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Policy Analysis

Moving from Protection to Prosperity: Evolving the U.S. Environmental Protection Agency for the next 50 years

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ABSTRACT: The people of the United States and the world owe the United States Environmental Protection Agency (U.S. EPA) a debt of gratitude for preserving, protecting, and defending human health and the environment for the past half century. As we celebrate the 50th anniversary of the founding of the U.S. EPA, there are two truths about the agency that are difficult to deny: (1) U.S. EPA and its people constitute a renowned agency that has greatly improved both environmental and public health in the United States, and has served as the leading model for nations around the world; and (2) the approaches, tools, structures, and legal frameworks that created the achievements of the U.S. EPA must evolve—and grow—to deal with the issues facing the country and the planet in the next 50 years. Building on the creativity, innovation, and brilliance of individuals and groups working at the U.S. EPA over the course of the last half century, we present 10 recommendations organized in three areas: organization, paradigms, and strategies and tools. Underlying these recommendations are the frameworks of sustainability and systems thinking and guiding these recommendations is the goal of evolving the Environmental Protection Agency to the Environmental Prosperity Agency.

THE EPA'S SUCCESS OF THE PAST 50 YEARS

The U.S. EPA was founded in 1970 during a time of political tumult and societal schisms marked by polarization and mass protests in the streets of America. It is appropriate, then, to reflect on this institution in 2020, another time marked by political tumult and societal schisms marked by polarization and mass protests in the streets, this time on a worldwide scale.

The environmental problems identified in the 1970s were plentiful, egregious, and obvious in the context of unprecedented concern.[1] This resulted in numerous pieces of bipartisan legislation seeking to address the problems of air (the Clean Air Act), water (the Clean Water Act), and solid waste (the Resource Conservation and Recovery Act). The results of the past 50 years demonstrate the effectiveness of these policies, with measurable improvements in all three areas, and ultimately in public health (e.g., lead in Figure 1).[2]

From regulating vehicle emissions to banning the use of DDT; from cleaning up toxic waste to protecting the ozone layer; from increasing recycling to revitalizing inner-city brownfields,[3] the EPA's achievements have resulted in cleaner air, purer water, and healthier land. These successes have preserved health and saved lives. While there was and will continue to be debate around the economic costs of these improvements, as these dramatic environmental actions were taking place, nevertheless the pace of economic growth and job expansion in the U.S. proceeded steadily (Figure 2).[4]

Many of the approaches that EPA pursued in its early decades relied on command-and-control regulatory strategies to target discrete, measurable, and high-priority problems like water contaminants and air toxins. The scientific models, analytical standards, and legal frameworks that emerged from these programs were adopted by nations around the world and served

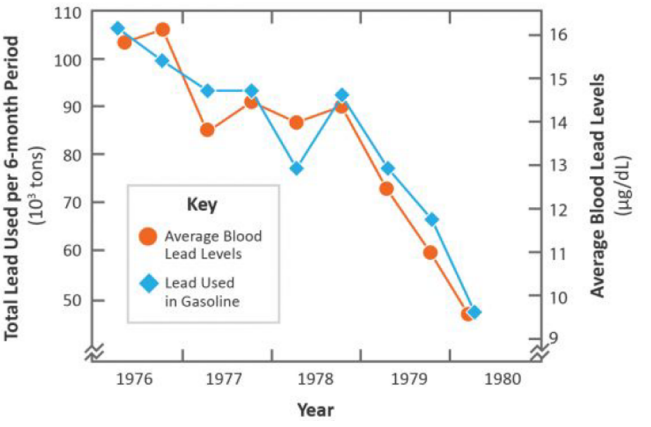

Figure 1. EPA standards led to parallel decreases in lead content of gasoline and blood lead level of the average American. Source: U.S. EPA/Environmental Criteria and Assessment Office (1986).[2]

an essential role in advancing international environmental protection.

The EPA's global influence has been one of the Agency's most important, yet least appreciated, roles.[1] From the Agency's creation to its ongoing work, the EPA, along with other sister

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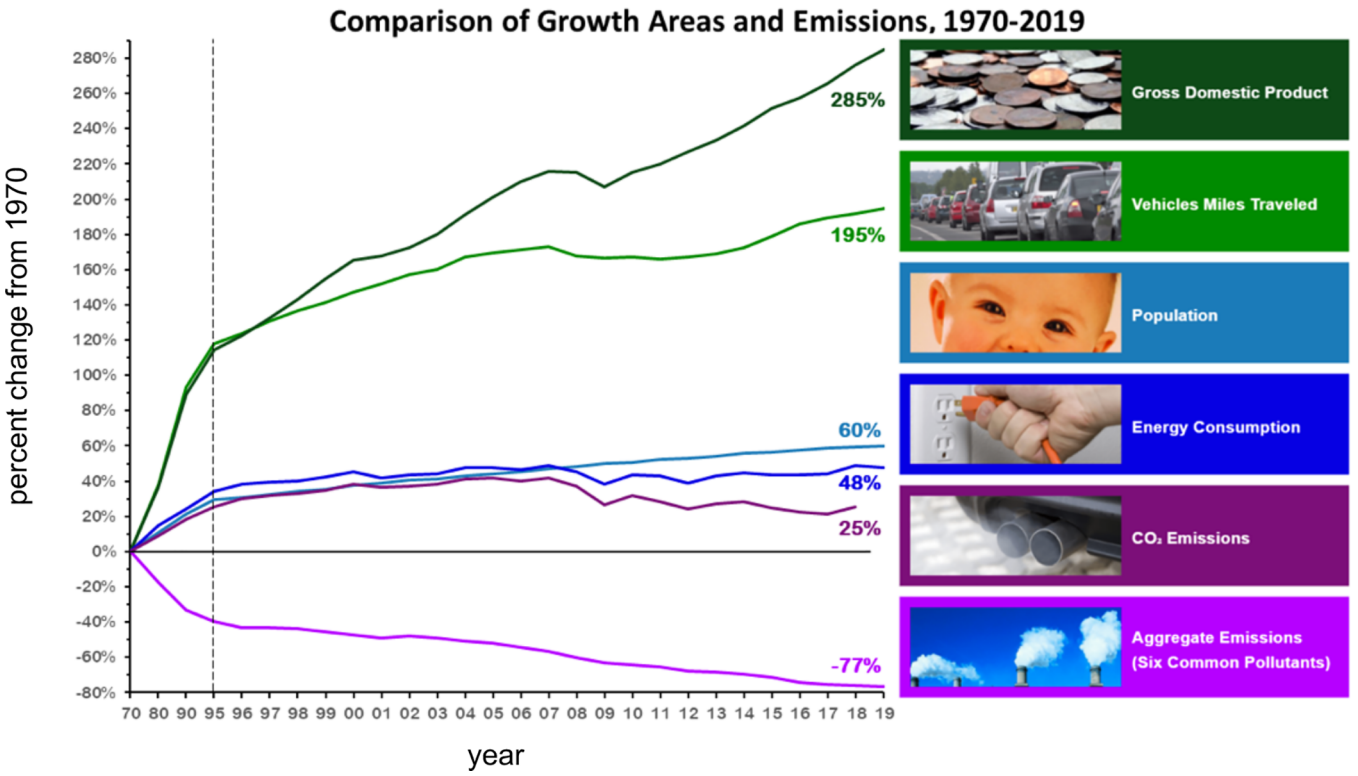

