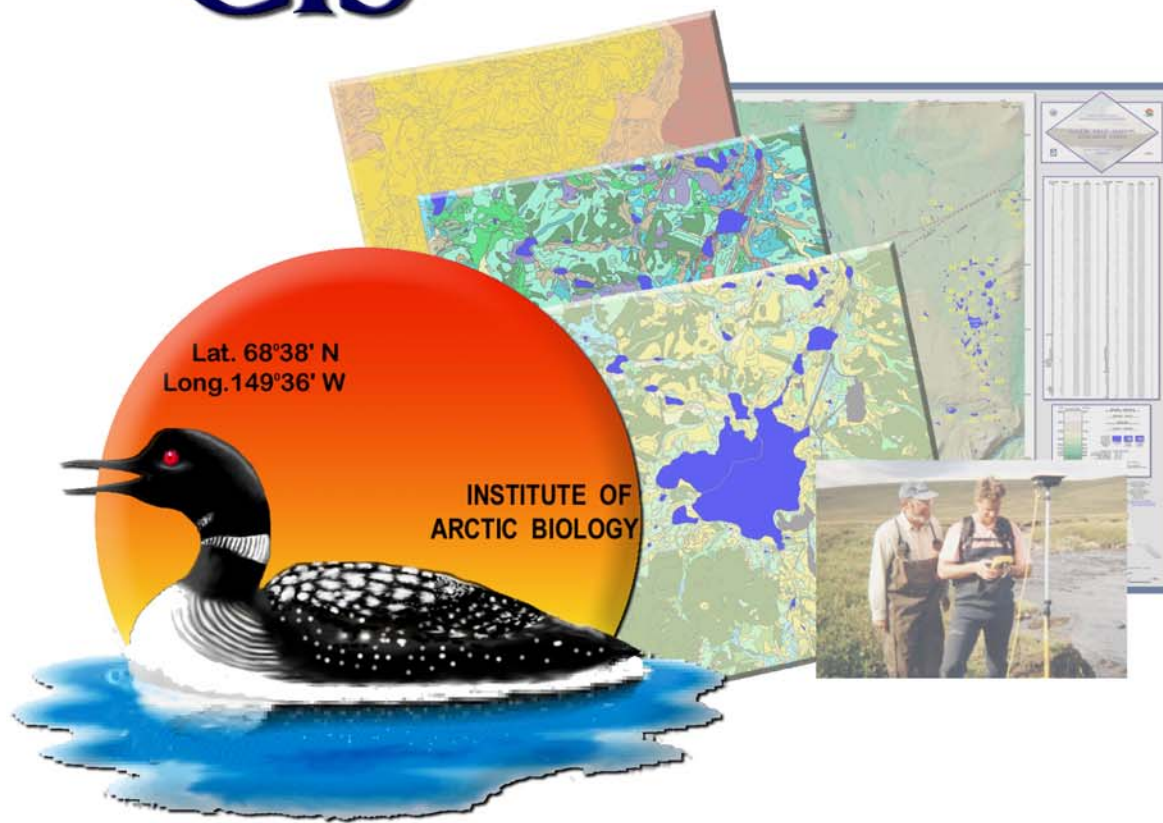
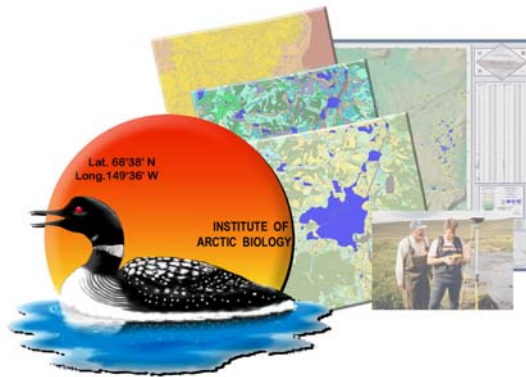

TOOLIK FIELD STATION GIS



ANNUAL REPORT 2002

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December 9, 2002

GIS & Remote Sensing for Toolik Field Station 2002



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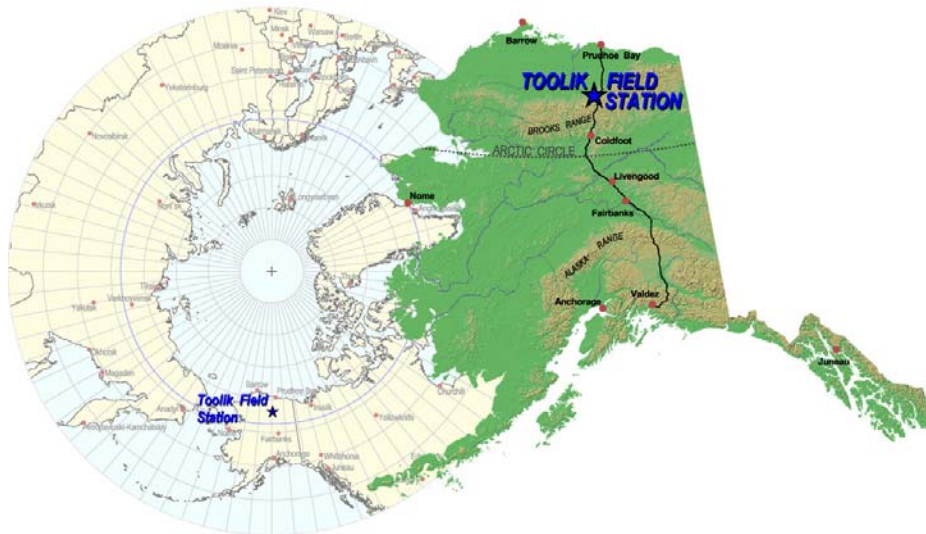
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1.0 MISSION STATEMENT & SUMMARY

Toolik Field Station is located in the foothills of the Brooks Range on Alaska's north slope and is administered by the Institute of Arctic Biology at the University of Alaska Fairbanks. The station supports a long-standing and rapidly expanding community of scientists and research projects representing individual and collaborative efforts from US and international institutions. Research based at Toolik covers topics in terrestrial and aquatic ecology, atmospheric science, physiology of arctic breeding birds, mammals and insects, and includes a broad range of temporal and spatial scales. Scientists' ability to successfully conduct research requires a multi-faceted support structure at the station. As a component of Toolik Field Station, the Geographic Information Systems (GIS) Office provides logistical and management support as an enterprise GIS, and fills an expansive role working directly with Principal Investigators administrators for the advancement of research and management.



The mission of Toolik Field Station GIS is to facilitate and enhance arctic research, and to increase research and management efficiency, effectiveness and capability. This is accomplished: 1) through Information Technology (IT) and GIS support of administrative and management infrastructure and production of planning tools for land management and permitting, and 2) through direct consultation and service to scientists via network and logistical support. Toolik GIS provides a rich spatial database, project-specific data development, spatial analysis, consultation and documentation. These services are available at the station during the summer field season, and through the Toolik GIS office at UAF year round. They include: an ongoing data development function, fast turnaround of daily requests, and detailed, intensive consultation on larger projects. Toolik Field Station GIS is also committed to engineering the database, hardware and personnel to anticipate future requirements and provide a legacy product to enhance the management and science conducted at Toolik Field Station and in the arctic.



The NSF sponsored Arctic GIS Workshop in January 2001 concluded that an Arctic Geographic Information Infrastructure (GII) has been developing both formally and informally over the years (Sorenson et al., 2001). Optimized coordination and communication will maximize the infrastructure's benefits to science, management and the public. As an arctic GII and Spatial Data Infrastructure (SDI) continue to take shape, Toolik GIS will take an active part as a node for data and as a cooperative participant in planning, coordination and execution.

Fulfilling the mission requires three basic types of activity: 1) maintenance, expansion and development of the Toolik GIS database, 2) timely response to daily requests, 3) specialized project-specific data development and 4) active collaboration and publication of the results with research scientists.

1) Data Development

Perpetual maintenance and expansion of the GIS database is central to almost all functions and services provided to the Toolik community. Data development is the most time and labor intensive component of any GIS initiative. Data development must be completed well in advance of the actual request so that community needs can be met in a timely and effective manner.

Most datasets are useful to a variety of projects for a variety of applications. Greater quantity and quality of available data enables more effective, targeted and flexible responses to community needs. The Toolik GIS is a single and cohesive database. All data are engineered to function in concert with minimal or no modification from one request/project to the next. Data development is an ongoing process improving the overall quality of the GIS database, while simultaneously handling user service requests and projects.

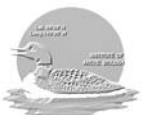
A smaller but growing component is project-specific data development. These datasets are also engineered to work within the larger database, and usually have ancillary value, but are initially developed to project specifications. These are often associated with specialized analysis and consultation with individual PIs.

2) Daily Requests

Much of the value of the Toolik GIS is its ability to accommodate requests with rapid turnaround. Requests range from logistical support to spatially explicit scientific data and are received year round. In most cases, results would not be very helpful if not provided within a few days or weeks. Currently, 'daily' requests are defined as requiring less than a few weeks of work to fill.

3) Specialized Requests

Since the inception of Toolik Field Station GIS in early 2001, data development and community interaction have fostered an atmosphere of expanded thinking which incorporates spatial data into research and management and enables much more elaborate landscape scale analysis. This aspect



of Toolik GIS represents the greatest value to current and future research projects. Drawing from a pre-existing GIS infrastructure including data and institutional knowledge of Toolik makes larger initiatives more efficient and plausible. To date, there are four such projects either underway or in the development stage (see 7.0 TIME ALLOCATION for brief descriptions).

4) Active Collaboration and Publication of Results

Toolik Field Station GIS provides researchers and managers with publication quality maps and data. These final products are used in government reports, refereed publications and talks at professional scientific meetings. I have also provided Toolik researchers with publication quality GIS analyses and results (see 'Science Support' section for more detail of this work).

The remainder of the Annual Report describes services by functional group: science support, management support, and computer network support. Each example provided will fit into one or more of the general activity types listed above.



2.0 DATA DEVELOPMENT

2.1 Summary

The Toolik Field Station GIS database has been developed from a variety of sources including agencies, past scientific research and in-house data creation. Initial efforts were to incorporate and synthesize the most fundamental and frequently used information (framework data), while later efforts have refined, enriched and expanded upon the original work. By the summer of 2001, datasets covering basic hydrography, topography, physical infrastructure, cadastral features and vegetation had been acquired into a central database and processed to function smoothly. During the 2001 and 2002 field seasons, field data were collected that improved existing information and added new features. Qualitative and quantitative information are continually added to existing data through interaction with scientists and managers.

