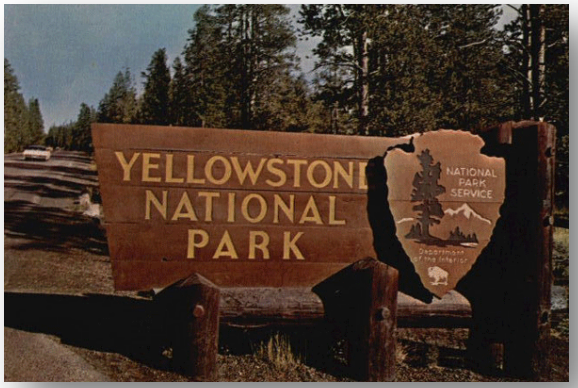


NEON NATIONAL ECOLOGICAL OBSERVATORY NETWORK

Domain 12 Core Site – Yellowstone National Park

September 23rd, 2014

National Ecological Observatory Network

… to *enable understanding* and *forecasting* of the *impacts* of ***climate change***, ***land use change*** and ***invasive species*** on *continental-scale* ***ecology*** by providing infrastructure to support research, education and environmental management in these areas.

CAUSES OF CHANGE

Climate Change: Understanding and predicting climate variability, including directional climate change and its impacts on natural and human systems

Land Use: Understanding and predicting changes in land use and land cover that are critical to biogeochemical cycling, ecosystem functioning and services, and human welfare.

Invasive Species: Understanding and forecasting the distribution of biological invasions and their impacts on ecological processes and ecosystem services.

Interactions and Feedbacks

RESPONSES TO CHANGE

Biogeochemistry: Understanding and predicting the impacts of human activities on the Earth's major biogeochemical cycles.

Biodiversity: Understanding the regulation of biological diversity and its functional consequences for ecosystems.

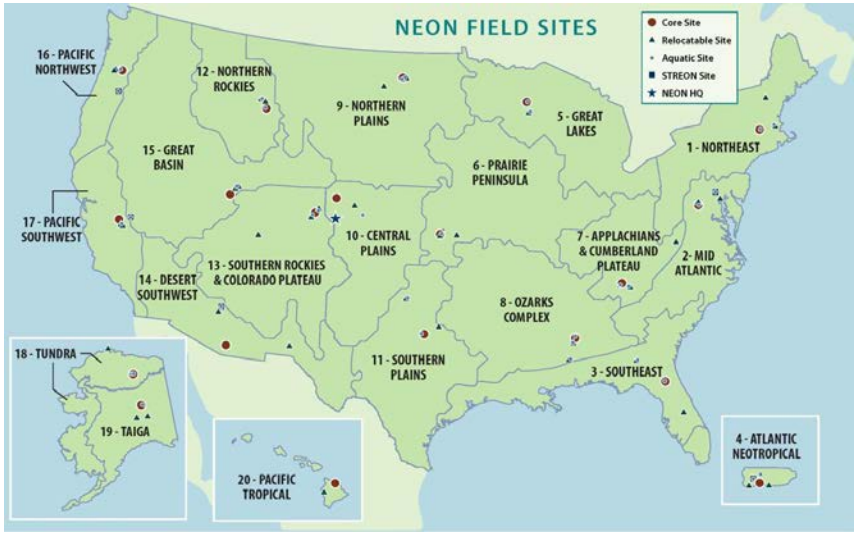
Ecohydrology: Understanding and predicting changes in freshwater resources and the environment.

Infectious Diseases: Understanding and predicting the ecological and evolutionary aspects of infectious diseases and of the interactions among pathogens, hosts/receptors, and ecosystems.

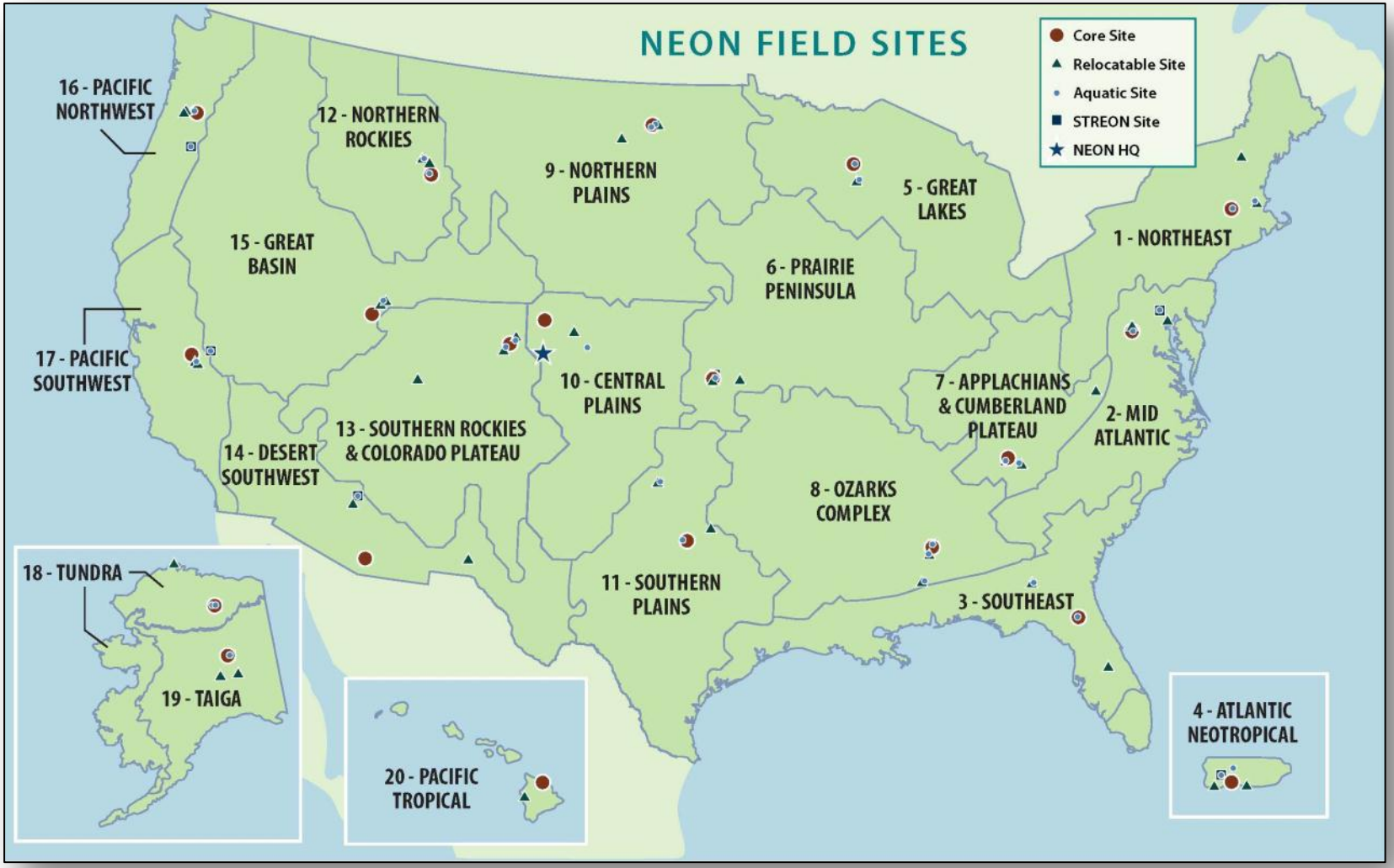
NEON Project

- NEON partitioned the U.S. into 20 eco-climatic domains

- NEON will collect site-based data about climate and atmosphere, soils, streams and lakes, and a variety of organisms



Domain Map



NEON Project - Continued

- Core sites are slated to operate for the 30-year lifetime of NEON (e.g. D12- Yellowstone)

- Relocatable sites are related to land use, invasive species, urban effects to operate for approximately 10 years (Bozeman, Paradise Valley).

- Aquatic sites including passive monitoring systems (Blacktail Deer Creek, Bozeman Creek).

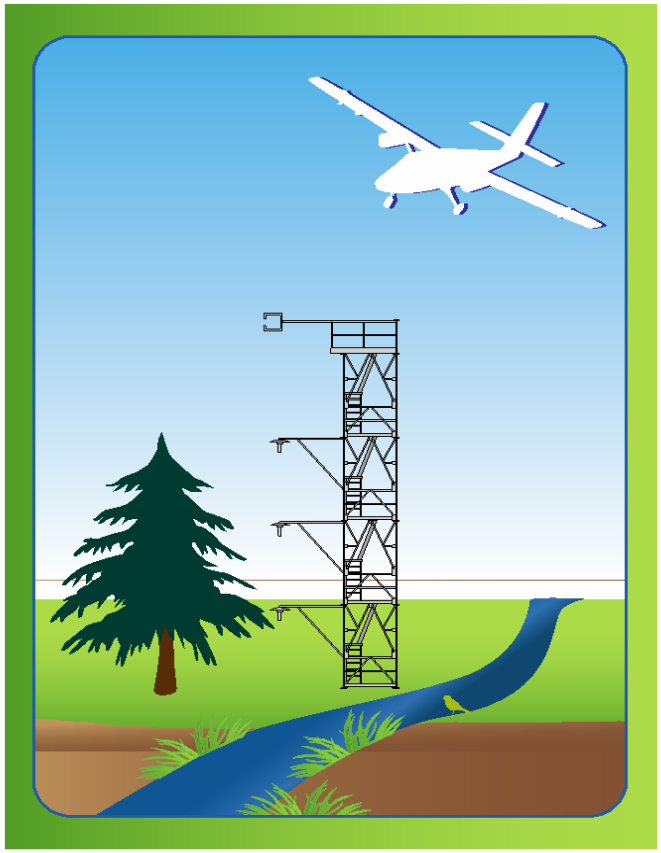
NEON is a *Facility*

- An Observatory
- A User Facility
- A Community Asset

An Integrated Observing System

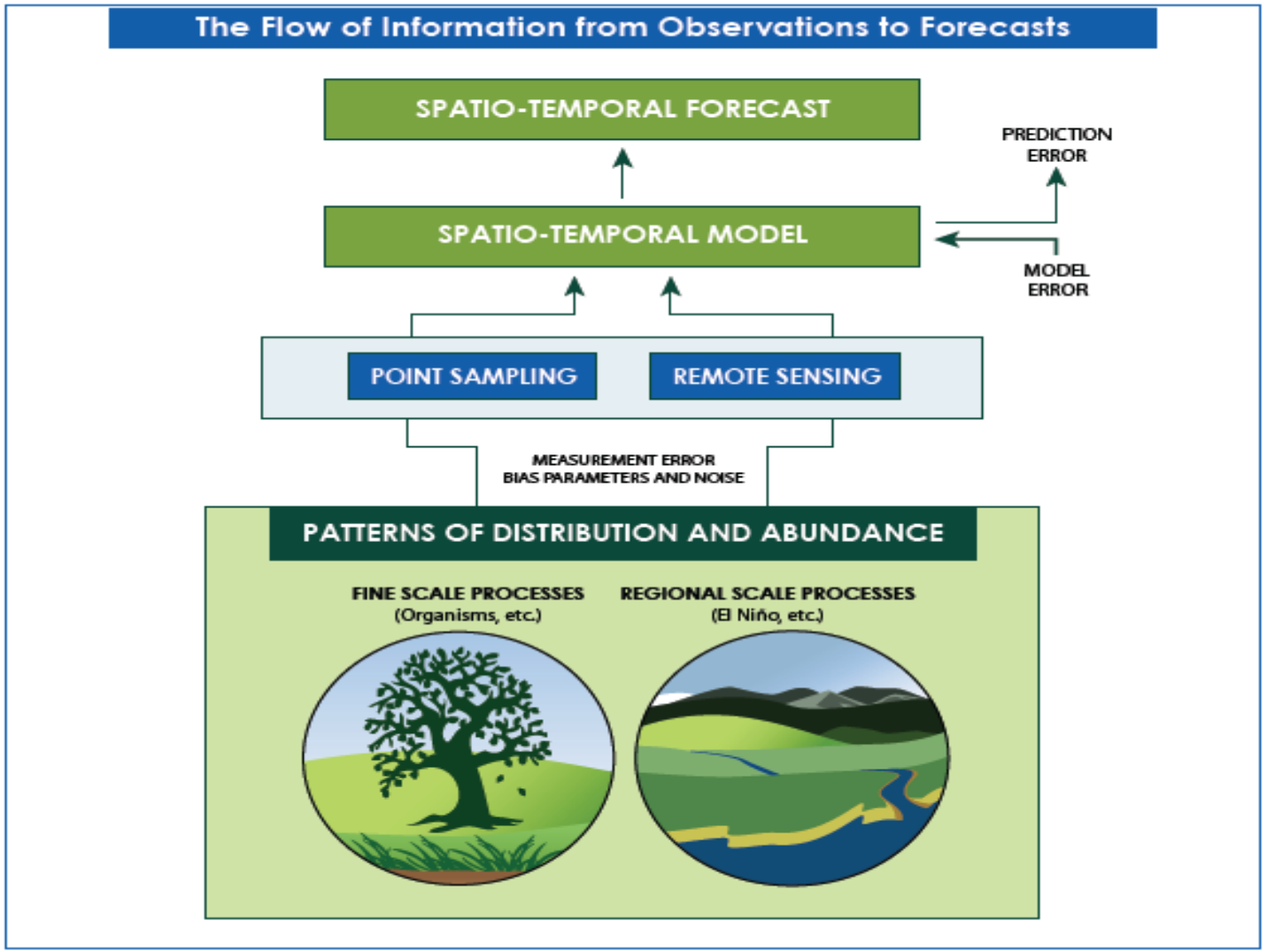
30 year period of observation

Observing Ecological Change



- Representative sampling
- Replication of gradients
- Detecting/attributing change over decades
- Comprehensive set biological observations
- Sentinel taxa -- terrestrial and aquatic
- Field and lab analyses state-of-the-art
- Standardized and transparent protocols
- QA/QC -- data quality and uncertainty

Spatial Scaling & Ecological Forecasting



NEON Data Access Policy

NEON WILL PROVIDE FREE AND OPEN ACCESS TO:

- All data*
- All metadata*
- All QA/QC information (process and data)
- Protocols and procedures used to collect data
- Instrument specifications, characteristics and performance
- Algorithms used to process data
- For PI users of NEON assignable facilities
    - Must comply with the above
    - *Proprietary period up to 18 months to validate and prepare data*

***Unless protected by the Endangered Species Act or other legislation**

What are the NEON Assignable Assets (AAs)?

