

Review Article

Past, Present and Future Challenges To Science and Sustainability At EPA: A Review

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Abstract

This paper reviews critical actions taken by EPA since the 1992 Rio Earth Summit to overcome its single media approach to environmental protection and advance the concept and practice of sustainability. Sustainability is defined as both a goal and a process that link economic growth, social well-being and environmental protection. Progress to the goal of sustainability has been slow since 1992 and more expedient action is needed today to address the growing pressures of climate change, urban population growth and social disparities, resource depletion, and increases in extreme weather events. To address future problems and achieve sustainable outcomes, EPA and all federal agencies must aim to

1. Anticipate and Responding To Future Trends;
2. Recognize the Nexus of Food-Energy-Water Systems and Links to Environmental and Social Justice;
3. Apply an Integrated Systems Approach to Problem Solving;
4. Use a Suite of Decision Support Tools to Help Decision Makers Understand The Consequence of Their Actions;
5. Recognize the Need For Flexible Environmental Management and External Collaboration.

The Adoption By The United Nations of 17 Sustainable Development Goals (Sdg) is A Clear Statement of Future Needs and A Driving Force For Action.

Keywords: EPA and Sustainability; Sustainability Science; Systems Thinking; Nexus Food-Energy-Water

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Introduction:

"We live in troubled times, but I feel good about myself, about my homeland and about all nations, and yes, about the future of humanity. And I will tell you why; I am on painkillers."

David Barry, March 22, 1999.

Putting the concept of sustainability into practice is more urgent today as we face increased challenges due to adapting to climate change and the increase in disaster and severe events, population growth, which in turn increases the stress on food, energy, water and ecosystem and biological losses. The recent adoption by the United Nations of 17 Sustainable Development Goals (SDG) is a clear statement of future needs and is a driving force for action. The goals and targets (see last section of this paper) aim to stimulate government and business actions over the next 15 years.

This paper shows how EPA has evolved to address the concept of sustainability by overcoming its traditional challenges of:

- How can a regulatory agency whose historic roots lie in controlling pollution implement the concept of sustainability?
- How does an agency organized by individual media offices (air, water, land) develop an integrated-systems approach to environmental protection?
- How does a federal agency without a specific mandate for sustainability promote and achieve sustainable development?

These challenges were clearly identified by the Organization for Economic Cooperation and Development (OECD) in their first "Environmental Performance Review" of the US in 1996. The OECD noted that "despite overall concern about the environment, the focus is still on separate issues and on remedying environmental deterioration rather than on the underlying causes of environmental problems." [1]

One way to break down silos is adopting an integrated and systems approach to environmental management. This was advanced in the EPA Strategic Plan (2000) which noted that "In the natural environment, air, land and water are not separate; they interact in complex subtle ways not always immediately apparent. Nature does not recognize the artificial distinctions created by legislation or regulatory programs that focus on single medium or pollutant, and EPA science must reflect these very real and powerful dynamics."

Today we call this the nexus of food-energy-water and land use. In practice achieving integrated management remains a major challenge as noted in a special issue of *Nature* (September 2015) which said that to "tackle the challenges facing society — energy, water, climate, food, health — scientists and social scientists must work together. Yet research that transcends traditional academic boundaries is still on the margins." [2]

Based on advances in science, management flexibility and multi-agency cooperation, EPA has taken many critical steps to advance sustainable operations. While progress has been slow, growing external pressures today demand more accelerated and integrated activities and a strong focus on integrated and system thinking. No long term trend, whether it be population growth or mega drought can be addressed by only one piece of legislation or thought one scientific area.

Hence, in looking ahead, what society needs is not painkillers, but innovation in science, flexibility in management, strong stakeholder collaboration, especially business and government and enhanced public understanding.

What is Sustainability?

The goal of sustainability was a vision cited in the 1970 National Environmental Policy Act (NEPA) which aimed to create and maintain "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."

Sustainable development was later defined in the 1987 UN Report "Our Common Future" as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [3] The UN Report noted that "sustainable development is a *process of change* in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations."

Following this 1987 Report, nations of the world met in Rio de Janeiro in 1992 for the Earth Summit on Sustainability. The outcome of that summit was an international plan called "Agenda 21," which is a non-binding agreement offering recommendations that nations, states or local governments could adopt. Agenda 21 aimed to support the process of change through scientific, policy and management recommendations that aimed to promote sustainable practices around the world. [4]

Since the Rio Summit, the definition and application of sustainability has been widely debated and is viewed today as:

- Both a **goal and a process** for dealing with problems

of the 21st century. The goal is to protect our future generations; the process involves use of technology, tools and approaches to achieve sustainable outcomes. Hundreds of decisions support tools are now available to help communities understand potential impacts of decisions. See for example GIWiz an interactive EPA web application that connects communities to EPA Green Infrastructure tools & resources. [5]

- Promoting actions to **improve** long term conditions rather than just sustaining or maintaining current conditions. Understanding long term trends, such as population growth and impact on society, is critical for building resilient and sustainable communities.
- Applying **integrated management** to problem-solving by recognizing the **nexus** of land-air-water-food actions and the need for systems thinking and resilient outcomes. Water, energy, food production, and land use must be considered in an integrated manner. For example, in the US today electricity generation accounts for about 40 percent of US freshwater withdrawals, while agriculture accounts for about 70 percent of total global freshwater withdrawals.
- Driving **innovation** in business practices and government management aiming not just to reduce the global footprint but improve production and operations. EPA has a long history of advancing innovation such as green chemistry and launching its “Technology for Sustainable Grants program.” [6] One example today of innovation in science is the White House initiative (2015) on “Smart Cities” which advances technology application across all agencies and business-government collaborations to help cities deal with rising social, economic and environmental problems. [7] In the business world, after examining sustainability initiatives in energy and manufacturing at 30 large corporations, a 2009 study published in the Harvard Business Review concluded that “sustainability is a mother lode of organizational and technological innovations that yield both bottom-line and top-line returns” and that “there is no alternative to sustainable development.” [8] According to the Dow Jones Sustainability Indexes: “Sustainability is a business approach that creates long-term shareholder value by embracing opportunities and managing risks that derive from economic, environmental and social developments.” [9]

nerships and public understanding. This is especially true for EPA, which is often criticized for imposing new regulations and or burdens on society. Advancing sustainability does not require new regulations, but requires strategic management and collaboration among government and business from national to local levels. The goal today at EPA is that “sustainability isn’t part of our work, it’s a guiding influence for all of our work.” [10]

