

NATIONAL ECOLOGICAL OBSERVATORY NETWORK:

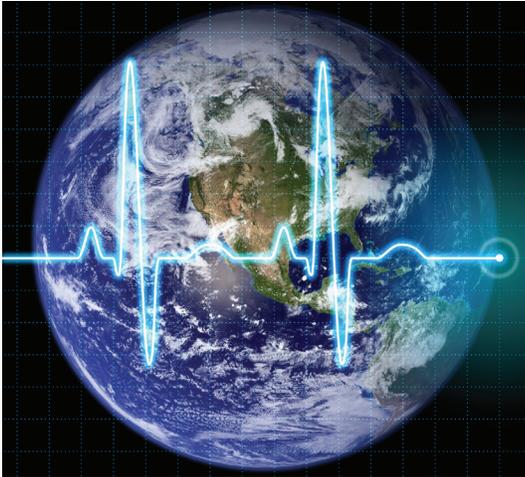
REVOLUTIONIZING ECOLOGICAL RESEARCH

April 18, 2013



The long awaited National Ecological Observatory Network (NEON), which will take the pulse of the nation's ecological health for decades, has kicked off important data collection and education activities.

Ecological research is currently being revolutionized. This is not hyperbole; it is fact.



NEON will be the world's first observatory to listen to the pulse of a continental ecosystem over multiple decades. Credit: NASA and Thinkstock (design by National Science Foundation)

The catalyst for this revolution is [NEON](#). NEON, which is currently under construction and is partially operational, will be a unique, massive and multidisciplinary nationwide infrastructure. It will be used to collect and synthesize data and produce educational/outreach materials on the causes of large-scale environmental changes and biological responses to them throughout the U.S. NEON's components will be geographically dispersed throughout the nation.

Some NEON operations have already started; others will start incrementally as construction continues throughout the next five years until NEON becomes fully functional in about 2017.

Resources produced by NEON will enable a nationwide user community to produce unprecedented analyses of environmental change on regional scales and throughout the U.S.; increase public understanding of environmental change; and promote science-based decision-making on natural resource issues.

DATA COLLECTION BY NEON

NEON will help revolutionize ecological research by, among other activities, collecting the first standardized measurements on ecological conditions across the U.S. over multiple decades and publically disseminating resulting information.

NEON will do this by:

- Continuously collecting selected suites of ecological measurements at 106 nationwide locations. These 106 locations were specially selected to represent the diversity of U.S. ecosystems. Additional locations will be added to represent extreme events, such as fires, droughts and hurricanes, as appropriate.

At each NEON location, ecological variables--such as pollution levels, land use, the diversity of plant and animal species, the health and types of vegetation, air temperature, and soil conditions--will be captured through 539 unique measurements. Many of these measurements have never before been collected in tandem to help identify long-term ecological trends.

All NEON measurements will be standardized across time and space. They will be collected by trained field crews as well as by cutting-edge, multidisciplinary, ground-based and airborne sensors and instrument networks.

Over about the next five years, each NEON location will go online after its construction has been completed and its sensors, instruments and other equipment have been tested to meet NEON's high scientific and technical standards. All NEON locations will go online by about 2017.

Measurements will simultaneously be collected from all NEON locations for approximately 30 years--from about 2017 to 2047. Because these measurements will be unprecedented in their geographical, temporal and topical coverage, they will support unprecedented analyses of the causes and impacts of environmental change.