Many of the desired additions and enhancements to the database require a combination of field reconnaissance and more recent, remotely sensed data. Twelve flights lines were flown on July 21, 2002 to obtain vertical airphotos. These airphotos function as spatial reference and improve spatial detail for both aquatic and terrestrial projects. This scale of remotely sensed information was previously lacking for the Toolik area and has greatly improved scientists' and managers' ability to identify, locate and measure crucial features.

Additional, complementary, remotely sensed data are compiled from a variety of sources including federal agencies, UAF spatial data labs and commercial service providers. The most prominent new dataset is the Digital Elevation Model (DEM) of the Kuparuk watershed which was made available to the NSF-funded research community this fall. The superior quality of this dataset compared to older DEMs permits dozens of new analyses and will help improve the spatial accuracy of other datasets.

A prominent example of new data capability from 2002 was the addition of Survey Grade GPS hardware and support through UNAVCO during June and July. Introduced as a pilot project, positive response among the community suggests it should become a permanent station service.

Data development is expected to continue in much the same manner, with new technologies and products being incorporated on a prioritized basis.

2.2 Synthesis of External Source Data

Toolik Field Station was fortunate to have access to pre-existing spatial data which sped the process of engineering an initial, functional GIS. However, pre-existing data must be manually processed for inclusion to ensure consistency, accuracy and congruency with the larger database.

For example, hydrographic data (lakes and streams) available from standard USGS sources must be assembled from tiles that correspond to individual quadrangle maps. Where tiles intersect, the features must be 'stitched' together by hand, and ancillary information about each feature beyond



its shape and location must added by a GIS technician. For example, names of lakes and streams, information about biota and nutrients, history of use, etc. are compiled and tied to appropriate features to add analytical utility to the data. Similar processing is required for most thematic datasets acquired from external sources. These datasets are now much more content rich than their predecessors. The spatial quality of the data is also under constant refinement. Spatial alignment among datasets is required for effective analyses, and is a semi-automated process. In many cases, the features are manually replaced due to inadequate spatial accuracy. The need for accurate measurements of lake surface area, for example, has led to GPS-derived lake margin data that replaces the original data for individual lakes (Figure 1). Many of these qualitative refinements are discussed further in the Data Enhancement subsection below.

The long term efforts of the Tundra Ecosystem Analysis and Mapping Lab (TEAML), now known as the Alaska Geobotany Center (AGC) under Dr. Skip Walker of the University of Alaska Fairbanks (UAF) has been another invaluable source for the Toolik GIS database. These data, although content rich, had to be retrieved from an archived format and reorganized to work with the Toolik GIS. Current and future efforts with this data are to add spatial detail through remote sensing and field work and to expand the spatial coverage of the data.

Several sources of remotely sensed data provide complementary information to the GIS. Archived Landsat TM, SPOT, U2 and AVHRR imagery, used widely for many years, are joined by new platforms such as MODIS, Quickbird, AIRSAR and IKONOS. Each platform offers different capabilities and used together they allow an immense variety of analyses at scales from the plot to the regional level. The primary task incorporating these datasets is spatial rectification (i.e. tying each image accurately to ground coordinates).

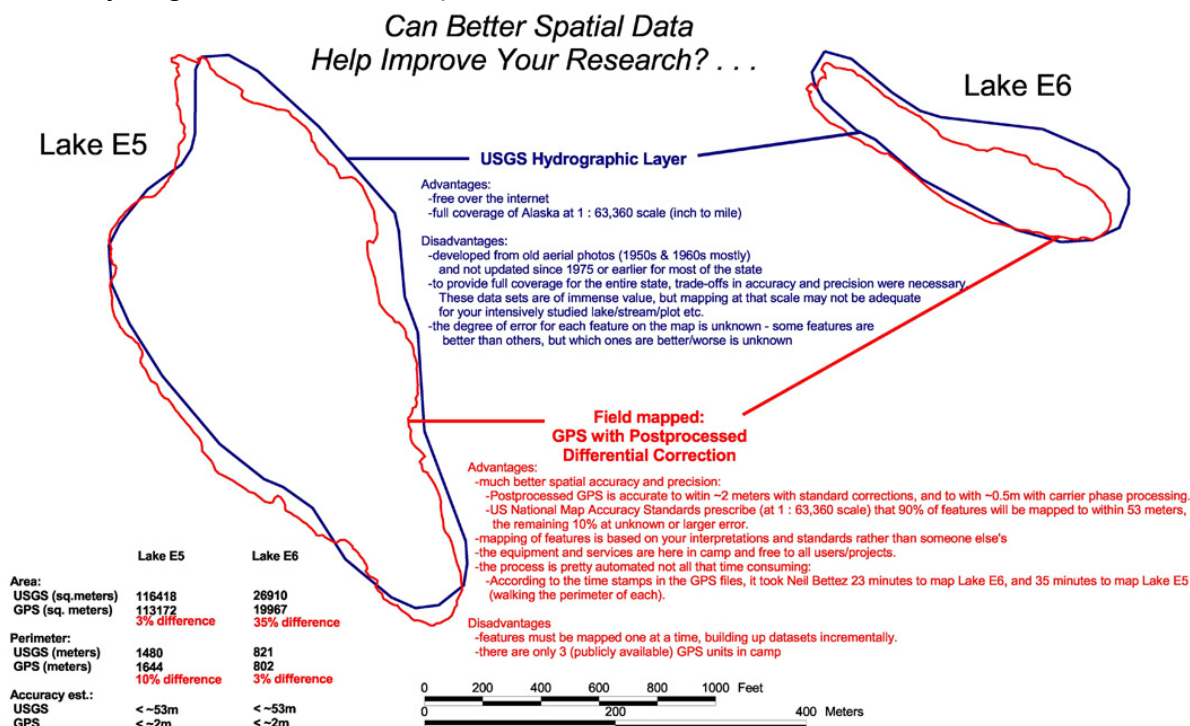


Figure 1. Spatial Accuracy/Precision Comparison: USGS Hydrographic Data vs. GPS Derived Data.



2.3 Data Created by Toolik GIS

Data created entirely by Toolik Field Station GIS is of three primary types: GPS field measurements, remotely sensed data, and derived products.

Field based GPS measurements add information about physical features (roads, watertracks, trails) and landscape activity (research plots, points of scientific interest, DOT material removal, archaeological sites) to the GIS database and provide input data for scientific analyses (hydrologic models, landscape models). GPS data quality is determined by present and predicted use. Data are always collected at the highest appropriate accuracy and with the greatest informational content possible to maximize utility now and in the future. Higher accuracy and data attribute content have a low cost in pre-collection planning compared to a high payoff in multiple uses of the data. To date several thousand features have been added to the Toolik GIS through field measurement.

Remotely sensed data such as airphotos flown on July 21, 2002 cover a spatial and temporal gap in data for the Toolik region. Twelve flight lines were developed to cover the areas of greatest interest to research and management (Figures 2, 3). These photos show landscape detail that is unavailable with any other product, and is useful for ongoing terrestrial and aquatic projects, and landscape management.

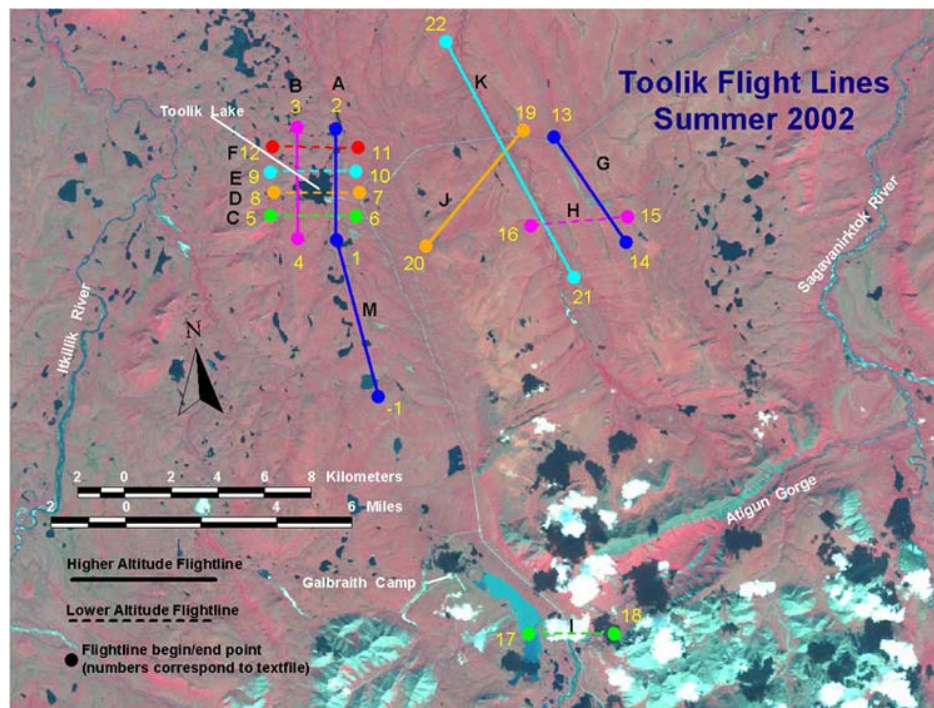


Figure 2. Vertical flight lines taken by Terraterpret on July 21, 2002. Project comprises 112 individual frames at two scales. Delivery of photos October 2002. Backdrop is Landsat TM Color-IR Composite (4-3-2) from July 7, 1999. Flights and photos funded by NSF-OPP via Toolik Field Station.



