Bulletin

GPS Status Report

{prepared for the Spring '92 LTER Coordinating Committee Meeting by W. Michener (NIN) with input from W. Jefferson (NIN), J. Porter (VCR) and R. Carlson (VCR)}

Two Pathfinder GPS units are located at each of the five regional centers. Most have been upgraded to 6-channel receivers and the remaining units are currently being upgraded. Several sites have established MOUs with the regional centers and are utilizing the Pathfinders at their sites. No significant problems have been reported to date.

The three high precision 4000SST units have been used to establish horizontal and vertical control points at the North Inlet and Central Plains Experimental Range LTER sites. The units are currently being utilized at the Virginia Coast Reserve LTER site to develop a large network of control points. By the end of 1992, the units will have largely paid for themselves based on the number of control points projected to be established and the costs charged by consulting firms to establish accurate control points. Scheduling activities are discussed below.

1992 Schedule for the High Precision Units

Now ---> March 15 Virginia Coast Reserve (requested by Randy Carlson)

March 15 ---> May 1 Sevilleta (requested by James Brunt)

September ---> October Andrews Forest (requested by Art McKee)

This schedule exhausts our allocation for 1992. Time slots for 1993 time are currently being reserved. Tentatively, the schedule for 1993 is designed to support GPS campaigns at the more northerly LTER sites. However, this can be adjusted depending on needs.

Preliminary 1993 Schedule for High Precision Units

May 1 ---> May 30 Hubbard Brook (requested by Steve Smith)

June ---> October are currently open.

A formal request must be submitted by email or snail mail to reserve a time period. Requests are dealt with on a first come - first serve basis. However, sites that have not had access to the units will be given preference over those sites that have. Some rough guidelines that may prove useful, based on experience at CPR, NIN and VCR:

(1) The total cost to ship the three receivers across country is @ $675. It is best if sites located close to one another can coordinate campaigns to reduce costs.

(2) The first 2-3 days of a campaign should be scheduled solely for testing and personnel training. All monuments should ideally be established prior to the campaign.

(3) Processing takes much longer than might be anticipated. We will attempt to get additional copies of the software if funding is available so that sites may process data at a more leisurely pace. Advanced processing software which supports network adjustment, etc. has been found to be useful at VCR. The Network currently does not own this software (retail costs are @ $20,000/copy, but we may be able to get a much reduced rate). If supplemental funding is available, this would appear to be an important item for consideration.

(4) UNAVCO provided one technician (gratis) for assistance with the VCR campaign. It may be very worthwhile for sites to consider bringing in a UNAVCO technician for the first couple days or so. Travel and per diem would only have to be covered by the LTER site. UNAVCO covers all salary expenses. This is much better than bringing in a consultant (which typically costs $200-400/day plus all expenses).

(5) All LTER sites are encouraged to tie into the international fiducial network. This requires slightly longer data collection times, but enables us all to develop much greater confidence in our control points.

(6) As more sites gain experience with performing GPS campaigns, all sites stand to benefit. Thus, it is useful to confer with individuals at those sites that have completed campaigns when developing your own plans. Presently, Jeff Jefferson and myself (North Inlet) and Randy Carlson and John Porter (Virginia Coast Reserve) have the most experience in planning and conducting campaigns. After May, presumably James Brunt and Greg Shore (Sevilleta) could also provide expert assistance.

GPS Support Vital to Long-Term Ecological Research Program

BY WILLIAM K. MICHENER

The National Science Foundation (NSF) initiated the Long-Term Ecological Research (LTER) Program in 1980 to support long-term ecological studies. The program is based on the concept that short-term studies can be misleading since they can't account for the natural processes and changes that occur over decades and centuries. Furthermore, long-term studies are necessary to place rare events or disturbances (e.g., hurricanes, fires, volcanic eruptions, etc.) into a realistic temporal context.

