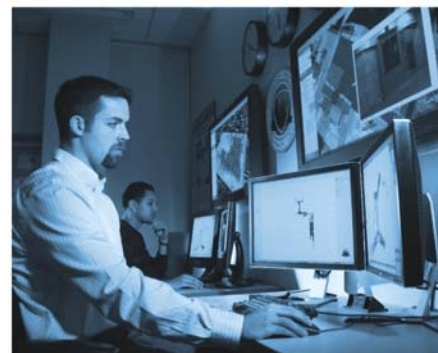


Environmental Research and Education Needs

An Agenda for a New Administration

David E. Blockstein | Cassandra Brunette



National Council for Science and the Environment

Improving the scientific basis for environmental decisionmaking

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David E. Blockstein and Cassandra L. Brunette, Editors

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Research and Education Initiatives: NCSE National Conferences 2000-2008

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National Conference Names and Dates

- C1. Improving the Scientific Basis for Environmental Decisionmaking, December 7-8, 2000
- C2. Sustainable Communities: Science and Solutions, December 6-7, 2001
- C3. Education for a Sustainable and Secure Future, January 30-31, 2003
- C4. Water for a Sustainable and Secure Future, January 29-30, 2004
- C5. Forecasting Environmental Changes, February 3-4, 2005
- C6. Energy for a Sustainable and Secure Future, January 26-27, 2006
- C7. Integrating Environmental and Human Health, February 1-2, 2007
- C8. Climate Change: Science and Solutions, January 16-18, 2008

See www.ncseonline.org/conference for conference presentations, summaries, and PDF's of reports

Introduction

The Obama Administration faces a daunting array of challenges. Underlying many of these challenges is the continually deteriorating condition of the environment and natural resources that sustain life on Earth. The challenges of ensuring a sustainable and secure future will not be met in a single Administration. However, it is critical that the Obama Administration start to change the trajectory of America's relationship with the environment.

Environmental protection and resource management that is not based on science is unlikely to provide positive outcomes for people and the planet. The challenges of preventing a global climate catastrophe, adapting to rapid and dangerous environmental change, ensuring safe supplies of food and water, transforming our energy supply and reducing demand, managing ecosystems to minimize irreversible losses of biodiversity, stabilizing human population, and protecting human health require substantial scientific knowledge. To meet these challenges require an educated populace and a diverse and competent work force prepared for the rapidly changing world of the 21st century.

Yet, our scientific knowledge and public and professional understanding of the environment is in many ways inadequate to these challenges. Research and education must be critical elements of a national strategy for environmental protection, a sustainable economy and a secure society.

Since 2000, the National Council for Science and the Environment (NCSE) has convened an annual National Conference on Science, Policy and the Environment. These conferences have provided the scientific and the policymaking community opportunities to discuss the key issues facing the US and the world, and develop ideas on how to harness the forces of science and education to improve the quality of life for all.

The topics and dates of these conferences are listed on the previous page. At each conference, the participants develop science-based recommendations on critical elements of the conference topic. This report organizes the recommendations relating to research and education policy from NCSE's first eight national conferences (2000-2008). It identifies research needed to improve scientific knowledge, and education needed to improve public understanding, professional capacity and a strong workforce.

The recommendations represent the collective wisdom of the more than 5000 scientists, engineers, students, and decisionmakers.

The recommendations cover critical topics including agriculture, biodiversity, the built environment, business, demographics, education, energy, forecasting, global climate change, health, security and water. They cover nearly every Cabinet department of the US government and many independent agencies. The recommendations are directed to specific agencies, but are often applicable to other agencies.

Few of these recommendations have been fully implemented. They collectively constitute an agenda that is a necessary foundation for science-based decisionmaking. There is a critical need for strategic approaches that involve interagency initiatives, often coordinated through the Office of Science and Technology Policy (OSTP).

The recommendations are grouped by topic and cross-referenced by agency and by the conference at which the recommendations were made.

Key themes include the following:

- Current investment in environmental and energy research and education is inadequate. The ability to prevent and solve environmental, economic and other societal challenges is bounded by limited investment in research and education.

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- Multidisciplinary and interdisciplinary approaches are essential. The human dimensions of issues are often ignored, and funding for approaches that explore human dimensions and coupled human and natural systems must be greatly expanded.
- Current programs must be enhanced by vigorous competitively awarded merit based research, integrated with training of the next generation of scientists, managers and citizens.
- Clearinghouses and other mechanisms are needed to link scientific information with the needs of decisionmakers.
- The goal of sustainability – ensuring healthy people and a healthy planet for many generations to come - must be achieved through life-long learning in partnership with research of the highest quality.

Original copies of the reports of the individual NCSE conferences are available at www.ncseonline.org/conference or by contacting NCSE at Conference@NCSEonline.org or 202-530-5810.

CONCLUSIONS

1. Healthy and economically productive societies require healthy environments.
2. Environmental issues are intimately linked with important economic, national security, health, social and ethical issues.
3. Research and education are essential for a strong economy.
4. Environmental research and education are essential for green jobs that provide scientifically and environmentally skilled workers in all parts of American society.
5. Scientific knowledge, understood by decision-makers (e.g., no “techno-babble”) is key to effective and durable decisions.
6. Enabling science to support energy and environmental decision-making requires:
 - a. investing in science, particularly cross-cutting and interdisciplinary, and its synthesis;
 - b. support for effective communication of science to decision-makers;
 - c. ensuring the integrity of science; and,
 - d. supporting a national culture of education and thoughtful problem-solving.
7. People come and go; enduring solutions require institutionalized changes.
8. A number of significant actions can be made by President Obama and his Administration with powers that already reside with the Office of the Presidency and with the federal agencies.
9. Many necessary actions to slow and ultimately reverse the rate of environmental degradation require the assistance of other nations, Congress, the scientific community, conservation organizations, landowners and the general public.
10. The environmental scientific and education community has much to contribute and is eager to be engaged.

CHAPTER 1: Research Recommendations by Topic 2000-2008

AGRICULTURE

Bioenergy

- C6-B10.¹ Agriculture and Bioenergy- Achieving Sustainability p. 15²
 - Universities, agencies, local government and communities, and industry should carry out research and education using an interdisciplinary systems approach to integrate new biomass feedstocks and efficient technology with traditional crops, focusing on environmental opportunities and impacts. (C6-B10 p. 15)
 - Research should be increased on bioenergy feedstocks at both the crop-specific level and at the broader feedstock integration level. Key topics include how to increase new crop yields through different technologies “breeding the harvest” in the context of environment impacts, harvesting technologies and products other than bioenergy. (C6-B10 p. 15)
 - Congress should increase funding for research and education to increase decision-maker awareness about the impact of biofuels production on the environment and community well being. (C6-B10 p. 15)
 - Using a cost-benefit analysis, researchers should develop measures of structure, function and performance in regards to the demographics and impacts of biofuel processing plants on community and environment. (C6-B10 p. 15)

Biotechnology

- C1. Environmental Implications of Biotechnology p. 5
 - The National Science Foundation should create an initiative to fund multidisciplinary research and education to better understand the environmental implications of biotechnology, possibly involving other federal agencies to provide joint funding. (C1 p. 5) (NSF)
 - The National Institute of Environmental Health Sciences (NIEHS) should provide funding for natural and social science studies on effects of biotechnology on non-target organisms. (C1 p. 5) (NIEHS)
 - Specific Research Needs:
 - Understanding consequences and impacts of biotechnology, including effects of genetically modified organisms (GMOs) on non-target species such as organic crops, wild plants, and pollinators. (C1 p. 5)
 - Studies of cross fertilization and cross hybridization of crops, as well as general studies of all, not only transgenic, crops. (C1 p. 5)
 - Research in bioinformatics and its application to agriculture as well as research on predicting the impacts of bioinformation on biotechnology and the environment, including risk assessment including field testing of GMOs before they are approved. (C1 p. 5)
 - Research on benefits including comparisons of effects of GMOs with those of products or processes for which GMOs are being substituted. (C1 p. 5)

Climate Change

- C8- B3. Animal Agriculture and Climate Change
 - Research priority: comparing methane and other greenhouse gas (GHG) emissions (in a life cycle analysis) from pastured animals as compared to

¹ Conference Notation: C6-B10 refers to the conference number and breakout number (Conference Six, Breakout 10)

² This represents the page number of the recommendation within our yearly Conference Report. (e.g. C6-B10 p. 15 is Conference Six, Breakout 10, Page 15)

- confined grain-fed animals, and determining the Green House Gas (GHG) emissions from production of meat, egg, and dairy products (C8-B3)
- The National Academy of Sciences should conduct a study, leading to a national science-based dialogue to discuss how meat consumption, processing, packaging, and waste impact GHGs. (C8-B3) (NAS)
- Researchers should develop sample policies and modeling analysis for local land-use bodies to use to actively preserve land for management-intensive grazing of animals in peri-urban areas. (C8-B3)
- **C8-B4. Minimizing agricultural impacts on climate; minimizing climate impacts to agriculture**
 - Develop long term data sets at the USDA Agricultural Research Service (ARS) to quantify and understand the impacts of climate on agriculture. (C8-B4) (USDA)
 - Perform a life cycle analysis of greenhouse gas emissions of all agricultural production systems, including controlled environment production systems in northern latitudes. (C8-B4)
 - Study the effects of climate change on pests and invasive species. (C8-B4)
 - Study the impacts of climate stress on livestock production and identify management practices to alleviate stress. (C8-B4)