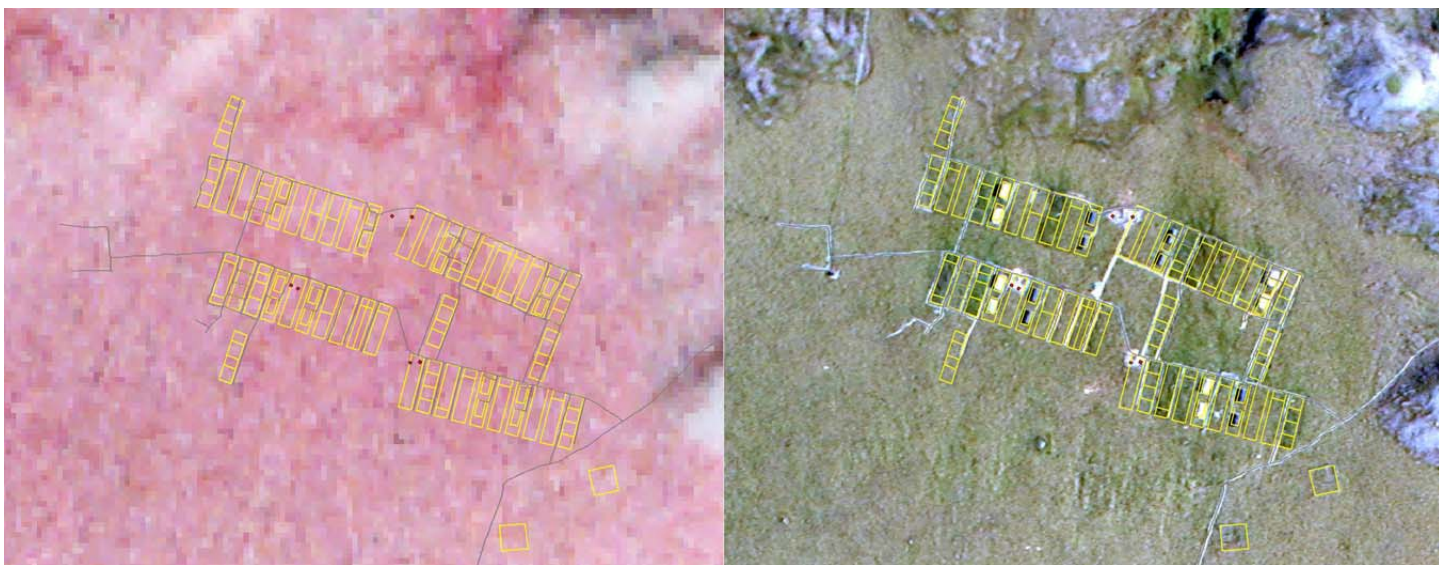


Figure 3. 1982 airphoto (left) and 2002 airphoto (right). Differences in spatial detail are easily visible. Outdated airphotos lack current features (e.g. plots, boardwalks) and current landscape conditions (e.g. treatment effects in fertilized plots).

Response to the new airphotos has been extremely positive among Toolik researchers. Initial uses include feature identification, backdrop for figures, field site planning, permit application and feature measurement (watertrack length, riparian zone width, size of disturbance etc).

Examples of derived data include comprehensive research plot location/attribute information; fine scale topographic measurements of the Toolik Lake inlet and outlet, Kuparuk River and Oksrukuyik Creek, a full catalog of road and trail infrastructure within twenty miles of the station, and the addition of hydrographic features not previously included in the GIS.

2.4 Data Enhancement

Data reworked and enhanced in the Toolik GIS effort comprises an important portion of the total dataset and greatly expands the capabilities of the GIS. In many ways it is a marriage of data created by Toolik GIS and data incorporated from external sources. Enhancements come in two basic forms: **1) Spatial Enhancement** and **2) Attribute Enhancement**. This process differs from synthesis of pre-existing data by making fundamental changes rather than just organizing and processing the data into a form that is user friendly and cohesive with the overall database. These fundamental changes require background and infrastructure and result in a modified dataset with new metadata and overall improved quality.

Spatial enhancements include adjusting feature locations to improve spatial accuracy, adding new features, and improving the detail of features represented. Several examples to date are noteworthy. Prior to the initiation of Toolik Field Station GIS, the best information on land ownership status in the Toolik area came from old, relatively crude maps produced in the late 1980s by the Bureau of Land Management (BLM). These maps had several major drawbacks including a lack of precision and detail, and outdated boundary lines. Working in cooperation with Mike Kleven of BLM, we determined the proper locations of boundary lines from master title plats, planning documents and



letters housed at BLM. Using this information along with other GIS layers in the database, I created a useful and accurate product which has been extremely helpful with permitting and administrative requests from such agencies as: BLM, the US Fish and Wildlife Service, National Park Service, Alaska Department of Transportation, and the Alaska Department of Natural Resources (Figure 4).

Another major initiative has been to replace hydrographic features by GPS field mapping and remote sensing to improve scientific capabilities in aquatic research. All hydrographic features originated with the USGS 1 : 63,360 quadrangle data developed from airphotos in the 1950s, 1960s and 1970s. While these data are invaluable as a synoptic coverage of hydrographic features, the detail is entirely inadequate for many desired research applications at the Toolik Field Station.

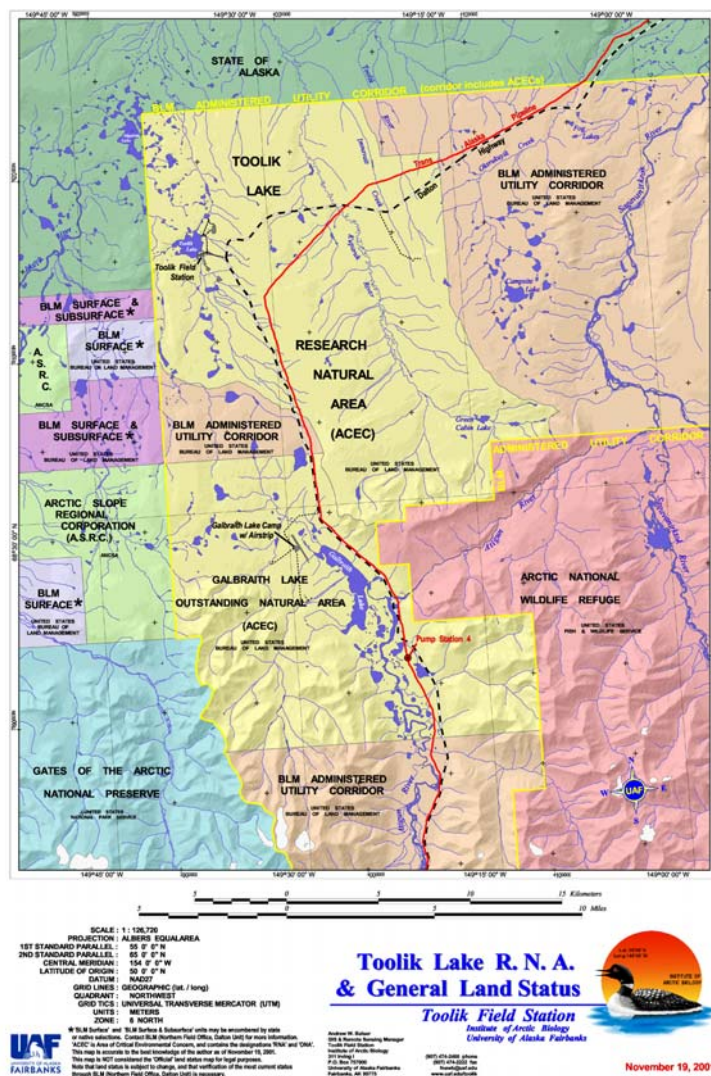


Figure 4. Updated Land Ownership Status in the Toolik Region. Previous data were coarse resolution, partially outdated and existed only as several, irreproducible, paper maps. The current map is distributed electronically and by hardcopy at Toolik Field Station, in Fairbanks, and at meetings and conferences.



3.0 SCIENCE SUPPORT

3.1 Summary

Spatial information needs of scientists are met by Toolik Field Station GIS at all stages of development and execution. Science support covers needs ranging from initial planning for field work, to production of publication quality maps and data. General logistics, field site selection, custom data development, spatial data analyses and assistance with using GIS data, hardware and software are all Toolik GIS functions. Within each of these sub-categories there are both 'daily requests' and more intensive 'project specific requests'. Daily requests are things like the development of field coordinates for reference, the production of user-friendly field maps, or the generation of some landscape metric. Project-specific requests require more intensive attention and consultation and become part of the request archive.

3.2 Logistics

Logistic support helps scientists locate study sites (e.g. provide map coordinates), comply with permit regulations, avoid inappropriate plot co-location and plan field research. For example, just prior to the 2002 field season, Dr. Bruce Peterson of the Marine Biological Lab and his group received a U.S. Fish and Wildlife permit for research within the Arctic National Wildlife Refuge boundary that required specified flight patterns and no-fly zones for helicopter access. I created a map of the entire route with developed coordinate lists and recommended flight vectors that was used by the helicopter coordinator, the pilot, and the research team (Figure 5). The map and supporting data were created and refined at the station as needed.

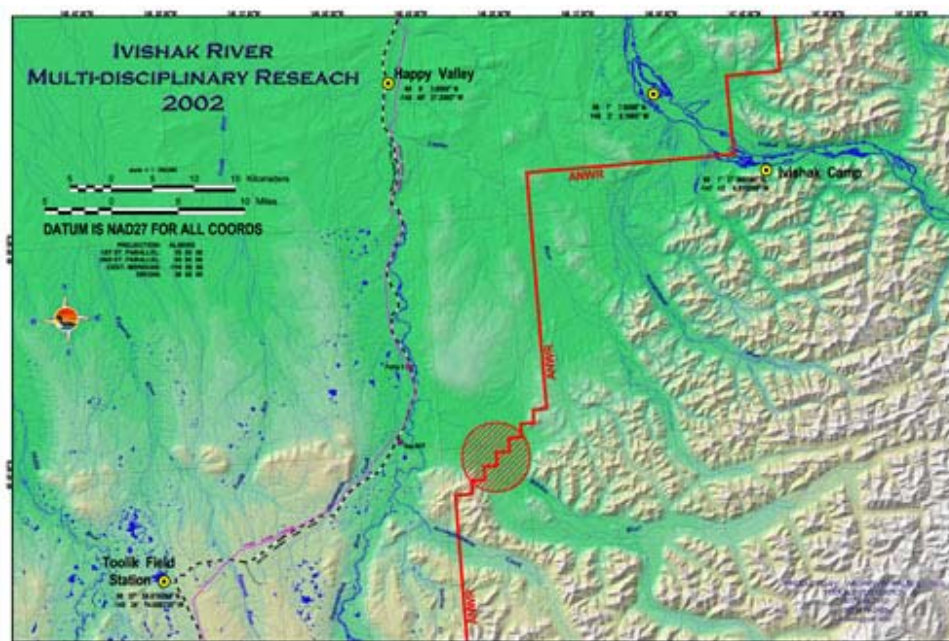


Figure 5. Map showing temporary Ivishak research camp, ANWR boundary, Toolik Field Station, no-fly zone and physical features. Coordinates and flight vectors are also included on the map, which was considered a project-specific request.



3.3 Site Selection

Toolik Field Station GIS vastly improves the efficiency and effectiveness of site selection for research for both aquatic and terrestrial science. Prior to the summer of 2002, I ran a series of analyses to identify streams meeting a list of key research and logistical criteria for Dr. Linda Deegan et al. of the Marine Biological Lab (Figure 6). In this particular case, the criteria required the use of topographic, hydrologic, geologic and geomorphic data layers, along with simple facility and infrastructure information. The results of this analysis identified eight candidate streams for further investigation. This process allowed the research team to spend more time on actual data collection rather than on site selection and radically reduced the number of helicopter and person hours required to complete the work.