Presently, NSF funds 18 LTER sites. The sites extend from northern Alaska to the Antarctic and are divided into five regions: northwest, southwest, midwest, northeast and southeast. A diverse array of environments are being studied, including agricultural, coastal, desert, forest (boreal, temperate and tropical), lake, river, stream and tundra ecosystems. Five core areas have been identified as central research themes at the 18 sites:

- patterns and control of primary production;
- spatial and temporal distributions of populations representing trophic structure;
- patterns and control of organic matter accumulation in surface layers and sediments;
- patterns of inorganic inputs and movements of nutrients through soils, groundwater and surface waters; and
- patterns and frequencies of site disturbances.

Hurricane Hugo inflicted extensive forest damage to a large area of coastal forest near North Inlet, S.C. Color infrared aerial photography and GPS ground surveys were used to generate this GIS data layer (inset).

GIS/GPS Development

During the mid- to late 1980s, LTER and NSF scientists recognized that access to newer technologies is essential to adequately address many of the questions inherent in the five core research areas, especially spatial patterns and processes. Consequently, over

the past three years all LTER sites have begun developing a GIS for their research areas. Furthermore, Landsat Thematic Mapper, SPOT and AVHRR imagery, as well as aerial photography, are routinely used at many of the sites to examine primary plant production patterns, delineate pertinent geomorphological features and assess the impacts of site-specific (i.e., fire) and regional (hurricanes, droughts, etc.) disturbances.

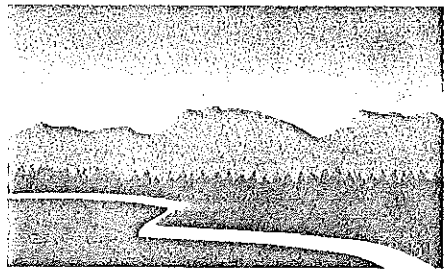
The most expensive and difficult aspect of GIS development is acquiring high-quality data layers. Incorporating both ground observations and remotely sensed data (particularly low-altitude aerial photography) into a GIS requires accurate knowledge of all ground control and sampling sites (points), boundaries (lines) and areas (polygons) on Earth's surface. The problems associated with obtaining accurate ground coordinates are exacerbated at LTER sites, which are usually located in undeveloped and isolated areas, are poorly mapped, are frequently covered by dense ground vegetation and contain few monumented ground control points.

Recognizing the problems associated with collecting accurate ground positions led the network of LTER sites to collectively purchase three high-precision (0.5 centimeter + 1 parts per million), dual-frequency global positioning system (GPS) receivers and 10 single-frequency hand-held GPS receivers. One LTER site in each of the five regions serves as the central repository for one pair of the portable single-frequency receivers. The GPS units are allocated on a regional basis to reduce shipping expenses and the time equipment spends in transit to the two or three other LTER sites in a specific region. The three high-precision GPS receivers are maintained at the University NAVSTAR Consortium (UNAVCO) in Boulder, Colo. UNAVCO receives NSF funding to support training, to maintain and repair GPS receivers, and to provide engineering assistance to GPS field campaigns for NSF-sponsored research projects.