Figure 2. U.S. trends in gross domestic product, vehicle miles traveled, population, energy consumed, carbon dioxide emitted, and aggregate air emissions from 1970 to 2019.[4] Note: CO_2 emissions estimate through 2018. (Sources: U.S. Greenhouse Gas Inventory Report; Gross Domestic Product: Bureau of Economic Analysis; Vehicle Miles Traveled: Federal Highway Administration; Population: Census Bureau; Energy Consumption: Dept. of Energy, Energy Information Administration; Aggregate Emissions: EPA's Air Pollutant Emissions Trends Data).

Federal agencies, served as a role model on environmental issues and lent its people and expertise to build similar organizations and assist in the development of the legal and regulatory frameworks in these countries. The EPA has played a significant role in the negotiation of international environmental treaties, the response to global environmental disasters, and in the sharing of scientific and technical expertise.[1] The EPA is a major reason why the United States has been considered (at least until recently) a global environmental leader.[1,5]

The EPA's successes of the past 50 years have been extraordinary, but the mechanisms used to achieve them are no longer adequate for future progress. From the organizational structure of the Agency to the regulatory framework underpinning its decision-making, much of the focus of the work by the EPA is on problems, rather than solutions. The EPA's emphasis has been on specific environmental harms and how to minimize, mitigate, or limit that harm. Its guiding question has been: What is the maximal amount of emissions that can be released into the environment to maintain some level of predetermined harm that is tolerable from a political, social and economic perspective?

While this approach has resulted in substantial progress in protecting environmental and human health, it is based on media-specific and single-pollutant risk-based frameworks. Rather than asking, "How much harm is acceptable?" and "How bad can we be and still maintain legal compliance?" the guiding questions for the next half-century need to focus on how to catalyze the Agency, its people, its partners, and its stakeholders to harness intellectual creativity, incentives, and drivers for systemic, systematic, and sustainable solutions to minimize or eliminate these harms.

EMBRACING SYSTEMIC, SYSTEMATIC, AND SUSTAINABLE SOLUTIONS

What would it mean to have an Environmental Prosperity Agency rather than an Environmental Protection Agency? What if the word "prosperity" explicitly meant that rather than protecting what is and what has been, we would instead strive to ensure that not only are the environment, ecosystems, and biosphere thriving, but also the health and well-being of the society and economy that depends on them? And if there were collective recognition and agreement that we want an EPA that strives for more than simply attempting to minimize the ongoing damage to our planet and our health, what changes would need to take place in order to make this a reality?

The first step may be an explicit acceptance that the concept of sustainability is not a political agenda, but rather it is fundamentally about preserving the natural resources that are the only way to maintain a society that is healthful enough to achieve a healthy economy. Without the biological and geological systems intact, in balance, and functional, it is not possible to maintain social systems that are just, peaceful and support a vibrant economy. While the three "pillars" of sustainability are often cited as environmental, social, and economic, it is more accurate to recognize that it is truly more of a hierarchical structure that a thriving economy cannot exist without a functioning society and society cannot exist without a healthy environment.[6]

The second step is adopting systems thinking. The laws written in the 1970s and 1980s were understandably focused on the air, water, and the land. But if one thing has become more obvious, as John Muir once noted, "when we try to pick out anything by itself, we find it hitched to everything else in the

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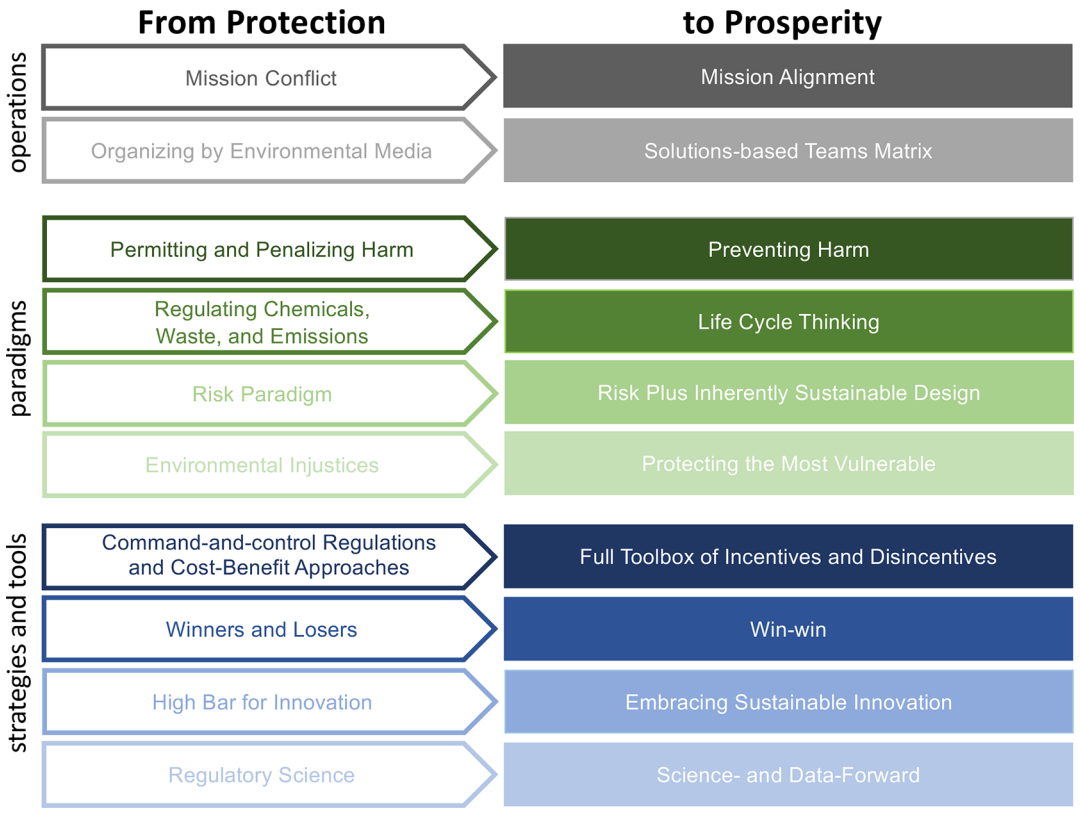

Figure 3. Recommendations on key areas to move EPA from a protection to a prosperity agency.

