Enhancing Network Connectivity at Harvard Forest

PROJECT SUMMARY

Over the last ten years the Harvard Forest has developed an integrated and cross-disciplinary research and educational program involving researchers and students from across the northeastern U.S. that focuses on the response of forest ecosystems to disturbance and stress resulting from natural and anthropogenic processes. During this period major improvements to computer facilities and telecommunications at the Harvard Forest have been completed with support from NSF and Harvard University. A recent facilities improvement award from NSF will be utilized to further enhance our computer facilities. However network connectivity at the Harvard Forest (which serves as both the administrative headquarters and the field site for the LTER program) still requires significant improvement. This proposal seeks to enhance connectivity at the Forest by (1) upgrading the speed of our network connection to the main University campus from 56 kbps to full T1, (2) extending our local computer network to the recently renovated Fisher and Raup houses, which provide residential, dormitory, and conference facilities for visiting scientists and students, and (3) extending our local computer network to the Environmental Measurement Site (EMS) tower, one of the core LTER experiments located in the forest at a distance of 1.5 km from the main facility. These improvements would build strongly on recent developments at the Harvard Forest, and would have a profound impact on scientists and students at the Forest, on Harvard Forest LTER scientists at other institutions, and on the growing user group of national and international scholars and scientists.

HARVARD FOREST LTER

Research Program

The landscape of New England was dynamic during pre-European times as a result of environmental change, natural disturbance and aboriginal impacts. However, through the last 300 years it has undergone a complete transformation as broad-scale deforestation for agriculture in the 18th and early 19th C gave way to land abandonment and extensive natural reforestation in the late 19th and early 20th C. Consequently, the major thrust of the interdisciplinary research effort at the Harvard Forest is to understand the modern structure, composition, and function of the largely second-growth forests in the context of the pre-historical forest landscape, natural environmental change, natural disturbance processes and recent human impacts. Thus, while we have intensive focused studies on individual disturbance and ecosystem processes such as hurricanes, gap dynamics, pathogens, nitrogen deposition, global climate change, and atmosphere-biosphere exchange, the unifying theme is the comparison of the response of forest ecosystems to these contrasting impacts.

Scientifically, the research program at the Harvard Forest is structured around five approaches: (1) reconstructive studies, in which paleoecological, historical, and modelling techniques are used to understand the pre-history and history of the landscape and to study processes that unfold over long periods of times or occur infrequently, (2) measurement and observational studies that seek to understand contemporary patterns and processes, (3) experimental studies in which ecosystems are manipulated to simulate important stressors or disturbances in order to study forest response in an integrated fashion, (4) integration of results within our research group and study region and with other research groups, and (5) application of results to natural resource management, conservation biology, and human health and environmental concerns. By covering a range of spatial scales (i.e. site, landscape, sub-regional, and regional scales) within a broad temporal perspective, we seek to place our intensive site-based studies at the Harvard Forest in a broad and general framework. We then seek to share the results as well as the discovery process of our research with a wide range of students, scientists, resource professionals, and the public.

Programmatically, our broad inter-disciplinary approach has been developed through involvement of diverse outside institutions and support from a wide range of agencies. The core of this research program is the NSF-funded Harvard Forest Long Term Ecological Research (LTER) program, which involves eight institutions, thirteen senior investigators, and has generated over 200 ecological publications since its initiation in 1988. A complementary program that involves a strong physical science team with expertise in atmospheric chemistry, meteorology, and modelling as well as ecosystem and ecophysiological ecology has been funded since 1990 by DOE through the National Institutes of Global Environmental Change (NIGEC) program. Also, since 1990 the Mellon Foundation has provided extensive support for research and training through the Harvard Forest Program in Land-use History, and since 1993 through the Harvard Forest Program for Ecological Training, the latter a joint effort with the Department of Organismic and Evolutionary Biology. Comparative studies of the landscape of Puerto Rico and New England have been promoted through the involvement of Harvard Forest researchers in two efforts: the LTER program at the Luquillo Experimental Forest, and a NASA program for Remote Sensing of Land-use Change. The policy and conservation implications of results from ecological studies at the Harvard Forest are being developed through two programs: a joint Program for Environmental Policy with the Kennedy School of Government at Harvard University and the Land-Use History of North America (LUHNA) pilot program supported by the National Biological Service. Finally, a new study on the long-term effects of land-use in the southern Yucatan region of Mexico has been initiated with funding from NASA and Clark University.