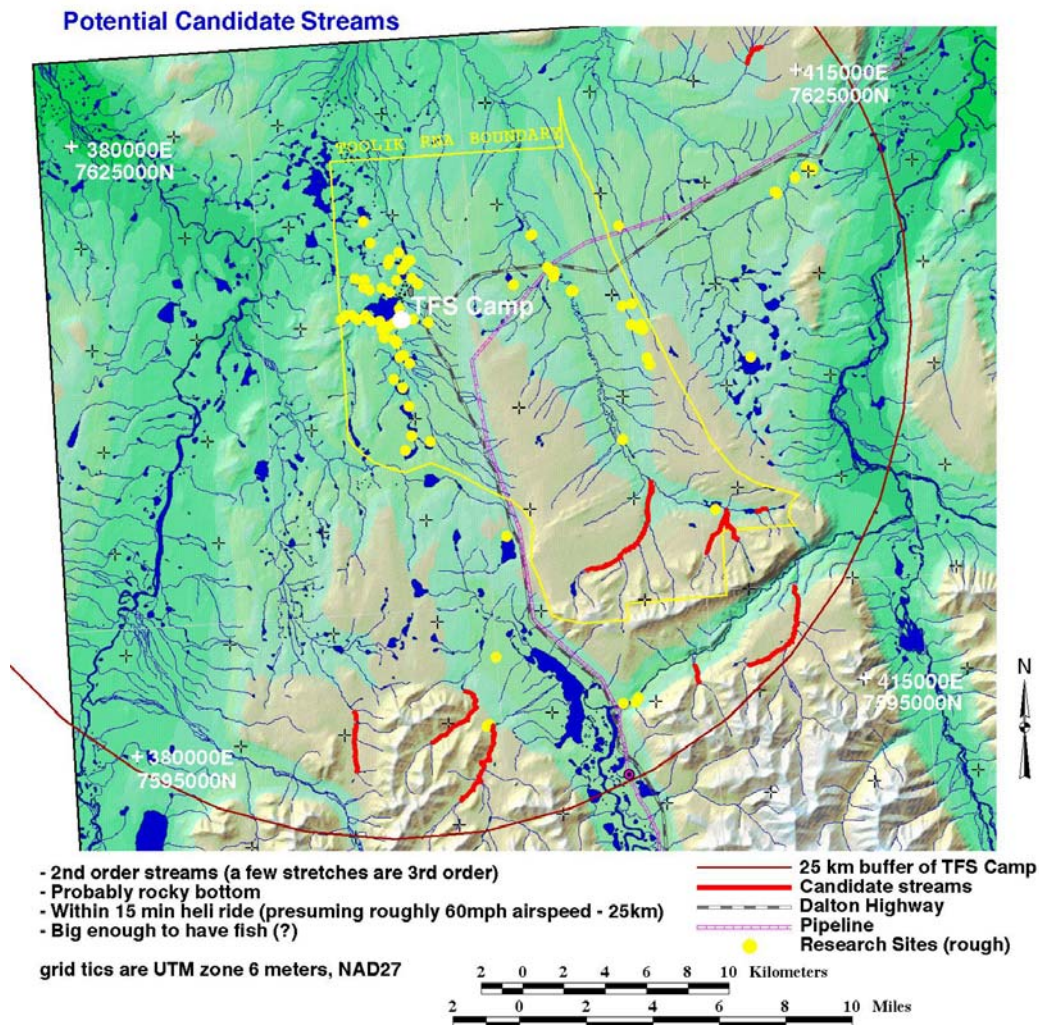


Figure 6. Map showing candidate research streams for the long-term fertilization project (as requested by Deegan et al.).



In another example, Dr. Laura Gough of the University of Alabama and Dr. Sarah Hobbie of the University of Minnesota needed to establish a new series of research sites as replicates to expand their analyses of arctic plant ecology. Their site selection criteria included landscape surface age, vegetation type and quality, soil chemistry, topographic characteristics and minimum site size. Using GIS layers and information derived for this project from airphotos and Landsat ETM+ imagery I located twenty-two candidate sites in two tundra types for further investigation. These data were provided as GPS waypoints, descriptive information and as maps (Figure 7). Their team used the results to prioritize and optimize their field reconnaissance efforts. This GIS analysis was essential for completion of this project.

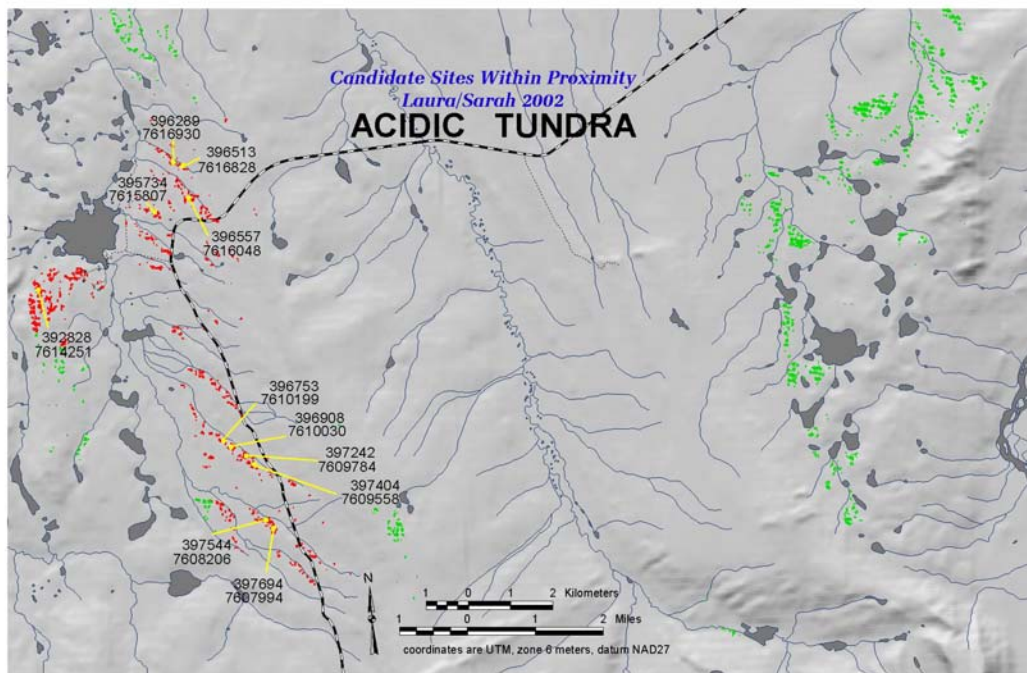


Figure 7. Candidate terrestrial sites provide for Gough and Hobbie's terrestrial research.

3.4 Scientific Analyses and Results

The Toolik Field Station GIS provides researchers with publication quality GIS analyses and results at many spatial scales. My spatial analysis of stream channel morphology during the summer of 2002 provided Dr. Zhenwen Wan and Dr. Joe Vallino of the Marine Biological Lab with essential, fine-scale data for their hydrologic model along a short stretch of the Kuparuk River. Work planned for 2003 includes larger landscape scale analyses of stream networks which will be incorporated into future modeling endeavors.

At a much larger spatial scale, analyses for Dr. Skip Walker et al. of UAF developed correlations between landscape surface age and vegetation type for a region of the north slope (Figure 8). The results synthesize information collected from a variety of research projects over the years and help draw broader conclusions about the ecosystem.



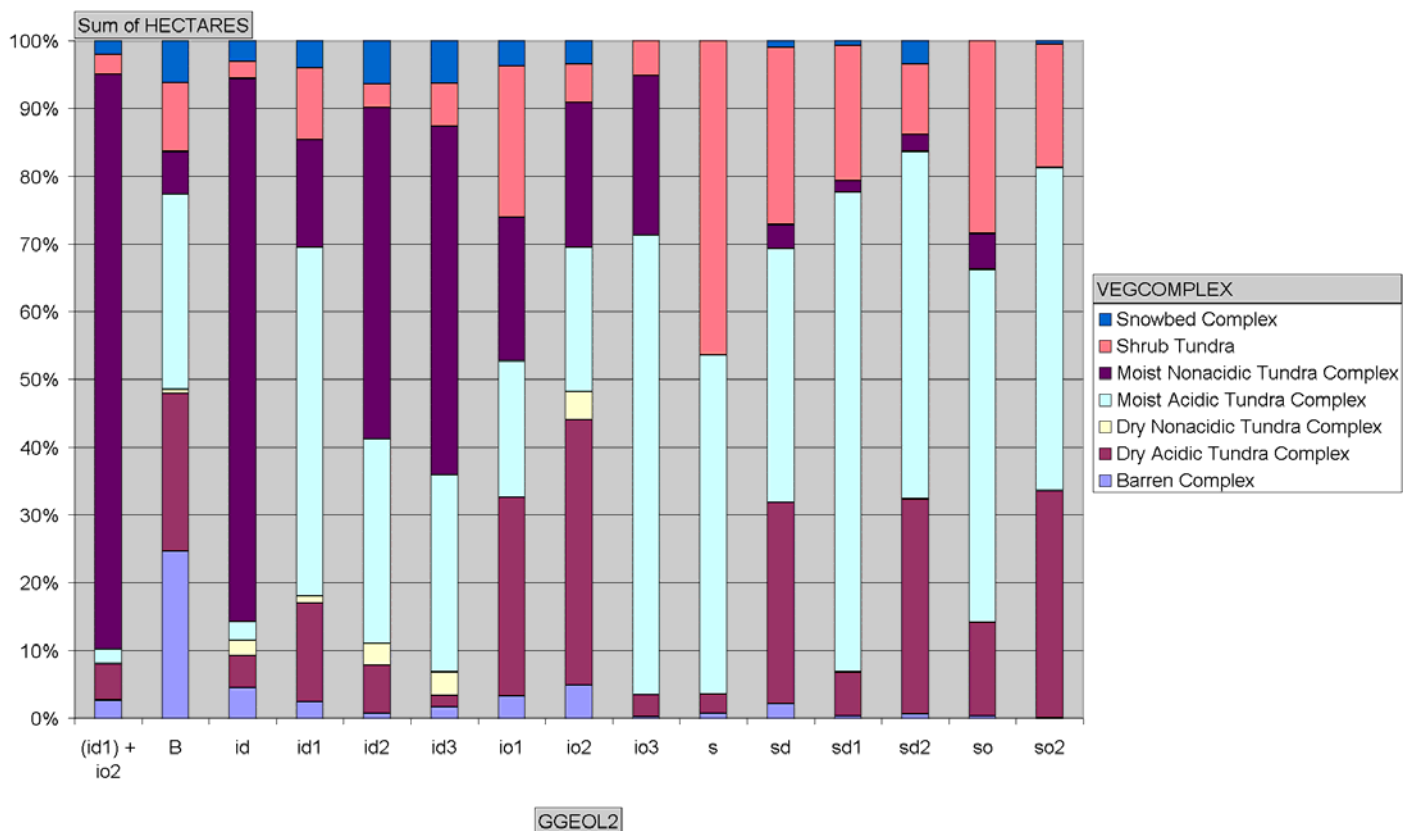


Figure 8. Results from a series of GIS analyses completed for Walker and his colleagues in 2002.