Universe".[7] As such, we must recognize that the focused yet fragmented reductionist approaches to environmental protection used in the past decades can, and have, worked well for obvious, egregious, and discrete problems like ubiquitous litter, visibly excessive air pollution, and contamination of waterways so drastic as to make recreational use unthinkable. However, it is wholly insufficient to deal with the challenges of the 21st Century.

Today's challenges are "wicked problems",[8−10] far more complex, integrated, invisible, and insidious. As such, they must be addressed by using approaches that understand the interrelationships and interconnectivity between air, water, and land; or climate, energy, water, food, and waste; or toxic chemicals, emissions, health disparities, and environmental justice. While this complexity may seem daunting, it is also potentially the greatest opportunity to transform the "environment" from an issue that is viewed as a cost to the economy to one that accelerates economic growth, from actions that divide to efforts that find common ground, and from goals that strive to stop damage to aspirations that want to achieve progress. We cannot effectively address problems in one area while ignoring the interconnectivity of all of the other areas.

Using the tools of systems thinking[11,12] will be critical in solving this century's environmental problems and the globe's sustainability challenges. Climate change, for example, is known to be inextricably linked to our energy infrastructure, which is inextricably linked to our water infrastructure and to our agricultural infrastructure, which is inextricably linked to our economy, social structures, health, and well-being. These kinds of connections are not merely useful in understanding cascading, nonlinear problems, they are essential in identifying cascading, nonlinear solutions. That is, solutions that are discrete actions, but because of their leverage through connections in the system, have multiplicative and exponential benefits to create greater and more sustainable good than the action would have in isolation.

RECOMMENDATIONS FOR AN ENVIRONMENTAL PROSPERITY AGENCY

The portfolio of past approaches are insufficient to protect human health and the environment for the next 50 years. The question we confront today is not whether the EPA has a history of accomplishment that has led and benefited people and the planet, but how to poise the agency for success in a world that has progressed scientifically, advanced technologically, and has increased its knowledge of the interrelatedness and dependency of environmental-economic-health-societal issues.[13]

While exceptional and innovative programs (e.g., Design for Environment, Safer Choice, EnergyStar, Climate Protection Partnerships, Labs21, etc.), have been introduced over the past 30 years,[14] they—and the underlying approaches—do not represent the vast majority of activity at EPA. However, learning from the successes of these programs, and expanding them, would enable the Agency to adapt to be ready for the challenges facing us over the course of the next 50 years. Many of the recommendations below are building on the creativity and innovation of individuals and groups working at the EPA over the course of the last half century, and recognizes that these exceptional efforts need to be provided with the funding, the staffing, and political will to be institutionalized and systematized.

The 10 recommendations (Figure 3), sorted by operations, paradigms, and strategies and tools, seek to use the new levels of awareness in sustainability and systems thinking to advance a model perhaps best described as an "**Environmental Prosperity Agency**". This model moves the actions of the agency solely

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from the problem of controlling, limiting, reducing, and banning harms to people and the environment to one that ***equally values*** the solutions of creation, discovery, invention, and implementation of beneficial sustainable products, processes, business models, and systems. In this way, the EPA of the next 50 years not merely protects but improves the environment and public health for all in ways that also advance societal and economic goals.

Operations. Mechanisms, tools, and organizational structures are all put in place to advance the mission of any organization and when they cease to be effective and reach the point of impeding progress, it is time for change. By instituting changes to these operational structures, it can facilitate EPA's efficiency and impact.

From Mission Conflict to Mission Alignment. EPA's mission is often perceived to be in conflict with one or more of its sister Federal agencies. Environmental regulatory restrictions and costs have been viewed as conflicting with the Department of Commerce's mission to promote trade and create jobs, or the Department of Energy's mission to advance energy production, or the Department of Agriculture's mission to improve food production intensity.[3] Often, these perceived conflicts are more about methods, not missions, and these conflicts can be avoided by shifting focus to systemic solutions from individual problems.

The EPA is part of a collection of Federal agencies that all have their own mission. It is critically important that the pursuit of these missions is at least additive, if not synergistic, and that they do not work against one another, diminishing the effectiveness of all. When the mission of the EPA appears to be in conflict with the mission of the Department of Commerce or the Department of Agriculture, it is because of misguided and too-narrow mission definitions. In the Executive branch, it is the responsibility of the White House Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the National Security Council to ensure coordination between the various Federal agencies. While historically the EPA has participated in various coordinating efforts, it is of particular importance going forward that the EPA strengthen its capacity to form extensive bilateral and multilateral relationships with the other Federal agencies, and aggressively embrace coordination opportunities provided by the Executive Office of the President in order to align agendas and priorities with other agencies and ensure that mission conflicts are avoided. This will be tested as the Biden Administration begins an aggressive agenda[15] to address climate change using the full breadth of the Executive Branch.

