEN developers to link these tools and update and harmonize the underlying datasets that multiple tools draw from.

Environmental Health Disparities

ORD research to address environmental health disparities is focused on better understanding the contribution of diverse factors to disproportionate risk, with an emphasis on how nonchemical stressors may potentially modify adverse health effects associated with exposures to chemical contaminants. These factors include the natural, built, and social environments in combination with biological factors and response. ORD focus includes continued updates to toxicity information on a chemical specific basis to improve the science supporting risk assessments.

A. NIH-EPA Centers of Excellence on Environmental Health Disparities Research: ORD/SHC STAR research centers co-funded with NIEHS, NIMHD and NICHD to stimulate basic and applied research to understand environmentally-driven health disparities and improve access to healthy environments for vulnerable populations and communities. These are designed to foster interdisciplinary research on complex interactions between social, natural and built environmental systems, conditions, and policies that result in unequal environmental health conditions and disproportionate impacts on (diverse) disadvantaged population groups, communities, neighborhoods and individuals. Research outcomes are expected to promote innovative strategies to: mitigate environmental exposures and health

disparities; alleviate system drivers of racial/ethnic and socioeconomic disparities; and improve access to healthy and sustainable environments for vulnerable populations. Proposals must include community-based research, mentoring, capacity building, and research translation and information dissemination. SHC Project 2.63 (Appendix Table A-2).

B. The SHC and ACE programs contain intramural EPA/ORD research designed to characterize the interrelationships between social determinants, non-chemical stressors and chemical agents. This includes research to identify neighborhood and social determinants and land use decisions that impact health outcomes, especially sudden death and respiratory disease. Further research is focused on environmental drivers of public health and wellbeing particular to minority communities, with a focus on asthma and other critical health outcomes in the context of stressors that include housing and transportation, socioeconomic status, access to medical care, exposures to pesticides, toxic metals, mold, and air pollution. Additional asthma research considers novel interventions to reduce asthma disparities. ORD research also considers how chronic stress alters the individual response to pollutants.

   It should be noted that the ACE research program has transitioned its research on National Ambient Air Quality Standards (NAAQS) and Multipollutant to new projects focusing on Protecting Environmental Public Health and Wellbeing (PEP). The PEP projects are not all focused on EJ, but they do explicitly address community-scale issues, the potential role of socio-economic status and other social determinants of vulnerability to the effects of exposure to air pollutants, the identification of modifiable factors in the built, natural, and social environment to reduce exposures, risks, and impacts associated with air pollution, and research translation and outreach. SHC Projects 2.62 & 2.63, ACE Projects PEP 1, 2, & 4.

C. EPA has a long-standing interest in cumulative risk assessment. The research described here is intended to advance CRA as an integrative approach for use by EPA Regions, program offices, and others, including communities.

   A current research emphasis in SHC, HHRA, and ACE is understanding the role of non-chemical stressors and developing analytical methods for cumulative risk assessments. ORD funded multiple grants through a 2009 RFA on this topic and will be producing a summary report on this body of research that addressed asthma, hypertension, central nervous system function in association with the urban environment, stress, and exposure to air pollutants or metals, and, in one case, in a community near a Superfund site. SHC Project 2.62

   The HHRA program has proposed research on CRA focused on analytical approaches, e.g., grouping stressors to simplify the inclusion of chemical and non-chemical stressors for human health CRA, on specific health outcomes, e.g., integrating non-chemical stressors into consideration of particulate matter and cardiac function; and on the integration of ecosystem services into CRA, e.g., analysis of green space measures and asthma incidence among children. This is part of HHRA's broad framework for integrating chemical and non-chemical stressors for cumulative risk assessment. Vulnerability information includes the incorporation of vulnerability and cultural factors as shown in Figure 3. HHRA Project 6.

Research into biological susceptibility includes investigating epigenetic mechanisms that might underlie adverse health outcomes associated with combinations of chemical and non-chemical stressors. Epigenetics refers to potentially inherited changes to molecules associated with human genes that change gene expression. These changes may be induced by a variety of conditions, including social stress. Research in the ACE program is aimed at understanding how socioeconomic and various biological factors may influence the response of individuals to mixtures of air pollutants. This research is also examining whether living in a disadvantaged neighborhood may be reflected in long-term epigenetic changes that, in turn, result in alterations of specific biologic pathways increasing the susceptibility to air pollutants. In September 2015, HHRA conducted a workshop on epigenetics and cumulative risk assessment with the goal of pushing forward EPA's understanding of the potential use of epigenetic change as an indicator of cumulative risk. With respect to community health, the question investigated was whether, in a population already exposed to significant stressors, an additional stress (even if not large in magnitude) can lead to some increase in the probability of disease through accumulated epigenetic load. HHRA Project 6; ACE Project PEP-2.

HHRA has also committed to incorporating susceptibility and vulnerability information into assessments in the Integrated Risk Information System (IRIS) and the Integrated Science Assessments (ISA) for NAAQS pollutants as well as for CRA. HHRA Projects 2 (IRIS) and 3 (ISA).

In addition, the CSS program has research activities on rapid exposure and toxicity assessment and on development of biological adverse outcome pathways for use in screening of potentially toxic compounds, and, ultimately, apply to risk assessment). This research can be applied to concerns raised by NEJAC (Table 3) for assessing new products and prioritizing chemicals for IRIS assessments. SHC Project 2.62, HHRA Project 6, CSS Topics 1 and 2.

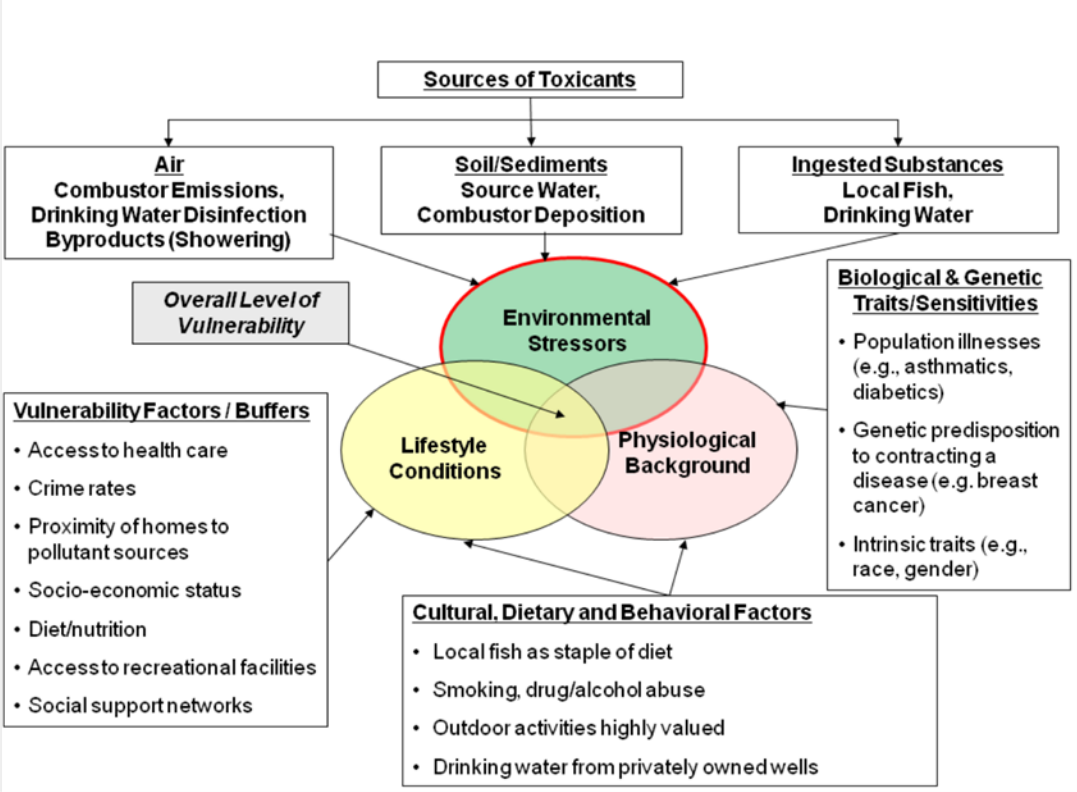

Figure 3. Cumulative Risk Assessment framework illustrating various potential roles of chemical and non-chemical stressors and buffers. Current area of emphasis in HHRA is incorporating ecological endpoints and future work will incorporate HSRP resiliency and SHC wellness indices.

