Solving the problems we face: the United States Environmental Protection Agency, sustainability, and the challenges of the twenty-first century

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Introduction

The trouble with our times is that the future is not what it used to be.

—Paul Valery (1948)

During the 1970s, environmental crises were highly visible and easy for the public to understand. In 1969, the Cuyahoga River caught fire in Cleveland, drawing national attention to the environment. Popular articles decried the “poisoned fish and troubled waters” affecting dozens of America’s waterways (Boyle, 1970). Air pollution led to 406 deaths in four days during a 1963 weather inversion in New York City.

The creation of the United States Environmental Protection Agency (USEPA) in 1970 was a response to the evident problems of industrial emissions and public health, and subsequent Congressional legislation aimed at reducing pollution. In the more than 40 years since, new and more complex problems have emerged as a result of population growth, urban development, and the globalization of industry. Today, we face a variety of newly apparent challenges, including climate change; declining biodiversity; threats to vital natural resources including water bodies, soils, forests, wetlands, and coral reefs; and increased health risks to minority urban communities, contributing to a pattern of “environmental injustice” (Clark et al. 2014).

How can society best address these problems? It is here that the concept of sustainability is becoming a driving force in business, government, and civil society.

Sustainability, as we understand it, is both a goal, aiming to enhance economic growth while protecting health and the environment, and a process, involving the application of a number of scientific decision-support tools, flexibility in regulatory decision-making and management, and collaboration and partnerships among all stakeholders. This Community Essay highlights the history of USEPA methods and how it is now inching toward a more sustainable, systems-oriented approach. While we focus largely on the history of USEPA, the lessons learned and the challenges ahead apply to all federal agencies and to federal-state and business-government collaboration.

Over the past four decades, USEPA has evolved to address environmental problems in a number of ways. The following discussion describes a progression of five major regulatory and management approaches that transpired over this period of time (Figure 1):

1. The starting point was end-of-pipe regulations
that limited or banned pollutants.
2. Regulations were enhanced by scientific assessment and management of risks to human health.
3. New solutions focused on reducing and/or eliminating the sources of pollution and promoting environmentally conscious design.
4. Environmental stewardship and innovative problem-solving became critical elements in overall environmental management.
5. Systems thinking is now helping decision makers achieve an integrated understanding of the consequences of their actions in terms of resilience and sustainability.

This historic review of domestic and international activities shows that, while significant progress has been made toward more sustainable management practices, the process has been slow and often reactive, rather than proactive. Ever since USEPA was created, there have been ongoing debates about its role and the economic impact of its regulation, as well as internal conflicts between the media-centric legal and management approaches to problem-solving (so-called “silos”). Understanding this context is critical for both academics and the general public to help in shaping future actions.

Emerging global trends demand a more timely and efficient approach to environmental management, because new crises are on the horizon. This is especially true of climate change, where despite a 40-year research effort that has affirmed the reality of global warming and its impact on society, the volume of greenhouse-gas emissions to the atmosphere has not been abated.

Other major issues are threatening planetary well-being. The Stockholm Resilience Center has identified and quantified a set of nine planetary indicators for which we have exceeded our “safe operating boundaries.” In addition to greenhouse-gas emissions, these include nitrogen flows, freshwater consumption, and biodiversity (Rockström et al. 2009). The USEPA, along with all agencies and the business world, must be responsive to what Rockström and colleagues (2009) call the “great acceleration” of many environmentally harmful trends.

USEPA’s future direction is now reflected in its 2014–2018 Strategic Plan, which identifies four critical cross-agency strategies and sets clear expectations for changing the way that the agency pursues its mission: 1) Working toward a sustainable future; 2) Striving to make a visible difference in communities; 3) Launching a new era of state, local, tribal, and international partnerships; and 4) Enhancing USEPA as a high-performance agency. 1 Through these initiatives, the agency aims to help create a resilient and sustainable society.

**USEPA’s Evolving Roles and the Problems We Face: 1970s to 2020s**

Table 1 shows the changing nature of USEPA’s approach to problem-solving, legislative and policy actions, and international drivers of change. The following sections trace these changes during each decade.

**The 1970s: A Time of Poisoned Fish and Troubled Waters**

In 1970, President Nixon turned to his Advisory Council on Executive Organization chaired by Roy L. Ash (the Ash Council) to recommend actions for dealing with emerging air- and water-pollution and waste problems. The Ash Council was visionary in identifying the need to resolve divergent views, integrate across federal agencies, and achieve sustainable economic growth. It recommended the consolidation of multi-agency environmental programs into USEPA, making two crucial predictions: 2

- “The enormous future needs for land, minerals, and energy require that the protection of our environment receive a powerful new impetus. In this, the nation will be on the ‘horns of a dilemma.’ The economic progress that we have come to expect, or even demand, has almost invariably been at some cost to the environment.”
- “Pollution is essentially a byproduct of our vastly increased per capita consumption, intensified by population growth, urbanization, and changing industrial processes. In the coming years, problems of environmental degradation will rise exponentially.”

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1 See [http://www2.epa.gov/planandbudget/strategicplan](http://www2.epa.gov/planandbudget/strategicplan).
2 For the text of the Ash Council memo, see [http://www2.epa.gov/aboutepa/ash-council-memo](http://www2.epa.gov/aboutepa/ash-council-memo).
Table 1: Evolution of EPA’s approach over the decades