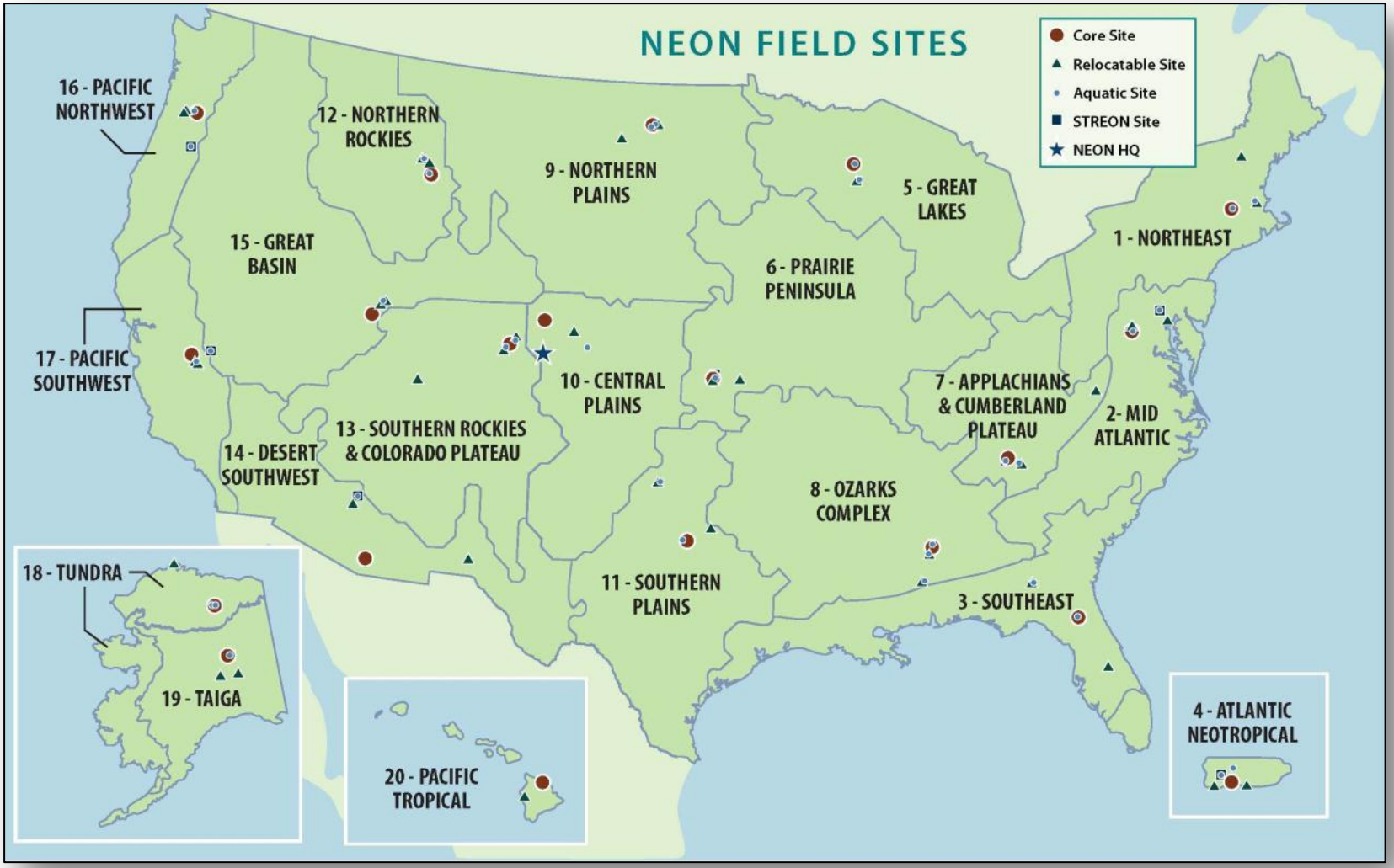
Requestable assets:

- PI-initiated deployments of one of the three Airborne Observation Plaforms (AOP)
- PI-initiated deployments of one or more of the Mobile Deployment Platforms (MDPs)
- Placement of additional sensors or instruments on NEON infrastructure (tower, aquatic platform)
- Access to archived samples and specimens

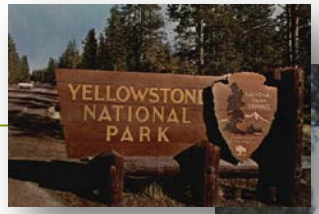
MDP Characteristics

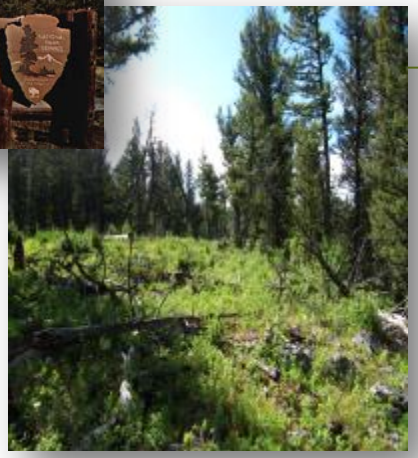
- PI requestable
- Mobile and rapidly deployable
- Modular design to meet varied research needs
- Campaign based measurements up to ~ 1 year
- MDP will include various modules which can be mixed to meet needs of research. Potential modules include:
  - Micrometeorology
  - Atmospheric chemistry
  - Ecohydrology & Soils
  - Organismal ecology
  - Education and outreach

Domain Map



Why Yellowstone?





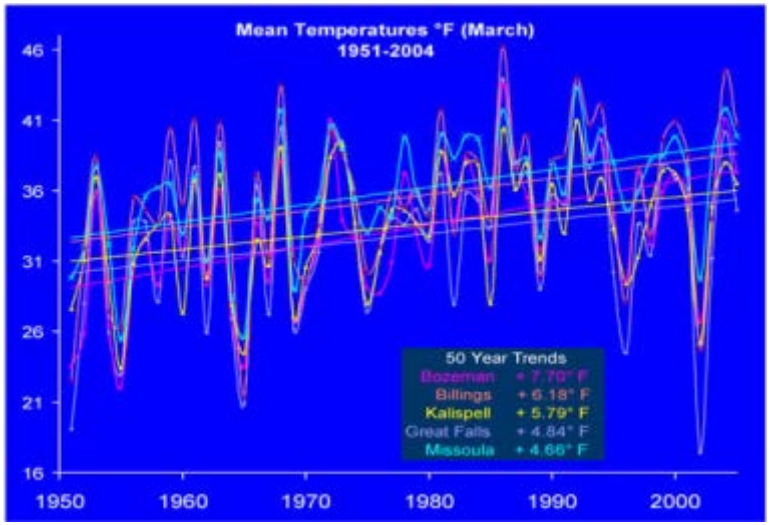
- **True wildland site**
  - GYE = largest intact wildland ecosystem in the lower 48
  - A critical ecological baseline
- **Sensitive to climate change – past & future**
  - Warmer, drier summers, warmer winters, earlier snow melt
  - Change in community composition, disturbance regimes and hydrology
- **GYE – YNP plus surrounding public & private lands**
  - Opportunity to assess impacts of population growth and land use change
  - Interaction with climate change

- **Representative of the Northern Rocky Mountain region**
  - Cold, dry continental climate
  - Vegetation patterns – valley grasslands, riparian woodlands, montane confer forests, and high-elevation alpine
- **Long history of research on the site – long term data set**
  - Climate, fire and ecological resources
  - NPP, population dynamics, community interactions
  - Invasive species and disease

Climate Change in this Region (IPCC)

- Reduced water availability
- Species at risk for extinction
- Increased risks for wildfire
- A change in disease vectors
- Heat waves, floods, and droughts
- Possible increase in cereal productivity
- Increased damage from floods and storms
- Decreased snowpack, more winter flooding, and reduced summer flows
- Pest, diseases, and fire impacts on forests

Montana's Changing Climate



Invasive species, changing the biological landscape

Canada thistle
Cirsium arvense

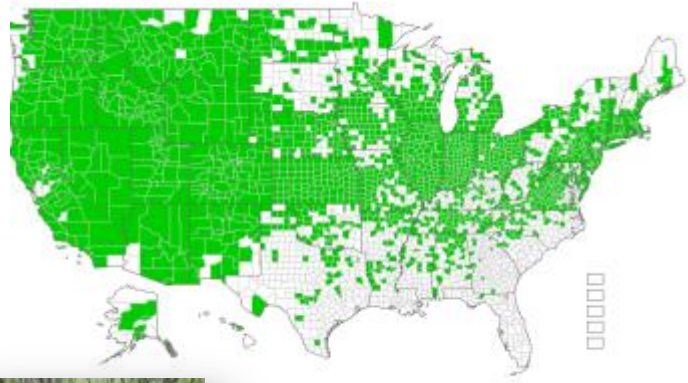
Dalmation toadflax
Linaria dalmatica

Ox-eye daisy
Leucanthemum vulgare

Leafy spurge
Euphorbia esula

Spotted knapweed
Centaurea maculosa

Houndstongue
Cynoglossum officinale



Cheatgrass
Bromus tectorum

Potential Benefits to Yellowstone

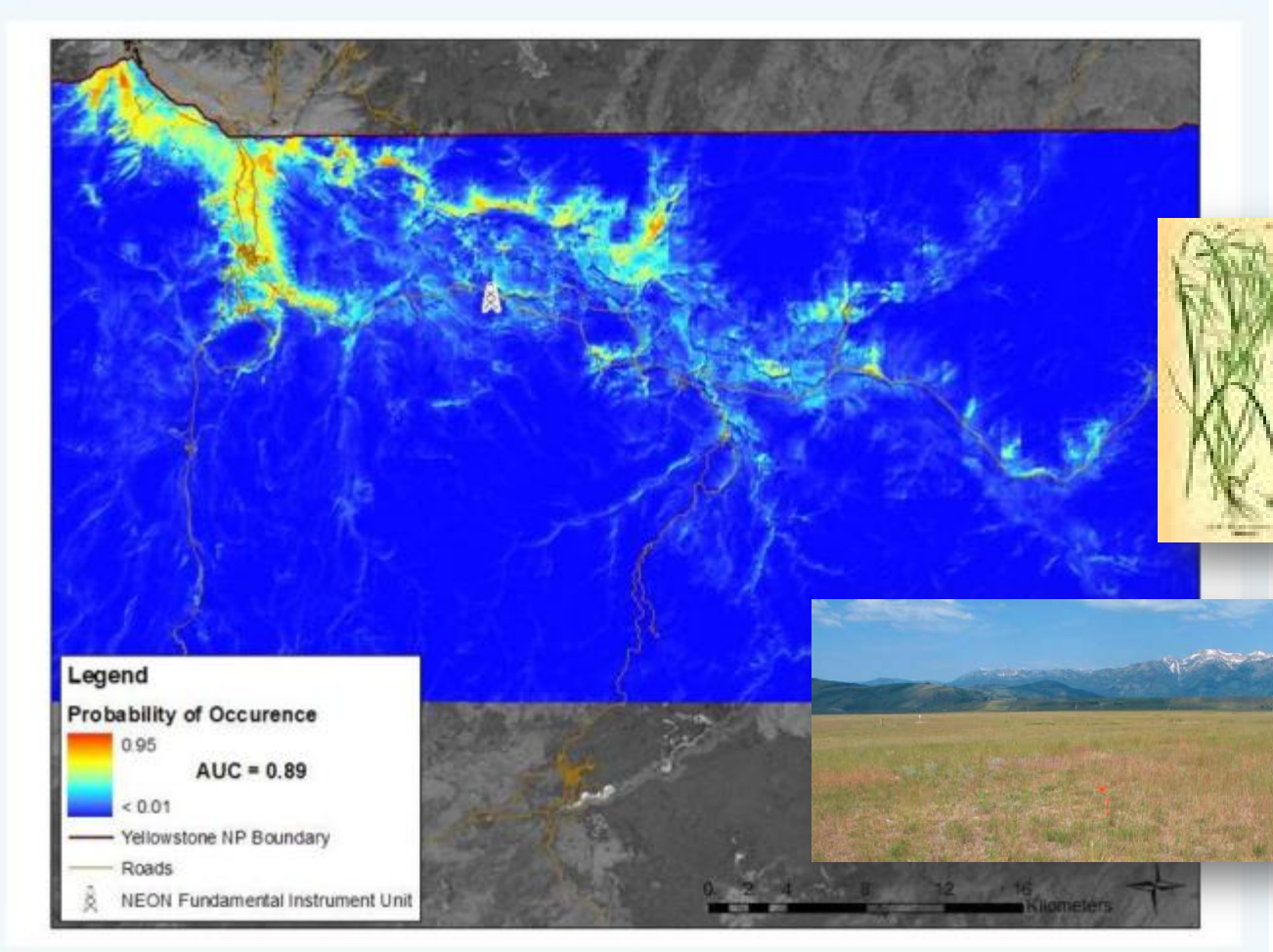
- Information to support management
  - Range condition and productivity
  - Relevance to wildlife populations
  - Ecosystem process information within GYE context

- NEON data complements past and on-going investigations
- TOS + AOP data → landscape perspective on productivity and composition

- Invasive species information
- Fire landscape and response to past and future fires

Scaling – Species Distribution Modeling

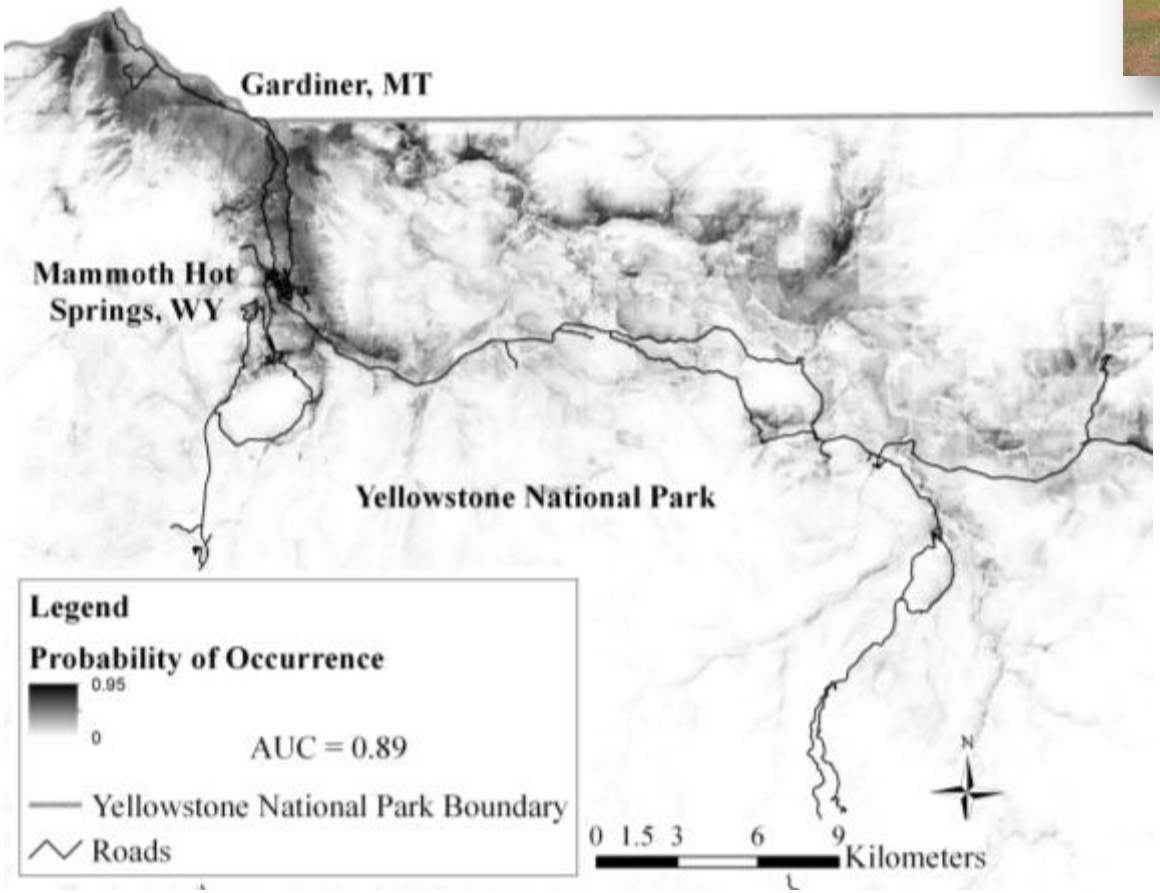
Suitable Habitat for Cheatgrass -- *Bromus tectorum*



