
EPA
RESEARCH
2015

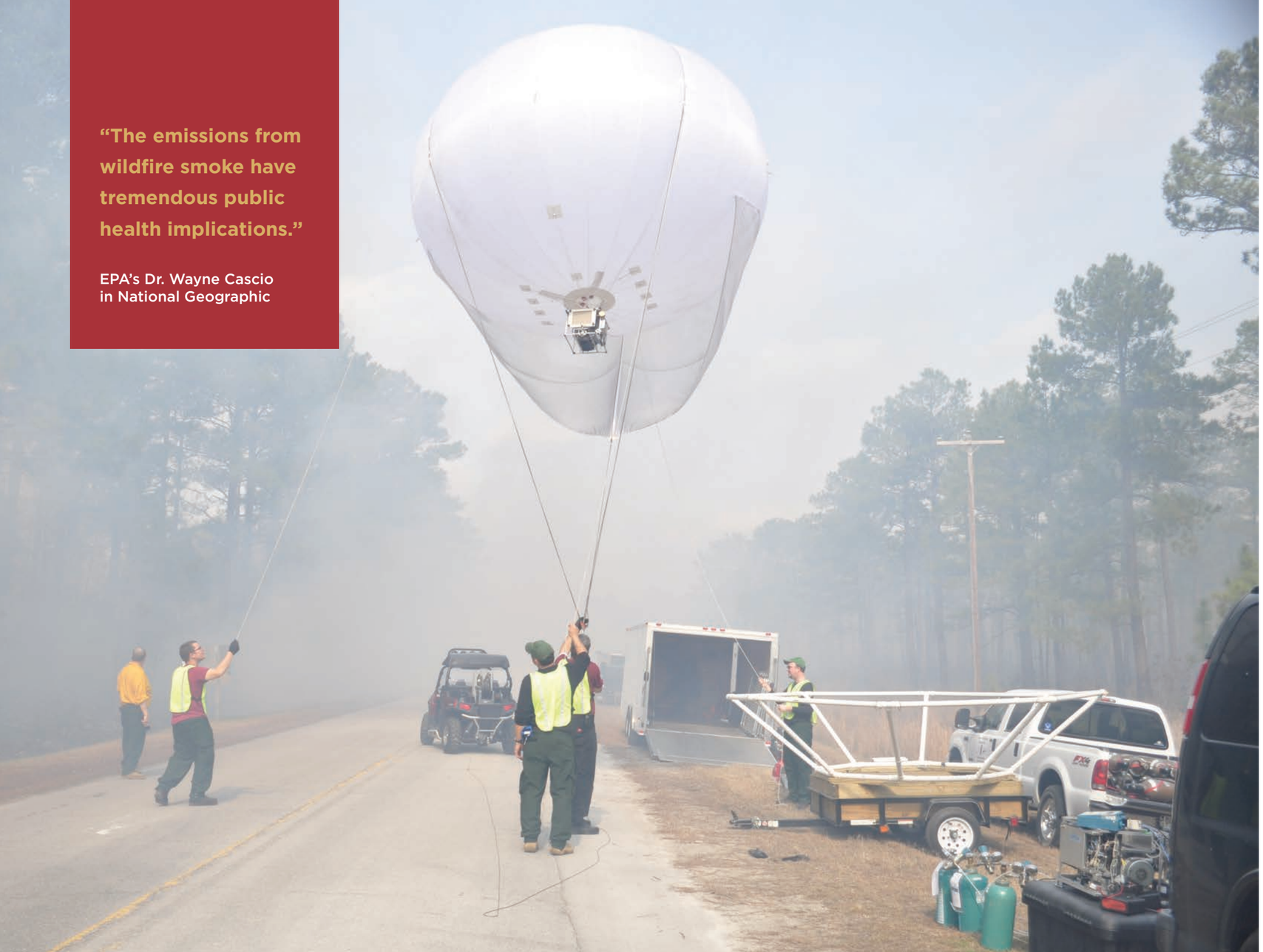
For more than 45 years, EPA researchers have provided the strong, scientific foundation that supports everything EPA does to meet its mission to protect human health and the environment. In 2015 alone, EPA researchers published 556 articles in peer-reviewed scientific journals, worked on projects ranging from understanding wildfire smoke emissions to helping protect small drinking water systems, and applied their expertise to emerging issues in times of environmental emergencies. While a single report outlining the work and achievements of just a single year would fill many volumes, this 2015 Yearbook highlights just a small sample of the critical impact of that work.