EPA also has significant opportunities to leverage the work of the Department of State, the Department of Health and Human Services, and the Department of Treasury in engaging global financial/lending institutions that can drive changes to benefit the protection of human health and the environment in the developing world. As our environmental problems have become more complex and as scientists have documented the global transport of chemicals, global climate change, and transboundary resource conflicts, the need for international collaboration and coordination has become increasingly apparent and urgent.[16] This can and should happen on many levels from the underlying data and science, to the subsequent policy frameworks, to the institutional infrastructure and organizations. Beyond the need to address these challenges as a collective global society, such engagement also offers the opportunity for systemic solutions rather than shifting environmental harms to different parts of the world and health burdens to different communities.[17]

From Organizing by Environmental Media to Solutions-Based Teams Matrix. For the most part, environmental statutes address only one medium (e.g., Clean Water Act; Clean Air Act).[18] Two other major statutes, the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) ideally apply to releases in all media, but in practice primarily address only land disposal issues.[19] While environmental chemistry has shown that chemicals move readily between media, the foundational U.S. environmental regulations do not. Many argue that controls on air pollutants, for instance, often result in the discharge of the same chemicals into the land or water without reducing the total number of harmful substances released into the environment.[19] For example, the Clean Air Act requires most utilities that burn high-sulfur coal to use scrubbers to remove sulfur dioxide from their flue gases, but this type of air pollution control produces three to six tons of scrubber sludge for every ton of sulfur dioxide removed from the air.[20] Industry deposits most of this sludge in landfills.[20] The limitations presented by this legal framing of environmental protection is reinforced and fortified by the analogous organizational structure of the EPA, with offices closely aligned with each media/statute.

There's an old design saying, "form follows function". The U.S. EPA perhaps has that saying backward because at the agency, function often follows form. Water standards are reviewed and enforced not because they are the greatest threat to human health of the environment but rather because it is simply what the Office of Water is legally mandated to do. The Office of Chemical Safety may recognize that the production of a new plastic will result in an extensive solid waste but it is not in its organizational mandate to address those issues. Since EPA personnel have labored in an organizational structure where too often "form enables dysfunction," it is necessary to pursue new organizational models.

In times of crisis, such as the 2010 oil spill in the Gulf of Mexico and the nuclear meltdown at Fukushima in 2011, the EPA draws together all of the capabilities and perspectives across the agency into the Emergency Operation Center. Together, all of the disciplines, skill sets, and resources of the agency are focused on the crisis at hand.[21] This model is critically necessary now, at a time when we have numerous environmental and public health crises—some immediate and acute while others are slow and chronic—emerging in real-time, such as climate change resulting in wildfires throughout the American West; hurricanes increasingly devastating the American South; environmental injustice and health disparities in communities that are disproportionality poor and of color; and biodiversity resulting in degraded ecosystem health. While these crises may be chronic conditions resulting in acute impacts, and unfold over years rather than days, they are also crises that require an integrated and cohesive response that incorporates all of the talents across the EPA.

The EPA's model must not continue to be fragmented, isolated, and myopically aligned with half-century old laws. It must instead break down old organizational barriers to create new agile, rapid response teams that are capable of addressing problems in the necessary time frame. This would require a complete restructuring of the EPAs organizational hierarchy. Instead of offices that are a reflection of outdated statutes, there would be a matrix that reflects the capabilities and resources

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within the agency. As problems are identified and prioritized, individuals from each of the "resource centers" would be assigned to work on that problem as part of a multidisciplinary team. These may range from small strike forces of a few individuals with the proper background for a short amount of time in discrete emergencies, to larger, complex teams that will be used to focus on an ongoing issue for years. One can envision that some examples may include longer-term efforts such as the Climate Change Mitigation and Adaptation Team, and the Zero-Waste and Circular Economy Team, where immediate-term focused efforts may be a Flint, Michigan Team, or a team to respond to a specific, unintentional environmental release. All of these efforts would benefit from a matrix organizational structure that brings together the full capabilities of the agency and allows it to more effectively leverage and interconnect with other efforts in localities, states, and other federal entities. Of course, this activity could be decoupled from organizational structure and implemented while the longer-term process of reorganizing the agency is pursued.

Paradigms. The way one frames a problem perhaps is the single largest determinant on how effective the resultant solutions will be in addressing the problem. The ability to envision a future state of environmental prosperity with a sustainable society and thriving economy is a function of our paradigms; the perspective from which we view the situations we face. The past 50 years of the EPA have had a set of paradigms that should be rethought and expanded in order to catalyze positive impact.

From Permitting and Penalizing Harm to Preventing Harm and Advancing Wellness? The majority of the regulatory programs at the EPA work through a mechanism of setting standards for pollutant levels or permitting allowable levels of emissions. At the founding of the agency there was a realization that, as a society, we needed to act quickly, so this approach made sense. Yet many observers have questioned whether such allowances are effective in improving the environment.[22] People have challenged them on the grounds that they are not a morally acceptable means of protecting human health and the environment because they do not eliminate pollution, merely set levels of "acceptable risk" (see The Risk Paradigm). A regulatory tourniquet developed in the 1970s is not optimal for 2020 and there needs to be mechanisms where the EPA drives long-term solutions to and continuous improvement in pollution prevention through sustainable design of infrastructure, products, and processes that make up our economy and society.[23]

As is the case with other federal and state environmental health and safety regulators, the EPA issues fines and other penalties to businesses and organizations that violate its rules. The EPA's compliance monitoring and enforcement program[24] is referenced expressly in virtually every EPA enforcement response and penalty policy[25] and endorsed in the EPA Environmental Appeals Board (EAB) penalty decisions.[26] In an average year, the EPA undertakes fewer than 22 000 inspections and 4000 civil judicial and administrative actions under multiple (and complex) environmental statutes for nearly eight million regulated entities.[27] At that rate, it would take over 360 years for the EPA to inspect all of the currently regulated entities.

These numbers emphasize the practical and pressing importance of establishing a credible deterrent to non-compliance. The question remains whether the penalties and sanctions are sufficiently robust to deter repeat offenders, and whether the costs of noncompliance do indeed exceed any economic benefits of noncompliance. This is a valid question because the vast majority of penalties remain modest. The median administrative penalties for the period 2001−2008 were approximately: $550 for Clean Air Act violations; $7,850 for Comprehensive Environmental Response, Compensation, and Liability—also known as Superfund—violations; $3,000 for Clean Water Act violations; $7,200 for Emergency Planning and Community Right-to-Know Act violations; $600 for Resource Conservation and Recovery Act violations; and $3,600 for Toxic Substances Control Act violations.[28]

Further, a robust and systematic understanding of the deterrence effects of environmental monitoring and enforcement across actors, plant characteristics, industry sectors, and geographic contexts is lacking. This is compounded by EPA's outstanding but still anecdotal and relatively small experimental efforts in voluntary programs and partnerships to understand the potential benefits to improved compliance and pollution prevention. For example, rather than addressing problems after they occur, EPA has an opportunity to fundamentally and systematically prevent harm. Science has recognized in the past half-century that all of the hazards (e.g., global, toxicological, and physical) associated with the chemicals of concern come from the inherent properties (e.g., solubility, volatility, bioavailability) that these chemicals possess, rather than their use scenarios or other circumstances. Because of this, it is possible to now move toward regulating classes of chemicals that have these properties or combinations of properties of concern, rather than pursuing individual chemicals one-by-one. More importantly, the pursuit of molecular design rules for reduced hazard is something that needs to be encouraged, supported, and implemented so that the next generation of chemical products and processes are benign and beneficial for people and the planet. In this way, EPA would be at the forefront of preventing harm, from a molecular basis,[29] fundamentally changing the nature of the chemicals and materials that make up the materials basis of our economy and society.