| EPA Approach                      | Legislative and Policy Actions                                                                 | Major Events and Drivers of Change                                                                 |
|----------------------------------|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| **1970s** Control “end of pipe” point sources of pollution. | • National Environmental Policy Act, Ash Council                                                 | • Time of “Poisoned Fish and Troubled Waters”                                                      |
|                                  | • Clean Water Act and Clean Air Act                                                            | • 1972: Stockholm Conference (Only One Earth)                                                     |
|                                  | • Resource Conservation and Recovery Act and Superfund                                          | • 1973: OPEC Oil Embargo                                                                         |
|                                  | • Energy conservation                                                                          | • Love Canal                                                                                        |
| **1980s** Assess risks to human health and the environment. | • Acid Rain Deposition Act                                                                     | • 1981: CEQ Report on Global Futures                                                             |
|                                  | • Environmental regulations                                                                    | • 1983: NRC Risk Management "Red Book"                                                            |
|                                  | • “Science-based” risk management                                                              | • 1987: World Commission on Environment and Development Report, Our Common Future                  |
| **1990s** Prevent pollution and foster safe product development. | • Environmental Justice                                                                       | • 1992: United Nations Conference on Environment and Development (Rio)                           |
|                                  | • Design for the Environment                                                                   | • 1992: Creation of the World Business Council on Sustainable Development                        |
|                                  | • Pollution Prevention                                                                         | • President’s Council on Sustainable Development                                                  |
|                                  | • Common Sense Initiative                                                                      | • United Nations Framework Convention on Climate Change                                           |
|                                  | • Project XL                                                                                   | • 2000: World Summit on Sustainable Development (Johannesburg)                                 |
|                                  | • Toxic Release Inventory                                                                      | • 2005: Kyoto Protocol enters into force                                                          |
|                                  | • Reinventing Environmental Regulations                                                        | • 2005: Hurricane Katrina                                                                        |
|                                  | • Setting Environmental Goals for America                                                       |                                                                                                    |
| **2000s** Enhance stewardship of the environment by voluntary programs, market incentives, and collaborative problem solving. | • Environmental Indicators                                                                     |                                                                                                    |
|                                  | • Collaborative Problem Solving                                                                 |                                                                                                    |
|                                  | • Environmental Stewardship                                                                    |                                                                                                    |
|                                  | • State and Local Leadership                                                                   |                                                                                                    |
|                                  | • Sustainable Materials Management                                                             |                                                                                                    |
|                                  | • EPA Report on the Environment (USEPA, 2008)                                                  |                                                                                                    |
| **2010s** Align environmental, social, and economic outcomes, and work toward a sustainable future. | • Application of Decision-Support Tools                                                       | • 2011: NRC Green Book                                                                            |
|                                  | • Green Infrastructure                                                                        | • Superstorm Sandy signals increased natural disasters                                            |
|                                  | • Legislative Flexibility                                                                      |                                                                                                    |
|                                  | • Systems Thinking                                                                             |                                                                                                    |
|                                  | • New Era of Business-Government Collaboration                                                 | • 2012: Rio+20 Earth Summit                                                                      |
|                                  | • Action on Climate Change                                                                     | • United Nations Sustainable Development Goals                                                     |
|                                  |                                                                                                 | • Climate Negotiation 2015                                                                        |

Note: List of Acronyms
Council on Environmental Quality (CEQ)

The Ash Council recommendations reflected the vision and goals of the National Environmental Policy Act (NEPA) of 1970, which established the Council on Environmental Quality (CEQ) and aimed to create “conditions under which humans and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans [emphasis added].” This NEPA language is remarkably similar to the widely-known definition of sustainable development produced by the Brundtland Commission a decade later (see the 1980s below).

During the 1970s, Congress addressed the obvious problems of air, water, and land pollution through media-specific environmental legislation, including the passage of the Clean Air Act (1970), Clean Water Act (1972), Endangered Species Act (1973), Safe Drinking Water Act (1974), Resource Conservation and Recovery Act (1976), and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund, 1980). The outbreak of illness in 1978 caused by contamination in the Love Canal neighborhood of Niagara Falls in the state of New York was described by USEPA as “one of the most appalling environmental tragedies in American history.”

During this period, immediate environmental problems were evident and legislative action was greatly facilitated by significant “bipartisan popular demand for federal leadership in solving the pollution problem” (Andrews, 2011) in sharp contrast to subsequent decades. One major challenge facing USEPA and other agencies is the perception that regulations impose adverse economic impacts on businesses or society. The lack of bipartisan support today has become a serious barrier (McCarthy & Copeland, 2014).

As USEPA began to organize itself, two major international events focused global attention on the emerging problems of sustainability and energy secu-

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3 For information on NEPA, see http://www.npi.org/NEPA.
4 See http://www2.epa.gov/aboutepa/love-canal-tragedy.
rity. In 1972, the first United Nations Conference on the Human Environment (subtitled “Only One Earth”) met in Stockholm. Russell Train, head of the Council on Environmental Quality (CEQ), led the American delegation and was prophetic in acknowledging that “economic development at the expense of the environment imposes heavy costs to health and quality of life generally—costs that could be minimized by forethought and planning” (Train, 2003). The conference final report emphasized the potential for depletion of natural resources and projected impacts of a global population that would grow to 7 billion by the year 2000 and to 9 billion by 2050.5

While the world began to address the link between economic and environmental issues, a new crisis emerged in October 1973 when the Organization of Petroleum Exporting Countries (OPEC) initiated an oil embargo against nations that had supported Israel in its recent war with Egypt and Syria. The ensuing energy crisis led to serious economic recessions in the United States and elsewhere. Since the embargo, the country’s dependence on oil and gas imports has been a significant political and economic issue, with nearly every president calling for energy independence.

As the decade ended, the United States faced critical issues of energy demand, pollution control, and a weakening economy. The newly created USEPA began its role as what New York Times writer Phillip Shabecoff (1993) called “the federal government watchdog, police officer, and chief weapon against all forms of pollution.”

The 1980s: A Time of Risk Assessment and Growing Interest in Climate and Sustainability

During the 1970s, scientists had observed the increase in acidity of some lakes and streams, due to long-range transport of atmospheric pollutants such as sulfur dioxide. Since acid rain was a regional, rather than a local, problem, federal action would be needed. In 1980, Congress passed the Acid Rain Deposition Act, which included a ten-year research program under the direction of the National Acidic Precipitation Assessment Program (NAPAP). This program underscored a growing reliance on science in addressing an immediate problem.

The 1980s was also a time where existing laws were strengthened through passage of the Resource Conservation and Recovery Act (RCRA) Amendments of 1984, the Safe Drinking Water Act Amendments of 1986, and the Superfund Amendments and Reauthorization Act (SARA) of 1986.

Building on this regulatory framework, USEPA had begun in 1975 to utilize risk assessment as its second major response to problem-solving. A 1976 agency report underscored the link between risk assessment and development of regulations, stating, “Rigorous assessments of health risk and economic impact will be undertaken as part of the regulatory process” (USEPA, 1976).6 During the 1980s, USEPA began to adopt new quantitative methods for risk assessment and analyzed the impact of 64 contaminants on water quality. It was under the tenure of Administrator Doug Costle (1977–1981) that USEPA began to cast itself as both a health and environmental agency, especially in its efforts to reduce cancer risk (Fiorino, 1995).