Foundation of Government Actions

In practice government actions are largely driven by a “pressure-state-response” (PSR) framework. *Pressure* refers to obvious environmental or economic issues demanding immediate attention. Here events often drive action. *State* refers to the environmental, political and economic concerns and business-government conflicts which impact decision-making. This is best illustrated by the long term conflict on dealing with climate change, *Response* refers to specific actions taken.

Table 1 shows the PSR framework for EPA since the 1970s. The first real focus on sustainability came after the 1992 Rio Earth Summit, when Congress asked EPA to prepare a report on its actions related to sustainability. This EPA Report to Congress recognized the existing barriers and outlined future challenges. It is here that the history in this paper begins. A broader historic view from the 1970’s to today, evolving from pollution control to pollution prevention to resilience and sustainability, is given by Hecht and Fiksel (2015.) [11]

Table 1

Pressure	State of Affairs	Response
<p>1970s</p> <p>Obvious sources of air, water and land pollution.</p>	<p>“Bipartisan popular demand for federal leadership in solving the pollution problem.”</p> <p>See: Richard Andrews, The EPA at 40: An Historic Perspective.” *</p>	<p>Congress passes media centric legislation including: 1970 Clean Air and Clean Water Act; 1973 Endangered Species Act; 1974 Safe Drinking Water Act; 1976 Resource Conservation and Recovery Act and 1980 Superfund Act.</p>

A critical part of the process of advancing the goal of sustainability is stakeholder engagement, business-government part-

<p>1980s</p> <p>Growing pressure on risks to human health.</p> <p>Progressive degradation and of the earth's natural resources.</p> <p>Poverty and environmental degradation in developing countries.</p>	<p>Environmental backlash. Between 1980 and 1983, the EPA lost one-third of its budget and one-fifth of its staff.</p> <p>Beginning of national debate on climate change.</p> <p>International attention on sustainability: 1987 UN Report on Sustainable Development.</p>	<p>Legislative amendments to RCRA and Superfund Acts</p> <p>1987 EPA "Unfinished Business" **</p> <p>1983 National Research Council (NRC) report on Risk Assessment ("Red Book".</p> <p>EPA expands activity on both health and the environment.</p>	<p>2000s</p> <p>Growing concern about emerging problems and long term trends.</p> <p>World Summit on Sustainable Development growing pressures for stakeholder engagement and partnerships.</p>	<p>Extensive political conflict over environment and climate change.</p> <p>Sagging U.S. economy and global economic recession.</p> <p>Business community, states and cities converging on advancing sustainability operations.</p>	<p>First EPA <i>Report on the Environment (ROE)</i> on indicators to track environmental conditions</p> <p>EPA advances "Our Common Future," and Sustainability Research Strategy (2007)</p> <p>2009, EPA, HUD and DOT "Partnership for Sustainable Communities."</p>
<p>1990s</p> <p>Growing impact of environmental pressures on disadvantaged communities-environmental justice.</p> <p>1992 Rio Summit and push for sustainable development.</p> <p>Beginning recognition of need for integrated management and growing concerns about long term trends.</p>	<p>Public attention on global issues including acid rain, deforestation and climate change.</p> <p>Business commitment to sustainability development.</p> <p>President Clinton 1995 calls for new era of environment management focusing on "reinventing environmental regulations."</p>	<p>1990 Creation of EPA Office of Environmental Justice</p> <p>1990 Pollution Prevention Act</p> <p>Post Rio creation of "President's Council on Sustainable Development" and focus on science and technology.</p> <p>1993 EPA Report to Congress on Sustainability.</p> <p>1994 Technology for Environment (TSE) grants program.</p> <p>1995 OSTP Bridge to a Sustainable Future focuses on science and technology.</p>	<p>2010s</p> <p>Climate change impacts.</p> <p>Extreme events drive need for resilient systems.</p> <p>Increase of extreme weather events.</p>	<p>Super storm Sandy creates new focus on resilience.</p> <p>Rising cost of dealing with extreme events.</p> <p>Focus on climate adaptation and sustainability goals.</p>	<p>2011 NRC Report on "Sustainability at EPA"</p> <p>National Climate Strategy and</p> <p>2014-2018 EPA Strategic Plan</p> <p>UN Sustainable Development Goals.</p>

*See article on EPA history. This may be one few times of bipartisan support for EPA rules and regulations. <http://scholarship.law.duke.edu/delpf/vol21/iss2/2/>.

**In 1986 and 1987, about 75 senior career managers and staff compared the relative risks posed by 31 environmental problems within four broad categories of risk: 1) human cancer risk, 2) human non-cancer health risk, 3) ecological risk, and 4) welfare risk. The Report was affirmed that business-as-usual was not path forward in the face of the environmental risks of the 1990s and beyond.