From Regulating Chemicals, Waste, and Emissions to Life Cycle Thinking. Similar to the shortcomings faced by managing complex environmental systems through individual media, there are comparable challenges to the current approach of regulating chemicals on an individual substance basis. By the time the United States Toxic Substances Control Act became law in 1976, tens of thousands of synthetic chemicals were in commerce with no evidence of their safety.[30] The law gave the EPA broad regulatory authority to require toxicity testing and reporting to determine whether the chemicals posed risks, but the 60 000-plus chemicals already in commerce were grandfathered into the law on the assumption that they were safe.[30] However, new chemicals were and are still generally considered on an individual basis, largely ignoring the scientific understanding that classes of compounds can and do behave similarly in terms of adverse impacts to human health and the environment.[31]

Humans, wildlife, and ecosystems are exposed to a large number of different mixtures of anthropogenic chemicals via air, water, food, consumer products, materials, and goods. In addition, new chemicals and new applications of existing chemicals are continuously introduced to the market.[32] Since the current regulatory practice is largely based on consideration of single chemical substances, the combined exposure to multiple chemicals raises concerns about the effects on health and the environment, including the underestimation of the

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potential risks.[33] The science of toxicology has advanced far beyond what was known in previous decades, while the way we assess and manage chemicals generally has not.[32]

Our current understanding presents an opportunity to change the way we consider chemicals and waste from a regulatory perspective to one of materials and resources design and management. It is not a new observation that there is no waste in nature, but rather what is discarded by one organism or process is utilized as a valuable input by another. While the waste paradigm of treatment and disposal has spawned a whole industry sector over the past decades, there have been thoughtful efforts at the EPA to move toward materials management[34] and advance the circular economy using the framework of industrial ecology.[35] Life cycle assessment has been around for several decades, and the EPA has been advancing the thinking and the sophistication of lifecycle models and tools.[36] What is somewhat ironic, then, is that so many of the traditional statute-driven programs usually do not utilize life cycle thinking.

The Office of Land and Emergency Management, with its many outstanding innovative initiatives, still orients the overwhelming majority of its resources and focus on the traditional requirements of legacy waste cleanups only. The Office of Air and Radiation as well as the Office of Water in their operations, in 2020, still have the majority of their efforts focusing on reducing emissions at the end-of-life stage only. If there is one thing that life cycle assessment has taught us, it is that simply shifting problems from one life cycle stage to another is not sustainable progress. Cleaning up legacy waste issues while knowing that pollutants and contaminants are still being generated and emitted may be a good business model for the environmental remediation sector, but it is not effective public policy.

EPA has described sustainable materials management as a systemic approach to using and reusing materials more productively over their entire life cycles.[37] This approach represents a change in how our society thinks about the use of natural resources and environmental protection. By examining how materials are used throughout their life cycle, materials can be used in the most productive way with an emphasis on using less, reduce toxic chemicals and environmental impacts throughout the material life cycle, and ensure we have sufficient resources to meet today's needs and those of the future.[38] As detailed in EPA's Sustainable Materials Management report,[38] more productive and less impactful use of materials helps our society remain economically competitive, contributes to our prosperity and protects the environment in a resource-constrained future. By holistically considering the entire life cycle, from cradle-to-cradle, unintentionally shifting problems from one stage to another or from media to another or from one geographic region to another can be avoided. This enables better decision-making to globally maximize environmental, economic, and social outcomes, rather than identifying local minima.

From the Risk Paradigm to Risk Plus Inherently Sustainable Design. Underlying virtually every regulatory approach at EPA is the risk paradigm. Risk assessment guides policymakers on their decisions regarding how and when to regulate, manage, and mitigate hazards. One of its most frequent uses is to assess the potential hazards posed by chemicals of concern in environmental media and consumer products. But these assessments, often decades-long and unwieldy, regularly fail to provide the answers and insights that policymakers need to make their decisions.[39]

It is difficult to overstate the role that the risk paradigm plays at the EPA as a prioritization tool, a decision-making framework, and a justification for regulatory and nonregulatory action alike. The agency has used risk as the rationale for the overwhelming majority of it actions *even prior* to its codification in the landmark National Academy of Sciences report "Risk Assessment in the Federal Government: Managing the Process" (The Red Book) in 1983.[40] So the question that arises after running the experiment for 50 years is: Is risk the correct framework to govern EPA's actions? EPA's scientists and risk managers have been at the cutting-edge of risk science since its inception, and are considered among the best in the world for environmental risk assessment,[41] but the critiques of the approach suggest that the time required for a full risk assessment makes the approach dangerously slow.[39,42] One only has to look at the EPA's efforts to assess the chemicals dioxin, perchloroethylene, trichloroethylene, and formaldehyde to understand the criticism; their reviews have been ongoing for literally decades.[43,44] It cannot be argued that risk assessment is as nimble or as agile as the mission of protecting human and environmental health require. The cost and time needed to construct a risk assessment significantly reduces its usefulness for effective, formal agency action.[44]

Perhaps the most serious criticisms of risk can be found in the U.S. National Research Council's report, "Science and Decisions".[39] This report reinforces the idea that the increasingly complex scientific issues underlying risk assessments exacerbate the problems that risk assessments are developed to support.[9] Further, it is clear that the outcomes of risk assessment are rarely directly suitable for decision-making, and so must be interpreted. Results of different studies of the same phenomena often conflict; uncertainties may be large; the conditions under which health and ecosystem threats are studied (or can be studied) usually do not match the conditions of interest for public-health or ecosystem protection.[39] These different approaches can yield conflicting results, and those conflicting results have contributed to concerns about the scientific credibility of risk assessments and related risk management decisions in general.[45] Of significance is also the inability of risk assessment to fully and adequately address issues of environmental justice and environmental health disparities due to statistical limitations of its models.

