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The Trump Administration and the Environment — Heed the Science

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Science-based policies and regulations have resulted in tremendous gains in environmental quality and reduced the population's exposure to harmful pollutants (Fig. 1). In the United States, the gains have been driven by major laws that were passed and amended by Republican and Democratic administrations alike (Table 1). For example, the 1970 Clean Air Act (CAA), signed by President Richard Nixon, called for a broad array of measures to improve air quality, addressing the major airborne pollutants and their sources. The resulting improvements in air quality have been substantial (Figs. 1 and 2) and have benefited human health.[1-3]

Nationally, laws covering the environment are implemented and enforced by several federal agencies, including the Environmental Protection Agency (EPA), which has a leading role on the environment, and through partnership with and delegation to the states. When first implemented, the laws and agency actions were based on a "command and control approach" driven by public demands to clean up visibly polluted air, water, and soil. Detection of additional chemical contaminants in air, water, and biota and scientific evidence of adverse health outcomes led to "risk assessment and management" as an additional approach to environmental control.

The EPA has also faced general challenges that transcend particular legislation, including a mandate for "environmental justice" to eliminate disparities in environmental exposures[4]; climate change, which was initially recognized as a problem by the Reagan administration; and other local and global sustainability issues resulting from a growing world population living in megacities on a limited land mass.

Climate change also provides a case study of the need for integrating the EPA's science with legal processes, since litigation has become a common tactic for both motivating and blocking regulatory actions. Greenhouse-gas emissions were not directly covered in the CAA, but in *Massachusetts vs. EPA*, the Supreme Court found that that law was sufficiently broad to cover such emissions from mobile sources.[5] President Barack Obama's Clean Power Plan, currently stayed by the Supreme Court, drew on the CAA to address carbon emissions from power plants.[6]

States' actions have also contributed to improving environmental quality. The California Air Resources Board implemented particularly stringent health-based standards for vehicle emissions, which fostered technological advances now in use worldwide. New Jersey's efforts to clean up hazardous-waste sites and require reporting of toxic releases also became models for national programs that have led to dramatic reductions

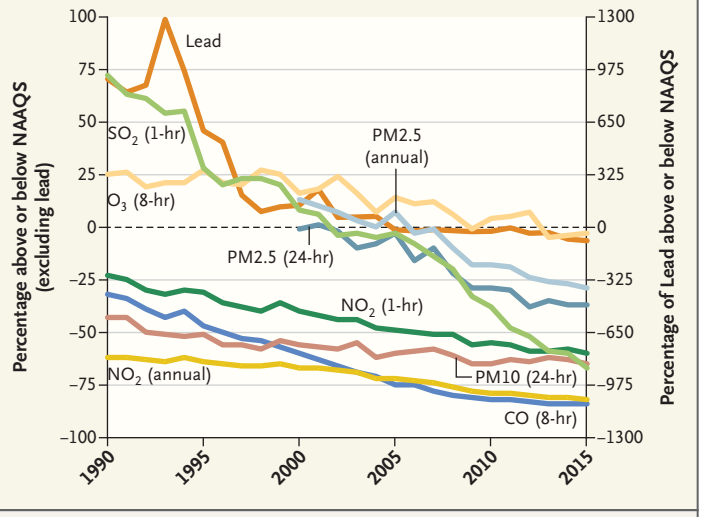

Figure 1. Changes in Concentrations of Criteria Pollutants, 1990–2015.

Data are from the EPA (https://gispub.epa.gov/air/trendsreport/2016/). NAAQS denotes National Ambient Air Quality Standards.

Table 1. Major Environmental Laws in the United States.

