

# A Continental-Scale Observation System for Examining Critical Ecological Issues



Agriculture Systems

Climate Change

Forest Management

Invasion Biology

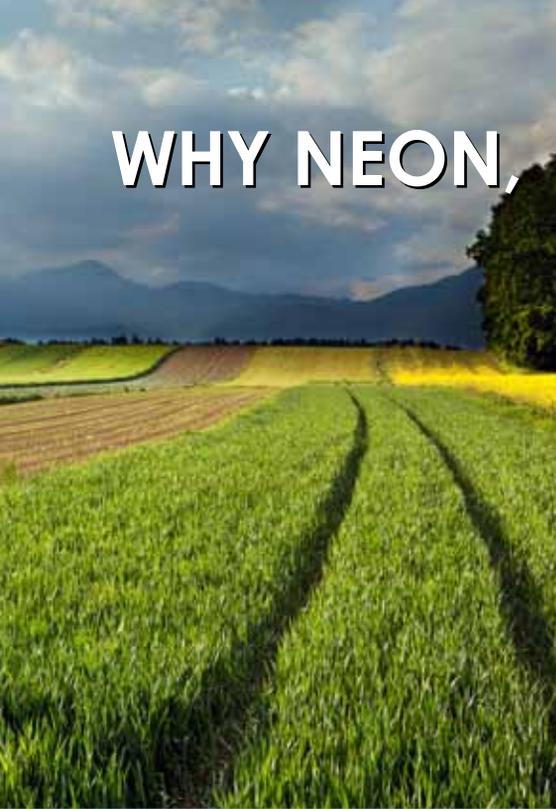
Urban Ecosystems



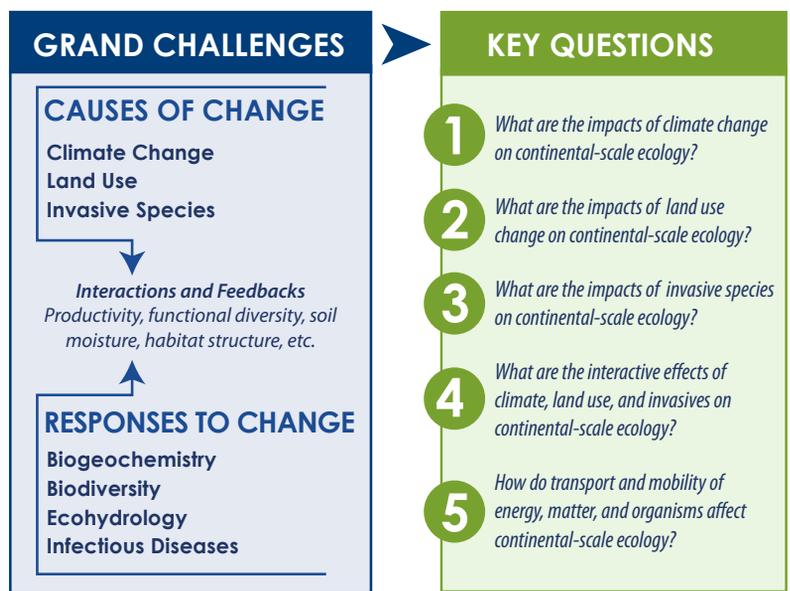
# WHY NEON,

# WHY NOW?

The world is now experiencing an era of rapid biological change as a result of human development. Ecosystems are increasingly stressed by climate, movement of invasive species over long distances, transport of pollution in the atmosphere, and human land use decisions. Ecologists must collect the vast amounts of global data needed to understand, forecast, and ultimately manage the changing biosphere and the services it provides. Analyzing these large-scale, complicated phenomena requires measuring or manipulating stresses and measuring their biological responses (Fig 1) at a larger scale than ever before, and NEON has been designed to provide the resources to do just that.

