A CONTINENTAL-SCALE STRATEGY FOR SOIL SAMPLING: OPPORTUNITIES FOR A NEON-NRCS PARTNERSHIP

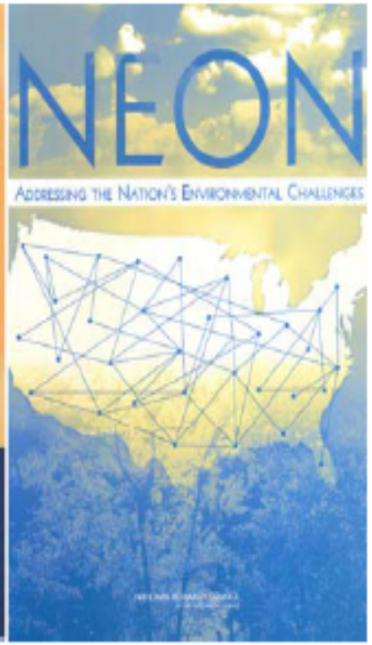
Edward Ayres and Eve-Lyn Hinckley
National Ecological Observatory Network (NEON)

NCSS, 18 June 2013

Grand Challenge areas

1. Biodiversity
2. Biogeochemical cycles
3. Climate change
4. Ecohydrology
5. Infectious disease
6. Invasive species
7. Land use

NRC (National Research Council). 2001. Grand Challenges in Environmental Sciences. Washington DC: National Academies Press.



NRC (National Research Council). 2003. NEON: Addressing the Nation's Environmental Challenges. Washington DC: National Academies Press.

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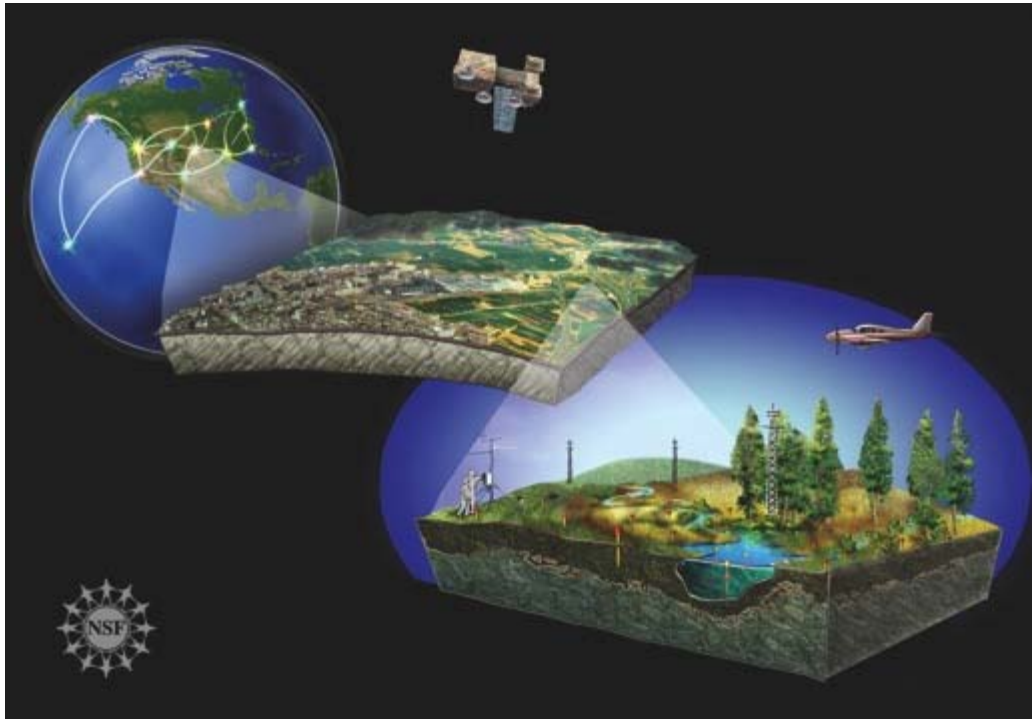
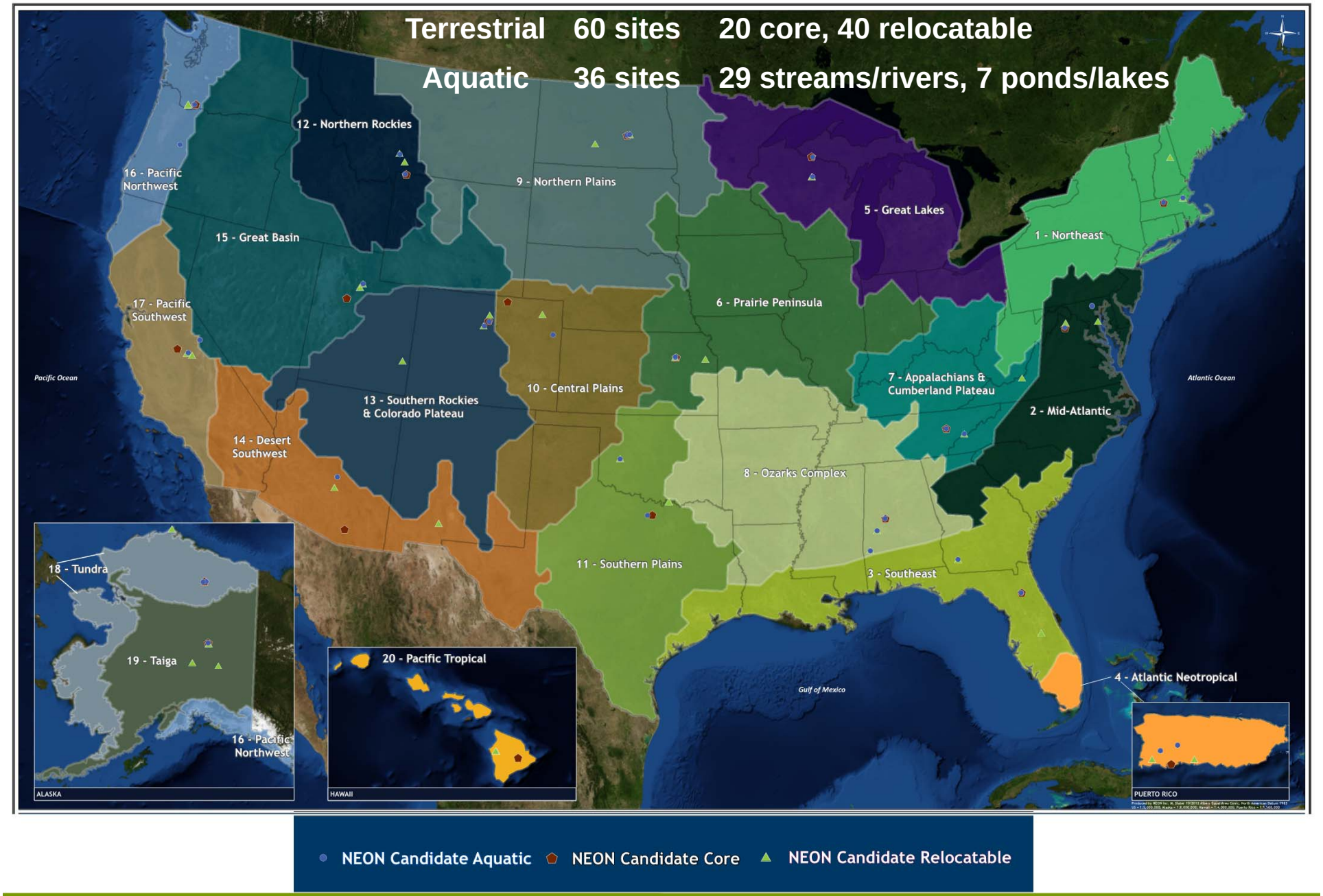
NEON

- NEON is a major NSF research facility comprised of scientists and engineers
- Understand how drivers – climate change, land use/land cover change, and invasive species affect ecological patterns and processes
- Enable study and forecasting of long-term ecological trends at multiple scales



