Monitoring Biodiversity

More automated eDNA collection and analysis

ENVIRONMENTAL POLICY INNOVATION CENTER

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Cracking the Code: Federal technology innovation to heal our natural environment

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Why This Matters

- Biodiversity and ecosystems are rapidly changing due to climate change, but our data on where those changes are occurring is severely limited.
- Genetic material from organisms in the environment, known as eDNA, is a key source of biodiversity information; its use could greatly expand if government agencies adopt more automated methods of gathering it.
- To date, limited understanding of eDNA, a patchwork of processes, and few standards for using it have slowed down adoption and left information gaps that hamper sound decision-making on conservation, protection, and restoration efforts.

What To Do

- Creating teams and criteria to evaluate eDNA technologies can accelerate adoption, help agencies find the right tools for their use cases, and avoid unnecessary bottlenecks.
- Clear and flexible directives from authoritative national bodies would immediately encourage the use of eDNA and technology to meet specific conservation and restoration needs.
- Current eDNA standards development, data collection, and technology evaluations are disconnected and should be better coordinated with a strategy, and an action-oriented forum, for interagency collaboration.

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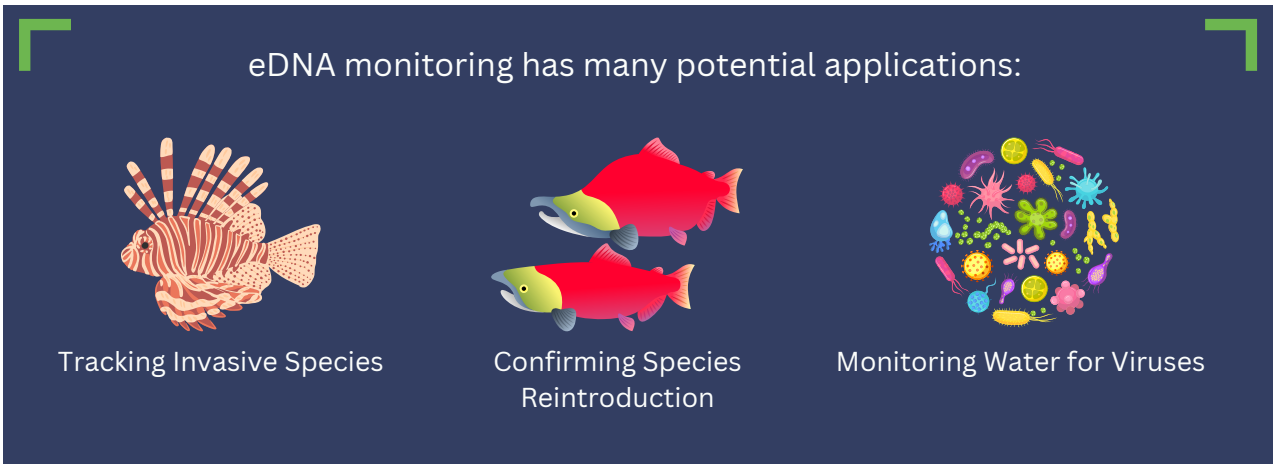
Why This Matters

Our climate is changing at an unprecedented rate, threatening biodiversity and resulting in rapid changes to the range of plants, animals, insects, and viruses. Knowing where and when these changes occur is essential for sound conservation, protection, and restoration decisions. Environmental deoxyribonucleic acid (eDNA) – genetic material released from organisms in the environment – is a key source of information about the presence of an organism. eDNA can be easily collected and is useful for many applications, including early detection of invasive species, tracking wildlife migration patterns, water quality monitoring, and detection of viruses (e.g., COVID-19) to inform policy design and environmental management and restoration decisions. As a result, several agencies, such as the U.S. Forest Service, U.S. Fish and Wildlife Service, and EPA, have built up capabilities to use eDNA for scientific purposes.

The typical way of collecting and analyzing eDNA, which involves manually collected samples that are analyzed in a lab, has advantages over traditional manual work, such as biological surveys. For example, biological surveys of freshwater mussels entail donning a wetsuit and diving into murky water where it may be difficult to identify the presence of mussels, even on a good day. Still, manual sampling and analysis of eDNA imposes significant limitations on the data available to answer key questions for environmental management, especially at larger scales (e.g., landscapes, forests, or watersheds).