In addition, HHRA's Topic 3 focuses on Community and Site-specific Risk. This research area addresses three issues to overburdened communities: the development of risk assessment values for compounds of concern found at contaminated sites (Provisional peer-reviewed toxicity values, PPRTVs); site-specific and Superfund regulatory technical support, and cumulative risk assessment methods and applications.

There is further discussion of cumulative assessment below in the section on Children's Environmental Health and epigenetics and in the section above on Decision Support Tools.

D. Children's Environmental Health (CEH): CEH is well-described in the research roadmap dedicated to that topic. Because more than 1 in 5 children in the US live in poverty, and the poverty rate of Black and Hispanic children is roughly twice that of White children (US Census, 2010), this is also a critical topic for the EJ Roadmap. The Children's Environmental Health and Disease Prevention Centers Program (SHC STAR research co-funded with NIEHS, Appendix Table A-2) addresses children's susceptibility and vulnerability to chemical exposures in the context of the communities in which they live, learn and play. Community engagement, community outreach and the incorporation of social determinants of health are major components of this program.

ORD/SHC's intramural research includes experimental studies using rodent models designed to characterize the interactions between selected non-chemical environmental factors of

concern in humans (e.g., psychosocial stress, poor diet, maternal obesity) and chemical stressors common to low-income and at-risk communities for induction of adverse outcomes following prenatal exposures. This research will interact with HHRA and ACE research that considers whether social factors may induce epigenetic re-programming, and whether the epigenome may become useful as a "biosensor" of environmental conditions, broadly defined such as those found in overburdened communities. HHRA is focusing on incorporating genetic and epigenetic susceptibility into cumulative risk assessment (CRA).

SHC has also funded extramural (STAR) research on Healthy Schools: Environmental Factors, Children's Health and Performance, and Sustainable Building Practices to inform school building design, construction and operation practices in order to foster safe and healthy school environments and maximize student achievement and teacher and staff effectiveness.

SHC Projects 2.62 & 2.63; HHRA Project 6; ACE Projects PEP 1, 2, & 4.

Tribal sustainability and well-being

To address Tribal sustainability, Native American institutions have recently increased emphasis on restoring and sustaining traditional, healthy approaches to life that link environmental, economic and social well-being. This requires evaluation of both environmental conditions and the many factors that contribute to disproportionate exposures and health disparities (e.g., availability of healthy food; restoring traditional foods; differences in exposure factors due to lifestyle and economic pressures). Furthermore, Tribal institutions raise questions about the impacts of stressors associated with climate change on their communities and lifeways (e.g., sea level rise, changing plant hardiness zones, drought, severe weather), and are working with EPA to develop tools that they can use to anticipate and adapt to these stressors.

A. Tribal Community Grants

The extramural STAR tribal research program is currently funding 6 research grants focused on sustaining health and environmental quality in tribal communities (funded 2014-2017). The research in these grants focuses on Tribal specific indoor air quality, impacts of climate change on Tribal health, water quality and access to traditional foods. These community-focused grants also include research relevant to children's environmental health and disproportionately impacted communities (Appendix Table A-2). These research areas are also priorities of EPA's Tribal Science Council.

The goal of these grants is to develop sustainable solutions to environmental problems that affect tribes by focusing on 1) health impacts of climate change on tribal populations, and 2) health impacts of indoor air pollution exposures that derive from or are directly affecting traditional tribal life-ways and cultural practices with specific emphasis on impacts to vulnerable groups within Tribal communities. Partnering institutions involve Tribal communities through both University-based and Tribal community-based projects, namely the Yurok Tribe Environment Program and Northern Arizona University working with the Alaska Native Tribal Health Consortium (to develop

a Yurok Climate Change Adaptation Plan for Water and Aquatic Resources); the Swinomish Indian Tribal Community (working with the Skagit System Cooperative and USGS Western Fisheries Research Center); Little Big Horn College and Montana State University working with Crow Tribal members and a Steering committee of Tribal stakeholders; The University of Tulsa, Cherokee Nation Environmental Program and other tribal partners working on home and school indoor air quality interventions; the Alaska Native Tribal Health Consortium (a non-profit organization) working on food and water security threats in arctic remote Alaska native villages; and the University of Massachusetts team working with Native North American subsistence hunters on air quality in tents.

The current grants extend the efforts and impact of this longstanding program, which has been in effect since 2000. ORD's report on a Decade of Tribal Science (EPA, 2013) summarizes extramural research focusing on cumulative chemical exposures and global climate change affecting tribes, while integrating cultural, ecological and human/public health aspects. Past recipients and research summaries are available at http://www.epa.gov/ncer/tribalresearch/recipients.html.

Extramural research on indoor air quality is complemented by ORD/SHC intramural research investigating factors that confer greater environmental public health risk in Tribal areas and communities. These include health impacts of indoor air pollution exposures that derive from or are directly affecting traditional tribal life-ways and cultural practices with specific emphasis on impacts to vulnerable groups within Tribal communities (SHC Project 2.63). This also includes the development of tools to aid in planning tribal housing (SHC RESES projects, Project 4.61). It also includes active research in the ACE program on cook stoves, including testing protocols, the impacts on indoor air quality and health, life-cycle analysis of fuel alternatives, and impacts on climate (ACE Project SEM-3).

B. Local Environmental Observer (LEO) Network

The climate is changing rapidly in Alaska. Local observers can detect changes in weather, landscapes and seascapes, and in plant and animal communities. The Alaska Native Tribal Health Consortium developed the LEO Network in 2009, recognizing the value of local and traditional knowledge and the need for a tool to document and share environmental observations. The purpose was to increase awareness about vulnerabilities and impacts from climate change, and to connect community members with technical experts. LEO uses web-accessible Google Maps to display observations of unusual or unique environmental events which are then shared with LEO members. The maps contain event descriptions, photos, expert consultations and links to information resources. LEO has grown to include hundreds of participants and is helping to increase understanding about the emerging effects of climate change. LEO Network recently announced the launch of LEO Viewer, a new mobile app for handheld devices. LEO Viewer is a global map and data interface. It allows viewers to experience through text, audio and images the observations and technical consults posted by network members. EPA has supported LEO since 2012, through its American Indian

Environmental Office's tribal assistance program and collaborations with its Region 10 Office serving Alaska. EPA's Office of Research and Development has also been engaged throughout in exploring citizen science and innovative approaches. LEO applies local and traditional knowledge, science and modern technology to record and share observations, and to raise awareness about the conditions in the circumpolar north. This successful collaboration with the US EPA was highlighted by Alaskan tribal leaders at the September 30, 2015 White House Citizen Science event.

C. Intramural research includes five research areas important to maintaining and improving Tribal sustainability and addressing Tribal Science council priorities.

1. Fish consumption and climate change impacts on Tribal health and well-being. This research is focused on assessing cumulative tribal exposures to methyl mercury, PCBs, and other contaminants mainly associated with fish consumption, with cost-benefit analyses to inform tribal decisions. Research approaches include dietary exposure modeling, meta-analysis of biomonitoring samples including data provided by Tribes, and GIS spatial mapping of Tribal exposures. Ideally, this research will be developed through a collaborative tribal case study (e.g., Penobscot Indian Nation, ME) to focus on cumulative exposures along with cost-benefit analyses of tribal decisions intended to restore heritage diets e.g., dietary patterns, dam removals. This research applies population-based exposure models developed to ensure chemical safety to the community/tribal scale. SHC Project 2.63

2. Proper functioning condition (PFC) of ecosystems: ecological assessments and restoration centered on Tribal culture and values and traditional ecological knowledge (TEK) to help manage ecosystem and human health issues. PFC research is aimed at reducing harmful risk to humans and the environment. Examples include using PFC to reduce risk in the Agency's use of TMDL methods (Clean Water Act and the new vision for TMDLs), improving water quality, understanding the risk associated with climate change, using Leading/Lagging Indicators of ecosystem integrity, improving Best Management Practices to reduce risk, improving environmental regulations, using big data for PFC assessments and others (EnviroAtlas/T-FERST), improving methods for human health and environmental risk assessment. This work also includes PFC Outreach/Capacity-building for Tribes including workshops, workshop reports, GIS and Remote sensing to support workshop field sites, Tribal cultural information, TEK, T-FERST and EnviroAtlas demonstrations, climate change, and individual PFC assessments, adaptive management and monitoring plans for individual Tribes as requested, natural toxic blooms (identification and sensing), work with other communities, other Programs, Regions, State and local communities and International Commission for Environmental Cooperation. SHC Project 2.63