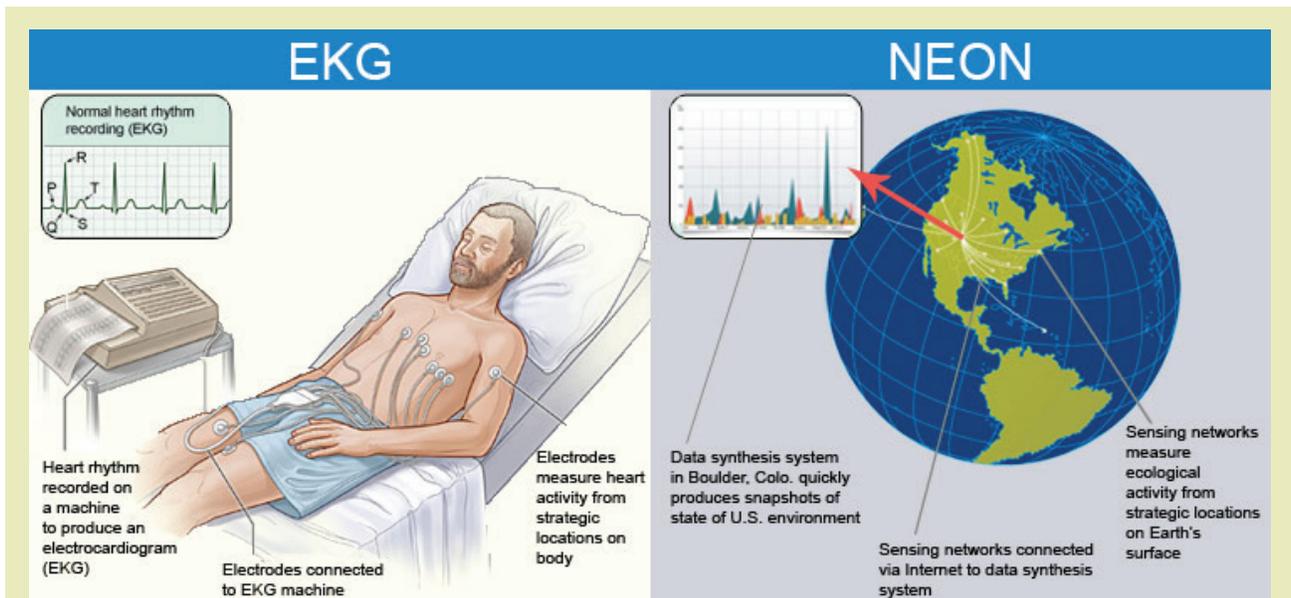
- Continuously transmitting raw data from NEON locations to computational resources at NEON headquarters via a state-of-the-art cyberinfrastructure.

- Using computational resources (including supercomputers) at NEON headquarters to link together collected raw data, subject it to rigorous quality control, and integrate it with selected existing, large-scale datasets, such as satellite data. These computer resources will also be used to further synthesize NEON data into more than 200 sophisticated, integrated, multidisciplinary products that will provide snapshots of the state of the environment, ecological forecasts and models of various ecological scenarios at regional and national scales over time.
- Rapidly releasing to the public raw data from NEON sites and resulting multidisciplinary products, as well as models and other tools that may be used to produce additional analyses of NEON data; and educational/outreach materials derived from NEON data.

These resources will be published on the Internet and made freely available via NEON's Web portal. This portal is expected to start posting provisional data in 2014 and be fully operational by about 2017.

All published NEON resources will be made freely available for use by a diverse nationwide user community that will include scientists, students, resource managers, stakeholder groups, educators and the public. Some members of this user community may collaborate and coordinate their research and educational activities by forming their own virtual, Internet-based networks.

NEON's user community is expected to produce various types of analyses of long-term regional and nationwide ecological changes--including the first apples-to-apples comparisons of ecological health in the U.S. over multiple decades, as well as maps, explanations and predictions of the primary impacts of humans on the natural world. Such resources will be designed to help society more effectively address critical ecological problems.



