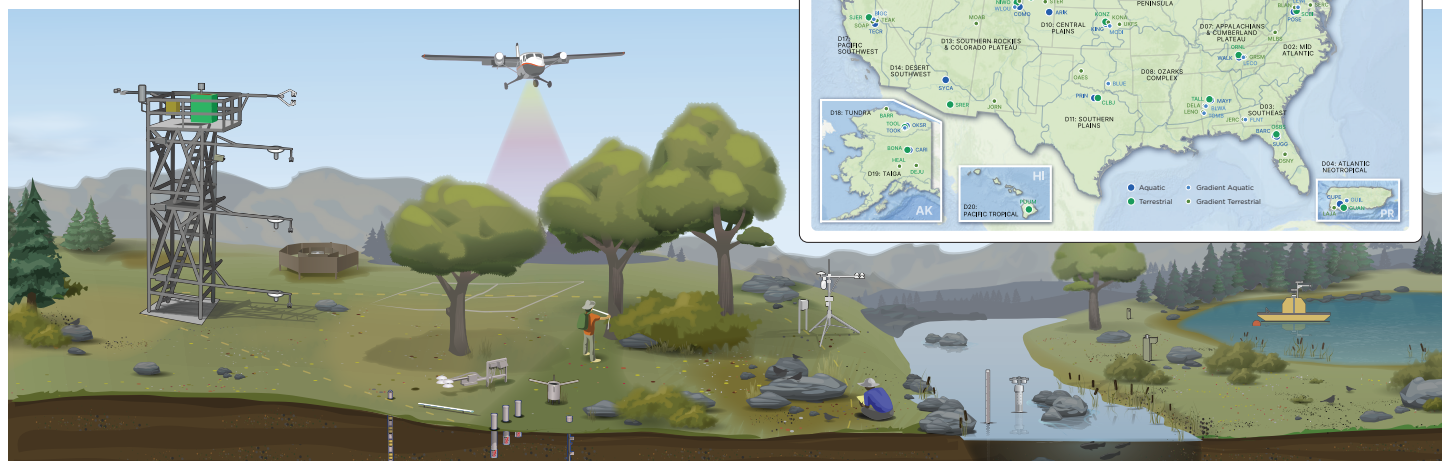


NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON) FIVE-YEAR STRATEGIC PLAN

STRATEGIC VISION FOR THE OBSERVATORY TO MEET THE DYNAMIC NEEDS OF THE RESEARCH COMMUNITY AND HARNESS EVOLVING TECHNOLOGY



NEON is designed to collect standardized data at 81 field sites across the U.S. that will quantify ecological change over time. NEON takes millions of measurements and collects thousands of samples every year across our automated instrument systems, terrestrial and aquatic observational sampling, and airborne observation platform as illustrated in the diagram here. Field sites are strategically located in many different types of terrestrial and aquatic ecosystems, enabling scientists to study and forecast ecological change over time at local, regional, and continental scales.

OUR MISSION

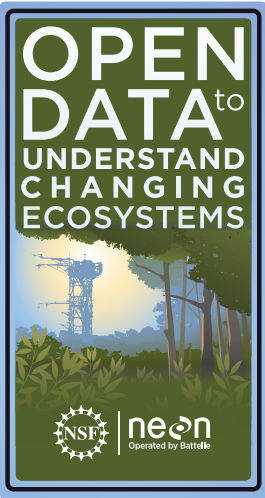
At NEON, our mission is to advance understanding of the complex interactions between ecosystems and the environment by providing open, high-quality, long-term ecological data and infrastructure.

NEON strives to be a catalyst for transformative research, enabling discoveries that inform ecosystem management, conservation strategies, and sustainable development by facilitating large-scale, integrated observations across the varied ecosystems of the United States. By combining state-of-the-art observational infrastructure, advanced sensor technologies, and robust data management, we enable the collection of open, high-quality, standardized data across scales and ecosystems. Please see the 'About NEON' section at the end of the document and the NEONscience.org website for more details.

While NEON has already been used extensively by the research community to address pressing ecological questions related to environmental and land use change, there is still much to be done to ensure its potential is realized for the benefit of science and society. Here we outline the key approaches we plan to take to further expand awareness and use of this globally unique platform.

Our mission is built upon three core pillars:

Observing: We maintain a comprehensive network of strategically located field sites, equipped with state-of-the-art instruments, and monitored through a comprehensive suite of sampling protocols. These sites enable us to capture critical ecological data on a vast scale, spanning terrestrial, aquatic, and atmospheric realms. Through our standardized protocols, we ensure data consistency and comparability, enabling scientists to study ecosystem dynamics and changes over time.