Irrigation

- **C4- Irrigation and agriculture p. 48**
 - Study the sociological and economic impact of the adaptability and acceptance of current technology and best management practices by the irrigation industry. (C4 p. 48)
 - Conduct research to develop crops and varieties with improved efficiency of water use and additionally respond to lower water quality while sustaining economic yield levels. (C4 p. 48)
 - Support research regarding ways for irrigated agriculture to use less water without degrading water quality. (C4 p. 48)
 - Support research to develop optimal irrigation management systems that incorporate timing, amount, and placement along with agronomic crop science. (C4 p. 48)

BIODIVERSITY

Biodiversity and Health

- **C7-B7. Biodiversity and Health p. 12**
 - There should be a coordinated multi-agency effort to fund and conduct research to understand the complex relationship of biodiversity and health. (C7-B7 p. 12).
 - Research priorities should include the understanding of:
 - The drivers and modes of change in biodiversity (C7-B7 p. 12)
 - The etiological mechanisms that connect changes in biodiversity and risks to human health (C7-B7 p. 12)
 - The patterns and changes that occur across disease systems and over different spatial scales. (C7-B7 p. 12)
 - Non-disease aspects of health including nutrition (crops and dietary resources) and psychological well-being. (C7-B7 p. 12)
 - Potential health impacts following ecological restoration (C7-B7 p. 12)

Bioinformatics

- **C5-B11. Working across spatial scales: from molecular to global p. 57-58**
 - Federal agencies should support research to identify important knowledge gaps in environmental forecasting based on molecular processes. (C5-B11 p. 57-58) (Federal)

- Federal agencies should increase support for bioinformatics research on gene-environment interactions:
 - An interagency initiative should be established to explore variations in gene expression and other molecular processes across the environmental range of an important species. (C5-B11 p. 57-58) (Federal)
- C1. Invasive Species p. 14
Funding agencies should establish new programs to facilitate interdisciplinary research, giving special attention to research that falls between the disciplinary cracks. (C1 p. 14)

Population

- C8-B15. Human population and demographics: Can stabilizing population help stabilize the climate?
 - Conduct research examining the role of migration, both internationally and internally, on vulnerability to climate change impacts and greenhouse gas emissions. (C8-B15)

BUILT ENVIRONMENT

Sustainable Communities

- C7-B4. The Natural Environment, Built Environment, and Social Environment P. 8
 - There should be a significant research effort to examine the costs and benefits of green neighborhood design. (C7-B4 p. 8)
 - Federal agencies (like CDC and EPA) should double research support that seeks to identify health consequences of living in sustainable communities and in sprawling communities. (C7-B4 p. 8) (CDC) (EPA)
- C7-B13. Setting Research Priorities for Health and the Environment p. 20
 - Agencies should fund research on:
 - How to strengthen critical infrastructure and study the effectiveness of restructuring existing hospital guidelines and physical facilities to improve resilience of facilities (C7-B13 p.20) (General Agencies)

BUSINESS & ECONOMICS

Economics

- C8-B11. Economics: Setting the price for carbon
 - More economic and policy research on government oversight, regulation, and management of allowance markets (e.g. price ceilings and price floors.) (C8-B11)
 - More research into the acceleration of the commercialization of carbon capture and sequestration technologies. (C8-B11)
 - More economic and policy research into how nations could make “border adjustments” to account for imports from countries that do not control GHG emissions. (C8-B11)
- C6-B1. Public Incentives vs. Market forces p. 5
 - Congress should create long term funding mechanisms for public/private sector research initiatives. (C6-B1 p. 5)

Sustainability

- C2. Business: Ecologically Sustainable and Economically Competitive p. 12
 - Provide aggressive support for research and assessment tools related to sustainable business practices such as industrial ecology, green accounting, materials flows analysis, evaluation of environmental services and nature of capital, as well as economic viability of renewable energy resources (C3 p. 12, C3 p. 21, C6-B17 p. 22)

DIVERSITY & DEMOGRAPHY

Demography

- C8-B15. Human population and demographics: Can stabilizing population help stabilize the climate?
 - Need more research on linkages among demographics, household incomes, consumption, and other socioeconomic factors in the context of climate change. (C8-B15)

Human Diversity

- C3. Diversity, Human Diversity in Education for a Sustainable and Secure Future p. 23
 - Research should be conducted to understand human diversity in a social and cultural context and to characterize the strengths and advantages of human diversity (C3 p. 23)
- C7-B3. Population, Gender, Justice, and Health p. 7
 - The scientific and policy communities should encourage empirical research on environmental vulnerability and vulnerable populations. (C7-B3 p. 7)

Population

- C8-B15. Human population and demographics: Can stabilizing population help stabilize the climate?
 - Research should be done concerning relationships among population growth, demographic movements, urbanization, available agricultural land base and carrying capacity with multiple climate change scenarios. (C8-B15)

EDUCATION RESEARCH (see Chapter 2 for Education Recommendations)

Behavior

- C6- B15. Why do people make the decisions they do?- Capitalizing on the Social Sciences p. 20
 - The federal government should explore potential sources of private funding and partnerships (including “non-traditional partnerships”) for energy research. Research priorities should include:
 - Studies to verify the extent to which environmental education changes behavior (and which educational systems are the most effective) (C6-B15 p. 20)

Education for Sustainable Development (ESD)

- C3. Educational Research, Suggested Guidelines for Education for Sustainable Development Research p.24
 - Research should help individuals, communities, states, and nations reach their sustainability goals and use these goals to guide programs, practice and policy. (C3 p. 24)
 - ESD research should look at the well-being of the students, not simply academic performance. (C3 p. 24)
 - ESD research should involve all three realms of sustainability—environment, society, and economy. (C3 p. 24)
 - For a research agenda to be successful over the longer term, it should outline ways to encourage and sustain dialogue among researchers, practitioners, and stakeholders. (C3 p. 25)
 - Reporting, sharing, and disseminating research findings and data must occur regularly and frequently. (C3 p. 25)

Large Scale Conservation

- C3 Large Scale Conservation p. 34
 - The National Science Foundation, other federal and state agencies, universities, and foundations should fund research on:

- Learning across geopolitical, social, and institutional boundaries in order to build capacity for large-scale conservation. (C3 p. 34) (NSF)

Universities

- C1. Higher Education p. 12
 - The National Science Foundation should fund training and research projects on sustainability and its integration into different aspects of university life by:
 - Providing “bit” sized grants (smaller projects about \$10,000). (C1 p. 12) (NSF)
 - Funding graduate student traineeships and fellowships related to sustainability. (C1 p. 12) (NSF)
- C3 Undergraduate Education p. 46
 - The National Science Foundation, Department of Education and foundations should support research on and assessment of the impact and effectiveness of sustainability education, research, and operations in higher education. (C3 p. 46) (NSF) (Department of Education and foundations)

ENERGY (see also Agriculture for Bioenergy)

Efficiency

- C8- B6. Energy Efficiency and Conservation
 - Increase research on use of heat and energy capture technology to increase efficiency. (C8-B6)
 - Fund research on how to integrate energy efficiency into other related policy arenas (health care, criminology, education, etc.) (C8-B6)

Energy Sources

- C8-B9. How to ensure wind energy is green energy.
 - Improve funding for priority monitoring and research, and increase agency staffing to address wind permitting issue. (C8-B9)
- C8-B10. Nuclear Energy: Using science to make hard choices
 - NSF should fund further research in perception and communication of nuclear and climate issues. (C8-B10) (NSF)
- C6-B3. Community Planning p. 7
 - State energy offices and research and development authorities should compile case studies of best practices on the linkages between energy efficiency and land use. (C6-B. p. 7)
 - The Departments of Commerce and Energy should sponsor more research through universities, national labs, and other research institutions on the impact of individual business decisions on local land use patterns, to build the business case for energy efficient land use planning. (C6-B3. p. 7) (Department of Commerce and Energy)
- C6- B17. Global and U.S. perspectives on the prospects of renewable energy. P.22
 - USDA should support and conduct serious research on industrial growth of hemp as an energy product. (C6-B17. p. 22) (USDA)

Funding

- C6-B11. Setting Research priorities: Who? How? Why? p. 16
 - The United States must immediately establish a multi-year (decadal) RD3 (research, development, demonstration, deployment) plan for energy sustainability and security.
 - The RD3 plan should be created by a multi-agency, multi-sectoral process, involving the National Academies of Science and Engineering. (National Academies of Sciences and Engineering)