In 1983, the National Research Council (NRC) published a landmark report (best known as the Red Book) entitled “Risk Assessment in the Federal Government: Managing the Process.” USEPA subsequently expanded its efforts on risk assessment, which gradually became the agency’s dominant paradigm. Shortly after publication of the “Red Book,” USEPA began issuing a series of guidelines for conducting risk assessments (e.g., in 1986 for cancer and chemicals and in 1992 for estimating exposures). While initial efforts focused on human-health risk assessment, the basic risk model was adapted in the 1990s to deal with risks to plants, animals, and whole ecosystems.8

Throughout much of the 1980s, climate change received extensive domestic and international attention. In the last days of the Carter administration, CEQ published Global Energy Futures and the Carbon Dioxide Problem, which recognized the challenge: “People have altered the face of the planet throughout history, but the power of today’s technology and our growing capacity to foresee, however uncertainly, the possible consequences of our acts put us in a new moral position. The responsibility for the carbon-dioxide (CO2) problem is ours—we should accept it and act in a way that recognizes our role as trustees of the earth for future generations” (CEQ, 1981).

While presidents from Nixon and Ford through Carter and Reagan were sensitive to the emerging climate-change issue, the concern was tempered by the need to deal with national economic problems. The tension between economic priorities and environmental concerns has continued to this day.

5 For the text of the report, see http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=97.

6 See also http://www.epa.gov/owser/riskassessment/rcra_toxicity.htm.

7 See http://www.nap.edu/catalog.php?record_id=366.

8 The history of risk assessment at the USEPA is at http://www.epa.gov/risk/history.htm.
On the international front, a major milestone in sustainable development occurred in 1987 when the Brundtland Commission (chaired by former Norwegian Prime Minister Gro Harlem Brundtland) proposed a long-term environmental strategy for achieving sustainable development by the year 2000 and beyond, and recommended ways to engage with this task (WCED, 1987).

**The 1990s: A Time of Social Justice, Pollution Prevention, and Design for the Environment**

One element of sustainability that links economic growth, environmental protection, and social well-being is preventing environmental harm to disadvantaged communities. A number of health threats during the 1970s and 1980s led USEPA to create the Environmental Equity Workgroup in July 1990, which ultimately evolved into the Office of Environmental Equity in 1992 (renamed in 1994 as the Office of Environmental Justice). In 1994, President Clinton signed Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations), which directed federal agencies to develop environmental justice strategies to address disproportionately high and adverse human health or environmental effects from their programs on minority and low-income populations. National attention to environmental justice issues has grown considerably and is now a key element in dealing with expanding urban development and climate-change impact.

The 1990s was also a time when USEPA began to seek to reduce rather than merely to regulate sources of pollution, beginning in 1990 when Congress enacted the Pollution Prevention Act. From an earlier focus on just controlling pollutants at the “end of pipe,” the focus expanded to preventing pollution, also known as “source reduction.” The USEPA launched many voluntary programs, such as the High Production Volume Challenge Program, which encouraged companies to make health and data on environmental effects available on high-volume chemicals produced or imported into the United States. Today, similar challenges, including voluntary pursuit of “zero waste to landfills,” can promote sustainability.

The USEPA’s focus on pollution prevention led to new programs that addressed product design and environmentally preferable purchasing. The agency recognized the need to work with industry to stimulate the design of products, processes, and technologies that are competitive but also environmentally preferable. Several nonregulatory, voluntary initiatives on safer chemical synthesis, comparative risk analysis, and alternative technology development merged to create USEPA's Design for the Environment (DfE) Program. Since 1992, this program has worked with scores of industrial sectors to encourage incorporation of environmental considerations, along with performance and cost, into decision-making. By promoting cleaner technologies, DfE encourages companies to pursue strategies that protect the environment more effectively and efficiently. During this era, USEPA helped to develop new tools such as life cycle assessment, which has become a standard part of the sustainability toolkit.

The Pollution Prevention Act also recognized the challenge of dealing with environmental issues in a more interconnected manner. Our environment, economy, and society are complex, interdependent systems. While we must enforce the Clean Air Act and the Clean Water Act, we must also recognize that air and water pollution are closely connected, and that they both impact economic growth and human well-being.

The need to integrate across USEPA programs was becoming more and more evident in the 1990s. This was not a new topic; breaking down silos has been a persistent challenge since the agency’s creation. Past USEPA administrators were well aware of the need for integrated systems thinking (Grossarth & Hecht, 2007).

- In the 1980s, Administrator Russell Train (1973–1977) expressed his concern with USEPA’s “compartmentalized nature” and its resulting ineffectiveness in dealing with pollutants, which “tend to move readily among air, water, and land.”
- Administrator Lee Thomas (1985–1989) stressed the need for cross-media reviews so that “we don’t just transfer pollutants from one medium to another.” USEPA made an effort in the early 1990s to advance integrated rulemaking through “cluster” working groups such as the pulp and paper regulatory cluster. Administrator William Reilly (1989–1993) highlighted the integral relationship between a healthy environment and a prosperous economy. He argued that economic activity depends on healthy natural systems and that economic growth can foster environmental protection.
- Administrator Carol Browner (1993–2001) launched the Common Sense Initiative in 1993, an experiment that addressed environmental management by industrial sectors rather than by different environmental media.

Despite these initiatives, progress on breaking down silos has been slow. Administrator Lisa Jackson (2009–2013) acknowledged the complexity of modern problems and the need for integrating
across air, water, and land programs when she launched a National Academy of Sciences study in 2011 on how to incorporate the concept of sustainability into USEPA (see the 2010s below).