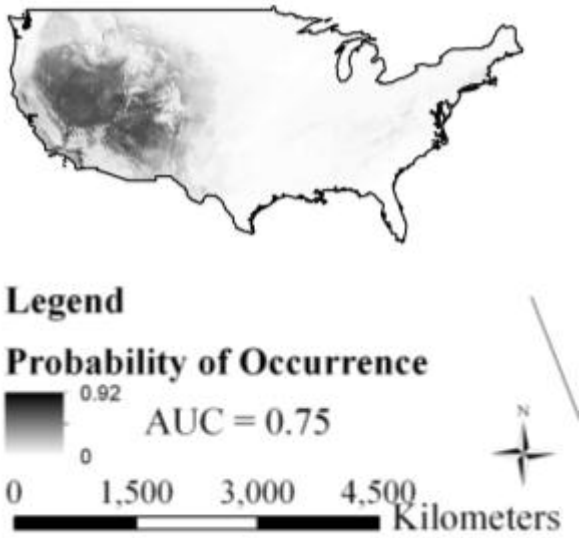
Scaling – Species Distribution Modeling

Suitable Habitat for Cheatgrass (Bromus tectorum)

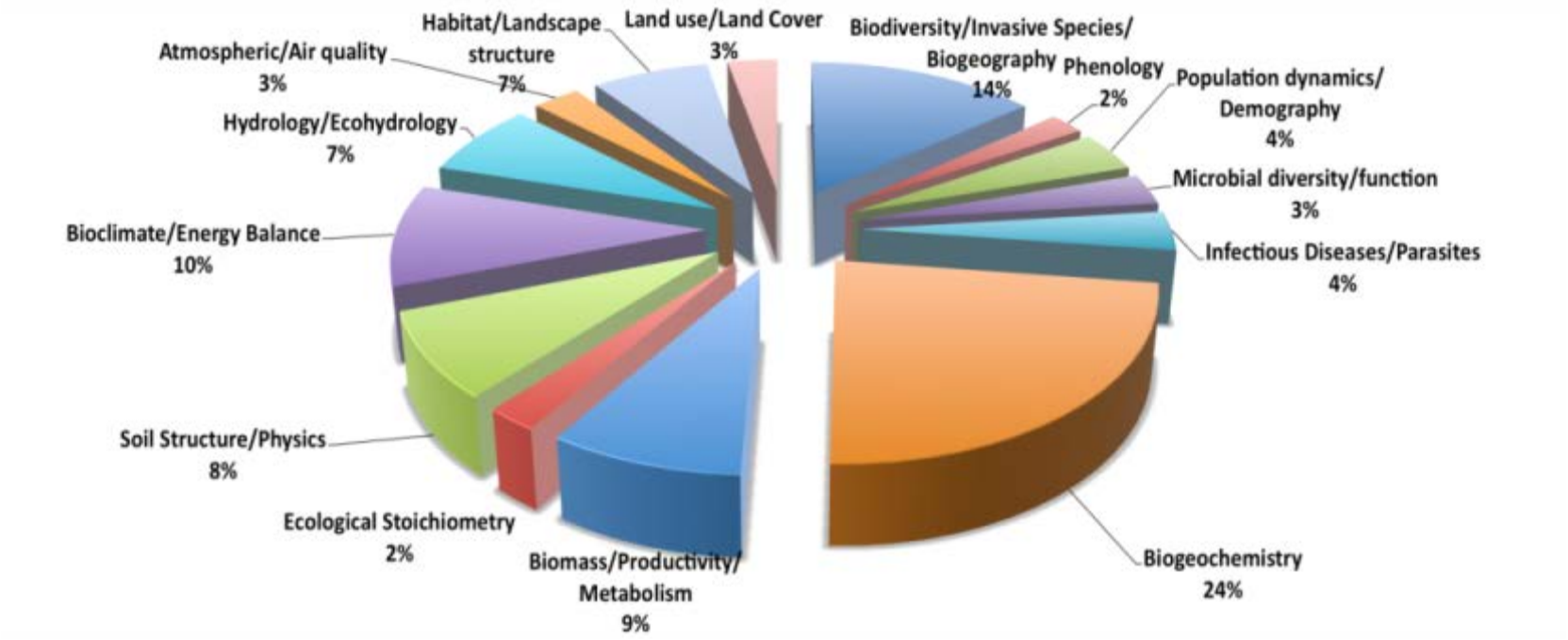
NEON Site at Yellowstone National Park



Continental US

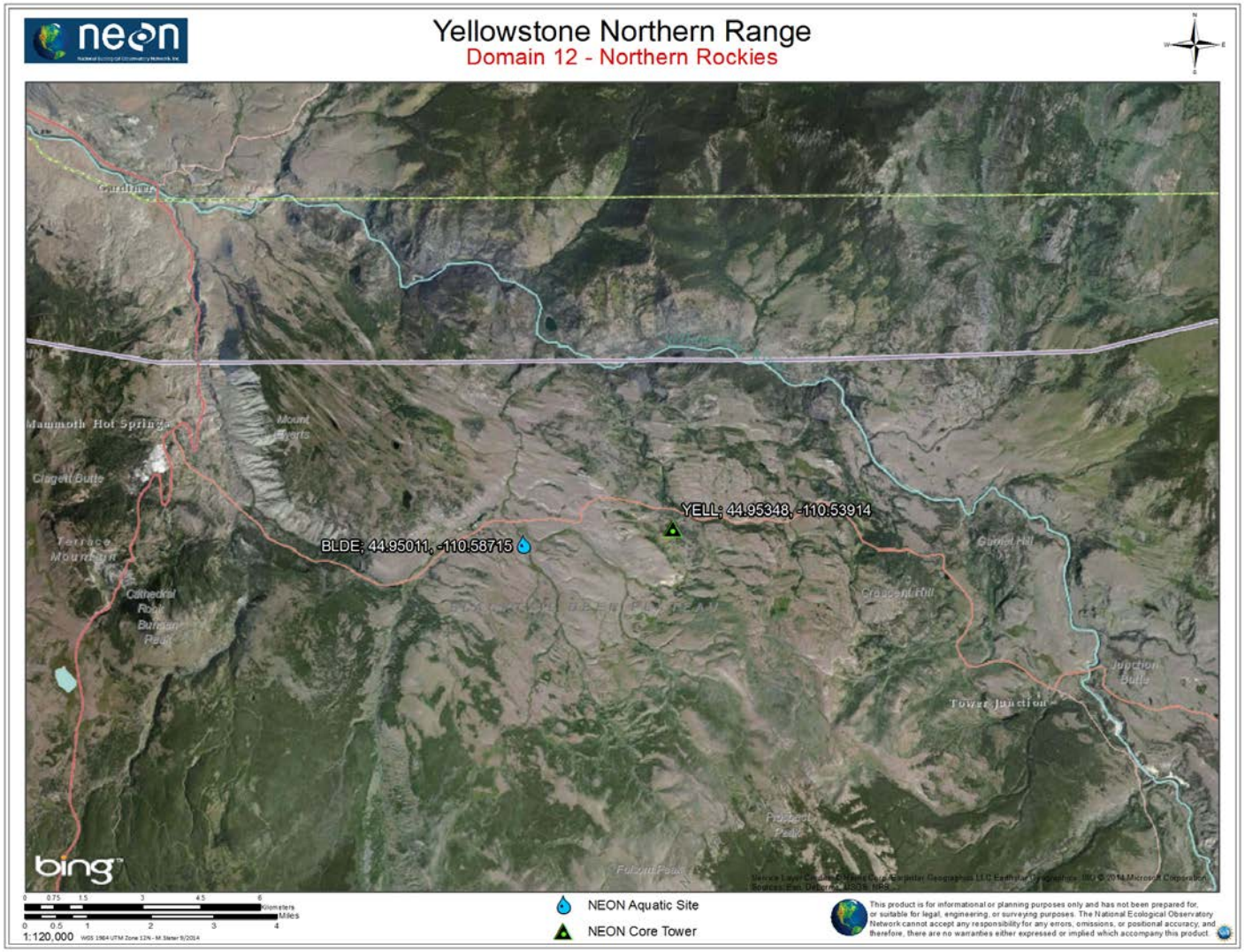


NEON Data Products



- **~ 1600 Level 0 data products (primary observations)**
  - *Raw voltages from sensors*
  - *Information on collected flora/fauna(e.g. counts)*
  - *External DNA or chemical analysis*
  - *Raw LiDAR returns*
- **~ 540 Level 1 data (QA/C, minimally processed)**
  - *One-minute average air temperature*
  - *Site-level species composition*
  - *Georectified LiDAR*
- **~ 75 Level 2 (rectified) & Level 3 (common gridded)**
  - *Gap-filled one-minute air temp (L2)*
  - *Gridded canopy nitrogen estimate (L3)*
- **~ 120 Level 4 (high-level, cross-subsystem integrative)**
  - *Net ecosystem exchange*
  - *Canopy nitrogen*
  - *Microbial diversity*
  - *Aquatic nutrient flux*

Domain 12- Core Site



NEON Site Activities

NEON Site Selection ***(Complete)***

FIU Site Characterization ***(In-progress)***

FCC Site Characterization (Geotechnical work, survey) ***(Complete)***

Site permitting efforts ***(In-progress)***

Completed building permit/land use permit

Construction initiation

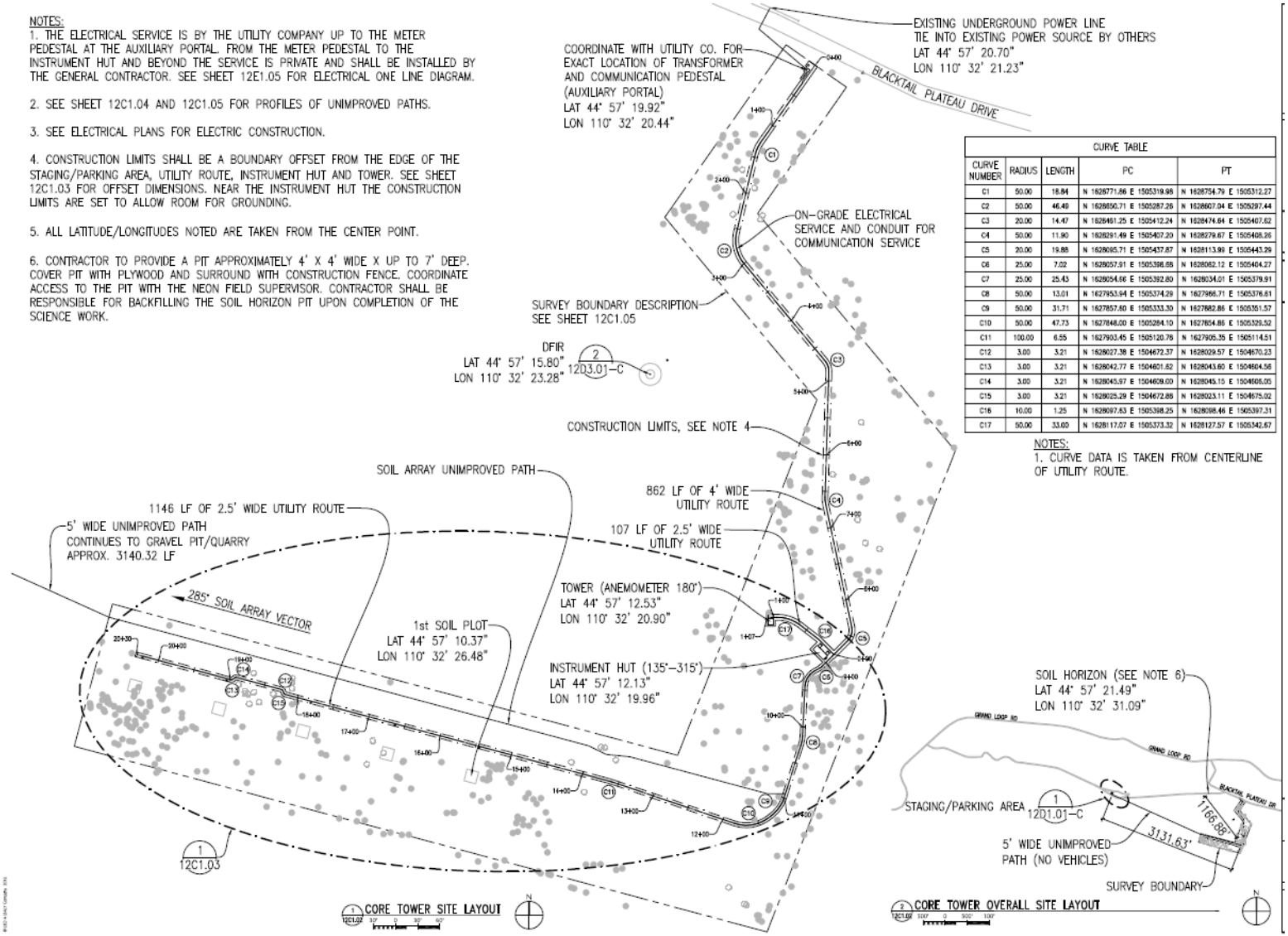
Tower Instrument Deployment

Estimated timeframe: 1.5-2 years

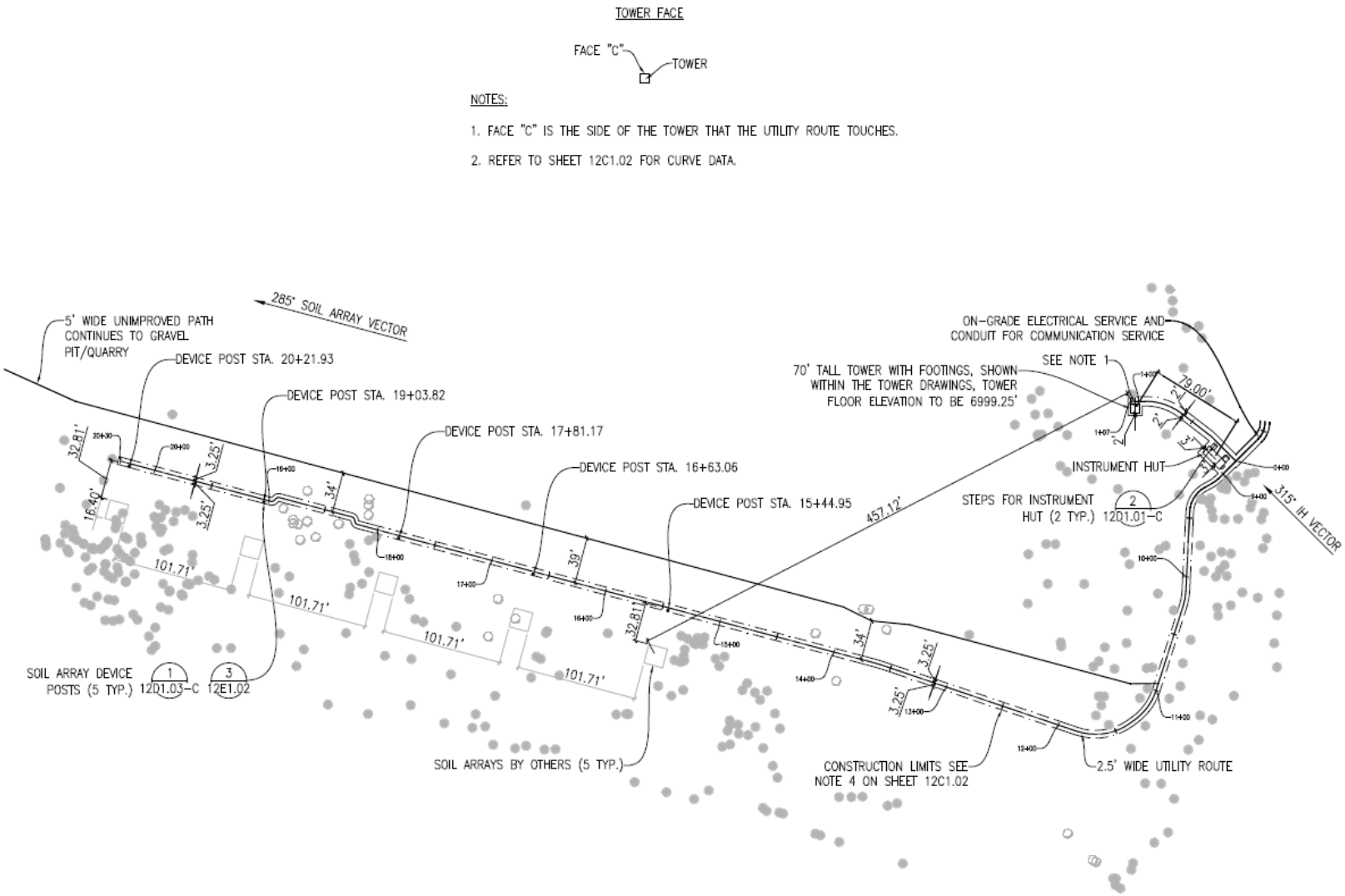
NEON Site Components

- Tower: Square lattice tower equipped with internal ship ladder system for access.
  - Foundation footprint: usually 8’x8’
  - The Tower will be 70.5’
- Instrument Hut:
  - 8’x20’x9’
  - Footprint: 10’x20’ foundation footprint
- (5) Device Posts will support a Power/Communication Box
- Access Path:
  - Width: 4’ to 2.5’
  - Unimproved Path.
- Soil Array: soil monitoring underground (2.5 inch diameter casing, no more than 7 feet in depth).
  - Requires power which will have a post and communication box mounted to post.
- Soil Pit: 6’X6’: Open for 3-5 days, construction supervisor on site.
- Power: Requires Grid Power
- Data: Requires data connectivity, may use cellular depending on cell coverage.