- Create a spatially-extensive, integrated dataset with standard methodology across all sites
- Provide data and physical infrastructure to the public
  - Construction complete: 2017
  - Web provisional data: 2014


Terrestrial 60 sites 20 core, 40 relocatable
Aquatic 36 sites 29 streams/rivers, 7 ponds/lakes
12 - Northern Rockies
16 - Pacific Northwest
9 - Northern Plains
5 - Great Lakes
1 - Northeast
15 - Great Basin
17 - Pacific Southwest
6 - Prairie Peninsula
Pacific Ocean
Atlantic Ocean
7 - Appalachians & Cumberland Plateau
10 - Central Plains
13 - Southern Rockies & Colorado Plateau
2 - Mid-Atlantic
14 - Desert Southwest
8 - Ozarks Complex
18 - Tundra
11 - Southern Plains
3 - Southeast
19 - Taiga
20 - Pacific Tropical
Gulf of Mexico
4 - Atlantic Neotropical
16 - Pacific Northwest
ALASKA
HAWAII
PUERTO RICO
NEON Candidate Aquatic
NEON Candidate Core
NEON Candidate Relocatable

NEON site design

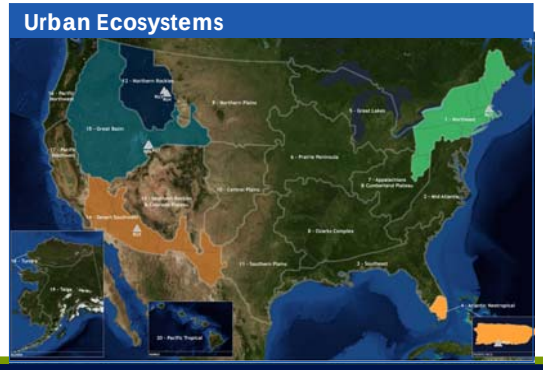
Agriculture Systems

Climate Change or Atmospheric Transport

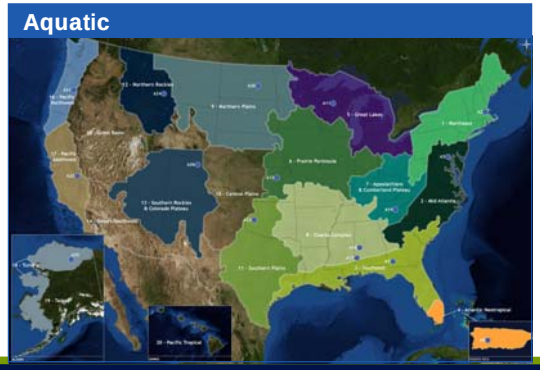
Forest Management

Invasion Biology

Urban Ecosystems



Aquatic



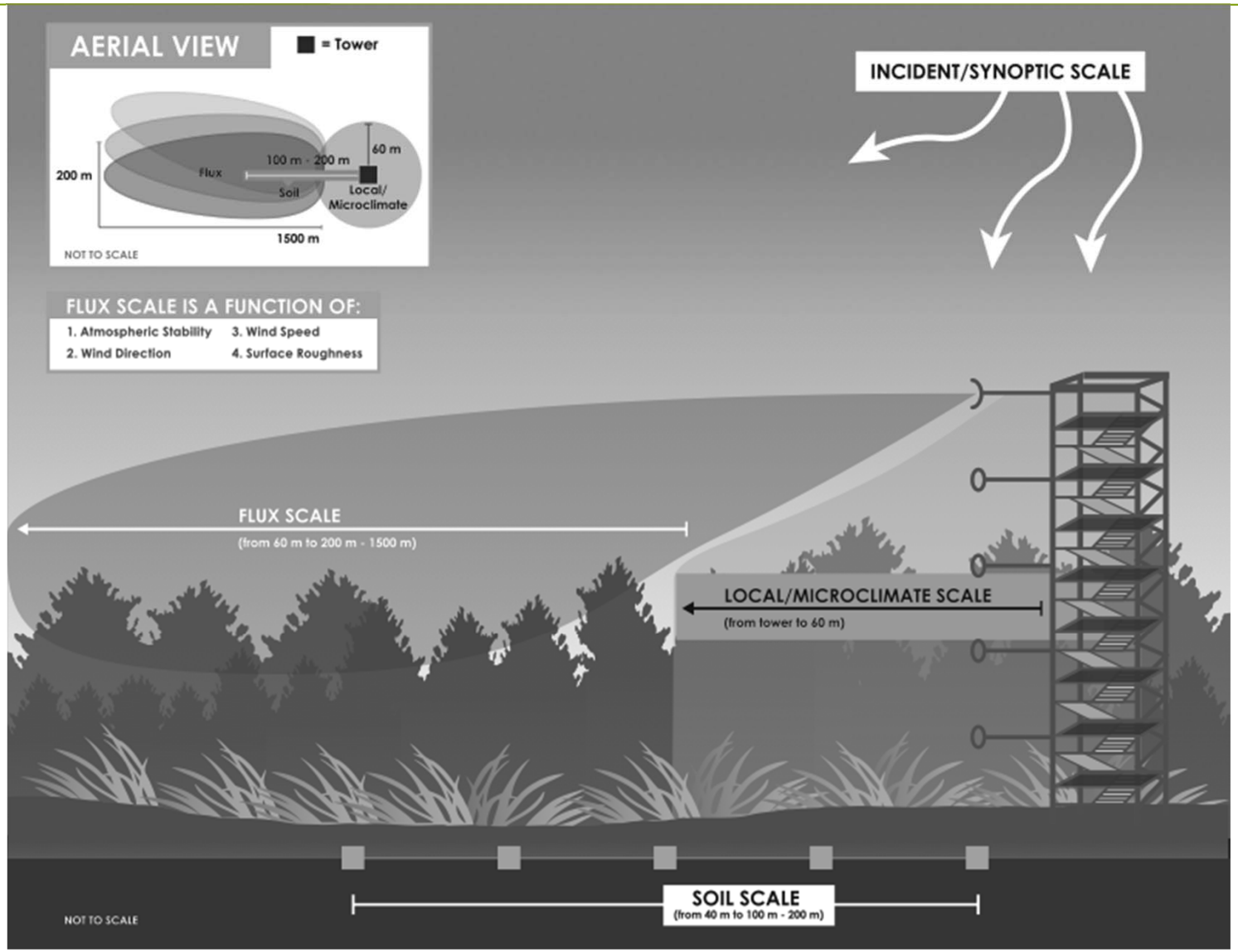
NEON Science Sub systems (alphabet soup)

FSU	Fundamental Sentinel Unit	Human Obs. Bioarchive
FIU	Fundamental Instrument Unit	Automated Instrumentation
AOP	Airborne Observation Package	Aircraft Remote Sensing
AQU	Aquatic/STREON	Human Obs/automated instrumentation
LUAP	Land Use Analysis Package	Satellite Remote Sensing +

Fundamental Sentinel Unit

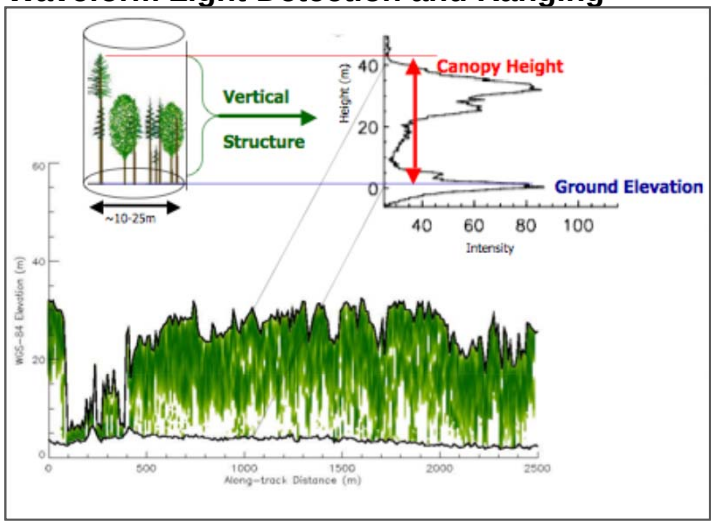
- Biodiversity
- Population Dynamics
- Productivity
- Phenology
- Infectious Disease
- Biogeochemistry
- Microbial Diversity and Function
- Ecohydrology