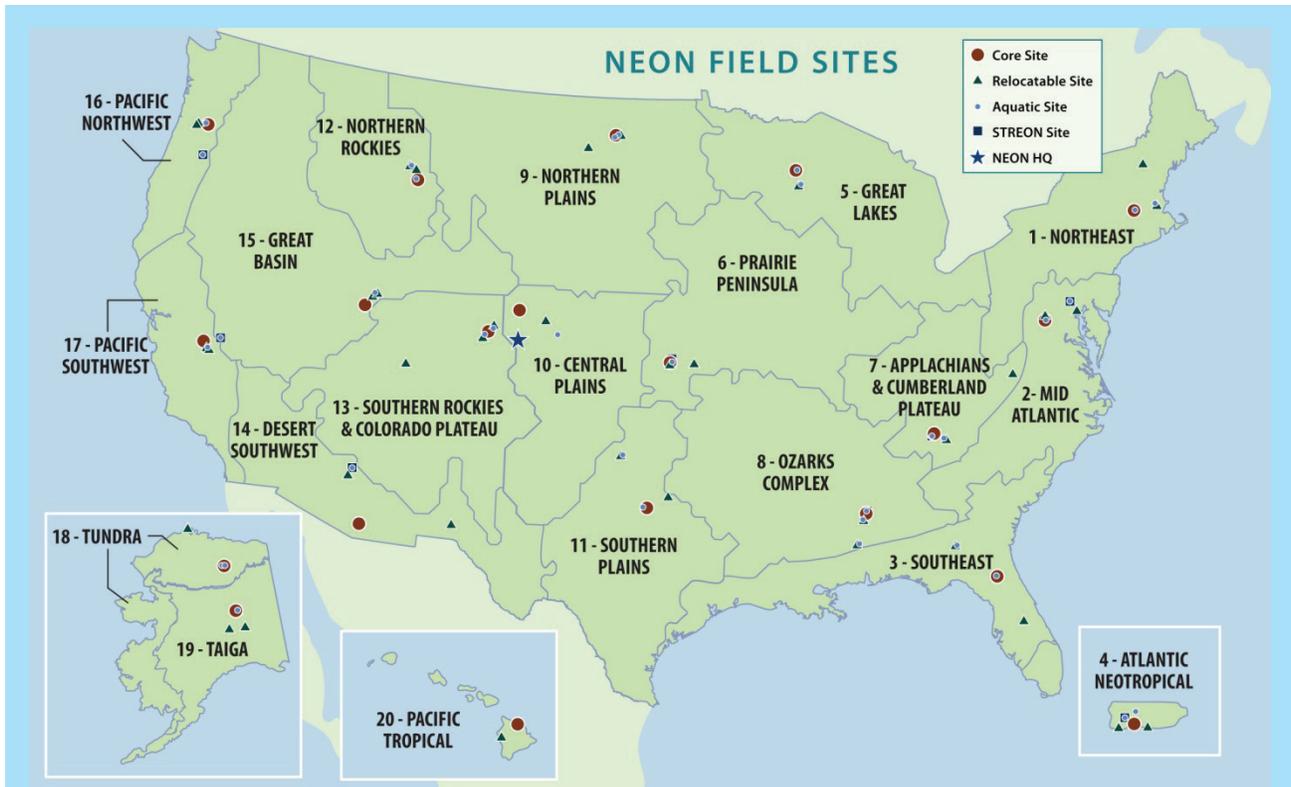
NEON: AN EKG FOR THE EARTH

Credit: National Science Foundation

An electrocardiogram (EKG) is a single instrument comprised of geographically distributed components; it is used to measure heart activity to detect problems in heart health. Similarly, NEON will be a single instrument comprised of geographically distributed components; it will be used to measure ecological activity to detect problems in the nation's ecological health.

Just as each EKG sensor is located to provide a unique 'view' of heart activity, each NEON sensor and field crew will be strategically located to provide a unique 'view' of ecosystem activity. And similar to EKG sensors that continually pulse standardized data to a centralized, synthesizing computer that displays resulting analyses, NEON sensors and field crews will continually pulse standardized data to a synthesizing cyberinfrastructure headquartered at NEON Inc. that will publish resulting information.

As a single observing scientific instrument, NEON is commonly referred to as an 'observatory' by scientists—even though NEON differs from the stereotypical conception of an observatory as a large telescope occupying one location.



NEON'S DESIGN

Credit: NEON Inc.

NEON's 106 data collection sites (60 terrestrial and 46 aquatic) have been allocated among 20 distinct eco-climatic domains—each of which represents different regions of vegetation, landforms, climate, and ecosystem performance.

Each domain contains a core site representing unmanaged, wildland conditions and two relocatable sites representing landscapes that are farmed, urbanized or otherwise disturbed by humans. Each relocatable site will operate for about five to 10 years and then be sited elsewhere. Stream Observation Network Experiment (STREON) sites will host experiments on stream ecology.

Additional data collection sites will be added to represent extreme events, such as fires, hurricanes and droughts.

Data from NEON locations will be transmitted via the Internet to computational, modeling and other resources based in Boulder, Colo. It will then be processed and synthesized into high-level products. Resulting data and high-level products will be published online to support analyses of long-term, large-scale ecosystem health conducted by NEON's user community.

With its coordinated, linked and integrated design, NEON will be a single national observatory, not a collection of regional observatories.

NEON MANAGEMENT

All NEON operations will continue for about 30 years until about 2047.

Funded by the National Science Foundation (NSF), NEON is managed by the National Ecological Observatory Network Inc., (NEON Inc.), an independent 501(c)3 corporation headquartered in Boulder, Colo.

