NEON Meeting

Harvard Forest, 1 August 2002
Summary by E. Boose with a few edits by D. Foster

HBR = Hubbard Brook, HFR = Harvard Forest, PIE = Plum Island

1. Participants. J. Aber (UNH Complex Systems Research Center, HFR and HBR LTER), E. Boose (HFR), E. Davidson (Woods Hole Research Center), M. Donoghue (Yale Biology/Peabody), A. Ellison (HFR), D. Foster (HFR), J. Hanken (Harvard OEB/MCZ), C. Hopkinson (MBL and PIE), B. Howarth (Cornell/MBL), G. Likens (Institute of Ecosystems Studies/HBR), J. Melillo (MBL, HFR), B. Schuster (Black Rock Forest), T. Fahey (HBR).

2. NEON Program. Reports from NEON workshops and interactions with NSF personnel.

- NSF ready to release RFP if budget is approved. NEON is a work in progress and fast track. NSF is concerned about getting the cart ahead of the horse, and is working to increase community involvement.
- Initial concept proposed by Bruce Hayden to Mary Clutter: How to position DEB for large instrument funding? Answer = distributed ecological observatories. History explains current constraints on funding & proposals.
- Initial competition = 2 sites. Subsequent competition = 4 sites. Goal = 15-20 sites encompassing ecological diversity of entire nation.
- Only one proposal from each region. LTER sites expected to take lead. Include museums & other sites as nodes.
- Focus = “nature and pace of biological change” at regional scale.
- Drivers = climate change, land-use change, atmospheric deposition, exotic species.
- Expected to address one or more national issues; e.g., invasive species, pests, diseases, genetically modified organisms.
- Core site must be a field station (not coastal).
- Secondary sites = 8-15, distributed, with tertiary sampling from secondary sites.
- Focus on high technology & communication networks, exotic species & biodiversity, census & monitoring of various taxa, sample archiving & storage capability. Some standard measurements (unlike LTER).
- Educational component: include REUs from smaller colleges.
- NFS is funding AIBS to develop guidelines and review process for NEON. AIBS concerned that NEON will be another LTER, for ecologists only.
- Possible regional centers**:** Northeast, Southeast, Pacific Northwest, Alaska, Southwest, Great Plains, Great Lakes, Rocky Mountain, Urban.
- Implemented as multi-institutional contracts.

3. NEON Budget. Current understanding of NEON budget.

- Setup. $20M over first 3 years to purchase or construct equipment. Overhead on salary for construction but not on equipment, no match required. Of the initial $20M: up to $4M to renovate existing labs & dorms (1:1 match required), $6-7M for base measurements common to all NEON sites, $2M for computers & communications, $10M at site discretion.
- Maintenance. $1M in first year, $2-3M in subsequent years (direct costs). 30-year program. Include salary for staff to maintain infrastructure.
- No annual budget for research. NEON scientists and others must obtain research funds from other sources. Favored status for proposals to work at NEON sites.
- A site could propose to offer a national service (e.g., gene sequencing). Costs for such services should not be included in budget.

4. Northeast NEON. What is special about New England / Northeast region?

- Best historical record embracing important land-use and land cover transformations.
- Best/longest water quality data.
- Highest & atmospheric deposits. "At end of nation's tailpipe."
- Rapid changes in key species – native and introduced aliens.
- Densest human population.
- Excellent museum collections.

5. Scientific Themes. Possible unifying themes for Northeast NEON.

1. Historical and ongoing land-use and land cover change provides a key and unique driver. Rise & decline of agriculture, forest regrowth, suburbanization. Existing information is piecemeal.
2. Metabolism. Organismal to landscape scale.
3. Spatial & temporal scales. Scale up measurements of net-C exchange, stream & precipitation chemistry.
4. Biodiversity – exotic species – species decline. Link structure & function. Create an inventory of organisms. Create distribution maps (current maps are poor). Digitize specimens. Need baseline biodiversity data, perhaps with focus on keystone species. Map genetic diversity of target microbial communities and relate to measurable functions. Study changes in food web.
5. Multiple stresses.
6. Linkages. E.g., hydrological flow & mass transport. Forests -> rivers -> coasts.
7. Eutrophication. Forests & coasts. Relate to species change. Nitrogen footprint increasing.

6. Scientific Stories. Stories of interest to both scientists and general public.

1. Sugar maple decline. Economic & cultural importance. Interesting roles of calcium storage, soil chemistry, fungi, diseases, climate change. Range is well

mapped. Study genetic diversity (include past specimens). Does sugar maple change sites or is sugar maple simply located on compatible sites? Comparison with historical processes (e.g. chestnut) and ongoing declines in other species (e.g., hemlock)

2. Amphibian decline. Relate to process. Impacts of decline are unknown.
3. Persistent organics. E.g., DDT, environmental estrogens, fertilizers.
4. Infectious diseases. E.g. West Nile, Lymes. Crows carry West Nile virus, but populations are growing.
5. Invasive species. E.g., Phragmites or purple loosestrife.