3.5 Hardware & Software Consultation

Many researchers want to take advantage of the tools available for spatial data work. Training and consultation on hardware, software and concepts provided by Toolik GIS helps initiate and maintain that process. Many scientists, students and staff want to incorporate GPS capabilities into their work. I have been able to advise them on which GPS unit will most likely suit their needs, and train them on its use once purchased. Toolik GIS also provides several types of GPS units to those who wish to borrow them. Post-collection management of the resulting data is also a function of the Toolik GIS lab. Many Toolik users wish to use the spatial data themselves, and I have been able to provide basic training and assistance on GIS functionality and cartography to a number of researchers.

Some projects require a much greater degree of assistance. Dr. John O'Brien of the University of North Carolina Greensboro conducted research in 2002 requiring bathymetric data for a number of lakes in the Toolik area. I provided Dr. O'Brien with hardware and software specification options for a system that would meet his needs. After speaking with him at length about the details of his spatial data needs, I compiled information from a number of vendors and passed the information along to his group.



3.6 Custom Data Development

Spatial data requirements are often project specific and require specialized planning, equipment and processing. Custom data development and management is what makes these projects possible and plausible. Dr. Doug Kane of UAF et al. require high density, high precision stream channel and stream bank data for hydrologic modeling, but traditional survey techniques for data collection are too time consuming for some of their studies. Toolik GIS provided survey grade GPS equipment and training; saw the project through field planning, data collection, post-processing, and analysis stages, and produced complex tables and figures (Figures 9). The results of this analysis produced richer data than possible with traditional survey techniques. Using terrain models we were able to show drastic changes in channel morphology from pre- to post flood and determine net changes in the stream channel geomorphology.

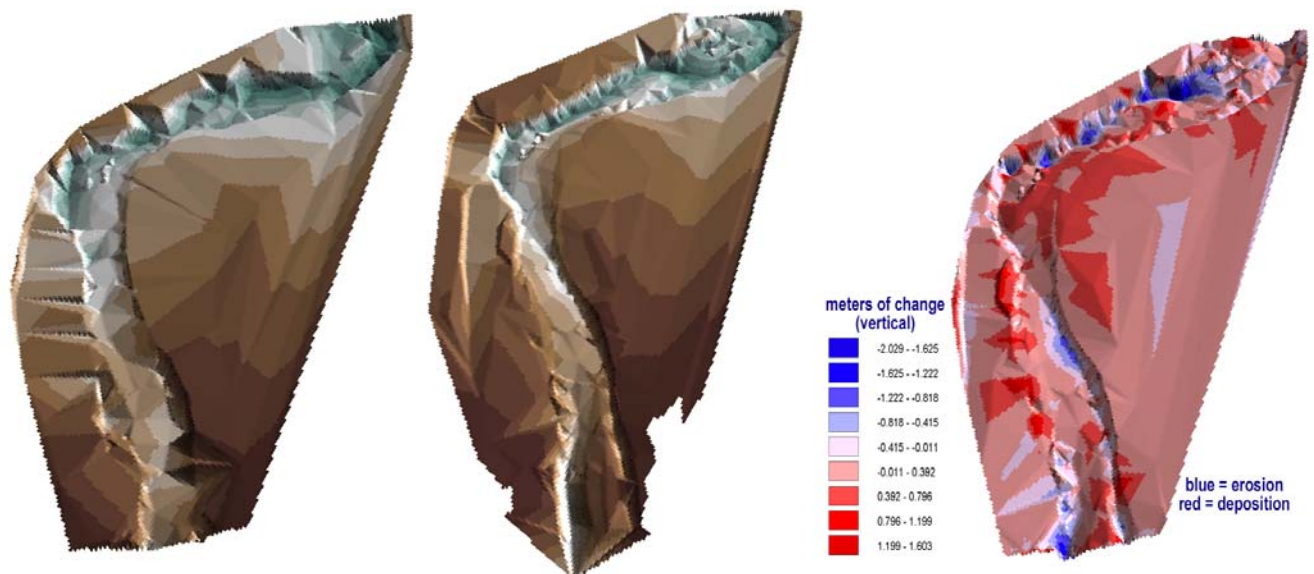


Figure 9. Terrain models derived from survey grade GPS work on the Kuparuk River. Stream channel morphology pre-flood (left), post-flood (middle) and net change (right).



Aquatic researchers led by Dr. John Hobbie of the Marine Biological Lab are interested in installing a weir on the Toolik Lake outlet. The scope of the project requires a rigorous study of the outlet and a detailed engineering report. Toolik GIS was able to provide the data critical for the engineering analyses performed by GW Scientific of Fairbanks. 3-D renderings provided additional help to scientists involved in the project (Figure 10).

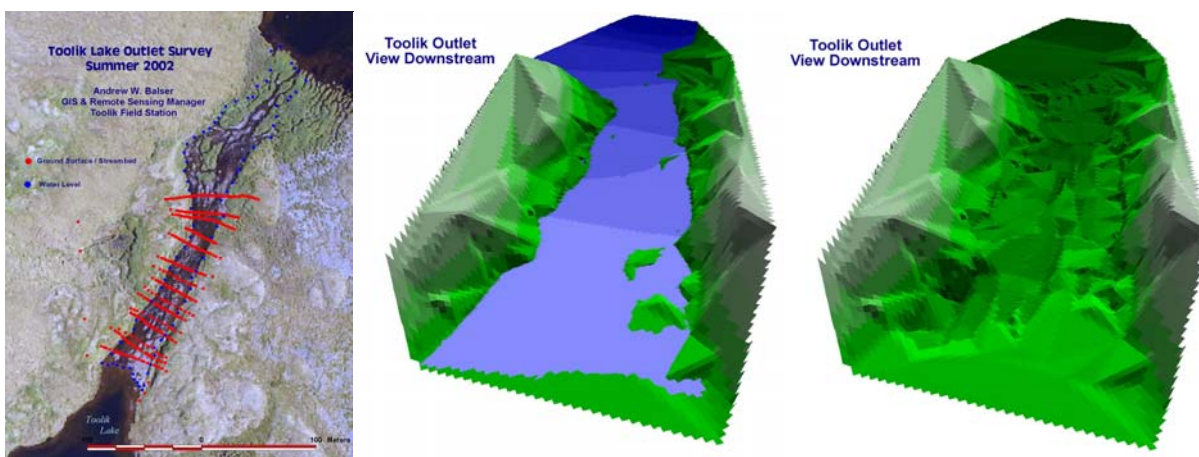


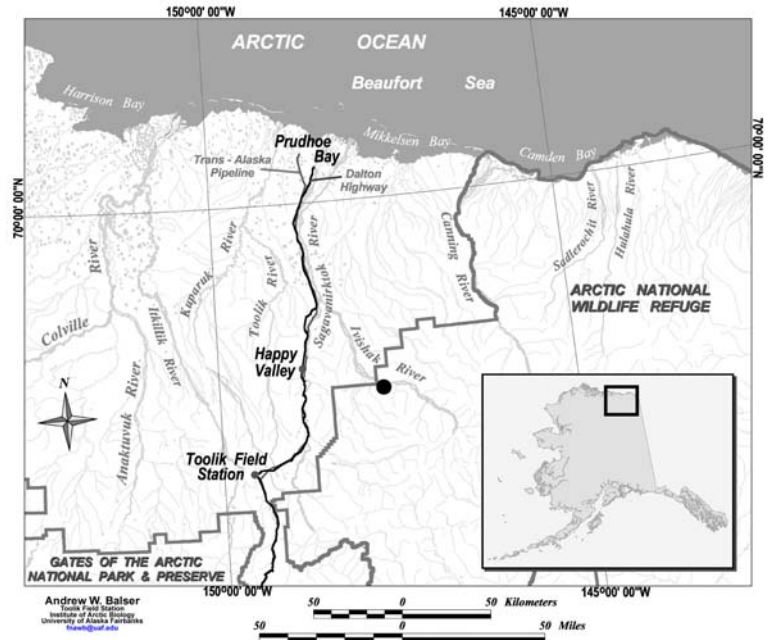
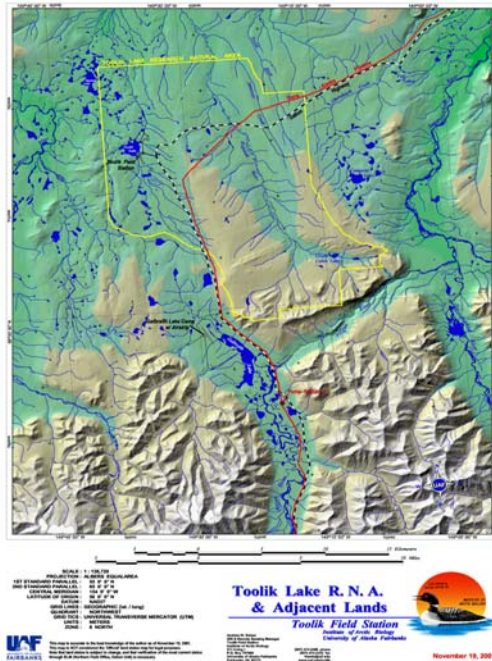
Figure 10. Toolik Lake Outlet Survey. Point locations collected (left) were processed into several products and derivatives such as 3-D renderings of the outlet both with (middle) and without (right) water.

3.7 Support for Publications

Toolik Field Station GIS provides researchers and managers with publication quality maps and data. These final products are used in government reports, refereed publications and talks at professional scientific meetings. For example, a series of maps are in production that will be published in the LTER synthesis volume, “Environmental Change in an Arctic Tundra Landscape” (Hobbie et al.). One of these is a location map of the Toolik Lake Research Natural Area which will be in the book (Figure 11).

Stream ecologists interested in the headwaters of the Ivishak River have also utilized the Toolik GIS database for publication quality maps (Figure 12). This map was provided for Dr. Diane Sanzone of the Marine Biological Lab for a paper entitled, “Nitrogen Cycling in Arctic Spring and Mountain Streams” which is currently in preparation. A color map was also produced for this project that will be used in talks at the North American Benthological Society meeting this coming spring.





Figures 11 and 12. Toolik Lake RNA map for the LTER Synthesis Book (in prep.) *Ecosystem Change in an Arctic Tundra Landscape* (left). Regional map for Ivishak springs (right) included in “Nitrogen Cycling in Arctic Spring and Mountain Streams” (in prep).