60% Design



Soil Array



Core Site Overview Map

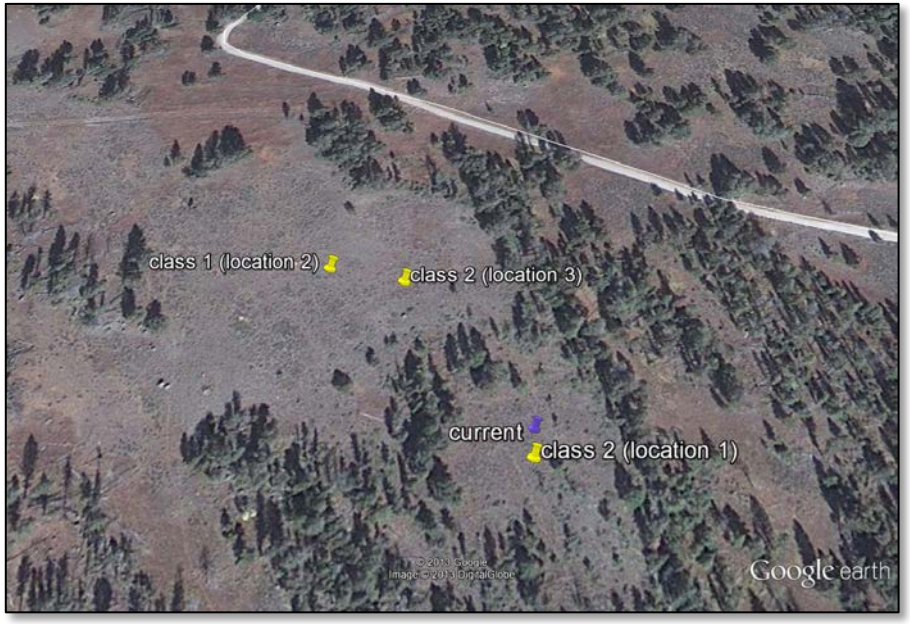
Image of comparable NEON tower

Example Soil Array

Physical Infrastructure

Physical Infrastructure

Double Fence Intercomparison Reference (DFIR)



Site Construction

Scheduled to begin Summer, 2015

Duration approximately 6 months.

NEON Construction limits: Strict limits are delineated to restrict equipment to construction area (8 feet wide at typical NEON sites).

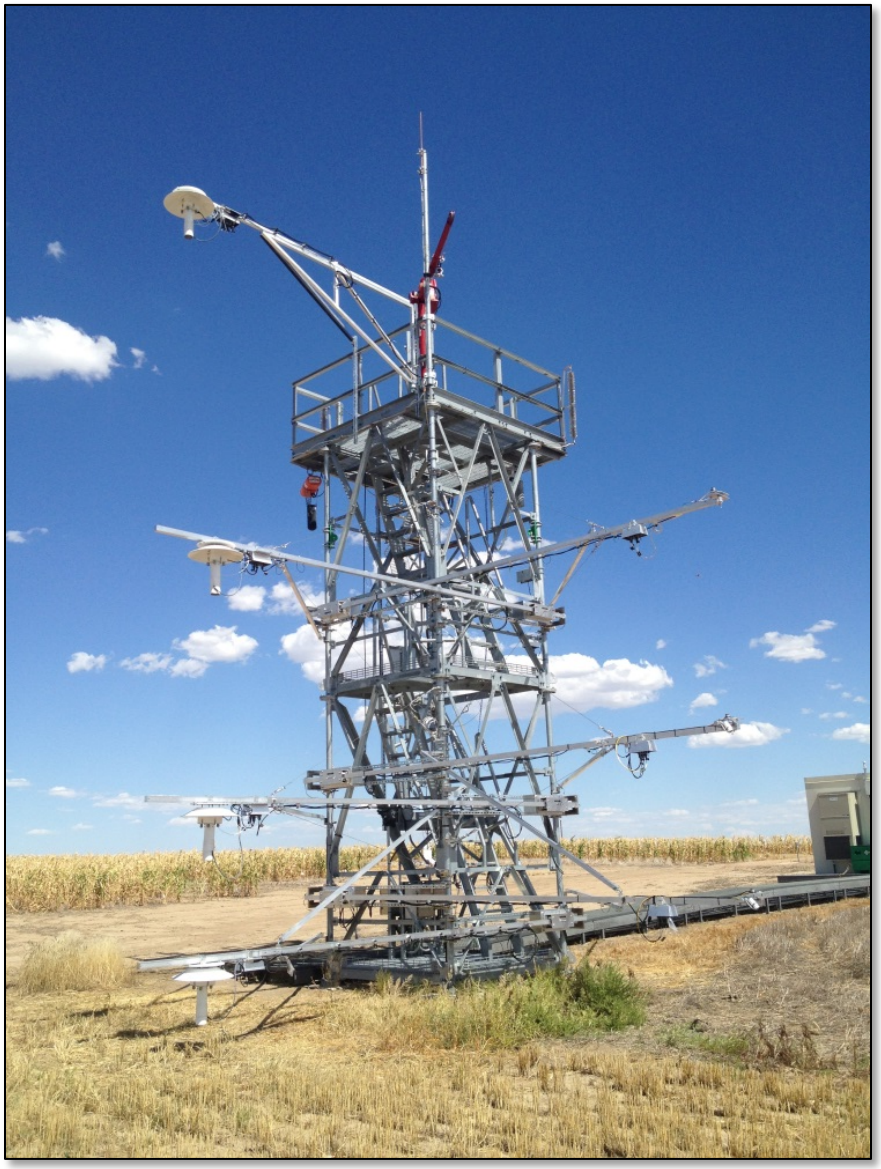
Construction staging : 40’x40’ parking area

Construction equipment may include:

- Mini-excavators
- Skid-Steer
- Pickup trucks

Sensors

- Tower and Soil Array at all 60 sites
- 37 Instrument Assemblies
- Over 2000 measurements including:
  - Meteorology
  - Radiation
  - Atmospheric Chemistry and Air Quality
  - Dust and Aerosols
  - CO2, H2O, and Energy Fluxes
  - Soil Measurements



NEON Observatory Subsystems

- **Terrestrial**
  - Organismal (TOS)
  - Instrumental (TIS)
- **Aquatic**
  - Organismal (AOS)
  - Instrumental (AIS)
- **Airborne** (AOP)