Now, the next generation of automated eDNA sampling and analysis technology has the potential to scale up the use of eDNA and overcome present day limitations associated with manual eDNA sampling and lab work. Auto-samplers could be used to collect significantly more samples, more frequently, and with greater sensitivity than traditional methods. New systems for eDNA sampling can also reach more remote areas than ever before, such as coastal areas and isolated lakes. Some new technologies can generate results in the field or increase the throughput at labs where the samples are analyzed, accelerating the timeline for obtaining actionable information.

Making use of these more automated methods and getting the best out of eDNA data across the public sector requires integrating new technology into workflows and systems at government agencies, sharing the resulting data more widely, and standardizing the data and its use in decision-making. Doing so is likely to require significant upfront investment in equipment and in the agency workforce to enhance skill sets in fields like bioinformatics. To date, progress on this front has been uneven, and not well coordinated, according to researchers and technology providers we interviewed. The time is right to build our nation's capacity to understand – and respond to – the many environmental changes we're witnessing.



What To Do

Increase capacity to evaluate and adopt new eDNA technologies

An inability to consistently and proactively evaluate new technology and methods for collecting eDNA data as they mature can lead to a significant gap between what is possible and what is operational. Many technology development efforts, including those for sampling and analyzing eDNA, begin as pure research efforts to test new approaches. However, as they begin to transition from novel to operational, agencies need to be ready to evaluate them for broader use with adequate technical capacity and clear, performance-based evaluation criteria in place to streamline the process. Teams tasked with evaluating modern eDNA technologies need expertise not only in eDNA and bioinformatics, but also in information technology and human centered design to ensure that agencies are investing in solutions, not just discrete technologies. Without the people and framework necessary to evaluate continually evolving eDNA technologies, agencies will struggle to find the right tool or data for their use case.

Past efforts to evaluate new, more widely applicable technologies such as air quality sensors – and to develop standards and evaluation criteria – can help inform agencies' approach to evaluating eDNA technologies. First, agencies need to ensure that sufficient capacity is in place to evaluate new systems and use cases, such as deploying automated sampling and analysis systems in remote locations; otherwise, this can act as a bottleneck and create long timelines for technology adoption that are incompatible with the staffing and funding needs of small innovative technology providers. Second, given the wide range of potential uses for eDNA, evaluation should be based on a set of performance metrics that helps potential users compare and understand the tradeoffs of different approaches, including current ones. It may be useful to establish several sets of performance "targets" for different use cases based on the level of certainty required. For eDNA, the evaluations needed would likely include lab certification and testing of automated sampling systems in the field.

Provide greater clarity on the uses of eDNA to encourage adoption

Historically, capacity to analyze eDNA data and its uses in federal agencies has developed organically based on specific research questions and the availability of resources, and has not been driven by legislation or policy. As a result, agencies have taken a more conservative approach to using eDNA in decision-making, with relatively few examples of its application in court proceedings, permits, and regulatory processes to date. A lack of established uses in decision-making has made it more difficult to move toward adopting better technology, such as certifying government and private sector labs. Clear but flexible directives to agencies on the use of eDNA at the national level – and proactive communication to government and private sector stakeholders – could accelerate the pace of adoption significantly. The White House Council on Environmental Quality (CEQ) and Office of Science and Technology Policy (OSTP), informed by a group of experts at agencies and/or the National Academy of Sciences, would be best positioned to offer national guidance encouraging the use of eDNA.

Create focal points for integrating data and tech evaluations

With generators and users of eDNA data spanning so many sectors, disciplines, organizations, and roles, effective use of eDNA has to be coordinated so that information on new technologies and data is shared with all who need it. Without deliberate coordination, agencies will conduct redundant technology evaluations for similar applications and may miss opportunities to leverage other agencies' data. Currently, eDNA technology providers have to meet individually with every program separately. Looking ahead, there are a variety of exciting opportunities to expand and integrate eDNA monitoring – yet they can only become a reality if robust coordination replaces duplicative efforts. One such example is integrating eDNA monitoring capabilities with the U.S. Geological Survey's (USGS) network of stream gauges to better understand links between water quantity, quality, and biodiversity.

Still, there are precious few coordination mechanisms at present and those that exist tend to be more limited efforts. For example, the National Invasive Species Council brings together a variety of agencies to issue recommendations around the use of eDNA in monitoring and preventing invasive species. While useful, realizing the full benefits of eDNA monitoring at scale using automated technology would require much broader coordination to ensure that a patchwork of processes and standards doesn't slow down adoption. A national strategy on eDNA and an action-oriented forum for interagency coordination would be useful steps in this direction, as long as they don't prevent action in the meantime. A sustained commitment to coordination, including dedicated capacity and digital infrastructure to operationalize such a strategy, will be essential.