Integrating: We foster interdisciplinary research and collaboration, bridging the gap between traditional ecological disciplines and emerging technologies. By integrating data from multiple sources, including remote sensing, and on-the-ground measurements, we provide a holistic view of ecosystem functioning and integrating across the interfaces of scales and disciplines. Our efforts aim to provide the information and infrastructure to enable the research community to identify patterns, detect trends, and understand the complex interconnections between species, communities, and their environment.

Sharing: We are committed to open science and broad dissemination of data, knowledge, and tools. By providing free and accessible data products, educational resources, and analytical tools, we empower researchers, educators, policymakers, and the public to engage in evidence-based decision-making and foster environmental stewardship.

OUR VISION

Our vision is a world where ecological understanding and sustainable stewardship of the Earth's ecosystems are at the forefront of decision-making. Through comprehensive data collection and open collaboration supporting cutting-edge research, NEON strives to inspire global environmental literacy, drive innovative solutions, and protect the planet for future generations.

OUR VALUES

- Transparency
- Safety
- Mission-driven
- Innovation
- Efficiency
- Service-oriented
- Quality
- Resilience
- User-focused

EXECUTIVE SUMMARY

As operators of the NSF NEON program and providers of long-term environmental data, our role is not to do research with the data we produce, but to enable the science of others. The foundational set of free and open data and samples that is our NSF mandate to collect, is not expected to change over the next 30 years, though new instrumentation, technologies, and partnerships will undoubtedly enable new capabilities. Even as we evolve our operations to capitalize on these, the scientific needs of NEON's users will also change in tandem. Many of the goals below reflect our intent to increase awareness and use of NEON resources across research areas, federal agencies, commercial entities, and the public, thereby broadening the community we serve. It is through the vision and actions of this broad community, and in partnership with the NSF, that emerging capabilities can be leveraged by NEON to add value to science.

As a NSF large facility of the NSF Biological Sciences Directorate, the data, samples, and infrastructure and the practices surrounding its use are unfamiliar to many. As we seek to educate, train and empower users (this is your facility), we will focus on values surrounding the NEON data and samples they use and in turn new data and samples that they produce. Similarly, as we train an ecological workforce, we will pass along the field-based training and practices at NEON that are at the root of field safety for an external workforce.

GOAL 1: ENABLE SCIENCE THROUGH PARTNERSHIPS

Be a respected platform that integrates with the biological research community through collaboration, community-adopted standards, data and sample usage, linked and interoperable data, standardized sampling methods, curriculum content, and research support services.

OBJECTIVE 1.1: EXPAND KEY PARTNERSHIPS ACROSS THE US FEDERAL GOVERNMENT

- Foster and grow U.S. Department of Energy Biological and Environmental Research partnerships, including key collaborations with the Joint Genome Institute, Environmental Molecular Sciences Laboratory, National Microbiome Data Collaborative, and AmeriFlux
- Expand partnership with the National Aeronautics and Space Administration to support emerging remote sensing applications (e.g., the Surface Biology and Geology Mission) and markets in alignment with its Earth Science to Action strategic goals, including increased data accessibility and interoperability and training
- Develop partnerships with key water science entities to further understanding of drivers and impacts of change on freshwater systems, including the United States Geological Survey and National Oceanic Atmospheric Administration (NOAA) National Water Center
- Foster partnerships with the federal agricultural sector to realize NEON's potential for contributing to key questions regarding food security, the bioeconomy, biodiversity, and regenerative agriculture, with an emphasis on the U.S. Department of Agriculture
- Explore potential partnerships with public health agencies, including the Centers for Disease Control and Prevention, to improve discovery and understanding of emerging pathogens and pathogen-environment and host-pathogen dynamics



200+
PARTNERSHIPS

Maximizing the scientific potential of NEON requires active collaboration with organizations that have related missions, from professional societies to governmental agencies to other research networks.