4.0 MANAGEMENT SUPPORT

4.1 Summary

Decision making by land managers, permit processors and the TFS Steering Committee for the Toolik region uses the Toolik GIS database to improve the quality of management decisions and help ensure the most effective, equitable and sustainable use of landscape resources for and by a complex group of stakeholders.

Federal and state agencies, the Institute of Arctic Biology of the University of Alaska Fairbanks, and the Arctic LTER have utilized the services of the Toolik GIS lab for metrics, maps and analyses for permitting, locating new gravel pits, preventing conflict between research and other landscape uses, identifying areas of critical concern, and for planning and tracking infrastructure and facilities at the field station.

The Toolik Natural Resource Tool synthesizes landscape information about human uses (science and non-science) and natural resources to address management concerns in a forward looking and dynamic way. Information developed by the Toolik GIS lab comprises this dataset. Using GIS data layers and information about current and past research and land use, this tool provides a comprehensive, proactive and highly effective planning tool for future research within the Toolik Lake Research Natural Area.

4.2 Basic Spatial Information

Basic information and metrics for the Toolik area are frequently requested for use by managers, administrators, facility planners and scientists. Frequently, simple measurements made using GIS equipment are used to answer questions that would otherwise slow decisions and possibly stall research. (e.g. how many miles of boardwalk are there?) The Bureau of Land Management (BLM) have utilized Toolik GIS resources many times. In the summer of 2002, BLM conducted permit compliance visits at Toolik and made extensive use of maps and metrics available to streamline site visits and correlate features with permit numbers. The Alaska Department of Transportation queried the GIS to ensure that no new gravel pits would be located where they would compromise research.



Facility planning has used the GIS to catalog locations of key infrastructure within the IAB administered Toolik Field Station. Within the lease boundary, fuel tanks, water tanks and other infrastructure have been described via maps and coordinate lists (Figure 13).

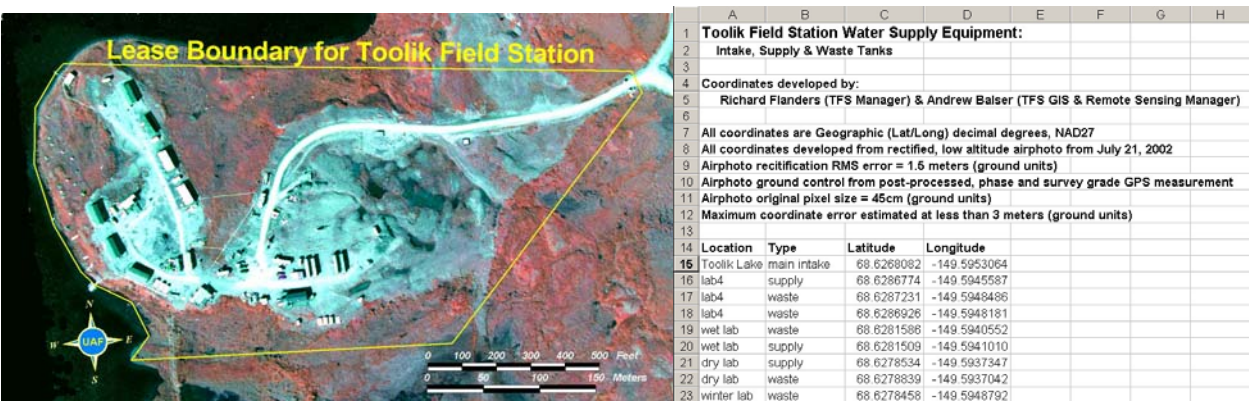


Figure 13. Toolik Field Station Lease Boundary and Infrastructure. Coordinates for water tanks as required for code compliance shown in table.

The Arctic LTER is currently renewing its BLM permit for work within the Toolik Lake Research Natural Area. Toolik GIS has provided new and more accurate coordinate lists and metrics for the permit renewal application. Maps and data (Figure 14) were submitted with the renewal application in December. Use of the GIS, which is constantly updated, automates much of this process and ensures a minimum of time necessary to compile required information for this and future permitting.

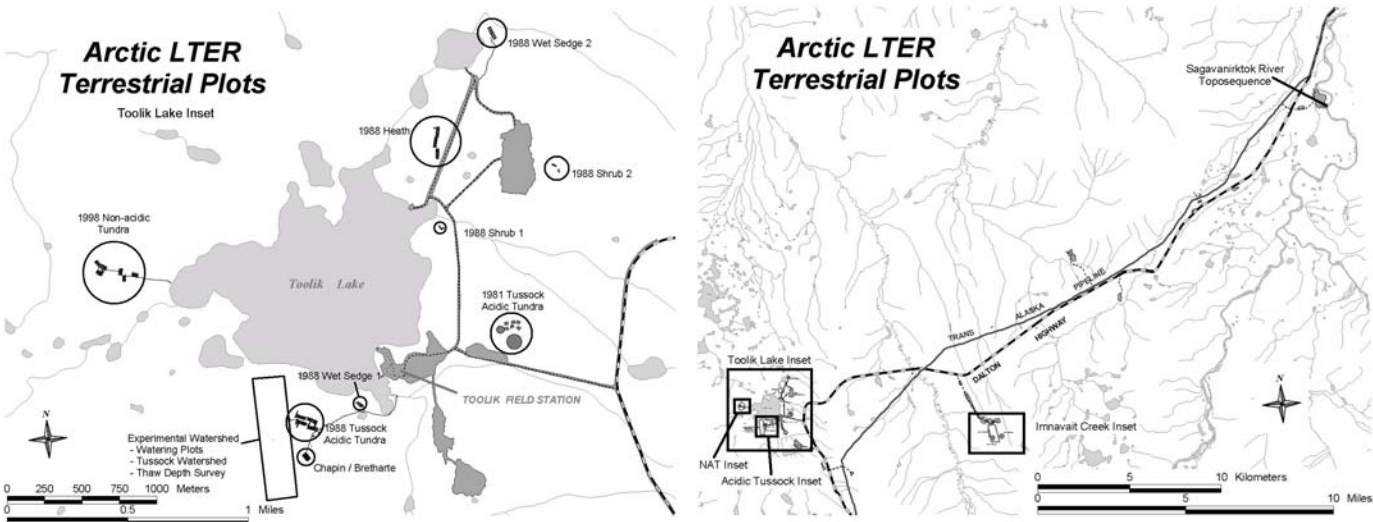


Figure 14. Maps of Arctic LTER terrestrial plots submitted with the most recent BLM permit renewal application.

4.3 Proactive Communication

Much of effective planning and management lies in communication and a proactive approach. Frequently, the distribution of maps alone is enough to inform different users of the landscape of each others' existence, and thereby avoid conflict. In other cases, Toolik GIS has been able to help in communication to ensure community input before decisions are made. One example is the network of towers providing cellular telephone coverage that is expanding up the Dalton Highway and through the Toolik area. Proposed tower locations were developed based upon utility and convenience for the business erecting them, and not necessarily with ongoing research in mind. Toolik GIS provided maps to accompany the public announcement which was forwarded to the Toolik community for comment (Figure 15). This way the entire community had the opportunity to object if their research would be in jeopardy, and to do so while changes in the proposal are still easy to make. Another example is the location of new gravel pits for Dalton Highway maintenance by the Alaska Department of Transportation (DOT). Because of previous map outreach to state agencies, Sarah Conn of DOT contacted me and requested a series of coordinate cross checks to ensure that no new gravel pit or material site would compromise ongoing scientific research originating from Toolik Field Station.

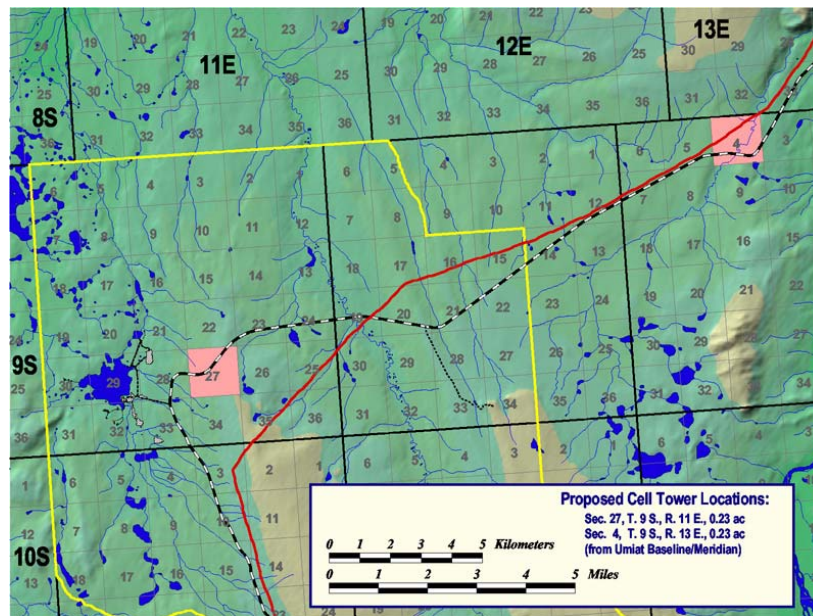
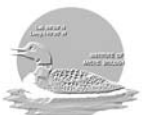


Figure 15. Proposed cellular telephone tower locations within the Toolik area. Pink squares mark proposed sites.

Preservation of natural resources is an important function of management, and BLM contacted Amy Carroll of UAF to catalog the presence of rare plants within a 2 mile radius of Toolik Lake. I provided Amy with a grid framework (Figure 16) to help organize her systematic approach, and provided a GPS unit and training for her field work. After data were collected, I provided GIS training adequate for her to express her findings in terms of vegetation polygons and maps. Amy's final product was a report including a series of maps submitted to BLM.



4.4 Long Term Management: *Toolik Natural Resource Tool*

The legacy of long term research and ecological data collection at Toolik is unprecedented in the Arctic. The rigorous data set collected over the last three decades has contributed enormously to our understanding of arctic ecosystems. To maximize the amount of high quality data collected at Toolik, access to relatively undisturbed natural ecosystems is essential. To this end, long term datasets must continue to be collected in a systematic fashion in relatively undisturbed ecosystems. Recent trends show a rapidly increasing demand on these natural resources within the Toolik Lake Research Natural Area.

The Toolik Field Station GIS is currently developing the Toolik Natural Resource Tool (NRT). Its primary goal is to synthesize information about the landscape and its present and past uses to provide a practical tool for the Toolik community and the BLM to better manage its natural resources into the future. Specific steps include: 1) compiling spatial, quantitative and qualitative information on current and past research, 2) organizing that information into a single, cohesive dataset, and 3) presenting and providing it at meetings and to individuals to make it as available as possible for decision making.