- Congress should appropriate funds and direct research agencies and organizations to collaborate to fund trans-disciplinary natural and social science research into integrated energy systems. (C6-B11 p. 16) (Federal)
- C8-B22. Availability of technology to mitigate climate change
 - Triple the level of federal funding for strategic research to develop the next generation of renewable energy and production energy technologies with efficiencies to meet the goal at a cost that will enable their adoption by lesser developed economies. (C8-B22)
 - The CCTP (Climate Change Technology Program) should provide the roadmap for providing the balance of funding technologies at the fundamental, strategic, and demonstration levels and to provide the correct mix of participation by government, industry, and academia. (C8-B22) (Federal)
- C6-B1. Public Incentives vs. Market forces p. 5
 - The federal government and others should:
 - Fund a multi-billion-dollar federal research and development program for reducing carbon emissions in energy production
 - Research on carbon capture and sequestration, nuclear energy and renewables. (C6-B1 p. 5)
 - Fund research investigating mitigation and adaptation strategies, including risks to coastal areas. (C6-B1 p. 5)
- C6-B10. Agriculture and Bioenergy- Achieving Sustainability p. 15
 - Congress should fully fund biomass related provisions of the 2005 Energy Policy Act, including research at the levels of applied fundamentals, innovation, and demonstration as well as commercialization support. (C6-B10 p. 15)
- C6-B15. Why do people make the decisions they do?- Capitalizing on the Social Sciences p. 20
 - The government should explore potential sources of private funding and partnerships (including “non-traditional partnerships”) for energy research. Research priorities should include:
 - Better ways to communicate energy consumption to individuals and communities and how consumption affects climate change, (C6-B15 p. 20)
 - Determining what kinds of feedback mechanisms and information streams are effective in changing energy consumption (C6-B15 p. 20)
 - Social science research to identify the underlying tensions and opportunities associated with the discussion of energy issues by various stakeholders. (C6-B15 p. 20)
- C7-B11. Energy, Air Quality, and Health p. 17
 - Government needs to consider the full range of incentives (e.g. marketing campaigns, fuel economy standards, rebates, taxes) to the private sector to invest in dissemination of cleaner energy technologies, including funding for the National Research Energy Laboratory. (C7-B11 p. 17) (Federal)

Infrastructure

- C6-B3. Community Planning p. 7
 - National labs and other research organizations should pursue technology research to optimize use of locally available renewable energy resources (such as landfills, municipal wastewater treatment plants, and biomass). (C6-B3 p. 7)
- C6-B9. Assessing Energy Impacts on the Environment and People. P. 13
 - More research is needed on the environmental impacts of dam removal and decommission of other generation projects (C6-B9 p. 13)

FORECASTING

Funding

- C5-B8. Cross-Sectional Connection: Engaging the private sector as a partner with the government p. 54
 - The federal government should create a program modeled after the small business incentives for research program to provide transitional funding for commercialization of large scale forecasting systems. (C5-B8. p. 54) (Federal)

Bioinformatics and Ecoinformatics

- C5-B11. Working across spatial scales: from molecular to global p. 57-58
 - Federal agencies should support research to identify important knowledge gaps in environmental forecasting based on molecular processes. (C5-B11. p. 57-58) (Federal)
 - Federal agencies should increase support for bioinformatics research on gene-environment interactions:
 - An interagency initiative should be established to explore variations in gene expression and other molecular processes across the environmental range of an important species. (C5-B11. p. 57-58) (Federal)
- C5-B16. Examining the role of eco-informatics in environmental decisionmaking. P. 61-62
 - Science agencies should work more closely with academia to create and sustain a viable national forum on the nexus between research and innovation in the area of eco-informatics and forecasting. (C5-B16 p. 61-62) (General Agencies)

Data Capture

- C5-B12. Forecasting environmental change of the landscape at a regional scale p. 58-59
 - Science agencies should support research and tools that improve our ability to incorporate nonlinearity, feedback, and threshold changes in regional environmental forecasting. (C5-B12 p. 58-59) (Federal)
 - Science agencies and universities should increase support for interdisciplinary environmental research and education regionally. (C5-B12 p. 58-59) (Federal)
- C5-B14. Facilitating the development of environmental sensors and sensor networks. P. 60
 - Researchers should recognize and address challenges in the broad deployment of sensors and sensor networks that would provide data for fundamental research, modeling, forecasting, and decision-making. Challenges include capturing adequately the spatial and temporal variability of the environment, consistent measurements across various media (e.g., nitrate in water, soils, and air), long term continuity, sensor comparability, and system and sensor integrity (e.g. biofouling or failure) (C5-B14 p. 60)
 - Fundamental research is needed to achieve robust coupling of sensors, modeling and forecasting. Advances in cyber-infrastructure are needed to effectively capture data from sensors and incorporate data into models. Tools need to be developed to better simulate, visualize, and make predictions and communicate results to the full range of users. (C5-B14 p. 60)
- C5-B15. Fusion and integration of satellite remote sensing and ground-based observations and presentation for environmental policy
 - The natural resource research, management, and regulatory communities should place greater emphasis on the generation, interpretation, and integration of geobotanical remote sensing and ground-based data for use by environmental decisionmakers. (C5-B15 p. 60-61)

- Researchers should develop data visualization techniques for presentation of integrated satellite remote sensing and ground based data to high level decisionmakers. (C5-B15 p. 60-61)

GLOBAL CLIMATE CHANGE

Adaptation

- C8-B15. Human population and demographics: Can stabilizing population help stabilize the climate?
 - Promote outcome-oriented research to influence climate change adaptation, and improve efficiency of projects based on African priorities. (C8-B15)
- C8-B21. The US Global Change Research Program (USGCRP)- What do we want from the next administration
 - Enhance focus on adaptation research and mitigation research and response strategies. (C8-B21)
 - Enhance research, assessment, and communication activities at regional-to-local scales. (C8-B21)
- C7-B13. Setting Research Priorities for Health and the Environment p. 20
 - Agencies should fund research on:
 - The relationships between climate change and disaster preparedness, including small frequent disasters since their effects accumulate. (C7-B13 p.20) (NOAA, CDC, DHS).

Interdisciplinary

- C8-B5. Mitigating Greenhouse Gases other than CO₂
 - Improve research and understanding regarding co-benefits and the range of environmental impacts associated with the interrelationships between air quality and climate change.(C8-B5)
- C1. Global Environmental Change p. 9
 - The National Science Foundation should enhance incentives for interdisciplinary research integrating natural and social sciences. (C1 p. 9) (NSF)
 - Federal agencies should fund long term observational and research efforts through endowments established by Congress (50-100 yrs.) (C1 p. 9) (Federal)
- C6-B1. Public Incentives vs. Market forces p. 5
 - Universities and government should establish research centers to support and integrate natural science and social science research on costs of global climate change. (C6-B1 p. 5)

Population

- C8-B15. Human population and demographics: Can stabilizing population help stabilize the climate?
 - Study the costs of providing universal access to voluntary family planning/reproductive health (FP/RH) services as a means to slow population growth. (C8-B15)
 - Develop an international scientific research program to which governments, private entities, NGOs and academics both in and out of Africa can contribute to develop fundamental natural science understanding for sustainable development. (C8-B15)
 - Develop greater understanding of climate change at the regional to local scale, including observations, models, and verification of models. (C8-B15)

HEALTH (see also Biodiversity for Biodiversity and Health)

Alternatives and Prevention

- C5-B10. Integrating economic, social, and environmental forecasting p. 56-57
 - Science agencies should increase investments in research that identifies alternative solutions and incentives as substitutes for practices that are hazardous to human health and the environment. (C5-B10 p. 56-57)
- C3. Planetary Health p. 37
 - Scientific research programs focused on health and medicine should shift their focus and funding support from searches for reactive cures to research on causation, prevention, and health promotion. (C3 p. 37)
- C3. Population Environment p. 38
 - Research and training initiative on water
 - National Institute of Child Health and Human Development (NICHD) should collaborate with other current and potential funders such as NSF to develop and fund a new multi-year, multidisciplinary research and training initiative focused on water. This initiative would help achieve the Millennium Development goal to halve the proportion of people without access to safe drinking water by 2015 and the World Summit on Sustainable Development goal to halve the proportion of people without access to sanitation by 2015. (C3 p. 38) (NICHD) (NSF)
- C7-B10. Socially-Mediated Linkages Between Resource Depletion and Health p. 16
 - Environmental and community health researchers should develop a balanced and prioritized research agenda with the objective of modeling social interactions to create models for planners that would project the effects of natural disasters and the role of social linkages in response. (C7-B10 p. 16)
- C7-B16. Ecology and Epidemiology p. 24
 - NIEHS should fund more research on the integration of ecology and disease (e.g., disease vectors). (C7-B16 p. 24) (NIEHS)

Impacts

- C6-B9. Assessing Energy Impacts on the Environment and People. P. 13
 - Basic research is needed on the extent and impact of exposure to emissions on human health and ecological systems. (C6-B9 p. 13)
- C7-B1. Integrating Environment, Culture, and Well-being p. 5
 - Researchers and scientists should make science on environmental health issues more understandable (C7-B1 p. 5)
 - Federal agencies should support research to investigate the linkages among human health, cultural health, healthy governance, and ecosystem health. (C7-B1 p. 5) (Federal)
- C7-B3. Population, Gender, Justice, and Health p. 7
 - Governments and private and public funders should promote trans-disciplinary research on the interactions of population, gender, environmental change, justice and health. (C7-B3 p. 7)
 - The research community and the U.S. government should monitor and evaluate the evolution of international work on the intersection of environment, health and human rights. A database of international law and principles of the right to a healthy environment should be maintained. (C7-B3 p. 7)
 - All scientific research on the impacts of environmental toxins on the human body should consider impacts on women as well as men, and especially on women who are pregnant or breastfeeding. (C7-B3 p. 7)
- C7-B4. The Natural Environment, Built Environment, and Social Environment. P. 8

