REF: Connectivity Supplement Request for Kellogg Biological Station LTER

CONTACT
G. Philip Robertson
Professor and PI, KBS LTER Project

1) background on the Kellogg Biological Station, including current computing capacity
2) a brief description of the KBS LTER Site, including a description of site data management
3) background on our K-12 outreach program,

1. The W.K. Kellogg Biological Station

The W. K. Kellogg Biological Station of Michigan State University (MSU) is a year-round research and education facility located in southwestern Michigan, about 100 km from the main MSU campus. Since its origin in the early 1950's, KBS has established a strong record of research, education, and service in the fields of ecology and evolutionary biology.

The Biological Station has a full-time research staff of about 50 people. There are eight resident KBS faculty who hold appointments in five MSU departments (Zoology, Botany and Plant Pathology, Microbiology, Crop and Soil Sciences, and Geology). In addition, there are annually about 20 graduate students and 4-5 postdoctoral researchers in year-round residence. During the summer field season, the scientific community of KBS swells to include on average 20 visiting scientists, 12 visiting graduate students (many of which receive summer support from an NSF-sponsored graduate Research Training Group [RTG] at KBS), about 80 undergraduate students taking summer classes, and 8-10 undergraduate student researchers participating in an NSF-sponsored Research Experiences for Undergraduates (REU) program at KBS.

The land base for KBS includes about 1,500 ha of diverse habitats, including forests, fields, streams, wetlands, and lakes. A total of 668 ha are contained within the contiguous station holdings, with an additional 240 ha located in the Kellogg Forest a few km to the south and 530 ha in the Lux Arbor Reserve. The Lux Arbor Reserve, located 17 km north of the station, contains a wealth of relatively undisturbed habitats, including ponds and wetlands, and the Reserve borders Middle and Lower Crooked Lakes. In addition, over 200 natural water bodies occur within a 30 km radius of KBS, as well as a number of small streams and rivers. This combination of natural and managed resources, all located near a modern, well-equipped laboratory provides an exceptional opportunity for ecological research.

Academic-Stack Buildings and Computer Facilities -

Individual faculty laboratories, offices, and common graduate student areas are located in the Academic Building, which was constructed in 1985 with a grant from the W.K. Kellogg Foundation, and in the attached Stack building (remodeled in 1985). Three graduate student offices house resident and visiting students, and each of these offices has a computer work area with two networked PC's and a printer. KBS Computer Services is staffed by a full-time computer specialist and part-time personnel. The KBS network at all locations has 130 computers, plus about 50 other networked peripherals and devices. Network servers host file services, SAS statistical software, network printer services, World-Wide Web servers, an e-mail server, and disk backup services. Common-use facilities include a graphics workroom with film recorder, color printers, and scanning devices. Our connection to the Michnet network is presently via a 128 Kbps ISDN line.

Visiting scientists and visiting graduate students have access to computers and the internet at a number of KBS locations, including the computer workroom, graduate student offices, and the KBS library. The KBS library is located in the Academic building. This branch of the MSU library receives over 200 journals, is staffed by a library clerk and a campus librarian, and has up-to-date computers and printers for database searching. Other common use facilities include darkrooms; isotope counting, CHN analysis, and microscope rooms; environmental chambers and autoclave; and common-use labs dedicated to electrophoresis and image analysis, and wet and dry labs for field sample processing.

Greenhouse -

A 3600 sq. ft. greenhouse (remodeled in 1986) is located near the Academic building and serves the needs of both terrestrial and aquatic researchers. The greenhouse has a total of seven separate growing areas accessible by a common hallway, with each area separately thermostated to control the heating and cooling system. One room of the greenhouse is a plant propagation area while another room has been wired to serve the higher power demands of water pumps and other equipment for aquatic research.

Lakeside Laboratory –

This facility, the original estate boathouse located on Gull Lake, was renovated in 1980 with NSF funds. It now provides year-round research space for visiting and resident researchers and includes a wet laboratory and dry laboratory on the ground level, and a dry laboratory and research cubicles on the upper level. Offices and labs in this building are scheduled to be ethernetted and connected to the KBS fiber optic backbone in the year 2000.