The 1992 Earth Summit in Rio de Janeiro represented a major milestone in advancing sustainability. While the world’s various geographic regions came to Rio with different priorities, the final consensus and nonbinding strategy, called Agenda 21, was endorsed by all of the conference participants. This document covered a range of issues, combining efforts to combat poverty, to change consumption patterns, to monitor population dynamics, to promote sustainable economic development, and to integrate environmental awareness into decision-making.9

A major outcome of the Rio Summit was increased business support for sustainable practices. In preparing for the meeting, a group of leading CEOs organized the World Business Council for Sustainable Development (WBCSD). Swiss industrialist Stephan Schmidheiny chaired the Council and served as advisor to Maurice Strong, the Secretary-General of the conference. The WBCSD in turn prepared a groundbreaking book called Changing Course that outlined a business perspective for sustainable development, stating that “Business will play a vital role in the future health of this planet” (Schmidheiny, 1992).

Following the Rio Summit, Congress asked USEPA to explain its role in sustainable development. This was the first time that the agency addressed how best to incorporate sustainability into its overall management. In its reply, USEPA acknowledged the importance of achieving sustainability, but noted that it “has not employed the concept of sustainability explicitly in an overall policy framework or programmatic objective,” (USEPA, 1993). The report identified a number of concerns, including the “minor role that sustainability plays in USEPA’s statutory authority” and the fact that “the full scope of planning and implementation of sustainable development policies extended well beyond the purview of EPA.” The report concluded that the concept of sustainable development “provides a useful framework for discussion of the Nation’s long-term environmental and economic priorities, although these concepts have not been developed yet to the extent that they provide a basis for EPA’s operational planning.”

This report to Congress underscores some of the barriers and challenges that USEPA and other agencies face in advancing sustainability. These include the boundaries of the traditional regulatory framework and the need for interagency collaboration—issues that remain problematic even today. In hindsight, the report also failed to recognize the important role that science and technology could play in striving for sustainability.10 Nevertheless, following the Rio Summit, President Clinton established a President’s Council on Sustainable Development that met from 1993 to 1999 and developed a series of reports and recommendations for creating a more sustainable America.11 Clinton’s 1995 initiative, “Reinventing Environmental Regulations,” outlined USEPA measures to institute “a new generation of environmental protection” including building more efficient regulatory systems, advancing science and innovation, and building state and local partnerships.12 It identified twelve long-range but realistic goals, consistent with current laws, that aimed to link environmental protection, health, and social well-being and thus reflected sustainability as defined by the 1992 Rio Summit.

Of these twelve goals, a key one was to have “every American city and community free of air pollutants that cause significant risks of cancer or respiratory and other health problems.” Ten years later, a report entitled Environmental Goals for America with Milestones for 2005 acknowledged the progress made since the 1970s but also highlighted the significant challenges ahead. The report noted that one half of the American people lived in an area where the air is too polluted to meet current health standards and that 35 to 40% of American’s rivers and estuaries were too polluted to support fisheries.

The 2000s: Innovation and Stewardship

In 2003, USEPA Administrator Christine Todd Whitman (2001–2003) launched the agency’s first Report on the Environment (ROE). The underlying idea was to give the public a snapshot of environmental conditions in the United States and to establish a set of indicators or metrics to measure changes over time. Such an effort involves considerable difficulty in both identifying appropriate metrics and collecting reliable and scientifically defensible data. The use of indicators or metrics is crucial for tracking emerging problems and measuring success in addressing them.

The 2003 report was updated in 2008, and was later transformed into a new online resource in 2014.13 The most recent report provides interactive access to more than 80 indicators of environmental conditions in the United States and, for the first time, includes four sustainability indicators that relate envi-

9 The full report is at http://sustainabledevelopment.un.org/content/documents/Agenda21.pdf.
10 See http://www.granitestatefutures.org/pdf/EPA_UN_Connection.pdf.
11 See http://clinton4.nara.gov/PCSD/Publications/index.html.
12 See http://govinfo.library.unt.edu/npr/library/rsreport/251a.html.
13 See http://www.epa.gov/roe.
environmental conditions to social and economic trends. These new indicators measure the “intensity” of resource flows (energy, water, municipal solid waste, and hazardous waste) relative to population and economic growth and are consistent with global trends in sustainability tracking by both business and government organizations.

The value of these reports stems from the fact that they highlight current conditions and identify areas of success or trends that need addressing, such as the continuing rise in total energy consumption. The reports aim to inform key decision makers in state and local government, as well as the general public, on the effectiveness of current environmental management approaches and to support collective future actions. The USEPA and most federal agencies now advance the development and use of web-based technology for informing the public about critical environmental issues. For instance, the agency now has an active “Games and Activity” website for educators, as do the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS). A more sophisticated site for government and business decision makers is the newly released EnviroAtlas (2014), with mapping capabilities that display the status of ecosystem services in selected areas of the United States.

It had been clear since the 1990s that problem-solving requires multi-agency collaboration. This led USEPA Administrator Mike Leavitt (2003–2005) to advance the concepts of collaborative problem-solving and environmental stewardship. The related concept of collaborative conservation, as outlined in Executive Order 13352, required USEPA and four other agencies to “actively engage all stakeholders” when implementing conservation and environmental projects. This order was followed in 2005 by Administrator Steve Johnson’s (2005–2009) challenge to USEPA career managers of the Innovation Action Council (IAC) to develop an environmental-stewardship strategy for USEPA. In preparing this report, IAC sought input both from within USEPA and from state environmental commissioners, Native American tribes, environmental experts, and opinion leaders. In 2005, the final report, **Everyday Choices: Opportunities for Environmental Stewardship**, linked the ideas of stewardship and sustainability, noting the need for new policies, technological innovation, and greater scientific understanding of the complex biosphere, as well as support for responsible stewardship and decision-making by firms, investors, communities, and governments at all levels.

During this decade, a broader problem-solving approach was getting increased attention. While still maintaining a core of sound regulations, USEPA recognized the need for a more integrated, systems-based, and cross-media approach to better address the new century’s challenges. This required that the agency’s efforts be expanded to collect, develop, synthesize, and disseminate integrated scientific and technical information; to identify metrics for determining progress toward national sustainability goals; to formulate cost-effective and innovative solutions consistent with smart economic growth; and to attract a new generation of exceptional minds by making the search for talent a strategic priority.