3. Natural toxin blooms research for forecasting and early detection of harmful algal blooms in Tribal areas. Tools will be developed to characterize toxins

(known and identifying/characterizing unknown toxins) produced from natural toxin outbreaks [i.e., Prymnesium (golden algae), microcystis; anabaena; cylindrospermopsis; euglena; and other as yet unidentified algal toxins]. Preliminary studies will focus on identifying key Prymnesium toxins produced in inland ponds/lakes that are on Tribal lands. Temporal, short- and long-term trends of the physicochemical relationships of pH, temperature, total Nitrogen, total Phosphorous, Calcium and Magnesium [and other potential chemical parameters], and the toxins produced will be analyzed to potentially develop predictive forecasting tool(s) (i.e., real-time chemical sensors) for natural toxin blooms. This research also includes potential health impacts of interactions between naturally occurring arsenic in ground water and algal toxins. SHC Project 2.63, SSWR Project 4.01

4. Tribal child care center research to understand how time is spent at Tribal child care centers and how that may affect young children's exposures to various chemical and biological agents. This proposed research is a collaboration between EPA Region 10, the Indian Health Service (IHS), and ORD. This research will provide data on the environmental concentrations of lead, allergens, pesticides, PCBs, and other chemical and biological agents in Portland Area Indian Country child care facilities. It will also provide valuable information on non-chemical stressors that young children who attend day cares may experience. SHC Project 2.63

5. Development of a Tribal Well-Being Index (TWBI) that integrates environmental, social/health, and economic domains to provide a metric for holistic well-being in the tribal context. This Index is useful for evaluating the potential impact of tribal decisions that affect ecosystem, social, and economic services on important contributors to well-being like social cohesion, education, and cultural continuity. TWBI is an index constructed from indicators from the environmental, socia/health, and economic domains. It is different than the Tribal Focused Environmental Risk and Sustainability Tool (T-FERST) described above. T-FERST is a broad information delivery and mapping tool tailored for tribal use. SHC Project 2.64

Climate justice

Climate change threatens human health and the environment, but its impacts do not affect communities equally. Emerging research has linked vulnerability and capacity to adapt to climate change impacts to socioeconomic and demographic characteristics (e.g., race, ethnicity and income), access to social health and environmental services, level of education and level of preparedness. The following highlighted research activities address the importance of building community resiliency to plan for, adapt to and recover from the unmitigated effects of climate change.

ORD is developing tools to assist community decision-makers and planners assess their vulnerability to the impacts of climate change, and better understand how all communities with emphasis on EJ communities might benefit from using these tools. ORD is actively

engaged with National Science Council, Office of Science and Technology Policy, Council on Environmental Quality, Federal Emergency Management Agency and Center of Disease Control and Prevention to develop improved information about community-level vulnerabilities, and is actively working at the interagency level to expand access to information on projected climate impacts more generally. These interactions enable EPA and ORD to ensure that EJ issues are incorporated into broader, cross-agency activities and programs.

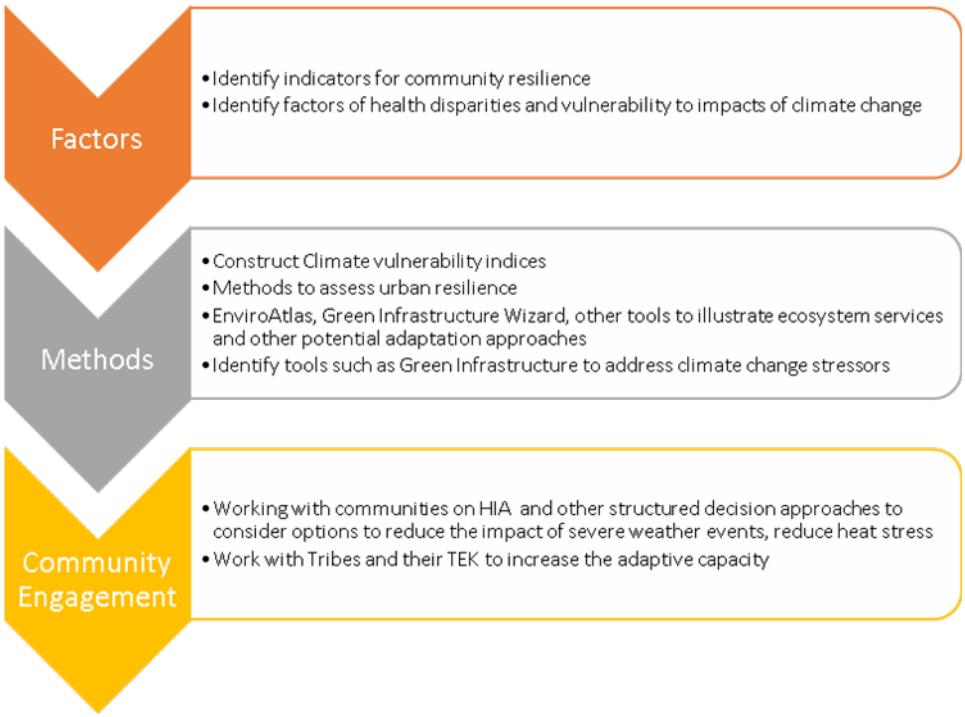

Figure 4. Integration of Research on Global Climate Change and Community Resiliency

ORD research to develop climate change resilience vulnerability includes:

A. Climate resilience screening index (CRSI) and Community Environmental Resilience Index (CERI). Climate resilience focuses on enhancing the performance of a system's capacity to adapt (built or natural) in the face of multiple hazards (e.g., sea level rise, increased variability of seasonal temperatures, increased incidence of storm events and flooding, etc.), rather than preventing or mitigating the losses associated with only specific events. To this end, SHC has proposed a feasibility assessment for building a CRSI, a composite measure of community functions as they relate to community sustainability. This effort proposes to leverage off the development of urban climate change resilience indicators from the ACE program as well as indicators and metrics used in existing community and climate resilience evaluations (e.g., Rockefeller Foundation-ARUP City Resilience Framework (2015), European Commission Index for Climate Resilient Development (2014). This index will describe a community's (e.g., region, state, county, city, town, neighborhood) capacity to recover societal and economic functionality, so that people living and working in these spatial units – particularly the most vulnerable – survive and thrive after encountering climate exposures. SHC Project 2.64

CRSI is linked to the Homeland Security Research Program (HSRP) research to develop a Community Environmental Resilience Index (CERI). This research, like the CRSI above, combines environmental and social science research. CERI is not focused specifically on stressors associated with climate change, but, rather, on improving community resilience to disasters that can affect human health and disrupt water, waste, and energy systems. CERI is part of a broader HSRP effort to develop tools and methods for effective preparedness and response, including environmental resilience assessment tools to minimize environmental risks associated with disasters, to both quickly return critical environmental and ecological services to functionality after a disaster and to reduce vulnerabilities and risks to future incidents. CERI will be producing a "Preliminary Assessment of EPA community-based resilience tools." The SHC program has a longer term effort focused on developing a synthesis report on quantitative and qualitative indicators of resilience in human and natural systems. HSRP topic: Remediating Wide Areas; SHC Project 2.64.

The ACE program has several efforts directed toward developing community resilience indicators. These efforts include the development of methods to assess urban resilience as a path toward sustainability under climate and land use changes. One of these methods will assess the capability of different types of communities to withstand the impacts of average and extreme climate changes without breakdowns in their economies, natural resources bases, or social systems (resilience). This project is designed to evaluate whether (1) differences in urban ecosystem resilience can be identified using common sets of metrics / composite metrics, (2) typologies of urban ecosystems may be developed based on characteristics of urban areas and other factors to extrapolate information to other urban ecosystems. The output of the urban resilience project is designed to provide outputs that can inform and help prioritize policies and measures that foster greater resilience. ACE Project CIVA-3.

