Internet supplement March 1999
North Temperate Lakes LTER
Supplement Proposal for Enhanced Field Station Internet Access
March, 1999

We request an Internet Upgrade supplement (Intellectual Infrastructure) to our North Temperate Lakes Long-Term Ecological Research award (DEB 96-32853) to enhance internet connectivity at our field sites. High speed internet connectivity at our field sites will be crucial for the long-term, regional, data collection, analysis and integration necessary to understand long-term phenomena and processes affecting lakes and their surrounding landscapes. We consider high speed internet connectivity at our field sites to consist of two separate, but interrelated, parts; (1) a T-1 or faster connection at the field stations themselves, and (2) high speed wireless internet access for researchers or data collecting instruments deployed in the field. Our vision is that a researcher or instrument located anywhere in our study areas, even in the middle of one of our study lakes, will have the capability for high speed internet connection. We request funds to move us closer to this goal.

Connectivity to Field Stations: Enhanced connectivity from our field stations to the internet is important in at least two ways. First, our LTER research routinely deals with large data sets such as those generated by satellite or earth-based remote sensing. The ability to move and access these data conveniently to and from our field stations is essential. Second, communication among our research team is critical to achieving an integrated and efficient research effort. Currently, our group's communication is done via email, telephone conference call, or travel between Madison and Trout Lake. High speed internet connectivity allows additional capabilities, such as videoconferencing and workshops, that would significantly enhance communication of Trout Lake with the Madison campus, the LTER network, and the rest of the scientific and education community. In addition, high speed communication will allow computer administrators located in Madison to configure and manage information systems located at Trout Lake.

Real Time Sensing of the Environment: Much of our data collection is done currently using instruments traditionally available to limnologists, many of which were first designed decades ago. Using high speed connectivity to sophisticated equipment at our field data collection sites, and making these data available to researchers over the web in real time, will improve significantly our data collection and analysis capabilities. This requires high speed connectivity to the internet at the site of the sensor, which is often in a relatively remote location, such as the middle of a lake. Importantly, this also will provide experience essential to the development of more expansive spatial arrays of sensors potentially possible in the future.

The North Temperate Lakes LTER project focuses its field research in two locations: the Northern Highland Lake District in northern Wisconsin, and four lakes and their surrounding landscapes near Madison in southern Wisconsin. The northern Wisconsin site is serviced by the Trout Lake Station, a remote field station of the Center for Limnology. The Trout Lake Station is located approximately 300 km north of Madison and 12 km south of Boulder Junction, the closest town. The station has reliable electrical and telephone service. The station is embedded in a forested landscape of relatively low relief and provides access to the more than 2500 lakes of the Northern Highland Lake District, roughly a circular region approximately 100 km in diameter in which the Trout Lake Station is near the center. The Trout Lake Station currently has a dedicated 56 Kbps line that terminates at the University of Wisconsin Stevens Point campus, about midway between Madison and Trout Lake.

The Laboratory of Limnology on Lake Mendota at the University of Wisconsin-Madison campus serves as the field station for the southern Wisconsin field site and as the administrative home of the Center for Limnology. Lakes in the southern field site are embedded in gently rolling agricultural and urban catchments. Currently, the Laboratory of Limnology on Lake Mendota has high speed access to the campus network (Asynchronous Transfer Mode at 100 Mbps).

We request funds to (1) upgrade the internet connection at the Trout Lake Station to a dedicated, Point-to-Point T-1 line, (2) purchase the necessary video conferencing equipment to allow group video communication and workshops via the internet between Trout Lake and Madison, and (3) deploy a series of instrumented buoys and roving units for our study lakes and their catchments and make the data they collect available in real time over the internet to the Trout Lake Station and the Madison Campus. The two partner schools in our Schoolyard LTER program, the Arbor Vitae-Woodruff Elementary School in Woodruff, and Prairie View Elementary School in Verona, already have access to the internet via modem connection or better.