The Toolik NRT is a dynamic tool that can be utilized for different possible purposes, but key is its use in landscape planning to identify areas of critical concern to remain as relatively undisturbed areas. BLM officials have already unofficially encouraged the idea of self-management within the research community as an ideal way to take advantage of the scientific community's expertise while still remaining in the loop and informed on research activity within the Toolik RNA. In many cases preservation will occur at the watershed level, which is logical from an aquatic perspective. In other cases, smaller sections will be set aside as control for adjacent research plots. In all cases, it will be up to the Toolik community to approve such decisions, and to perpetually re-evaluate the management of the resource.

Much of this will be accomplished through analysis of the landscape through the lens of a classification system. A number of variables that describe the type and duration of research contribute to the classification and intensity of research. An example of high intensity research is Shaver et al's terrestrial plots which include significant manipulation, infrastructure, and some destructive sampling resulting in significant alteration of the plant communities. An example in aquatic research is Peterson et al's long term fertilization of the Kuparuk River, which has significantly altered the chemical, physical and biological attributes of the river over several kilometers, with potential consequences to surrounding areas.

The greatest value of the Toolik NRT is the synthesis of otherwise disparate data to help in the overall decision making and management of research within the Toolik Lake RNA. Because it brings together the knowledge and expertise of the Toolik community with a rich synthesis of spatial data the Toolik NRT comprises an unprecedented opportunity for the highest quality management, and for collaboration among scientists, managers and administrators.



The Toolik NRT covers the entirety of the 77,408 acre Toolik Lake RNA, and uses a 100 meter by 100 meter grid to divide the terrestrial landscape into management units. Currently existing features of human impact (roads, gravel pads, the pipeline) and aquatic features are considered single, discrete landscape units (Figure 18)

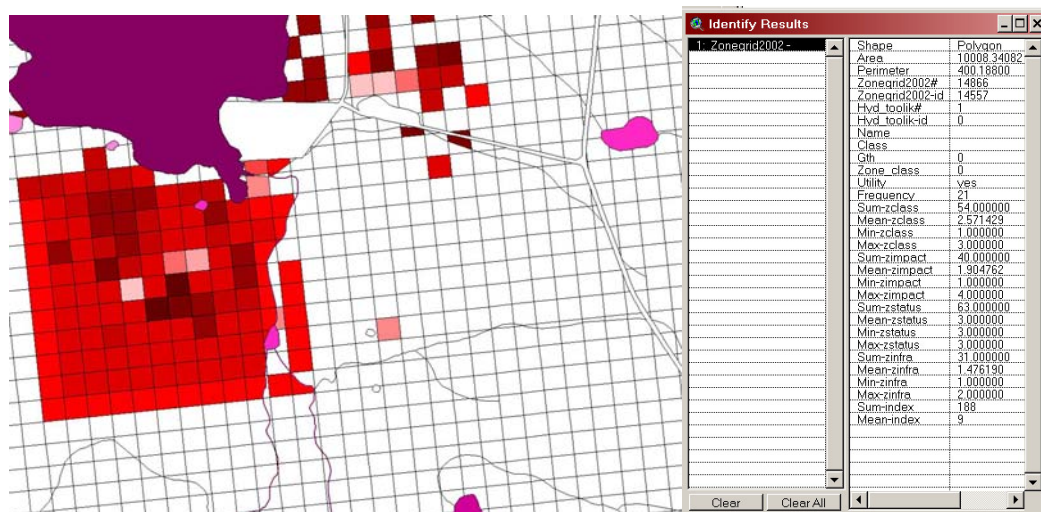


Figure 18. Landscape units in an area on the south side of Toolik Lake. Each grid cell is a 100m square units of terrestrial landscape. Each aquatic feature (Toolik Lake, each stream) is considered a single landscape unit. Each cultural feature (road, gravel pad) is also considered a single landscape unit. The table shows the information stored for each landscape unit, which is the basis for classification, query, and decision making. The intensity of color in the grid relates to the intensity of research within each grid cell as described by the variables in the table.

Each landscape unit contains combined information from all activity within that unit. Figure 19 shows all of the research plots within one landscape unit. The color coding corresponds to characteristics of the research plots contributing to effects on the landscape. Combined by simple formula into an index number for the landscape unit allows scaling from the ground level of individual research plots up to the landscape level of discrete landscape units.

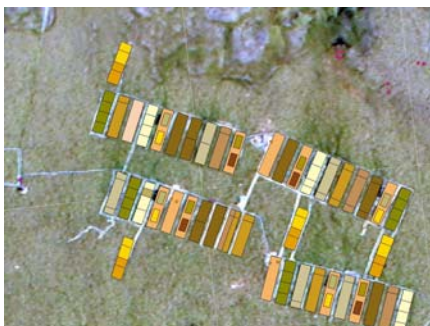


Figure 19. Individual research plots within one landscape unit.



These data, in conjunction with the overall Toolik GIS database, can be quickly used to answer questions about landscape resources and use. Here is a hypothetical example that addresses an existing concern at Toolik. Terrestrial cover types within one mile of Toolik Field Station are in high demand for research because of the logistical advantage of working close to the station. Most new projects require relatively undisturbed terrain of a particular vegetation or surface type. Without adequate planning, research plots would eventually use up certain types of terrain, leaving nothing for preservation or for future use. A simple analysis could be run within a few minutes to help select areas for preservation. In Figure 20, the red areas represent acidic tundra suitable to set aside for preservation based on the hypothetical analysis.

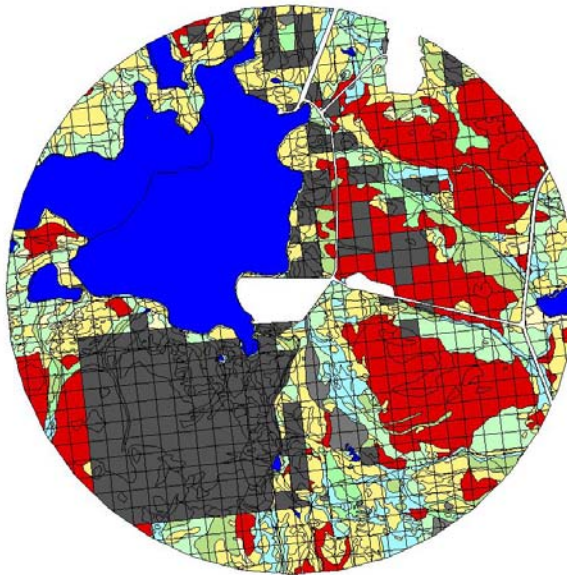
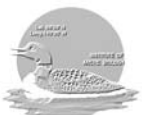


Figure 20. Results of a hypothetical analysis for landscape management and preservation.



5.0 COMPUTING AND NETWORK SUPPORT

5.1 Summary

Toolik GIS also provides computing and network support for users at the Toolik Field Station. Since 2001 the station has offered high speed internet connectivity and IP telephone service during the summer field season. The primary responsibility for design, implementation and maintenance falls on UAF's Department of Computing and Communications, but their staff reside entirely in Fairbanks, so Toolik GIS provides users with computer support while at the field station.

Toolik users come from over fifty research institutions around the US and abroad and use upwards of a dozen different operating systems. Each institution has its own internet configurations, and to use the internet at Toolik they must reconfigure their machines to work within UAF's specifications. Most users request assistance in configuring their machines correctly.

At the facility level there are occasional tasks performed on behalf of the Department of Computing and Communications staff since it is not cost effective to house a full time staff member from that department at the station. Hardware checks and maintenance are the predominant form of assistance provided at this level. These functions are provided both on my own and in consultation with staff in Fairbanks and comprise perhaps a few dozen tasks each field season.

5.2 User Assistance

User assistance is generally a simple matter requiring about 20 minutes per user request. The vast majority of requests involve changing the user's computer settings from their home institution's specifications to those of UAF. Cataloging the necessary steps to change the computer back again once they return home is another service provided. These requests tend to coincide with camp arrivals so there are several periods during the summer when these requests are constant (for several days). On rare occasions users need me to provide space on the Local Area Network (LAN) for data and documentation to be shared among researchers. Computing and network resources of Toolik GIS can handle these requests, increasing the utility of the internet infrastructure at the station.

5.3 Network Maintenance Tasks

Network maintenance is predominantly hardware related and is often performed without the need for consultation with UAF. Minor problems with wireless bridges, antennas, patch panels and wiring occur on a semi-regular basis as a result of the remote conditions in camp and the high demands placed upon the system. These problems are brought to my attention by users from the various buildings at the station, and most can be handled decisively within one or two days. Occasionally larger problems arise requiring more intensive efforts and consultation with specialists in Fairbanks. For example, an unusually strong electrical storm in 2002 disabled the primary control box hardware and software and several wireless bridges. Over the course of several days the problems were diagnosed and repaired with help from Tim Larrabee in Fairbanks. By the third day, full functionality was restored.



6.0 MEETINGS & TRAVEL

Alaska Surveying and Mapping Conference	Anchorage, AK	February 13 -15
Arctic LTER Annual Meeting	Woods Hole, MA	February 28 – March 3
UNAVCO Survey GPS Training	Barrow, AK	May 10 -12
Toolik Field Station	Toolik Field Station	May 16 – August 24
Toolik Field Station	Toolik Field Station	October 6 - 12
Toolik Annual Steering Committee Meeting	Fairbanks, AK	December 5 - 6
Marine Biological Lab	Woods Hole, MA	December 9 - 13

Meetings and travel in 2002 increased the visibility of Toolik Field Station GIS, fostered interactions with the research community, increased the scope and quality of services provided and ensured that the Toolik community would have the benefits of the GIS database while at the station for the entire field season.

Two annual meetings, the Arctic LTER and the Toolik Steering Committee Meeting are very productive for decision making and communication. These meetings address topics at both the project specific and general levels. Discussions with users provide me with a much better understanding of the community's needs and how to meet those needs. They also allow community members to see the possibilities the GIS analysis can offer, leading to better developed requests, ideas and proposals. This interaction also helps me better anticipate needs before they arise, so I am prepared to provide better services during the field season. Direct discussions also ensure that expectations and reality stay closely paired, keeping satisfaction levels high.

In December I visited the Marine Biological Lab at Woods Hole on a less formal basis as a visiting researcher. This pilot trip was designed to test the benefit of interacting with users over a longer time period in a less structured setting. The greatest benefits of this trip were an ability to handle requests more quickly, and to spend time developing and refining new ideas to the point of action. It seems likely that this sort of trip (to a set of users' home institutions), perhaps on an annual or semi-annual basis, would be a consistently productive endeavor.



