Using GIS in High School Community Based Education

by Mark Ericson

Abstract

Students participating in Santa Fe Indian School's Community Based Education Model learn to use the GIS program ArcView as an essential component of an interdisciplinary curriculum that engages students in studying current, relevant and important issues identified by community partners. Geospatial Analysis allows students to visualize their community field work and home reservations in ways that expand their knowledge of environmental geography, traditional and legal boundaries, neighbors and neighboring jurisdictions, helping students to develop a better sense of place and understanding of physical influences on community sustainability and sovereignty.

Introduction

High School students in the Santa Fe Indian School Community Based Education Model use GPS and GIS technology and software to manage data from community based environmental fieldwork, use Spatial and 3-D analysis to visualize their reservations and surrounding lands, and use Hydrological Modeling to derive stream channels and watershed basins to better understand the water sources their communities depend on. Watershed science and Environmental Geography are overarching concepts in a flexible, dynamic, interdisciplinary curriculum that also includes Mathematical Modeling, Tribal Government and Communications. We work closely with community members who are equal partners, and who help to identify current, relevant, and important issues for student study and weekly community fieldwork. Students have used their knowledge, skills, experience, and enhanced community interest to further their educations and become contributing members of their communities.

History and Organizational Structure

In 1996, interdisciplinary classes began in a course of field based investigations in partnership with four tribes. Intel provided initial funding, and generously donated computer technology, which allowed the early inclusion of ArcView in the curriculum. The program has been funded ever since by the Department of Energy. Regular meetings with community contacts, designated by the community leadership, help program staff identify themes of study that strive to involve the students in valid work that aids the communities by supplementing on-going scientific studies conducted by the tribes' environment departments. Equal partnership by the tribes is an essential component that has contributed greatly to the success of this program, and gives it a special significance in the school curriculum.

Three fundamental questions formed the basis for the program and curriculum development. Will students become more interested and motivated to learn if the curriculum involves working in the communities with community members on issues that are current, relevant and important?

Will such experiences lead young people to pursue higher education and/or work within their own tribes? How can computer and other technology be used to help students learn about, and conduct research on, community based issues?

The participating communities range from 15 to 70 road miles in distance from the school. To accommodate the need for students to visit and work in the communities on a weekly basis, the students attend blocked classes every afternoon. Students receive credits for four courses - Environmental Science, Mathematical Modeling, Tribal Government and Communications – taught by three teachers. A community liaison helps facilitate communications and facilitate meetings with tribal leadership and representatives on a regular basis so healthy relationships with the partner communities are maintained. Students are divided into four teams, one for each community. Each student travels to his or her team community each week. Since the inception of the Community Based Education Model (CBEM), approximately 200 students have participated. Students self-select and classes consist of sophomores through seniors whose schedules and graduation requirements do not preclude participation. While there are prerequisite math and science skill levels that are desirable, interested students who have not attained these levels are not discouraged. Classes often consist of students with a range of abilities, including students with special education needs.

Each participating community has different research priorities. As the CBEM curriculum has evolved to accommodate these priorities, common themes have emerged that form the core of the curriculum. Air, water and soil quality, surface and groundwater monitoring, biodiversity assessments, and intergenerational teaching, have emerged as common threads, and environmental geography and watershed science are overarching concepts that embrace the many different activities undertaken according to the wishes of the community partners. Regular meetings with community partners allow methods to be evaluated and refined, and often require curriculum to respond to shifting priorities and focus in the communities. To the extent possible, field science methodologies are used that produce data that can be validated and defended, with the intention of producing useful information for the tribes that they may not otherwise have the time and personnel to generate.

Curriculum Development and Use of GIS

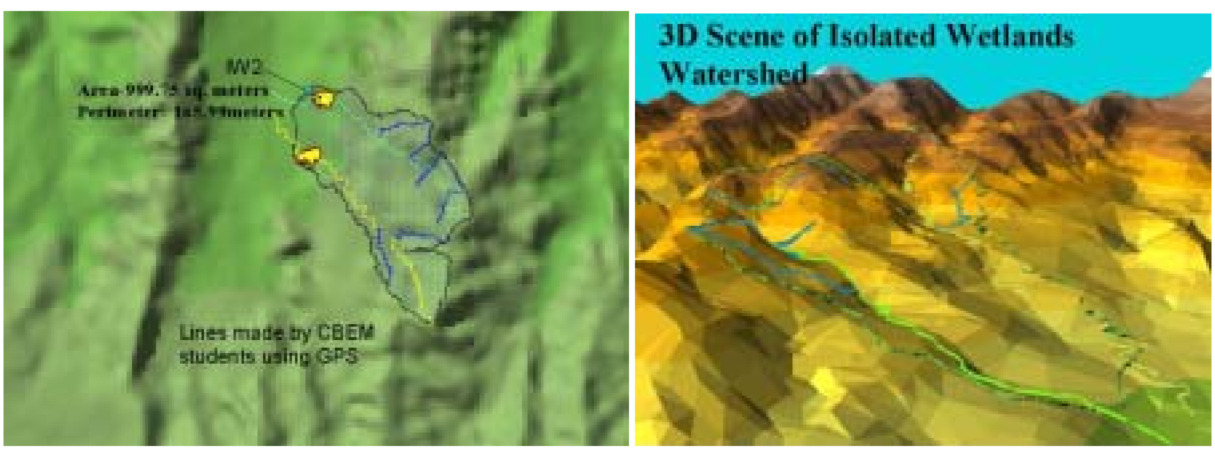
From the beginning of the school year, students are introduced to GIS through the ArcView program, learning initially how to create basic maps by adding layers, practicing tools in hot-linking internet research on countries and phenomena of interest. They learn about different projections and coordinate systems, so that they can begin to understand the importance of making certain decisions when setting up GPS data loggers to take position files. Through thematically based curriculum students learn and develop a variety of capabilities, from how decisions are made to how phenomena are spatially oriented. Students with all different levels of accomplishment in traditional academic settings come away with a common cultural educational experience. By studying community-relevant issues in a global context, students gain a better understanding of the complex relationships between their own communities and the outer world. GIS facilitates this tremendously through ArcView exercises that teach basic ArcView skills while helping students develop a deeper appreciation for the spatial organization of the planet.