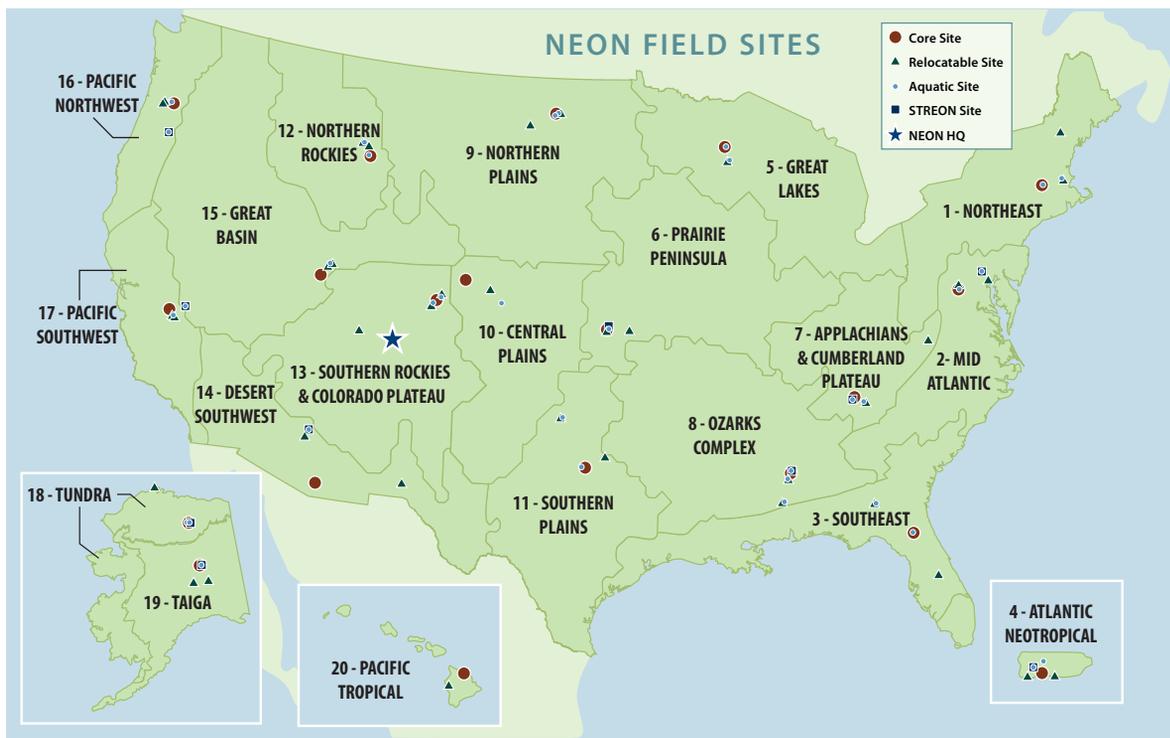


More than a decade of discussion and planning by the ecological research community has led to the design and data requirements of NEON. The resulting NEON framework will deliver consistent, long-term observations collected on a schedule, around which PI- and project-based research can be built.



(Fig 1) NEON is designed to address seven Grand Challenge areas in Environmental Science that have been translated into five key questions that frame the study of continental-scale ecology.

NEON is a user facility that provides free and openly available data and a variety of other resources for use by the public. Science user facilities provide resources that can be efficiently shared over many investigators and educators, or are too costly for individuals or institutions to maintain. Such facilities also make state-of-the-science capabilities accessible to a wide range of users. As ecologists seriously begin to address ecology at the continental scale, the comprehensive data, spatial extent and remote sensing technology will allow a large and diverse user community to tackle new questions at scales not accessible to previous generations of ecologists.



# A CONTINENTAL-SCALE DESIGN

NEON's measurement strategy is designed to observe both the causes of ecological change (such as climate and land use) and biological responses to change from site to continent. NEON also coordinates operations with other research, networks, and observatories. All NEON data measurements are made consistently across NEON sites using rigorously managed calibrations and are traceable to national or internationally recognized standards.

## Integration and Scaling

NEON science goals require a statistical sampling design that allows inference at regional and continental scales. This design unites point and process observations with remote sensing and statistical data to develop spatio-temporal analyses and forecasts.

At the site level, NEON will collect a combination of terrestrial and aquatic biological measurements and samples as well as atmospheric, soil and water measurements. Plot and organism-scale data will be coordinated with landscape-scale airborne data and with existing national data sets to create an integrated system of observations. The system is intended to bridge scales from that of individual plants and stands, captured by plot and tower observations, to that of satellite-based remote sensing.

## Data Products

All site-based and remotely sensed data are collected, sent back to headquarters, processed and then made available through the NEON web portal. NEON provides openly accessible, quality-controlled data, from raw, field-collected data to a set of integrative, multidisciplinary data products that address key, high-level questions derived from the Grand Challenges.

In order to collect ecological data in a strategic manner, NEON has partitioned the U.S. into 20 eco-climatic domains, each of which represents different regions of vegetation, landforms, climate, and ecosystem dynamics.