Environmental Research and Education Needs: An Agenda for a New Administration
National Council for Science and the Environment

- Federal agencies should support collaborative research into the relationships between human habitats and healthy people. (C7-B4 p. 8) (General Agencies)
- Federal Agencies should actively support research into the disparities of health impacts related to the physical environment. (C7-B4 p. 8) (General Agencies)
- C7-B11. Energy, Air Quality, and Health p. 17
 - The EPA should create a stable but ambitious regulatory climate that encourages technological innovations, monitoring, and long term research about the health effects of energy choices. (C7-B11 p. 17) (EPA)
- C7- B17. Ecological and Human Health Risk Assessment and Health Impact Assessment of development policies, programs, and projects p. 24
 - Funding agencies and universities should increase research that provides insights into effects of combinations of biological, chemical, physical, and psychological stressors on a variable population and understanding methods of action for individual chemicals. (C7-B17 p. 24)
- C8-B35 Climate Change and Human Health: Engaging the Public Health Community
 - Congress should substantially increase funding for research on health impacts of climate change. (C8-B35) (Federal)

Metrics

- C7-B22. Designing for complementarity among programs generating environmental and health information p. 30
 - As human health data and information are collected under specific use and disclosure protections, the National Science and Technology Council (NSTC) should direct its participating agencies to develop workable approaches and models for advancing synthesis of their environmental health research data and information. (C7-B22 p. 30) (NSTC)
 - The OSTP should request that the national academies conduct a case study using the integration of multidisciplinary research in climate as an example of integration across “stressors” (that is, disease, land use/land change, and pollution.) (C7-B22 p. 30) (OSTP)
- C7-B13. Setting Research Priorities for Health and the Environment p. 20
 - HHS, NIH/NLM, CDC, NOAA, FSW, USFS, USGS, state agencies, and private organizations such as Google should develop a methodology and database for health risk management and mitigation measures. (C7-B13 p.20) (General Agencies)
- C7-B23. Measuring the Outcomes of Policies and Programs p. 31
 - CDC, NIH, and AHRQ need to fund and conduct a pilot project to determine whether current datasets and tools are adequate for environmental health outcomes and, if not, what should be measured. The pilot project needs to link environmental exposure data to health data. (C7-B23 p. 31) (CDC) (NIH) (AHRQ)

INDICATORS

- C2. Sustainable Community Indicators: Experiences, Lessons Learned, and Evolving Opportunities in the United States p. 22
 - Those who develop indicators should assist in setting the research agenda, participate in research, and use scientific results. (C2 p. 22)
 - Research is needed to understand and remove barriers, including information gaps, to the effective implementation and use of indicators, especially in the area of equity and social and economic well being of communities. (C2 p. 22)
- C5-B10. Integrating economic, social, and environmental forecasting p. 56-57
 - Science agencies should increase investments in research that identifies meaningful indicators of human health, animal health, and environmental change

that can be useful on a local level and that may have global implications. (C5-B10 p. 56-57)

- C6-B9. Assessing Energy Impacts on the Environment and People. P. 13
 - Research is needed to quantify the acute and chronic cumulative impacts of multiple stressors on the environment and to quantify the direct and indirect impacts of energy production. (C6-B9 p. 13)

INTERDISCIPLINARY

- C5-B10. Integrating economic, social, and environmental forecasting p. 56-57
 - The National Science Foundation should further recognize the value of interdisciplinary environmental research and increase funding for research on complex environmental systems, including NSF's priority area on biocomplexity in the environment. (C5-B10 p. 56-57) (NSF)
 - NOAA and other mission agencies should increase investments in and support for interdisciplinary environmental research. (C5-B10 p. 56-57) (NOAA)
 - Science agencies should increase funding for social science research to better understand the environmental decision-making processes. (C5-B10 p. 56-57)
- C5-B13. Working across temporal scales- integrating short-term and long-term approaches p. 59
 - The National Science Foundation should support social science research on the perceived value of ecosystem services to various societal components as well as the factors that affect the credibility of an ecological forecast. (C5-B13 p. 59) (NSF)
- C7- B20. Journalists, Mass Media, and Decision-making p. 28
 - The trend of government agencies monitoring interviews and preventing access to publicly-funded scientists should be reversed. Publicly-funded researchers should not be barred from talking with journalists or the public. Publicly-funded research should not be sequestered. (C7-B20 p. 28)

SECURITY

- C3. Environmental Security p. 27
 - Funding agencies like the National Science Foundation should support multidisciplinary research on the complex social, political, economic, and cultural relationship inherent in environmental security issues. (C3 p. 27) (NSF)
 - Federal resource management agencies and educational institutions jointly should develop concrete strategies and tools aimed at critical analysis, understanding, and interpretation of complex ecosystem interactions and dynamic relationships. (C3 p. 27) (Federal)
- C3. Geographic Learning p. 28
 - The National Science Foundation should continue to expand its approach toward integrative sciences by including a focus on environmental sustainability in every program announcement. (C3 p. 28) (NSF)

WATER

Data Collection

- C4- Protecting and Restoring Estuaries p. 49-50
 - Conduct estuary research and education programs with an awareness that the dynamics and health of estuaries are intimately tied to the dynamics of the watersheds that feed them. (C4 p. 49-50)
 - Encourage Congress to increase funding for innovative research efforts such as those that are focused on developing new tools for understanding estuary systems (i.e., environmental and economic modeling, GIS, LIDAR), long term

monitoring, analysis and synthesis across federal, local, state, and tribal governments and agencies. (C4 p. 49-50) (Federal)

Decision-making

- C4- Research and data needs for better decision-making on water quality p. 46
 - Provide more useful research and information by:
 - Connecting environmental conditions to human health research. (C4 p. 46)
 - Considering scale in going from small watersheds to large watersheds of policy interest. (C4 p. 46)
 - Making models flexible to incorporate emerging science and targeted to key management decisions. (C4 p. 46)
 - Developing remote sensing technologies for the study of water quality. (C4 p. 46)
- C8-B15. Human population and demographics: Can stabilizing population help stabilize the climate?
 - Study climate change impacts on water resources and infrastructure for water systems. (C8-B15)

Economics

- C4- Managing Demand for Water p. 42
 - Conduct additional research to improve understanding of the risks, costs, and benefits of water reuse and recycling technologies and to identify governmental (local, regional, etc.) mechanisms that facilitate the adoption of reuse/recycling technologies. Emphasis should be placed on disseminating existing and future research findings to relevant entities and organizations. (C4 p. 42)
 - Conduct research to identify impediments to adopting progressive rate structures (i.e., conservation-orientated) and publicize successful applications of such. In addition, conduct research to determine the effectiveness of incentives such as pricing to change water use behavior. (C4 p. 42)
 - Conduct research to identify good examples of existing and/or potential institutional mechanisms that allocate water efficiently and equitably, including the concept of intergenerational equity. (C4 p. 42)

Health

- C7-B6. The Ocean and Human Health p. 10-11
 - Scientists need to develop integrated conceptual models extending from oceanography through organismal biology, health effects/risks, and economic effects/environmental valuation to help predict and prioritize environmental health activities. (C7-B6 p. 10-11)
 - Federal agencies should ensure that ocean observing systems are constructed as vehicles that organize, communicate and analyze data, as well as collect it, leading to interdisciplinary systems analysis, predictions, and policy recommendations. Environmental scientists should work with physicists and IT specialists to design and locate the observing systems, including instrumentation for ocean observing systems, so that they will produce data to fit the scientific questions and problems on environmental and human health. NRC, NOAA, NASA, CDC, USGS, and other federal agencies should standardize sensing and monitoring data including epidemiological information from human and animal populations. (C7-B6 p. 10-11) (NRC) (NOAA) (NASA) (CDC) (USGS) (General Agencies)

Pollution Prevention

- C4- Control of non-point source pollution p. 44
 - Develop research models and tools to implement a no-net-runoff policy and to make associated changes in planning and zoning requirements (C4 p. 44)
- C4- Water infrastructure needs for the 21st century p. 44

- Encourage USDA and EPA to fund research in methods to prevent pollution as opposed to treat pollution in order to meet environmental and health regulations. (C4 p. 44)

Use

- C4- Allocating water for people and ecosystems p. 40
 - Encourage federal agencies to conduct research on how people use water and how social sciences can be used to better inform public choices about water use. (C4 p. 40) (Federal)
- C4- Economics of sustainable water use. P. 43
 - Support research that yields:
 - Ways to capture and equitably distribute costs of environmental degradation. (C4 p. 43)
 - Improved understanding of the life cycle cost of decisions and metrics (rigorous and transparent) to measure this. (C4 p. 43)
 - More accurate measurement of the impacts of subsidies and value of ecosystem services (e.g., Arizona Project). (C4 p. 43)
 - Opportunities to create enforceable and transferable rights to water.
 - Economic methodologies to determine the total costs and benefits of water use except for drinking and sanitation services. (C4 p. 43)
 - Pricing schemes that best establish market incentives for environmental sustainability and equitable and efficient water use, noting the importance of considering population growth and location choice. (C4 p. 43)