OBJECTIVE 1.2: PROMOTE TRANSDISCIPLINARY AWARENESS OF THE NEON PROGRAM



- Conduct in-reach across NSF Directorates and engagement with the NSF Biological Sciences Synthesis Centers
- Expand activities in new research arenas through targeted outreach emphasizing the broad utility of NEON's Research Support Services to facilitate piloting of new technologies and to support NSF-funded initiatives with emphasis on leading-edge computational approaches, such as the Ecological Forecasting Initiative, National Center for Atmospheric Research, and the National Artificial Intelligence Research Resource Pilot



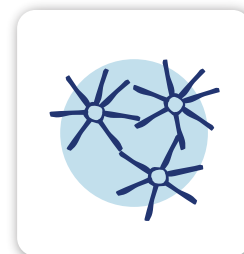
- Develop new partnerships that reach different audiences, including use-inspired commercial entities, such as those developing data science, agricultural, and remote sensing applications
- Elevate NSF branding across NEON infrastructure to reach the broader public, particularly at sites with high visibility
- Enhance media collaboration with the NSF Biological Sciences Directorate and Office of Legislative and Public Affairs teams to expand audience base

- Develop and disseminate consistent messaging on the responsibilities of NEON, NSF, and the community with respect to their roles in advancing science



OBJECTIVE 1.3: INSPIRE AND SUPPORT THE EXPANSION OF THE GLOBAL SCIENTIFIC LANDSCAPE OF ENVIRONMENTAL MONITORING INFRASTRUCTURE

- Support the Global Ecosystem Research Infrastructure (GERI) to enable interoperability of data across international networks
- Identify and foster working relationships with developing ecological networks, such as South Korea, to facilitate their realization and explore harmonization of methods and data
- Explore development of international standards for environmental repositories akin to astronomical repositories
- Continue engaging with NEON's core ecological and environmental science communities to ensure its value in enhancing PI-driven science through its broad and deep contextual information and in furthering continental-scale biology, e.g., in collaboration with the NSF Long-Term Ecological Research network



OBJECTIVE 1.4: INCREASE NEON ENGAGEMENT WITH BROADER IMPACTS PARTNERS

- Continue Domain outreach and staff engagement with local communities to increase visibility of NEON and uptake of data and services
- Broaden engagement to support translational applications (e.g., health, economic, data scientists, development entities, decision- and policymakers)
- Encourage NEON staff to pursue leadership in and collaboration with partner organizations, such as through advisory committee appointments
- Seek new relationships with the public affairs or communications staff within partner organizations for increased impact on decision- and policymaking

GOAL 2: MAXIMIZE OPERATIONAL EXCELLENCE AND AVAILABILITY OF HIGH-QUALITY DATA

Provide trusted, freely available, high quality, national-scale, critical data and samples that are easily accessed and made rapidly available for use to enable an informed and predictive understanding of ecological responses to environmental changes.

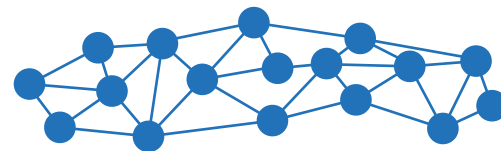
OBJECTIVE 2.1: IMPROVE DATA PIPELINE EFFICIENCY, FLEXIBILITY, AND SECURITY

- Continue development of existing technical investments in open platforms for NEON code development and data processing, using open-source containers such as Docker in data pipelines (encompassing data ingest, processing, and publication); integrate the Google Cloud Platform (GCP) resources to align with this open technology stack
- Use GCP to enable scalable and robust, production-level object storage and reduce the time from data processing to availability on the data portal to users across the globe
- Offer additional data formats to enhance use by cloud native tools such as Cloud Optimized GeoTIFF, Apache Parquet, Zarr, and others

- Mature Information Assurance (i.e., cybersecurity) posture in collaboration with the NSF
- Evaluate new satellite direct communications infrastructure for tablet-based field collection

OBJECTIVE 2.2: OPTIMIZE TOOLS FOR INSTRUMENTATION MAINTENANCE

- Improve asset tracking and lifecycle management through improved data analytics and monitoring to optimize calibration frequencies and fine-tune inventory levels for efficiency
- Expand capabilities of mobile-enabled workflows for field maintenance
- Explore AI applications to enable predictive instrumentation maintenance to increase data availability
- Leverage asset tracking and lifecycle management to enhance supply chain resilience, mitigate obsolescence, and improve asset performance
- Foster partnerships with organizations such as NOAA Global Monitoring Laboratory and the National Institute of Standards and Technology to explore potential synergies to improve operational efficiencies including infrastructure resources usage, technological developments, instrumentation selection and standardization of calibration and operation



5.6 BILLION
DATA POINTS DAILY
 (~65K data points/sec)

NEON collects billions of data points from 81 field sites across the United States, including on terrestrial, aquatic, atmospheric, and remote sensing measurements. Data is standardized and made available to the community through the NEON Data Portal.