During this period, the new discipline of sustainability science was emerging as a basis for sustainable solutions. Kates (2001) and his colleagues identified seven critical questions concerning sustainability:

1. How can the dynamic interactions between nature and society—including lags and inertia—be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?
2. How are long-term trends in environment and development, including consumption and population, reshaping nature-society interactions in ways relevant to sustainability?
3. What determines the vulnerability or resilience of the nature-society system in particular kinds of places and for particular types of ecosystems and human livelihoods?
4. Can scientifically meaningful “limits” or “boundaries” be defined that would provide effective warning of conditions beyond which the nature-society systems incur a significantly increased risk of serious degradation?
5. What systems of incentive structures—including markets, rules, norms, and scientific information—can most effectively improve social capacity to guide interactions between nature and society toward more sustainable trajectories?
6. How can today’s operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?
7. How can today’s relatively independent activities of research planning, monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning?

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14 See [http://water.epa.gov/learn/kids/drinkingwater/gamesandactivities.cfmiste](http://water.epa.gov/learn/kids/drinkingwater/gamesandactivities.cfmiste), [http://games.noaa.gov](http://games.noaa.gov), [http://water.usgs.gov/edu](http://water.usgs.gov/edu).
15 See [http://www.epa.gov/research/enviroatlas](http://www.epa.gov/research/enviroatlas).
16 See [https://www.fedcenter.gov/Bookmarks/index.cfm?id=57](https://www.fedcenter.gov/Bookmarks/index.cfm?id=57).
Building on these elements of sustainability science, USEPA developed its first Sustainability Research Strategy (2007). The agency’s sustainability research strategy encouraged program offices to move toward developing sustainable water infrastructure, managing materials rather than waste, overseeing ecosystems and ecoservices, and emphasizing green chemistry and urban sustainability (including green-building design and low-impact development).

The agency further advanced these concepts in a report called Sustainable Materials Management: The Road Ahead, which built on a 2002 report, Beyond RCRA: Waste and Materials Management in the Year 2020, to advance a roadmap for fulfilling human needs while using less material. The more recent report advanced new approaches for reducing lifecycle impacts across the supply chain, requiring fewer material inputs (reduce, reuse, recycle), using less toxic and more renewable materials, and considering whether services can be substituted for products. All of the above actions were reflected in remarks to Resources for the Future by Administrator Johnson who said, “I believe America is moving into a new phase of environmental protection…evolving from pollution control to pollution prevention to sustainability.”

On the international front, the new American agenda fed into the next international sustainability conference, the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, which resulted in over 260 government-business and nongovernmental organization (NGO) partnerships to advance sustainable outcomes. The USEPA, the United States Agency for International Development (USAID), and several other federal agencies were engaged in many of these new partnerships, such as the “Water for the Poor” initiative, which addressed the concern that more than one billion people lack access to clean water. Clean energy initiatives included a Partnership for Clean Fuels, where USEPA played a key role in advocating elimination of leaded gasoline and reduction of sulfur in diesel and gasoline fuels. In the Johannesburg Declaration, heads of state also recognized that to change current patterns of consumption and production was one of the “overarching objectives of and essential requirements for sustainable development.”

Following the WSSD meeting, many state and local governments in the United States began to take a leadership role in advancing sustainability. The governors of Washington State and Oregon issued executive orders guiding government procurement and polices, Minnesota established sustainability goals and indicators, and New Jersey became a leading proponent for state-level green planning. In addition, many major cities adopted sustainability principles to guide their operations, including reduction of greenhouse-gas emissions. The USEPA, in partnership with the federal Department of Housing and Urban Development (HUD) and the Department of Transportation (DOT), is today providing significant resources to help cities and states advance sustainability planning. At the end of the decade, in 2009, President Obama signed Executive Order 13514 on Federal Leadership in Environmental, Energy, and Economic Performance instructing federal agencies to prioritize reduction of greenhouse-gas emissions and to prepare annual sustainability strategies that would shape their internal operations.

The 2010s: Growing Global Footprint and New Directions for USEPA

It is abundantly clear today that the world faces a growing number of problems related to climate change, population growth, expanded industrial development, and urban development. A report from the Global Footprint Network estimated that, if current trends continue, by the 2030s we will need the equivalent of two Earths to support the world’s population.

How do we deal with these problems? While it may be clear that new strategies are needed, such as system science, integrated air-water-land approaches, and collaborative problem-solving, it is still a challenge to develop bipartisan support for USEPA and other agencies to expand on their existing legislative mandates. One agency effort to build a consensus on future actions was to commission the turn to the National Academy of Sciences (NAS) in 2010 to prepare a report on making sustainability operational at USEPA (National Research Council, 2011). The USEPA gave the NAS panel four charges:

1. What should be the operational framework for sustainability for USEPA?
2. What scientific and analytical tools are needed to support the framework?
3. How can USEPA decision-making processes

17 See http://epa.gov/research/sciencematters/april2011/pdf/EPA_12057_SRS_4.pdf.
18 See http://www.epa.gov/smm/vision.htm#vision2.
19 See http://www.rff.org/Publications/Resources/Documents/165/RFF-Resources-165_StephenJohnson.pdf.
20 See http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/Engl is h/ WSSD Plan Impl.pdf.
21 See http://www.footprintnetwork.org/en/index.php.
22 See http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/pdf/E9-24518.pdf.
23 See http://www.epa.gov/livability/partnership/index.html.
rooted in the risk-assessment/risk-management paradigm be integrated into this new sustainability framework?

4. What expertise is needed to support the framework?

The resulting NAS report, widely called the “Green Book,” made a number of significant recommendations, including going beyond the risk paradigm and adopting a sustainability framework with an emphasis on assessment of economic, social, and environmental impacts. The study affirmed that, while significant progress has been made on environmental protection, the United States now faces new and more complex challenges, and “that more traditional approaches to environmental protection are not likely to be effective.” The NAS report specifically called for USEPA to adopt a sustainability framework for decision-making. It also made clear that “sophisticated tools are increasingly available to address the complex and challenging issues that go beyond current risk management or major threats.”

All of the report’s recommendations received strong support from “listening sessions” involving USEPA stakeholders and representatives of other federal agencies. However, reflecting the age-old problem of “mission creep,” the report also evoked some criticism. For example, Fox News asserted that USEPA “wanted to change how it analyzes problems and makes decisions, in a way that would give it vastly expanded power to regulate businesses, communities and ecosystems in the name of “sustainable development” (Russell, 2011). Nevertheless, the recommendations in the Green Book and subsequent USEPA actions are in no way an expansion of regulatory authority, but rather an effort to address problems with an integrated and pragmatic approach. The NAS study prompted Administrator Lisa Jackson (2009–2013) to articulate that “the time is now” for the principles of sustainability to help guide the agency in solving current environmental problems.