Post Rio Business Leadership

A critical outcome of the of the Rio Summit was the creation of the World Business Council for Sustainable Development (WBCSD) and the publication of the book *Changing Course* by Stephen Schmidheiny (1992.) [12] Schmidheiny, founder of the WBCSD, argued that for companies to successfully compete domestically and internationally, they must adapt to new market conditions, which include concerns about the environmental impacts of their products as well as their process and

production methods. In organizing the BCSD, he recognized the commercial and environmental benefits of “greening of industry” and became a strong advocate for sustainable development and industrial ecology. This built on work already begun by the European Union which aimed in its 2000 Lisbon Report to become the most competitive and dynamic knowledge-based economy in the world.

From 2000 on business support for sustainable development has grown steadily. In 2012 on the 20th anniversary of the 1992 Earth Summit, government and business leaders meeting again in Rio committed made over 700 commitments and pledges of near 500 billion dollars for collaborative actions. The outcome of the meeting clearly demonstrated the global business commitment to achieving sustainable practices, as well as the importance of business-government collaboration.

1993 EPA Report to Congress: Barriers to Overcome to Achieving Sustainability:

Following the Rio Summit, Congress asked EPA to prepare a report on “Sustainable Development and the Environmental Protection Agency” and “describe in detail how EPA has incorporated or plans incorporate the concept of sustainable development into the Agency’s operations.”

In response to Congress, the EPA Report acknowledged that EPA has not employed the concept of sustainability explicitly in its overall policy programs. EPA has “developed its programs and projects primarily to fulfill statutory mandates that do not specify sustainability as an objective.” The Report did however offer good insight into the problem of making sustainability operational and identified four critical factors that needed to be addressed in shaping future activities. [13]

1. The “minor role that sustainability plays in EPA’s statutory authority.”
2. “In contrast to the straightforward concept of sustainability, was the “less certain” nature of its application and relevance to specific policy decisions.” While not explained in detail, this factor likely refers to regulatory or policy actions.
3. “That sustainability programs not duplicate existing programs such as the recently created Pollution Prevention program.” This comment was rather short sighted, when you realize the goal of reducing and/or recycling waste and pollution is a first step toward achieving sustainable practices. Why aim merely to reduce toxic waste when we can eliminate it with new chemicals and processes?
4. That “the full scope of planning and implementing sustainable development policies extended well beyond the purview of EPA.”

The 1993 Report did conclude that the concept of sustainable development “provides a useful framework for discussion of the Nation’s long-term environment and economic priorities” but also noted that “these concepts have not been developed yet to the extent that they provide a basis for EPA operational planning.”

EPA noted that while “the precise meaning of sustainable development is still the subject of scientific and political discussion, consensus does exist on several of its fundamental tenants. First, sustainable development requires a long term perspective for planning and policy development; Second, sustainable development must build on and reinforce the interdependence of our economy and our environment; Third, sustainable development calls for new, integrative approaches to achieve economic, social and environmental objectives.”

The EPA report also noted that enhancing public awareness and participation was critical, noting “that the nation can only achieve and maintain sustainable development when its citizens understand this concept and embrace it as a national priority.”

Looking ahead, EPA advised Congress that it would seek a dialogue with the public, Congress, and other government agencies to identify ways to integrate sustainable development into both the Agency’s operations and national environmental and economic policy. The final Report also noted that broad objectives, like sustainable development, require anticipatory and integrated approaches to environmental problems.

Report to Congress and State Leadership on Sustainability

The 1993 EPA Report to Congress also recognized and highlighted efforts ongoing at the state and city level. The Report cited efforts in the Northwest noting that sustainable development initiatives are underway to examine new approaches “for achieving long term improvements in environmental quality by using sustainable development as an integrating objective.”

In 1993 and today the states of Washington and Oregon were/are leaders in the Pacific Northwest advancing the concept of sustainability. In 1993 the *Washington Environment 2010* Report was a joint effort of the State of Washington and EPA toward developing an environmental agenda which identified major environmental challenges facing Washington and set forth recommendations for creating a sustainable future. In the Northwest, Portland, Seattle, and Olympia had forward-looking sustainability programs.

Since 1993, sustainability ideas and practices have taken root in hundreds of state and local communities in the United States and around the world and dozens of cities have been identified as sustainability leaders. Among the most cited leaders in 2015 are Portland, San Francisco, Seattle, Minneapolis, Austin,

Eugene, New York City, Salt Lake City, Grand Rapids, Philadelphia, Chicago and Los Angeles. These cities are cited for their work in advancing renewable energy, GHG emission reduction, LEED Certified buildings, recycling, green infrastructure and resilient planning. [14]

Over the same period EPA has made community engagement a priority research and policy issue with a strong focus on disadvantaged communities. What happens at state, local, and tribal levels is an important yardstick for measuring progress on sustainability. This has been reinforced by UN Secretary General Ban Ki-Moon who has said (2013) that “Our struggle for sustainability will be won or lost in cities.”

Innovation and Science Driving Action to Overcome Barriers

Following the Rio Summit, President Clinton established the President’s Council on Sustainable Development that met for six years from 1993 to 1999 and developed a series of reports and recommendations for creating a more sustainable America. [15]

It was during this period from 1992 to 2002, that technology and innovation began to become a driving force of change for sustainability. During much of 1994 to 1996, the White House Office of Science and Technology Policy (OSTP) and many private foundation convened dozens of meetings across the U.S. on how technology can address current and future problems. One OSTP Report (“Bridge to a Sustainable Future”) emphasized the importance of cities and states noting that “Our nation’s future strength will in large part be built on the viability of our nation’s communities. We must make choices today that increase the sustainability and desirability of our cities, towns and rural areas if we are to preserve our natural environment and build a strong domestic economy.” [16]

The OSTP Report emphasized the need to look at issues in a more integrated manner. Across the country, hundreds of communities were finding that piecemeal approaches to community issues fail to address their problems. Hence many were taking a new approach based on the concept of sustainability. Many were also developing new indicators to measure progress toward sustainability. Minnesota, for example, had set 19 goals for the state’s future and used 70 indicators to track progress. Minneapolis and other Midwest cities were all competing for the unofficial title of most sustainable city. In Chicago, Mayor Richard M. Daley formed a sustainability team that worked hard to advance sustainability through procurement and engineering polices. In Texas, the city of Austin adopted the concept of sustainability as guiding principle for develop-

ment decisions.