We invite you to flip through this EPA Research 2015 Yearbook to get a flavor for the innovative and important work that is continually unfolding at EPA research labs and field sites around the country and across the world.

To learn more, visit **www.epa.gov/research** and follow us on **Twitter @EPAresearch.**

Algal bloom in Lake Erie in 2011. *See page 16 for information.*

Photo credit: Jesse Allen and Robert Simmon, NASA Earth Observatory, using USGS Landsat



"The emissions from wildfire smoke have tremendous public health implications."

EPA's Dr. Wayne Cascio
in National Geographic

Wildfires Research

The World Health Organization estimates that each year more than seven million people worldwide die as a result of air pollution exposure. While many studies have examined the effects of air pollution caused by emissions from motor vehicles, coal- or oil-burning power plants, and industrial sources — there is limited knowledge of the short and long-term health impacts of smoke emissions from wildfires and controlled burns. Wildfires in the US are increasing in frequency and intensity partly due to climate change and land management practices. EPA is using its expertise in air quality research to fill the scientific gaps to understand how smoke affects air quality and climate change, and to develop tools to prevent and reduce health impacts from smoke emissions.

Among a number of research activities, EPA scientists launched tethered balloons (called aerostats) with lightweight air sensors to learn more about pollutants emitted from wildfires. Rather than placing larger monitors at the perimeter and ground level of a wildfire, sensor-equipped balloons can be sent into the rising smoke plume to measure pollutants directly. These, and other integrated sensors and lightweight samplers being developed, can provide more robust smoke emissions data. EPA researchers have also simulated how a warning advisory might impact the health and economic repercussions related to wildfires. In other studies of wildfire effects on local populations, EPA scientists found that the smoke traveled long distances and increased hospitalizations due to asthma and heart ailments. They also found that if people follow advisories, they can protect their health and significantly reduce the economic health cost of wildfires that result from hospital visits, productivity losses, and mortality. Research results can be used by doctors, nurses, public health officials, and others to help prevent health problems related to breathing wildfire smoke.

An aerostat outfitted with air sensors in North Carolina.

Advancing Exposure Science to Rapidly Evaluate Chemicals

EPA is responsible for ensuring the safety of thousands of chemicals used by the public and scientists alike. Traditional chemical testing is expensive and time consuming, so only a small fraction of these chemicals have been fully evaluated for potential human health effects. To assess the potential for a chemical to cause adverse effects, it is important to understand exposure, which is how – and in what amounts – chemicals get into our bodies. EPA researchers are addressing this need and are leading the forefront of exposure science by developing innovative ways to rapidly estimate exposures to thousands of chemicals. These innovations and advances in exposure science, when coupled with EPA's high-throughput toxicity data, can be used to quickly evaluate and prioritize thousands of chemicals for their potential to cause health risks. As a suite of exposure science tools and data used for chemical evaluations, the following four examples showcase how EPA's advances have transformed exposure science in a very short time.

ExpoCast provides high-throughput exposure estimates for thousands of chemicals and looks at multiple routes of exposure. ExpoCast has been used to develop exposure estimates for over 1,900 chemicals.

Stochastic Human Exposure and Dose Simulation High-Throughput model (SHEDS-HT) estimates population-level exposures. It quickly accounts for multiple routes, scenarios, and pathways of exposure to understand the total exposure a population could have to a chemical.

Chemical Product Categories Database (CPCat) contains information on how 43,000 chemicals are used in consumer products. Understanding how these chemicals are used, and in what products, helps researchers determine potential routes of exposure.

