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Closing the Environmental Data Gap

Information limitations are severely constraining our ability to identify and understand emerging environmental problems, devise interventions to address them, and evaluate whether our responses work.

The compelling evidence that the global climate is changing significantly and will continue to change for the foreseeable future means that we can expect to see similarly significant changes in a wide variety of other environmental conditions such as air and water quality; regional water supply; the health and distribution of plant and animal species; and land-use patterns for food, fiber, and energy production. Unfortunately, we are not adequately monitoring trends in many of these areas and therefore do not have the data necessary to identify emerging problems or to evaluate our efforts to respond. As threats to human health, food production, environmental quality, and ecological well-being emerge, the nation's leaders will be handicapped by major blind spots in their efforts to design effective policies.

In a world in which global environmental stressors are increasingly interactive and human actions are having a more powerful effect, the need for detailed, reliable, and timely information is essential. Yet environmental monitoring continues to be undervalued as an investment in environmental protection. We tolerated inadequate data in the past, when problems were relatively simple and geographically limited, such as air or water pollution from a single plant. But it is unacceptable today, as we try to grapple with far more extensive changes caused by a changing climate.

The effects of climate change will be felt across the globe, and at the regional level they are likely to present unique and hard-to-predict outcomes. For example, a small change in temperature in the Pacific Northwest has allowed bark beetles to survive the winter, breed prolifically, and devastate millions of acres of forest. Although scientists are working to improve forecasts of the future and anticipate such tipping points, observation of what is actually happening remains the cornerstone of an adequate response. Society needs consistent and reliable information to establish baselines, make projections and validate them against observed changes, and identify potential surprises as early as possible.

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Fortunately, two developments are helping to facilitate the collection of more and better data. First, new technologies and techniques allow us to capture data more efficiently and effectively. Second, society is demanding greater accountability and the demonstration of true value for environmental investments. The ability to easily share large amounts of information, to combine observations from different programs by linking them to specific geographic locations, to monitor many environmental features from space or by using new microscale devices, and other innovations can greatly extend the reach and richness of our environmental baselines. At the same time, many corporations, foundations, and government entities are working to track the effects of their actions in ways that will demonstrate which approaches work and which do not. In much the same way as the medical community is embracing evidence-based medicine, managers are moving toward evidence-based environmental decisionmaking.

Recognition of the scale of environmental problems is also spurring increased collaboration among federal, state, local, and private entities. Wildlife managers recognize that species do not respect state or federal agency boundaries and that adequate response demands range-wide information. Likewise, addressing the expanding "dead zone" in the Gulf of Mexico demands collaboration and data from across the Mississippi River basin in order to understand how farmers' actions in Missouri affect shrimpers' livelihood in Louisiana. Evidence of this recognition and the collaboration it demands is growing. For example, state water monitoring agencies, the Environmental Protection Agency (EPA), and the U.S. Geological Survey (USGS) have developed a new multistate data-sharing mechanism that greatly expands access to each others' data. And, public and private entities are increasingly working together in efforts such as the Heinz Center's *State of the Nation's Ecosystems* report, as well as in more local efforts such as the integrated monitoring of red cockaded woodpeckers by private timber companies, the U.S. Fish and Wildlife Service, state agencies, and the Department of Defense.

Despite these efforts, a coherent and well-targeted environmental monitoring system will not appear without concerted action at the national level. The nation's environmental monitoring efforts grew up in specific agencies to meet specific program needs, and a combination of lack of funding for integration, fragmented decisionmaking, and institutional inertia cry out for a more strategic and effective approach. Without integrated environmental information, policymakers lack a broad view of how the environment is changing and risk wasting taxpayer dollars.

Since 1997, the Heinz Center's *State of the Nation's Ecosystems* project has examined the breadth of information on the condition and use of ecosystems in the United States and found that the picture is fragmented and incomplete. By publishing a suite of national ecological indicators, this project has provided one-stop access to high-quality, nonpartisan, science-based information on the state of the nation's lands, waters, and living resources, using national data acceptable to people with widely differing policy perspectives. However, there are data gaps for many geographic areas, important ecological endpoints, and contentious management challenges as well as mismatched datasets that make it difficult to detect trends over time or to make comparisons across geographic scales.