Reflecting the recommendations in the NAS Green Book, USEPA’s Office of Research and Development (ORD) in 2011 realigned its multiple research arms into six consolidated programs, all of which emphasize systems thinking and development of sustainable solutions. The ORD also expanded its efforts to demonstrate application of systems science and business-government collaboration in what was called an “innovation cycle for sustainability,” where stakeholder engagement plays a key role in guiding innovation (Hecht et al. 2014). The concept of “systems thinking” has emerged as a holistic approach for understanding the dynamic interactions among complex economic, environmental, and social systems, and for evaluating the potential consequences of new policies, technologies, and operating practices. There is a vast and growing literature on systems thinking, and the environmental and ecological sciences have been an important domain of application (Odum, 1994; Holling, 2001).

The USEPA has begun applying systems thinking to advance sustainability, using the Triple Value Model shown in Figure 2. First developed for the Organization for Economic Cooperation and Development (OECD), the Triple Value Model is a framework for systems thinking that explicitly defines the linkages and value flows among three major catego-

![Figure 2 The triple value model: linkages among environmental, social, and economic systems.](image-url)
ries of systems—industrial, societal, and environmental (Fiksel, 2012). Moreover, using this framework it is possible to construct policy-simulation models that enable integrated assessment of the costs and benefits of proposed interventions.

This model is currently being applied in New England, where USEPA’s Region 1 and ORD launched a pioneering study on a systems-modeling approach to address nutrient impairment in sensitive waterways. The approach was piloted in the Narragansett Bay watershed, resulting in a policy-simulation tool that draws upon extensive stakeholder input. The tool, called Narragansett–3VS (Triple Value Simulation), features a dashboard-style interface that enables users to explore different scenarios, interpret results, and evaluate outcomes of new policies or interventions. The USEPA and its regional partners are using this model to support strategic dialogue about alternative policies for water-resource management, which helps to build shared understanding among diverse groups including state and local governments, technical experts, and concerned citizens.24 Region 1 is now replicating this systems approach in the Cape Cod area and similar 3VS models are being designed to address sustainability issues in other regions of the United States (Fiksel et al. 2014).

The next step in implementing the NAS recommendations is reflected in the USEPA 2014–2018 Strategic Plan, which identifies “Working toward a sustainable future” as a cross-agency goal. Building on the long history described in this essay, the agency’s strategic plan states:

EPA will consider and apply sustainability principles to its work on a regular basis, collaborating closely with stakeholders. Our traditional approaches to risk reduction and pollution control cannot always fully achieve our long-term and broad environmental quality goals. The interplay between different environmental statutes and programs also requires renewed attention to improve “synergy” and long-term solutions. To this end, EPA will also embrace a commitment to focused innovation to support solutions that will advance sustainable outcomes.25

Considering that the first mentions of sustainability can be traced back to the 1970 NEPA vision, the 1987 Brundtland Report, and the 1992 and 2002 United Nations conferences, it has taken a long time to adopt this agency-wide goal. The setting today is more conducive than in the recent past, as evidenced by the United Nations Conference on Sustainable Development in 2012, organized on the 20th anniversary of the original event in Rio de Janeiro, with the theme of “The Future We Want.” The conclave resulted in governments and businesses making over 700 pledges to action, amounting to approximately $500 billion. The outcome of this meeting clearly demonstrated the global business commitment to achieving sustainable practices, as well as the importance of business-government collaboration (Hecht et al. 2012).

**Lessons Learned and Next Steps**

The rationale behind this Community Essay is that we all must study history and plan ahead to avoid unsustainable practices and unintended consequences. History examines the past, but it can also suggest a vision of the future. “That men do not learn very much from the lessons of history is the most important of all the lessons of history,” wrote Aldous Huxley (1959).

USEPA was created in the 1970s to deal with obvious environmental problems, but the problems of today are far more complex. The Earth’s natural resources are being stressed by the rising demand for land, water, and energy. Continued economic growth requires effective land-use management and sustainable manufacturing and production. And social well-being requires eliminating poverty, improving human health, and expanding employment. Climate change, possible national conflicts over natural resources, rising costs of commodities and energy, and other risks threaten outcomes in environmental protection, economic growth, and social well-being.

Moreover, the future course of world affairs is unpredictable, and any strategy that relies on the status quo, or business as usual, will be challenged by chaotic external pressures and turbulent change. The planetary ecosystem will be under even greater pressure by 2050 when global population will exceed 9 billion, some 30% higher than 2000. Realizing the concepts of sustainability and resolving the dilemma of “sustainable growth” in both developed and developing nations will remain a challenge.

The history covered in this Community Essay makes one thing clear. The problems that society faces today are not due to lack of scientific knowledge, but rather the need to develop policies and approaches that promote economic development with minimal adverse impact on the environment. More effective government-government and

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24 See http://www.epa.gov/research/docs/3vs-tool-nutrient-mgt-narr-bay.pdf.
25 See http://www2.epa.gov/sites/production/files/2014-04/documents/epa_strategic_plan_fy14-18.pdf.
government-business-society collaboration is needed to address today’s problems while avoiding future ones.

In the twenty-first century, USEPA must continue to expand its activities beyond its traditional roles as a regulator and risk assessor. It must redouble its efforts to overcome management challenges such as silos separating programs and/or agencies; be flexible and innovative in implementing existing regulations; engage stakeholders to understand their needs, constraints, and priorities; encourage partnership and collaboration among government, business, and NGOs to design comprehensive approaches; and develop decision-support capabilities to help policy makers and decision makers implement sustainable and resilient solutions.

To advance the strategy of “working toward a sustainable future,” and drawing on the lessons in this Community Essay, we propose the following seven next steps:

1. **Develop Clear Sustainability Goals**

   A common vision helps drive actions and hence USEPA should establish a number of sustainability goals. One starting point is to identify shared goals between business and government, such as sustainable manufacturing, resource productivity, and waste reduction. These objectives can be achieved by reducing toxic chemicals in products and increasing recycling; managing materials rather than waste to enable more efficient production and reuse; and reducing the intensity of energy, water, and material use in production and supply-chain operations. The USEPA can similarly identify goals in common with cities and communities, such as increased green infrastructure to control stormwater runoff, harnessing of ecosystem services to reduce community costs, enhanced resilience in the design and management of infrastructure, and elimination of harmful environmental and health impacts on disadvantaged communities.

