TERRY F. YOSIE

Transforming How the Environmental Protection Agency Does Science

The environmental risks embedded in today's globally integrated economies require an updated approach to scientific and regulatory decisionmaking.

For the past half century, the US Environmental Protection Agency (EPA) has applied a common regulatory framework to the implementation of public health and environmental statutes that primarily involves focusing on discrete sources of air, land, or water pollution. This strategy has been successful in reducing the presence of specific compounds that can be harmful in the environment. But that is as far as it goes.

This method—known as command-and-control regulation—was very much of its time and continues as EPA's predominant policy framework. Consider, for example, how car pollution is regulated. EPA restricts the emission of individual pollutant classes, such as carbon monoxide and nitrogen oxides escaping from tailpipes. Sometimes the agency targets multiple pollutants at once, as it did this year when finalizing new rules to ratchet up vehicle emission standards and reduce pollution. Ultimately, these updated regulations will require adoption of cars and trucks that aren't powered by fossil fuels—principally electric vehicles (EVs).

But because EPA scientists and administrators focus on protecting the public from particular pollutant exposures, they are unable to adequately address the broader question of what this EV transition will mean for the environment and for human health. The agency has not studied the release of greenhouse gases and other pollutants from the extraction of lithium, manganese, nickel, and other materials necessary to build EV batteries and other vehicle components. Neither has it evaluated population and ecosystem exposures to new sources of pollution associated with the manufacture of EVs. EPA scientists have also not identified impacts from extracting more water in areas already stressed by limited water resources, nor have they determined health and environmental risks from transporting, storing, and processing materials used in EV production, or assessed pollution levels from EV use in commercial vehicles or by consumers.

EPA's knowledge gaps also span other major health and environmental challenges. These include: controlling emissions in the power-generation sector, even as the transition is underway from coal and natural gas to renewables and nuclear energy; decoupling plastics production from reliance on natural gas—another necessary transformation in the age of climate change; and managing the 10,000 variants of per- and polyfluoroalkyl substances (or PFAS, commonly called "forever chemicals") that are present in thousands of communities across the country and are associated with a range of reported health effects.

As EPA's toolkit expands to include life cycle analysis, data analytics, and other methods, a significant and fundamental challenge will be developing the capacity to understand key relationships between future pollution sources and economic

and energy transformations currently underway. Today's globally integrated economy, with millions of supply-chain and value-chain pollution sources, has rendered the single-pathway method of command-and-control regulation ineffective. Contemporary challenges are systemic in nature; each originates from multiple kinds of sources and economic enterprises. Agencies such as EPA need to modernize their approach to scientific and regulatory decisionmaking to better understand the causes of contemporary environmental risks and respond to them effectively.

Researchers have begun to assess environmental and health impacts from multiple aspects of a product, service, or industrial process—starting with the production of raw materials and continuing through manufacturing, distribution, use, and disposal. This "systems" approach to research planning and environmental decisionmaking can yield both innovations and insights to protect future public health and the environment. Consequential reform is possible: the One Environment–One Health framework, an interdisciplinary approach first developed by epidemiologists working to prevent disease transmission between wildlife and humans in the early 2000s, has been adopted in various parts of the US government and among international institutions. The framework has motivated a systems approach to the science and regulation involved in ensuring a livable and sustainable human habitat.

This need for a shift from single-media regulation to a systems approach occurs in the context of other significant changes: concerns about environmental justice; the energy transition away from fossil fuels; accelerating climate change; and unpredictable new technologies as widely dispersed as social media, artificial intelligence, and biotechnology—not to mention possible new limits on the agency's regulatory and enforcement authority, such as those triggered by recent Supreme Court rulings. For all of these challenges, a modernized EPA, implementing the One Environment–One Health framework, would have much to offer. A question, then, is what prevents the agency from taking this different course. And an even more important question, perhaps, is how exactly to foster the necessary changes.