Wastewater

- C4- Water, sanitation, and human health p. 43
 - Research on appropriate technologies should be conducted, including on distributed waste water treatment facilities, and develop improved methods for measuring population health and vulnerability. (C4 p. 43)
 - The prevalence of water-related diseases should be researched, evaluated, and estimated, including microbial diseases and chronic diseases caused by non-microbial contaminants. (C4 p. 43)
 - Research to investigate the most effective methods for deploying U.S. financial resources to significantly improve drinking water quality around the world, aiming at financial sustainability and low cost water treatments. (C4 p. 43)
- C4- Water infrastructure needs for the 21st century p. 44
 - Encourage the federal government to support research to both identify and treat newer pollutants (e.g., drugs, endocrine disruptors) and biological agents and to identify the effects of these pollutants and agents on humans and animals. (C4 p. 44) (USDA) (EPA)
 - Encourage the federal government to support research into the identification of impacts of water and wastewater treatment processes through their life cycle, including impacts of the operation of these treatment facilities on the local environment. (C4 p. 44)
- C7-B5. Ecology of Water and Health p. 9
 - Public and private funding should be encouraged to address systems research on chemical synergies in the environment, contaminants, and diseases (e.g., air/water interface), including the tools needed to monitor environmental effects. (C7-B5 p. 9)

CHAPTER 2: Education Recommendations by Topic 2000-2008

BUSINESS

Clearinghouse

- C6-B13. Consumer and Decisionmaker Education p. 18
 - There should be a federal clearinghouse for energy consumer education and “marketing” information (DOE together with EPA), because there is so much information that it is hard to find and access. (C6-B13 p. 18)

TEACHER PROFESSIONAL DEVELOPMENT

Educational Materials

- C1. Public Education p. 18
 - Environmental Protection Agency (EPA), National Science Foundation (NSF), and Department of Education (DOED) should promote the dissemination and use of the North American Association for Environmental Education (NAAEE) “Guidelines for Excellence” in EE to ensure that scientifically accurate and instructionally sound EE materials are used by educators. (C1 p. 18) (EPA, NSF, DOED)
- C3. Teacher Professional Development, The Link to Success (and Change) in Education: Transforming Professional Development with Teachers p. 43
Federal and state departments of education should support the development and dissemination of high quality materials to all districts, including those with the most need and the most to gain from alternative, but effective, methods of instruction. (C3 p. 44)

GENERAL

- C1. Public Education p. 18
 - National Science Foundation (NSF), Environmental Protection Agency (EPA) and other federal agencies should increase support for EE curriculum development and dissemination through non-formal education programs such as 4-H, scouting, zoos, aquariums, nature centers, museums, etc. (C1 p. 18) (NSF, EPA)
- C8-B18. Coastal Management and Climate Change
 - Congress should fund education programs supporting integrated natural science and public policy to develop and acquire curricula specific to regional climate impacts at K-12 through university levels. (C8-B18) (Federal Government)
- C5-B10. Integrating economic, social, and environmental forecasting p. 56
 - Federal agencies should allocate significant funding for interdisciplinary environmental research that incorporates physical and social sciences and local knowledge in ways that build local capacity to better manage local resources. This research should be used to understand broader geographic impacts and to develop or support public education campaigns.

HEALTH

Public Health

- C7-B19. Bringing Health into Environmental Education p. 27
 - Government funding agencies and private funders should provide support for innovative initiatives that integrate environment and human health by:
 - Adopting a more collaborative approach to create programs that support interdisciplinary research on environment and human health education. (C7-B19 p. 27)

- Incorporating training on the linkages between environment and human health, and about systems thinking in all federal-sponsored public health training programs. (C7-B19 p. 27)
- C1. Biodiversity and Ecosystem Health p. 4
 - The federal government should develop, sustain and coordinate a multi-agency program in disciplinary and interdisciplinary education and training about natural resources, including public education, K-12 and higher education, and professional development. (C1. p. 4)

HIGHER EDUCATION

Interdisciplinary education and training

- C5-B1. Connecting forecasts with policymakers p. 48
 - Colleges, universities, and funding agencies should provide incentives for interdisciplinary training of students. (C5-B1 p. 48)
- C5-B10. Integrating economic, social, and environmental forecasting p. 56
 - The National Science Foundation should expand and increase support for programs that foster collaborative interdisciplinary integration such as the Integrated Graduate Education, Research and Training (IGERT) program.
 - Federal agencies should allocate significant funding for interdisciplinary environmental research that incorporates physical and social sciences and local knowledge in ways that build local capacity to better manage local resources. This research should be used to understand broader geographic impacts and to develop or support public education campaigns.
- C1. Higher Education p. 12
 - To better understand the concept of sustainability and to foster faculty and student involvement, funding should be increased for curriculum development, graduate studies, and fellowships. This funding should:
 - Encourage development and evaluation of interdisciplinary curricula and support their dissemination (C1 p. 12)
 - Provide opportunities for students to learn off-campus in local communities. (C1 p. 12)
 - NSF should fund training and research projects on sustainability and its integration into different aspects of university life by:
 - Providing “bite-sized” grants (grants for smaller projects on the order of \$10,000 each.) (C1 p. 12) (NSF)
 - Funding graduate student traineeships and fellowships in areas relating to sustainability. (C1 p. 12) (NSF)
 - Funding research on how to measure sustainability. (C1 p. 12) (NSF)
 - Support culturally-sensitive transfer of knowledge among people in different societies. (C1 p. 12) (NSF)

K-12 EDUCATION

Curriculum

- C1. Sustainable Resource Management p. 20
 - The Department of Education, the Environmental Protection Agency (EPA), and the National Science Foundation (NSF) should support education and training, including curriculum development on sustainability for teachers of grades K-12. (C1 p. 20) (DoED, EPA, NSF)
- C3. Diversity, Human Diversity in Education for a Sustainable and Secure Future p. 23
 - Education About Diversity
 - A national K-12 curriculum should be developed and implemented that is tied to a measurable set of environmentally-focused learning objectives and

includes recognition of human diversity of students, faculty, communities, and society as a whole. (C3 p. 23)

- C3. K-12 Implementation, Integrating Environment and Sustainability across the K-12 Educational Enterprise p. 33
 - Policy
 - Federal and state governments should include standards for and appropriate assessment of comprehension of environmental and sustainability concepts and issues. (C3 p. 33) (Federal Government)
- C6-B17. Global and U.S. Perspectives on the Prospects for Renewable Energy p. 22
 - The U.S. Department of Education should use new state assessment tests to include renewable energy in the curriculum (science literacy standards to include renewable energy). (C6-B17 p. 22) (DoED)

Funding

- C3. K-12 Content, Identification of Essential Learning p. 32
 - Funding
 - Funding and other resources for educators throughout the educational system should be increased to allow for the development and incorporation of sustainability concepts into educational materials and practices. (C3 p. 32)
- C7-B9. Children's Minds: Environment, Development, and Mental Function p. 15
 - Congress should pass "Healthy and High Performance School" legislation and ensure that every school has the funding to meet these standards. (C7-B9 p. 15) (Congress)
- C5-B10. Integrating economic, social, and environmental forecasting p. 56
 - Federal agencies should allocate significant funding for interdisciplinary environmental research that incorporates physical and social sciences and local knowledge in ways that build local capacity to better manage local resources. This research should be used to understand broader geographic impacts and to develop or support public education campaigns. For example:
 - The U.S. Department of Education and other education agencies should support interdisciplinary studies (integrating natural and social sciences) at the primary and secondary education levels. Relevant fields of study include human and physical geography, biogeography, sustainability (including resource consumption), and ecology. (C5-B10 p. 57) (DoED)

General

- C1. Federal Government Structure p. 7
 - Scientists and policymakers need to be educated broadly and must understand each other's disciplines and perspectives. (C1 p. 7)
- C3. Teacher Professional Development, The Link to Success (and Change) in Education: Transforming Professional Development with Teachers p. 43
 - Overarching recommendation: Policymakers and decisionmakers need to be educated about the issues facing education professionals, and should support current exemplary efforts to improve the education systems in their areas and nationwide. (C3 p. 44)

PUBLIC EDUCATION

Community Education

- C1. Public Education p. 18
 - Environmental Protection Agency (EPA), U.S. Department of Energy (DOED), and National Science Foundation (NSF) should cooperatively develop and implement a yearly assessment of public environmental knowledge (expanded from the existing NEEF/Roper Starch Survey). (C1 p. 18) (EPA, DOED, NSF)
- C7-B21. Innovative Uses of Information Technology p. 29
 - The President should establish a governmental consortium to coordinate environment and health information and foster public outreach and training, in

person or online. This consortium should create incentives for such public education and the dissemination of information. (C7-B21 p. 29)