In support of White House activities, EPA in 1996 created its first sustainable development challenge grants (SDCG) program where proposers were asked to address problems related to “current patterns of growth and public investment/disinvestment that accelerate loss of open space and wetlands, fragment habitat, and increase consumption of fossil fuels for energy and transportation.” These grants were intended to encourage communities to recognize and build upon the fundamental connection between environmental protection, economic prosperity and community well-being.” [17]

The SDCG program was consistent with other community-based efforts EPA has initiated including the Brownfields Initiative, Environmental Justice Small Grants Program, the President’s American Heritage Rivers Initiative, Watershed Protection Approach, Transportation Partners, the Smart Growth Network, the Community-Based Environmental Protection Approach, and the Sustainable Urban Environment effort.

At the same time several reports from EPA’s Science Advisory Board (SAB) also highlighted activities needed for a more sustainable future. These included: *Beyond the Horizon: Using Foresight to Protect the Environmental Future* (1995), *Toward Integrated Environmental Decision-making* (2000), *Commentary Resulting from a Workshop on the Diffusion and Adoption of Innovations in Environmental Protection* (2001), and *Industrial Ecology: A Commentary by the EPA Science Advisory Board* (2002). [18]

The SAB Report “*Beyond the Horizon*” advised EPA to anticipate and respond to futures issues. Their analysis of stresses and changes on society led them to suggest that “thinking about the future is more important today than ever before, because ever-faster change is shrinking the distance between the present and the future.” [19] Hence by the end of the 1990s, progress was being made on advancing the concept of sustainability in to EPA operations.

Creating the EPA Research Program on Sustainability

Following the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, EPA Deputy Administrator Linda Fisher (now the Sustainable Development Officer for Dupont) and the Assistant Administrator for the ORD, Paul Gilman both recognized that advances being made in science both in government and business and mounting pressures on communities and states required more national focus on sustainability. Both agreed that the best platform for advancing sustainability was based on science and technology. Hence Gilman created a new position in ORD which I assumed as “Director for Sustainable Development.”

ORD's vision and strategy was to make sustainability the integrating concept across our broad research agenda. Science is a key driver for all of EPA activities and EPA's core research focused largely on the science necessary to support the development of regulations and on human risk assessment. Research was also now focused on ecosystem protection and the development of tools and approaches to help decision makers better understand consequence of proposed actions. While recognizing that such actions are essential, ORD also recognized that new efforts on sustainability science were needed.

In essence ORD goal was to create a new way of dealing and addressing problems in manner later defined by Chad Holiday the CEO of Dupont in 2005 as a "SEE of Change" (Social, Economic and Environmental.)

Beginning in 2003, ORD in partnerships with other programs embarked on several strategic paths to support sustainability. Elements of the 2003 actions are not very different from key elements of the current EPA Strategic Plan for 2014 -2018. ORD aimed to:

- Better define what sustainability is and advance public education and training. ORD did this by creating the first sustainability website, launching the People, Prosperity, and the Planet (P-3) student grant programs and creating sustainability training (2007) which today (2015) is one element of EPA planning for 2015-2016. The web link showcased sustainability related programs across EPA and promoted sustainability to the general public (www.epa.gov/sustainability.) The P-3 grants program challenged students to design, and implement scientific and technical solutions to environmental challenges. [20] Since 2004 this grant program has stimulated exciting and innovative projects among universities to address global sustainability challenges.
- Lead by example and create new research grant programs to engage stakeholder and demonstrate the value of integrated management. ORD's new grant program "Cooperative Network for Sustainability" launched this effort.
- Leverage external support and greater inter-office cooperation. For example, ORD organized a major international workshop "(Managing the Future)" and organizing an economic forum ("Sustainability Well Being and Environmental Protection.")
- Advance sustainability science through a new Sustainability Research Strategy. This was aimed to expand

systems thinking and promote development and use of decision support tools.

Sustainability Training

Sustainability Training was a first effort to advance sustainability across EPA. In 2007 ORD, the Office of Policy and Regional offices launched a major EPA-wide training, the goals of which were to 1) Provide an overview of sustainability concepts, principles and models; 2) Demonstrate how sustainability makes sense through case studies; 3) Describe current sustainability activities; and 4) Illustrate how to apply sustainability principles to work, home, and community

Participants learned from examples of best practices and case studies especially from Regional Offices on how sustainability is put into practice to meet growing challenges of non-sustainability in such areas as water and wastewater, energy, agriculture, and materials and chemicals usage. Today sustainability training is again a major EPA focus.

The Cooperative Network for Sustainability

The concept of our external grants program called the Cooperative Science and Technology Network for Sustainability was aimed at funding innovative regional projects that addressed a stated problem or opportunity relating to sustainability. A key goal was to involve as many stakeholders as possible in specific multidisciplinary projects that demonstrated the value of sustainable management approaches. Gilman had called such regional programs "laboratories for sustainable development." The "laboratory" was not a physical institution but a geographic focus where all stakeholders could come together to address issues in an integrated manner.