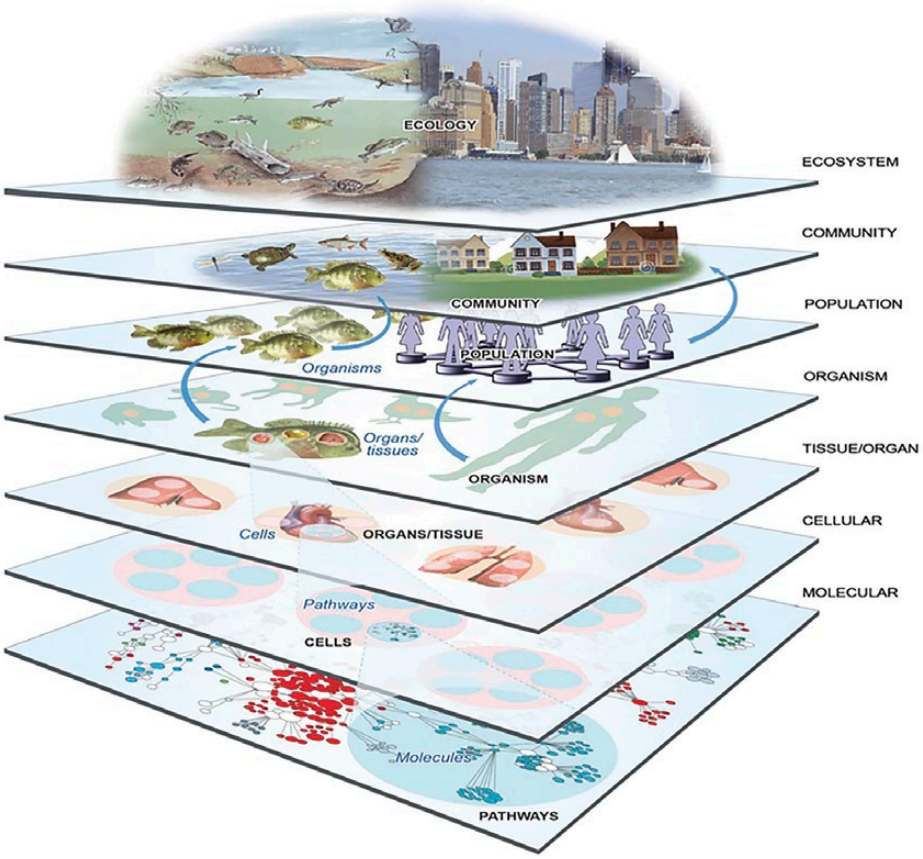
The path forward: One Environment–One Health

A chief obstacle to systems thinking is EPA's antiquated culture and strategy for generating scientific information and presenting it to policymakers, business executives, and consumers. In a deeply interconnected and rapidly changing world, EPA must develop a culture of innovation and collaboration that moves away from the single-pathway approach. In its place, the agency urgently needs a new framework for generating knowledge that can identify more policy options for decisionmakers and stakeholders and also disseminate expertise to the public in a transparent way.

A scientific culture of innovation and collaboration rests on two pillars. First, it is essential that regulators appreciate the interdependencies of human and environmental health. Second, they must mobilize multiple scientific disciplines and institutions to address risks affecting both human and environmental endpoints. These are also the cornerstones of One Environment–One Health. In their recent report *Transforming EPA Science to Meet Today's and Tomorrow's Challenges,* the National Academies of Sciences, Engineering, and Medicine recommend that EPA adopt the One Environment–One Health framework to govern both its selection of research projects and its processes for communicating results to policymakers, businesses, the media, and consumers.

> A significant and fundamental challenge will be developing the capacity to understand key relationships between future pollution sources and economic and energy transformations currently underway.

There are a number of key differences between One Environment–One Health and EPA's current approaches to planning for science and decisionmaking. Importantly, One Environment–One Health provides a systems lens for identifying and evaluating risks. Following this framework means studying the full life cycle of each challenge across each level of the biosphere, beginning with organelles and cells to tissues and organs, individual organisms, the communities they comprise, and ultimately ecosystems assembled from interacting species. Crucially, research of this sort integrates data and knowledge provided by multiple stakeholders across disciplines. Their perspectives help to assure that studies ask the appropriate questions and anticipate the full range of impacts, including secondary and tertiary consequences. By taking advantage of such collaboration, research carried out under the One Environment–One Health framework can lead to emergent



Source: National Academies of Sciences, Engineering, and Medicine, Transforming EPA Science to Meet Today's and Tomorrow's Challenges, *https://doi.org/10.17226/26602. Reproduced with permission from the National Academy of Sciences, courtesy of the National Academies Press, Washington, DC.*

solutions that would not be discovered using more traditional, siloed methods of research and public-policy management.