2. **Develop Flexibility in Rule-Making and Integrate Activities Across All USEPA Programs**

   Drawing on the lessons of the past 40 years, it is clear that USEPA must integrate regulatory activities across its air, water, land, and chemical programs. These linkages are crucial in addressing issues such as the energy-water-land nexus, sustainable agriculture, waste management, and urban development. To avoid piecemeal solutions, USEPA should change some core program processes in setting regulations, permitting, and enforcement. One successful model is the advancement of green infrastructure as an alternative to costly “gray” infrastructure. The USEPA must work internally to define multiple ways to create linkages across programs, and engage with other agencies to jointly address key sustainability problems where multi-agency regulations are involved. Today, USEPA is committed to breaking down silos and working on linkages among air, water, land, and waste. For example, a major effort on the energy-water nexus is now being pursued by several USEPA programs as well as by states and other agencies.

   The USEPA is also demonstrating flexibility in permits as in the case of the Kendall Power Station in Boston, where discharges of hot water into the Charles River were harming fish and recreational activities. In February 2011, USEPA’s New England Regional Office issued an innovative wastewater permit that calls for converting the waste stream (thermal discharge) into a valuable product (steam) and piping it across the river for sale in Boston. In addition to significantly improved water quality, the arrangement yields improved air quality by replacing steam from older, coal-burning boilers. The local power station earns revenue from the sale of steam, and new jobs have been created to construct the conduits carrying the steam from Cambridge to Boston.

3. **Promote Resilience and Sustainability**

The increasing turbulence of the global economy, coupled with climate volatility, has led to renewed interest in resilience at multiple scales, ranging from local governments to multinational enterprises. Resilience can be defined as “the capacity for a system to survive, adapt, and flourish in the face of turbulent change and uncertainty” (Fiksel, 2007). For example, ecosystems such as forests and wetlands are capable of recovering from severe damage and evolving in response to changing conditions. In contrast, systems designed by humans are vulnerable to natural disasters, technological failures, and other disruptions.

   A recent NRC (2012) study underscores the need to build greater resilience in communities, including flexibility, adaptive capacity, and infrastructure redundancy. This report recommends that the federal government “incorporate national resilience as a guiding principle,” while a second study identifies “enhancing resilience of communities to extreme events” as one of four priority areas for interagency collaboration to improve sustainability (NAS, 2013). As advanced by Executive Order 13636, the concept of resilience is now being implemented across federal agencies.

   Events drive action, and one of the most visible global trends has been the sharp increase in natural catastrophes during the past three decades, which has

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26 See [http://www.ncsl.org/research/environment-and-natural resources/overviewofthewaterenergynexusinthesouth.aspx](http://www.ncsl.org/research/environment-and-naturalresources/overviewofthewaterenergynexusinthesouth.aspx).
been linked to climate change (Kuczinski & Irwin, 2012). Other destabilizing pressures include rapid urbanization, resource depletion, and political conflicts. As planetary systems become more tightly coupled and volatile, the incidence of “black swan” events (those that are deemed improbable yet have massive consequences) seems to be increasing (Taleb, 2007). These stressors have led to a rethinking of national security priorities and a new emphasis on resilience in both business and government affairs.

Generally speaking, sustainability and resilience are mutually reinforcing. The more sustainable we are, the less we expose ourselves to unpredictable disruptions. The more resilient we are, the less we risk compromising our future well-being. Therefore, sustainability enhancement efforts should consider the resilience of both human and ecological systems. In other words, we need to improve our capacity to adapt to changing conditions like fuel prices and to buffer against unforeseen disruptions such as natural disasters. In a complex and turbulent environment, resilience is essential for achieving sustainability, as well as national security and economic prosperity.

Today, many urban communities are concerned about resilience in the face of the “stress nexus” that connects water, energy, and food. Dwindling water resources threaten to disrupt energy and food production, while rising energy prices are likely to lead to increasing costs for supplying both food and water. Moreover, these critical resources are dependent on the availability of land, materials, and infrastructure, all of which, in turn, depend on natural capital. Currently, USEPA is working to incorporate awareness of resilience into the tools and indicators used to enhance decision-making. For example, the National Homeland Security Research Program has developed a framework of resilience indicators that considers all hazards, ranging from terrorism to industrial accidents to natural disasters.27

4. Develop and Implement System Science and Decision Support Tools

The best decisions are made when there is a clear sense of the expected consequences—not an easy task in a complex and changing world. The House Committee on Science in its 1998 report entitled Unlocking Our Future advanced the idea that science and scientific tools should improve decision-making:

While acknowledging the continuing need for science and engineering in national security, health and the economy, the challenges we face today cause us to propose that the scientific and engineering enterprise ought to move toward center stage in a fourth role; that of helping society make good decisions. We believe this role for science will take on increasing importance, as we face difficult decisions related to the environment.

It is here that systems thinking can play an important role in revealing the hidden consequences of proposed actions. The USEPA and other agencies have now embraced development and implementation of many instruments to inform decision-making and to help achieve more resilient and sustainable outcomes, such as the 3VS tool described earlier. The USEPA has published an extensive inventory of science-based assessment tools and approaches that are available to support sustainable decision-making.28

In its air, water, and community programs, USEPA has developed a large number of decision-support tools. One such instrument that has been widely tested the Community-Focused Exposure and Risk Screening Tool (C–FERST), a user-friendly guide to community mapping, information access, and decision support, helping to assess risks, set priorities, and inform decisions affecting public health. The ORD is partnering with programs of USEPA and other federal agencies to implement C–FERST in selected communities.29

Another example is a tool called PLACES (Planning Land and Communities to be Environmentally Sustainable) that encourages and enables local jurisdictions to direct their land-development strategies to sustain the ecosystem services necessary to protect the environment and human health.30

Similarly, the National Stormwater Calculator tool, released in 2013, is a desktop application that estimates the annual amount of stormwater runoff from urban drainage systems at a specific site, based on local soil conditions, slope, land cover, and historical rainfall records.31 It supports planning, analysis, and design of alternative stormwater-management systems to reduce flooding, combined sewer overflow, nutrient impairment of water bodies, and health risks. Users can enter any location in the United States and select different scenarios to evaluate a variety of green-infrastructure methods, such as porous pavement and bioretention landscapes.