B. EnviroAtlas: Additions to existing tools that illustrate the links between ecosystem services and potential mitigation of climate change impacts such as heat stress, extreme weather events, water quality and quantity; Incorporation climate scenario time series viewer into EnviroAtlas to allow users to consider potential changes over time of temperature, precipitation, water supply and demand, sea level rise. SHC Project 1.62

C. Wildfires: ACE research on the actual and perceived impact of a wildfire on a local community in terms of social, economic, and environmental consequences showing that forecast-based interventions can reduce the health and economic burden of wildfires. This is critical for EJ because this research also showed that health impacts were significantly worse in a lower socio-economic status community. ACE Project PEP- 1, 2, & 4

D. Climate change impacts in communities with contaminated sites: Identifying key factors and interrelationships between social determinants of health, other non-chemical stressors, and chemical agents with respect to climate change-related impacts for vulnerable populations residing near water/wastewater treatment facilities or contaminated sites. This proposed research will draw together a broad range of community vulnerability indicators to conduct GIS-based statistical analyses to examine (a) most vulnerable communities in the U.S. from potential flooding of water/wastewater treatment facilities or contaminated sites; and (b) disparities associated with the most vulnerable communities and particular groups based on

socioeconomic, racial and ethnic factors, as well as proximity to water/wastewater treatment facilities or contaminated sites vulnerable to flooding. SHC Project 2.63.

E. Research on technology for small water systems, particularly for those in extreme areas (Appendix Table A-2). These grants are designed to increase community resilience to threat to their drinking water supplies. The grant to a consortium of colleges led by Lincoln University, a historically Black College and University, is focused on the development and implementation of surface water treatments. A second grant is focused on Point of Use Water Treatment Systems in the Paso del Norte Region. This aims to develop small drinking water treatment systems through community participatory research in the twelve colonias in the Paso del Norte Region that includes El Paso, TX and Otero and Dona Anna counties of New Mexico. SSWR Project 6.03.

F. See section on Tribal Sustainability and Well-being for additional research addressing potential impacts and adaptation to climate change.

G. **For additional discussions and details on specific research gaps and priorities, please refer to the Climate Change Research Roadmap.**

IV. Research Gaps & Priority Research Needs

EPA's National Environmental Justice Advisory Council has produced an extensive set of recommendations for integrating environmental justice in the EPA's research enterprise (NEJAC, 2014). These recommendations are summarized in Table 2. The comprehensive reach of this table from NEJAC makes it a helpful summary of the breadth of recommendations received by ORD from a number of advisory groups. The SAB-BOSC, for example, emphasized the need for community input. NACEPT goes into more detail emphasizing the development of monitoring and assessment technologies along with technologies to better communicate real-time information about ambient pollution levels and for emergency response.

While there is not adequate space in this Roadmap to address all of these issues, it is notable that for many of them, ORD and the Agency have activities addressing these needs (bolded text on Table 2), though the level of effort varies for each of these items. For example, this Roadmap lists a considerable body of research focused on the needs of American Indians (Table 3, Item 1-1); this research does not, however, address the needs of all indigenous peoples. For issues like the need to partner to advance access to health care in communities experiencing environmental inequities (Table 3, Item 1-17), ORD has initiated programs like Healthy Heart to deliver critical environmental health information to practitioners in communities such as North Carolina's "Stroke Belt," developed research on the efficacy of preventative measures in wildfires areas referenced above in the section on Climate Justice, and funds research that informs research translation actions by Pediatric Environmental Health Specialty Units but does not play a direct role in providing health care. ORD is more deeply engaged in the development and application of Health Impact Assessments (HIA) (Table 3, Item 1-14). ORD's work to increase the rigor and use of science in HIA has been noted by the National Prevention Council, who identify the EPA as the federal government leader in this area, and groups such as the National Association of City and County Health Organizations (NACCHO) are using ORD's report on HIA as

instructional material (personal communication). ORD's initial HIAs were done in partnership with EPA's Regions and local government and community groups from overburdened communities.

The non-bolded areas highlights some of the existing gaps in ORD's portfolio. These are mainly in the areas of community engagement in setting the research agenda and assessing outcomes.

1) Community engagement (Table 3, Item 2-1): ORD has made great strides in performing or funding community-engaged research, but not necessarily in engaging communities themselves in setting this research agenda. This need was emphasized by the EPA Science Advisory Board – Board of Scientific Counselors Executive Council: Incorporate input from communities to identify problems associated with environmental, biological, behavioral, social, economic, and spatial stressors, and how they inter-relate.

In the area of Community-Engaged Research, ORD includes provisions requiring or strongly recommending community engagement in funding to STAR Centers for Children's Environmental Health and Minority and Health Disparities, and the newly funded ACE Centers.

ORD's SHC research program has directed its researchers to conduct actionable research on problems formulated at the stakeholder level, and to conduct its research through participative and collaborative case studies to build on stakeholder expertise and to focus research and development on the end-user. SHC has expanded its funding for research proposed by EPA's Regions for community-scale projects through its Regional Sustainable Environmental Science (RESES) program; many of these projects address community engagement and environmental health in overburdened tribes or communities near ports, roadways, or contaminated sites or who are considering green infrastructure approaches to myriad problems rooted in stormwater or wastewater handling. All of ORD's national Research Programs collaborate with EPA's Regions in Regional Applied Research Efforts (RARE), many of which address issues in overburdened communities. And the Citizen Science research and outreach led by ACE has engaged communities.

But these efforts, while engaging communities, are not necessarily working with communities to set the research agenda – in most cases, it is a university partner or EPA Region that is acting as a surrogate for the community in proposing the research to go forward. ORD's SHC did sponsor listening sessions during the early development of its program, but these focused on broad areas of interest to planning at community governance levels.

EPA's STAR program has demonstrated the benefits of truly engaged CPBR, with community partners driving research in areas like health and safety for families of pesticide applicators. Recently ORD researchers have begun to engage with community members at the biannual Community Involvement Training Conferences (CITC) and have found these to be extremely helpful in orienting them toward the development of their technological or science products. The July 2015 CITC was sponsored by EPA's Office of Air and Radiation, Region 4, the Office of Environmental Justice and the Office of Land and Emergency Management. ORD should work with EPA's Programs, Regions, Office of Sustainable Communities, and with community stakeholder groups to greatly increase opportunities for direct interaction of its scientists with community members. These could be at listening sessions, perhaps sponsored jointly by ORD and EPA's Regions, which are incorporated into ORD's regular planning cycle. This could also occur at events such as the workshop (July 2015) sponsored by ACE to build capacity for Citizen Science where ORD scientists can learn more about community needs for measurement or other technology. These events are important because they could provide opportunities for community members to engage directly in the development of the science and technology through their experience with the usability and applicability of the tools.

2) Assessing outcomes (Table 3, Items 3-1, 4-1, 4-2): Assessing direct outcomes resulting from ORD research is often challenging. This is because while ORD provides science and technology, EPA's programs are largely implemented through its Program and Regional Offices or through delegated parties at the state level. That said, the importance of monitoring or assessing outcomes of decisions made that affect community well-being is at the heart of much research in ORD's National Research Programs. For example, the SHC StRAP emphasizes the development of structured decision making approaches like HIA that include a cycle of monitoring or assessment of outcomes to drive further improvement of conditions or adaptive management. It has put resources into developing indicators and indices, such as the Human Well Being Index, as metrics of both baseline conditions and to evaluate changes brought about by voluntary or regulatory practices. The HSRP similarly employs a structured cycle included "Lessons Learned" to reduce vulnerabilities and increase resilience to contamination events or natural disasters.

ORD offers its science and tools needs to its partners in programs such as OLEM's Brownfields program, the Great Lakes National Program Office, EPA's Regions, and ATSDR for planning remediation or restoration activities. It needs to engage these partners further to evaluate the longer term outcomes of community-scale actions in terms of progress toward restoration of the environment and broad community revitalization – the real steps toward sustainability. Continued support for Citizen Science will be critical to these efforts; it will be especially to develop clear standards and use of Citizen Science data by communities in communicating with the Agency. These standards should be developed through collaborations with ORD, EPA Program Office, technology developers, and community stakeholders.