Proposers were asked to 1) identify a problem or opportunity relating to sustainability and explain its long-term importance or significance for an identified EPA region; 2) articulate the use of science and engineering, including data or information to be collected and synthesized; 3) define short- and long-term success in terms of environmental, economic, and social measures and explain how progress will be tracked; 4) identify partners and collaborators for the project; 5) articulate a plan for transferring tools, approaches, and lessons to other states, localities, regions or industries.

This idea built on a long standing effort by ORD to deal with the focus of science in the Regions. In September 2002 EPA's Region 4 (in Atlanta) hosted a Science Summit with senior Regional and ORD leadership to discuss science needs in addressing regional problems. Paul Gilman addressed the broad questions of better understanding how EPA regions use science in their decision-making and obstacles to overcome. Region 4 and ORD championed a cross regional effort to draft a report completed in August 2003 entitled "Science in Regional Decision Making." [21]

While the Report did not mention the goals of sustainability it did highlight the need for decision support tools and looking at problems in a more integrated manner. Recommendations from the Report noted that the Agency “should provide tools to make relevant environmental data available in a comprehensive format” and “better understand the interactions among air, water, and land pollutant discharges and habitat alterations in each community/ecosystem.”

Building on past activities and promoting the new Science Network, Gilman wrote an editorial for *Science* that was published on May 18, 2004. The intent of the editorial, “New EPA Focus on Science and Technology for Sustainability” was to lay out our vision for a new era of EPA research. Gilman began the editorial with a quote from former Administrator Bill Reilly “that EPA is at its best when it views its role as not just custodial but as cutting edge, providing leadership and prescribing answers to key environmental problems.” Gilman ended the editorial saying that meeting the economic and environmental challenges of the future demands require us to developing the best scientific tools and encouraging the development and application of new and innovative technology to achieve a sustainable future.”

Today, EPA is leading efforts to develop and apply a suite of decision support tools at community and city levels to advance long term planning for sustainable outcomes. An extensive listing of available tools is now on line. [22]

The Innovation Action Council (IAC) and Everyday Choices

Parallel to ORD’s focus on research, Administrator Steve Johnson (2005) challenged EPA career managers of the then existing internal Innovation Action Council (IAC) to develop an environmental “stewardship” strategy for EPA. In his charge, the Administrator noted that “in addition to operating effective regulatory and enforcement programs, EPA is gaining substantial experience with stewardship approaches – including voluntary programs, market incentives, recognition and leadership programs, pollution prevention, environmental education, information and collaborative problem solving. Although these stewardship efforts are designed to produce environmental results, EPA can improve their effectiveness with a more unified strategy and with clear goals and priorities.”

Focusing on many aspects of environmental governance, the concept of stewardship reflects the idea of shared responsibility among environmental stakeholders. Stewardship calls for corporate management to evolve from basic compliance through “beyond compliance,” to long-range strategic planning and sustainability management. While the emphasis was on stewardship, the outcome was to achieve more sustainable practices. Hence, sustainability was a vision and stewardship was the approach.

The IAC sought input from both within EPA and from state environmental commissioners, tribes, environmental experts and other opinion leaders. The IAC Report was the first explicit statement of EPA senior leadership focusing on recommendations for sustainability outcomes. Linking stewardship and sustainability, the Report noted the need for new policy and technological innovation and a stronger role for EPA on sustainability research.

Following this Report in a speech to Resource for the Future in 2006 Johnson said “I believe America is moving into a new phase of environmental protection . . . evolving from pollution control to pollution prevention to sustainability.”

Following release of the IAC Report, ORD and the Policy Office working with EPA’s Regions launched extensive interviews of career EPA staff across programs and regions. In response, staff acknowledged the importance of sustainability and supported the general philosophy, concepts and principles of sustainability. They noted that the time to address sustainability was timely. There was however some disagreement and confusion pertaining to EPA’s mission and, in particular, statutory authority and the Agency’s ability to address sustainability. Hence EPA’s traditional barriers were still to be overcome.

Related to ORD activities and the need for research, the consensus report suggested that ORD should support the research that provides the scientific basis for the Agency to use as it moves forward.

External Outreach: 2005 ORD Workshop and Forums

With emphasis on sustainability, ORD hosted a major international workshop on “Meeting the Future: A Research Agenda for Sustainability.” International scholars focused on applied tools, methods, and cutting-edge research on sustainable development. Case studies, models, and methodologies for making sustainability operational across a range of sectors and issues were highlighted and future research needs were identified. The workshop aimed to contribute to commitments made in the Johannesburg 2002 World Summit on Sustainable Development (WSSD) to “build greater capacity in science and technology for sustainable development, with actions to improve collaboration and partnerships on research and development and their widespread application among research institutions, universities, the private sector, government and non-government organizations and networks, as well as between and among scientists and academics of developing and developed countries.”

Following the workshop in May, ORD also organized a forum in December 2005 on “Sustainability Well Being and Environmental Protection” and invited experts from the physical sciences, economics, and public policy to provide input into developing EPA’s sustainability research strategy. The forum

summary (Koehler and Hecht, 2006) noted that a central element of the proposed ORD Research Strategy “is better integration of ongoing traditional physical and biological research with behavioral and economic research. This is particularly important as society faces difficult decisions related to simultaneously promoting an equitable manner of economic growth, environmental protection, and social wellbeing.” [23]

Forum participants noted that sustainable development policies can have a far-reaching impact on how products are manufactured, how energy is produced, how water is managed and virtually every other aspect of the economy. They proposed that EPA and other agencies need to review existing policies and tools and assess how these and other policies can best be used to advance goal of sustainability. Participants also noted that greater public literacy on issues related to sustainability is needed and that EPA needs to communicate more with the general public on sustainability-related issues.

The benefits of both events were to enhance better understanding of the concept of sustainability, advance the need for new science strategies, promote collaboration and partnership with stakeholders and advance cultural change among core EPA employees concerned about EPA’s role and statutory authorities.