Title	Regulation	Year of Passage and Significant Amendments	Description
Clean Air Act (CAA)	42 U.S.C. §7401	1970, 1977, 1990	Authorizes the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and welfare from hazardous air pollutants. The law regulates air emissions from stationary and mobile sources.
Occupational Safety and Health Act (OSHA)	29 U.S.C. §651	1970	Ensures worker and workplace health and safety by providing a place of employment free from recognized hazards such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress, or unsanitary conditions.
Clean Water Act (CWA)	33 U.S.C. §1251	1972	Establishes the fundamental structure for regulating discharges of pollutants into U.S. waters and quality standards for surface waters (e.g., pollution-control programs such as setting wastewater standards for industry and permit programs to control discharges).
Safe Drinking Water Act (SDWA)	44 U.S.C. §300	1974, 1986, 1996	Protects the quality of water that may be designated for drinking use, whether from surface water or ground water sources. EPA establishes minimum standards to protect tap water and requires all owners or operators of public water systems to comply with health-related standards.
Toxic Substances Control Act (TSCA)	15 U.S.C. §2601	1976, 2016	Provides EPA authority to require reporting, record-keeping and testing requirements, and restrictions relating to chemical substances or mixtures during production, importation, use, and disposal of chemicals. Chemicals include polychlorinated biphenyls (PCBs), asbestos, radon, and lead-based paint. Other substances, such as food, drugs, cosmetics, and pesticides, are generally excluded.
Federal Insecticide, Rodenticide, and Fungicide Act (FIFRA)	7 U.S.C. §136	1947, 1972, 1996	Governs the registration, distribution, sale, and use of pesticides in the United States. All pesticides distributed or sold in the United States must be registered (and licensed) by EPA. According to the statute, a pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest or for use as a plant regulator, defoliant, or desiccant, or any nitrogen stabilizer.
National Environmental Policy Act (NEPA)	42 U.S.C. §4321	1969	Ensures that all branches of government give proper consideration to the environment prior to commencing any major federal action that significantly affects the environment. The most notable NEPA requirements are Environmental Assessments and Environmental Impact Statements, which are assessments of the likelihood of impacts from alternative courses of action. Projects governed by this statue include airports, buildings, military complexes, highways, and parkland purchases.
Resource Conservation and Recovery Act (RCRA)	42 U.S.C. §6901	1979, 1986	Gives EPA the authority to control hazardous waste from "cradle to grave," including generation, transportation, treatment, storage, and disposal. RCRA also sets a framework for management of nonhazardous solid wastes by focusing on waste minimization and phasing out land disposal of hazardous waste.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund)	42 U.S.C. §9601	1980, 1986	Provides a federal "Superfund" to clean up uncontrolled or abandoned hazardous-waste sites in addition to accidents, spills, and other emergency releases of pollutants and contaminants into the environment. EPA is authorized to implement the Act in all 50 states and the District of Columbia and all U.S. territories. The identification, monitoring, and response activities in Superfund sites are coordinated through the state environmental protection or waste management agencies.

in emissions and protection of drinking-water resources.[7]

The intended policy directions described to date by President Donald Trump and his appointees, and likely to be supported by Republicans in Congress, raise concern about future environmental regulations and protection, particularly if utilization of fossil fuels, including coal, is fostered over sustainable alternatives; if reduction of greenhouse-gas emissions through national action is abandoned; and if congressional action narrowing the definition of waters subject to

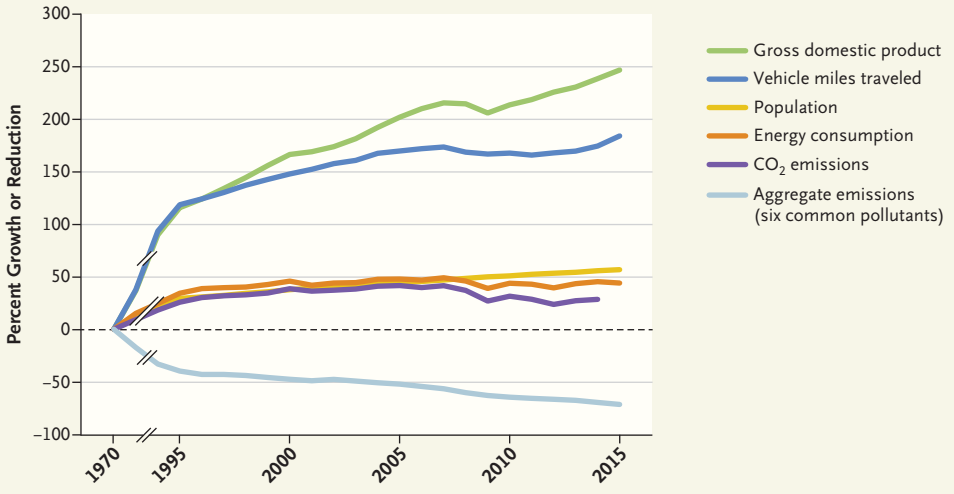

Figure 2. Changes in Economic Indicators and Pollutant Emissions, 1970–2015.
Data are from the EPA (https://gispub.epa.gov/air/trendsreport/2016/).

EPA regulation, a measure that President Obama vetoed in 2016, becomes law,[8] damaging water quality.

Our views on the environment and health are shaped by long careers as researchers who have been extensively engaged in state and national environmental policy. We believe that scientific evidence provides the foundation for environmental protection and underscores the necessity, enshrined in U.S. environmental laws, of protecting human health.