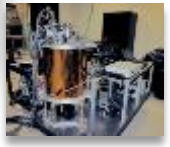


Field Sampling

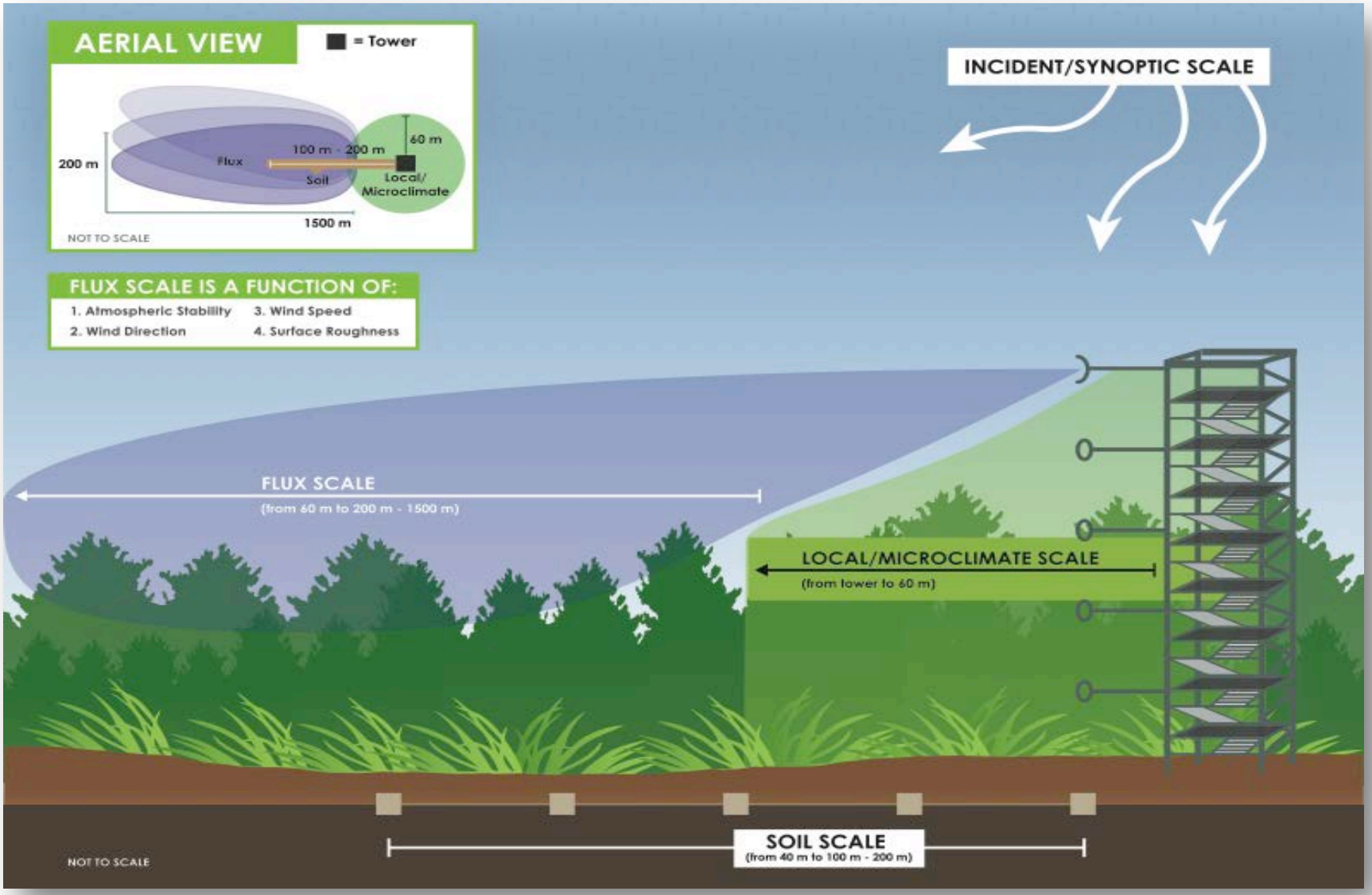

Towers


Surface and ground water


Satellite Data



Airborne Remote Sensing

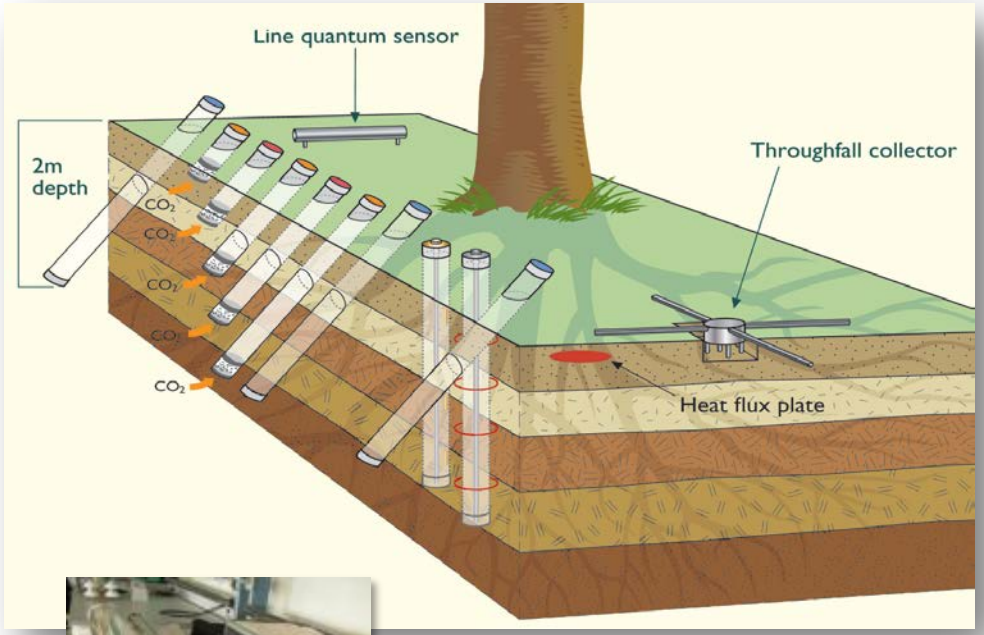
TIS – Terrestrial Instrument System



TIS - Soil Array

Physical and carbon cycle responses

- Temperature
- Moisture
- Carbon dioxide flux (soil respiration)
- Root growth



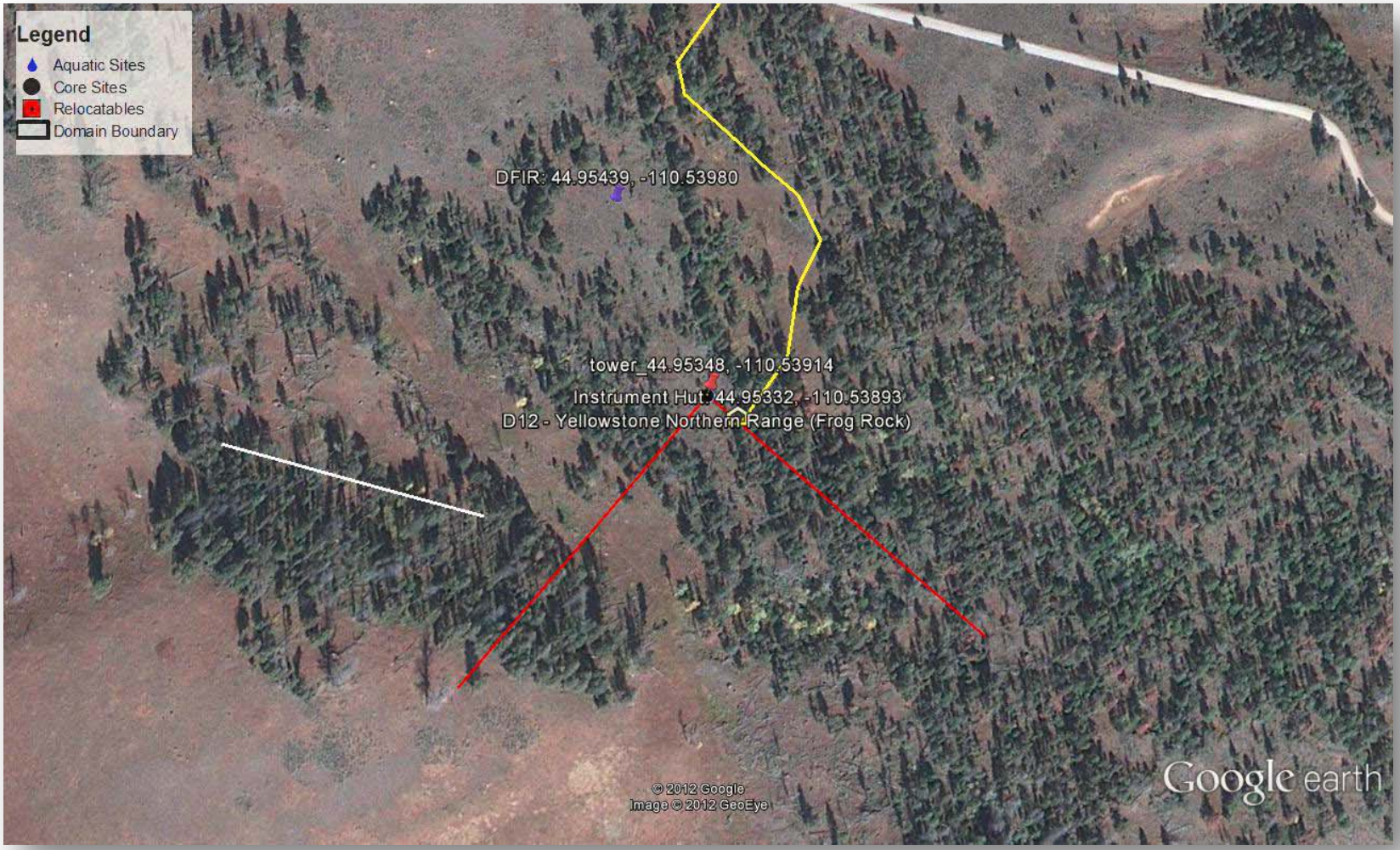
Atmospheric Measurements

Ecosystem carbon, water and energy balance

- Temperature
- Humidity
- Wind
- Precipitation
- Radiation
- CO^2
- Pollutants – e.g., ozone and reactive nitrogen

Calibration for remotely sensing – Correct AOP for effects of incoming solar radiation, aerosols and water vapor

Airshed

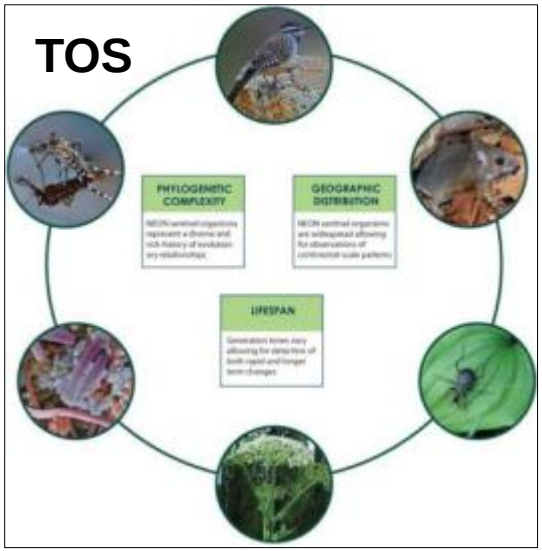


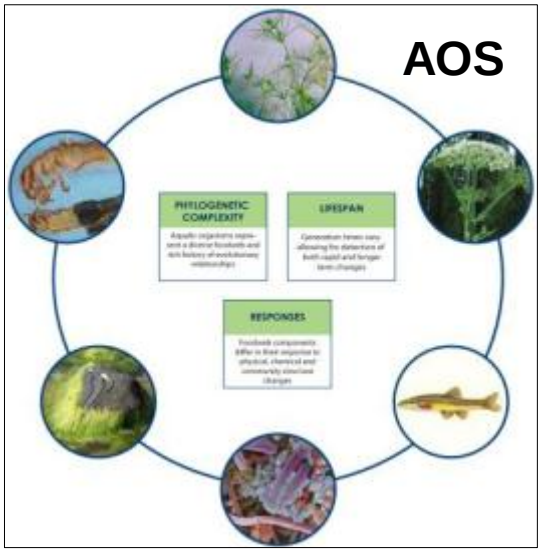
Aquatic & Terrestrial Organismal Sampling

Provide standardized, diverse measurements related to…..

- Biodiversity & Invasive Species
- Phenology
- Population Dynamics
- Microbial Diversity & Function
- Biogeochemistry & Productivity
- Ecohydrology
- Infectious Disease

Not easily measured with fixed instruments



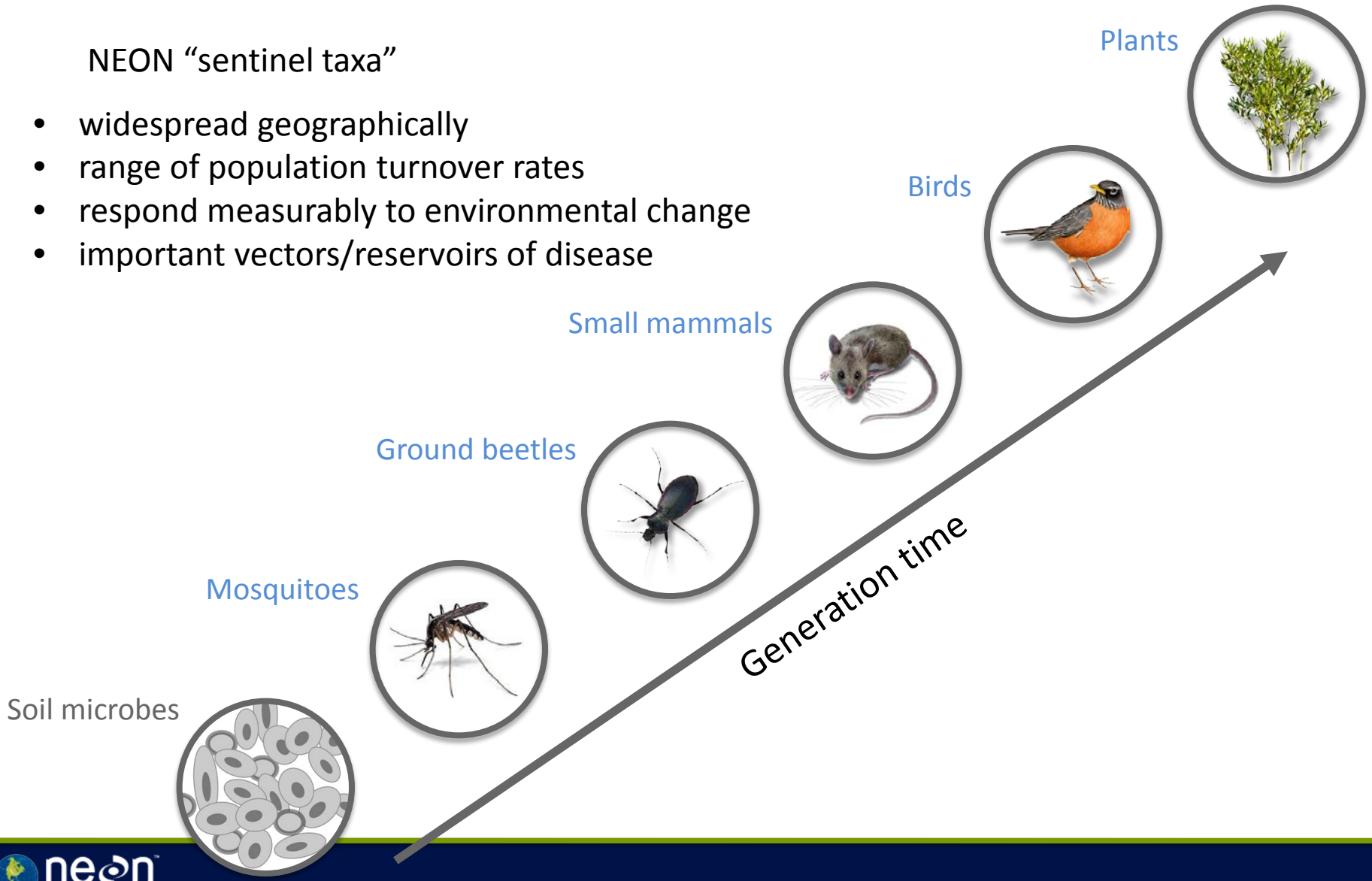


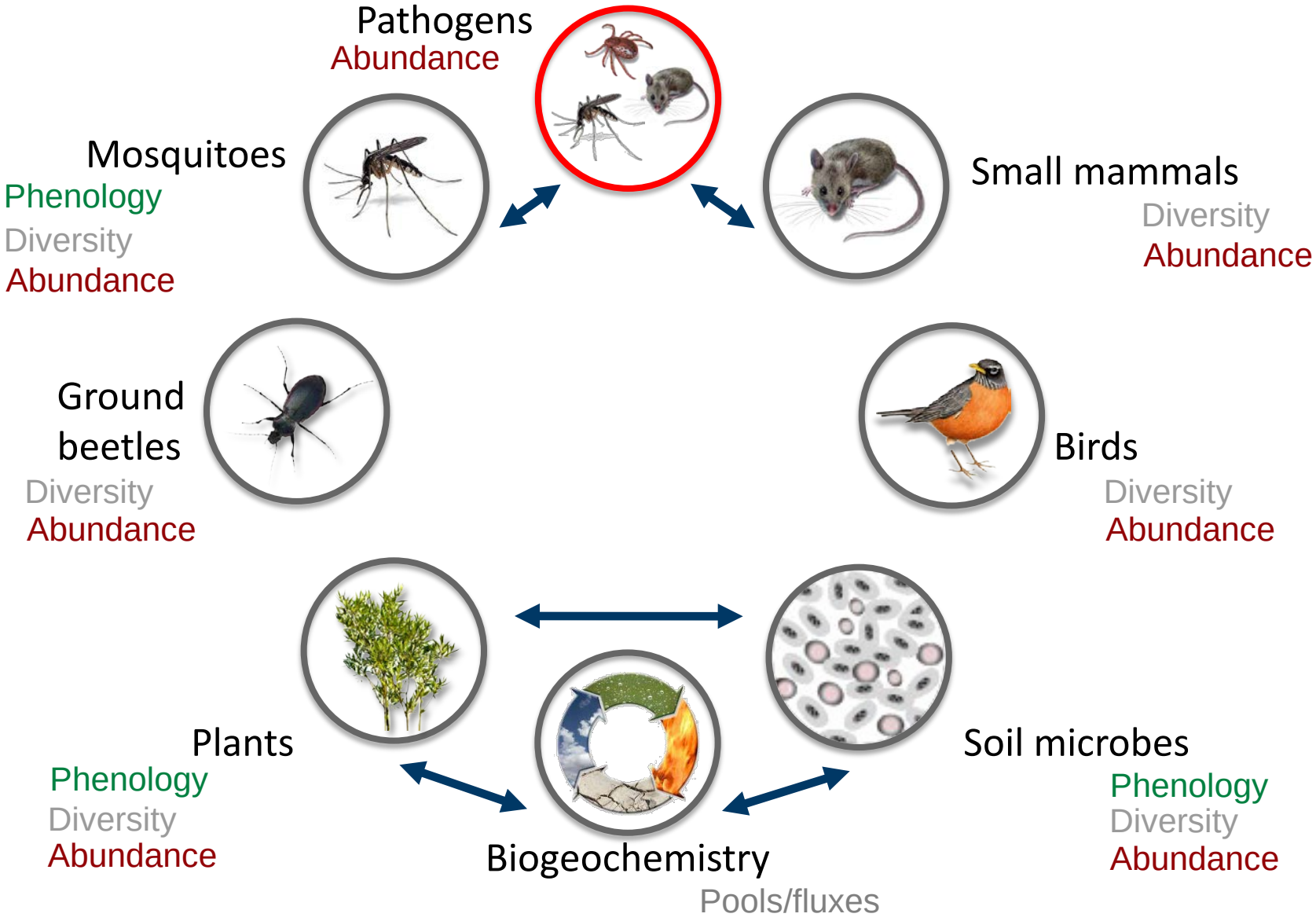
Terrestrial Observation System (TOS)

Ecological foci

NEON "sentinel taxa"

- widespread geographically
- range of population turnover rates
- respond measurably to environmental change
- important vectors/reservoirs of disease





