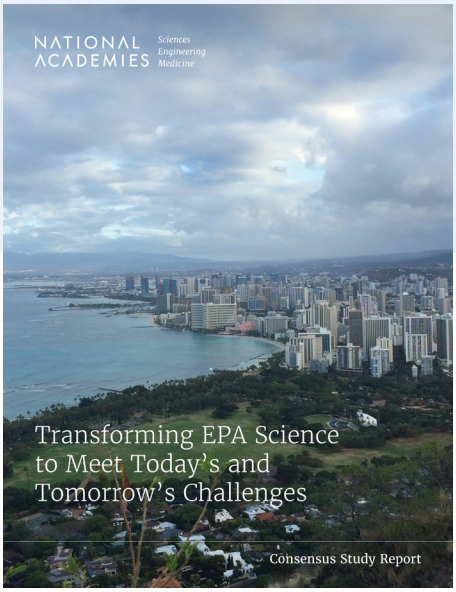
Transforming EPA Science to Meet Today's and Tomorrow's Challenges



Since its establishment in 1970, the mission of the U.S. Environmental Protection Agency (EPA) is to protect human health and the environment. EPA develops regulations, ensures compliance, and issues policies, in coordination with state, tribal, and local governments. To accomplish its mission, EPA should be equipped to produce and access the highest quality and most advanced science. And it must do that in a way that can effectively anticipate and address a range of complex challenges that environmental protection faces in coming decades, while providing science to support the numerous statutory environmental protection mandates for which EPA is responsible.

EPA's Office of Research and Development (ORD) provides the scientific bases for regulatory and public health policies that have broad impacts on the nation's natural resources and quality of human life, and that yield economic benefits and incur compliance costs for the regulated community. In addition, ORD develops the agency's core research capabilities, providing tools and methods for meeting current and anticipating future environmental challenges, such as the risks to health and the environment posed by climate change. ORD research aids in the development of responses to emerging threats, provides scientific methods for ecological and human health risk assessment, and serves as a national and international resource for the advancement of environmental science. ORD recognizes that continued accomplishment of EPA's mission requires research that anticipates the most challenging problems, develops and adapts emerging scientific tools, and identifies and implements innovative solutions.

To illustrate the kinds of complex environmental problems facing ORD, the report describes three of the key challenges: (1) holistically

addressing interconnected human health and ecological risks; (2) characterizing and managing environmental justice and cumulative exposures and health risks facing diverse populations; and (3) anticipating and responding to the human health and environmental impacts of climate change.

Based on its review of those illustrative challenges and consideration of others, the report calls for ORD to pursue all of its scientific aims in a new framework—to apply systems thinking to a One Environment–One Health approach in all aspects of ORD's work. To accomplish this, the report provides actionable recommendations on how ORD might consider incorporating emerging science and systems thinking into the agency's research planning, so that ORD can become an increasingly impactful organization.

A ONE ENVIRONMENT–ONE HEALTH APPROACH FOR ORD

The One Environment–One Health provides a framework to enhance ORD's scientific capability for considering the complex interactions among environmental, social, and economic systems for support of EPA's mission, as depicted in Figure 1. It also provides a framework for setting priorities for the pursuit of the most important scientific capabilities ORD will need for elucidating the multiple stressors to humans and ecosystems arising from societal activities; the multiple paths by which exposures from those stressors can occur; and the effects of those exposures at the cellular, organismal, population, community, and ecosystem levels. Incorporating the One Environment–One Health approach will require a number of actions to ensure that ORD not only effectively supports EPA in carrying out its environmental protection roles but also *leads* the agency toward better anticipating what integrative science capabilities will be needed to meet environmental challenges of the future.

EPA has begun to consider a broadened view of the One Health approach developed by public health communities in examining and taking action on interactions among humans, animals, and the environment, especially in understanding the origins and spread of infectious diseases. The One Environment–One Health framework can help ORD integrate the One Health concept into its research context.