Fundamental Instrument Unit



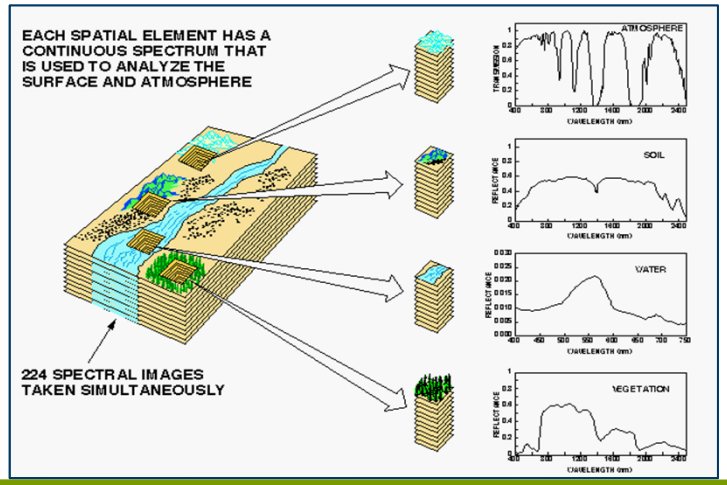
Airborne Observing Platform

Waveform Light Detection and Ranging



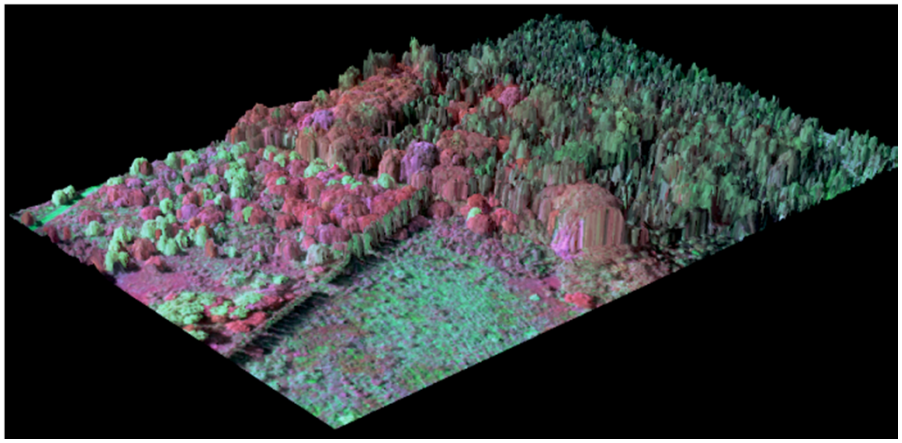
+

High-fidelity Imaging Spectroscopy



What are we after?

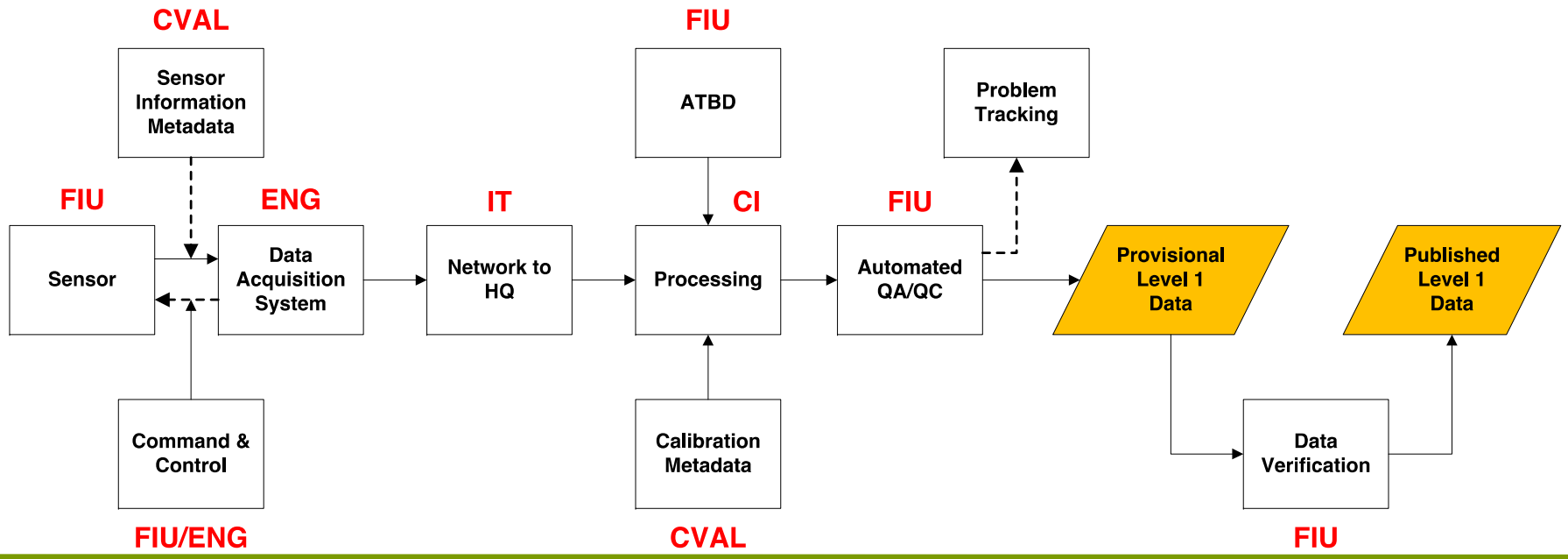
- Detailed chemical, structural and taxonomic information on ecosystems at fine spatial resolution



- Bridge the scales from organisms (i.e., trees or shrubs) as captured by plot sampling, to stand, to the scale of satellite

Data Flow

- **Integrated the Data Flow Designs**
  - Command, Control, and Configuration (C^3) documentation
  - Advanced QA/QC approaches
    - Plausibility tests which will be used for Site Acceptance Testing
  - Algorithm Theoretical Basis Documents, L0 to L1 DPs
  - Data Verification Algorithms