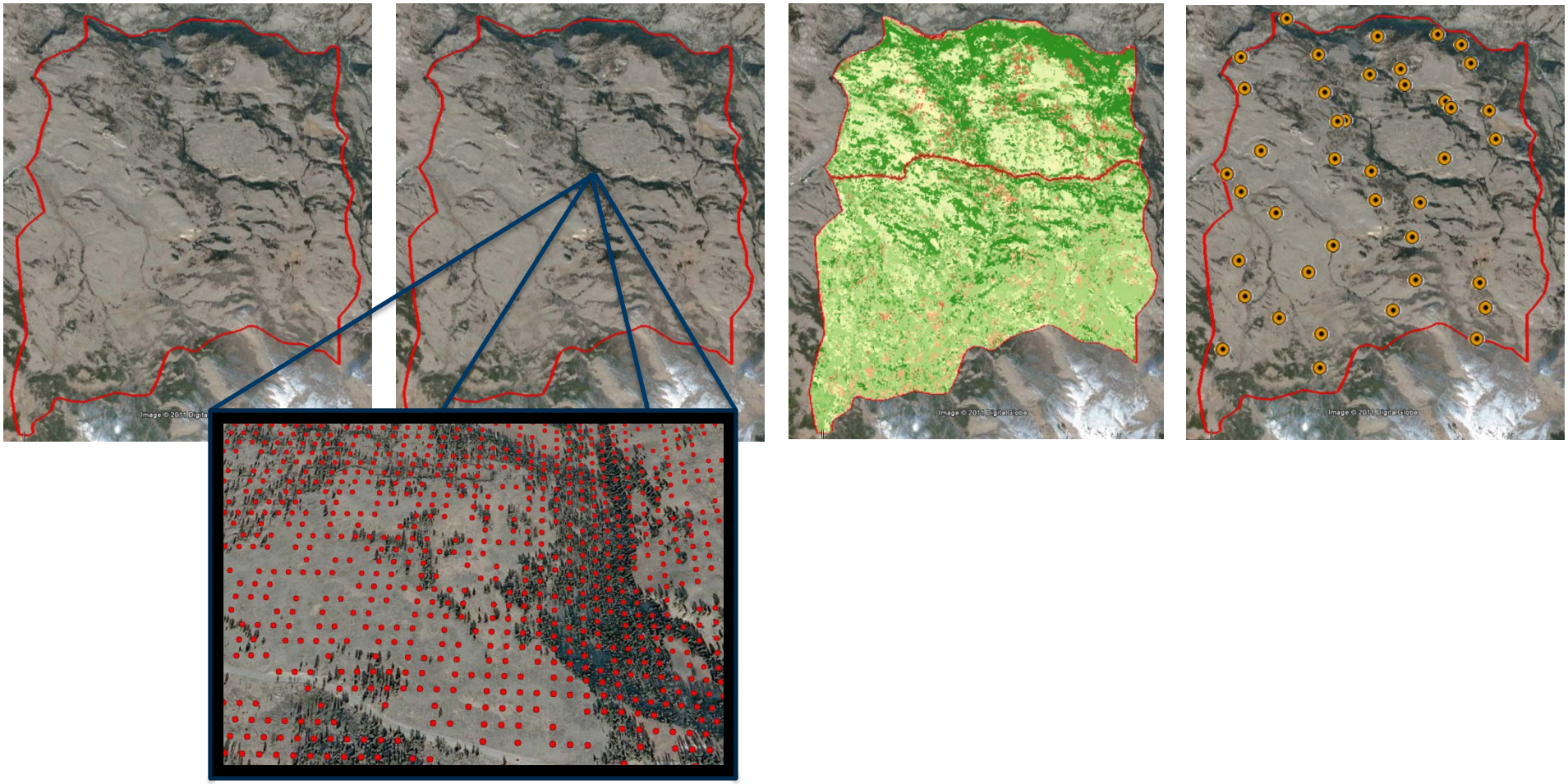
Sample Design

Site Boundary

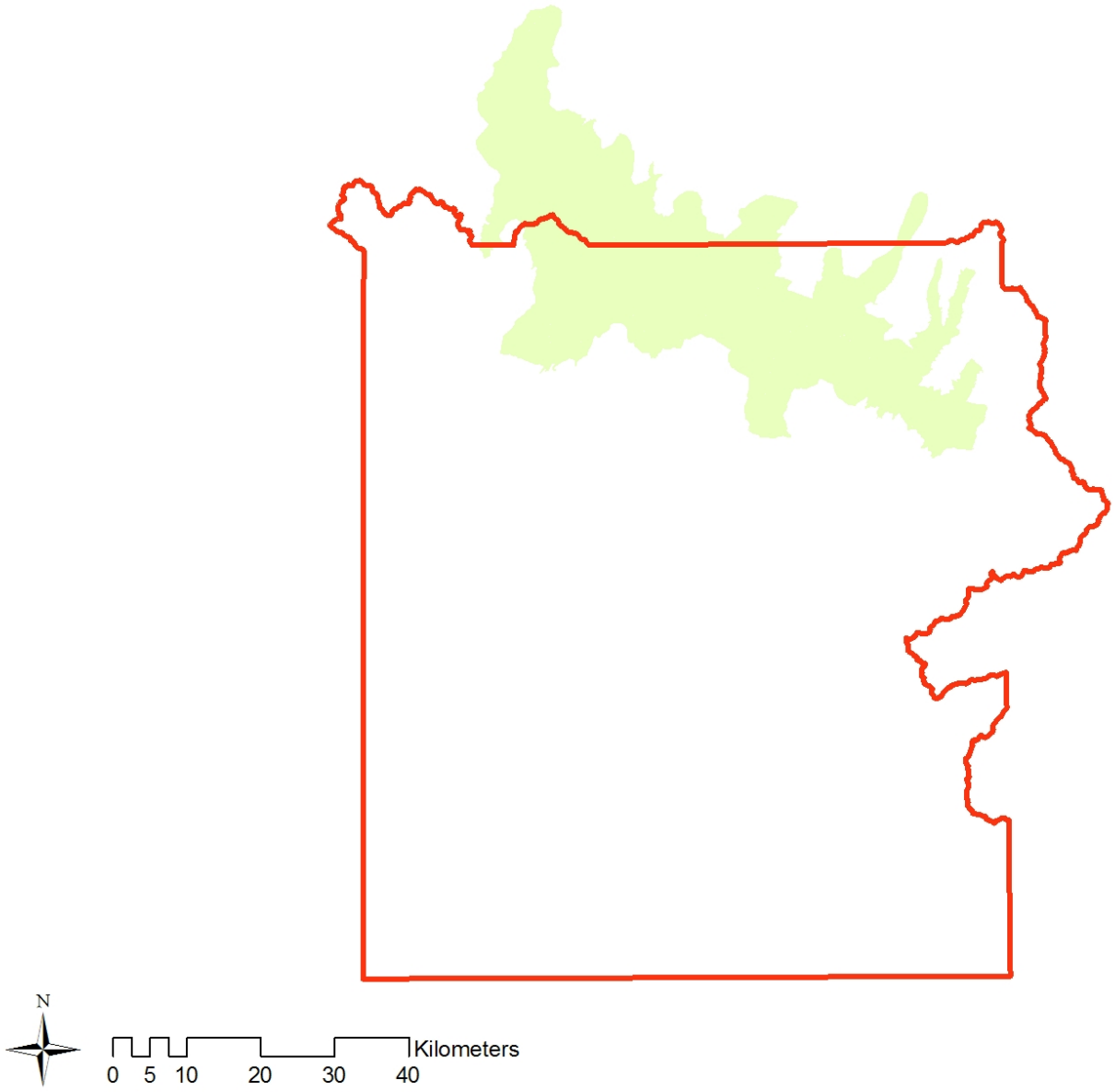
Spatial Balanced and Random Grid

Stratified by Vegetation Type

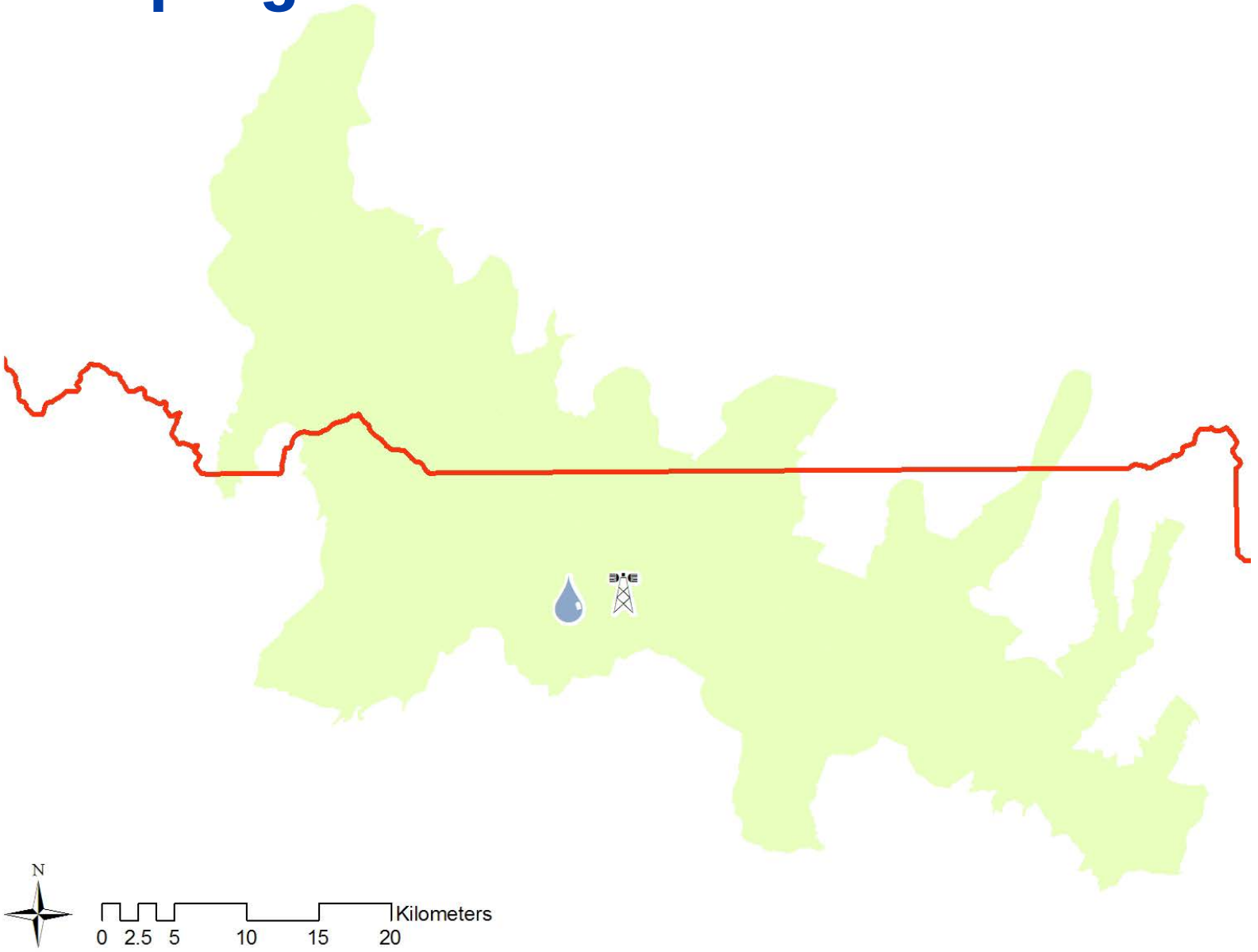
Study Locations



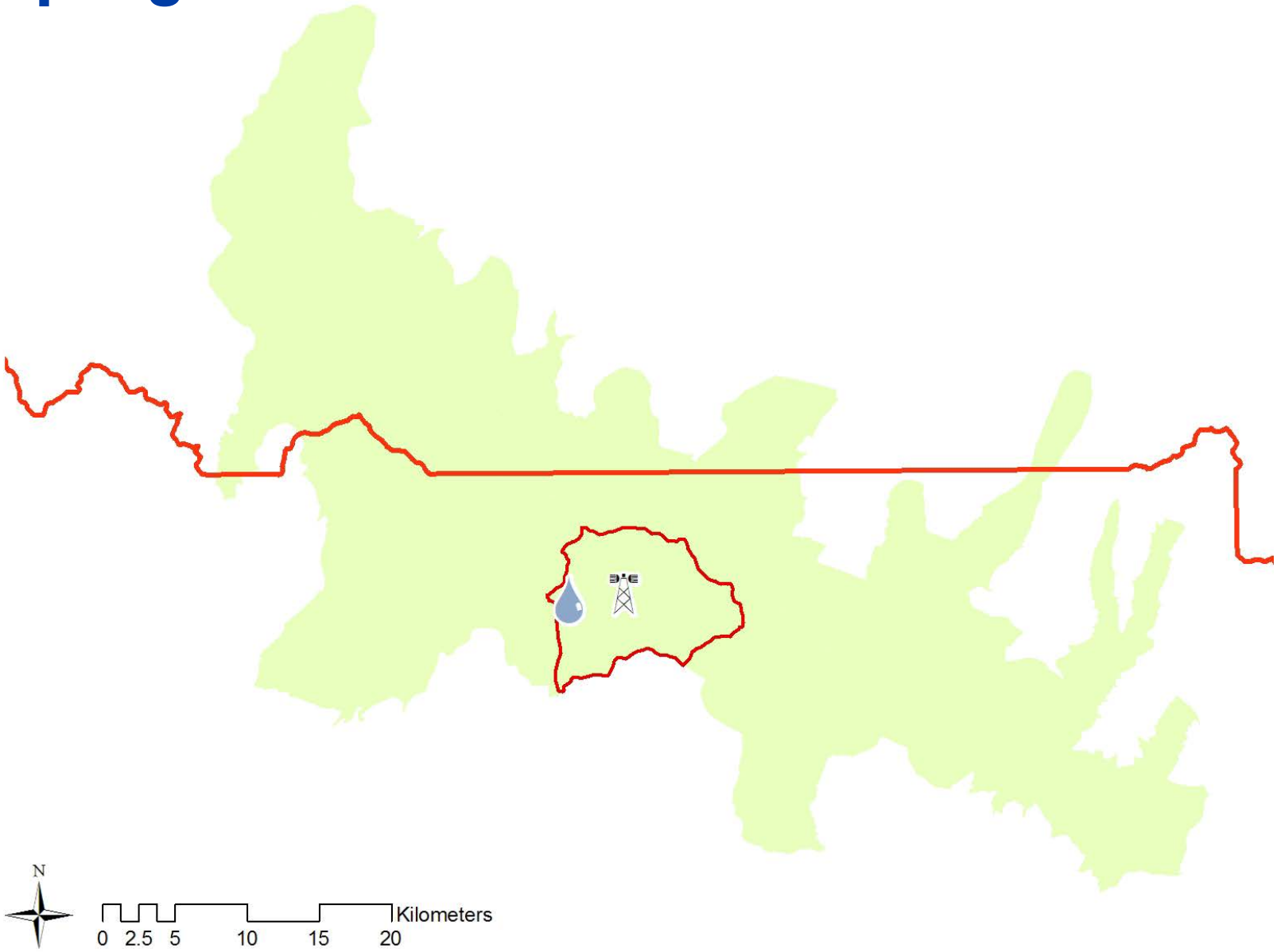
Sampling Area



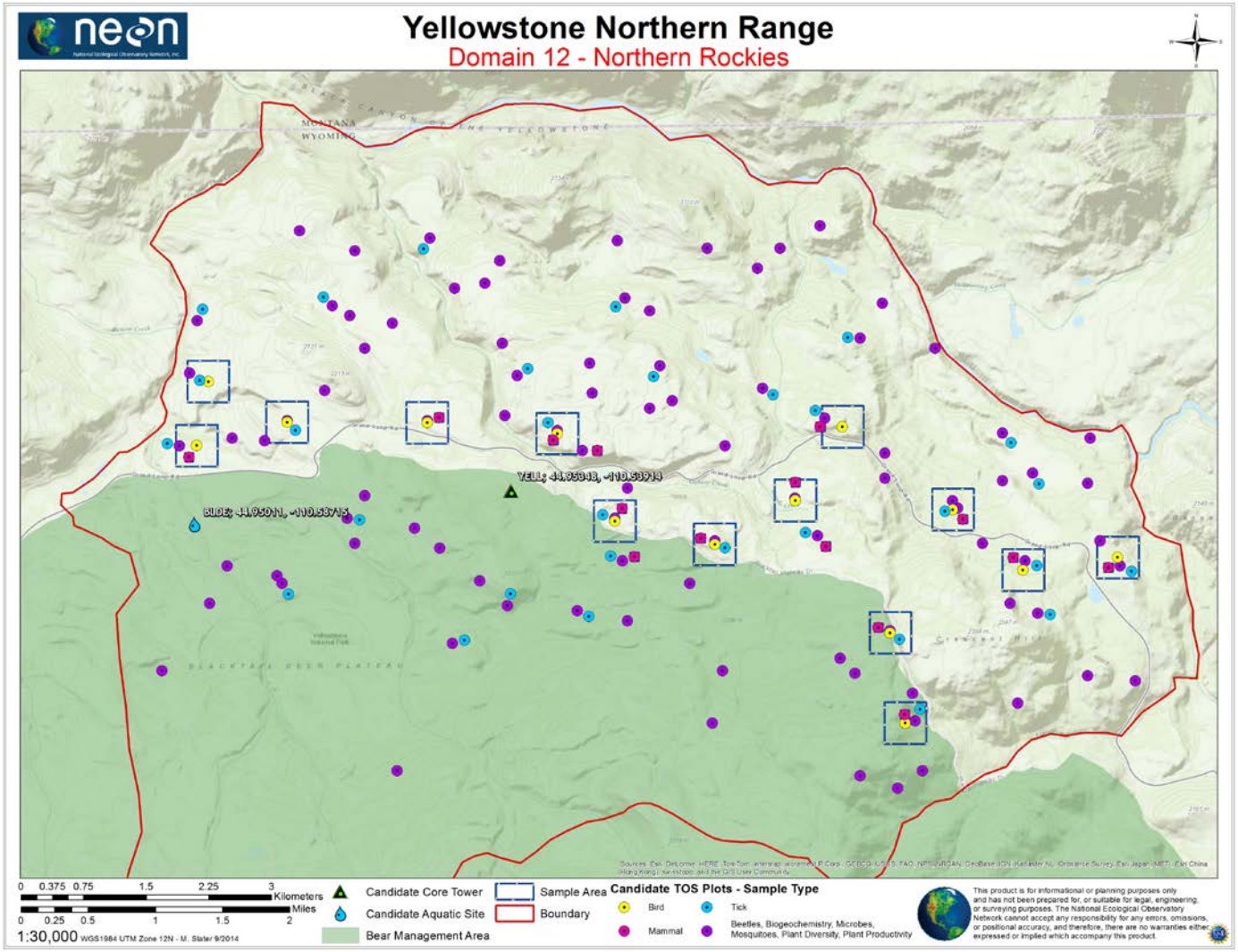
Sampling Area



Sampling Area

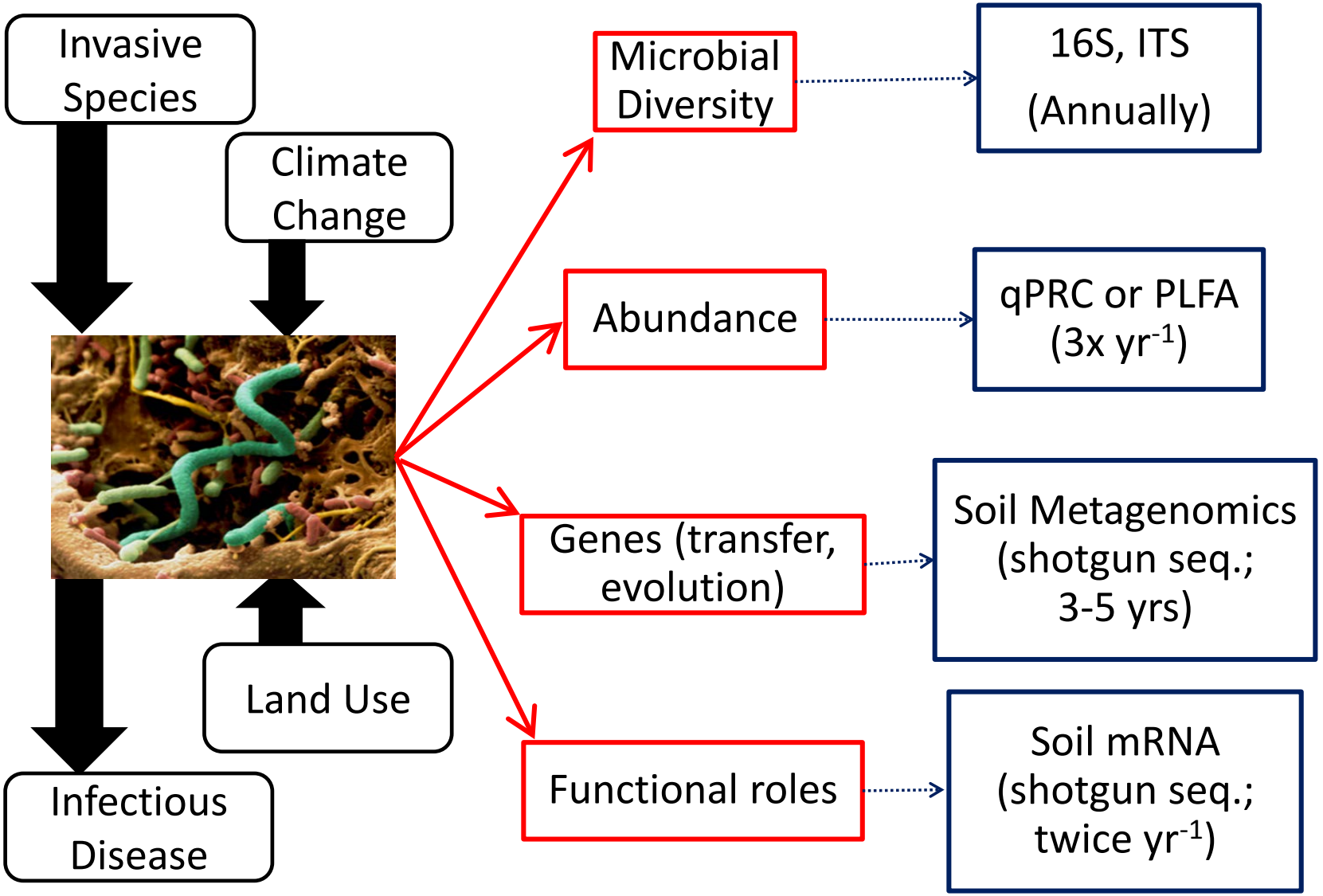


Preliminary Plot Distribution

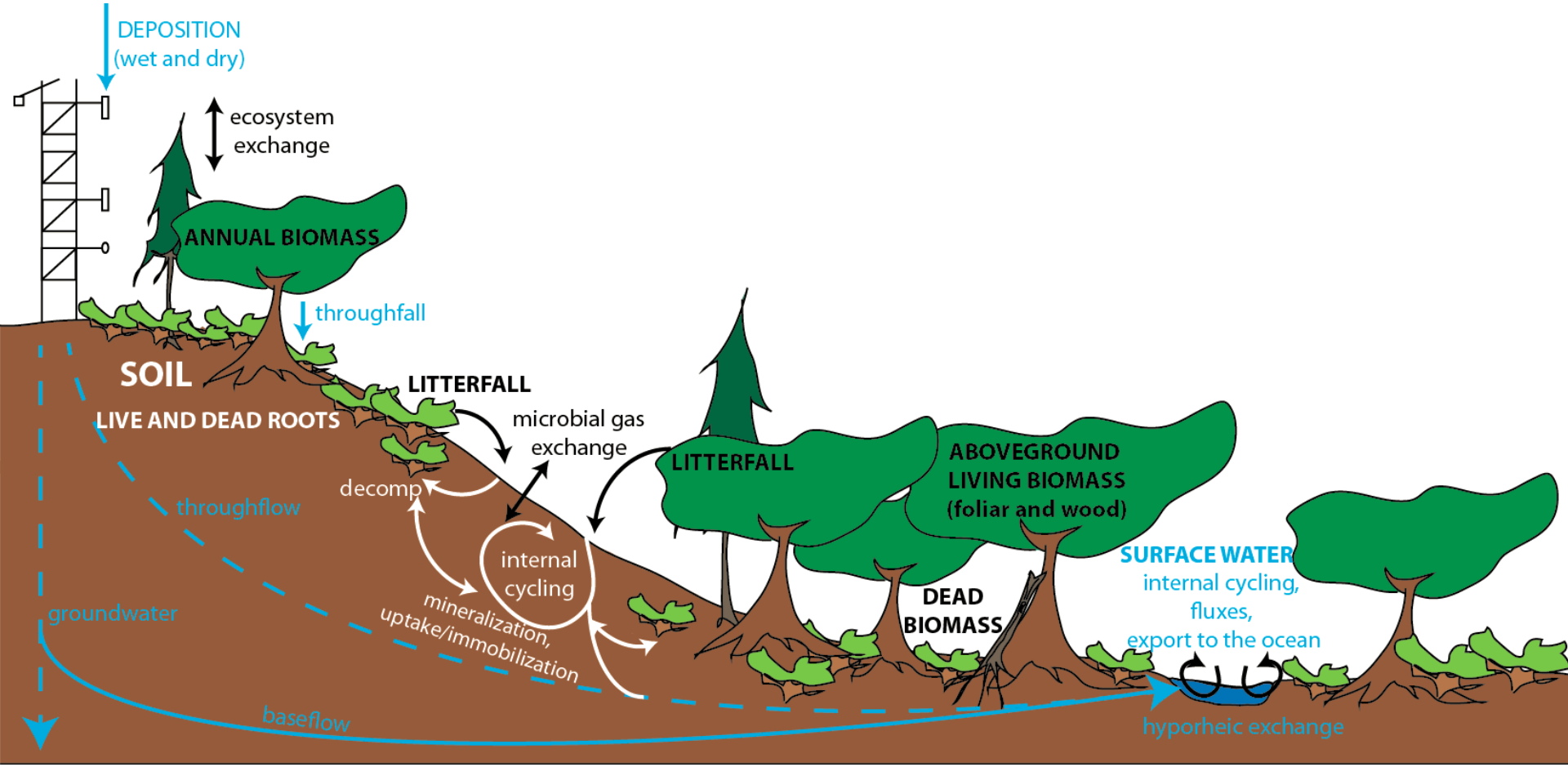


Soil microbes

- Sampling occurs throughout a site
- 4 soil cores per plot (2.5” diameter x 30” depth)
- Samples also used for soil nutrient analyses
- 4-10 plots are sampled monthly every year
- 40 plots sampled every 5 years



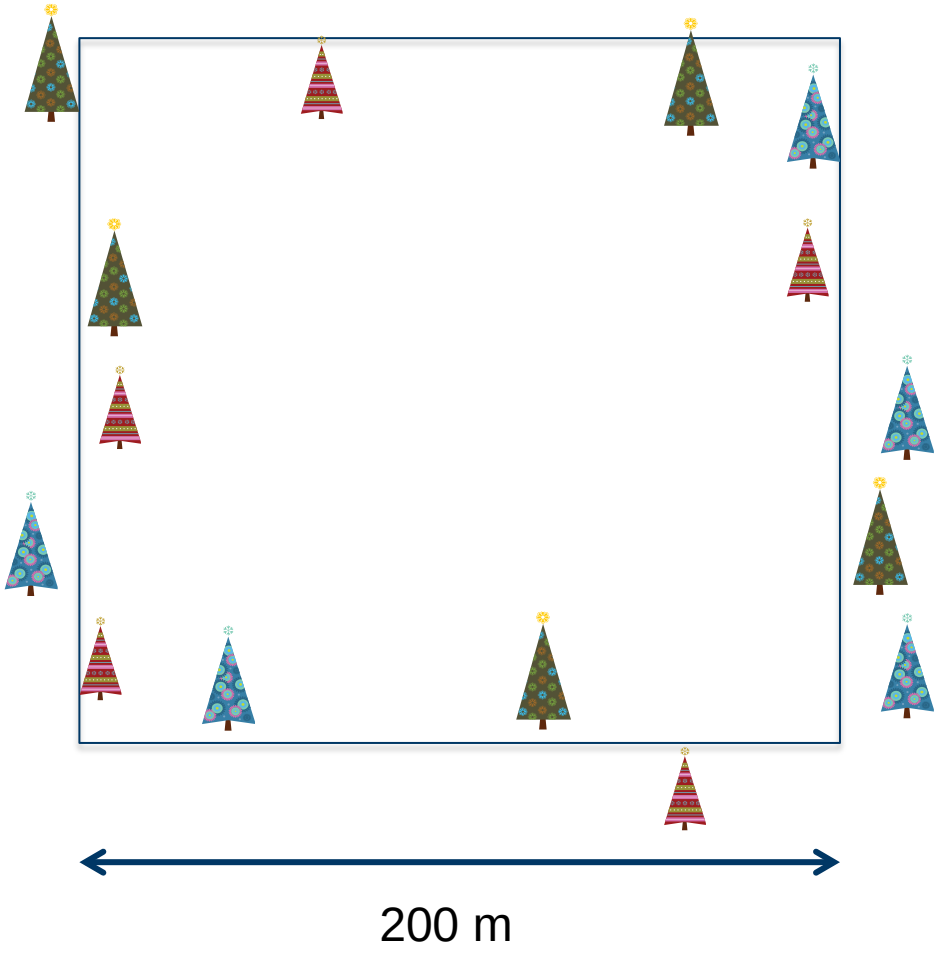
Biogeochemistry



Plant Diversity

Plant phenology

- Mix of understory and overstory species.
- Phase 1: (first 3-5 years) 2 most dominate overstory species and the single most dominant understory species at the site (20-30 individuals per species).
- Phase 2: Phase 1 species + 17 new species selected through weighted randomization; Up to 100 plants, ≥5 individuals of each species