Field Laboratories -

A number of field laboratories augment the research facilities on site. These year-round field laboratories were developed to provide convenient access and support for sampling the diverse habitats available at KBS. One of these laboratories is the Field Ecology Lab, located next to old field habitats; another is the Farming System Center, located adjacent to agronomic areas; and a third is the Pond Lab, located next to 18 experimental ponds built with NSF funds in 1971.

Conference Facilities -

In addition to academic and field ecology facilities, KBS also maintains a Conference Center that is staffed year-round, with a cafeteria and overnight accommodations for >100 guests. The Conference Center is used exclusively for academic and research programs during the summer, including undergraduate and graduate field courses and research activities, including the REU and K-12 programs.

2. The KBS LTER Site

The KBS LTER Site represents the agricultural or row-crop ecosystem. Research at the site is directed towards understanding ecological interactions underlying the productivity of both annual and perennial field crops. These include corn, soybean, and wheat rotations as well as forage crops such as alfalfa, and agroforestry crops such as poplars. Contrasts with natural forest and old field (successional) sites provide important points of comparison for gauging the effects of intensive management on the ecology of organisms in modern field crop ecosystems.

Research Overview -

One of the organizing questions of the KBS LTER Project centers on the role of biodiversity in the agricultural landscape, and in particular on the functional significance of diversity with respect to ecosystem function. To the extent that agronomic management reduces the structural complexity of various biotic communities within the crop ecosystem, the primary questions become:

- what are the key features of the row-crop ecosystem that regulate biotic complexity
- what -- if any -- are the ecosystem-level consequences of a reduction in complexity, and
- to what extent can we manage complexity to lessen what may be an escalating need for subsidies.

A principal thrust of KBS LTER research is to address questions related to this biotic simplification, i.e. to the patterns, causes, and consequences of changes in community complexity as a function of row crop ecosystem management. We focus on three major taxonomic groups of central importance to row-crop ecosystem function:

1. soil microbial and soil invertebrate communities affect organic matter dynamics and biogeochemical processes critical to crop growth;
2. communities of aboveground consumers -- pathogens and insects operating at several different trophic levels -- that can severely affect primary productivity in outbreak years; and
3. plant communities, which largely drive nutrient dynamics and both belowground and insect community structure.

The consequences of changes in complexity will be expressed at the ecosystem level as changes in primary productivity and nutrient cycling.

Experimental Design -

Most KBS LTER research is carried out in a series of 11 types of plant communities, ranging from annual corn-soybean-wheat rotations to late-successional deciduous forest. All communities are replicated within the landscape. Our experimental design provides four annual cropping systems managed with a range of chemical-input intensities (from full to zero chemical inputs); two perennial cropping systems (one herbaceous [alfalfa] and the other woody [*Populus* sp.]); and two successional communities (one historically tilled and one never tilled). In 1993 we added three additional communities to the design, for a total of 5 unmanaged communities that now include three later successional oldfields abandoned from cropping 40-60 years ago, three planted conifer stands, and three older-growth hardwood stands.

This design provides a wide range of replicated communities with the same pedogenic history that differ in key ecological characteristics (e.g. plant species diversity, productivity, litter quality, microclimate). This allows us to test specific hypotheses from which we can better infer the ecological mechanisms that confer productivity in row-crop ecosystems – mechanisms that can then be tested with specific manipulative experiments. Baseline measurements are taken from all 11 community types, but not all communities are used to test every project hypothesis.

Data Management and Computing Needs -

Computing needs within the KBS LTER fall within 3 categories: investigator communication (both text and data transmission), communication with field instrumentation (both experiment and data acquisition hardware), and long-term data management. KBS LTER data management is supervised by a full-time data manager. The LTER database (including our web site at http://lter.kbs.msu.edu) is maintained on an NT server, part of the Station LAN. The value and effectiveness of our web-based data management system is reflected in the increasing number of students and investigators involved in the LTER project who rely on the web as their first or primary point of contact for site data, where previously they contacted individuals in the core lab. The database is also used by non-KBS researchers; we typically record >100 different non-MSU users per day. The data sets used most frequently by these outside users included weather, net primary production, biodiversity, and spatial data.