- C6-B13. Consumer and Decisionmaker Education p. 18
 - U.S. Department of Energy should implement the new energy education initiative in the Energy Policy Act of 2005. (C6-B13 p. 18) (NCSE, DOE)

Funding

- C1. Public Education p. 18
 - The Administration should make environmental education (EE) a top priority and encourage and fund EE partnership programs involving federal agencies, and state, tribal, local and private organizations. (C1 p. 18) (Federal)

TEACHERS

Support

- C3. Teacher Professional Development, The Link to Success (and Change) in Education: Transforming Professional Development with Teachers p. 43
 - Overarching recommendation
 - The federal government should provide support for a seamless continuum of professional development from aspiring educators to master practitioners in sustainability and environmental education through the following:
 - Continuing Professional Development
 - Teachers should receive higher compensation and increased classroom support based on self-initiation of professional development and working in particularly challenging school systems. (C3 p. 43) (Federal Government)
 - All educators should have access to exemplary materials and resources including funding for off-site programs. (C3 p. 43) (Federal Government)
 - Resources
 - Communities must aid teachers, schools and districts in providing the best experiences and instruction for their students and creating safe learning environments that improve the performance and behavior of students. Support can be provided in a variety of ways, including cash, materials, tools, skills, mentoring, and other resources. (C3 p. 44) (Federal)
 - For urban educators in particular, funding should be available to use the environment as an integrated context for student instruction. (C3 p. 44) (Federal)
- C3. Undergraduate Education, Transforming Undergraduate Education for Environment Sustainability p. 45

Training

- C1. Public Education p. 18
 - Environmental Protection Agency (EPA), National Science Foundation (NSF), and U.S. Department of Education (DOED) should encourage and support the availability of pre-service and in-service teacher training in EE for all teachers. (C1 p. 18) (EPA, NSF, DOED)
- C1. Global Environmental Change p. 8
 - The NSF and the Department of Energy (DOE) should fund teacher training programs in global environmental change that involve international components. (C1 p. 9) (NSF, DOE)
 - Congress should reauthorize the 1990 Environmental Education Act and increase the funding in this area by at least an order of magnitude. (C1 p. 18)

TOOLS

Clearinghouse

- C3. Educational Research, Suggested Guidelines for Education for Sustainable Development Research p. 24
 - Communication
 - There should be a “clearinghouse” dedicated to ESD, which should include program evaluations as well as basic research. (C3 p. 25)
 - This overall strategy of promotion of the ESD research agenda should engage researchers, practitioners, and users of the data from many different disciplines. (C3 p. 25)
- C3. Geographic Learning, Designing National Programs for Local and Global Impacts p. 28
 - National Clearinghouse
 - There should be a national clearinghouse on sustainability education so that people can find mentors, practices, curriculum, and other resources. (C3 p. 28)
- C3. Green Campuses, Creating Green Campuses: Practicing What We Teach p. 30
 - Information clearinghouse
 - There should be an international clearinghouse for information about campus and community sustainability projects. (C3 p. 30)
- C3. Sustainability-Security Curricula, Developing Curricula to Integrate Sustainability and Security p. 41
 - Electronic clearinghouse
 - There should be a national web-based resources for life-long sustainability education, including case studies of what works. (C3 p. 41)

Environmental Communication

- C1. Public Education p. 18
 - Environmental Protection Agency (EPA), in cooperation with U.S. Department of Education (DOED), should assist states in integrating environmental literacy assessments in their on-going state assessments in order to develop baseline data on student environmental literacy. (C1 p. 18) (EPA, DOED)

Research Recommendations by Department and Agency

Agency for Healthcare Research and Quality (AHRQ)

- C7-B23. Measuring the Outcomes of Policies and Programs p. 31
 - CDC, NIH, and AHRQ need to fund and conduct a pilot project to determine whether current datasets and tools are adequate for environmental health outcomes and, if not, what should be measured. The pilot project needs to link environmental exposure data to health data. (C7-B23 p. 31) (CDC) (NIH) (AHRQ)

Center for Disease Control (CDC)

- C7-B4. The Natural Environment, Built Environment, and Social Environment. P. 8
 - Federal agencies (like CDC and EPA) should double research support that seeks to identify health consequences of living in sustainable communities and in sprawling communities. (C7-B4 p. 8) (CDC) (EPA)
- C7-B13. Setting Research Priorities for Health and the Environment p. 20
 - Agencies should fund research on:
 - The relationships between climate change and disaster preparedness (even small frequent disasters because their effects accumulate. (C7-B13 p.20) (NOAA, CDC, DHS).
- C7-B23. Measuring the Outcomes of Policies and Programs p. 31
 - CDC, NIH, and AHRQ need to fund and conduct a pilot project to determine whether current datasets and tools are adequate for environmental health outcomes and, if not, what should be measured. The pilot project needs to link environmental exposure data to health data. (C7-B23 p. 31) (CDC) (NIH) (AHRQ)

Climate Change Technology Program (CCTP)

- C8-B22. Availability of technology to mitigate climate change
 - The CCTP (Climate Change Technology Program) should provide the roadmap for providing the balance of funding technologies at the fundamental, strategic, and demonstration levels and to provide the correct mix of participation by government, industry, and academia. (C8-B22) (Federal)

Department of Commerce (DOC)

- C6-B3. Community Planning p. 7
 - The Departments of Commerce and Energy should sponsor more research through universities, national labs, and other research institutions on the impact of individual business decisions on local land use patterns, to build the business case for energy efficient land use planning. (C6-B3 p. 7) (Department of Commerce)

Department of Education (DOED)

- C3 Undergraduate Education p. 46
 - The National Science Foundation, Department of Education and philanthropic foundations should support research on and assessment of the impact and effectiveness of sustainability education, research, and operations in higher education. (C3 p. 46) (NSF) (Department of Education and Foundations)

Department of Energy (DOE)

- C6-B3. Community Planning p. 7
 - The Departments of Commerce and Energy should sponsor more research through universities, national labs, and other research institutions on the impact of individual business decisions on local land use patterns, to build the business

case for energy efficient land use planning. (C6-B3 p. 7) (Department of Commerce)

Department of Homeland Security

- C7-B13. Setting Research Priorities for Health and the Environment p. 20
 - Agencies should fund research on:
 - The relationships between climate change and disaster preparedness (even small frequent disasters because their effects accumulate. (C7-B13 p.20) (NOAA, CDC, DHS).

Environmental Protection Agency (EPA)

- C7-B4. The Natural Environment, Built Environment, and Social Environment. P. 8
 - Federal agencies (like CDC and EPA) should double research support that seeks to identify health consequences of living in sustainable communities and in sprawling communities. (C7-B4 p. 8) (CDC) (EPA)
- C7-B11. Energy, Air Quality, and Health p. 17
 - The EPA should create a stable but ambitious regulatory climate that encourages technological innovations monitoring, and long term research about the health effects of energy choices. (C7-B11 p. 17) (EPA)
- C4- Water infrastructure needs for the 21st century p. 44
 - Encourage USDA and EPA to fund research in methods to prevent pollution as opposed to treat pollution in order to meet environmental and health regulations. (C4 p. 44)
 - Encourage the federal government to support research to both identify and treat newer pollutants (e.g., drugs, endocrine disruptors) and biological agents and to identify the effects of these pollutants and agents on humans and animals. (C4 p. 44) (USDA) (EPA)

Federal Government (unspecified)

- C6-B1. Public Incentives vs. Market forces p. 5
 - The federal government and others should:
 - fund a multi-billion-dollar federal research and development program for reducing carbon emissions in energy production
 - Research on carbon capture and sequestration, nuclear energy and renewables. (C6-B1 p. 5)
 - Fund research investigating mitigation and adaptation strategies, including risks to coastal areas. (C6-B1 p. 5) (federal)
- C7-B11. Energy, Air Quality, and Health p. 17
 - Government needs to consider the full range of incentives (e.g. marketing campaigns, fuel economy standards, rebates, taxes) to the private sector to invest in dissemination of cleaner energy technologies, including funding for the national research energy laboratory. (C7-B11 p. 17) (Federal)
- C5-B8. Cross-Sectional Connection: Engaging the private sector as a partner with the government p. 54
 - The federal government should create a program modeled after the small business incentives for research program to provide transitional funding for commercialization of large scale forecasting systems. (C5-B8 p. 54) (Federal)
- C5-B11. Working across spatial scales: from molecular to global p. 57-58
 - Federal agencies should support research to identify important knowledge gaps in environmental forecasting based on molecular processes. (C5-B11 p. 57-58) (Federal)
 - Federal agencies should increase support for bioinformatics research on gene-environment interactions:
 - An interagency initiative should be established to explore variations in gene expression and other molecular processes across the