RESEARCH, EVIDENCE, AND POLICY

The CAA represents a useful model to show how scientific evidence has guided regulation to benefit public health. From its initial passage, the CAA was grounded in a paradigm of evidence-based action — the notion that peer-reviewed research identifies risks to be remediated and points to approaches for reducing them (Table 1). The CAA's handling of "criteria pollutants" — generally, major pollutants such as ozone and fine particles with adverse effects that are readily identifiable at outdoor levels — exemplifies an evidence-based approach.[9,10] The Act requires the EPA to review the relevant evidence on each criteria pollutant every 5 years. This review process has spurred development of scientific evidence to guide the EPA administrator in determining whether the National Ambient Air Quality Standards need revision.

Since the CAA's passage, despite an increase of more than 50% in the U.S. population and a 250% increase in the gross domestic product, there has been a 70% reduction in emissions of criteria air pollutants (Fig. 2), and an increasing number of lives have been saved each year (160,000 in 2010).[11] Substantial emission reductions have also been achieved for nearly 200 other hazardous air pollutants covered by the 1990 CAA Amendments. Other evidence-based policy successes related to air pollution include a marked decrease in acid rain, with associated health benefits attributable to the associated decrease in fine particles, and reversal of the decline of the stratospheric ozone layer.[12]

Risk-assessment processes used to identify hazards and characterize the associated disease burden are another path by which research findings support pollution control. A four-element risk-assessment paradigm was formulated in the 1983 National Academy of Sciences "Red Book" report: hazard identification, dose-response assessment, exposure assessment, and risk characterization.[13] Risk assessment has been refined through practice and scientific advances and is now a widely applied framework for managing environmental risks. Science-based risk assessment is also a preferred approach in settling

international trade disputes: for example, it has been a primary basis for U.S. victories in World Trade Organization deliberations over European restrictions on U.S. agricultural products.

Substantial national and global research capacity has been developed to generate the evidence and conduct the risk evaluations needed to guide public health and environmental protection policy. Academic environmental health researchers are largely supported by the National Institutes of Health and particularly the National Institute for Environmental Health Sciences, which funds 22 centers. The EPA has substantial relevant research capacity, as do the Department of Energy, the Food and Drug Administration, the Centers for Disease Control and Prevention, and other agencies. The industrial sector also has capacity. Research on the environment is collaborative and international, given the global nature of many environmental problems, and it is most effective when it's cross-disciplinary. This research capacity is vital to setting evidence-based policies.

In addition to scientific evidence, environmental decision making takes into account the costs and benefits of control, stakeholder interests and influence, and populations' concerns, often most powerfully expressed by advocates. The uncertainties in the scientific evidence also figure in decision making.[14] As physicians know, the desire for greater certainty must be balanced against the potential problems caused by delay. Unfortunately, sowing doubt about scientific evidence has become a widely used strategy for delaying or blocking actions that could affect the bottom lines of particular industries.[15]

UNFINISHED BUSINESS AND EMERGING PROBLEMS

Although substantial gains have been made, environmental pollution remains a significant public health problem. Increasingly sensitive exposure-assessment methods have revealed the scope of human and ecosystem exposures to chemical and physical agents of potential concern.[16] Rapid advances in analytical chemistry, which have allowed detection of ever smaller amounts of chemical agents in environmental and biologic samples, are not yet matched by advances in our understanding of the health consequences of the exposures. Fortunately, continued development of new techniques based on advances in molecular toxicology and related disciplines promises to provide the scientific information needed to respond to public concerns raised by the detection of hazardous agents in our immediate environment and our bodily fluids.[17]

One important contribution of environmental health science has been the testing techniques now used by both the chemical industry and government regulators to exclude chemicals from production (i.e., not manufacturing certain chemicals and not allowing certain chemicals in commercial products). As with any preventive activity, it is difficult to estimate the number of cancers, fetal malformations, or other adverse effects that would otherwise have occurred. Newer approaches based on molecular toxicology promise improved premarketing tests that will help protect the public and forestall further loss of confidence in the chemical and pharmaceutical industries.[18]

A particular public concern is the widespread contamination of the planet with persistent pollutants, many of which are detectable in blood specimens obtained in population surveys. The scope of known adverse consequences of pollution exposure has also grown. Epidemiologic findings suggest that possible lasting consequences of early-life exposures and air pollution may contribute to long-term changes such as brain aging.[19] The new "-omics" methods, such as genomics and metabolomics, are beginning to advance our understanding of who is exposed and who is susceptible to health effects. New high-throughput methods for toxicity testing of chemicals will be helpful in screening substances for hazards but will need to be complemented by improvements in understanding and evaluation of risk levels in populations. Thus, we need to maintain the capacity to conduct cutting-edge research and to grapple with the application of the results in formulating evidence-based policies. We have the opportunity to refine public health protection using the same methods and principles that underlie "precision medicine."