1. T-1 Internet connection at the Trout Lake Station

We propose to implement a Point-to-Point T-1 connection to the Trout Lake Station through a contract with the University's Division of Information Technology, which will provide the service. We will be on a statewide network, BadgerNet, which has been established to promote high speed internet connectivity to university campuses throughout Wisconsin. Being part of this network will allow us to connect Trout Lake in northern Wisconsin to the Laboratory of Limnology in Madison with a minimum number of hops

and avoid congestion associated with commercial use of the net. We currently contract with the Division of Information Technology for the 56 Kbps service to Trout Lake and have found the service and support to be reliable.

Costs associated with the Trout Lake T-1 connection are outlined in Table 1, below. The annual costs cover phone line rental and system administration by the Division of Information Technology. We request funds to cover six years of annual costs. We will also need to upgrade the Trout Lake router and purchase ethernet switches to better integrate the local area network at Trout Lake.

We are also actively investigating an alternative framework that would yield D3 speeds at Trout Lake for approximately similar costs. This would involve joining a local consortium of K12 schools, one of which is associated with our Schoolyard LTER program, and laying approximately 1 mile of fiber optic line. We will actively pursue this option should it look favorable.

2. Video Conferencing Capability between Trout Lake and Madison

As the North Temperate Lakes LTER project has grown both in scope and number of principal investigators, effective communication between scientists and staff at Trout Lake and Madison has become more of an important issue. Currently, communication is done by email, telephone call, or travel (8 hours round trip) between Trout Lake and Madison. We routinely hold meetings every two weeks, alternating between meetings of principal investigators only and those involving the entire project staff. Both types of meetings involve personnel at Trout Lake and in Madison. In addition to these group meetings, daily communication occurs year round among small groups of project personnel between Trout Lake and Madison. Finding ways to enhance efficient communication among project personnel is an important need. Our goal is to find ways to make efficient and quality communication among personnel as independent as possible of physical location.

High speed internet access between Trout Lake and the Laboratory of Limnology will allow us to introduce video conference capability. We believe that video conferencing will greatly enhance communication between scientists and staff at these two major field stations of the North Temperate Lakes LTER project. Not only will video conferencing be useful for group meetings and workshops, but it will also enhance collaboration among smaller working groups. For examples, a graduate student and mentor could interactively develop scientific meeting presentations; two researchers could simultaneously view computer model runs; and we could provide training sessions on field use of equipment or computer software from remote locations. We request funds to establish two video conferencing stations, one at the Trout Lake Station and one at the Laboratory of Limnology. Each site will be equipped with hardware and software dedicated to videoconferencing. Hardware at each location will consist of a computer, a video camera, a computer video projector, a touch pad drawing tablet that serves as an electronic "white board", and a document camera capable of displaying high resolution images of paper documents. We will use Microsoft Netmeeting software, which is available for free download over the net. Each videoconferencing workstation will be connected directly to a T-1 connection. Details of the requested equipment are given in Table 2.

3. Internet Connectivity to Remote, Portable Environmental Sensing Platforms

Our vision of high speed internet connectivity at our field sites consists of more than a building wired for T-1 connection and the enhanced communication that such a connection allows. Our goal is to provide a research environment where a researcher or instrument can access the internet at high speeds anywhere at the field site, including relatively remote sites such as the middle of a lake.

The ability to have instrumented buoys on lakes making measurements at sub-daily frequencies and having these data available real-time over the internet will allow us to more fully understand the mechanisms underlying year-to-year differences in lake dynamics. One of the major scientific underpinnings of the North Temperate Lakes LTER project is the collection, maintenance, and analysis of its long-term core data sets. To date, with the exception of meterological data and an instrumented raft on Sparkling Lake, we have been limited to a frequency of data collection for standard limnological data of every two weeks during the open water season and every five weeks during ice cover.

Because of the rapid dynamics that typically occur in lakes, it is likely we are missing short-term dynamics that can have important long-term effects and provide new annual parameters of lake behavior. For example, phytoplankton have life spans of hours to days and algal biomass can peak and wane in a matter of days to weeks. These fast dynamics have important implications for oxygen concentrations, CO2 dynamics, microbial communities, and zooplankton growth. As another example, several of our shallow lakes mix occasionally throughout the summer. Each mixing event replenishes nutrients to the surface waters with potentially important consequences for food webs. With our current sampling frequency we do not characterize these events well. Moreover, in the deeper lakes the timing of thermal stratification in the spring can influence the algal and zooplankton dynamics for the rest of the growing season. Because of limited data on short-term thermal dynamics of lakes, validation and analysis of predictions of physical models of thermal dynamics of lakes is made difficult. We have ongoing collaboration with physical modelers who require high frequency thermal data.