- environmental range of an important species. (C5-B11 p. 57-58)
(Federal)
- C5-B12. Forecasting environmental change of the landscape at a regional scale p. 58-59
 - Federal science agencies should support research and tools that improve our ability to incorporate nonlinearity, feedback, and threshold changes in regional environmental forecasting. (C5-B12 p. 58-59) (Federal)
 - Federal science agencies and universities should increase support for interdisciplinary environmental research and education regionally. (C5-B12 p. 58-59) (Federal)
- C1. Global Environmental Change p. 9
 - Federal agencies need to fund long term observational and research efforts through endowments established by Congress (50-100 yrs) (C1 p. 9) (Federal)
- C8-B35. Climate Change and Human Health: Engaging the Public Health Community
 - Congress should substantially increase funding for research on health impacts of climate change. (C8-B35) (Federal)
- C7-B1. Integrating Environment, Culture, and Well-being p. 5
 - Federal agencies should support research to investigate the linkages among human health, cultural health, healthy governance, and ecosystem health. (C7-B1 p. 5) (Federal)
- C3. Environmental Security p. 27
 - Federal resource management agencies and educational institutions jointly should develop concrete strategies and tools aimed at critical analysis, understanding, and interpretation of complex ecosystem interactions and dynamic relationships, such as dynamic simulation modeling. (C3 p. 27) (Federal)
- C4- Protecting and Restoring Estuaries p. 49-50
 - Encourage Congress to increase funding for innovative research efforts such as those that are focused on developing new tools for understanding estuarine systems (i.e., environmental and economic modeling, GIS, LIDAR), long term monitoring, analysis and synthesis across federal, local, state, and tribal governments and agencies. (C4 p. 49-50) (Federal)
- C4- Allocating water for people and ecosystems p. 40
 - Encourage federal agencies to conduct research on how people use water and how social sciences can be used to better inform public choices about water use. (C4 p. 40) (Federal)
- C7-B13. Setting Research Priorities for Health and the Environment p. 20
 - Agencies should fund research on:
 - How to strengthen critical infrastructure and study the effectiveness of restructuring existing hospital guidelines and physical facilities to improve resilience of facilities (NSF, NIST, HHS, DHS, and DOT), (C7-B13 p.20) (NSF) (NIST) (HHS) (DHS) (DOT)
- C5-B16. Examining the role of eco-informatics in environmental decision-making. P. 61-62
 - U.S. science agencies should work more closely with academia to create and sustain a viable national forum on the nexus between research and innovation in the area of eco-informatics and forecasting. (C5-B16 p. 61-62) (General Agencies)
- C7-B13. Setting Research Priorities for Health and the Environment p. 20
 - Federal agencies should explicitly outline funding procedures and decision-making processes for risk management of human and ecosystem health hazards. (C7-B13 p.20) (General Agencies)
 - HHS, NIH/NLM, CDC, NOAA, FWS, USFS, USGS, state agencies, and private organizations such as Google should develop a methodology and database for health risk management and mitigation measures. (C7-B13 p.20) (General Agencies)

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- C7-B4. The Natural Environment, Built Environment, and Social Environment. P. 8
 - Federal agencies should require collaborative research into the relationships between human habitats and healthy people. (C7-B4 p. 8) (General Agencies)
 - Federal Agencies should actively support research into the disparities of health impacts related to the physical environment. (C7-B4 p. 8) (General Agencies)

National Academy of Sciences (NAS)

- C8- B3. Animal Agriculture and Climate Change
 - The National Academy of Sciences should conduct a study, leading to a national science-based dialogue to discuss how meat consumption, processing, packaging, and waste impact GHGs. (C8-B3) (NAS)
- C6-B11. Setting Research priorities: Who? How? Why? p. 16
 - The U.S. must immediately establish a multi-year (decadal) research, development, demonstration, deployment (RD3) plan for energy sustainability and security (C6-B11 p. 16) (Federal)
 - The RD3 plan should be created by a multi-agency, multi-sectoral process, involving the National Academies of Science and Engineering. (National Academies of Sciences and Engineering)
 - Congress should appropriate funds and direct research agencies and organizations to collaborate to fund trans-disciplinary natural and social science research into integrated energy systems. (C6-B11 p. 16) (NAS)

National Institutes of Health (NIH)

- C7-B23. Measuring the Outcomes of Policies and Programs p. 31
 - CDC, NIH, and AHRQ need to fund and conduct a pilot project to determine whether current datasets and tools are adequate for environmental health outcomes and, if not, what should be measured. The pilot project needs to link environmental exposure data to health data. (C7-B23 p. 31) (CDC) (NIH) (AHRQ)
- C7-B16. Ecology and Epidemiology p. 24
 - NIEHS should fund more research on the integration of ecology and disease (e.g., disease vectors). (C7-B16 p. 24) (NIEHS)
- C3-Population Environment p. 38
 - Research and training initiative on water
 - National Institute of Child Health and Human Development (NICHD) should collaborate with other current and potential funders such as NSF to develop and fund a new multi-year, multidisciplinary research and training initiative focus on water. This initiative would help achieve the Millennium Development goal to halve the proportion of people without access to safe drinking water by 2015 and the World Summit on Sustainable Development goal to halve the proportion of people without access to sanitation by 2015. (C3 p. 38) (NICHD) (NSF) (World Summit on Sustainable Development)

National Oceanic and Atmospheric Administration (NOAA)

- C5-B10. Integrating economic, social, and environmental forecasting p. 56-57
 - NOAA and other mission agencies should increase investments in and support for interdisciplinary environmental research. (C5-B10 p. 56-57) (NOAA)
- C7-B13. Setting Research Priorities for Health and the Environment p. 20
 - Agencies should fund research on:
 - The relationships between climate change and disaster preparedness (even small frequent disasters because their effects accumulate. (C7-B13 p.20) (NOAA, CDC, DHS).

- C7-B6. The Ocean and Human Health p. 10-11
 - Federal agencies should ensure that ocean observing systems are constructed as vehicles that organize, communicate and analyze data, as well as collect it, leading to interdisciplinary systems analysis and predictions/policy recommendations. Environmental scientists should work with physicists/IT specialists to design and locate the observing systems, including instrumentation for ocean observing systems, so that they will produce data to fit the scientific questions/problems on environmental/human health. NRC, NOAA, NASA, CDC, USGS, and other federal agencies should standardize sensing and monitoring data including epidemiological information from human and animal populations. (C7-B6 p. 10-11) (NRC) (NOAA) (NASA) (CDC) (UGS) (General Agencies)

National Science Foundation (NSF)

- C1. Environmental Implications of Biotechnology p. 5
 - The National Science Foundation should create an initiative to fund multidisciplinary research and training to better understand the environmental implications of biotechnology, possibly involving other federal agencies to provide joint funding. (C1 p. 5) (NSF)
- C1. Higher Education p. 12
 - NSF should fund training and research projects on sustainability and its integration into different aspects of university life by:
 - providing “bit” sized grants (grants for smaller projects about \$10,000). (C1 p. 12) (NSF)
 - funding graduate student traineeships and fellowships in areas relating to sustainability. (C1 p. 12) (NSF)
 - funding research on how to measure sustainability. (C1 p. 12) (NSF)
- C3 Undergraduate Education p. 46
 - The National Science Foundation, Department of Education and Foundations should support research on and assessment of the impact and effectiveness of sustainability education, research, and operations in higher education. (C3 p. 46) (NSF) (Department of Education and Foundations)
- C3 Large Scale Conservation p. 34
 - The National Science Foundation, universities foundations, and other federal and state agencies should fund research on (C3 p. 34) (NSF):
 - learning across geopolitical, social, and institutional boundaries in order to build capacity for large-scale conservation
- C8-B10. Nuclear Energy: Using science to make hard choices
 - NSF should fund further research in perception and communication of nuclear and climate issues (C8-B10) (NSF)
- C5-B10. Integrating economic, social, and environmental forecasting p. 56-57
 - The National Science Foundation should further recognize the value of interdisciplinary environmental research and increase funding for research on complex environmental systems, including NSF’s priority area on biocomplexity in the environment. (C5-B10 p. 56-57) (NSF)
- C5-B13. Working across temporal scales- integrating short-term and long-term approaches p. 59
 - The National Science Foundation should support social science research on the perceived value of the ecosystem services to various societal components as well as the factors that affect the credibility of an ecological forecast (C5-B13 p. 59) (NSF)
- C1. Global Environmental Change p. 9
 - The National Science Foundation should enhance incentives for interdisciplinary research integrating natural and social sciences. (C1 p. 9) (NSF)

- C3-Population Environment p. 38
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- C3. Geographic Learning p. 28
 - The National Science Foundation should continue to expand its approach toward integrative sciences by including a focus on environmental sustainability in every program announcement. (C3 p. 28) (NSF)
- C3. Environmental Security p. 27
 - Funding agencies like the National Science Foundation should support multidisciplinary research on the complex social, political, economic, and cultural relationship inherent in environmental security issues. (C3 p. 27)

National Science and Technology Council (NSTC)

- C7-B22. Designing for Complementarity among programs generating environmental and health information p. 30
 - As human health data and information are collected under specific use and disclosure protections, the National Science and Technology Council (NSTC) should direct its participating agencies to develop workable approaches and models for advancing synthesis of their environmental health research data and information. (C7-B22 p. 30) (NSTC)

Office of Science and Technology Policy (OSTP)

- C7-B22. Designing for Complementarity among programs generating environmental and health information p. 30
 - The OSTP should request that the national academies conduct a case study using the integration of multidisciplinary research in climate as an example of integration across “stressors” (that is, disease, land use/land change, and pollution.) (C7-B22 p. 30) (OSTP)