During NEON's approximately 30-year life span, tens of thousands of nationwide researchers, students, decision-makers, natural resource managers, educators, stakeholder groups, citizens and others will use or rely on NEON resources.

DEMOCRATIZING RESEARCH

NEON will help broaden participation in ecological research by making available high-quality data and associated resources to people and organizations that would otherwise be unable to obtain such data.

For example, NEON's user community will include researchers and students at community colleges, undergraduate institutions, minority-serving institutions, small universities and nonprofit organizations. Many such individuals have traditionally been prevented from collecting ecological data because they have lacked necessary resources for doing so--including funding, large blocks of uninterrupted time, access to field locations and laboratories, high-powered computers for synthesizing data, and cadres of laboring graduate students. But NEON may help such individuals work around their data collection constraints by providing them with high-quality data that they can analyze and incorporate into original research projects and publishable papers, and thereby advance science.

In addition, resource managers in minority communities and small government organizations will be able to incorporate important, but otherwise unobtainable, NEON data into decision-making on pressing natural resource issues. A case in point: Southwestern Indian Polytechnic Institute (SIPI), which is a National Indian Community College in New Mexico, is currently training students--including current and future resource managers--in how to use NEON data. Discussed in an [NSF article](#), this training is designed to help Native Americans address the impacts of climate change on their lands.

The public accessibility of NEON data from desktop computers along with NEON's education/outreach activities--some of which started several years ago, will invite increasing numbers of nonscientists to contribute to ecological research. As a result, non-scientists may ultimately generate landmark discoveries in ecology, similar to the way they have recently done in astronomy.

TOPICS ADDRESSED BY NEON SCIENCE

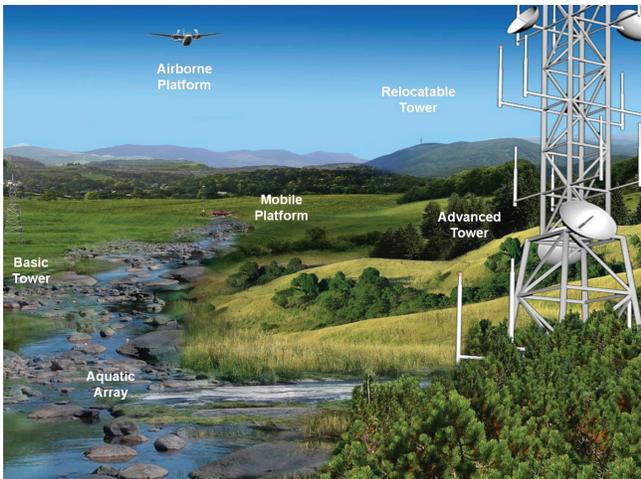
Specifically, NEON will be used by scientists to better understand the causes of climate change, land use changes and invasive species and the impacts of these phenomena on natural resources and biodiversity throughout the United States, including Alaska, Hawaii and Puerto Rico.

Research using NEON data will involve:

- Investigating the causes of climate change, land use changes and invasive species, and biological responses to these changes at 106 locations that were statistically selected to represent the complete spectrum of diverse, complex ecosystems that exist in the U.S. These locations include 60 terrestrial locations and 46 aquatic locations.



As part of his training on the use of NEON data, a student at Southwestern Indian Polytechnic Institute presents his research on beetle infestation impacts to the 2012 National Tribal Geographical Information Systems conference in Albuquerque, N.M. Credit: National Tribal GIS Conference



The infrastructure of a NEON location, Credit: CH2MHILL



A NEON instrumentation scientist characterizes a NEON location in Alabama, Credit: NEON Inc.

- Conducting experiments at selected locations within NEON's 106 representational locations. These experiments include the Stream Observation Network Experiment (STREON). STREON will be a long-term experiment designed to identify the responses of stream ecosystems located in various climates to the following two prominent forms of environmental change: 1) eutrophication, which involves additions of high levels of nutrients that can be ecologically harmful at high concentrations; and 2) the removal of large fish and other large animals such as crustaceans, mollusks and insects.

STREON will involve simulating chronic nutrient loading and the exclusion of large animals in 10 streams spanning the continental U.S. over a period of about 10 years, and measuring the resulting changes in processes, such as oxygen production, the decomposition of organic wastes, and the abundance and diversity of stream organisms. Results will help scientists predict the differing impacts of ecological changes on streams with differing temperatures, nutrient levels and hydrology.