OBJECTIVE 2.3: LEVERAGE COMMUNITY EXPERTISE WITH RESPECT TO OPERATIONS AND DATA QUALITY

- Continue to engage with expert advisory groups to consult on operational improvements and sampling design optimizations
- Participate in initiatives organized by the scientific community such as working groups and conferences
- Increase communication and transparency with end-users on how community feedback is addressed and how it impacts operational changes



AOP DATA
>100 TB
PUBLISHED ANNUALLY

NEON's Airborne Observation Platform (AOP) collects high-resolution remote sensing data over NEON sites with an aircraft-mounted payload that includes an imaging spectrometer, lidar, and camera. Over 100 TB of data are generated from these efforts each year, including raw data, intermediate processing products, published products, and quality assurance data.

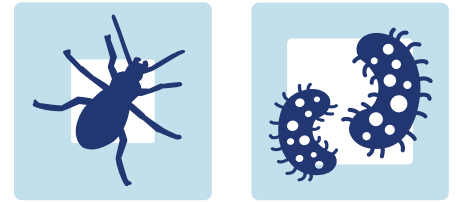
- Continue to engage with data users to support continual improvement in quality control in data collection and processing, including publicly sharing data processing algorithms via version-controlled source code repositories such as GitHub and containers and facilitating community review and refinement
- Proactively engage with suppliers to enhance obsolescence and supply-chain planning

OBJECTIVE 2.4: ENHANCE PERFORMANCE ASSESSMENT ACROSS THE PROGRAM

- Engage the services of program evaluators to refine Observatory metrics
- Conduct facility condition assessments for all physical infrastructure in accordance with NSF requirements
- Conduct targeted and efficient audits and integrate lessons learned to support continual improvement
- Enhance risk management practices in collaboration with the NSF to minimize the effect of threats and maximize the impact of opportunities

OBJECTIVE 2.5: MATURE PROCESSES TO IMPROVE QUALITY, STANDARDIZATION, AND SAFETY OF DATA COLLECTION

- Identify and act upon areas for improved effectiveness with internal training processes and products
- Optimize the assessment and auditing of data collection and maintenance implementation
- Continue fostering a strong field safety culture to actively identify safety concerns and bring resolution to potential hazards
- Continue automation and refinement of data product-specific quality routines, including flagging thresholds, custom front-end controls, and custom post-collection checks



100,000+
SAMPLES ADDED
PER YEAR

The Observatory assures high-quality, comparable data through standardized and quality-controlled data collection and processing methods.

OBJECTIVE 2.6: EARLY IDENTIFICATION AND RESOLUTION OF OPERATIONAL CHALLENGES TO ENHANCE OBSERVATORY RESILIENCE

~22/day **8,000+**
Incidents Annually

With a distributed Observatory and thousands of assets at risk from the environment, NEON averages over 8,000 incidents annually, from natural disasters, to vandalism, to exposure to elements and animals. NEON staff monitor, repair, and replace equipment and materials as needed.

- Expand and improve operational health monitoring of all data collection systems to enable faster identification of challenges
- Provision staff with tools to resolve challenges faster using an integrated database that communicates across large, dispersed teams
- Enhance service management framework to better capture changes through automation, and reduce the time to implement changes and respond to alerting through better integration with Observatory systems
- Expand adoption of continuous improvement tools to provide early detection visibility

GOAL 3: HARNESS EVOLVING TECHNOLOGY TO CATALYZE DISCOVERY

Enable frontier science needs to provide an optimized, forward-looking technological and observational platform to be used as a catalyst for research and innovation.

OBJECTIVE 3.1: ADAPT TO MEET THE CHANGING NEEDS OF THE NEON USER COMMUNITY

- Ensure community-responsive evolution of the NEON data portal by conducting a full user interface and user experience testing suite and redesign process to meet the most pressing needs of our growing user community
- Work with the NSF to establish a process and frequency for community review and evaluation of the demand for current NEON resources, including assets, data products, sites, and samples to inform opportunities for evolution


OBJECTIVE 3.2: DEVELOP FORWARD-LOOKING VISION THROUGH EMERGING TECHNOLOGIES

- Establish a technology roadmap with community input (including instrumentation, software, computational infrastructure) in consideration of end-of-life, obsolescence and technological developments
- Establish a NEON Innovation Advisory Council that includes experts from industry, academia, and agencies with expertise in the breadth of technologies that NEON relies upon for data capture, delivery, and accessibility
- Engage in dialogues/workshops around future integration of Artificial Intelligence/Machine Learning in the Observatory