3) Promoting training of the next generation (Table 3, Items 2-5, 2-6): EPA Administrator Gina McCarthy hailed the success of the ORD –Region 2 Citizen Science project in Newark saying, "Community-based air monitoring projects like this one make public health a priority and pay multiple dividends. We not only gain valuable information, we also help community members gain the skills and experience they need to conduct citizen science projects in their communities to better protect their families." ORD has long played a role in funding fellowships at the university and post-graduate level to advance STEM capacity, with an emphasis on underserved communities and the economic opportunities that higher education brings. It needs to move beyond that to build an infrastructure and partnerships to increase the capacity of community members to engage meaningfully in the policy and planning decisions that affect their communities. ORD, working with Regional partners, has taken small steps. For example, local community colleges developed a curriculum based on C-FERST in Portland, OR and Tacoma, WA and engaged in citizen science to map features of their communities. Further development of academic-community partnerships to build capacity along with the development of educational curricula that can incorporate sophisticated GIS and other scientific information delivery and visualization tools into secondary education have the potential to promote direct engagement of the community in the decisions that affect their lives.

Table 3. Summary of the NEJAC (2014) Recommendations. Bold lettering indicates ORD activities in those areas (adapted from NEJAC, 2014).

TOPIC AREA	Opportunities to address environmental inequities	Community inclusive processes	Tailoring ORD tools for community use	Assessing impact of ORD research	Skills needed to address EJ
RESEARCH NEEDS, GAPS AND FRAMEWORK	**1-1. Incorporate Research Needs of American Indians, Alaskan Natives**, Native Hawaiians and Other Indigenous Peoples **1-2. Advance Research on Health Disparities** **1-3. Conduct and Collect Data for Longitudinal Studies** **1-4. Support Biomonitoring Research** **1-5. Conduct Research and Collaborate to Identify and Address Air Quality "Hot Spots"** **1-6. Conduct Research to Support Diesel Exhaust Regulations** **1-7. Conduct Research on Potential Disproportionate Impacts of Climate Change Effects, Mitigation and Adaptation** **1-8. Revise the EPA's Definition of Sustainability** **1-9. Conduct Research on Incentivizing Business Performance Beyond Compliance** **1-10. Amplify Uncertainty Analyses to Inform Risk Assessment, the Application of the Precautionary Principle and Decision Making** **1-11. Assess New Products**		3-1. Collect Data for Evaluating Improvements in Environmental Conditions and Health Outcomes		
RESEARCH AGENDA DEVELOPMENT IN COLLABORATION WITH STAKEHOLDERS	**1-12. Prioritize Chemicals in IRIS Process** **1-13. Investigate Potential Disproportionate Effects of Pesticide Exposure of Rural and Urban Farmworkers**	2-1. Engage Communities in Setting the Research Agenda	3-2. Encourage Collaboration in Setting the Research Agenda **3-3. Identify and Engage Relevant Stakeholders** **3-4. Engage Stakeholders in the Development of Research Products and Tools**		
RESEARCH IMPLEMENTATION, PARTNERSHIPS AND FUNDING	**1-14. Promote Health Impact Assessment Method** **1-15. Adjust Extramural Research Review Process** **1-16. Investigate Environmental Contribution to Health Disparities** **1-17. Partner to Advance Access to Health Care in Communities Experiencing Environmental Inequities**	**2-2. Incorporate Community-Engaged Research Models Into Research Program Implementation** **2-3. Build Community Capacity through Partnerships and Technical Assistance**	3-5. Develop Personnel Exchanges		**5-1. Increase Social Scientists on EPA Staff and as Consultants** **5-2. Enhance Training of ORD Scientists**
RESEARCH TRANSLATION AND COMMUNICATION	**1-18. Translate Research to Policy Makers**	**2-4. Communicate Community-Engaged Research** **2-5. Increase Use of Technology to Communicate and Educate Stakeholders** **2-6. Promote Environmental Justice Education and Training of the Next Generation of Scientists and Engineers**			
RESEARCH EVALUATION	1-19. Evaluate the EPA's Integration of Environmental Justice into Decision-Making			4-1. Assess Research Outputs' Support of Environmental Justice Outcomes 4-2. Assess Effectiveness of Stakeholder Partnerships **4-3. Assess Use of EPA Tools**	5-3. Assess Effectiveness of Environmental Justice Training for Staff

V. Summary

ORD's EJ Roadmap is the first documentation of ORD's existing and on-going research supporting the Agency's implementation of environmental justice. The EJ Roadmap is presented as a summary inventory of ORD's research efforts, categorized by four overlapping EJ science challenges: 1) Developing decision support tools for identifying and prioritizing concerns, assessing cumulative impacts, and evaluating mitigation options; 2) Improving our understanding of environmental health disparities and developing methods and data for assessing cumulative risks; 3) Tribal sustainability and well-being, and 4) Climate justice.

ORD research reflects attention to the myriad issues raised by environmental justice and captured through discussions with advisory groups like the NEJAC, NACEPT, the IOM, and EPA's own Science Advisory Board and ORD's Board of Scientific Counselors. Areas for increased emphasis include direct engagement with communities in setting research directions, assessing the outcomes of decisions affecting communities and assessing the utility of ORD tools for addressing EJ issues, and building community capacity to directly engage in environmental decision making.

Appendix A. Environmental Justice-Related Research Projects

The project titles reflect preliminary alignments in the 2016-2019 Strategic Research Action Plans. Programmatic changes may result in project name changes, realignment, mergers, or splits that are not reflected in this table. Key Questions Addressed refers to the questions listed in the Research Scope section of the Environmental Justice Research Roadmap.

Table A1. ORD projects including environmental justice research.

National Research Program, Project Number Key Questions Addressed	Title
ACE CIVA-3 KQ: 1, 3, 8, 9	Climate Change Impacts, Vulnerability and Adaptation: Systems-based Approaches for Sustainable Solutions • Integrated response strategies such as combined climate adaptation and mitigation actions with decision support tools
ACE EM-3 KQ: 1, 2, 7	Changing the Paradigm for Air Pollution Monitoring • Village Green • Air Sensor Toolbox for Citizen Scientists and low-cost air sensor performance evaluations • RETIGO for data visualization on GIS backdrop and interface with C-FERST, EnviroAtlas • Fugitive, area source, and fenceline monitoring
ACE PEP-1 KQ: 3, 4, 5, 9	Local and Regional Characteristics Influencing Public Health Impacts in Healthy and At-Risk Populations • Near road, near port exposures and wildfire health impacts • At-risk populations
ACE PEP-2 KQ: 2, 4, 5, 6	Modifiable Factors that Influence Air Pollution-related Public Health Impacts in Healthy and At-Risk Populations and Inform Risk Mitigation Strategies • Understanding the role of modifiable factors such as diet, exercise, exposure to green space, social stressors in the association between air pollution and environmental public health • Identification of actions that mitigate exposure to air pollution and reduce health effects
ACE PEP-4 KQ: 1, 2, 3, 4	Translate Research into Actions that Protect Public Health and Wellbeing • Healthy Heart • Wildfire vulnerability index • Environmental literacy
ACE SEM-3 KQ: 1, 8, 9	Sustainable Energy and Mitigation: End-Use Impacts • Cookstoves – Health and Climate Benefits of Cleaner Technologies
CSS Topic 1 KQ: 4, 6	Chemical Evaluation: High Throughput Toxicology, Rapid Exposure and Dosimetry • Contributes to assessing new products, chemical prioritization
CSS Topic 2 KQ: 6	Complex Systems Science: Adverse Outcome Pathway Discovery and Development • Contributes to assessing new products, chemical prioritization
CSS Topic 3 KQ: 1	Lifecycle analytics • Providing the tools to evaluate alternatives
HHRA-1, -2 KQ: 5, 6, 7	Integrated Risk Information System (IRIS) Assessments and Updates • Incorporation of susceptibility and vulnerability information
HHRA-4 KQ: 5, 6	Provisional Peer-Reviewed Toxicity Values