Plant phenology

Sampling frequency

- Weekly for 3 weeks prior to anticipated onset of leaf greening,
- 3x/week until full canopy formed,
- Every other week until 3 weeks prior to anticipated senescence,
- Weekly until first individual reaches trigger leaf off,
- 3x/week until all leaves are dropped during first 3 years

Acer saccharrum
(photo by EG Denny, NPN)

Plant productivity, biomass, and biochemistry

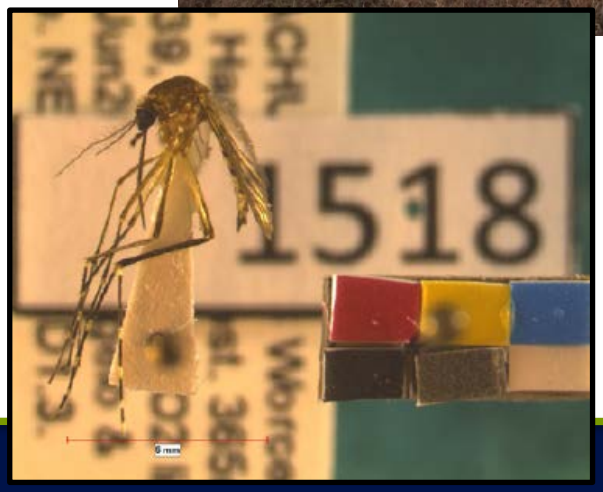
Ground beetle diversity & abundance

- Pitfall traps will be deployed at 10 of the base plots in which plant biodiversity is measured.
- Four pitfall traps will be located on the center of the north, south, east and west edges of the plots.
- Traps collected every week during the snow-free season.
- Identified by expert taxonomists and using DNA barcoding.

Mosquito diversity, phenology, abundance, & disease

Mosquito diversity & abundance

- 10 plots sampled for 40 hours every 2 weeks .
- Off season - Sampling occurs weekly for 1 night if the daily temperature for 5 consecutive days is above 4ºC.
- Visual identification & DNA barcoding
- Infectious disease testing (West Nile, Dengue, etc.)