OBJECTIVE 3.3: SUPPORT COMMUNITY-DRIVEN INITIATIVES TO EXPAND NEON CAPABILITIES

- Identify technical and costing requirements for community-driven additions to the NEON infrastructure and communicate these with the NSF; the following are most requested to date: acoustic recording devices, remote cameras, methane flux instrumentation, carbon flux measurements from aquatic systems, drones to increase frequency of remote sensing data collection, NEON protocol training modules adapted and available for external community use, and cloud tools to analyze and use NEON data
- Collaborate with partners and research community to assess and prioritize efforts to strategically enable additional Analysis- and AI-Ready datasets and other derived data products that increase the usability of NEON data; strengthen partnerships with data providers such as Environmental Data Initiative to host and share these datasets

PHYSICAL INFRASTRUCTURE



airborne observation platforms.....	3
flux towers.....	47
water quality stations.....	57
meteorological stations.....	89
groundwater wells.....	197
soil sensor arrays.....	235

With its 81 terrestrial and aquatic sites and 3 airborne instrument payloads, NEON collects numerous data products through the instrumentation system, comprised of flux towers, aquatic and meteorological stations, ground wells, soil arrays, and more.

GOAL 4: ENHANCE DISCOVERABILITY, ACCESSIBILITY, AND USABILITY OF NEON DATA AND SERVICES

Deliver educational and training resources to the next generation of ecologists and environmental scientists to expand the community for effective discoverability and use of NEON data, samples, and technology.

OBJECTIVE 4.1: LEVERAGE PARTNERSHIPS TO EXPAND & EVOLVE DATA SKILLS TRAINING RESOURCES IN RESPONSE TO USER NEEDS

- Collaborate with NSF synthesis centers to maximize the utility of their platforms, infrastructure, and professional networks to increase reach and utilization of NEON data
- Explore integration of data tools into the NEON data portal and into relevant NEON data skills tutorials and trainings with partners such as CyVerse
- Develop external funding proposals with partners to develop curricula, data packages, and training resources to enhance knowledge and use of NEON data and samples by end users
- Foster and grow partnerships to develop and deliver data skills training

- Expand, extend and maintain a suite of online NEON-specific data skills tutorials and code resources to facilitate NEON data use

OBJECTIVE 4.2: IMPROVE ACCESS TO DIGITAL RESOURCES

- Implement data portal improvements based on user feedback to improve the user experience with the data portal
- Solicit a periodic (every 5 years) review of current digital resources, training, and tools by an external group such as ACCESS Computing
- Refresh messaging and content of the neonscience.org website

OBJECTIVE 4.3: ENHANCE OPENNESS AND FAIRNESS OF NEON DATA AND SAMPLES

- Enable broader discoverability, leveraging environmental metadata and data aggregators, enabling search capabilities through a larger dictionary of keywords mapped to community-supported ontologies, and developing additional visualization tools that encompass a broader array of NEON data products
- Focus on interoperability as a key feature of NEON's partnerships, incorporating community standards, collaborating with partners on shared vocabularies, mapping vocabularies, and developing tools that integrate datasets from NEON and other sources, such as the ecocomDP package
- Scale up available tools for working with NEON's remote sensing data, including improving discovery, visualization, and download functionality of these large datasets via the NEON portal and API, adding products, sites, and years to the public datasets in Google Earth Engine, incorporating versioning and uncertainty estimates
- Prioritize improvements in land use data for NEON sites in collaboration with users, site hosts, and the Site Management and Disturbance Technical Working Group

OBJECTIVE 4.4: EXPAND AND ENHANCE NEON'S RESEARCH SUPPORT SERVICES

- Increase awareness of NEON's Research Support Services (NRSS) to increase their use in the range of supported science
- Increase understanding of how to leverage NRSS for potential users through additional outreach, support, and tools
- Engage the research community and funding agencies to optimize NEON's infrastructure offerings, focusing on the most valued services
- Create and implement a communication campaign to highlight the potential for both the research and commercial sectors to leverage these services to pilot new technologies

OBJECTIVE 4.5: BUILD THE NEON OWNERSHIP OF USERS

- Conduct a community needs assessment every five years to identify specific education, training, and outreach activities and inform the development of a Strategic Engagement Plan for the Observatory
- Host biennial NEON Convergence Summits to facilitate research collaborations, convene the research community, and enable their efforts to broaden the complexity and type of research questions that can be addressed by using NEON data and samples



DOWNLOADS/MONTH
4,500 USERS/MONTH

Users of NEON data can download over 180 data products through the NEON Data Portal.