As the diagram illustrates, One Environment–One Health applies a systems-thinking approach, with a sequence of steps to integrate information from multiple scientific disciplines. Each step is linked to consideration of all layers of the biosphere. Collaboration across organizations will enhance identification of scientific and technical advances for meeting future environmental and health challenges.

A roadmap for EPA transformation

Broadly speaking, there are four areas in which EPA can improve its capacity to achieve a culture of innovation and collaboration. These improvements would be critical investments in the agency's future as well as in the health of the people and ecosystems it serves.

First, the agency could do more to leverage information technology. The One Environment–One Health framework is data-heavy: the physical environment is the source of much of those data—and a rich source at that. Digital technologies provide the means of collecting, integrating, analyzing, and using all kinds of information. For instance, mitigating problems of environmental justice requires integrating many kinds of knowledge about particular communities, including knowledge of their demographics, disease burdens, access to medical care, and pollution loadings. Obtaining such extensive data involves multiple inputs, such as from sensors that trace pollutants as well as the participation of community residents surveying their health and location information.

This data gathering could lead to more knowledge relevant to decisionmaking. For example, machine learning may be valuable in detecting patterns of risks across multiple pollutant exposures and identifying stresses affecting humans and critical nonhuman species. Integrated datasets can be used to compare relative toxicities for a range of pollutant exposures and estimate their effects. Doing this sort of modeling could expand the options available to decisionmakers. For example, by prioritizing risks in communities that are exposed to complex mixtures of pollutants, decisionmakers can develop more effective strategies to protect the health

of people and environments in the area—using not only regulatory tools, but also direct stakeholder engagement.

EPA has already begun a transition to more formally adopting such monitoring methods, both in research and community surveillance, through a series of initiatives in lower-income communities in the lower Mississippi River and other regions. Further, it has promulgated regulations to limit hazardous chemical emissions of ethylene oxide and other substances.

A second area for improvement can come through nurturing innovation networks, both within EPA and by crossing over boundaries to other institutions. No single organization possesses the resources, workforce skills, or technology platforms necessary to develop effective solutions to problems at local, regional, or global scales. Those solutions will only come from innovation ecosystems: organizations and people with common or complementary objectives working together by exchanging information, talent, and resources.

For instance, a key environmental protection innovation of recent years has seen corporate water users and their suppliers collaborating to reduce carbon emissions and water consumption across their business activities. Innovation is, after all, a social process; it happens at the intersection of diverse cultures and missions. Professionals working together across disciplines and harnessing varied points of view are essential for innovation, regardless of organizational structures. A small number of loosely connected teams or enterprises can innovate; so can large-scale global corporations and partnerships.

A number of recent innovations—the use of satellites to detect methane releases to the environment from oil and gas operations in remote locations, for example, and more systemic identification of plastics ingredients across product life cycles—embody the multidisciplinary collaboration that yields creative solutions to large-scale problems. In each case, scientists from academia, government, business, nongovernmental organizations, and philanthropies worked in teams and leveraged resources to design research projects aimed at addressing global problems.

Third, and related to the above, it is essential that EPA develop a wider culture of innovation and collaboration that can operate at the scale of current and future problems. Most scientific organizations have a history of collaboration with select research partners. But as public health and environmental challenges grow more complex—with any given challenge involving and influencing more and more industries, ecosystems, and human populations—these partnerships must evolve beyond narrow project- and subject-specific focuses. Collaboration must be as systemic as the problems themselves.

What, concretely, does this look like? For starters, agencies like EPA should cultivate collaboration among major players within particular industrial sectors while convening nationwide and global multistakeholder partnerships. EPA researchers could serve as brokers, creating collaboration platforms and developing commitment mechanisms. EPA or other agencies can use their role as conveners to encourage adoption of collaborative research plans in which all major partners join together to co-define research objectives and participate as co-decisionmakers in management and oversight of research and funding. Agency conveners can improve transparency in research planning as well as in reporting results, which would strengthen accountability among the partners and enhance the credibility of research findings. And organizations like EPA, through their global professional networks, are well-positioned to expand international collaboration with the goal of addressing transborder problems such as climate change, water scarcity, ecosystem stress, declining biodiversity, and the environmental consequences of geopolitical conflicts.