Tick-borne diseases

- Sampling occurs every 3 weeks in 6 plots
- 15-20 minute drag around perimeter of plot.
- Larval, nymphal and adult ticks will be collected and counted.
- Nymphal and adult ticks will be analyzed for disease prevalence.
- Infectious disease testing (esp. Lyme disease)

Small Mammals

Mark-recapture techniques

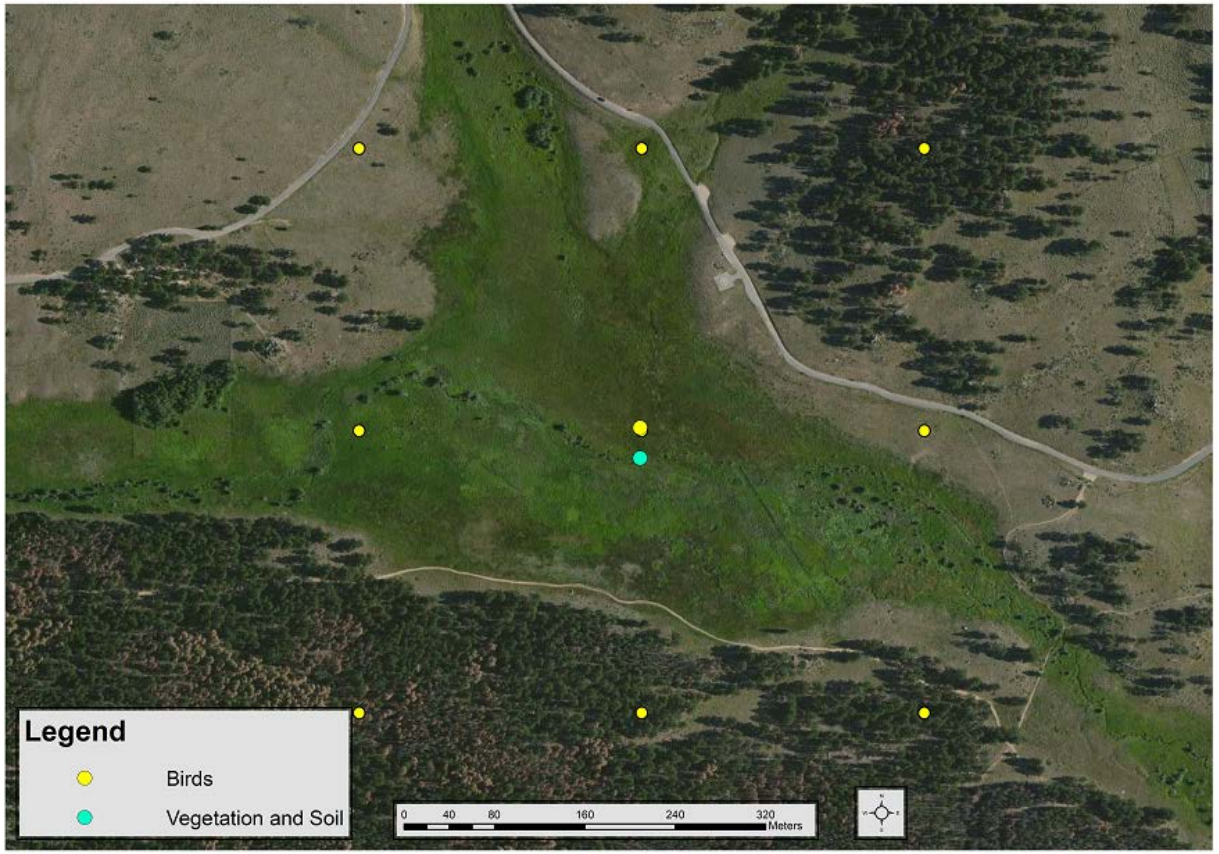
- Density estimation & demography
- Blood collection for small mammal-borne disease (e.g. hanta virus)
- Ear punches (genetic barcoding)

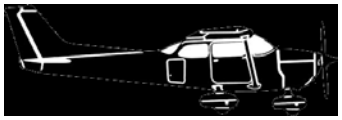
Monthly trapping bouts using a grid design

- 6 trapping grids; blood collection at subset (3-4 grids)
- 100 Sherman traps on 1 100x100 grid, spaced 10m apart

Breeding Birds

- 15 grids per site
- 9 point grid, 250m between each point
- 6 minutes per point
- Distances estimated
- Includes riparian areas





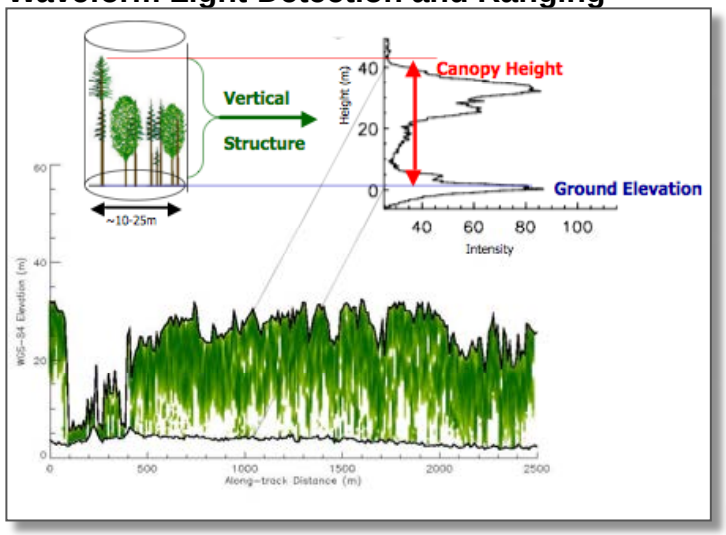
Twin Otter aircraft

Airborne sensors

- spectrometer: veg biochemistry, cover type and fraction
- LiDAR: veg structure, biomass
- high resolution camera: land use and cover

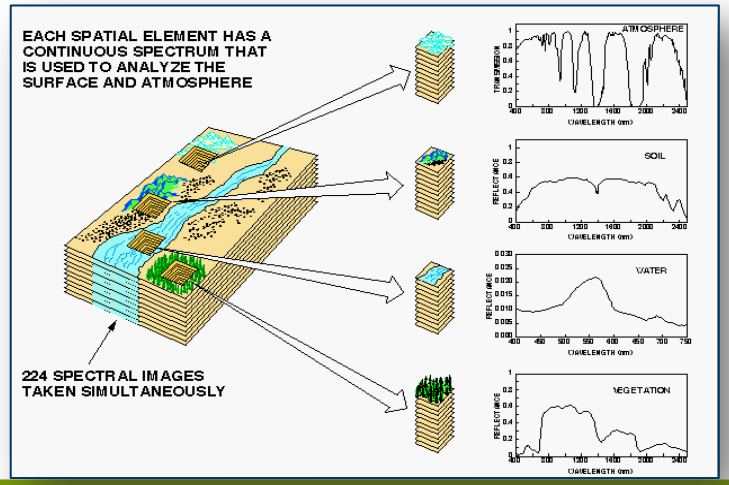
Airborne Observing Platform

Waveform Light Detection and Ranging



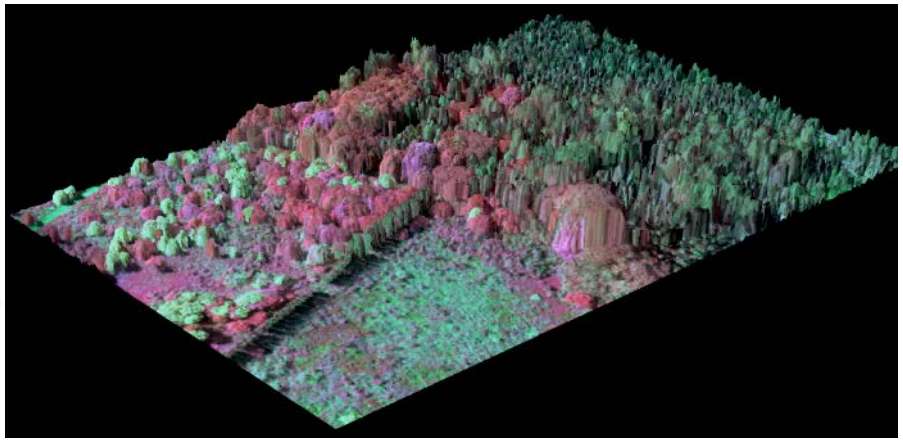
+

High-fidelity Imaging Spectroscopy



What are we after?

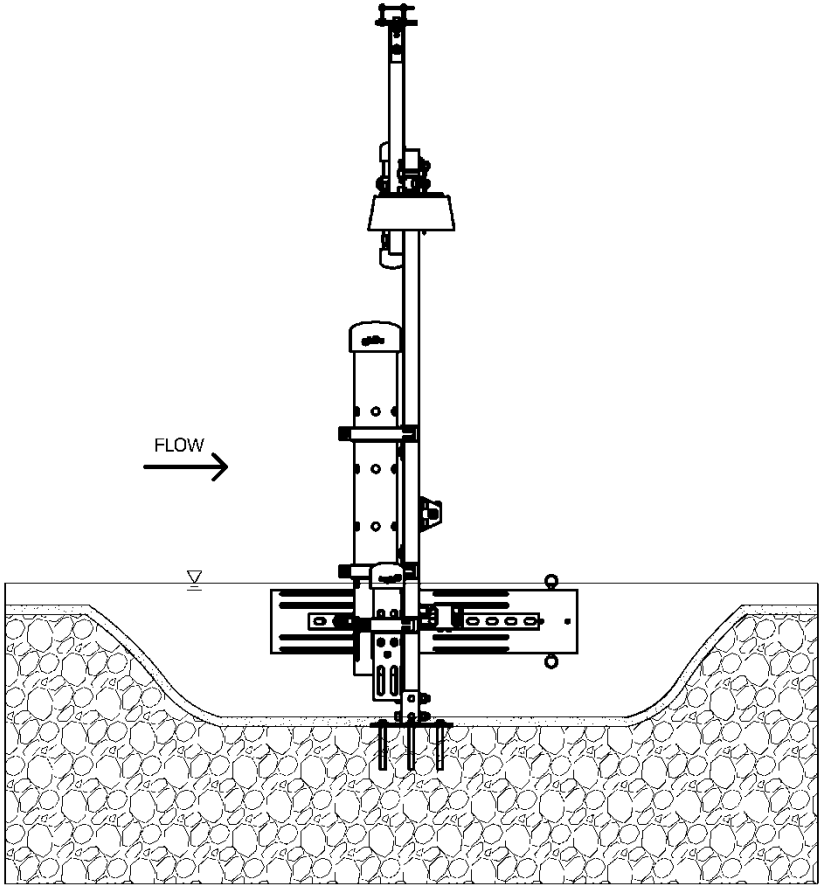
- Detailed chemical, structural and taxonomic information on ecosystems at fine spatial resolution



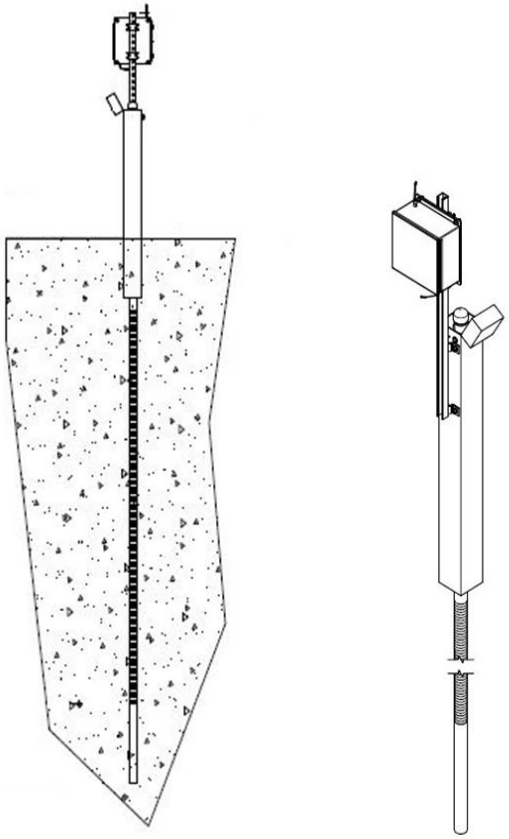
- Bridge the scales from organisms (i.e., trees or shrubs) as captured by plot sampling, to stand, to the scale of satellite

Aquatic Location

S1&S2 Infrastructure Setup



Groundwater Wells

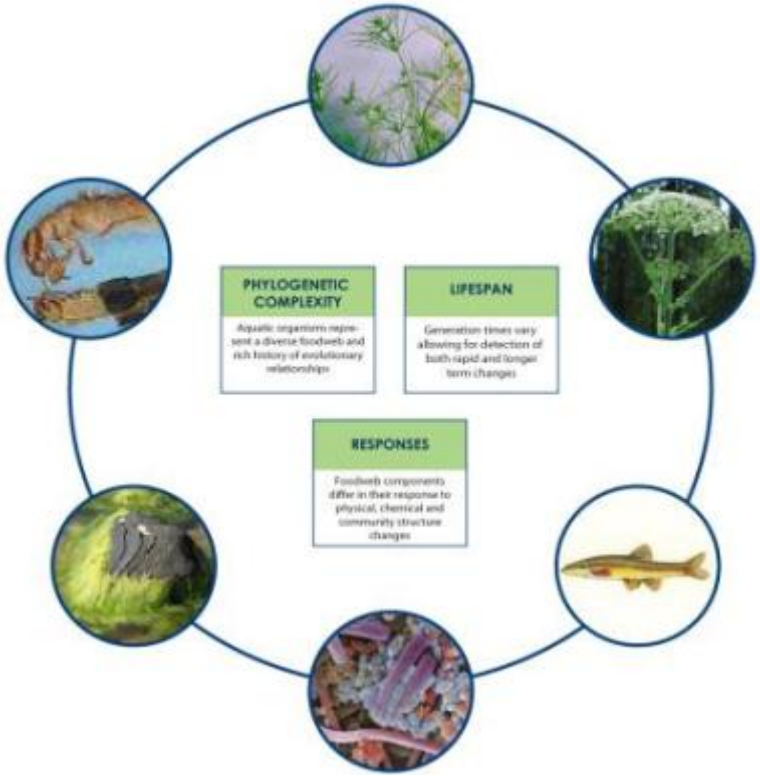


The exact location of wells may vary during the drilling process due to the dense presence of boulders in the subsurface which were observed during the visit. These will be hard to detect from the surface using geophysical methods due to their size and may pose an issue if one is encountered during the drilling activities. Thus, actual locations of wells will vary slightly from the plan if a subsurface obstruction is encountered.

Aquatic Design- Met Station

Aquatic Observation System (AOS)

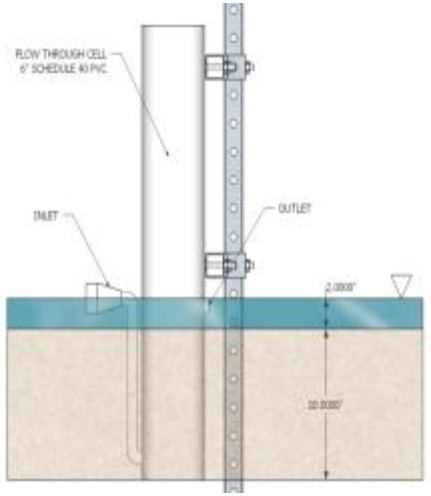
- Algae
- Aquatic macrophytes, bryophytes and lichens
- Aquatic microbes
- Zooplankton
- Aquatic invertebrates
- Fish
- Aquatic habitat
- Sediment chemistry
- Water chemistry



Aquatic Instrument System (AIS)

- **In-stream**
  - $Temp_{water,}$ DO, turbidity, pH, conductivity
  - Chromophoric dissolved organic matter
  - Nutrient Analyzer – nitrate, phosphate, ammonia
  - Photosynthetically active radiation (PAR)
- **Near-Stream – Micrometeorology**
  - $Temp_{air}$, precipitation, barometric pressure, PAR, net radiation
  - Wind speed and direction
  - Camera
- **Groundwater**
  - Temperature, level and conductivity

Sensor Design



Overview Video

https://www.youtube.com/watch?v=7silgM1uOAs&feature=player_embedded

Rehabilitation and Reclamation

•NEON will restore the site to host requirements.

•NEON can remove all infrastructure as well as restore the area impacted by NEON with native vegetation per site host requirements.

NEON Questions

Key Questions Framing Continental-Scale Ecology

1. What are the impacts of **climate change** on continental-scale ecology?
2. What are the impacts of **land use change** on continental-scale ecology?
3. What are the impacts of **invasive species** on continental-scale ecology?
4. What are the **interactive effects** of climate, land use and invasives on continental-scale ecology?
5. How does **transport and mobility of energy, matter and organisms** affect continental-scale ecology?

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