In addition, many "old" problems persist, and "surprises" can unfortunately be anticipated. For example, the exposure of the population of Flint, Michigan, to lead in drinking water is a reminder that problems we have considered solved may not be. Although there are thousands of offshore oil rigs, the Deepwater Horizon disaster was a

"surprise," and it led to questions about immediate and longer-term consequences for the Gulf Coast ecosystem and the health of workers and the populace at large.[20] Environmental and human health consequences of unconventional oil and natural gas development ("fracking") exemplify an emerging problem that requires strategic investigation.[21]

The EPA has worked for many years to develop an assessment method for integrating individuals' risks from exposures to multiple different chemicals and to also incorporate the effects of stressors related to health and social welfare. Newer molecular approaches, such as epigenetics and measurement of telomere length, show early promise as scientific bases for such integration.[16] Addressing issues related to sustainability will require better integration of health and ecologic assessments with economic and social sciences, including further developments in the use of life-cycle assessment and trade-off analysis.[22]

WHAT IS AT STAKE?

We have heard warnings from the new U.S. administration about reduced regulation, promotion of fossil fuels, and abandonment of measures to curb greenhouse-gas emissions. Though the administration cannot immediately change our bedrock environmental legislation, it can, through appointments, executive actions, and reduction or elimination of funding, affect research, policy, and implementation and enforcement.

For example, removing science from the EPA by weakening or abolishing the Office of Research and Development (ORD), as has been threatened, would be particularly harmful. The ORD is the country's preeminent environmental research organization, a cornerstone of our global leadership in environmental science, and a key player in the training of environmental health scientists. In 1970, when both the EPA and the Occupational Safety and Health Administration (OSHA) were formed, Congress indirectly set up an experiment. The EPA's organizational structure contained scientific research capacity in ORD, whereas OSHA's science came from another agency, the National Institute of Occupational Safety and Health, whose White House and congressional oversight differed from OSHA's. Almost half a century later, there can be little doubt that the EPA has been far more successful than OSHA in developing science-based policies, in part because of its internal research capacity.

The administration can also affect regulation through the Office of Management and Budget and its Office of Information and Regulatory Affairs, which reviews significant regulatory actions, weighing their costs and benefits. There is reason for concern that the Trump administration will weaken key science-based legislation, erode environmental research capacity, and move away from decision making grounded in science.

CONCLUSIONS

Throughout the history of U.S. environmental protection, unforeseen challenges have had to be addressed with the best available science. Some of these challenges have grown out of technological advances, such as the development of nanotechnology with the potential for adverse consequences for human health and ecosystems; some have been caused by human activities, ranging from oil spills to anthrax contamination of buildings; and some have been due to emerging diseases such as Zika. We are certain that unforeseen challenges will continue to arise and that we therefore need a vibrant environmental health science enterprise.

The quality of the environment is an important determinant of population health. The key stakeholder here is the public, which aspires to have a cleaner, healthier environment. Gallup poll data show continued public concern about the environment, a preference for environmental quality over economic growth, and a majority belief that climate change is a "real problem."[23] In many ways, Trump's campaign rhetoric on the environment recalled that of Ronald Reagan in 1980. But by the time of his 1984 reelection bid, Reagan had replaced his initial EPA leadership with leaders supportive of environmental goals; their accomplishments would include removal of lead from gasoline and the first EPA funding for studies related to global climate change. The Heritage Foundation, the conservative think tank, opposed Reagan's warming toward the EPA but argued that his initial EPA leadership had been mistaken in reducing scientific efforts and that evidence was necessary for intelligent approaches to environmental manage-

ment.[24] The new administration would do well to take that lesson to heart.

As environmental scientists experienced in the development of evidence-based policy, we have several recommendations for the Trump administration. First, we believe that evidence-based decision making on the environment should not be abandoned. Reasoned action and acknowledgment of scientific truth are fundamental to democracy, public health, and economic growth. Scientific evidence does not change when the administration changes.

Second, the administration should continue to engage and seek advice from the broad community of scientists. Abraham Lincoln created the National Academy of Sciences to provide advice to the government, acknowledging the need for science to inform governance. Third, research funding and scientific capacity related to the environment should be enhanced, not reduced, to enable us to grapple with ongoing and emerging problems and to carry out the research needed to reduce the uncertainties surrounding adverse effects of environmental challenges. Cutting funding is certain to leave uncertainties unaddressed. Fourth, environmental monitoring and surveillance should be sustained and at the ready to address the inevitable emerging problems and disasters, both foreseen and unforeseen.

Fifth, since it is abundantly evident that environmental processes related to globalization and the scientifically indisputable effects of greenhouse gases will play a growing role in causing disasters and other challenges to human health, it would be inappropriate and potentially disastrous to pause action on mitigation, particularly in concert with the wider community of nations.

Finally, the administration should not abandon the majority and most critical stakeholder, the American people, for a coterie of special-interest stakeholders.

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