Sustainability Research Strategy

EPA advanced the goals of stewardship and sustainability and for the first time made stewardship and sustainability a new element of Goal V (“Enhance Society’s Capacity for Sustainability through Science and Research”) of its 2007-2011 Strategic Plan, calling for “conducting leading-edge, sound scientific research on pollution prevention, new technology development, socioeconomic, sustainable systems, and decision-making tools.” Supporting these goals, ORD developed a sustainability research strategy aiming to influence all EPA programs by advancing a more systems approach to program management. [24]

The strategy identified 5 key research objectives:

1. System understanding: Understanding the interconnections, resilience and vulnerabilities over time of natural systems, industrial systems, the built environment and human society. “Based on our understanding that environmental problems are rarely contained within a single resource or geographic area, we must develop and implement integrated and systems-based approaches to meet society’s needs today and ensure a more sustainable future.”
2. Decision support tools. Design and develop scientific tools and models to assist decision makers. This is a critical role for EPA and is today a major element of

EPA operations across all programs.

3. Technologies: Identify and develop inherently benign and less resource-intensive materials, energy sources, processes, products and systems. Today advance technologies offer innovative tools to help cities. A new project launched by the White House in 2015 called Smart Cities builds on technologies to help cities become more sustainable. See for example the ORD work on “Village Green.” [25]
4. Collaborative decision-making: Develop an understanding of motivations for decision making and develop approaches to collaborative problem solving.
5. Metrics and indicators: Develop metrics and indicators to measure and track progress toward sustainability goals, to send early warning of potential problems to decision makers and to highlight opportunities for improvement. Clearly a major activity today both domestically and internationally as the UN developed the first set of Sustainable Development Goals and indicators.

The Strategy also outlined the pressures affecting life in the 21st century and the need for future planning: “A combination of forces—including unprecedented growth in population, economy, urbanization, and energy use—are imposing new stresses on the earth’s resources and society’s ability to maintain or improve environmental quality.” The report also was forward looking in defining what eventually would be called the nexus of land-water energy.

EPA’s external Science Advisory Board (SAB) reviewed and endorsed the “Agency’s proposal to establish a research program focused on sustainability because the results from such a program will improve the scientific foundation for a sustainable environment.” They noted that “Environmental protection has primarily been achieved through regulations and enforcement. The Committee applauds the Agency’s steady movement towards a systems-based approach to environmental decision-making that reflects the complexity of the world in which we live and effectively balances environmental protection and societal interests.” [26]

The SAB was prophetic in noting the needed management and cultural change necessary to achieve sustainability. They said “although the science in the Plan is sound, it is unlikely that the Agency’s sustainability outcomes will be achieved within five-years. Success in that time frame requires greater resources, both human and financial. Obviously, a workforce with experience and expertise relating to sustainability is necessary. A management structure aligned with a systems-based approach to environmental decision-making is also vital. Creative human resource programs can draw on both expertise

within the Agency's current workforce and uniquely trained individuals from outside the Agency to foster a capable sustainability workforce."

The Strategy was followed by several other important EPA activities and reports such as the Office of Solid Waste's efforts in 2009 on developing a national plan on materials management to promote sustainable use of materials. [27] Today sustainable materials management including life cycle analysis, waste reduction and recovery are important goals of business and government practice.

In 2009, EPA also began to partner with the Department of Housing and Urban Development (HUD), and the U.S. Department of Transportation (DOT) to form a "Partnership for Sustainable Communities" aiming to help communities improve access to affordable housing and transportation while protecting the environment. Today this is one key EPA effort to address urban development especially in disadvantaged communities.

Unfortunately in the Pressure-State-Response model, the later years of the Bush Administration (2004 to 2008) there was little support for sustainability at the national level. By contrast the business world and States and cities were well out front advancing sustainability goals and practices. At the same time a key study published in 1999 by the National Research Council further demonstrated the need for more actions on sustainability. In "Our Common Journey: A Transition to Sustainability" the NRC noted that the support and or criticism of sustainable development was largely influence by political circumstance (the "state" of PRS.) [28] The NRC Common Journey Report noted that as the 20th century draws to a close, the difficulties of actually achieving sustainable development have become increasingly difficult due to "political problems, question of financial resources, equity and the competition of other issues for the of decision makers." This classic Report did however emphasize the need to reinvigorate "the essential strategic connection between scientific research, technology development and society's effort to achieve environmentally sustainable improvements in human well-being."

At the national level, the next stage would fall to the new Administration under President Obama who in March 2009, appointed Yale professor and father of green chemistry Paul Anastas the new Assistant Administrator for research. Anastas joined EPA in January 2010 and a new phase of advancing sustainability began.

Making Sustainability Operational at EPA

During his 2 year tenure, Paul Anastas aimed to make sustainability the "True North" for ORD research. He reinforced the historic trends that "scientific and technological innovation is

essential to the success of our mission." Recognizing the urgency of moving forward, in his first six months he launched internal training to give ORD's senior managers a better understanding of how to integrate sustainability into traditional EPA research activities. He also directed ORD senior managers to work reorganization of ORD research around a sustainability framework. ORD leaders worked extensively to reorganization ORD's research programs into 6 areas with a stronger focus on sustainability, especially at the state and community level:

- The Air, Climate and Energy research program is looking at the consequences of different energy choices to help highlight sustainable choices.
- A major focus of our Safe and Sustainable Water Resources research program is evaluation of green infrastructure approaches to identify more sustainable options. Also, SSWR is emphasizing water and wastewater re-use, and the concept of wastewater as a resource.
- The Sustainable and Healthy Communities research program is focusing on sustainability indicators and decision support tools to help the Agency and the States evaluate decisions through a sustainability lens.
- The Chemical Safety for Sustainability research program includes work on life cycle analysis methods and in molecular design to make products safer from the start.
- The Homeland Security research program is broadening its view to encompass "resiliency" - to help communities prepare for and recover from environmental aspects of all disasters.
- In Human Health Risk Assessment, development of methods for cumulative risk assessment will support the consideration of multiple exposure and cumulative impacts in environmental policy and decisions.