The depth of these gaps can be seen in three case studies, two of which concern chemical elements (nitrogen and carbon) that play vital roles in global ecosystems but can also create havoc in the wrong times, places, and concentrations. The third case considers the condition of our nation's wildlife.

Controlling nitrogen pollution

Nitrogen is a crucial nutrient for animals and plants as well as one of the most ubiquitous and problematic pollutants. Nitrogen in runoff from sewage treatment plants, farms, feedlots, and urban lawns is a prime cause of expanding dead zones in many coastal areas. Nitrogen in the air contributes to ozone formation and acidification of lakes and streams, as well as to overfertilization of coastal waters. Several nitrogen compounds are also potent greenhouse gases, and nitrogen in drinking water can cause health problems for children. In the environment, nitrogen moves readily from farmlands and forests to streams and estuaries, shifting across solid, liquid, and gas phases, and from biologically active forms to more inert forms and back again. Thus, any nitrogen release can result in multiple effects in sometimes quite-distant locations.

Controlling nitrogen pollution involves public and private action at the national, state, and local levels. We put air pollution controls on cars and power plants, invest in municipal sewage treatment, educate farmers and suburban residents on the risks of overfertilization, and design greenway strategies to cleanse runoff. Understanding how nitrogen moves through the environment is crucial to designing these controls effectively.

The delivery of nitrogen to streams and rivers, and thus to coastal waters, is highly variable by region, with very high levels originating in the upper Midwest and Northeast, and much less from other areas. However, data on nitrogen delivery from streams to coastal waters are not available in a consistent form for more than half the country—essentially all areas not drained by the Mississippi, Susquehanna, or Columbia Rivers. This includes, for example, much of Texas and North Carolina, where major animal feeding operations, a significant source of nitrogen releases, are located.

Moreover, nationally consistent monitoring is available only for limited areas, precluding more detailed tracking that would allow better understanding of the relationship between on-farm management strategies and nitrogen releases. Nitrogen in precipitation is not measured in coastal areas of the East, where it may contribute as much as one-third of the nitrogen delivered to estuaries such as the Chesapeake Bay.

Without such data, regulators cannot understand what inputs are contributing to the problem, which ones are being effectively addressed, and which ones remain as targets for future reduction. As a result, pollution control agencies are left without comprehensive feedback about baseline conditions and whether control strategies are effective, and thus are unable to fully account to the public for their success or failure.

Carbon Storage

Carbon is another element that plays a critical role in ecosystems but, in excess, is now wreaking havoc in the atmosphere. Carbon dioxide and methane (a carbon compound) are the major contributors to global warming, but carbon is also vital to ensuring the productive capacity of ecosystems, including the ability to provide services such as soil fertility, water storage, and resistance to soil erosion.

Carbon dioxide in the atmosphere has increased by more than 30% as compared with preindustrial concentrations, and methane concentrations have increased by more than 150%. Moreover, the data show that, so far, efforts to reverse these increases have been overwhelmed. Through measures designed to increase carbon stored in plants, soils, and sediments, where it does not contribute to the greenhouse effect, it is possible to help offset carbon emissions.

Different ecosystem types store carbon differently. For example, forests store more carbon than many other ecosystems and store more of it above ground (in trees) than do grasslands. Data-gathering by the U.S. Forest Service's Forest Inventory and Analysis program documented an average annual gain of nearly 150 million metric tons of forest carbon per year in recent years, whereas cropland and grassland soils data show more modest carbon increases. We do not yet have comprehensive data on changes in carbon storage in all U.S. ecosystems and so cannot quantify the total contribution of ecosystems to offsetting the approximately two billion tons of carbon dioxide released in the United States each

year. Changing carbon levels are not yet comprehensively monitored in wetlands and peat lands, urban and suburban areas, and aquatic systems. There are also gaps in national-scale data for carbon in forest soils and aboveground carbon in croplands, grasslands, and shrublands.