7. Scientific Objectives.

1. Document change in region.
2. Establish causal linkages.
3. Tell a few complete stories of interest to people (e.g., sugar maple decline, amphibian decline, infectious diseases)

8. Experiments. Watershed-level manipulations.

1. Species eliminations / exclusions. Remove sugar maple from watershed at HBR.
2. Throughfall elimination to simulate drought at HFR.
3. Eutrophication experiment at PIE.
4. Large-scale soil warming

9. Conceptual Diagram.

FACTORS ⇔ (METABOLISM ⇔ BIODIVERSITY)

- Factors = climate change, land-use change.
- Metabolism = eddy covariance, towers & weirs, hyperspectral center (w. GIS), technology inputs.
- Biodiversity = invasive species & species loss, genomics center, retrospective center (w. GIS), SEM center, digital imaging.
- Metabolism ⇔Biodiversity = watershed manipulations.

10. Equipment.

- Small aircraft.
- Hyperspectral instruments. Create partnership with industry to design / build new instruments. Still a new technology. Good for coastal zone studies. Use to create map of nitrifiers. Correlate with eddy flux data.
- Tall towers (up to 1000 ft) for extensive boundary layer measurements.
- Eddy flux towers. Add some fixed towers (like HFR & Holland). Roaming towers would extend spatial coverage, models could fill in temporal gaps. Combine with hyperspectral & stream chemistry data.

- Computer facility for managing, analyzing & visualizing very large data sets. Expensive, not currently in use by ecologists.
- Super GIS facility.
- Weirs for downstream, non-forested locations.
- Gene sequencers & environmental SEM.
- Automated gas analysis.
- Small mass spectrometers for isotope analysis. Reduce current processing delays.

11. Current Resources (3 LTER Sites, collaborators, field stations, museums)

- Harvard – Museum of Comparative Zoology, Herbaria, HFR.
- Yale – Peabody Museum.
- Cornell – supercomputer facility. Expressed interest in NEON
- HBR
- PIE-MBL – microbial observatory.

12. Discussion.

- Look forward & backward. Utilize information in existing collections. “Retrospective data capture.” Most collections and historical data still on paper.
- Automated instruments could reduce salary costs in some areas, but skilled personnel still needed (e.g., EMS).
- Instruments will become antiquated in ~10 years. Make best measurements possible now.
- Inclusion of infectious diseases (e.g. West Nile, Lymes) could bring in medical & public health scientists.
- Mixed model could combine focus on keystone species as well as entire taxa (e.g., fungi).
- Knowledge of landscape is currently the biggest limitation to predictive models.
- Organizational model: Administrator, Executive Committee, staff to maintain infrastructure (equipment, data).
- Compare models in other fields: supercomputer centers, supercolliders, Hubble telescope. Ecology more diverse, less standardization of methods.

13. Concerns.

- What will the science be? No clear examples to date. NSF will use the RFP to define the scientific objectives.
- How to attract the best scientists with no research budget?
- No equivalent to LTER Network Office, no long-term champion at NSF. Cross-division projects at NSF rarely last. How will program be managed at NSF?
- Added pressure on prototype sites to develop good scientific questions and push for long-term support at NSF.
- How to include agricultural & urban systems for New England?

- Significant administrative challenge. Centralized model would overwhelm field site like HFR.
- Significant information management challenge. Would information management be centralized? Need additional personnel.
- Significant specimen collection & maintenance challenge. Archiving may outpace analysis.
- NEON staff must both run operation and raise research funds.

14. Tentative Plan.

- Site = New England plus some part of New York.
- Possible core site = Harvard Forest.
- Strong emphasis on distributed model to reduce impacts on HFR.
- Hire administrator to run program.
- Use $20M to purchase equipment and “road test” by addressing initial science questions. Build infrastructure so others could address other questions.
- Build on existing strengths. E.g., eddy flux towers at HFR & Howland, hydrological studies at HBR, REU programs at HFR and elsewhere, Black Rock educational program, museum outreach programs. Add isotope & biodiversity measurements to current long-term experiments at HFR.

15. Write-ups.

- Manipulative experiments.
- Scientific stories.
- Regionalization methods.
- Retrospective methods.

Long-Term Biological Change in New England

(Draft Outline and Ideas for Discussion From 2000 Meeting)

Introduction

Our most pressing environmental problems are neither short-term nor small-scale. Regional to continental shifts in land use, air quality, and introduced organisms bring the tangible effects of human activities to remote areas. Time lags in ecosystem response, interactions with climate variability at the annual and decadal time scales, and the tremendous momentum behind patterns of human population distribution and economic activity all combine to assure that continuous, long-term measurements of ecosystem function and species distribution become increasingly valuable as the period of measurement increases.