	• Information to make informed decisions about cleaning-up contaminated sites to protect human health in nearby communities
HHRA-6 KQ: 5, 6, 7	Cumulative Risk Assessment Methods and Applications • Integrating chemical and non-chemical stressors, including community stressors, impacts of green space, for CRA • Epigenetics: Potential mechanism through which nonchemical stressors increase susceptibility to chemical stressors • Multiple stressor, multimedia research to inform CRA
HSRP – Remediating Wide Areas KQ: 9	Community environmental resilience to disasters • Community Environmental Resilience Index
SHC 1.62 KQ: 1, 2, 3, 9	EnviroAtlas • Community scale mapping of access to nature's benefits with demographic and other population information • Proposed climate change vulnerability information
SHC 1.63 KQ: 1, 2	Environmental Workforce and Innovation • Greater Research Opportunities fellowships • People, Prosperity, and the Planet (P3) Student Competition for Innovation
SHC 2.62 KQ: 1, 2, 3, 4, 5 , 6, 7, 8	Community Public Health and Well-Being • Information access, mapping, and community engagement tools: C-FERST, T-FERST, CCAT • Health Impact Assessment • Bioavailability and Urban Soils • Biological (including epigenetic) basis for asthma and other high priority environmental health outcomes in the context of social and neighborhood factors and exposure to pollution • Screening level models for near road and ports • Non-chemical stressors and analytical methods in cumulative risk assessment including STAR funded RFA
SHC 2.63 KQ: 1, 2, 3, 4, 5, 6, 7, 8, 9	Assessing Health Disparities in Vulnerable Groups • Children's Environmental Health, including NIEHS-EPA Centers of Excellence with community engagement • Health Disparities, including NIH-EPA Centers of Excellence • Epigenetic research into early chemical and non-chemical determinants of later disease or poor birth outcomes • Tribal Science, including STAR funded RfA • Climate change impacts in communities with contaminated sites
SHC 2.64 KQ: 1, 3, 5, 9	Indicators, Indices, and the Report on the Environment • Human and Tribal Well-Being Indices • Climate Resilience Screening Index
SHC 4.61 KQ: 1, 2, 3, 7	Integrated Solutions for Sustainable Communities • Integrated Ports Assessment • Regional Environmental Science (RESES); multiple projects on community engagement, HIA, ports assessments, sustainability in overburdened communities
SSWR 4.01 KQ: 8, 9	Reducing Impacts of Harmful Algal Blooms • Health impacts, water availability, tribal sustainability
SSWR 5.02 KQ: 1, 2, 9	Support increased adoption of green infrastructure into community stormwater management plans and watershed sustainability goals: Information and Guidance through Community Partnerships. • Collaboration on Health Impact Assessment

	• Decision support for Green Infrastructure solutions
SSWR 6.03 KQ: 2, 7, 8	Water Systems: Transformative approaches and technologies for water systems • STAR research on small water systems, including colonias in US-Mexico Border area

Table A2. STAR Research Addressing Environmental Justice

EPA Office of Research and Development Science to Achieve Results (STAR) grant solicitations and awards that include community engaged research, research on exposure and health disparities and the contribution of non-chemical stressors or social determinants of health, tribal sustainability, and engineering solutions for issues in overburdened communities. Hyperlinked locations provide more detail on each of these solicitations.

Title	Research Program	Project or Topic	Description	Completion Date
Children's Environmental Health and Disease Prevention Centers Program	SHC	2.63	EPA-NIEHS Children's Environmental Health and Disease Prevention Centers (joint with NIEHS) (14 currently active). Includes safety of farmworker families and urban asthma research.	2016
Children's Environmental Health and Disease Prevention Centers Program	SHC	2.63	A new Children's Centers RFA to be funded in 2015 solicited proposals with increased emphasis on how nonchemical factors and social determinants of disease may exacerbate the risks associated with pollutants, making it especially relevant to health disparities and EJ concerns.	2020
STAR Tribal Research Grants	SHC	2.63	Six grants focused on the development of sustainable solutions to environmental problems that affect tribes by focusing on 1) health impacts of climate change on tribal populations, and 2) health impacts of indoor air pollution exposures that derive from or are directly affecting traditional tribal life-ways and cultural practices with specific emphasis on impacts to vulnerable groups within Tribal communities.	2017-2019
Centers of Excellence in Health Disparities MOU	SHC	2.63	Ten Centers of Excellence in Health Disparities, Joint with NIMHD through MOU (2012-14) are evaluating how disproportionate environmental exposures, especially in air and water, in combination with a diverse array of non-chemical factors including: social (including racial/ethnic composition), built environment (such as poor housing, access to recreation facilities), lifestyle (such as smoking) and economic stressors (such as lack of access to healthy food) contribute to health disparities. A variety of negative health outcomes are considered including: cardiovascular disease, diabetes, poor mental health, and cancer. Some centers are using geospatial and temporal analyses to examine relationships and syndemic effects among health disparities and environmental factors. Emphasis in others is placed on community-based outreach and interventions.	2014

NIH-EPA Centers of Excellence in Health Disparities	SHC	2.63	A new cross-agency STAR RFA (2014) created in partnership with NIH (NIEHS, NIMHD and NICHD) will fund Centers of Excellence in Health Disparities to stimulate basic and applied research to understand environmentally-driven health disparities and improve access to healthy environments for vulnerable populations and communities. It is designed to foster interdisciplinary research on the complex interactions between social, natural and built environmental systems, conditions, and policies that result in unequal environmental health conditions and disproportionate impacts among (diverse) disadvantaged population groups, communities, neighborhoods and individuals. Outcomes of this research are expected to promote innovative approaches and strategies to mitigate environmentally driven exposures and health disparities, alleviate system drivers of racial/ethnic and socioeconomic disparities, and improve access to healthy and sustainable environments for vulnerable populations. Proposals must include community-based research, mentoring, capacity building, and research translation and information dissemination. (Centers to be funded in late 2015).	2020
STAR RFA on Understanding the Role of Nonchemical Stressors and Developing Analytic Methods for Cumulative Risk Assessments	SHC	2.62	This includes grants on: CBPR to develop New Methods for Analysis of Cumulative Risk in Urban Populations; Effects-Based Cumulative Risk Assessment in a Low-Income Urban Community near a Superfund Site; Effects of Stress and Traffic Pollutants on Childhood Asthma in an Urban Community; Hypertension in Mexican-Americans: Assessing Disparities in Air Pollutant Risks; Combined Effects of Metals and Stress on Central Nervous System Function	2014-2016
STAR P3 Grants	SHC	1.63	Innovation small grants to universities; these address STEM education goals and specific research goals. Grantees include: DePaul University - Community -based Soil Quality Assessment as a Tool for Designing an Urban Green Infrastructure Network to Manage Runoff; University of California - Davis Small scale Ecosystem Engineering: Development of Household Level Greywater Treatment Systems; Mississippi State University - User-friendly Design Tools for Sustainable Wastewater Treatment in Rural and Disadvantaged Communities	
STAR Grants on Small Water Systems	SSWR	Water Systems, Project 3	These include: a grant to a consortium of three Missouri Universities, led by Lincoln University of Missouri, a Historically Black College and University, to identify THMs and N-nitrosamines associated with elevated Dissolved organic carbon/dissolved organic nitrogen in surface water supplies, and develop and implement water treatment technologies to reduce the health threats.; Point of Use Water Treatment Systems for Improving Sustainability and Environmental	2015 - 2017

			Justice in the Paso del Norte Region; a grant for small systems and Native American communities to develop, test and demonstrate small drinking water treatment methods to remove common groundwater constituents in extreme environments using readily available materials, such as biochar.	
Water Infrastructure Sustainability and Health in Alabama's Black Belt	SSWR	Water Systems, Project 3	This STAR grant is designed to examine water and health in the "black belt" of Alabama. This is a region where there is a large minority population that is historically, and currently underserved and economically disadvantaged. The grantees are conducting a prospective cohort study that follows 900 households for eighteen (18) months and includes active surveillance of household water quality and health outcomes. Researchers are working with residents in rural Hale, Wilcox, and Sumter Counties in Alabama.	2015
Air Pollution Monitoring for Communities	ACE	PEP	This solicitation seeks research on: (1) empowering communities and individuals to take action to avoid air pollution exposure using low-cost portable air pollution sensors; (2) ways communities and individuals interact with air pollution sensors and their data; (3) methods for understanding and managing the quality of data from air pollution sensors; and (4) how sensors and sensor networks compare to traditional air quality monitoring methods. Given the potential for portable air pollution sensors to enable communities to reduce exposure and risk, substantial engagement with community groups is encouraged. Research that will advance the ability of communities and individuals to take action to avoid air pollution exposure is of particular interest.	2019
Experimental Interventions to Facilitate Clean Cook stove Adoption, Promote Clean Indoor Air, and Mitigate Climate Change	ACE	SEM	This study will use price and social interaction experiments to provide valuable information about technical and behavioral dimensions of stove adoption and use. Climate modeling will provide a realistic assessment of the range and timeframe of foreseeable climate benefits resulting from widespread stove adoption. The project builds on preexisting partnerships with two Indian NGOs already promoting stoves in rural communities to take advantage of existing connections to stove-using households in diverse parts of India. Both NGOs are well-established and well-staffed with gender- and caste-sensitive personnel who will facilitate our entry into the complex social terrain of rural India.	2016
A Non-targeted Method for Measuring Multiple Chemical Exposures among a Demographically	CSS	Topic 1	This grant will use enhanced biomonitoring methods to characterize chemicals found in a racially diverse cohort of pregnant women. The results should show: (1) whether pregnant women are exposed to more environmental organic acids	2014

Diverse Population of Pregnant Women in Northern CA			than previously understood, (2) whether there are racial or ethnic differences in exposures, and (3) whether there are correlates with socio-economic status.	