Non-Targeted Analyses measurement methods offer unique means to screen for chemicals in a variety of environmental and biological media, providing quantitative exposure information.

Through its Science to Achieve Results (STAR) program, EPA has also actively engaged the academic research community in the effort to advance exposure science. In 2015, EPA funded five universities to conduct innovative research to advance methods for characterizing real-world human exposures to chemicals associated with consumer products in indoor environments.

Christopher Nuzzaco/Thinkstock

JohnnyH5/Thinkstock

Drinking Water: Small Systems, Big Solutions

Across the country, 97 percent of the 153,138 public drinking water systems are considered small systems, meaning they serve fewer than 10,000 people. While many of these small systems consistently provide safe and reliable drinking water to the people they serve, they face enormous challenges in their ability to maintain, replace, and improve their technologies because they have fewer resources than larger systems. The research conducted by EPA scientists and engineers is helping state and local personnel, as well as small systems personnel, deliver high quality drinking water to their customers by providing information, tools, and technical assistance. In 2015, EPA hosted monthly webinars to share current small systems research and communicate directly with state personnel and other drinking water and wastewater small systems professionals. The webinar series, *Challenges and Treatment Solutions for Small Drinking Water and Wastewater Systems*, has provided information and training to hundreds of state and local agency personnel across the country. In 2015, the webinar series attracted more than 7,800 participants from all 50 states and U.S. Tribal Nations and Territories, as well as international participants, and provided 3,300 continuing education credits. In addition to the webinars, the free, public annual U.S. EPA Drinking Water Workshop offers in-depth training and information for handling small drinking water systems problems and compliance challenges. Additionally, through the Science to Achieve Results program, EPA has funded two National Research Drinking Water Centers to study technologies that will reduce, control, and eliminate groups of chemical or microbial contaminants in small water systems.

Citizen Science

There is a growing interest from the public to learn more about what's going on in their community: *What's in the air I breathe? What does it mean for my health and the health of my family? How can I learn more about these things and even be involved in the process? Is there a way for me to measure, learn, and share information about my local air quality?* EPA is helping people answer these questions.

Training Citizen Scientists

Researchers at EPA have developed the virtual Air Sensors Toolbox for Citizen Scientists to help people learn more about local air quality where they live, work, and play. Researchers partnered with the Ironbound community in Newark, NJ, which faces multiple air pollution problems, to design and develop a compact Community Science Air Monitor that houses sensors for particulate matter and nitrogen dioxide.

This experience fueled the development of a training workshop for 30 community science groups and led to the development of Citizen Science Toolbox. One of the toolbox resources is the Air Sensors Guidebook, which explores low-cost and portable air sensor technologies, provides general guidelines on what to look for in obtaining a sensor, and examines important data quality features. To help people understand the current state-of-the-science, the toolbox also includes the Sensor Evaluation Report, which summarizes performance trials of low-cost air quality sensors that measure ozone and nitrogen dioxide. Easy-to-understand operating procedures for select low-cost sensors also have been developed.

In addition to the toolbox, EPA has provided air sensors training to citizen scientists and others interested in community air quality monitoring. In 2015, EPA hosted a training workshop for 800 participants to share tools used to conduct citizen science projects and provide information on successful air monitoring projects. EPA also developed online training videos so that more people have access to information on emerging technologies and community air monitoring. All of these training materials are available online at **www.epa.gov/air-research/air-sensor-toolbox-citizen-scientists.**

Citizen scientists assemble air monitors in the Ironbound community in Newark, NJ.

Researcher Sam Garvey demonstrates an air monitor to citizen scientists in the Ironbound community.