Site Description

The 1200-hectare Harvard Forest in north-central Massachusetts has been operated as a silvicultural and ecological research facility by Harvard University since 1907. The Forest lies in the New England Upland physiographic region, with moderate local relief ranging from 220 m to 410 m above sea level. The Forest lies in the Transition Hardwood-White Pine-Hemlock forest region. Dominant species include red oak (*Quercus borealis*), red maple (*Acer rubrum*), black birch (*Betula lenta*), white pine (*Pinus strobus*) and hemlock (*Tsuga canadensis*). Approximately 7% of the Forest is occupied by plantations of diverse composition and age. Detailed stand records, including prior site history and repeated growth measurements, are available for each plantation and many natural stands. A well-developed network of woods roads provides good access to all areas in the Forest.

Physical Plant

The physical plant of the Harvard Forest is unusually complete as a base for experimental research in forest ecology, ecosystem sciences, and forest microbiology. The brick headquarters complex consists of Shaler Hall, the John G. Torrey Labs, the Harvard Forest Archives complex, and the Fisher Museum. Shaler Hall, with nearly 15,000 square feet of space, contains offices, research laboratories, a seminar room, a library of 22,000 volumes, dining and kitchen facilities, and a photographic suite and darkroom. Three laboratories are used primarily for paleoecological, morphological and nutrient studies. A computer laboratory equipped with digitizing board, scanner, and related equipment is used extensively for research in spatial analysis and GIS. The adjacent garage complex has been converted into the Harvard Forest Archives for historical documents, data, plant and soil samples, and materials in cold storage. The Torrey Laboratory has been completely renovated for nutrient analyses, glasshouse studies, and trace gas analysis. University-owned houses and apartments include the recently renovated Fisher and Raup Houses which provide residential and dormitory space for visiting scientists, conferees, and students.

The Fisher Museum houses the Harvard Forest Models, twenty-three dioramas portraying the history, ecology and management of central New England forests. The Gould Audio Visual Center and lecture hall with seating for sixty persons is also on the first floor. On the second floor are exhibits related to forest ecology, root biology, soil science, plant/pathogen interactions, the effects of disturbance on vegetation, and the local history of land-use in Petersham. Offices and a complete herbarium of the local flora also share the second floor. The Fisher Museum Building provides some 10,000 sq ft of space devoted primarily to public education and partly to scientific research.

Computer Facilities and Network Connectivity

Computer systems and telecommunications at the Harvard Forest have developed at a remarkable rate over the last ten years, with funding from NSF and Harvard University. Highlights include the creation of a GIS Laboratory (1989), wiring of the core facility (Shaler Hall, Torrey Lab, and Archives) for telephone and data (1994), installation of a new telephone system with voice mail and cost accounting (1994), and installation of a network connection to the main University campus in Cambridge, Massachusetts (65 miles away) via a leased telephone line at 56 kbps (1995). Computer systems have evolved from half a dozen CP/M and early DOS machines to nearly 50 networked PC's running Windows 3.1, Windows 95, and Windows NT. Electronic mail service is provided by Unix servers on the main campus. The Harvard Forest Web page resides on LTERNET, a Unix server at the LTER Network Office in Albuquerque, New Mexico, and is augmented by CGI (common gateway interface) programs running on a Windows NT machine at the Harvard Forest.

A recent facilities improvement award from NSF (DBI-9812263) will be used in the coming months to make the following improvements to our computer facilities: (1) Two computers will be installed at the Fisher House and one computer at the Raup House for general use by visitors and students, (2) two high-capacity Windows NT computers will be installed in Shaler Hall as local servers, and (3) new computers and peripherals will be installed in the GIS Laboratory in Shaler Hall. The positive impact of these improvements would be greatly enhanced by the connectivity upgrades contained in this proposal (especially the upgrade of our network connection to a full T1, and the extension of our local network to the Fisher and Raup buildings).

Environmental Measurement Site (EMS)

One of the core experiments for the Harvard Forest LTER is carried out at the Environmental Measurement Site (EMS), located in the forest approximately 1.5 km from Shaler Hall. The EMS houses a long-term eddy flux facility for measuring atmosphere-biosphere exchange of CO_2, ozone, heat, and water vapor (with 10 years of data), as well as a designated network chromatograph from the Climate Monitoring and Diagnostic Laboratory (a NOAA-Harvard collaboration) for continuous measurements of halocarbon pollutants, CO, CH_4, and other gases. All of the instrumentation operates continuously, and would benefit enormously from Internet connectivity. A LAN is currently in operation at the site but is not connected to the outside world.