It is possible to conclude that after 50 years of experience with the dominant risk paradigm, that it is necessary for a new paradigm that:

- is timely and responsive to the mission it is meant to support;
- provides sufficient results for justifying action; and
- is well-suited and relevant to the challenges of protecting human health and the environment.

Risk-based approaches have had successes in addressing part of the problem in the past, but they are ill-suited to solve today's wicked environmental challenges.[14] Today's problems call for a systems approach that looks at a problem holistically to formulate sustainable solutions to environmental issues.[14,46]

The EPA must move away from a risk-only framework to ensure that protection of health and the environment is for *everyone* no matter the size of your cohort (even if it does not provide enough statistical strength to justify a modeling conclusion), no matter your socio-economic status, etc. This means embracing emerging tools to ensure sustainability and equitability. While conceptual frameworks, models, and tools including life-cycle analysis, full-cost accounting, ecosystem

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services valuation, industrial ecology, biomimicry, green chemistry, green engineering and sustainable design, and circular economy were not even imagined in 1970, most have been well-documented in the 2012 National Academy of Sciences, "Sustainability and the U.S. EPA" (the Green Book)[47] and need to be fully operationalized into the decision-making processes of the EPA going forward. As detailed in the report, there is growing recognition that current approaches aimed at decreasing existing risks, however successful, are not capable of avoiding the complex problems in the United States and globally that threaten the planet's critical natural resources and that put current and future human generations at risk, including population growth, the widening gaps between the rich and the poor, depletion of finite natural resources, biodiversity loss, climate change, and disruption of nutrient cycles.[47] Further, the tools for sustainable decision-making are advancing in development and implementation while the potential economic value of sustainability to the United States is recognized to not merely decrease environmental risks but also to optimize the social and economic benefits of environmental protection.[47]

From Environmental Injustices to Protecting the Most Vulnerable. Perhaps one of the most stunning examples of the limitations of EPA's approach to carrying out its mission are the instances where exposures to pollution and other environmental risks are unequally distributed by race and socioeconomic class. Hundreds of studies conclude that, in general, ethnic minorities, indigenous persons, people of color, and low-income communities confront a higher burden of environmental exposure from air, water, and soil pollution caused by industrialization, militarization, and consumer practices.[48] These environmental injustices have resulted in a failure to realize the promise that "all people and communities are entitled to equal protection of environmental and public health laws and regulations"[49] and result in acute, chronic, and even intergenerational adverse impacts to health and well-being in these already vulnerable communities.[48]

Despite the best of intentions, the results of the past 50 years are that the most well-off in our society are the most protected and the most vulnerable are the least protected. Government agencies at the Federal, State and local level and municipal authorities need to improve their performance to ensure environmental justice, rather than contribute toward environmental injustice.[50] This was mandated in President Clinton's Executive Order 12898, which requires all federal agencies to take action to ensure environmental justice.[51] In order to stop unequal protection from environmental hazards, Dr. Bullard has recommended that the EPA—along with other government agencies—should guarantee the right to environmental protection, prevent harm before it occurs, shift the burden of proof to the polluters, obviate proof of intent to discriminate, and redress existing inequities.[52]

As important as mitigating the disproportionate share of the burden is ensuring an equitable share of the benefits, when it comes to the environment through the development of healthy and sustainable communities through new community paradigms that are holistic and integrative, empowering and equitable, inclusive and participatory, culturally diverse and spiritually nourishing, economically just and regenerative.[53] This is not just a responsibility to consider those living within the borders of the United States but to effectively assist and enable nations where the need is greatest to realize this vision.

Strategies and Tools. To make the organizational transitions most effective and to realize the visions presented in the paradigms operational, it is important that underlying strategies and tools evolve and expand. A strategy is an explicit expression of intent providing a blueprint for budgeting, staffing, prioritization, operations, programming, partnership, and implementation decisions. Tools are integral and essential to enable outcomes that support a strategy's success.

From Command-and-Control Regulations and Cost-Benefit Approaches to a Full Toolbox of Incentives and Disincentives. The EPA's command-and-control approach has been criticized that it:

- is unduly rigid, unnecessarily cumbersome, and costly;
- fails to accommodate and stimulate innovation in resource-efficient means of pollution prevention;
- fails to prioritize risk management wisely;
- is patchwork in character, and does not have a coordinated approach to environmental problems that span across different environmental media and often ignores functional and ecosystem interdependencies; and
- relies on a remote, centralized, bureaucratic apparatus that lacks adequate democratic accountability.[54]

While praising the EPA's past accomplishments, critics of its command-central planning system maintain that, going forward, its inherent limits cannot ensure sustainable environmental progress at tolerable social cost.[54]

In parallel, cost-benefit analysis has emerged as the dominant force for justifying rule-making and taking regulatory actions, and yet the analytical tools have been shown to be inherently limited.[55] One of the main concerns with cost-benefit analysis is its reliance on tools like "willingness-to-pay," which introduces significant structural bias toward wealthier individuals.[56] The approach to compensate for this flaw faces the philosophical limitation that you cannot put a price on the priceless, and you cannot quantify the unquantifiable, that is, health and life. The cost-benefit framework futilely aims to compare public costs with private benefits and private costs with public benefits. Recent controversial changes to the underlying assumptions only highlight how easy it is to corrupt the cost-benefit analyses by neglecting the co-benefits.[57]

This is further compounded by the inherent assumption in cost-benefit analyses that future health, life, and environmental systems are devalued through discounting. While currency is widely considered to inflate over time, ecosystem services are degraded through emissions and other human activities, which make them more precious, and so more costly to protect or procure over time. With continued environmental degradation, natural systems and the health and well-being that rely on them become more scarce and more precious. Therefore, any delay in action in protecting the environment results in greater costs, contrary to the models of neoclassical economics.