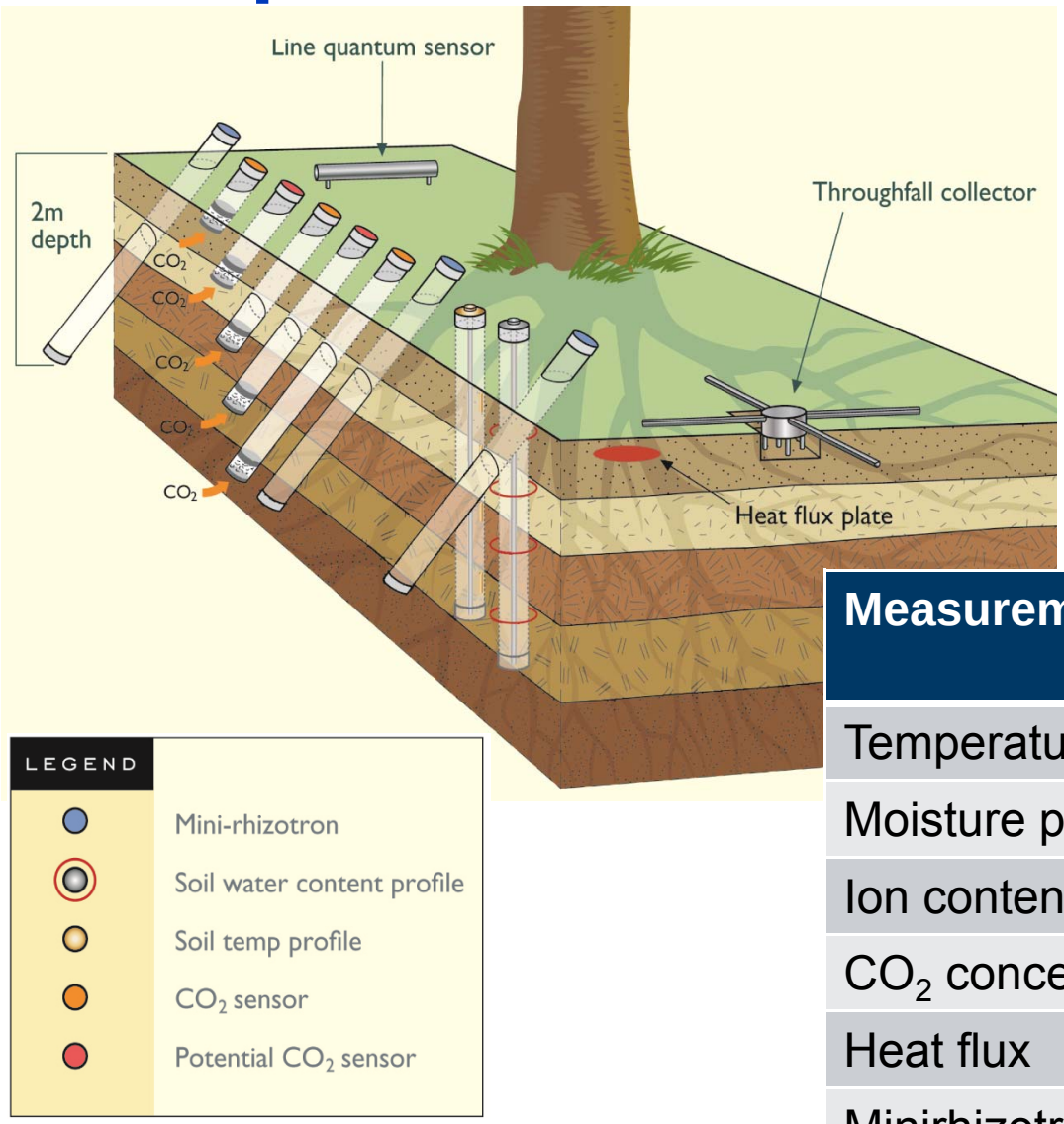
TOWER-BASED SOIL MEASUREMENTS

Edward Ayres | National Ecological Observatory Network (NEON)

Sensor-based soil array layout

- 5 soil plots per site
  - 5 x 5 m each
- In locally dominant soil type
- In tower airshed
- Line power and communication (within ~250 m of tower)
- 1 soil pit

Soil plot measurements

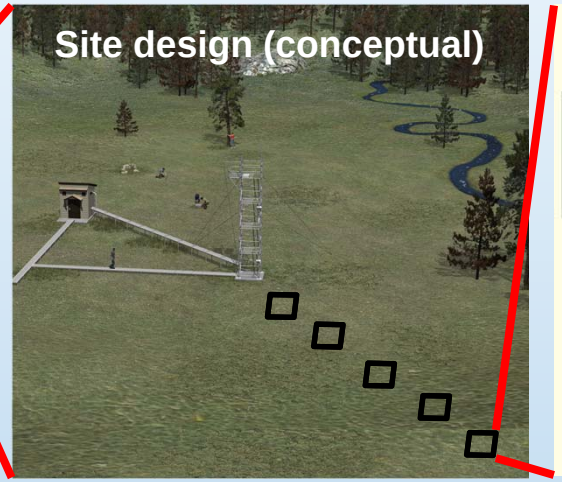


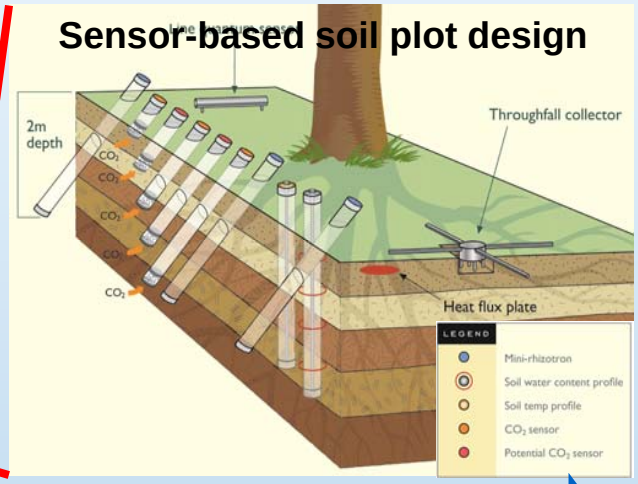
- Sensor depths by soil horizon
  - Up to 2 m at most sites
  - Up to 3 m at permafrost sites

Measurement	Number of sensors
Temperature profile	7-9
Moisture profile	8
Ion content (salinity) profile	8
CO_2 concentration profile	≥3
Heat flux	1
Minirhizotron	2-3

Representativeness - approach

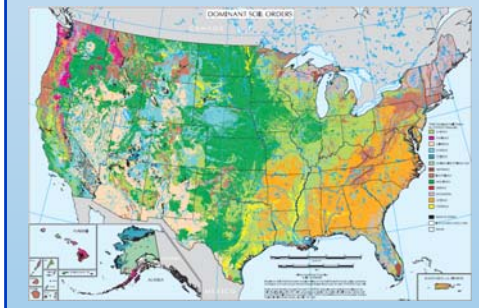
Soil measurements must be representative a many spatial scales