Ecological GPS Applications

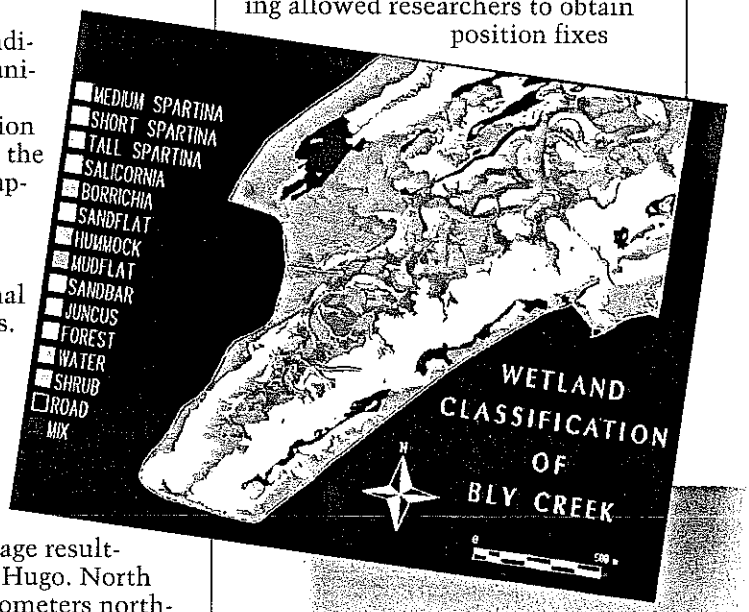
The single-frequency hand-held GPS receivers provide accuracy from 2 meters to 5 meters after differential post-processing. Since being acquired in early 1990, the receivers have been used extensively throughout the LTER network of sites. Research and archaeological sites, as well as man-made structures, have been mapped to provide both scientific and management tools for the LTER sites. GPS position fixes of landmarks visible from the air have been particularly useful for registering aerial photography and remotely sensed data. At many of the grassland and forested sites, the extent of wildfires is being mapped to be coordinated with remotely sensed data and develop a site history for future research. Sites where plant biomass observations have been made are being mapped for integration with satellite imagery. Examples of other GPS activities include mapping of flow topography and material flow in watersheds, mapping of plant individuals and communities for mortality studies and vegetation maps, and mapping the appearance and disappearance of active springs as point sources of water to correlate with animal aggregation patterns.

The hand-held GPS receivers have been instrumental in efforts at the North Inlet LTER site to map and quantify the extent and severity of damage resulting from Hurricane Hugo. North Inlet, located 90 kilometers northeast of Charleston, S.C., covers approximately 80 square kilometers and consists of barrier islands, intertidal salt marshes and low-lying coastal forest. Hurricane Hugo was classified as a Category 4 storm with a 100-year return period. Hugo made landfall at Charleston near high tide on Sept. 22, 1989. The North Inlet LTER site experienced high winds, as well as a storm surge that traversed the barrier islands, flooded the Spartina salt marshes and caused



ocean water to flood a large area of the coastal forest. Landsat Thematic Mapper and SPOT imagery, aerial reconnaissance missions and ground truth surveys along 10 forest transects were used to assess hurricane-related impacts to the barrier island system, salt marshes and a large forested region bordering the North Inlet LTER site.

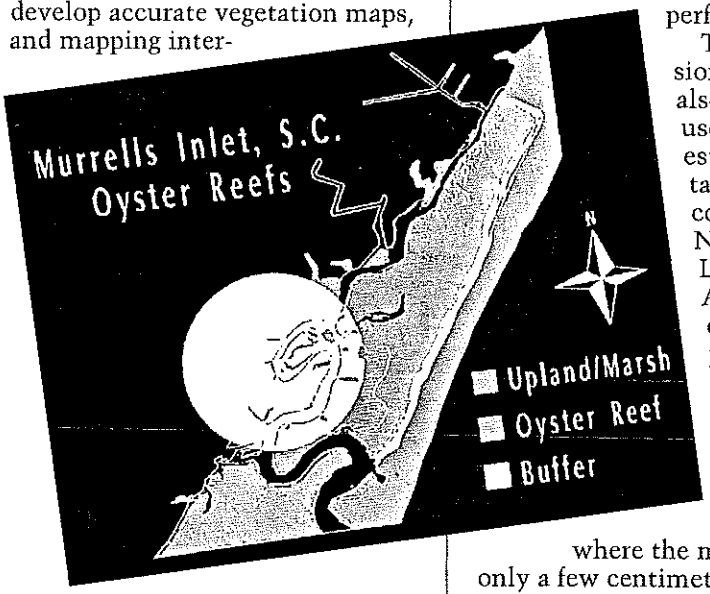
The hand-held GPS receivers were used to relate ground observations along the transects, as well as observations made on the barrier islands and in portions of the forest that experienced variable damage, to aerial photographs and satellite imagery. Differential post-processing allowed researchers to obtain position fixes



A vegetation classification was developed for one of the major North Inlet, S.C., marsh basins (inset). The map was based on extensive ground truth data in conjunction with GPS surveys.

accurate to approximately 2 meters. The GPS units also proved useful for relocating monuments and sampling sites that had been damaged or covered by debris during the hurricane.