Research carried out under the One Environment–One Health framework can lead to emergent solutions that would not be discovered using more traditional, siloed methods.

There are multiple benefits of such collaborations. Research initiatives gain access to talented professionals from a range of disciplines and institutions. Collaborations help build constituencies and buy-in across scientific enterprises. Partners can leverage each other's resources to enable research at a significantly larger scale. By negotiating commitments, partners harmonize their priorities, allowing them to efficiently contribute to collective goals. And collaborations gain expanded capacity to disseminate scientific results, enabling them to reach broad audiences and speak with the authority of multiple expert organizations.

The fourth intervention in EPA's innovation culture is to foster open scientific communication using social media platforms. Open communication facilitates collaboration and trust in science, which in turn can

help researchers and policymakers get the most out of One Environment–One Health. The framework prioritizes exchange and public impact, both of which demand sharing scientific data among researchers and organizations that use scientific findings to drive decisionmaking.

Importantly, the scientific community and the many organizations informed by science must be empowered to reduce public skepticism. The audience for scientific communication has grown and changed dramatically thanks to the online revolution in information sharing. Vocal and well-organized groups can absorb scientific information and distort it; many reject the evidence base of business and public policy decisions. Many consumers of scientific information are casting doubt on the credibility, relevance, and ethical underpinnings of research findings, as well as the motivation behind policies designed to protect public health and the environment. Scientists and agencies such as EPA need more effective means to counter distrust.

Today, EPA and its partners engage the public primarily by using traditional tools, such as conference presentations, publication in peer-reviewed literature, websites, and the public comment mechanism built into the regulatory process. These are necessary tools, but they are not sufficient to meet shifting expectations for transparency surrounding data collection and use.

To respond to these challenges, scientists and their sponsoring organizations should embrace the more open system One Environment–One Health calls for. In particular, scientists can supplement existing communication platforms with social media initiatives. Four strategies in particular can help. First, researchers in science-based organizations can use their online presence to communicate about their conformity with established standards for scientific ethics. Second, scientists should collaborate with communications professionals to develop clear, data-driven messages for dissemination via social media. Third, science-based public policy should include citizen-facing reports of major studies or groups of studies. Aimed at everyday readers who don't have scientific expertise, such reports would help to contextualize scientific findings in a broader narrative relevant to and comprehensible by nonexperts. Finally, EPA and other science-based regulators should expand and integrate their research into classroom materials, promoting scientific literacy via education systems.

Applying One Environment–One Health to large-scale problems

Replacing the single-endpoint or single-media approach with the One Environment–One Health framework would be transformative, enabling EPA to prioritize decisionmaking relevant to public health and environmental protection problems that are truly urgent today. This approach will also prepare EPA to address new problems as they arise.

Consider how this structure might operate in some of these significant real-world challenges. One pressing difficulty is food waste, a major contributor to three simultaneous planetary crises. Food production is fossil-fuel intensive, so waste needlessly adds to carbon emissions; food waste also aggravates problems otherwise associated with climate change, affecting, for instance, water resource availability. Industrial-scale agriculture is further linked with ecosystem and biodiversity loss. Finally, runoff of agricultural nutrients and pesticides is a serious source of pollution. As it is, the United Nations Environment Programme estimated that in 2021, food waste from households, retail enterprises, and the food-service industry globally totaled 931 million metric tons, and the amount of waste is growing.

Organizations like EPA, through their global professional networks, are well-positioned to expand international collaboration with the goal of addressing transborder problems.

A major challenge in ongoing efforts to solve the food waste problem, both locally and globally, lies in the fragmented relationships among farmers, food collection and transport systems, processing businesses, retail establishments, and consumers. The lack of data exchanges and collaboration among these value-chain participants mirrors disjointed policy design by governments and investment decisions by businesses.

The One Environment–One Health approach facilitates comprehensive solutions by promoting open-source data that everyone—including farmers and consumers—can use to better appreciate their interrelated roles in the food system. Within those data sources are clear signals that could aid in resolving a growing planetary problem. Integrated knowledge of the food value chain would encourage governments and businesses to raise the bar, developing innovative agricultural practices that improve efficiencies in energy and water use and implement postharvest refrigeration technologies to prolong the life cycle of food products.