Village Green

EPA is exploring new ways to measure local air pollution while also helping communities understand the air around them. Through the Village Green project, EPA is building next generation air monitoring systems that also function as public park benches in cities across the country. The Village Green benches were designed and developed by EPA scientists, operate on solar and wind power, and are made of recycled materials. The benches use sophisticated air quality measurement equipment to provide real-time data on two common air pollutants (fine particle pollution and ozone) and weather conditions such as wind speed, temperature, and humidity. The data is streamed live on the web with minute-by-minute updates that can be accessed at **www.epa.gov/air-research/village-green-project.** The communities, including local students, are using this data to improve public understanding of air quality and to increase community awareness of local air quality conditions. In 2015, benches were installed in Philadelphia, PA, Washington, DC, Kansas City, KS, Hartford, CT, and Oklahoma City, OK.

"Citizen science is a great example of combining the creativity, expertise, and power of researchers and the public to understand environmental health and find solutions."

Tom Burke, ORD Deputy Assistant Administrator and EPA Science Advisor

Students sit on the Village Green bench located outside of the Durham County Library in North Carolina.

Toolbox for Responders following Radiological Events

When disaster strikes, a quick response is crucial. Decisions that are made during the first hours and days immediately following a radiological incident can have a profound impact on the cost and amount of effort needed for cleanup activities. Decision makers need a variety of trusted options when responding to a radiological incident like a dirty bomb or a nuclear accident.

That's where EPA science can help. In a week-long demonstration, EPA researchers, in collaboration with the Department of Homeland Security Science and Technology Directorate, took technologies that looked promising in the lab and tested them in a larger, urban environment in Columbus, Ohio. The event showed how the technologies can be applied at a city-wide scale using readily-available equipment. Some of the technologies demonstrated included stabilization technologies—like fire retardant, wetting agents, and chloride salt—to reduce resuspension and tracking of radiological contaminants. Researchers even tested a variety of technologies to decontaminate vehicles so that responders don't spread contamination from the hot zone to clean areas.

This demonstration provided the necessary information to build a "toolbox of options" that responders can rely on while planning for any kind of radiological contamination incident. The toolbox provides decision-makers with information on what works in specific situations and what is needed for response planning. This information will likely decrease costs, and more importantly, could save lives in the event of a radiological event.

Researchers spray decontamination foam as part of the demonstration in Columbus, Ohio.

Advancing Sustainable and Healthy Communities

EPA is exploring how to promote Health Impact Assessments (HIAs) as a tool for advancing sustainable, healthy communities. HIAs investigate how a proposed program, project, policy, or plan may impact health and well-being – and inform decision makers of these potential outcomes – before the decision is made. Engaging stakeholders, community members and community decision makers in the HIA process provides an approach to evaluate options and select those that maximize health benefits, and/or reduce the harmful impacts of proposed actions such as building renovations or sewer/stormwater upgrades. Agency researchers recently completed an HIA case study in the Proctor Creek neighborhood of Atlanta, Georgia.

This HIA supported the Proctor Creek community as it worked to address challenges related to contamination and storm water management. The creek itself is currently on the state's "impaired waters" list because of unsafe fecal coliform levels and is a subject of frequent flooding due to poor stormwater infrastructure. EPA researchers worked with local residents to conduct an HIA to evaluate how elements of a proposed green infrastructure project might improve conditions in and around Proctor Creek and impact public health in the community.

Researchers make measurements to assess the role of urban soils in the local water cycle and scope the potential use of green infrastructure to provide ecosystem services.

Science to Support Clean Water

About 117 million Americans – one in three people – get drinking water from small streams that are considered "Waters of the U.S." and protected by the Clean Water Act under EPA's landmark 2015 Clean Water Rule. The scientific foundation for this rule came from the report *Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence*.

In the report, EPA researchers assess the scientific evidence regarding the effects that streams, non-tidal wetlands, and open waters have on larger downstream waters such as rivers, lakes, and estuaries. Researchers conducted an extensive review of more than 1,200 peer-reviewed, published scientific studies to learn how small streams and wetlands connect to larger, downstream water bodies.