Appendix B: ORD's 16 Making a Visible Difference Communities

*Note: these efforts are in a variety of stages. Some are still more formative than others.

Region 1

- **Lawrence, MA** - ORD will provide expertise and tools to Region 1 and local community to help develop strategic water plan and green infrastructure for better CSO control, water quality compliance, and also to evaluate and improve drinking water supply resilience for residents' wellbeing.
- **Bridgeport, CT** - ORD will provide expertise, data and tools to Region 1 and local communities for climate vulnerability assessment and adaptation planning of wastewater infrastructure.

Region 2

- **Newark, NJ** – The MVD project for Newark, NJ will include data and approaches from the EPA Region, ORD, local community groups, and potentially state and other agencies. We plan to form a collaborative partnership in order to leverage expertise and problem-solving experience in order to improve local resiliency and to develop risk reduction actions.

Region 3

- **Newport News, VA** - ORD will support Region 3 in conducting a cumulative risk assessment associated with the port of Hampton Roads, VA.
    - ORD is also working with Region 3 in the Newport News/Norfolk area as part of the Rockefeller 100 resilient Cities initiative.
- **Dover, DE** - C-FERST, applying the successful approach from Region 10, doing community outreach and engagement, and partnering with local community colleges and universities. Translating success in Region 10 to other communities.

Region 4

- **N. Birmingham, AL** – There are two portions to this Regional Sustainability and Environmental Science (RESES, ORD-based competitive funding for collaborative projects) project: an EnviroAtlas portion and a National Stormwater Calculator portion. ORD will collaborate with the City of Birmingham and Jefferson County to obtain and input the county's LiDAR data into the Community Component of EnviroAtlas to provide high resolution data on ecosystem services and community benefits specific to Birmingham. The City will use the results of the EnviroAtlas analysis in their green infrastructure planning processes to gain a better understanding of how its decisions can affect ecological and human health outcomes. The second portion is to add a costing module to the National Stormwater Calculator (NSC) to assist the City in determining the costs of various stormwater control measures. Originally, it was hoped that the RESES project would allow the City to compare green and gray infrastructure options and develop a web application for the NSC, but there are insufficient resources to accomplish this goal. These two functions will be considered for later projects.

- **Proctor Creek, Atlanta, GA** - Green infrastructure HIA for the entire Proctor Creek Watershed.

Region 5

- **Mill Creek, Cincinnati, OH** – The City of Cincinnati has already undergone a great deal of transformation with regards to stormwater and developing a more sustainable community. In 2013, for example, they received approval from EPA to cancel their plans to build a 40 million gallon tunnel in lieu of storm sewer separation and green infrastructure projects to reduce stormwater entering the combined sewer system.

  EPA Scientists are collecting hydrology and water quality data at a large Cincinnati green infrastructure project at St. Francis Apartments where a 2-tiered parking lot has been converted to extensive rain gardens. We have already provided pollutant concentration data into and out of the rain gardens to Cincinnati's Municipal Sewer District (MSDGC) to help inform their estimates of pollutant load changes associated with green infrastructure. A report presenting and interpreting the full data set from St. Francis will be completed as a final product of this study and share with MSDGC and Region 5.

  In addition to the St. Francis pilot study, ORD will contribute to a new pilot effort led by Hamilton County to develop an incentive program for green infrastructure (rain barrels and/or rain gardens) on private homeowner properties in the Kings Run area. Information from the previous ORD Shepherd Creek study has already informed their current Kings Run proposal, and we will continue to provide technical support and information as it is helpful to the process. For example, new estimates of life cycle costs of the rain gardens and rain barrels from the Shepherd Creek study are being developed. This information will be shared with Hamilton County and MSDGC to inform their Kings Run planning process.

- **Milwaukee, WI** - ORD's EnviroAtlas: application of community-scale coverage.
  - EnviroAtlas is a collection of interactive tools and resources that allows users to explore the many benefits people receive from nature, often referred to as ecosystem services. Though critically important to human well-being, ecosystem services are often overlooked. Using EnviroAtlas, many types of users can access, view, and analyze diverse information to better understand how various decisions can affect an array of ecological and human health outcomes.
- **SE Chicago, IL** – Recently added to the ORD list. RARE-granted Village Green station at a public elementary school and also developing educational outreach with those students.

Region 6

- **Alexandria/Pineville, LA** - Working with Regional staff to enhance a sustainability assessment to help local wood preserving operations to utilize sustainable materials management approaches as well as performing ground water plume delineation and reviewing ambient and property line air monitoring data.

- **Crossett, AR** - Cumulative risk assessment of paper plant-related pollution rippling through urban environment and fish consumption

Region 7

- **Omaha, NE** - The City of Omaha has demonstrated that a hybridized system utilizing both green and grey infrastructure methods with the goal of reducing sewer overflows is the most efficient and cost-effective approach to managing stormwater runoff. Specifically, the city is demonstrating the utility from investigating soil properties (take strategic soil core samples) prior to designing an infiltration-based Green Infrastructure (GI) technology for a specific area, plot or property. Between 2012 and 2014 demonstration took place at sixteen study sites throughout Omaha. This approach has been used to confirm and otherwise direct proper application and location of the GI techniques at 23 sites in Omaha. Documentation and outreach materials, describing these practices and results have been prepared and are being used by stakeholders. A collaborative relationship between the Omaha public works, Nebraska Department of Environmental Quality, University of Nebraska, USGS, EPA Region 7 and ORD have contributed to understand Green Infrastructure and ultimately support the city's CSO long term plan which has direct impact on the community.

  Additionally a demonstration GI project was selected by the City of Omaha to investigate and track through FY2017 the long term performance and natural dynamic properties of a specific site. ORD and R7 are collaborating with USGS's Nebraska Water Science Center developing, implementing and documenting a monitoring strategy for showcasing environmental and economic efficiencies of GI for stormwater overflows. An EPA kiosk is set up at the University of Nebraska, Omaha Extension. The kiosk is a communication tool between EPA and the community to relay up-to-date information about the project and provide a resource for understanding GI technologies.

  This MVD project will showcase the approach of designing and monitoring a GI project from up to 23 different sites in the Omaha community.

Region 8

- **Sun Valley, Denver, CO** - Systems assessment of and recommendations for the Sun Valley neighborhood around the light rail station. The goals for the neighborhood are to improve connectivity, vibrancy, economic opportunities while maintaining cultural diversity and a sense of place. ORD will use experience gained from the Durham, NC light rail study.

Region 9

- **Imperial Valley, CA** - ORD will contribute expertise (and, if $ found, possibly loaned equipment) to Imperial for air monitoring, with data communication and application

Region 9 is looking to enhance an existing community air quality research study, which involves distributing a large number (~30) of low cost particulate matter air monitors that report real-time concentrations and do live-reporting of the data to the public. This existing study could be strengthened in multiple different ways to have greater impact. Region 9 and ORD have had multiple discussions on approaches to enhance the existing project and provide support to the community.

Region 10

- **N/NE Portland, OR** - Holistic support for community needs - land use, brownfields, urban waters, air, equity in development.
    - Awarded RESES (Regional Sustainability and Environmental Science): Making a Visible Difference in N/NE Portland: Engaging Communities; Using Citizen Science to Assess and Address Children's Environmental Health from Transit and Air Pollution; Paul is working to integrate this into the whole Portland effort.