The NEON program offers a unique opportunity to establish a set of perennial observatories with the explicit goal of measuring long-term changes in environmental stresses and biological processes using state-of-the art and emerging technologies. We propose a program of long-term measurements and inventories supported by advanced remote sensing, other new technologies and modeling, to assess current environmental trajectories and ecosystem responses across the New England region and in a series of natural experiments and large-scale manipulations.

The program will be centered at the Harvard Forest in central Massachusetts and through collaboration with a consortium of field stations, measurement sites, research programs, LTER projects, and educational collaboratives will provide an informed perspective on the most critical environmental processes in the broader New England region.

Purpose

The research program will identify and assess the impacts of the pressing environmental stressors affecting biological processes as conditioned by legacies of past changes in the New England region.

We perceive the most important current and future stressors to include:

- **Land use** activity and changes in land-use policy, especially urban and suburban expansion, resource use (logging, hunting, agriculture), conservation, and recreation
- The introduction of **exotic species** including pathogens and naturalized plants and animals
- Physical and chemical **climate change**
- Natural **disturbance** by storms, wildlife, and fire

The critical biological response parameters include:

- **Structural** changes in cover, age and size distributions
- **Compositional** changes in abundances of organisms, populations, rare, threatened and endangered species, and gene pools
- **Functional** changes in physiology (health), productivity, hydrology, biogeochemical cycles, and fluxes between the atmosphere and biosphere

In New England current conditions and future responses of critical environmental processes are conditioned by **ecosystem legacies** of prior land use, climate change, and disturbance. Consequently the environmental stressors and biological responses will be assessed in the context of past and ongoing ecosystem trajectories.

Structure

We propose a multi-tiered approach to capture the characteristics as well as mechanisms of major stressors and responses.

Regional Level: Many important stressors operate at broad scales across the entire New England landscape and can only be understood at this regional level. Assessing gradients and variation in these drivers of environmental change as well as emergent ecosystem responses is critical to understanding the mechanisms of change and to identifying key processes for intensive landcape and site study. Assessments will focus on key processes and on response variables such as atmospheric trace gas concentrations that (1) integrate many ecosystem processes and provide insights on regional metabolism, (2) have the potential to feedback on other broad-scale processes like climate change, and (3) can provide validation for model development. Assessments will be based on advanced remote sensing and airborne analyses, modeling, and regional measurement networks and archived data and will tie into three LTER sites (HBR, PLU, HFR), xxx field stations, and yyy collaborative centers. Measurements will focus on:

- Regional variation in environment, forest structure, land cover and vegetation composition
- Concentrations of CO_2 and other trace gases that are indicative of regional metabolism and forest productivity and are important feedbacks to the climate system
- Broad-scale disturbance processes and the movement of exotic organisms
- Changes in regional land policy (?)

Landscape to Sub-regional Level: With a range from urban centers in Boston and Worcester (New England's two largest cities) to extensive coastline in Cape Cod and the ilands of Martha's Vineyard and Nantucket to the broad Connecticut River Valley and up to the Berkshire Mountains, the state and landscapes of Massachusetts capture many of the important social, physical, and biological gradients in New England. In order to analyze processes that operate on a more local level and to utilize the available data and technologies most efficiently we will focus many measurements and studies on

Massachusetts and its sub-regions. We will also use these analyses to summarize conditions around the eddy covariance towers used in the large-scale experiments, and as drivers for ecosystem models which will be used to predict region-wide atmosphere/biosphere exchange rates. Assessments will focus on variation and gradients at physiographic and landscape scales and will include high spatial resolution hyperspectral remote sensing data, inventories, networks of field measurements, modeling, regional collections, and public data and cartographic sources. Measurements will focus on:

- Land use and land cover change
- Resource uses, especiallyt logging, agriculture, and conservation
- Impacts of disturbance, including exotic pathogens
- Biodiversity and changes in R,T, and E spp.

Ecosystem Level: Long-term measurements on control and experimental areas offer critical platforms for a wide variety of process-level, mechanistic, and quantitative field studies over multiple decades. These studies will take advantage of the site histories and existing research and experimental studies at Harvard Forest and other field stations. We will include natural experiments and large-scale manipulations in order to assess current and projected stresses and disturbances in the New England landscape, including:

- The impacts of the hemlock woolly adelgid and associated logging of hemlock on forest and aquatic ecosystem structure and function
- Invasive plant species effects on community organization, regeneration dynamics, and ecosystem function
- Forest fragmentation through conversion and human activity
- Climate change simulated through a large-scale (30 x 30 m) soil warming perturbation assessing feedbacks between plants and soils in response
- Nitrogen deposition interactions with forest disturbance assessed through nitrogen addition and forest harvesting manipulations coordinated with multiple eddy covariance towers for measurement of large-scale integrated forest ecosystem response (other treatments? How about a large scale irrigation/drought experiment?)
- Do we want to coordinate a biogeochemistry experiment with Hubbard Brook? Could get messy and/or expensive.