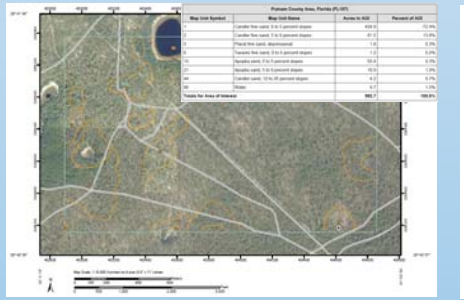


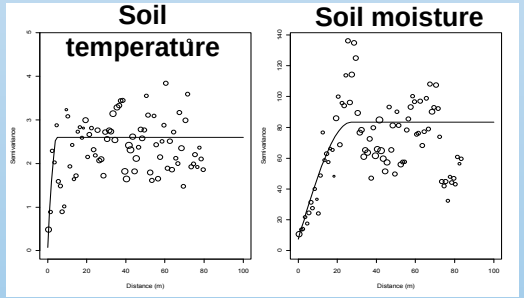


Spatial scale

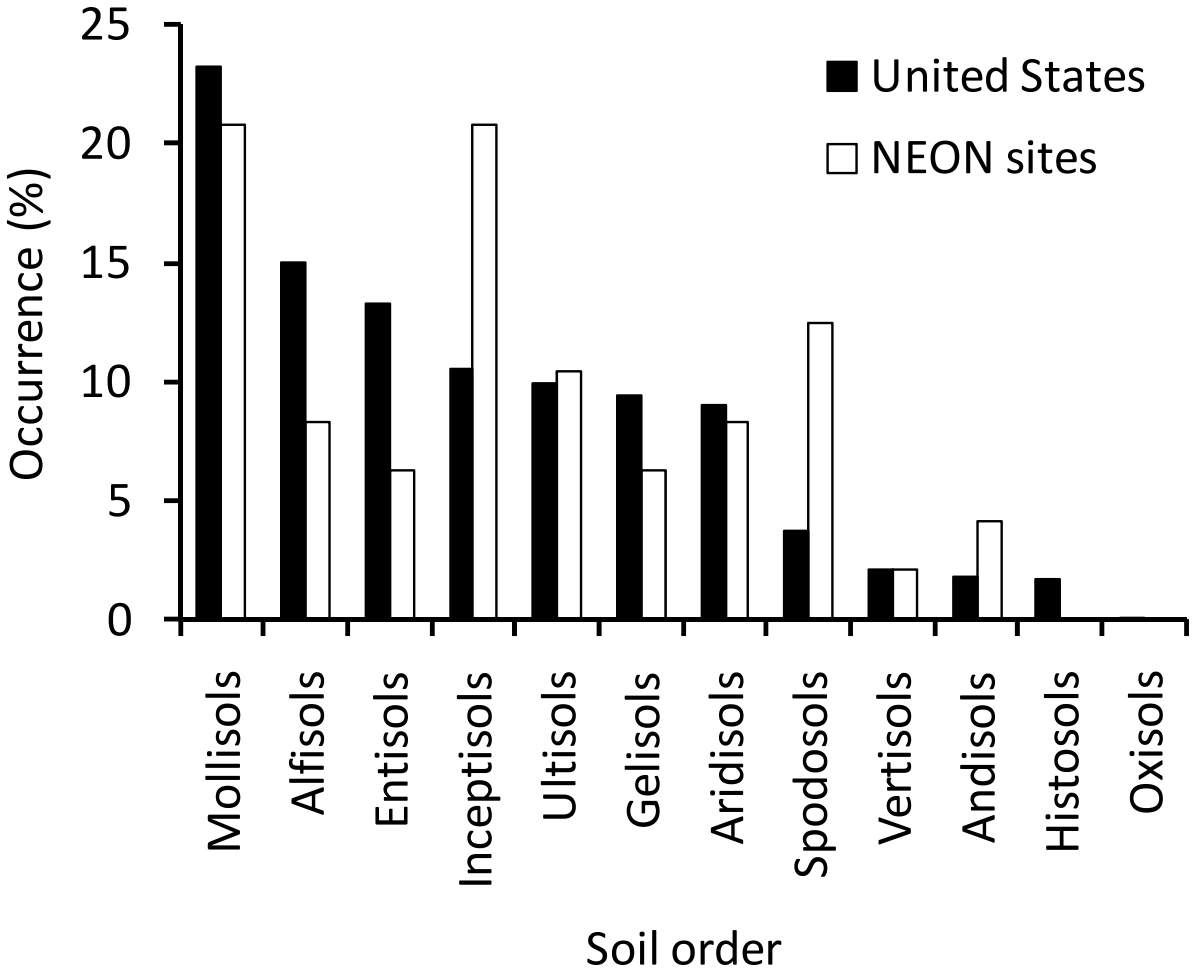
1000s km | 100s m | meters







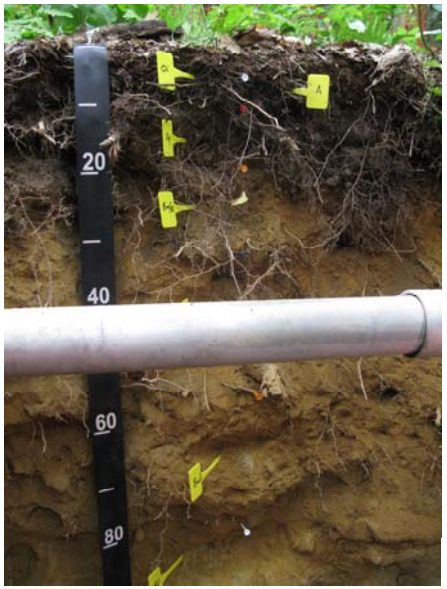
Representativeness - results



- **Continental scale**
  - Every major US soil order is represented
- **Site scale**
  - Soil measurements will be ≥90% spatially independent at 77% of sites

Soil pit – characterization

- 1 pit per site (dug prior to sensor deployment)
- 2 m deep
- Same soil type as soil plots, but outside tower airshed
- Sampled by horizon to determine:
  - Horizon depths
  - Physical & biogeochemical properties
    - Texture, bulk density, pH, total C, N, P, K, etc



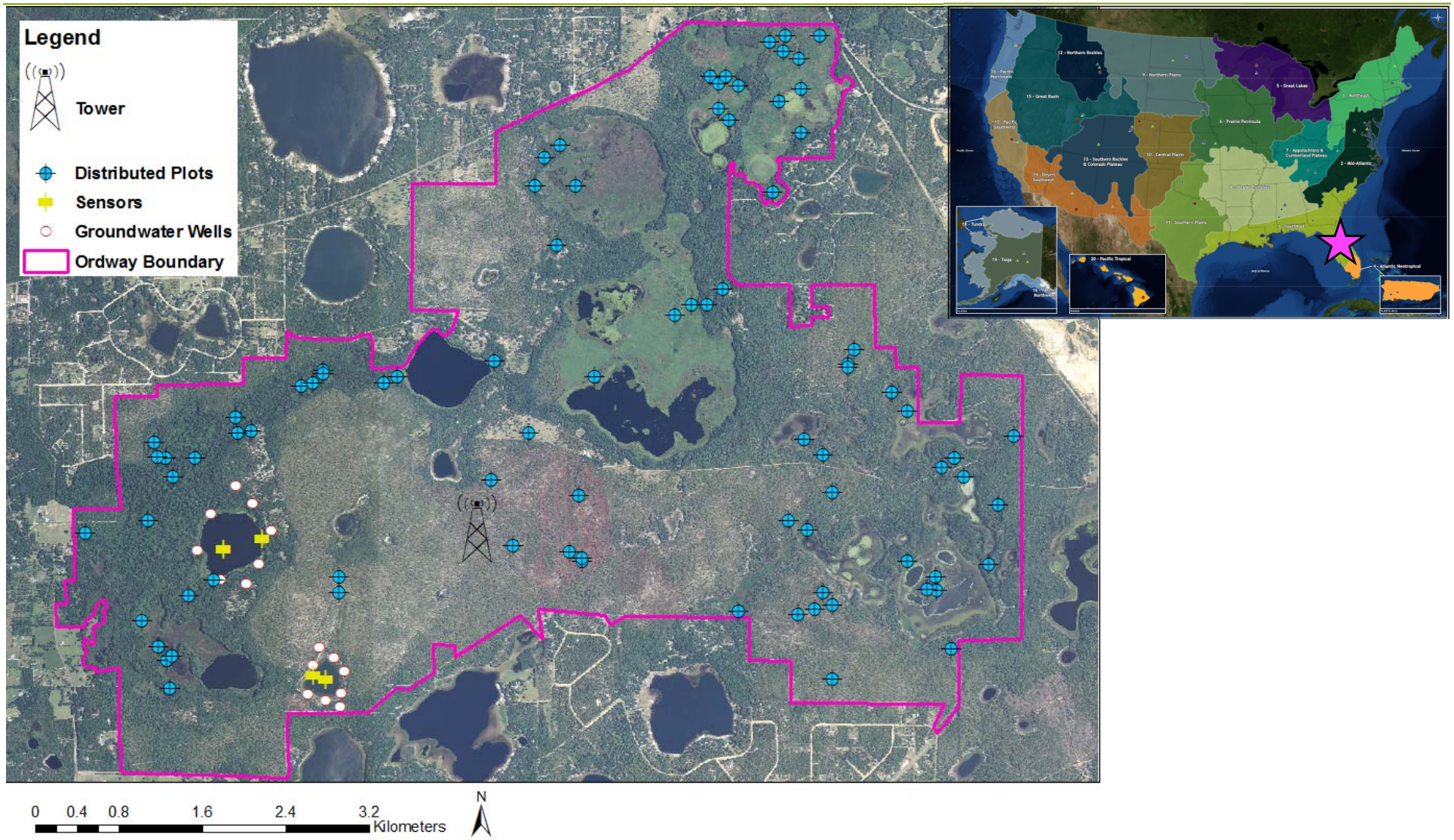
Soil pit - archiving

- Air-dried and sieved (2 mm)
- 1.2 kg soil per horizon
  - 4x 300g subsamples
- Available to researchers

DISTRIBUTED SOIL MEASUREMENTS

Eve-Lyn Hinckley | National Ecological Observatory Network (NEON)