Researchers found that the scientific literature clearly demonstrates that streams, regardless of their size or frequency of flow, strongly influence the function of larger waters downstream. Many wetlands and open waters located outside of riparian areas and floodplains provide functions that could benefit larger, downstream waters, even when they lack connections on the surface. Based on both the extensive state-of-the-science report and the rigorous peer review process it received, this report makes it clear: what happens in these streams and wetlands has a significant impact on downstream water bodies, including our nation's largest waterways.

Stakeholder Engagement around Human Health Risk Assessment

EPA researchers develop assessments, reports, and tools that provide comprehensive information about the human health and environmental effects that might result from exposures to contaminants in land, water, and air. This work plays a vital role by informing EPA decisions to clean up Superfund sites, develop or revise national pollution standards, and make regulatory decisions in communities across the country.

EPA is committed to advancing the science of conducting human health risk assessments, including those conducted by the Integrated Risk Information System (IRIS) program. To further this commitment, EPA has been addressing recommendations made by the National Research Council that will help advance the IRIS program, including efforts to streamline IRIS documents, enhance transparency, and engage stakeholders early in the development of its assessments. EPA has taken many actions to accomplish these, one of which is increasing the number of opportunities for the public to interact with and give input to IRIS human health risk assessments. Through public IRIS meetings and science workshops in 2015, more than 700 government, industry, academic, and non-governmental scientists and representatives have participated in public discussions on chemical-specific issues and on broader, overarching scientific topics relevant to human health risk assessment research. By including a diverse range of scientific and stakeholder perspectives, EPA ensures its assessments will be useful for all stakeholders while reflecting the current state-of-the-science.

Prasit Rodphan/Thinkstock

The Tox21 robot, developed in a collaboration between EPA, NIH, and FDA, helps conduct high-throughput screenings.

Groundbreaking Approach Used by EPA's Endocrine Disruption Screening Program

Evidence shows that the endocrine systems of humans and certain wildlife are adversely affected by exposure to particular chemical contaminants. These chemicals can disrupt the hormone systems of the body leading to developmental malformations, interference with reproduction, increased cancer risk, and disturbances in the immune and nervous systems. Historically, chemicals were not tested for their potential for endocrine disruption at environmental exposure levels. To address this, EPA established the Endocrine Disruption Screening Program (EDSP) in 1998 to screen and test chemicals for possible effects on the endocrine system.

In June 2015, EPA announced the plan to formally incorporate computational toxicology and high-throughput screening methods in EDSP, which will accelerate the pace of screening, decrease costs, and reduce animal testing. These new methods quickly screen chemicals for their ability to interact with the endocrine system, specifically the estrogen receptor pathway, and there is ongoing work to add androgen and thyroid models to this program. The incorporation of these approaches for screening represents one of the first applications of EPA's computational data and models to inform policy. This transformative move may pave the way for future applications of these data in a diversity of decision contexts at EPA, including conducting high-throughput risk assessments.

Harmful Algal Blooms

EPA is going above and beyond the agency's traditional methods of monitoring harmful algal blooms in water. EPA has joined NASA, NOAA, and USGS to use satellite data to monitor algal blooms and develop an early warning indicator system for toxic and nuisance blooms. The new multi-agency effort builds on previous NASA ocean color satellite sensor technologies created to study the global ocean's microscopic algal communities. EPA researchers provide the science that links the current and historical satellite data on cyanobacteria blooms provided by NASA, NOAA, and USGS to monitor changes in the environment, assess economic impacts, and protect human health.

The first step in the five-year project is creating a reliable, standard method for identifying cyanobacteria blooms in U.S. freshwater lakes and reservoirs using ocean color satellite data. NOAA and NASA lead the way in using ocean satellite data for monitoring and forecasting harmful algal blooms. EPA is integrating these data into decision-making processes and developing a mobile application called CyAN. The app uses satellite-derived information to help make initial water quality assessments and quickly alert managers to potential problems and emerging threats. Researchers are also conducting a large-scale investigation of potential causes of harmful algal blooms in U.S. freshwater systems. The innovative use of satellite data to monitor and report blooms throughout a region or state will help with management of bloom events and significantly reduce risk to the public.