EXAMPLES OF KEY CHALLENGES ASSOCIATED WITH ENVIRONMENTAL PROTECTION

Holistically addressing interconnected human health and ecological risks: Human health cannot be well protected in unsafe environments, and the environment cannot be well protected in the face of detrimental human activities. Most human health issues under the purview of EPA arise from environmental exposures that can also cause effects on wildlife and ecosystems.

Characterizing and managing environmental justice and cumulative exposures and health risks facing diverse populations: Mounting evidence shows that intrinsic factors (e.g., preexisting disease and life stage) and extrinsic factors (e.g., poverty, racism/discrimination, and social inequality) can lead to differential exposure and susceptibility to impacts from environmental chemical exposures and other stressors, leading to significant community and population differences in health risks. Cumulative risk refers to the combined risks from aggregate exposures to multiple stressors.

Anticipating and responding to the human health and environmental impacts of climate change: People and ecological communities have experienced climate change impacts through extreme precipitation and heat wave events; increased frequency of severe flooding in coastal areas due to sea level rise and storm surge; and more frequent and devastating wildfires due to hotter, drier, and longer fire seasons. Vulnerability to climate change is determined by the ability of a community or household to anticipate, cope with, resist, and recover from the direct and indirect impacts of extreme weather events and geophysical shifts, such as sea level rise, hurricanes and floods, heat waves, air pollution, and infectious diseases.

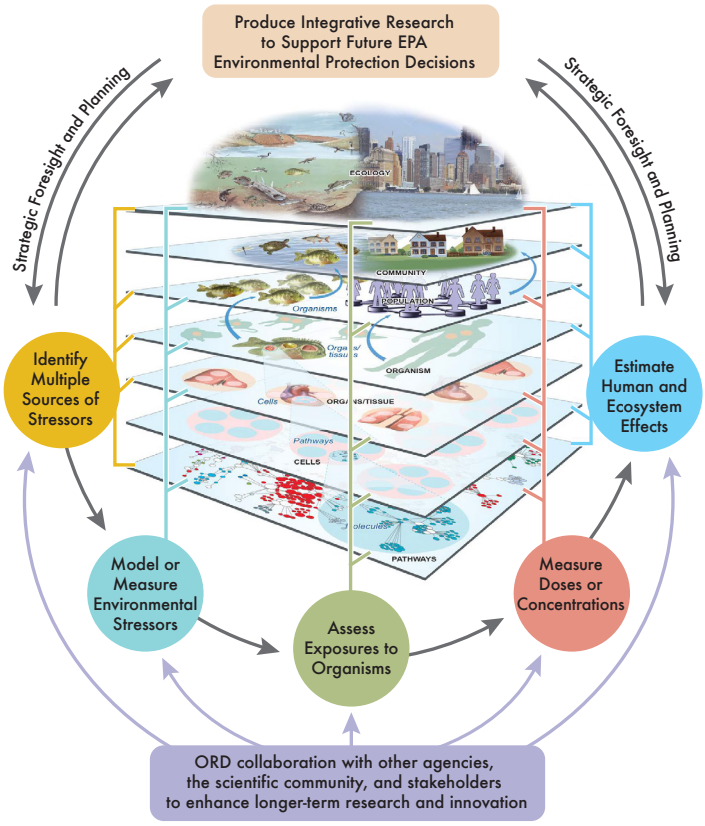


FIGURE 1 Applying a One Environment–One Health framework involves sequential scientific steps to integrate information from various scientific disciplines. Each step is linked to consideration of all layers of the biosphere.

INTEGRATING SCIENTIFIC AND TECHNOLOGICAL ADVANCES INTO THE EPA SCIENTIFIC ENTERPRISE

The report identified major actions ORD should take to ensure that it can implement systems thinking for a One Environment–One Health approach in the most effective way: by improving current strategic planning, innovation networks, collaboration, and communications.