3. K-12 Outreach

We are in the beginning stages of formally incorporating a K-12 outreach program into our LTER work. KBS as a field station has a long history of both K-12 and informal education, including professional development activities for K-12 teachers. Of particular note are a recent science curriculum reform project funded through the W.K. Kellogg Foundation (*Youth Education* Project), ongoing NSF Summer Science Institute Teacher workshops, and a summer institute for scientifically gifted high school students (*Habitats and Organisms*).

Our new LTER-specific outreach centers on two rural school districts in the KBS area. With modest initial funding from NSF beginning this year, we have initiated a program to incorporate LTER science into the curriculum at the middle school level (grades 6-8) in the two districts. To date, this effort has involved 3 planning meetings with district-wide curriculum directors, teachers, and KBS co-PI's, and a 1-day workshop held this fall to introduce the teachers to the LTER site, to LTER science, and to allow them to identify curriculum priorities for joint development. Fifteen science teachers (12 middle school teachers, 2 high school teachers, and 2 elementary science specialists) participated in the workshop. A week-long workshop to be held in June 1999 will produce specific curriculum modules for use the 1999-2000 school year.

Our goal as LTER researchers is to facilitate a teacher driven, teacher developed curriculum that will not replace but rather enhance and expand the current middle school science curriculum. We have chosen to concentrate at the middle school level for now because this was the level the district curriculum directors identified as having the greatest need (based on standardized test scores), and because of linkages that could be facilitated both down to the elementary levels and up to the high school.

What is the curriculum we plan to enhance? A major part of the core Michigan science curriculum is focused on understanding ecosystems. Specific objectives at the Elementary, Middle School, and High School levels relate to 5 over-arching ecosystem-level questions:

1. How are parts of an ecosystem related and how do they interact;
2. How is energy distributed to living things in an ecosystem;
3. How do communities of living things change over a period of time;
4. How do materials cycle through an ecosystem and get reused in the environment; and
5. How do humans and the environment interact.

During the September workshop we identified three major topics that could be developed into inquiry-based modules: Succession, Nutrient Cycling, and Energy Flow. By establishing modules that emphasize the process of succession, C and N cycling in different habitats, and the roles and causes of disturbance in these habitats we expect teachers to be better able to deliver key ecosystem concepts and facts. Because the modules will be inquiry-based, students will also be further exposed to the hows and wherefores of doing science, i.e. receive hands-on experience with the scientific method, from formulating testable questions to analyzing collected data.

We anticipate establishing long-term building-based experiments – e.g., successional plots at each school – in order to provide teachers a local context in which to conduct experiments. KBS involvement is projected to include providing resource scientists to each building, hosting a field trip to KBS for each middle school science class (there are about 1200 middle school students in the two districts), helping to establish and maintain www pages on which long-term data can be accumulated and analyzed, and helping to assess and redesign the modules as needed. We would like to provide (and the teachers would like to have) resource scientists in the respective middle school buildings on a regular basis, and also available electronically. With sufficient funding, this might take the form of graduate students assigned to specific teachers to facilitate experimental design, field sampling, and sample and data analysis for the modules that will be developed at the June workshop. The modules will be developed to use existing resources at each school, though we hope to approach other funding sources to supplement equipment and instrumentation on hand. For example, a ceptometer to measure light interception and a portable IRGA to measure CO_2 fluxes come immediately to mind as simple instruments that would be amenable to a middle school science classroom.

With sufficient connectivity resources, we would also be able to incorporate into our curriculum modules activities with high-bandwidth requirements. These might include access to remotely sensed environmental imagery as well as interfaces to large long-term databases. Additional bandwidth would also provide valuable distance learning opportunities such as allowing students at multiple sites and workstations to videoconference among themselves and with LTER scientists (both at KBS and at other LTER sites) about experimental results or data analysis and interpretation issues.

Summary

Thanks very much for the opportunity to apply for this support. We believe that internet connectivity is a crucial aspect of providing access to KBS LTER science – for use by project scientists, for use by the broad scientific community with interests in our databases, and for use by and with our K-12 (indeed, K-16) science constituents. We're very pleased that NSF recognizes the importance of this access. If you have any questions about this request please don't hesitate to contact me; I can be reached by email or fax (616/671-2351) if not by phone (616/671-2267).