Algal bloom in Lake St. Clair.

"The vantage point of space not only contributes to a better understanding of our home planet, it helps improve lives around the world."

NASA Administrator
Charles Bolden

NASA Earth Observatory image by Joshua Stevens, using Landsat data from USGS.

Report on the Environment

EPA's Report on the Environment (ROE) is an interactive, web-based resource for tracking how national environmental and human health conditions are changing over time. These trends are captured in a set of 85 objective scientific indicators based on data from a variety of sources including EPA and other federal agencies, universities, and non-governmental organizations. The ROE indicators and the supporting contextual scientific content are each reviewed by scientific experts to ensure that they are based on valid and unbiased measurements.

Indicators are organized into five different themes—Air, Water, Land, Human Exposure and Health, and Ecological Condition—and address questions relevant to EPA's mission of protecting human health and the environment. The indicators are frequently updated as new information is made available to provide the latest data, and new indicators are added when relevant. By better understanding the condition and trends of the environment and human health in the United States, EPA can more effectively prioritize areas for action, and foster efforts that improve trends.

bpperry/Thinkstock

Chinook salmon are just one species for which Web-ICE can estimate a chemical's toxicity.

Helping Protect Endangered Species from Chemical Exposure

EPA researchers are improving the science for evaluating the risk of chemical exposure to better protect threatened and endangered species. One part of this research effort includes an aquatic endangered species case study in the Sacramento River Basin, CA. Working closely with the California Department of Pesticide Regulation, the agricultural community, and other state and federal partners, EPA held a workshop in October, 2015 to provide training and to coordinate the federal and state processes required to comply with the Endangered Species Act (ESA). This engagement demonstrated how, in order to add value and increase the impact, tailored and context-specific research products can be developed at the national and state levels. The workshop discussed new scientific approaches for identifying and evaluating the species of interest and the nature and extent of chemical use in the river basin. Participants improved their understanding of the biology and ecology of endangered species within the study area, the geography influencing chemical fate and transport within the study area, and the application, use, and economic considerations of pesticides.

Another research effort that aids in protecting endangered or threatened species is the expansion of the Web-based Interspecies Correlation Estimation (Web-ICE) tool. Web-ICE estimates a chemical's acute toxicity to aquatic and terrestrial organisms, and a recent expansion of the tool includes the addition of several threatened or endangered species of mussels and fairy shrimp. Web-ICE will be used by EPA program offices and EPA regions in endangered species risk assessments and biological evaluations.

Water Security Test Bed

Our nation's water distribution systems can be vulnerable to contamination-causing events such as industrial accidents, natural disasters, or terrorist attacks. EPA works with water utilities to protect these distribution systems and clean up systems that do become contaminated. Whether purposeful or accidental, contamination of these systems can threaten people's health and result in large economic impacts. Water utilities need strategies to protect water systems and to quickly and effectively clean up water and infrastructure so that service can be promptly and confidently restored.

To better protect—and if necessary, decontaminate—our nation's water, EPA researchers have partnered with Department of Energy's Idaho National Laboratory to build the Water Security Test Bed: the nation's first full-scale, above-ground drinking water distribution system. The test bed is a replica of a portion of a municipal drinking water pipe system, with its first phase of development comprised of 445 feet of above-ground, cement-lined pipes plus fire hydrants. Since most of the nation's water systems are not brand new, the test bed uses 30-year old weathered pipes that were exhumed from the ground nearby. The above-ground test grid allows researchers to easily tailor the system to address a wide variety of applied science questions.

Over the next several years, EPA and partner researchers will conduct experiments using various biological, chemical, and radioactive simulants that replicate highly-toxic materials. Approaches to contamination detection, infrastructure decontamination, and water treatment developed at lab and pilot scale will be demonstrated at this full-sized system. Results from this work will be easily transitioned for use by utilities because the tests have been conducted in a real distribution system.