Other receiver uses at the North Inlet LTER site include mapping salt marsh plant communities to develop accurate vegetation maps, and mapping inter-



GPS technology allows LTER scientists to map the distributions of oyster reefs and project impacts of specific dredging activities on adjacent oyster populations.

tidal oyster reefs. One large, ongoing study involves comparing oyster growth and reef development at 30 intertidal oyster reefs in North Inlet with 30 reefs located in Murrells Inlet, S.C., a nearby urbanized estuary. GPS receivers allow scientists to map the reefs, establish sampling sites and revisit those sites at monthly or annual intervals. Incorporating GPS data into a GIS also enables researchers to provide accurate information to resource managers. For example, it is possible to project the potential impact of a specific dredging project on adjacent oyster populations.

The three high-precision dual-frequency receivers are initially being used to establish horizontal control points within the LTER sites. During October 1991, for example, six benchmarks providing first-order control were established within the Central Plains Experimental Range LTER site. This site is located on the Pawnee National Grassland, northeast of Boulder, Colo. Previously, no benchmarks were available within the site. The six benchmarks will allow scientists to rapidly establish a GPS base station over a known point, or to more readily perform surveys using conventional surveying methods. Moreover, the accessibility of benchmarks in protected areas precludes the need to station personnel at the GPS base when surveys are being performed.

The high-precision GPS units also have been used recently to establish horizontal and vertical control at the North Inlet LTER site. Accurate vertical control points are particularly important for research in southeastern U.S. salt marshes where the movement of only a few centimeters up or down in the intertidal zone can result in dramatic shifts in plant and animal species community composition. In addition, the GPS receivers can provide accurate periodic measurements of tide gauge heights. To predict the potential effects of sea level change on coastal plant and animal communities, it is first necessary to understand how these communities respond to natural fluctuations in sea level. Researchers also must be able to determine whether the sea level is rising or the piers on which their tide gauges are mounted are sinking.

Establishing horizontal and vertical control at each LTER site is the highest priority for the high-precision GPS units during the next two years. However, many LTER sites also have established plans to incorporate routine high-precision surveying as an integral component of their overall research plan. For example, accurate vertical elevations of groundwater wells located throughout a watershed will enable scientists to track the movement of waterborne nutrients across the landscape. Such studies would not be possible or would be prohibitively expensive without access to high-precision GPS equipment.

GPS technology supports increased scientific productivity at the LTER sites. In addition, many applications that depend on accurate vertical control are now possible. By using GPS, intervisibility between sites is not required; fewer personnel are required; and GPS surveys can be performed under inclement weather conditions that would hinder or prohibit conventional surveys. With a hand-held GPS receiver, it is theoretically possible to obtain more than 100 position fixes in a single work day (assuming four minutes/site occupation). This ability to rapidly acquire position fixes allows scientists to incorporate many new attributes into GIS data layers for sophisticated spatial analyses. The high-precision dual-frequency receivers have proven especially useful at the LTER sites that often must calculate solutions based on long baselines between the base and remote receivers. Also, three of the LTER sites are located at high latitudes where ionospheric disturbances affect the propagation of radio signals. The dual-frequency receiver supports calculation of an "ionosphere-free" solution.

Accurate geographical positions are essential for registering ecological ground observations with remotely sensed data, and for incorporating ecological data into GIS data layers. GPS technology will serve an integral role in meeting these needs and facilitating sophisticated spatial analyses. Continued receiver miniaturization and cost reductions will make GPS technology accessible to more scientists and resource managers for many diverse applications.

William K. Michener is a research assistant professor with the Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina.

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