The challenge ahead is to better inform the public and all stakeholders on the availability of such

27 See http://www.epa.gov/sustainability/analytics/resilience.htm.
28 See http://www.epa.gov/ordntntr/ORD/NRMRL/irpcd/projects/places.htm.
29 See http://www.epa.gov/hsad/c-ferst/.
30 See http://www.epa.gov/ordinmtr/ORD/NRMRLLrpcd/projects/places.htm.
31 See http://govinfo.library.unt.edu/npr/library/rsreport/251a.html.
Table 2 Points to consider for actions affecting sustainability and resilience

| Sustainability Questions                                                                 | Resilience Questions                                                                 |
|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 1. Will the action protect human health and the environment? Will it integrate and optimize | 1. Does the action take into account the full spectrum of risks and disruptive forces that may affect both human and natural well-being? |
| environmental, economic, and social benefits?                                               | 2. Does the action recognize the interdependence of the built environment, infrastructure, and the biophysical environment, including the potential for cascading failures? |
| 2. Will the action conserve natural resources—energy, water, materials, land, ecosystems, and | 3. Will the action help to reduce the exposure and vulnerability of critical industrial and ecological assets to extreme events, such as natural disasters or catastrophic failures? |
| air—through prudent use/reuse, protection, and/or restoration?                              | 4. Does the action increase the inherent robustness, reliability, flexibility, agility, and/or effectiveness of existing economic and social activities, even for unforeseen threats? |
| 3. Does the action reflect an orientation toward life cycle, multimedia integration, pollution prevention, minimizing wastes and toxics, and advancing multiple goals through systems thinking? | 5. Does the action result from considering a diverse portfolio of resilience capabilities available from both public and private organizations that share common goals? |
| 4. Does the action consider the full diversity of available policy and program tools to stimulate and reinforce sustainable outcomes, innovating and collaborating wherever necessary? | 6. Does the action seek to strengthen the resilience of existing systems by learning from prior disruptions and adapting, rather than simply returning to “normal” operation? |
| 5. Will the action improve people’s lives, creating better and healthier communities rather than just correcting problems? Does it consider vulnerable populations (e.g., children and the elderly) who may bear disproportionate burdens? | 7. Will the action identify leading indicators of potential disruptions, keep track of external forces and trends, and identify new scenarios that may create future challenges? |
| 6. Does the action identify meaningful sustainability outcomes and include appropriate metrics? Are there plans to track progress, learn from experience, innovate, and adapt? |  |
| 7. Does the action include plans to share as much information as possible and engage citizens to take active responsibility for achieving sustainable outcomes? |  |

5. **Promote Government-Government and Business-Government Collaboration**

Government collaboration and business-government partnerships are keys to achieving sustainability. One successful example of effective inter-agency cooperation is the Partnership for Sustainable Communities among USEPA, HUD, and DOT to promote adoption of sustainable community practices. In 2009, the three agencies agreed to work together on critical urban development goals. They have worked together to help communities set a vision for sustainable growth and apply federal transportation, water-infrastructure, housing, and other investments in an integrated approach to better protect the environment and reduce greenhouse-gas emissions. The agencies also collaborated on tools and metrics to benchmark existing conditions, measure progress toward achieving community visions, and increase accountability. This partnership also aims to remove barriers against coordinated housing, transportation, and environmental protection investments. Today, in areas such as urban resilience, broader partnerships are needed among federal agencies, states, cities, and the business community.

6. **Anticipate Risk and Take Steps to Avoid, Reduce, and Mitigate Future Problems**

In the coming decades, USEPA’s mission must be expanded to ensure long-term environmental quality and sustainability. It is unfortunate that government and business often engage with serious problems only after a disaster has occurred. While we have long debated how to respond to climate change, it took Superstorm Sandy to propel actions on resilience and climate adaptation. Events like this can drive action but can also cost billions of dollars. We do not want a world where we have to rebuild our institutions because of environmental or economic disasters. The USEPA and other agencies must expand the risk paradigm and adopt a new role as innovative problem-solvers focused on environmental stewardship and resilience at a broad scale. Sustainable development must avoid Benjamin Franklin’s adage that “It is not until the well runs dry that we know the worth of water.” To this end, USEPA must work with all stakeholders to recognize early warning signals and take anticipatory steps.

7. **Promote Greater Public Understanding of the Links Between Environment and Economy to**
Advance Greater Stewardship of the Environment

The USEPA’s ability to create leverage by partnering with business and state and local governments will be limited if the public still regards the agency’s role as strictly regulatory. Back in the 1970s, USEPA began to reach out to the public. One effective educational tool, called “Documerica,” hired freelance photographers to capture images relating to environmental problems and everyday life. In light of current political divisions and attacks on USEPA, the agency must do more to expand its role as an educator and build public understanding of and support for sustainability. The agency must work with communities, cities, states, and academic institutions to make the practice of resilience and sustainability an American reality. Table 2 illustrates the types of questions that USEPA employees and stakeholders should address regarding their day-to-day decisions and actions.

Conclusion

This Community Essay has offered an historical perspective on USEPA actions toward sustainable development. Today, more than ever, there is a growing understanding of the linkages among economic growth, social well-being, and environmental protection. While existing regulations provide an important environmental safety net, they are not sufficient to deal with today’s complex and interdependent problems. In the future, government and businesses must collaborate to ensure strong economic growth while protecting the environment. To address the problems of the twenty-first century, society needs a combination of strategies, including creative use of existing environmental policies and regulations, innovative application of science and technology, and partnership and collaboration among stakeholders. Public understanding and bipartisan support for the goals and process of sustainability will be critical to making these changes possible.

Authors’ Note
Views expressed in this article are those of the authors and do not necessarily reflect the views or policies of USEPA. Mention of trade names or commercial products does not constitute agency endorsement or recommendation for use.

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33 See http://www.flickr.com/photos/usnationalarchives/collections/72157620729903309.
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