- Identifying the causes and impacts of selected extreme events such as fires, floods, droughts and hurricanes. These studied events may occur inside or outside of the 106 NEON locations. (See discussion below of the ongoing study on the impacts of the 2012 High Park wildfire in Colorado.)

In addition, NEON will produce various educational/outreach resources that will be used by educators, policymakers, the public and others to promote public understanding of science and science-based decision-making on natural resource issues.

CUTTING-EDGE TECHNOLOGIES USED BY NEON

NEON measurements will be collected and processed with cutting-edge technologies. These technologies include:

- **Ground-based sensors** placed in soils, perched on towers, and--where appropriate--lodged in streams. These sensors will collect measurements on ecosystem conditions such as soil temperature, light intensity, air temperature, humidity, levels of air and water pollutants and nutrient levels.
- **Trained field crews** that will sample populations of diverse plants and animals, including invasive and migrant species and other sentinel organisms that are indicators of change, and collect soil and water measurements at NEON locations.
- **Airborne Observation Platform (AOP)** comprised of state-of-the-art remote-sensing instruments deployed in three Twin Otter airplanes. The AOP's remote-sensing instruments can quickly collect high-resolution measurements—down to 1 meter. In addition, the AOP can capture data from much larger areas than ground sensors or field crews. In fact, a single flight by the AOP may measure the individual tree heights, leaf area and leaf chemistry of 15 million trees.



(left) A tower at NEON's Sterling, Colo. location. Such towers will collect data on air chemistry, meteorological conditions and light conditions. Towers are designed to be hardy enough to operate while pelted by hail, hit by howling winds, and subjected to extreme heat or cold, *Credit: NEON Inc.*

(top)The Airborne Observation Platform (AOP) uses cutting-edge remote-sensing technologies to collect detailed data over large areas on various factors such as land use, pest and pathogen outbreaks, and wildfire impacts. The AOP's technologies include recently developed instrumentation that itself represents a major scientific advance, *Credit: NEON Inc.*

(bottom)A NEON staff scientist on a test flight of the fully instrumented Airborne Observation Platform, *Credit: NEON Inc.*

The AOP will fly scientist-defined and routine patterns over NEON locations to measure various factors such as vegetation cover and health, ash cover, plant species, soil quality, land use and topographic characteristics. Repeat flights over the same areas may reveal temporal changes in such factors.

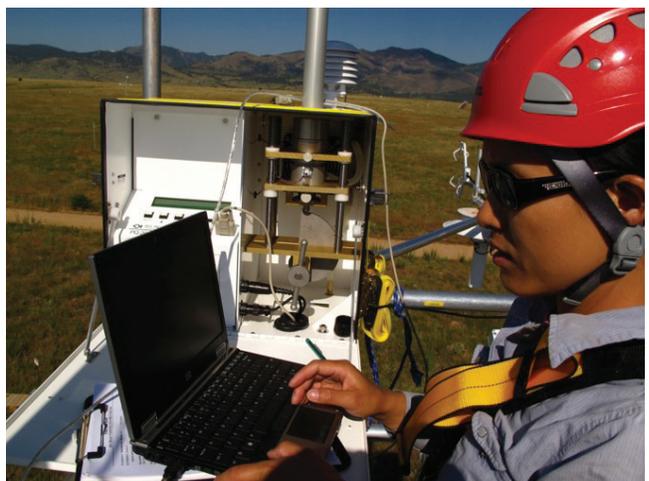
Information produced by the AOP will help bridge the gap between ground-based observations and satellite-based remote-sensing. An example of a large-scale ecology issue that may be studied using the AOP is the spread and impact of the mountain pine beetle in western North America. (Also, see the discussion below of the AOP's role in the ongoing study of the impacts of the High Park wildfire.

- **Laboratory, experimental and biological archive facilities** deployed throughout the U.S.
- **A state-of-the-art cyberinfrastructure** that will be used to link and integrate measurements derived from site-based sensors, field data, the AOP, experimental facilities, laboratory facilities and existing continental-scale datasets (such as satellite data and economic and social data) to computational, analytical and modeling capabilities.

WHY IS NEON SPECIAL?

NEON will be a unique, precedent-setting research platform because:

- NEON will simultaneously provide data to improve understanding of the causes and impacts of environmental changes. By contrast, most existing environmental research networks either address the causes of environmental changes (such as air pollution) or their impacts (such as beetle infestations)--but not both, as NEON will do.
- NEON will be the first facility to collect consistent, standardized time-series biological measurements across the U.S. NEON will thereby enable long-term, large-scale processes to be investigated as never before. This is important because many ecological processes that are critical to human well-being play out over decades and over large regional and continental scales.