Example of instrumented site: Ordway-Swisher, FLA



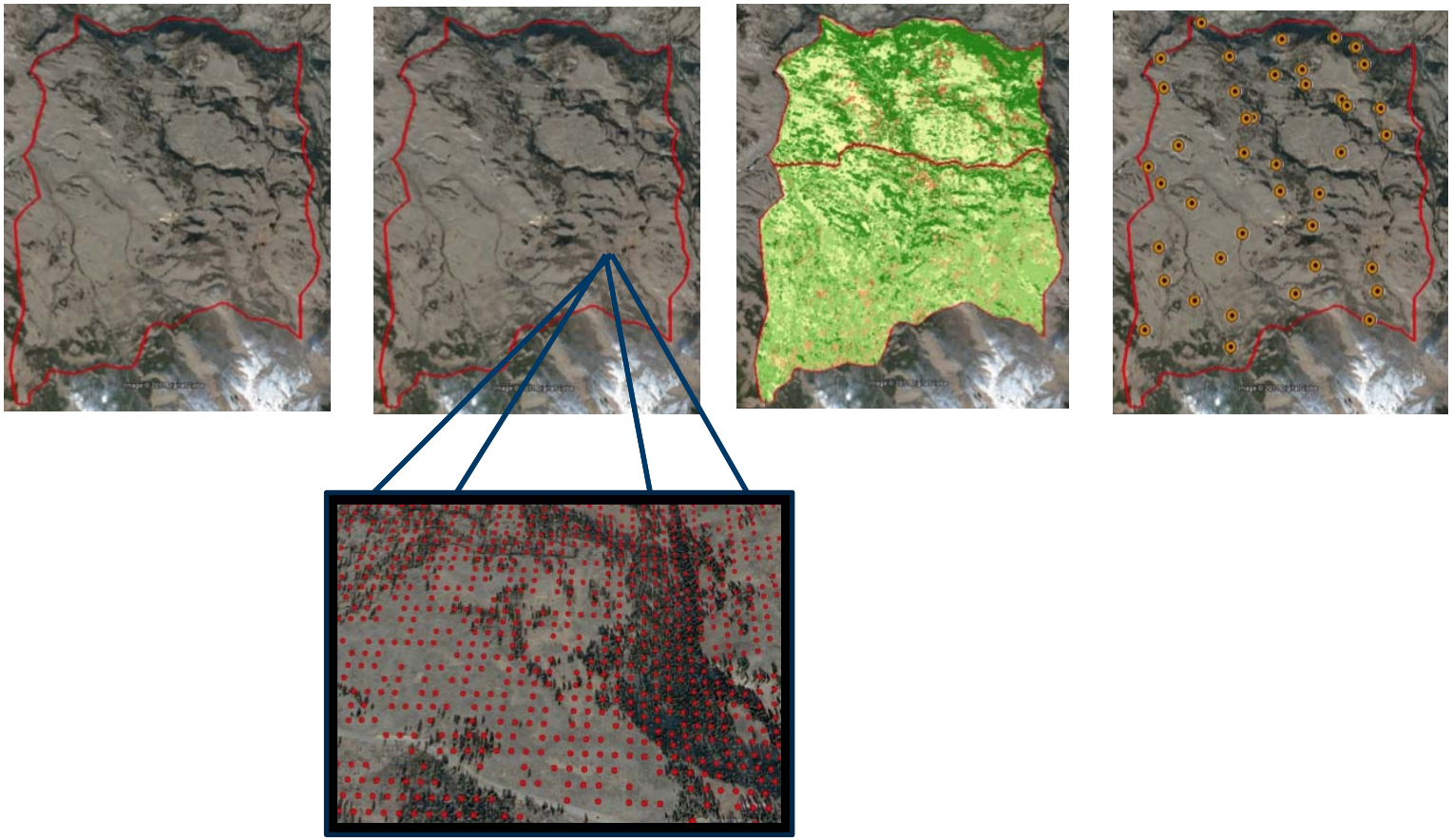
Reversed Random Quadrat-Recursive Raster (RRQRR)