As we expand our ability to track carbon in the landscape, we will increasingly be able to quantify how different land management practices help or hinder carbon sequestration by ecosystems and to project future changes and set priorities more accurately. Baseline measurements and routine monitoring are also important in determining how changing temperature and moisture conditions as well as disturbances such as invasive weeds, wildfires, and pest outbreaks affect carbon storage. As we expand and improve our carbon-monitoring capability, managers will be able to answer critical questions such as how rising temperatures are affecting northern peat lands and whether invasive weeds and wildfires are causing U.S. rangelands to lose carbon rather than store it.

As policymakers, land managers, and entrepreneurs push the frontiers of biofuel production and develop new institutions such as carbon-offset markets, greater investments will be needed to produce reliable sources of information about changes in carbon storage at relevant geographic scales. The technology exists or is being developed to gather data more rapidly, more efficiently, and at lower cost. Global agreements on mechanisms for including terrestrial carbon storage in the climate change solution can spur additional investment to refine technologies and implement monitoring systems. What is needed is a commitment to providing the necessary information and a strategic view of what data are needed and how they should be gathered and shared.

Tracking wildlife population trends

Most American would agree that fish and wildlife are an important part of the nation's heritage. Each year, millions of Americans spend time hunting, fishing, or just enjoying wildlife for its intrinsic worth and beauty. Native species provide products, including food, fiber, and genetic materials, and are central components of ecosystems, determining their community structure, biomass, and ecological function. From bees that pollinate agricultural crops worth billions of dollars a year to oysters that filter coastal waters, wildlife provides a variety of services of direct benefit to humans.

During past decades, wildlife management often focused on huntable and fishable species. More recently, concern about loss of species and habitat has created a broader agenda that includes reducing the danger of extinction of other species and managing habitat to support several goals.

Simply knowing how many species are at risk of extinction is a crucial starting point. State-based Natural Heritage scientists consider how many individuals and populations exist, how large an area the species occupies (and when known, whether these numbers are decreasing or not), and any known threats. The data are compiled at a national scale by NatureServe, a nonprofit organization that also establishes standards for collecting and managing data to ensure that they are updated frequently enough to identify real trends. However, differential funding and sampling frequencies among the states has led to mixed data quality.

Information about extinction risk provides a crucial early warning to identify species in need of attention. In many cases, however, such status information is not backed up with information on how populations have changed over time, making it difficult to determine whether a population's increased risk levels are due to a historical decline, a recent decline, or natural rarity—scenarios that can require quite different management responses. In 2006, NatureServe reported that information on short-term population trends was available for only about half of the vertebrate species at risk of extinction and only a quarter of invertebrates. The Breeding Bird Survey, managed by the USGS, has proven a consistent long-term source of population data, as have surveys of a number of charismatic species such as monarch butterflies. For many species, however, including many threatened species, population trend data are simply not available.

Our society spends significant amounts to conserve wildlife. In addition, land use and other activities can be disrupted or delayed if endangered or threatened species are present. Understanding which species are declining and which are not is crucial to maximizing the effectiveness of public spending and minimizing the effect of protections on private actions. Many recent conservation challenges have involved species not limited to small regions. As we have noted, no single state or federal agency can address the challenges facing these species alone, and consistent range-wide information is the lingua franca on which collaborative plans can be built.

Species-status information is only one of the keys to good wildlife management. Tracking phenomena such as unusual deaths and deformities provides a glimpse into overall ecosystem conditions. However, collection of these data is limited to certain species, such as marine mammals, while in other cases changes in reporting procedures make data impossible to compare.

In recent years, scientists have become increasingly aware of the threats to ecosystems from invasive species. Weeds cause

crop losses, aquatic invasives clog channels and water intake pipes, and plants must be killed or animals trapped when they interfere with native species. Despite these effects, and the fact that federal spending on control and related programs exceeded $1 billion in 2006, little standardized data exists on invasive species, making a broad assessment of the threat and the effectiveness of society's response difficult. The only group for which data are available at a national scale is fish, and even in this case the data are limited.