A technician checks sensor calibration to ensure that it complies with NEON's high-quality control standards. *Credit: NEON Inc.*

Such long-term, large-scale processes cannot be studied with existing research networks--either because their life-spans are confined to short funding cycles or to the length of individual careers, or because they address geographically or topically restricted questions.

By contrast, NEON measurements will provide sufficient accuracy, precision, sampling and replication to support the detection of decadal trends amidst diurnal, seasonal and inter-annual variation. No other stand-alone system--either public or private--can provide the scientifically validated suite of data measurements that NEON will provide.

- NEON measurements will be made publically available on the NEON portal after they have been subjected to quality assessments, as necessary. By contrast, many existing networks have proprietary periods for data release or simply do not deliver data widely.
- NEON's flexible infrastructure will be uniquely deployable as needed, to accommodate advancing knowledge and abrupt, unpredictable natural events.
- NEON will promote public engagement in science via educational activities, such as citizen science and internship programs, and the distribution of various educational/outreach products.



Various types of NEON sensing instruments will be rapidly deployed to locations subjected to major events such as hurricanes, floods, droughts and insect outbreaks. Credit: NEON Inc.



SELECTED RECENT ACHIEVEMENTS IN NEON DEVELOPMENT

Bringing to fruition more than 10 years of planning, various important construction, research and outreach/education milestones have recently been achieved in the development of NEON. While each of these milestones is significant in its own right, they collectively represent a major leap forward in the creation of NEON. Here are some examples of these milestones.

Data Collection: In summer 2012, NEON and Colorado State University (CSU) initiated a [joint study](#) on the causes and impacts of the High Park wildfire in northern Colorado, which started on June 9, 2012.

This wildfire, which was located outside of the 106 representational NEON locations, was selected for a special NEON study because:

- It was the second largest and second most destructive fire in recorded Colorado history. It burned more than 135 square miles, destroyed hundreds of homes and killed one person.



(left) The High Park wildfire, which burned in the mountains near Fort Collins, Colo., was started by lightning on June 9, 2012, and raged out of control for weeks, Credit: Colorado National Guard

(right) The High Park wildfire burn scar in Poudre Canyon, Colo. on Oct. 3, 2012. A joint NEON/Colorado State University study of the fire's entire huge burn scar and adjacent areas will provide critical data to communities that are still coping with post-fire issues involving water quality, erosion and ecosystem restoration, Jennifer Walton, Credit: NEON Inc.

- CSU researchers had been fortuitously studying the fire area before the fire started, and had thereby generated rare, pre-fire baseline data on the area's ecology.

NEON kicked off the High Park study by using the AOP during the summer and fall of 2012 to collect measurements over the fire's entire burn scar and adjacent unburned areas. These AOP flyovers represent the first time that a comprehensive airborne remote-sensing system of the AOP's caliber has been used to study wildfire causes and impacts, as well as the first time that the AOP has been used to collect data for use in near real-time (rather than in prototype exercises).

The AOP's measurements of the study area offer unparalleled precision on the extent and condition of surviving vegetation, plant species, ash cover, soil properties and other factors. This information is currently being used to produce high-definition, 3-D images of the study area, as well as other types of rich ecological data covering the entire study area.

Results from the AOP, together with CSU's ground-based assessments, may be used to support the development of a comprehensive assessment of the fire's natural causes and impacts as well as support regional recovery efforts conducted by the U.S. and state forest service and the cities of Fort Collins and Greeley, Colo.--both of which have water supplies that are likely to be affected by post-fire erosion.

The study may also help scientists define how preexisting conditions influenced the behavior and severity of the fire and how the fire's patterns are affecting recovery of vegetation, wildlife and water resources. In addition, the study may also be incorporated into efforts to refine models of fire behavior and help improve future firefighting decisions and post-fire management decisions.

Construction of NEON locations: In 2012, civil construction was completed and a sensing tower was outfitted with electronic sensing instruments at a NEON location in Sterling, Colo. This tower will soon start collecting atmospheric measurements--the first measurements to be collected from one of NEON's 106 locations.