Site Boundary

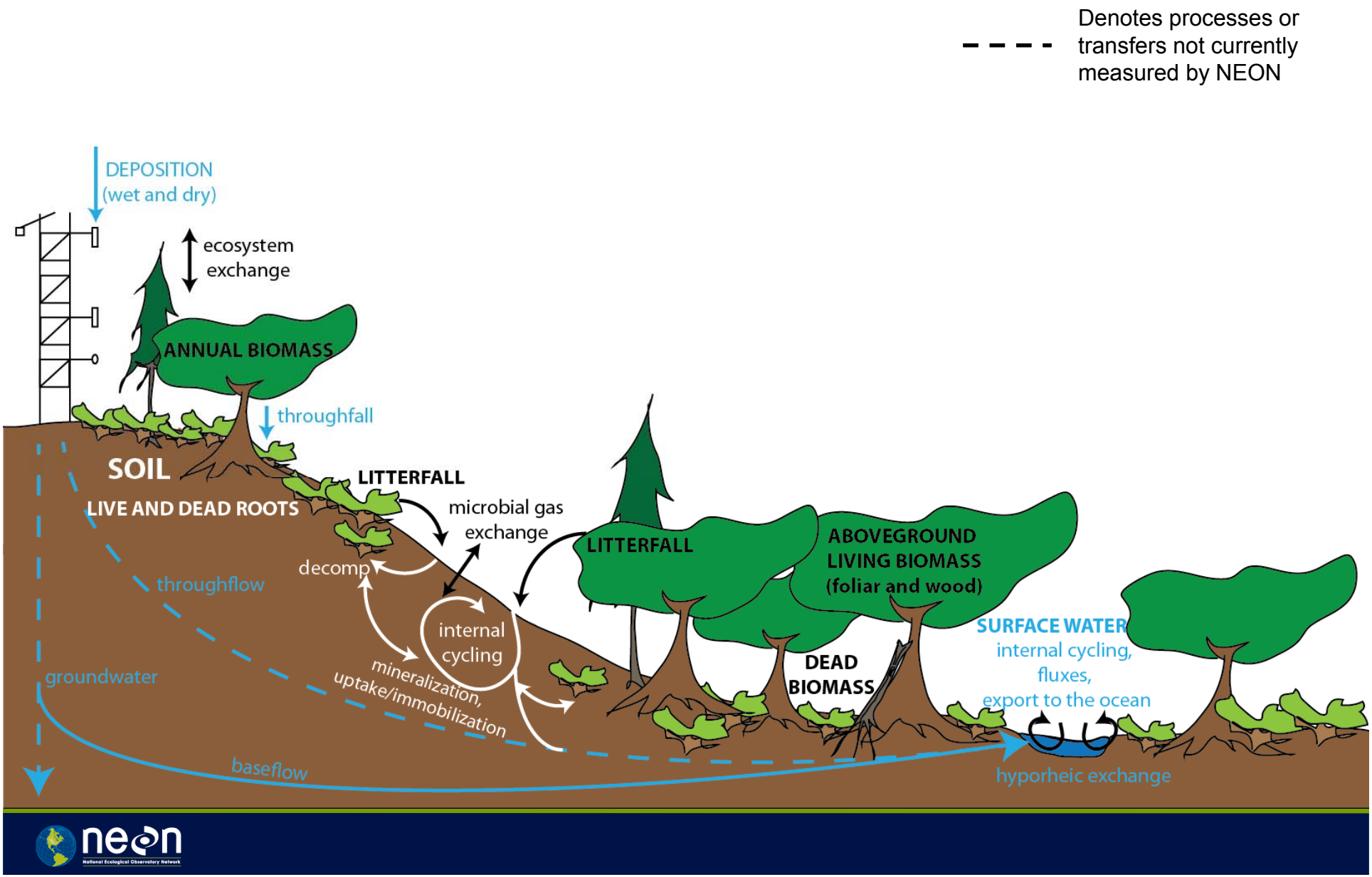
Spatial Balanced and Random Grid

Stratified by Vegetation Type

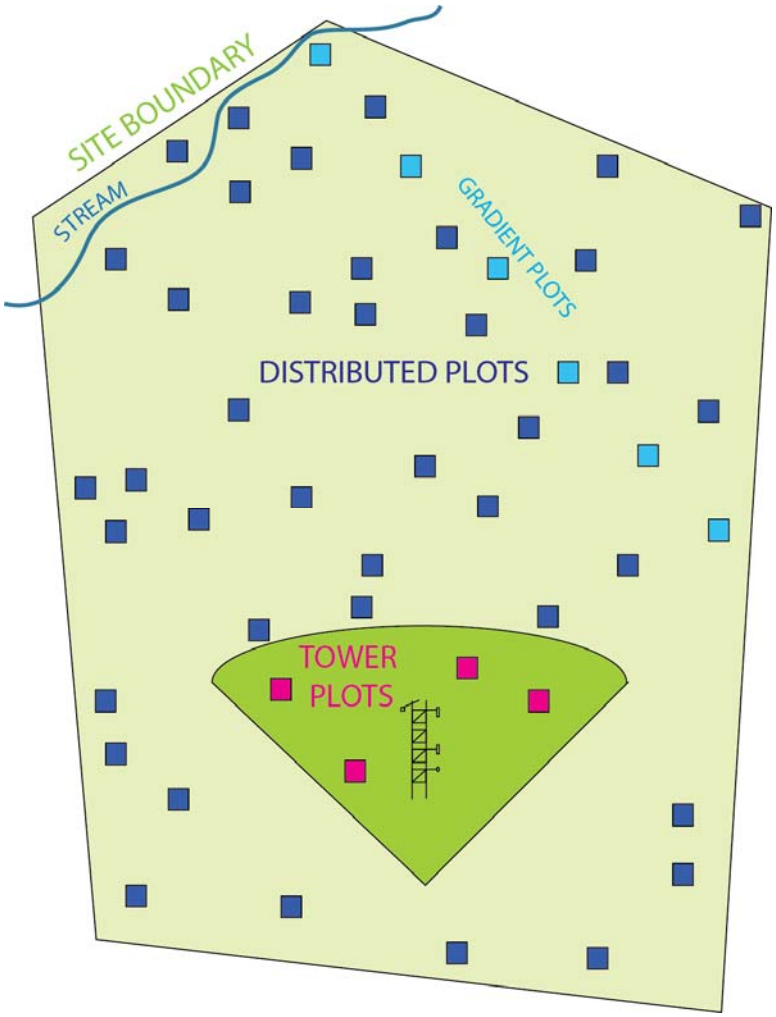
Study Locations



Pools, processes, and transfers measured (and not measured) by NEON



Proposed Sampling Design

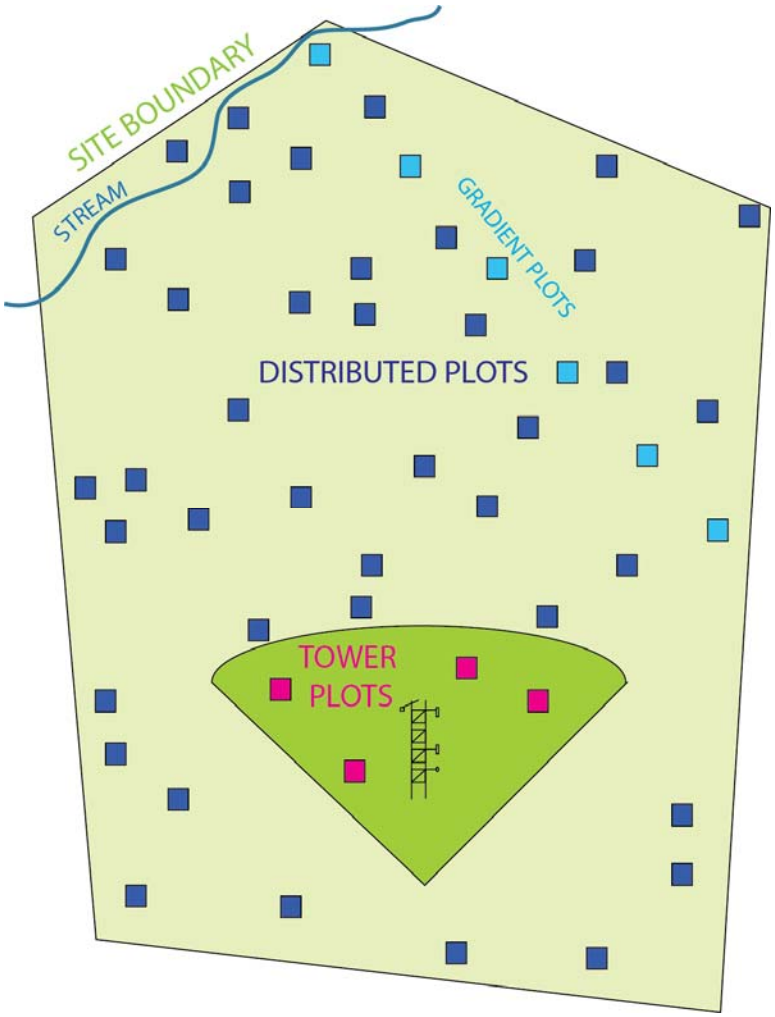


TOWER PLOTS:
Spatially-limited, intensive sampling

DISTRIBUTED PLOTS:
Spatially-extensive, infrequent sampling

GRADIENT PLOTS:
Sampling along topographical gradients

Proposed Sampling Design

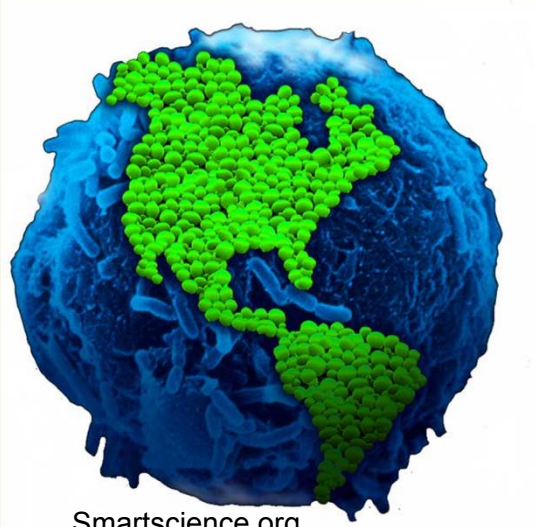


TOWER:
Trace gas fluxes (bimonthly)
Process rates (bimonthly)
Microbial community and function (monthly)

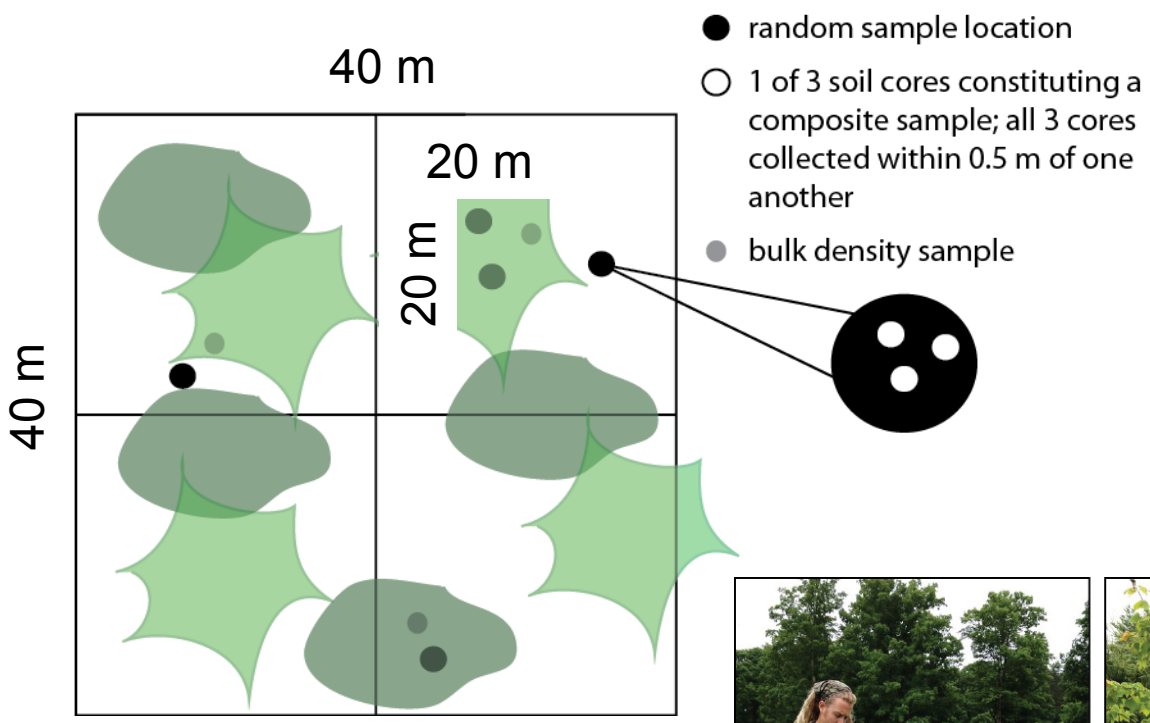
DISTRIBUTED:
Trace gas fluxes (annual)
Process rates (annual)
C and nutrient stocks (every 5 y)
Continuous soil temp and vwc