United States Department of Agriculture (USDA)

- C8-B4. Minimizing agricultural impacts on climate; minimizing climate impacts to agriculture
 - Develop long term data sets at the USDA Agricultural Research Service (ARS) to quantify and understand the impacts of climate on agriculture. (C8-B4) (USDA)
- C6- B17. Global and U.S. perspectives on the prospects of renewable energy. P.22
 - USDA should support and conduct serious research on industrial growth of hemp as an energy product. (C6-B17 p. 22) (USDA)
- C4- Water infrastructure needs for the 21st century p. 44
 - Encourage USDA and EPA to fund research in methods to prevent pollution as opposed to treat pollution in order to meet environmental and health regulations. (C4 p. 44)
 - Encourage the federal government to support research to both identify and treat newer pollutants (e.g., drugs, endocrine disruptors) and biological agents and to identify the effects of these pollutants and agents on humans and animals. (C4 p. 44) (USDA) (EPA)

United States Geological Survey (USGS)

- C7-B13. Setting Research Priorities for Health and the Environment p. 20
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Education Initiatives by Department and Agency

Congress

- C1. Global Environmental Change p. 8
 - Congress should reauthorize the 1990 Environmental Education Act and increase the funding in this area by at least an order of magnitude. (C1 p. 18)
- C8-B18. Coastal Management and Climate Change
 - Congress should fund education programs supporting integrated natural science and public policy to develop and acquire curricula specific to regional climate impacts at K-12 through university levels. (C8-B18)
- C7-B9. Children's Minds: Environment, Development, and Mental Function p. 15
 - Congress should pass "Healthy and High Performance School" legislation and ensure that every school has the funding to meet these standards. (C7-B9 p. 15)
- C1. Public Education p. 18
 - The Administration should make environmental education (EE) a top priority and encourage and fund EE partnership programs involving federal agencies, and state, tribal, local and private organizations. (C1 p. 18)

Environmental Protection Agency (EPA)

- C1. Public Education p. 18
 - NSF, EPA and other federal agencies should increase support for EE curriculum development and dissemination through non-formal education programs such as 4-H, scouting, zoos, aquariums, nature centers, museums, etc. (C1 p. 18)
 - Environmental Protection Agency (EPA), National Science Foundation (NSF), and U.S. Department of Education (DOED) should promote the dissemination and use of the North American Association for Environmental Education (NAAEE) "Guidelines for Excellence" in EE to ensure that scientifically accurate and instructionally sound EE materials are used by educators. (C1 p. 18)
 - Environmental Protection Agency (EPA), U.S. Department of Energy (DOED), and National Science Foundation (NSF) should cooperatively develop and implement a yearly assessment of public environmental knowledge (expanded from the existing NEETF/Roper Starch Survey). (C1 p. 18)
 - Environmental Protection Agency (EPA), National Science Foundation (NSF), and U.S. Department of Education (DOED) should encourage and support the availability of pre-service and in-service teacher training in EE for all teachers. (C1 p. 18)
 - Environmental Protection Agency (EPA), in cooperation with U.S. Department of Education (DOED), should assist states in integrating environmental literacy assessments in their on-going state assessments in order to develop baseline data on student environmental literacy. (C1 p. 18)
- C1. Sustainable Resource Management p. 20
 - The Department of Education, the Environmental Protection Agency (EPA), and the National Science Foundation (NSF) should support education and training, including curriculum development on sustainability for teachers of grades K-12. (C1 p. 20)

Federal Government

- C5-B10. Integrating economic, social, and environmental forecasting p. 56
 - Federal agencies should allocate significant funding for interdisciplinary environmental research that incorporates physical and social sciences and local knowledge in ways that build local capacity to better manage local resources. This research should be used to understand broader geographic impacts and to develop or support public education campaigns. For example:

- The U.S. Department of Education and other education agencies should support interdisciplinary studies (integrating natural and social sciences) at the primary and secondary education levels. Relevant fields of study include human and physical geography, biogeography, sustainability (including resource consumption), and ecology. (C5-B10 p. 57)
- C3. Teacher Professional Development, The Link to Success (and Change) in Education: Transforming Professional Development with Teachers p. 43
 - Overarching recommendation
 - The federal government should provide support for a seamless continuum of professional development from aspiring educators to master practitioners in sustainability and environmental education through the following:
 - Continuing Professional Development
 - Teachers should receive higher compensation and increased classroom support based on self-initiation of professional development and working in particularly challenging school systems. (C3 p. 43)
 - All educators should have access to exemplary materials and resources including funding for off-site programs. (C3 p. 43)
 - Resources
 - Communities must aid teachers, schools and districts in providing the best experiences and instruction for their students and creating safe learning environments that improve the performance and behavior of students. Support can be provided in a variety of ways, including cash, materials, tools, skills, mentoring, and other resources. (C3 p. 44)
 - For urban educators in particular, funding should be available to use the environment as an integrated context for student instruction. (C3 p. 44)

National Science Foundation (NSF)

- C1. Public Education p. 18
 - National Science Foundation (NSF), Environmental Protection Agency (EPA) and other federal agencies should increase support for EE curriculum development and dissemination through non-formal education programs such as 4-H, scouting, zoos, aquariums, nature centers, museums, etc. (C1 p. 18)
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- Support culturally-sensitive transfer of knowledge among people in different societies. (C1 p. 12)
- C1. Global Environmental Change p. 8
 - The National Science Foundation (NSF) and the Department of Energy (DOE) should fund teacher training programs in global environmental change that involve international components. (C1 p. 9)
- C5-B10. Integrating economic, social, and environmental forecasting p. 56
 - Universities should alter their reward systems in order to facilitate integration among disciplines. The National Science Foundation should expand and increase support for programs that foster collaborative interdisciplinary integration such as the Integrated Graduate Education, Research and Training (IGERT) program. National Academy of Sciences should foster additional collaborative, interdisciplinary environmental research and elect more members who conduct this type of research. These changes should be spearheaded by leaders of these institutions and by individuals involved in the collaborations. (C5-B10 p. 57)
- C5-B11. Working across spatial scales: From molecular to global p. 57
 - Universities should strengthen multidisciplinary environmental training by exposing students to multiple fields, rewarding faculty for conducting interdisciplinary research, building on the success of NSF's Integrated Graduate Education, Research, and Training (IGERT) program, and other mechanisms. (C5-B11 p. 58)
- C1. Public Education p. 18
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U.S. Department of Education

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- C6-B17. Global and U.S. Perspectives on the Prospects for Renewable Energy p. 22
 - The U.S. Department of Education should use new state assessment tests to include renewable energy in the curriculum (science literacy standards to include renewable energy). (C6-B17 p. 22)
- C1. Global Environmental Change p. 8
 - The NSF and the Department of Energy (DOE) should fund teacher training programs in global environmental change that involve international components. (C1 p. 9)
- C5-B10. Integrating economic, social, and environmental forecasting p. 56

Environmental Research and Education Needs: An Agenda for a New Administration
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- Federal agencies should allocate significant funding for interdisciplinary environmental research that incorporates physical and social sciences and local knowledge in ways that build local capacity to better manage local resources. This research should be used to understand broader geographic impacts and to develop or support public education campaigns. For example:
 - The U.S. Department of Education and other education agencies should support interdisciplinary studies (integrating natural and social sciences) at the primary and secondary education levels. Relevant fields of study include human and physical geography, biogeography, sustainability (including resource consumption), and ecology. (C5-B10 p. 57)
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U.S. Department of Energy

- C1. Global Environmental Change p. 8
 - The National Science Foundation (NSF) and the Department of Energy (DOE) should fund teacher training programs in global environmental change that involve international components. (C1 p. 9)
- C6-B13. Consumer and Decisionmaker Education p. 18
 - NCSE should work with U.S. Department of Energy on the new energy education initiative in the Energy Policy Act of 2005 and should seek funding for the initiative. (C6-B13 p. 18)

About the National Council for Science and the Environment

The National Council for Science and the Environment is an NGO dedicated to improving the scientific basis for environmental decision-making.

The Council specializes in programs that bring together individuals, institutions and communities to collaborate on broad-based projects that cannot be carried out by individual entities.

The Council has 160 affiliated universities and colleges whose leaders participate in the Council of Environmental Deans and Directors (CEDD) at the Council of Energy Research and Education Leaders (CEREL.)

The Council's annual National Conference on Science, Policy and the Environment brings together representatives from all levels of government, leaders in research and education, NGOs and business to develop strategies for improved decision-making on critical environmental challenges. Most of the recommendations included in this memo were jointly developed at these conferences by groups representing the communities mentioned.

The Council supports multi-stakeholder bodies drawn from the same breadth of communities mentioned above, to guide the development and deployment of decision-making tools to address specific environmental challenges. These include the National Commission on Science for Sustainable Forestry.

The Council is also the Secretariat for the Environmental Information Coalition, an open membership group of institutions and individuals creating an online resource, the Earth Portal, to connect the public with high quality environmental information. At the center of the Earth Portal www.earthportal.org is the Encyclopedia of Earth – often referred to as “the Environmental Wikipedia with Quality Control.” <http://www.eoearth.org/>

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