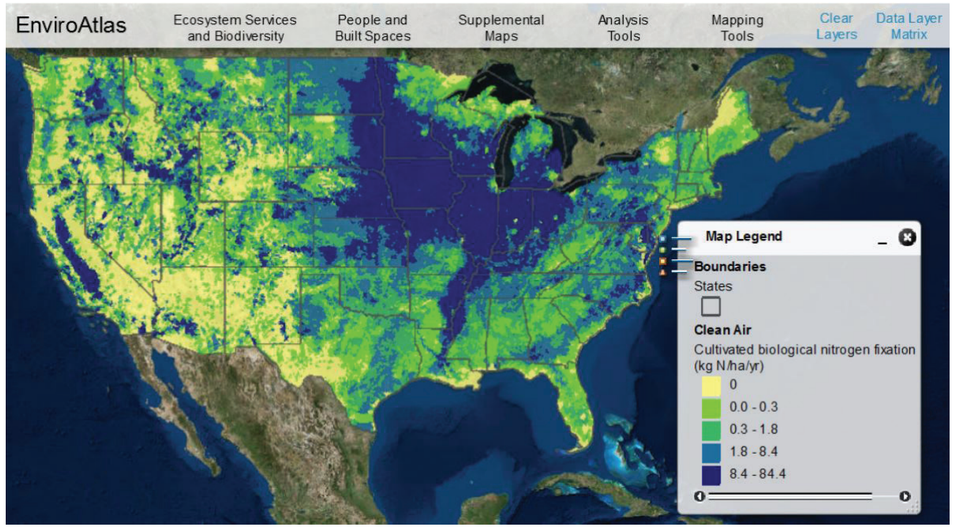
The test bed is made up of 445 feet of above-ground pipes.

EnviroAtlas

EPA researchers and external partners have developed EnviroAtlas, a collection of online interactive tools and resources that allow the public to explore the many benefits they receive from nature (known as ecosystem services) and make informed decisions that will keep their communities healthy and resilient. EnviroAtlas provides ecosystem services-based data sets, sophisticated geographic information systems, and visualization tools to present multilayered maps and other resources. People can easily view, analyze, and download EnviroAtlas data and tools to help ensure sound decision making for building prosperous communities while conserving natural resources. EnviroAtlas includes the Eco-Health Relationship Browser, an interactive tool that uses published science to illustrate the important connections between ecosystems, ecosystem services, and public health outcomes.

EPA's EnviroAtlas also serves as the ecosystem services "resource hub" to the EcoINFORMA initiative. As a component to a Presidential initiative on understanding nature's benefits, EcoINFORMA is designed to facilitate assessments of the impact of climate change, pollution, and other stressors on ecosystems, as well as assessments of management responses to such stressors.

You can use EnviroAtlas by going to **www.epa.gov/enviroatlas.**



This map, developed with EnviroAtlas, shows the average application rate of synthetic nitrogen within US watersheds.

2015 BY THE NUMBERS

1200+
peer-reviewed and published scientific studies went into EPA's Connectivity Report, which supported the Clean Water Rule

556
articles EPA researchers published in peer-reviewed journals

700+
stakeholders participated in EPA Integrated Risk Information System public meetings

5
Village Green benches installed in 2015 to help communities understand their local air quality

445
feet of pipes used in the full-scale Water Security Test Bed

7893
people, including drinking water and wastewater system managers, trained through EPA's Small Drinking Water Systems webinars

85
indicators in the Report on the Environment that help researchers track trends in environmental and human health

830+
citizen scientists trained through EPA's Air Sensors workshops and webinars

117
million Americans get their drinking water from small streams that need protection under the Clean Water Rule

46
teams of college students that will develop innovative and sustainable designs through EPA's People, Prosperity, and the Planet program

United States Environmental Protection Agency
Office of Research and Development
Washington, DC 20460

Stay Connected to EPA Research:

EPA Research Homepage: epa.gov/research
Twitter: @EPAresearch
EPA's It All Starts with Science blog: blog.epa.gov/science
More stories about EPA Research: epa.gov/sciencematters