These research plan which put a strong emphasis on systems thinking, development and application of decision support tools, and collaborative partnerships.

The National Research Council (NRC) Study "Sustainability and the EPA"

In analogue to the 1983 NRC study on risk assessment, known as the "Red Book," which became a strong factor in shaping EPA's subsequent work on risk assessment, Paul Anastas also proposed a new study (later to be referred to as the "Green Book") on how to make sustainability operational at EPA. [29] The study which would impact all of EPA was approved by Ad-

administrator Lisa Jackson to address four basic questions:

- What should be the operational framework for sustainability for EPA?
- What scientific and analytical tools are needed to support the framework?
- How can the EPA decision-making process rooted in the risk assessment/risk management (RA/RM) paradigm be integrated into this new sustainability framework?
- What expertise is needed to support the framework?

The NRC organized an impressive committee chaired by Dr. Bernie Goldstein from the University of Pittsburgh, who was a former research leader at ORD. The committee also included Paul Gilman, ORD's first leader of sustainability, and Neil Hawkins, the vice president for sustainability at Dow Chemical. In launching the study at the time of EPA's 40th anniversary (2010), Administrator Jackson reflected on EPA history and the changing nature of environmental problems:

"As we celebrate 40 years of incredible accomplishments, we find ourselves at a critical juncture. We have a new awareness of environmental complexity and, at the same time, we have new tools, insights, and experiences to guide our mission. It is time to rise to the challenges of today, using the best of what we have, to meet the needs of the current generation while preserving the ability of future generations to meet theirs as well."

Green Book Recommendations

On September 15, 2011, the NRC released their report "Sustainability and the US EPA." Many recommendations were made building on the history described in this paper including:

- Go beyond the risk paradigm and adopt a sustainability framework emphasizing an assessment of economic, social, and environmental impacts.
- Set 3-5 year breakthrough objectives.
- Develop a sustainability "toolbox" that can help decision makers make better decisions.
- Identify future problems, consider solutions, and develop projections of environmental conditions and problems.
- Train the current work force on sustainability and hire multidisciplinary professionals.
- Put greater emphasis on long-term, multi-media and systems activities in R&D planning.

Following the Report Administrator Lisa Jackson launched months of "listening sessions" with EPA stakeholders to get their reaction to the recommendations. This was a good strategy to receive stakeholder feedback. From December 2011 to May 2012, EPA held over 100 listening sessions with more than 500 participants from business, NGO, academic, and social groups. These listening sessions conveyed a strong commitment to sustainability and support for EPA to move in that direction. Table 2 identifies the top 10 conclusions of the listening sessions summarized by ORD and the Office of Policy.

Table 2

1. Clearly articulate EPA's case for carrying out its mission to protect human health and the environment in a manner that optimizes the social, environmental and economic benefits of its decisions.	6. Work with stakeholders to develop integrated regulatory/non-regulatory and cross-program strategies that address key sustainability opportunities.
2. Integrate sustainability approaches into EPA's culture and governance.	7. Work with other federal, state and local agencies to coordinate policies, funding, regulations, research and reporting and to achieve sustainable outcomes on a national scale.
3. Walk the talk and lead by example in EPA's own operations.	8. Improve processes for addressing the social and economic impacts that public and private environmentally related actions have on communities, especially EJ communities.
4. Increase public discussion, actions and partnerships that create a healthier, more prosperous, equitable and sustainable society.	9. Collaborate to develop analytical and decision support tools and underlying metrics and data for use by EPA and by partners.
5. Incorporate sustainability approaches into EPA rulemaking, regulatory implementation, enforcement and grant program	10. Use improved metrics and indicators to evaluate progress and make improvements.

In a memo to EPA staff in December 2012, Administrator Jack-

son said:

“It is time to use the principles of sustainability to help guide us in solving environmental problems. Many forward-leaning stakeholders – from the biggest corporations to the smallest towns – are seizing opportunities to introduce sustainable processes, technologies and practices. During the past year businesses have told us that managing resources sustainably – including minimizing wastes and toxics, cutting greenhouse gas emissions and reducing energy and water use – is not only the most cost-effective way to protect human health and the environment, it also is critical to their growth and profitability.”

The administrator acknowledged the historic role of the Green Book and said “we soon will be taking significant steps to build on these recommendations. I am confident that this new approach will enable us to achieve dramatic strides both in our traditional regulatory programs and, perhaps more importantly, in many collaborative efforts with our partners in the private and public sectors.”

EPA Strategic Plan 2014-2018 and Public Engagement

In February 2013 Administrator Jackson left EPA and the Agency began to prepare its required Strategic Plan 2014-2018. Two additional NRC studies supported additional actions on sustainability. The “Sustainability for the Nation” (2013) strongly emphasized the need for integrated decision making and identified 4 priority problems: nexus of energy-food and water, need to address diverse and healthy communities, enhance resilience of community to extreme events and promote human health and wellbeing. [30]

A second NRC report “Sustainability Concepts in Decision-Making: Tools and Approaches for the EPA” (2014) re-enforced the history described in this paper. The report concluded that EPA has many opportunities to further apply sustainability tools and approaches across the spectrum of its activities, and it should do so as rapidly as is practicable. Again, reflecting emerging and interrelated challenges, the Report urged EPA to use the concepts of sustainability to strengthen a systems-thinking approach. [31]

These latter two Reports came at a time of new EPA leadership. In June 2013, the Senate confirmed Gina McCarthy as the new EPA administrator. Gina McCarthy announced five strategic goals and three cross cutting strategies including “working toward a sustainable future.” (Table 3.)