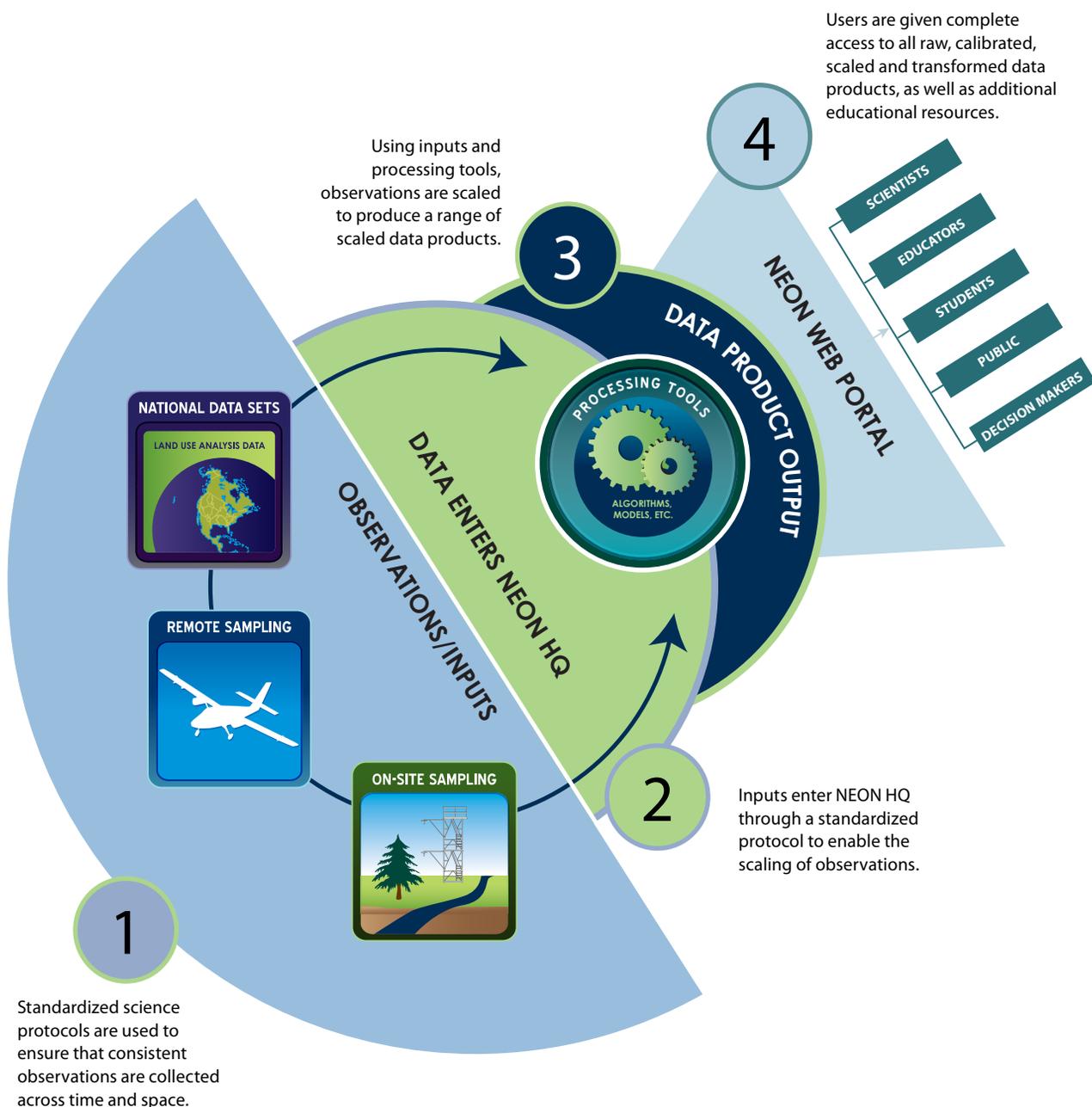
Each domain includes:

- One core site (representative of unmanaged wildland conditions)
- Two relocatable sites (focused on human land management effects on ecosystems)
- In addition, each site may be co-located with an aquatic site (focused on changes to aquatic systems over time and how they are interlinked with terrestrial systems)

Taken together, the core sites represent a baseline for ecological conditions that can be compared to one another or to the conditions at the relocatable sites. The relocatable sites are currently located to collect data on the following science themes: agricultural systems, climate change, forest management, invasion biology and urban ecosystems.