The old adage of "When the only tool is a hammer everything looks like a nail." is often repeated in the regulatory world and there are those that simplistically believe that in regulatory agencies, all you can do is regulate. However, the *mission* of the EPA is not to regulate, rather, regulation is simply one tool to meet its mission. Over the years, the agency has developed other mechanisms of education, awareness, regulatory relief, and voluntary programs that have resulted in not only important benefit to human health and the environment, but also benefited the goal of mutual goodwill within communities that were often at odds.[23,58] The policy mechanisms for increasing the supply of innovation to realize systematic and sustainable solutions could include expansion of supplementary environmental projects;[59]

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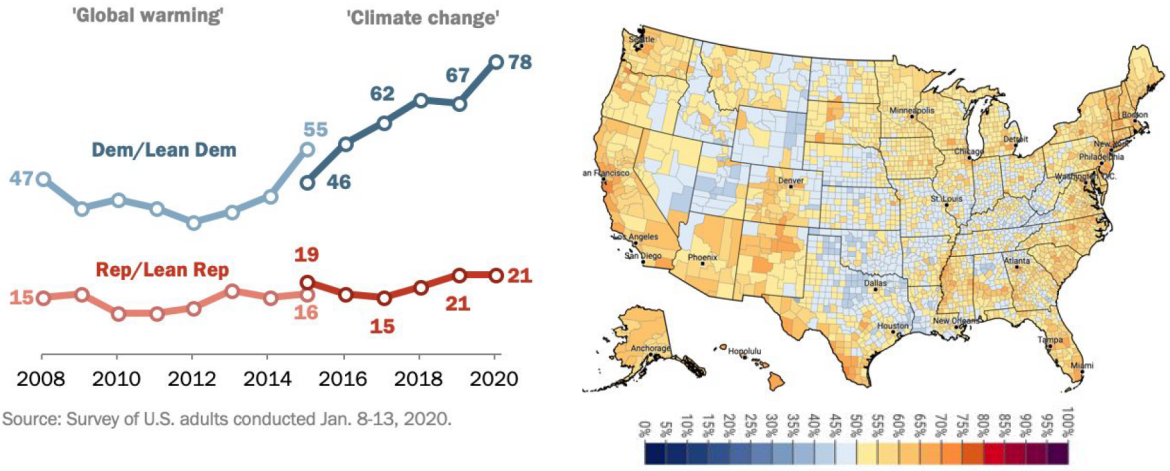

Figure 4. Diverging level of support for environmental issues by (a) political party affiliation[28] and (b) geography (represented by % of adults who think Congress should do more to address global warming by county; survey includes data through March 2020).[29]

investment tax credits (through partnership with the Department of Treasury); patent life extension (through partnership with the Department of Commerce) for green innovations; and funding for research, development and demonstration.[60] Demand-side opportunities include standards and eco-labels, economic incentives, procurement and demonstration, as well as information-based programs.[60,61] This range of an "expanded toolbox" to achieve environmental prosperity is an important step in EPA's evolution.

From Winners and Losers to Win-Win. It has often been correctly noted that during the early decades of the EPA, the agency and its mission enjoyed enthusiastic, bipartisan support and the accomplishments of the agency were implemented by Republican and Democratic Administrations alike (e.g., the Clean Air Act passed the Senate without a single "nay" vote). Yet in recent decades, a partisan split has emerged on the level of support for environmental issues (Figure 4).

Originally the EPA was universally viewed as bringing benefits to all citizens of the United States (clean environment and improved health). Now, however, the agency is viewed by some as taking away things that they value (water rights, land rights, freedom to operate their businesses and farms as they see fit). This shift in perspective is at least partially due to the regulatory and command-and-control methods that the EPA has employed.[62] The EPA's methods often specify that there is a problem that needs to be addressed, but seldom provide a way to address it. As the environmental problems become more complex and distributed, the solutions to them become more challenging for the typical business person or farmer to implement.[14,63] The burden has often been placed solely on the "regulated community".

The issues of the future will undoubtedly require innovation of all types, including technological, policy, and social.[33] These innovations will most likely not be generated by the same communities that have to abide by new regulatory standards or permitting requirements. The National Academy of Sciences has repeatedly reported that support for innovation through basic research, demonstration, development, and commercialization can bring both environmental and economic benefits.[64] Of course, these successes are further enhanced through public-private partnerships between government, industry (including trade associations), academia, and/or civil society.[64,65]

For 50 years, the default value for how the EPA sought to curtail pollution and environmental damage was to internalize the externalities: in other words, to make the polluters pay a price. This was done through command-and-control regulations that required permitting costs, fines for violation, and other punitive measures. It set up a dynamic of winners and losers, that to be in environmental compliance with the law and regulations would be a costly proposition from the perspective of the regulated community. This model would add no value to your business, to your farm, or to whatever endeavor you were pursuing. It would merely add a cost, and this created disincentives to compliance. Said another way, it created great incentives for noncompliance.

It is possible to move away from win-lose scenarios, thus provide the opportunity to create win-win scenarios. In the win-win scenarios, those in compliance gain great economic benefit, and the environment benefits and public health improves. There is a business adage that says, "When is an expense not an expense? When it is an investment." By turning the protection of environmental and public health into a wise investment that increases the bottom line and raises top line growth, there is an incentivizing of compliance and a disincentivizing of non-compliance. This is mainly due to the fact that you do not need to legally compel or regulatory threaten individuals or companies to do something that is in their recognized self-interest.

There are numerous examples where the agency has promoted this type of win-win scenario. The Design for Environment program, launched almost 30 years ago, encouraged people to develop new products and processes that were environmentally beneficial and in the process created new markets that have been extremely profitable, as manifested by the Safer Made Program.[66] The Green Chemistry Program established by EPA in 1991, has been adopted by nations and businesses around the globe[67] and has led to the establishment of the Green Chemistry in the Commerce Council (GC3) that over 200 companies ranging from manufacturing to retail have joined. Similarly, Energy Star, a voluntary energy efficiency-labeling program operated jointly by the United States Department of Energy and U.S. EPA, was established in 1992. Since its inception it has saved approximately 20 exajoules of energy, and subsequently 50 teragrams of carbon emissions, while saving homeowners and businesses money on their energy

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bills. Extraordinary programs such as these already implemented by the EPA need to become ordinary and typical of EPA's work. It is only when win-win is the rule and regulatory command-and-control (the old win-lose framework) is the exception that a win−win vision can be realized..

From a High Bar for Innovation to Embracing Sustainable Innovation. Since there is definitionally a need for change in order to move from the unsustainable trajectory that we are currently on to a sustainable one, it is clear that innovations will be crucial in this process. However, many of the protocols and reviews put in place over the years at EPA have put a high bar in place for a new innovation to be allowed in the market. While this barrier to innovation is perhaps most well-known for things such as new chemicals being introduced into commerce where they had to reach a higher risk standard than chemicals already existing in commerce, there are barriers which support the status-quo also with regard to technology, policy, and scientific methods, and the EPA must pivot to a culture where innovation is embraced while simultaneously ensuring safety.