A second problem that could be addressed using the One Environment–One Health framework is plastic waste.

More than 10 million metric tons of plastic waste enter the oceans each year from land-based sources, and that figure is expected to rise to 20 million metric tons per year by 2050. Simultaneously, less than 10% of plastic materials are recycled, and 32% of plastic packaging is not captured in collection systems. Yet even as huge amounts of plastic become waste streams, worldwide production is exploding. In the US Gulf Coast region alone, 10 new plastic production plants and 17 plant expansion projects are planned over the next five years.

Since 2022, delegates from 175 countries have been attempting to negotiate an internationally binding treaty to curb plastic pollution, including in the marine environment. But the various national delegations are at loggerheads over specific commitments, which include production limits for particular plastics, investment in waste-collection infrastructure, and provisions to encourage enhanced recycling and reuse of plastics. This is an opportunity to apply a systems-thinking approach to plastic waste—as opposed to managing individual elements of the problem (e.g., waste management or enhanced recycling)—to address its many interconnected challenges.

Applying a One Environment–One Health framework could help develop more robust solutions. Using innovative, cost effective, data-rich labeling systems to track plastics could make recyclable and reusable waste easier to identify. But even bigger results could come from research assessing the environmental and social impact of plastics across their life cycles, particularly if agencies and businesses encourage collaboration among researchers and product-makers to invest in design for recyclability. These efforts would help to establish an analytically sound foundation for recycling targets set by governments while also formalizing extended-producer responsibility programs, which task manufacturers with handling products at the end of their useful lives. Finally, implementing the framework would encourage assessment of greenhouse gas emissions from plastics production as part of climate change policy development and business planning.

The example of plastics is just one way that the use of One Environment–One Health and interoperable datasets can help society learn how to better control the fate of materials already in use and design future products to avoid waste.

Making more robust decisions

Within EPA and across federal, state, and local governments, many individual elements of a One Environment–One Health approach to scientific planning and decisionmaking are already in place. However, these elements are not sufficiently coordinated. Government agencies need to further invest in building cohesiveness, continuity, and scope into the use of the framework. When they do, many citizens will be surprised to learn just how much data analysis can contribute to solving problems of both immediate and longer-term concern across a growing range of health and environmental challenges. Importantly, greater transparency can improve the credibility of research findings, building confidence in science among both public- and private-sector stakeholders and encouraging greater buy-in.

In June 2024, the US Supreme Court ruled in *Loper Bright Enterprises v. Raimondo* that a four-decade precedent of federal court decisions to defer to agency interpretations of statutes, known as *Chevron* deference, was no longer valid. This decision could affect government policy decisions across a range of public health, environmental, pharmaceutical, financial integrity, telecommunications, and workplace safety issues. But it will require years, if not decades, of subsequent litigation to clarify the intent and scope of judicial authority over regulatory policy development. Still, many of today's statutes are, in fact, clear and specific in their language and scope—and EPA, along with other agencies, will still need to retain its ability to conduct research and assess risks to inform policymaking choices.

Adopting new and transparent frameworks for assessing risk and building consensus among stakeholders could prove invaluable to agencies as they navigate this period of legal uncertainty. As public health and environmental policymaking become more driven by stakeholder expectations, implementing a One Environment–One Health framework can further inform and empower these stakeholders in their communications with government agencies, and thereby further legitimize actions the latter may consider.

In this and other circumstances, the One Environment–One Health framework for research and analysis can provide decisionmakers inside and outside government with a more complete understanding of health and environmental challenges. And, by advancing this outcome in a transparent manner, it can add credibility and value to efforts to address major risks of the present and future. Compared to current frameworks that focus on individual pollutants and pathways, One Environment–One Health, with its foundation in systems thinking, can provide more significant support to EPA and other agencies to advance their ultimate goals: healthier people and a healthier planet.

Terry F. Yosie *is a sustainability advisor to business, government, and nonprofit organizations and universities. He has served as director of the US Environmental Protection Agency's Science Advisory Board, in senior-level positions in the chemical and petroleum sectors, and as CEO of the global nonprofit World Environment Center.*