The Cross-cutting strategy “working toward a sustainable future” put strong support on systems science and integrated approach to decision making. This strategy specifically focuses on several actions to enhance EPA’s sustainability work:

- Incorporate sustainability principles into regulatory, enforcement, incentive-based, and partnership programs;

- Use available incentives, education, information, and disclosure to enhance the ability of markets to reward sustainability;
- Coordinate grants, contracts, and technical assistance to promote sustainable outcomes;
- Advance sustainability science, indicators, and tools;
- Promote new ways to encourage technology-focused innovation that supports Agency priorities for sustainability.
- Use systems-based approaches that account for linkages between different environmental systems.

ORD’s reorganized research programs are a strong foundation for these goals.

Table 3

GOALS	CROSS CUTTING STRATEGIES
Goal 1: Addressing Climate Change and Improving Air Quality	Working Toward a Sustainable Future
Goal 2: Protecting America’s Waters	Working to Make a Visible Difference in Communities
Goal 3: Cleaning Up Communities and Advancing Sustainable Development	Launching a New Era of State, Tribal, Local, and International Partnerships
Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution	Embracing EPA as a High-Performing Organization
Goal 5: Protecting Human Health and the Environment by Enforcing Laws and Assuring Compliance.	

Today 24 years since the Rio Summit, EPA is developing the action plans to make sustainability operational across the Agency. The recognition of integrated and systems thinking is now embedded in many regional activities. Renewed efforts are underway to ensure everyone understand what sustainability is and how it affects day to day operations. As noted on the EPA sustainability web page (www.epa.gov/sustainability) “sustainability “isn’t part of our work, it’s a guiding influence for all of our work.” It has taken decades to get to this point.

Summary: The Challenges Ahead

The history summarized in this paper has shown how long it can take to integrate the concept of sustainability in government operations. Unfortunately this was also true in dealing with climate change (Hecht, 2014.) [32] Hence today we are adapting to climate change rather than preventing it.

Today, achieving the goal of sustainability is more urgent in view of major trends affecting global society. By 2030 with world population over 9 billion, the projected demand for food, water, and energy will grow by approximately 35, 40, and 50 % respectively. Sustainability goes beyond just a narrow focus on sustainable water use, or energy or food production, or land management. Instead, sustainability reflects the nexus among economic growth, agricultural needs, and demand for energy and water. While it has taken decades to reach this point, there is a need for accelerated action due to pressures and trends that will impact society over the coming decades. These include:

- Climate adaptation/mega droughts/sea level rise
- Urban population growth/human health and safety/growth of disadvantaged communities
- Aging water infrastructure/water usage/energy-water-food nexus
- Increase in disaster and severe events/need for resilient infrastructure
- Land loss to urban development/ecosystem decline
- Combined health risks/aging population

All of these trends pose a threat to economic growth, human health and environmental protection. It is apparent that climate change will have dramatic effects on the nation's water infrastructure, watersheds and ecosystems, and communities. Cities are now faced with increased challenges to prepare for droughts, extreme heat days, and other effects of climate change, while rebuilding their decaying infrastructures. How will these cities sustain themselves? What actions are needed now to prepare for the future? There is also a significant increasing trend in natural disasters. The UN Global Assessment Report predicts that disasters are expected to cost the global community up to \$300 billion annually in the coming decades. This links the concept

Resiliency as a key element of sustainability. [33]

Events drive action and it took Super storm Sandy in October 2012 to advance significant attention to building more resilient infrastructures. Resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. Now as we think about sustainability we need also to incorporate resilience in managing our systems. The challenge ahead is to act in ways that avoid or mitigate future disasters.

The push to address sustainability is further advanced today by the adoption of the UN Sustainable Development Goals (September, 2015.) The 17 Goals are being embraced by business and governments including ensuring access to affordable, reliable, sustainable and modern energy, building resilient infrastructure and ensuring sustainable consumption and production patterns. [34] The US is committed to addressing these goals many of which address critical social issues including ending poverty and hunger and achieving food security and sustainable agriculture. EPA and USDA have announced a commitment to meet Goal 12 to reduce food waste by 50 percent by 2030. EPA is working with dozens of industries to advance this objective. [35]

For each goal there is a set of targets. For example for Goal 6 on ensure availability and sustainable management of water and sanitation for all, the targets are:

- Improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and increasing recycling and safe reuse
- Substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity
- Implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
- Protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
- Support and strengthen the participation of local communities for improving water and sanitation management

The Global Reporting Initiative (GRI), the United Nations Global Compact and the World Business Council for Sustainable Development (WBCSD) have joined forces to mobilize the private sector as a key player in achieving our world's Sustainable Development Goals (SDGs). These groups are working with companies across the world and have launched a new website to highlight tools available to help achieve the SDG. [36] The guide will support companies to align business strategies with the Goals including an inventory of indicators that can be used by companies to assess their impact against particular SDGs.

For the next generation, business and government must be visionary and forward-looking in helping create a sustainable world. Given the pressures of the world today, society must accelerate progress to (1) anticipate and responding to future trends; (2) recognize the nexus of food-energy-water systems and links to environmental and social justice; (3) apply an integrated systems approach to problem solving; (4) use a suite of decision support tools to help decision makers understand the consequences of their action; (5) recognize the need for flexible environmental management and external collaboration;

and (6) reach out to all stakeholders with new technologies and information.

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