A key but lagging indicator of Observatory efficacy is research publications, which are published months to years following discovery. Data show that the use of NEON is increasing, with over 1,000 publications specifically using NEON data, samples, or other resources. These data come from Dimensions and the Global Biodiversity Information Facility.

- Leverage NEON's Ambassadors and Postdoctoral Fellows programs to convene and mentor early career researchers on access and use of NEON infrastructure, data, and samples in alignment with their research priorities and pursuit of future funding
- Facilitate the development and distribution of tools that visualize NEON data, such as the *Grafana* widget, to support NEON Site Host objectives and engagement



The NEON Ambassador Program empowers and connects researchers and educators eager to augment NEON's engagement with communities. Ambassadors receive training in group-facilitation and creative problem-solving, as well as in NEON best practices.

GOAL 5: FOSTER AN ENGAGED WORKFORCE

Foster a culture that attracts, retains and empowers a talented workforce where perspectives of all members are respected and valued.

OBJECTIVE 5.1: DEVELOP AND RETAIN TALENTED STAFF

- Leverage Battelle mentorship activities to ensure NEON leads are fostering a supportive coaching environment for professional growth, and development for staff and promote informal mentorship opportunities within technical teams
- Promote Battelle's professional development offerings, including tuition assistance, publication support, professional memberships, proposal development, certification, technical upskilling, and rotational assignments across Battelle labs and programs
- Publicize career opportunities from across Battelle to NEON program staff to encourage lateral and promotional job changes within the organization, providing new challenges and career advancement opportunities
- Continue supporting conference participation in relevant technical, scientific, and engagement conferences

PEOPLE

~600 total staff

320+ full time

250+ SEASONAL
Domain techs



In addition to the teams at Headquarters, NEON works in 24 states and 1 U.S. territory across 20 Domains, and requires the staff to support data collection and in-field sensor calibration and maintenance. In addition to full time staff, we hire 225-250 seasonal staff annually across the Observatory.

OBJECTIVE 5.2: BUILD A CULTURE OF BELONGING

- Foster a culture of excellence, working collaboratively on creative science and technology solutions, and demonstrating appreciation for each other's expertise along the way, through regular communication from NEON leadership and key Battelle leaders
- Reinforce the NEON Code of Conduct with annual staff training and sharing the Code of Conduct with external participants ahead of all NEON events
- Support staff engagement in Battelle activities that enhance career development, expand professional networks, and contribute to personal development

ABOUT NEON

The National Ecological Observatory Network is a continental-scale observation facility designed to collect long-term open access ecological data to better understand how U.S. ecosystems are changing. NEON is funded by the U.S. National Science Foundation and is operated and managed by Battelle. The Observatory maintains a comprehensive network of 81 strategically located field sites across 20 ecoclimatic Domains that cover the contiguous 48 U.S. states, Alaska, Hawaii, and Puerto Rico, along with a headquarters office and an airborne observation platform (AOP) hangar in Boulder, Colorado. Each Domain represents a distinct region of vegetation, landforms, climate, and ecosystem dynamics.

NEON collects integrated biological, physical, and chemical measurements and samples at all its field sites using a combination of field-based protocols, as well as in situ and remote sensing methods and technologies, to support the study of complex ecological processes. NEON provides standardized, consistent data at unprecedented spatial and temporal scales, as well as resources and infrastructure to support the scientific community.

NEON takes millions of measurements and collects thousands of samples every year. The Observatory delivers high-quality, comparable data products through standardized and quality-controlled data collection and processing methods. NEON provides open access data and archival samples and is planned to collect data for 30 years. Data products are readily accessible in standard formats used throughout the scientific community. NEON also provides documentation and tutorials to support understanding and interpretation of its data products. The NEON Biorepository is built to house millions of samples collected at NEON field sites over the course of NEON's lifetime. These samples are available for loan to researchers for study, including for destructive purposes. NEON infrastructure may be used by the research community through the cost-recoverable NEON Research Support Services program.

Since its inception, NEON has relied on expertise within the science, education, and engineering communities to advise on the design, construction, and maintenance of the Observatory with the goal of optimizing its operations. NEON values our user community and strives to provide services and resources that meet the community's evolving needs. We aim to achieve an optimized Observatory with a robust, active, and innovative NEON user community that transforms science and maximizes NEON-related research over the next 30 years and beyond.