By enhancing our ability to measure short-term dynamics of physical, chemical, and biological variables we will also be able to address, on a theoretical level, how variance is related to timescale. For example, in a perfectly turbulent system we expect variance to be related to increasing timescale linearly with a negative slope. Understanding the variance versus timescale relationship of algal blooms, for example, would allow us to determine at what timescale processes other than turbulence become important in influencing these blooms. Moreover, we will be able to compare these relationships among a set of physical, chemical, and biological variables. This builds on our earlier work at North Temperate Lakes LTER of understanding mechanisms influencing interannual variability of broad suites of variables.

We propose to use wireless, spread spectrum radio technology to provide high speed data communication between remote field sites and our field stations. These radios consume low amounts of power, can reach up to 25 miles line-of-sight, and are capable of transmitting at speeds from 115 Kbps to slightly faster than T-1 speeds.

We will develop two types of remote instrument packages: instrumented buoys and "roving internet units." We will deploy an instrumented buoy over the deep hole in each of three lakes. The buoys, such as those designed and engineered by Apprise Technology and other suppliers, consist of a surface float and a tethered underwater sensor package that has buoyancy control and can be raised and lowered throughout the water column at programmed intervals. Data will be continuously transmitted via spread spectrum radio to a relay located on a communications tower near the Trout Lake Station or a tall building near the Laboratory of Limnology on Lake Mendota and sent on to a file server at the field station where it will be published on a web site. The buoys are powered by solar panels attached to the floats. They are currently being used by others on the Great Lakes and several inland lakes in Minnesota. We will mount a variety of sensors on each buoy including sensors for temperature, dissolved oxygen, conductivity, pH, turbidity, ammonia, total dissolved gas, nitrate, chloride, downwelling radiation, and chlorophyll. Each buoy will also be equipped with standard meteorological instruments to measure air temperature, relative humidity, and wind speed. In the future we anticipate adding sensors for light transmissivity, pCO_2, and acoustic sensors capable of detecting zooplankton and fish-sized particles.

The roving internet units will be designed to be highly portable and capable of being configured with a variety of sensors. The basis for the roving units are a ruggedized laptop computer and a spread spectrum radio. We request funding for three of these basic units, one at Trout Lake Station, one at the Laboratory of Limnology, and a backup unit. Other potential applications include field data entry via keyboard with immediate transmission to the field station, or capability of accessing large data files via the internet while at remote locations in the field.

We anticipate needing to locate a receiving spread spectrum radio on a tower that has near line of sight to the field locations. In the north we will lease space on a 300 foot communications tower owned by Wisconsin Electric Power Company and located within 5 miles of Trout Lake Station. In the south we will mount the radio on the top of the 13 story Atmospheric, Oceanic and Space Science building. Corresponding receivers are required at the two field stations.

Specific items and their costs are detailed in Table 3, below. For some items we have been able to negotiate discounts for multiple orders. While individual suppliers are identified for illustration, the University of Wisconsin makes such purchases through a bidding process.

Summary

We propose to (1) provide a T-1 connectivity to the Trout Lake Station, (2) use the T-1 connectivity to implement video conferencing capability between the Trout Lake Station and the Laboratory of Limnology on Lake Mendota at the Madison Campus, and (3) install internet connectivity directly to remote field sites on our lakes and in our catchments to real time data collecting sensors. Collectively, the T-1 internet connection for Trout Lake, videoconferencing capability, and remote, portable environmental sensing platforms connected to the internet will enhance greatly our technical capabilities at our field stations to take advantage of internet connectivity. The increased connectivity will enhance participation and efficiency in research and educational workshops and conferences. The increased connectivity also will allow time integration of field measurements, incorporation of short-term variability into our characterization of the long term behavior of lake ecosystems, and facilitate analyses of algal blooms and other ecological processes at appropriate time scales for characterization. This project is a key step towards developing the North Temperate Lakes LTER field sites to serve an extended spatial array of environmental sensors that will become necessary in the next generation of environmental observatories.