GRADIENT:
Soil water (bimonthly, as available)
Resin bags

Microbial Sampling

Microbial Assemblage	How assemblage changes	How we measure changes in the assemblage
 Smartscience.org	Community composition changes	**Microbial Diversity (16S and ITS; annually)**
	Changes in genes within the community (evolve, transfer)	**Soil Metagenomics (shotgun sequencing; 3-5 y)**
	Changes in functional roles within the community	**Soil mRNA Seq (shotgun sequencing; 3X y^{-1})**
	Changes in abundance of community members	**Biomass (qPCR or PLFA; 3X y^{-1})**

Co-located sampling



PLOT-SCALE:

- Diversity and abundance
- Structure
- Chemistry

SITE-SCALE:

- Gradient to calibrate AOP
- Site-scale value

Photos by C. Meier

THE NRCS-NEON PARTNERSHIP

What NRCS brings, what NEON brings

NRCS: Soils and stakeholders

NRCS Land Resource Regions

NEON: Ecology and infrastructure

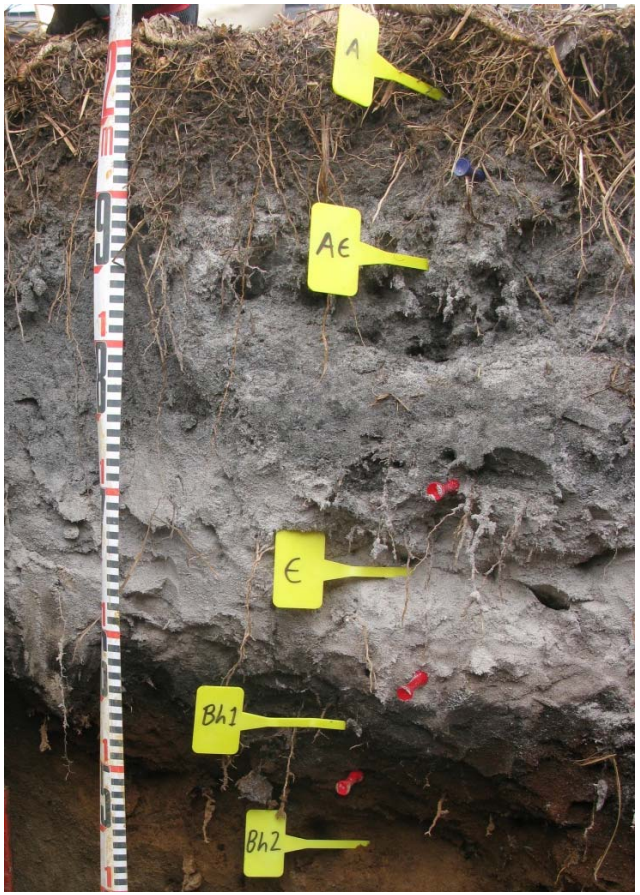
NEON Domains

Opportunities to strengthen both groups through interaction between staff scientists, sharing of tools and approaches, collaborative research.

NRCS role in NEON soil pit characterization

Soil profile description

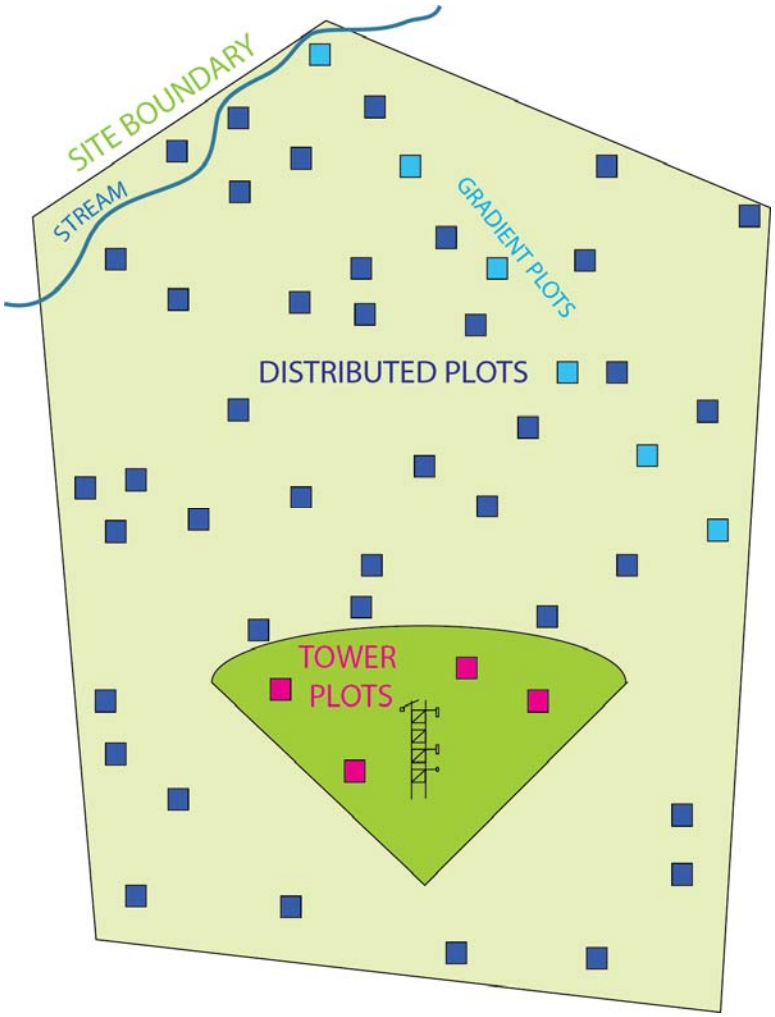
- NRCS Soil Scientist performs description
- Description guides NEON sampling, done by horizon to 2 m
- Opportunities for NRCS
  - Contributes to mapping
  - Potential type specimen



Soil analyses – NRCS Soil Survey Lab

- Includes:
  - bulk density,
  - pH,
  - electrical conductivity,
  - texture,
  - total C, N, S, Al, Ca, Fe, K, Mg, Mn, Na, P, Si, Sr, Ti, & Zr

Site Characterization: Soils



One-time effort at each NEON site

NRCS soil scientist and NEON personnel

Key physical, chemical, morphological properties necessary to interpret/relate other data.

NEON Resources available to community

Taskable assets:

- Mobile deployment platform
- Remote sensing aircraft

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Archives:

- Soils, plants, beetles, mosquitos, ticks

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Data, algorithms, and Q/QC

- Uncertainty reported with each value
- Metadata, including measurement and processing information

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New technology and methods

- Sensor assembly designs
- Sampling strategies

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Research opportunities at NEON sites
- NEON provides data and infrastructure
- NRCS scientists interest: Surface water flows at 3 NEON sites with contrasting hydrology

National Ecological Observatory Network

The National Ecological Observatory Network is a project sponsored by the National Science Foundation and managed under cooperative agreement by NEON Inc.

Contact information

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