Strategic Planning: ORD should build on its valuable Strategic Research Action Plan process to adopt a broader, proactive stakeholder model of research planning and management while simultaneously establishing a strategic foresight assessment team that evaluates emerging factors and trends on an ongoing basis.

Innovation: ORD often lacks consistency or larger-scale planning in how it approaches research design or investments. Therefore, ORD should create and maintain an innovation network that embodies both hardware and software advancements, management system improvements, systems thinking, and multi-institutional collaboration for research and development of scientific tools for direct application to newly emerging health and environmental priorities.

Collaboration: ORD should institute an approach to research collaboration that expands and strengthens collaboration with its partners, establishing shared goals, and enabling and fostering open innovation toward achieving them.

Communications: ORD's current approach to scientific communications can be significantly improved through a multi-pronged effort to upgrade communications skills and tools, including a full array of social media utilization and collaborations with other organizations to promote good science.

ACQUIRING AND APPLYING EMERGING TOOLS AND METHODS WITHIN A ONE ENVIRONMENT–ONE HEALTH FRAMEWORK

Measurements and Databases to Inform Exposure Assessments

Collection of more precise exposure data can improve risk estimates and lead to improved public health and ecosystem protection, such as better characterization of high-risk populations. The report recommended that ORD:

1. Integrate data from remote sensing and monitoring at the Earth's surface into computer models
2. Expand the use of local-scale and personal monitoring data
3. Develop a water quality data system similar to EPA's air quality system
4. Establish an integrated database on environmental quality, exposure, and pollutant toxicity

Biotechnology

ORD should strengthen and maintain its expertise to evaluate and monitor the potential human health and ecosystem impacts of new biotechnology applications, such as changing the genetic information of microorganisms to make desired products.

Participatory Research

To better capitalize on the energy and talents of communities with an interest in environmental health, ORD should develop methods for collecting and validating data to inform EPA decision-making.

Big Data and Machine Learning

ORD should foster the development of collaborative machine learning frameworks that train algorithms to integrate diverse datasets rapidly for use in assessing combined risks from different stressors.

ENHANCED INTEGRATION OF SCIENTIFIC AND TECHNOLOGICAL ADVANCES INTO ORD

Leadership

To ensure an inclusive, agency-wide approach to the integration of scientific and technological advances, the Assistant Administrator for ORD and the Chief Scientist should be active participants in agency decision-making. Those efforts also should include active representation of program and regional managers in the stages of early planning through the science implementation and regulatory applications.

Workforce for Science and Innovation

ORD is a global leader in environmental science, with outstanding scientific personnel. However, most of the science staff is trained in traditional disciplines in biological and other natural sciences. ORD should conduct an evaluation of current and future scientific staff needs, including the greater diversity of disciplines to address the social, ecological, public health, and data sciences.

Identifying Strategic Resources for the Future of EPA Science

ORD has had a steep decline in total funding, personnel, and the amount of extramural research support it can provide. Current funding levels and continual uncertainty about future funding restrict ORD's capacity to provide critical science support to EPA for addressing future environmental threats.

Strategic planning for meeting the needs for EPA science in the coming years should include a strategic analysis of ORD resource needs for the future, including workforce development, intramural and extramural research support, emergency response capabilities, regulatory program support, and computing and other information technology resources.

CONCLUSION

Shifting to a more extensive application of systems thinking will require a commitment to science leadership, enhancing substantially its approach to strategic planning, investment in new and broader expertise and tools, and a reimagined and inclusive commitment to communication and collaboration. It will also challenge ORD leadership to make decisions about priorities for implementing the committee's recommendations in the face of constrained resources.

The result will build on ORD's already substantial contributions to ensure that its science is ahead of the curve, and its science voice informs all of EPA's efforts to tackle the environmental challenges it will face for decades to come.

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FOR MORE INFORMATION

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