7.0 TIME ALLOCATION

Tasks performed by the Toolik Field Station GIS vary depending upon time of year, and have evolved substantially since the inception of the program in early 2001. In general, science support requests are most frequent during the spring and summer, management/administrative needs are greatest during the fall and early winter, and computer and network support occur exclusively during the field season. Data development comprised the majority of time during the first year of operation, but various needs, requests and initiatives rapidly expanded to compete for priority.

Presently, Toolik GIS tasks are a prioritized backlog including data development, metadata documentation, moderately time consuming requests, and a few large initiatives. Short term requests, by their nature, tend to be filled in the most timely fashion and often circumvent the larger priority list. Data development and moderately time consuming requests are handled with variable delay, though always to the satisfaction of the client.

There are several larger scale initiatives that are essentially on permanent hold for lack of time. The functions described in the Data Development, Science Support, Management Support and Computer & Network Support sections require more than the time available to fulfill. Some requests must be deferred or turned down, leaving no large blocks of time for more sophisticated analyses and elaborate projects that extend the utility and value of the GIS as a whole.

Some examples of larger scale projects that would be underway if time were available include: 1) the initial work for a web based hierarchic GIS working with Walker et al., 2) expansion of the detailed landscape datasets with the use of remote sensing to cover more of the intensively used areas around Toolik, 3) modeling and remote sensing analyses for Ed Rastetter et al. of the Marine Biological Lab, 4) a stream network analysis with Peterson et al., 5) a comprehensive, internet based data and documentation distribution node and 6) a GIS enhanced web tool for NSF OPP. Items 1, 5 and 6 also represent steps toward a greater Geographic Information Infrastructure (GII) for arctic research as identified at the Arctic GIS Conference in Seattle in January, 2001 (Sorenson et al., 2001).

It is my sincere hope that as the track record of the Toolik GIS lab grows, that the lab resources will grow as well including more personnel.

	Science Support Requests		Management Support Requests		Data Development		Comp. / Network Support
	daily	larger	daily	larger	Framework	Project Specific	
Field Season	25%	20%	5%	5%	10%	20%	15%
Rest of Year	20%	15%	10%	25%	20%	10%	<5%

Time allocation percentages by category and time of year.



8.0 FUTURE

8.1 Scope of Support

It is the intent of Toolik Field Station GIS to continue to expand upon the services already provided. Since its inception in early 2001, the office has seen a steadily increasing number of requests for services, and a shift toward requests for large-scale projects and more sophisticated analyses. Data development, science support, management support and computer/network support are all core functions that are expected to continue and increase with time and which demand more time than is available at present. As new data and analyses are incorporated into the GIS, the potential for expanded use increases. For example, information about landscape zoning from the Toolik Natural Resource Tool, which existed initially for its own sake, can be combined with remotely sensed and GIS data to test how well the effects of zoning implementation match original predictions. The greatest return on investment from a GIS is the long term capability to call upon the database for an almost limitless number of analyses based upon otherwise disparate data incorporated into a single, organized, cohesive format. The capacity for new discovery, improved monitoring, more realistic modeling and more accurate mapping and measurement are limited, in the long run, by time.

The role of Toolik GIS should also be central to the expansion of Geographic Information Infrastructure (GII) and Spatial Data Infrastructure (SDI) as described in Sorenson et al., 2001). The cumulative body of data centered at Toolik and the expansive nature of the Toolik community, comprising hundreds of researchers from over 50 national and international institutions, make it an appropriate, logical and valuable contributor and cooperator in arctic GII and SDI development. This expansion will include scaling up to regional, state and circumpolar levels with data and analyses, collaboration with other arctic research nodes, and interaction and consultation in infrastructure development.

8.2 Personnel

The vision for Toolik Field Station GIS in the next two years is to develop a lab of three employees to fully cover all requests and services described in this report, and to expand services in both scale and scope. The team will be a complementary mix of skills and background to cover GIS, remote sensing, network support, and will collectively have a strong background in the biological and physical sciences. In an expanded version of the current Toolik GIS, the team will maximize interaction with the Toolik community to derive the greatest benefits from the resources of the GIS lab.

The mission of Toolik Field Station GIS is to facilitate and enhance arctic research through direct consultation and service to scientists and through support of administrative and management infrastructure. This vision for the Toolik GIS lab will meet the mission, and provide dynamic and highly effective services into the future.



9.0 SERVICES AVAILABLE

This is a generalized list of services available through the Toolik Field Station GIS office.

9.1 Year Round Services

- Map reproduction and distribution
- Custom cartography/figures
 - Hardcopy maps
 - Powerpoint figures
 - Publication figures
- Data and metadata distribution
- Custom data development
- Simple metrics
 - Coordinate locations
 - Estimates of area, distance
 - Landscape characteristics
 - Presence/absence/number of specific features
- Custom analyses
 - Site selection
 - Landscape characteristics
 - Synthesis of field data with spatial data
 - Modeling
 - Data manipulation

9.2 Field Season Services (additional to Year Round Services / May – August at the Station)

- GPS equipment available to Toolik users
 - Recreational grade (2 to 5 meter precision)
 - Post-processed (code and carrier phase; to sub-meter precision)
 - RTK (real-time kinematic) processed (to sub-meter in real-time)
 - Survey grade (to sub-centimeter precision)
- GPS technical training (informal)
- GPS field work/consultation
 - Mission planning
 - Data collection
 - Post-processing
 - Data manipulation
 - Data distribution and archiving
- Assistance for site location and landscape/permit management
- Assistance for field planning and last-minute adjustment
- Spatial data support for aircraft-based work (helicopter and small fixed-wing)



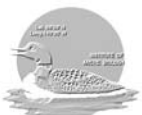
10.0 PEOPLE & INSTITUTIONS SERVED

PI/Administrator/Group	Affiliation	Daily Request (< 5 days)	Larger Request (> 5 days)
MANAGEMENT SUPPORT			
Dr. Brian Barnes *	UAF / TFS Steering Committee	Y	X
Bob Schneider *	U.S. BLM	Y	X
Harry Bader	Alaska Dept. of Nat. Resources	Y	
Sarah Conn	Alaska Dept. of Transportation	X	
Tim Hammond	U.S. BLM	X	
Dr. Tom Hamilton	U.S. Geological Survey		X
Dayle Sherba	U.S. BLM	X	
SCIENCE SUPPORT			
Dr. John Hobbie *	Marine Biological Lab	Y	X
Dr. John O'Brien *	UNCG	Y	Y
Dr. Skip Walker *	UAF	Y	Y
Dr. Gaius Shaver *	Marine Biological Lab	Y	X
Dr. Anne Giblin *	Marine Biological Lab	Y	Y
Dr. Marilyn Walker *	UAF	Y	
Dr. Knute Nadelhoffer *	Marine Biological Lab	Y	
Dr. Ed Rastetter	Marine Biological Lab	X	X (on hold)
Dr. Marc Steiglitz *	Lamont-Doherty	Y	X
Dr. Sarah Hobbie	U. of Minnesota	Y	
Dr. Laura Gough	U. of Alabama	Y	
Dr. Donie Bret-harte	UAF	Y	
Dr. Anne Hershey *	UNCG	Y	
Dr. Chris Luecke *	Utah State U.	Y	X (in progress)
Dr. John Wingfield *	U. of Washington	Y	
Dr. Bruce Peterson *	Marine Biological Lab	Y	Y (1 in progress)
Dr. Breck Bowden	U. of Vermont	Y	X
Nancy Auerbach	Colorado State U.	Y	
Marin Kuizenga *	VECO	Y	
Dr. Alex Huryn *	U. of Maine	Y	
Dr. Sally MacIntyre	UC Davis	Y	
Dr. George Kling *	U. of Michigan	Y	
Dr. Steve Oberbauer *	Florida International University	Y	X
Paddy Sullivan	Colorado State University	Y	
Dr. William Fitzgerald *	U. of Connecticut	Y	
Dr. Dan Doak *	U. of Colorado	X	
Dr. Doug Kane *	UAF	Y	X

* indicates a group (PI s, research assistants, students, post-docs, staff)

X indicates single request

Y indicates multiple requests



11.0 CATALOG OF EQUIPMENT

11.1 Computers

Dell

Precision 330 Desktop (1.2Ghz, 80Gb hard drive, 1.2Gb memory)

Inspiron Laptop (1.2Ghz, 20Gb hard drive, 1.2Gb memory)

Palm Pilot

11.2 Peripherals

EPSON Stylus Pro 9500 large format (44") Color Plotter

Context FSC 5010 large format (36") Color Scanner

Hewlett-Packard 2500CM Color Printer

EPSON Expression 1600 Scanner

11.3 GPS

Trimble

GeoExplorer3 (x2)

ProXR (x2)

5700 (Survey Grade)

11.4 Major Software

ESRI (GIS)

ARC/INFO 8.0.2

ArcGIS 8.2

ArcView 3.2

ENVI (Image processing)

Adobe (Figures, graphics)

Photoshop 6.0

Acrobat 5.0

Trimble (GPS)

Pathfinder Office 2.8

GPSurvey 2.35

Macromedia (Figures, graphics, web)

Flash 5.0

Freehand 9.0

Dreamweaver 4.0



12.0 LINKS

Toolik Field Station GIS Annual Report 2002:

http://www.uaf.edu/toolik/Reports/NSF_TFS_GIS02.pdf (Acrobat file 2.5Mb)
http://www.uaf.edu/toolik/Reports/NSF_TFS_GIS02.doc (Word document 11.5Mb)

Locator Maps of Toolik Field Station:

<http://www.uaf.edu/toolik/maps/akmap.html>
<http://nrm.salrm.uaf.edu/~abalser/request/locator2.jpg>

Basic Map of Toolik Lake:

<http://www.uaf.edu/toolik/maps/lake&pad.html>

Thematic Maps of Toolik Lake Region:

<http://www.uaf.edu/toolik/maps/rna.jpg>
<http://www.uaf.edu/toolik/maps/rna2.jpg>
http://nrm.salrm.uaf.edu/~abalser/glacgeo11_13_01b.gif
http://nrm.salrm.uaf.edu/~abalser/25kveg_2_17_03b.jpg
<http://nrm.salrm.uaf.edu/~abalser/qth.jpg>
http://nrm.salrm.uaf.edu/~abalser/ivi_slope.jpg

13.0 REFERENCES

Recommendations for a Geographic Information Infrastructure to Support Arctic Research: Outcomes of the Arctic GIS Workshop, 22 – 24 January 2001, Seattle, WA. Mark Sorenson, William F. Manley, Renee D. Crain and Wendy K. Warnick (eds.). The Arctic Research Consortium of the U.S. (ARCUS). Fairbanks, AK. 2001. 49pp.