Education and Outreach: Several active and on-going programs in New England currently offer quality science outreach programs to both K-12 and adult populations. We propose that developing strong links to these programs is the most efficient method for communicating the results of this project to the public. Specific programs with which these links will be sought include:

- Black Rock Forest, linked to the NYC schools at K-12
- The Globe/Forest Watch Program at the University of New Hampshire working with high school teachers in New Hampshire and Maine, Appalachain Mountain Club, and the Boston Museum of Science. Boston/Arnold Arboretum
- Worcester. Ecotarium, Clark University

Potential Collaborators

Harvard
- OEB – Missy Holbrook, Colleen Cavanaugh, Doug Causey, Kathleen Donohue Insects, molecular?
- DAS – Ralph Mitchell
- Arnold Arboretum/HUH/N.E. Botanical Club – NE flora, plant conservation
- EPS

U.S. Forest Service
- WMNF and GMNF
- Hollinger

National Park Service
- Northeast Region Environmental Assessment
- Appalachian Trail Monitoring Program with AMC, C.H.W. Foster
- Parks – CCNS, Acadia, Other

UNH
- Globe/Forest Watch // Boston Museum of Science // AMC - Education

N.E. LTER Sites
- Hubbard Brook – USFS, Cornell, Syracues, IES
- Plum Island

UMass
- Wildlife – Field, Fuller, McComb
- Entomology – Joe Elkinton

Clark Geography
- Remote Sensing - Billie Clark, Worcester Co. Project

State Agencies (NE-Wide)
- EOEA – Mass.
- Heritage Programs
- Fish and Wildlife
- MDC

CT Insects/pathogens – Wargo, McClure
Black Rock Forest (Bill Shuster, Director)
- Science – Lamont?
- Education Program

The Nature Conservancy // MAS // TTOR
IES?
Dave Fitzjarrald, Kathy Moore – Meteorology, etc.
Other Universities – VT, ME, CT

DRF 9/03/00 Updated 10-3-02

Matrix: Environmental Drivers vs Biotic Responses and Characteristics Affected
(see matrix at end)

Cells filled to indicate type, intensity, and scale of activity in that area
e.g., C dynamics assessed at stand, landscape, sub-region, regional scales

Environmental Drivers

Legacies

Suburbanization

Logging

Hunting

Conservation

Introduced Organisms
- Pathogens – HWA, Asian Longhorn
- Exotic plants and animals

Climate Change

Atmospheric Stresses
- N Deposition
- Ozone
- CO_2

Natural Disturbance – Windstorm, Ice storm, Fire

Biotic Responses and Characteristics Affected

Vegetation Structure and Composition
- Age, size distributions
- Regeneration dynamics

Forest productivity
Carbon dynamics
Trace gas fluxes
N cycle

Biodiversity
- Wildlife
- Rare, Threatened ,Endangered species
- Genetic diversity and composition

Water quality (quantity)
Approaches (Scale: Site, sub-regional, regional)

Measurements

Permanent plots
Eddy flux
Airborne sensors
Remote sensing

Inventories – e.g., species, assemblages

Experimental studies

Natural experiments – e.g., HWA, logging, suburbanization, ice storms

Large-scale experiments and watershed manipulations

LTER experiments: N saturation, warming, hurricane, DIRT

Large (30 x 30 m) warming plot

Logging – with eddy flux, etc.

Modeling
Retrospective, current conditions, projections

Historical studies – establish legacies; quantify current trajectories

Harvard Forest NEON Environmental Stressors and Biological Responses

	Structure		**Composition**				**Function**		
	Age/Size	Cover	Abundance	Population	RTE Species	Genetic	Physiology / Health	Productivity / C Dynamics	Trace Gases
Land-use / Policy									
Suburbinzation									
Resource Use									
Logging									
Hunting									
Agriculture									
Conservation									
Exotics									
Pests									
Invasive Species									
Climate Change									
Physical									
Meteorology									
LT Climate									
Chemical									
N deposition									
Ozone									
CO_2									
Disturbance									
Wildlife									
Storms									
Fire									

Approaches

AS	Airborne Sensors	FS	Field Sampling
CD	Census Data	GS	Government Surveys
D	Dendrochronology	I	Inventories
EM	Experimental Manipulation	M	Modeling
EN	Experiment Naturel	RC	Regional Data (NOAA, USGS, USFS)
FM	Field Measurement	RS	Remote Sensing (Satellite 1970s ->, Air Photo 1930s ->)