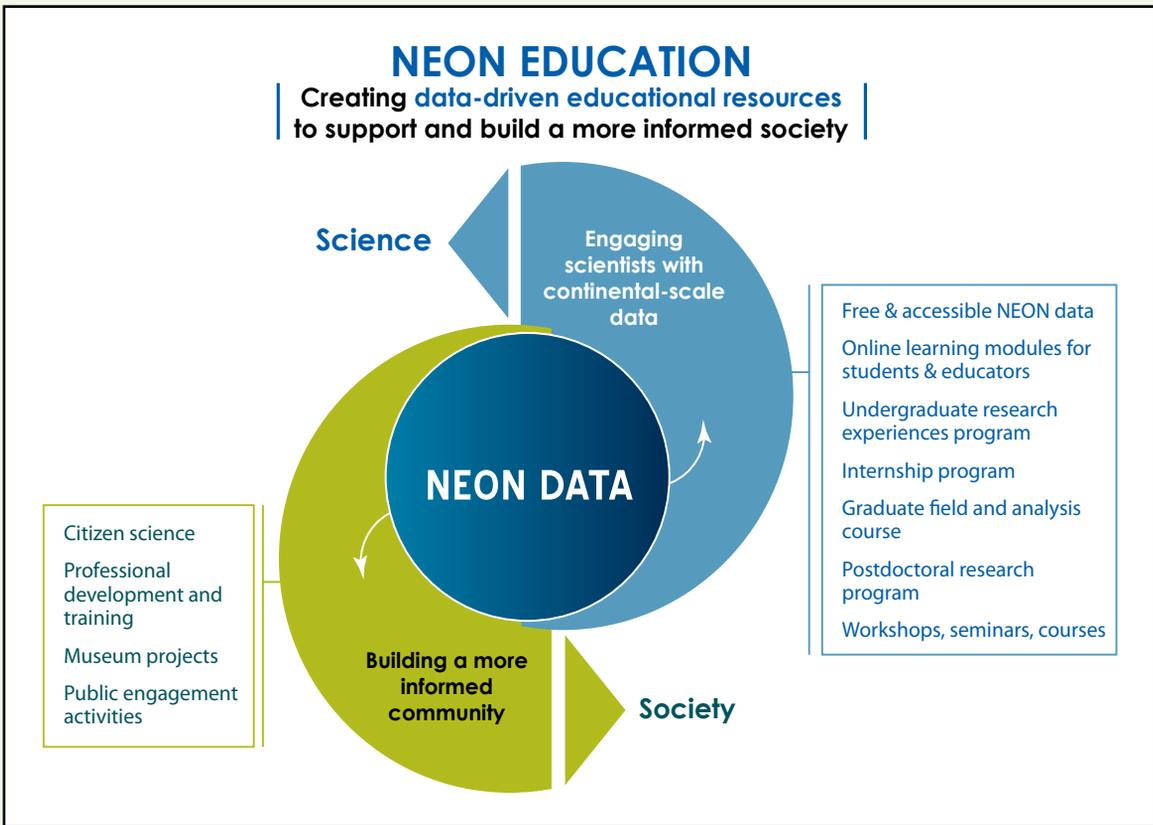
NEON provides an open access approach to its data and information products that will enable scientists, educators, planners, and decision makers to map, understand, and predict some primary effects of humans on the natural world and effectively address critical ecological questions and issues.

# HOW NEON PROCESSES AND PROVIDES RESOURCES



DATA PRODUCTS BY CATEGORY AND GEOGRAPHIC SCALE				
	LOCAL (SITES)	REGIONAL (AOP)	NATIONAL (LUAP)	NATIONAL (DATA + MODELS)
Biomass/Productivity/Metabolism	✓	✓	✓	✓
Soil Structure/Physics	✓	✓	✓	✓
Bioclimate/Energy Balance	✓	✓	✓	✓
Hydrology/Ecohydrology	✓	✓	✓	✓
Habitat/Landscape Structure	✓	✓	✓	✓
Biodiversity/Invasive Species/Biogeography	✓	✓		✓
Population Dynamics/Demography	✓		✓	✓
Land Use Land Cover		✓	✓	✓
Biogeochemistry	✓	✓		
Microbial Diversity/Function	✓			✓
Atmospheric/Air Quality	✓		✓	
Phenology	✓			
Infectious Diseases/Vectors	✓			
Ecological Stoichiometry	✓			

ABOVE : NEON data products include everything from raw site-based measurements, to regional remote sensing data, to modeled outputs scaled over space and time.



ABOVE: NEON's data-driven educational resources support a science-literate society by engaging scientists, students, educators, citizen scientists, and decision makers in exploring continental-scale ecological questions and contributing to new scientific discoveries.