When the EPA was established and the legal frameworks and programmatic structures were put into place, there was no Internet. We did not understand the human genome. Phones had dials on them and made phone calls, only. The innovations of the past 50 years simply could not be imagined at the time of the EPA's creation. And yet many of the ways of doing business at the EPA has stayed fairly true to what was established 50 years ago. The EPA has spent 50 years implementing a "half-strategy" of setting a regulatory floor below which we must not go. The other half of the strategy should be to drive continuous improvement beyond regulatory compliance by promoting and supporting innovation.

The EPA initially provided clarity and criteria to the private sector by communicating what instrumental analytical capabilities were necessary for EPA and the regulated community to accomplish their environmental mission and measure environmental problems. In the process, EPA helped launch a worldwide industry in analytical chemistry that touched many business sectors. In the same way today, EPA needs to provide a statement of technological needs and criteria that will mobilize the private sector to not merely assist the agency in accomplishing its mission, but rather to innovate and provide solutions to current and emerging environmental problems.

These innovations may spawn new products and sectors in the future, including building materials that preserve indoor air quality while enabling net zero energy buildings. Perhaps they will yield next generation plastics and composites that offer superior performance than current materials and yet are renewable, degradable, or recyclable—thus supporting the "circular economy." The innovations that can emerge from clear market signals sent by EPA—not measuring problems but solving those problems,—may be beyond our current awareness, but they can follow in the same path as previous innovations that protected human health and the environment while also achieving economic prosperity and sustainable jobs.

From Regulatory Science to Data- and Science-Forward. Over the decades, the U.S. EPA has built a science infrastructure. This was based on a three-pronged approach of: (1) regulatory science that was focused on the scientific analysis and assessment of data for the development and implementation of regulatory actions; (2) intramural research conducted in-house that, while directly related to the agency's mission, maintained the broader research capabilities of the development of new tools, methods, new insights that proved to be useful for a wide range of applications from seeing emerging risks to human health and the environment to allowing for effective emergency response in environmental crises; and (3) extramural research that engages the environmental research community through grants and cooperative agreement in ways that both provide research insights as well as maintain the pipeline of environmental scientists necessary for the environmental protection workforce at all levels. In recent years, in addition to sustaining significant budget reductions, this crucial triad has become out of balance by focusing primarily on short-term actions. For the U.S. EPA to meet its goals of science-based protection of human health and the environment, a balanced science enterprise needs to be restored.

The pace of scientific advances over the past 50 years has been astoundingly rapid, especially in many of the fields directly related to the mission of the EPA. Advances in toxicology, data science, and sensor technology have gone through evolutions that have, in some cases, created entirely new industrial sectors that did not exist at the founding of EPA. The process by which new methodologies, new scientific techniques, and new analytical protocols are integrated into the work of EPA has, perhaps, become even slower than it was a half-century ago.[62,65] EPA scientists and decision-makers are at times faced with the following conundrum: use what they know is state-of-the-art science but has not yet received all of the procedural approvals, or use the approved methods and protocols that they know are out of date. The process for reviewing, approving, and implementing new science should at least be conducted as fast as the research that developed the new science.

The scientific endeavor of the EPA has been fundamental in the successes of the past 50 years, the EPA's science focus has largely been on analyzing what has happened in the past (i.e., contamination or chemical spill cleanup), rather than trying to improve the future (i.e., avoiding contamination or preventing chemical spills). A Science- and Data-Forward EPA means moving away from measuring, monitoring, reviewing, and endlessly assessing the health and ecological problems of the past in ways that contribute to regulatory paralysis-by-analysis, and toward science and data for solutions.

There has been an information revolution since the creation of the EPA, but there is a genuine question about how effectively the agency has utilized or benefitted from the advances made in that revolution. Big data analytics have been implemented in high-throughput screening at that EPA's National Center for Computational Toxicology for over a decade,[68] yet the results are not being fully and systematically utilized in agency decision-making. The ability to reduce regulatory burden from time-consuming permitting and compliance certifications could be (theoretically) practically eliminated using real-time integrated sensor technologies.[17] Distributed, networked monitoring of air and water quality, as well as human and wildlife exposure levels, could be achieved at a fraction of the cost with dramatically enhanced data quality using technology that exists today. To be unequivocally clear, EPA scientists in the Office of Research and Development and throughout the agency are respected as being among the best in the world and are today developing "new approach methods" (NAMs) and exploring the exposome using state-of-the-science high-throughput methodologies. The point is that these scientists should be supported in allowing these new scientific advances to be fully utilized in all aspects of the EPA's mission.

In the coming 50 years the EPA will need to utilize the tools of the scientific and technological revolutions that are happening

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today if the agency stands a chance at addressing the daunting issues and challenges that we face in the years to come. Big data analysis will be required to understand the trends and anticipate the coming consequences of a changing climate on everything from asthma to agriculture. Genomics and synthetic biology will be necessary to elucidate the mechanisms of harm and the solutions to the adverse consequences from exposure to the plethora of molecular pollutants. Ubiquitous, integrated, real-time sensor technology will be required to avoid tragedies in accidental releases of toxics and enable awareness of individuals, Citizen Scientists,[69] about the quality of their air and water that allows them to avoid problems in their homes and neighborhoods. Science and "big" data may revolutionize how we monitor environmental quality, understand how humans interact and respond to human activity,[70] and how the environment responds to human activity.[71] While it has always been recognized that science and data will not be the only important factors in every EPA decision, it is equally true that they must be a part of all EPA decisions.

CHANGE IS AT THE CORE OF EVOLUTION

The call for the evolution of the Environmental Protection Agency to the Environmental Prosperity Agency is not as new or as radical as it may seem. The collection of observations about the limitation of the current approaches and even many of the recommendations for a new path forward have been thoughtfully discussed for years. Many of them have reached the point of being obvious. The implementation of these recommendations in many cases are conceptually straightforward and do not require human and financial resources nearly as much as they require a change in thinking and a change in perspective. It does not cost a penny to change one's mind but that change is often the highest barrier.

With a critical mass of people from all slivers of the political spectrum and all corners of the stakeholder universe converging on this vision of a win-win EPA, the time is now for evolution to come and the next 50 years to begin.

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Notes

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