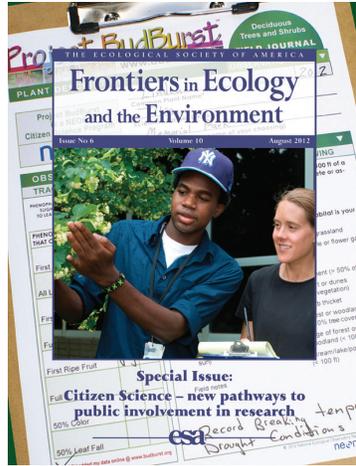
Standing up for Science. On June 8, 2012, federal officials, scientists and students marked the official start of NEON construction at a groundbreaking event at Harvard Forest in Petersham, Mass. Credit: NEON Inc.

Also, during the summer of 2012, [ground was broken](#) at two major NEON locations: 1) Harvard Forest in Petersham, Mass.; and 2) the Ordway-Swisher Biological Station in Melrose, Fla. Since then, civil construction has been completed at the Ordway-Swisher Biological Station. Sensing equipment will soon be attached to the location's tower and then calibrated to prepare for data collection. Updates about construction progress at NEON locations are posted on the [NEON Inc. Website](#).

Outreach/Education: A proponent of "learning by doing," NEON facilitates varied real-world outreach activities for decision-makers, scientists, students and the public. For example, since 2010, NEON has managed Project BudBurst, a national network of more than 13,000 registered volunteers. [Project BudBurst](#) is dedicated to measuring the timing of plant life cycle events, such as leafing and flowering, as they respond to seasonal changes across the U.S.

In addition, in 2012, NEON helped raise the stature of citizen science among scientists and nonscientists by contributing to: 1) a high-profile [scientific conference](#) on citizen science; 2) a popular [Special Issue](#) of the Ecological Society of America's journal, *Frontiers in Ecology and the Environment*, that was devoted to citizen science; and 3) a well-publicized NSF [Webcast](#) on citizen science. Also in 2012, NEON opened the [NEON Citizen Science Academy](#), which has already registered hundreds of educators in online courses on running citizen science programs.

(left) The cover of the August 2012 issue of *Frontiers in Ecology and the Environment* on the topic of citizen science, which was guest edited by Sandra Henderson, a senior education specialist at NEON and director of NEON's Project BudBurst. This Special Issue was the most requested issue in *Frontiers'* history. Credit: Central photo: © C. Calvin/University Corporation for Atmospheric Research. Background photo: © D.L. Ward/NEON



(right) Senator Mark Udall of Colorado with staff from NEON Inc. and the National Center for Atmospheric Research on Capitol Hill during Climate Science Day on Feb.16, 2011. Credit: U.S. Senate

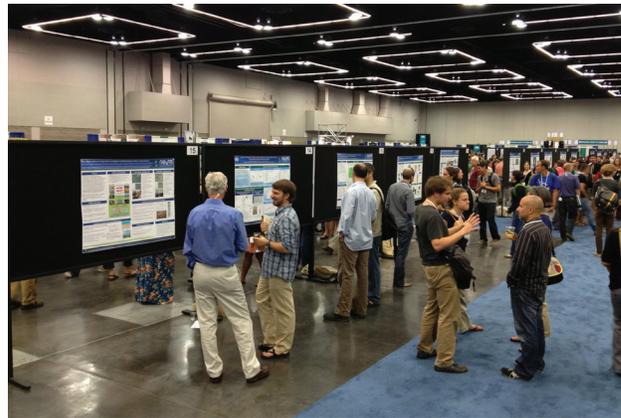


Other NEON achievements include the recent kick-off of a new [internship program](#) for college students, as well as the continuation of [annual Climate Science Day](#) on Capitol Hill, which is designed to foster dialogue between NEON scientists and legislators on the science of climate change.

STAY TUNED ON NEON'S PROGRESS!

Keep track of NEON's ongoing achievements with these resources:

- NEON Inc.'s [Website](#) multimedia materials cover NEON's history and future, provide updates on NEON's scientific, educational/ outreach and construction activities, and announce NEON career opportunities.
- [NEON Notes](#): The official blog of NEON, which showcases ideas, thoughts and questions generated by NEON Inc. staff and partners.
- NEON's quarterly emailed [newsletter](#)
- The Project BudBurst [Website](#)
- [Twitter](#), [Facebook](#), and [LinkedIn](#)



Staff from NEON Inc. discuss science topics during a poster session at the annual meeting of the Ecological Society of America. Credit: NEON Inc.