# NEON'S CORE SYSTEMS FOR



## ON-SITE SAMPLING

### Terrestrial Biological Sampling

NEON will quantify the impacts of climate change, land use, and biological invasions on terrestrial ecology by sampling key groups of organisms (sentinel taxa) and soil. The sentinel taxa were selected to include organisms with varying life spans and generation times, and wide geographic distributions to allow for standardized comparisons across the continent.

NEON terrestrial biological measurements will be made on the following:

- Plant biodiversity
- Plant biomass, leaf area, and chemical composition
- Plant phenology
- Birds
- Ground beetles
- Mosquitoes
- Small mammals
- Infectious disease
- Biogeochemistry
- Soil Microbes

### Aquatic Sampling

NEON will observe key physical, biological, and chemical drivers of ecological change, as well as responses to those factors, in freshwater systems. These observations will further our understanding of how aquatic systems are changing and how such changes (e.g., to water balance and nutrient fate) are linked with changes in the terrestrial environment.

Aquatic measurements will be made on the following sentinel taxa and media:

- Algae
- Aquatic macrophytes, bryophytes, and lichens
- Aquatic microbes
- Isotopes
- Aquatic invertebrates and zooplankton
- Fish
- Surface water and groundwater
- Sediment
- Aquatic habitat

### Terrestrial Instrument Measurements

NEON will observe key physical and chemical climate causes of ecological change—as well as ecosystem-level responses to those causes—in terrestrial ecosystems to advance understanding of how the structure and function of these systems are changing. NEON will also measure how these changes are linked to changes in the diversity and function of organisms in both terrestrial and aquatic systems.

Atmospheric measurements include:

- Key climate inputs
- Bioclimate variables
- Chemical climate inputs
- Carbon cycle changes
- Water cycle and surface energy balance

Soil observations include:

- Temperature profiles
- Soil moisture profiles
- Carbon dioxide
- Root growth and phenology

# OBSERVATIONS

## REMOTE SAMPLING



### Airborne Observations

NEON will conduct annual flights over each site, building a robust time series of landscape-scale changes by collecting consistent airborne data. These airborne measurements are collected by an instrumentation package that will provide meter-scale spatial resolution to allow measurements at the level of individual organisms or small groups of organisms. This observation system is designed to measure land use change; vegetation canopy biochemistry, structure, and heterogeneity; and changes in vegetation state and performance, including the presence and effects of invasive vegetative species. The direct measurements from the instrumentation package are spectral radiances, LiDAR returns, and photogrammetric images. These data can be analyzed to produce a set of critical data products:

- Canopy chemistry
- Canopy moisture
- Leaf area
- Canopy and landscape structure
- Canopy height
- Land cover
- Diversity
- Disturbance

## NATIONAL DATA SETS



### Land Use Analysis Package (LUAP)

NEON will combine its data with a series of existing national data sets to provide a suite of observations of both causes of change in ecosystems and responses to change for continental-scale analyses. The data suite includes existing datasets, primarily from relevant federal agencies, on past and current land use practices as well as economic and social data that are useful for prediction of future land use processes. It also includes basic continental-scale data on ecosystem performance derived from satellite remote sensing, and soils and topographical data from national databases.

### Specimens and Samples Collections

A curated collection of organisms, key body parts of organisms, and soils, termed the NEON Collection, will be open to researchers for analysis, both now and in the future as new technologies emerge. Samples and specimens collected during regular annual sampling will be archived at partner facilities to provide a record and reference for future studies of biological change. Digital collections (e.g., photographs of live organisms) will also serve as an archive of sensitive or rare organisms (e.g., fish, lichens/bryophytes) that should not be removed from the sites.

# NEON: A COMMUNITY RESOURCE

DESIGNED TO SUPPORT THE STUDY AND FORECASTING  
OF CONTINENTAL-SCALE ECOLOGICAL CHANGE IN THE U.S.



## THE PLANNED LIFETIME OF NEON

CONCEPT & DESIGN

SITES BUILT OUT

DATA COLLECTION

2004-2011

2012 - 2017

2017 - 2046



NEON has been shaped by thousands of colleagues who helped conceive, design, plan, review, and promote NEON since its inception more than a decade ago. NEON would not exist without the continued contributions of expertise, time and support of the scientific community. NEON is funded by the NSF Major Research Equipment and Facilities Construction (MREFC) Program and managed under cooperative agreement by NEON, Inc.

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