Managing the nation's environment involves keeping track of many more components than nitrogen, carbon, and wildlife. These three central management challenges, however, illustrate the degree to which information limitations constrain society's ability to understand what issues must be faced, devise interventions to address these issues, and evaluate whether those interventions work. Although the challenge is clear and urgent, and there are some promising signs of increased collaboration and information sharing, more is needed.

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Building a coherent system

As the planet warms, we have begun to experience a variety of changes in ecosystems, the first signs of the environment's own potentially bumpy road ahead. To deal with the changes, policymakers need objective, detailed, big-picture data: the type of data that decisionmakers have long relied on to understand emerging economic trends. Yet, as noted above, data gaps still abound, obscuring our understanding of the condition and use of the nation's ecosystems. In *The State of the Nation's Ecosystems 2008*, only a third of the indicators could be reported with all of the needed data, another third had only partial data, and the remaining 40 indicators were left blank, largely because there were not enough data to present a big-picture view.

No responsible corporation would manage an asset as valuable and complex as the ecosystems of the United States without a better stream of information than can currently be delivered. We certainly do not wish to throw rocks at the dedicated professionals who manage environmental monitoring programs. Unfortunately, however, their work has been accorded low priority when it comes to setting environmental budgets, and independence, rather than collaboration, has been the primary strategy for managing these programs.

Dealing with the type of gaps we have discussed will require additional investment plus a serious commitment to harnessing the resources of existing environmental monitoring programs into a coherent whole. Identifying a small suite of environmental features that need to be tracked, identifying overlapping and incomplete coverage between programs,

and establishing standard methods that can allow different programs to contribute to a larger whole are the kinds of steps that a nation truly committed both to the power of information and the value of our environment would take.

Congress should consider establishing a framework by which federal, state, nongovernmental, private, and other interests can jointly decide what information the nation really needs at different geographic scales, identify what pieces already exist, and decide what new activities are needed. This might be part of upcoming climate change legislation (which might also provide a funding source), but the imperative of improving the information system should not necessarily wait for this complex legislation to pass. The Obama administration has the opportunity to build on more than 10 years of experience in identifying environmental indicators and devising ways to integrate them more effectively. Federal and state agencies can radically increase the degree to which information consistency across related programs is treated as a priority. Nascent efforts such as the National Ecological Status and Trends (NEST) effort, begun in the waning days of the Bush administration, should be energized, expanded, and formalized. (This effort is beginning work on what may eventually become a formal system of national environmental indicators.) Oversight entities such as the Office of Management and Budget and congressional appropriators and authorizers can demand answers to questions about why multiple data collection programs exist, who they are serving, and why they cannot be harmonized to meet the larger-scale needs of the 21st century. They can also pay serious attention to requests for funds to support a larger and more integrated system. For example, it might be appropriate to consider one-time infusions of funds to ensure the consistency of state water-quality monitoring, something states are inadequately funded to do and have never been expected to do.

Building such a system is not a federal-only affair but rather should be governed as a collaborative venture among data users and producers to help ensure utility and practicality. Such a system would help distinguish between truly important needs and ones that may serve only minor interests, eliminate duplicative monitoring efforts, and provide incentives for more coordinated monitoring, including increased cooperation between states and federal agencies. Perhaps most important, such a system could ensure continued, consistent, high-quality, nonpartisan reporting, so that decisionmakers from a variety of sectors can rely on the same information as they forge ahead.

Recommended reading

The Heinz Center, *Environmental Information: A Roadmap to the Future* (Washington, DC: The Heinz Center, June 2008).

The Heinz Center, *Filling the Gaps: Priority Data Needs and Key Management Challenges for Reporting on Ecosystem Condition* (Washington, DC: The Heinz Center, May 2006).

The Heinz Center, *The State of the Nation's Ecosystems 2008* (Washington, DC: Island Press, 2008).

National Academy of Public Administration (NAPA), *A Green Compass: Institutional Options for Developing a National System of Environmental Indicators* (Washington, DC: NAPA, 2007).

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U.S. Government Accountability Office (GAO), *Environmental Indicators: Better Coordination Is Needed to Develop Environmental Indicator Sets That Inform Decisions*, GAO-05-52 (Washington, DC: GAO, November 2004).

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