Appendix C: Abbreviations used in document

ACE: Air, Climate and Energy Research Program, ORD, US EPA

ATSDR: Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services

BOSC: Board of Scientific Counselors – FACA group for Office of Research and Development, US EPA

CA: Cumulative assessment

CBPR: Community-based participatory research

CCAT: Community Cumulative Assessment Tool

CEH: Children's Environmental Health

CERI: Community Environmental Resilience Index

C-FERST: Community-focused Exposure and Risk Screening Tool

CHPAC: Children's Health Protection Advisory Council – FACA group for Office of Children's Health Protection, US EPA

CITC: Community Involvement Training Conferences

C-LINE: Community Line-source screening level model to estimate air quality near roadways or other "line" sources based on emissions inventories, meteorological data, and analytical models of air dispersion

C-PORT: Community Port screening level model to estimate air quality from line, point, and area sources in port locations based on emissions inventories, meteorological data, and analytical models of air dispersion

CRA: Cumulative risk assessment

CRSI: Climate Resilience Screening Index

CSO: Combined sewer overflow

CSS: Chemical Safety for Sustainability Research Program, ORD, US EPA

EJ: Environmental Justice

EO: Executive (Presidential) Order

EPA: Environmental Protection Agency

FACA: Federal Advisory Committee Act of 1972

FR: Federal Register

FY: Fiscal year

GI: Green infrastructure

HHRA: Human Health Risk Assessment Research Program, ORD, US EPA

HIA: Health impact assessment

HSRP: Homeland Security Research Program, ORD, US EPA

HWBI: Human Well-Being Index

ICC: Ironbound Community Corporation, Newark , NJ

IHS: Indian Health Service

IOM: Institute of Medicine, National Academies of Science

IRIS: Integrated risk assessment system, HHRA / NCEA, ORD, US EPA

ISA: Integrated science assessment of NAAQS pollutants

KQ: Key question

LEO: Local Environmental Observer

MSGDC: Municipal sewer district of Greater Cincinnati

MVD: Making a Visible Difference implementation plan for EPA cross-cutting strategic goal

NAAQS: National Ambient Air Quality Standards

NACCHO: National Association of City and County Health Organizations

NACEPT: National Advisory Council on Environmental Policy and Technology

NAS: National Academies of Science

NCEA: National Center for Environmental Assessment, ORD, US EPA

NEJAC: National Environmental Justice Advisory Council

NEPA: National Environmental Policy Act of 1969

NICHD: National Institute of Children's Health and Human Development, one of the NIH

NIEHS: National Institute of Environmental Health Science, one of the NIH

NIH: National Institutes of Health

NIMHD: National Institute of Minority Health and Health Disparities, one of the NIH

NRP: National Research Program

NSC: National Stormwater Calculator

OLEM: Office of Land and Emergency Management, formerly OSWER

ORD: Office of Research and Development, US EPA

PCB: Polychlorinated biphenyl organic chemical compound

PEP: Protecting Environmental Public Health project in ACE program, ORD, US EPA

PFC: Proper functioning condition – method for evaluation of ecological condition

PPRTV: Provisional peer-reviewed toxicity value

RESES: Regional Sustainable Environmental Science awards funding (internal to EPA) for ORD-Regional collaborative projects, SHC, ORD, US EPA

RETIGO: Real-time Geospatial Data Viewer

RFA: Requests for Applications for grant solicitations

SAB: Science Advisory Board FACA for US EPA

SHC: Sustainable and Healthy Communities Research Program, ORD, US EPA

SSWR: Safe and Sustainable Water Resources Research Program, ORD, US EPA

STAR: Science to Achieve Results granting program, ORD, US EPA

STEM: Science, Technology, Engineering, Mathematics education

StRAP: Strategic Research Action Plan (for each of ORD's National Research Programs)

TEK: Traditional ecological knowledge, usually refers to knowledge residing in tribal communities

T-FERST: Tribal-focused Environmental Risk and Sustainability Tool

TMDL: Total maximum daily load for water-borne contaminants

TWBI: Tribal Well-Being Index

US EPA: United States Environmental Protection Agency

USET: United Southern and Eastern Tribes

USGS: United States Geological Survey

WHO: World Health Organization

References

CHPAC, 2013. Social Determinants of Health. http://www2.epa.gov/sites/production/files/2014-05/documents/chpac-sdh-letter-nov-2013-final.pdf

Commission for Racial Justice, United Church of Christ, 1987. Toxic Wastes and Race in the United States: A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Wastes Sites. http://d3n8a8pro7vhmx.cloudfront.net/unitedchurchofchrist/legacy_url/13567/toxwrace87.pdf?1418439935

deFur, PL, Evans, GW, Cohen Hubal, EA, Kyle, AD, Morello-Frosch, RA, Williams, DR, 2007. Vulnerability as a function of Individual and Group Resources in Cumulative Risk Assessment. Env Health Perspect 115:817-824.

DHHS, 2010. Healthy People 2020. http://www.healthypeople.gov/2020/default

EPA, 1992. Reducing Risk in all Communities. http://www.epa.gov/environmentaljustice/basics/ejbackground.html

EPA, 2004. Toolkit for Assessing Potential Allegations of Environmental Injustice. http://www.epa.gov/environmentaljustice/resources/policy/ej-toolkit.pdf

EPA, 2011. Plan EJ 2014. http://www.epa.gov/environmentaljustice/plan-ej/science.html

EPA, 2013a. Draft Technical Guidance for Assessing EJ in Regulatory Analysis. http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/ejtg.html

EPA, 2013b. Decade of Tribal Science. http://www2.epa.gov/sites/production/files/2015-08/documents/results-impacts-summary-010714.pdf

EPA, 2014a. Fiscal Year 2014-2018 EPA Strategic Plan. http://www2.epa.gov/sites/production/files/2014-09/documents/epa_strategic_plan_fy14-18.pdf

EPA, 2014b. 2014 Plan EJ 2014 Progress Report http://www.epa.gov/environmentaljustice/plan-ej/#reporting

EPA, 2014c. EPA Policy on Environmental Justice for Working with Federally Recognized Tribes and Indigenous Peoples. http://www3.epa.gov/environmentaljustice/resources/policy/indigenous/ej-indigenous-policy.pdf

EPA, 2015a. EPA Strategic Directions on Using Citizen Science for Environmental Protection – charge to NACEPT. http://www2.epa.gov/sites/production/files/2015-09/documents/nacept_charge_on_citizen_science_final.pdf

EPA, 2015b. Guidance on Considering Environmental Justice during Development of Regulatory Actions http://www3.epa.gov/environmentaljustice/resources/policy/considering-ej-in-rulemaking-guide-final.pdf

EPA, 2015c. Sustainable and Healthy Communities Strategic Research Action Plan. http://www2.epa.gov/research/strategic-research-action-plans-2016-2019

Federal Register 1994: Federal Actions to address Environmental Justice in Minority Populations and Low-Income Populations. vol 59 no 32 (February 16, 1994).

IOM, 1999. Toward Environmental Justice: Research, Education, and Health Policy Needs http://www.nap.edu/catalog/6034.html

Morello-Frosch, et al 2011. Understanding the cumulative impacts of inequalities in environmental health: Implications for policy. Health Affairs 30(5):879-887.

NACEPT, 2012. Technologies for Environmental Justice Communities and Other Vulnerable Populations
http://www2.epa.gov/sites/production/files/documents/2012_0215_nacept_ej_vp_letter_with_case_studies_web.pdf

National Research Council, 2009. Science and Decisions Advancing Risk Assessment. Washington, DC: National Academies Press.

National Research Council, 2012. Science for environmental Protection, the Road Ahead. Washington, DC: National Academies Press.

NEJAC, 2014. Recommendations for Integrating Environmental Justice into the EPA's Research Enterprise. http://www.epa.gov/environmentaljustice/resources/publications/nejac/nejac-research-recommendations-2014.pdf

U.S. Census Bureau, 2010 American Community Survey. Child Poverty in the United States 2009 and 2010: Selected Race Groups and Hispanic Origin. https://www.census.gov/prod/2011pubs/acsbr10-05.pdf

World Health Organization, 1948. Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948