IMPROVEMENTS TO NETWORK CONNECTIVITY

Overview

We propose upgrades to our network connectivity in three areas: (1) The most critical area is the speed of our network connection to the University and the Internet. A site review of our LTER program, conducted by NSF in June 1997, recommended that "a T1 communications link should be a priority in the near future," but costs to date have been prohibitively high. We request funds in this proposal to upgrade our 56 kbps link to a full T1 for six years. (2) We propose to extend our local network from the core facility (Shaler Hall, Torrey Lab, and Archives) to the recently renovated Fisher and Raup houses. This upgrade would involve wiring both buildings for data and installing underground optical fiber from Shaler Hall to each building, and would provide full Internet access to visiting scientists and students in these residential and conference facilities. (3) We propose to extend our local network from Shaler Hall to the EMS (Environmental Measurement Site) tower located in the forest at a distance of 1.5 km from Shaler Hall. This extension, combined with the T1 upgrade described above, would make it possible to monitor equipment and download data from Cambridge (where the scientists running the experiment are located), greatly reducing operating costs and loss of data.

Connection to University Network

We propose to upgrade our network connection to the University from 56 kbps to a full T1 (1.54 mbps). The University would provide the necessary hardware upgrades at the Harvard Forest and in Cambridge. We request funds to cover the phone service installation fee ($1890) and six years of annual phone charges ($113,640). These figures are estimated costs from Bell Atlantic one year ago, plus ten percent.

The upgrade to a full T1 represents a 28-fold increase in connectivity speed for our facility. This upgrade would dramatically improve our ability to access the World Wide Web, to exchange data over the network, and to collaborate with scientists at other locations, making the Harvard Forest a more attractive research site for many scientists. It would also enable us to store and manage our Web page locally (not feasible with the speed of our current connection), improving the quality and timeliness of Harvard Forest resources on the Web for virtual visitors. Remaining on the Harvard network would ensure our continued access to University resources, including access to software and to restricted administrative and financial databases on Harvard servers.

Connection to Fisher and Raup Houses

We propose to extend our local network from Shaler Hall to the Fisher and Raup Houses (distances of 600m and 300m, respectively). This upgrade would involve installing underground optical fiber from Shaler Hall to both buildings, wiring both buildings with category 5 data cable, and installing three network hubs. These prices are estimates based on conversations with Harvard University networking personnel and the contractor (Comm-Tract) that wired our core facility in 1994.

The Fisher and Raup Houses provide residential and dormitory facilities for visiting scientists and for students associated with the Harvard Forest summer research program. The Fisher House also provides meeting space for small to medium-sized conferences. The proposed extension of the Harvard Forest local network to these buildings, combined with the upgrade of our network link to T1, would provide full Internet access to visitors and students using these facilities, reducing demand on the computer laboratories in Shaler Hall and enabling conferences to utilize network access during meetings.

Connection to EMS Tower

We propose to extend our local network from Shaler Hall to the EMS tower. When the EMS was installed in 1989, electrical power and telephone lines were extended from Shaler to the EMS in a dug trench, later back-filled with sand. We request funds to excavate and back-fill the trench, and to install 12-strand optical fiber with termination at both ends. The excavation work would be carried out by the Harvard Forest, and the estimated cost is based on recent and similar projects. Material and labor costs for the optical fiber installation are based on vendor catalog prices and conversations with the wiring contractor (Comm-Tract).

Internet connectivity would provide significant benefits for the EMS project, including: (1) Routine automatic status checking for instrument anomalies or faults. Critical data losses have occurred in the past due to the delay in discovering power outages, computer hang-up, etc. (2) Routine downloading of calibration files to allow remote QA/QC and to provide early warning of problems. (3) Data transfer of full data sets (10 - 20 mb/day). This would save enormous amounts of travel and time for personnel based in Cambridge. (4) Operator intervention over the network to restart instruments after faults. Currently this can be done only on site. In addition, the fiber optic cable could be used to extend network connectivity to other ongoing or future experiments in the general vicinity, such as the Harvard Forest Soil Warming Experiment.

Benefits to Research and Education

The proposed improvements to network connectivity would build strongly on recent developments at the Harvard Forest, and would have a profound impact on the growing user group of national and international scholars and scientists. On-site visitors and staff

would benefit from better access to scientific resources on the Internet and from improved local connectivity. Off-site visitors would benefit from improved access to Harvard Forest resources made possible by faster connectivity and local management of the Harvard Forest Web page. The larger research community would benefit from increased opportunities for collaboration and advances in data management that would result from the proposed improvements.