Hot-linking never-before known locations with internet-researched pictures or websites helps develop computer multi-tasking skills.

Water, energy, topsoil, biodiversity, exotic invasive species - all are rich subjects for study, often linking recent newspaper articles with important inter-community events. Offering many diverse ways to integrate fundamental curricular math, science, social studies and communications objectives in synergistic ways, a modern, current and important context for learning provides the stimulation and new experiences that youth need to feel connected to vast processes that affect their lives. If they are inspired to pursue further education, go to work for their communities, or in any way have a deeper appreciation and understanding for the natural world that is the very essence of their community's sustainability and survival, then this educational method may itself be sustainable, and survive.

Mapping Fieldwork

Developing a map, going through the many steps necessary to learn and relearn how to see a landscape for the first time, is a process that engages all students in learning skills that are completely new to all of them. From seeing the initial themes of state, county, reservation boundaries and stream channels from state engineer files, in low-resolution format, to using the Spatial Analyst extension for merging imported Digital Elevation Model (DEM) grids (10 meter resolution), clipping interest areas, deriving stream channels and watershed basin boundaries, the student has participated in a truly original exercise of creativity, with no preconceived notions about who is better than who possible. When GPS points and lines are processed to appear in a hillshaded or 3D TIN view, the student has learned the current limits of resolution, which, happily for the student, may lead to trudging around with a data logger in the field (Figs. 1 & 2).



Figures 1 & 2: The watershed of a small, isolated wetlands GPSed and mapped by CBEM students.

Once fieldwork can be accurately represented on views made with DEMs, opportunities arise for inquiry-based exploration of the spatial analysis potential. Biodiversity study zones, with limitless potential for environmental data input (Figs. 3 & 4), and hot-linking groundwater monitoring well locations to scenic photography and depth-to-water data tables, or photo points at a potential wind energy site (Fig. 5) are examples. The author believes that spatially orienting multi-disciplinary learning, combined with diverse physical experiences, enhances student understanding of complex social and environmental phenomena.

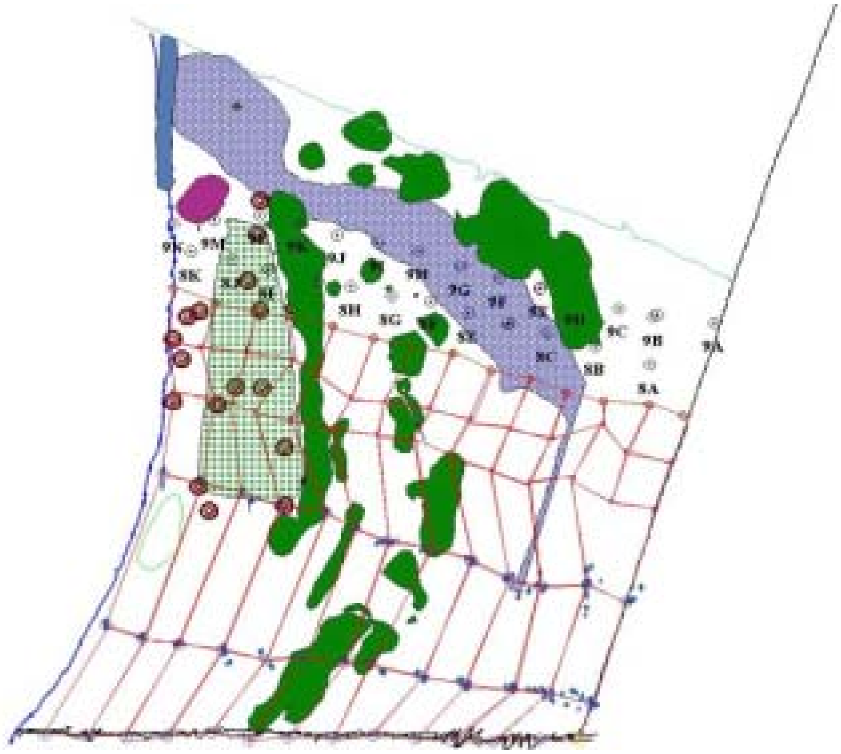


Figure 3: GPSed study plots and features of a Forest Restoration project
on the banks of the Rio Grande.

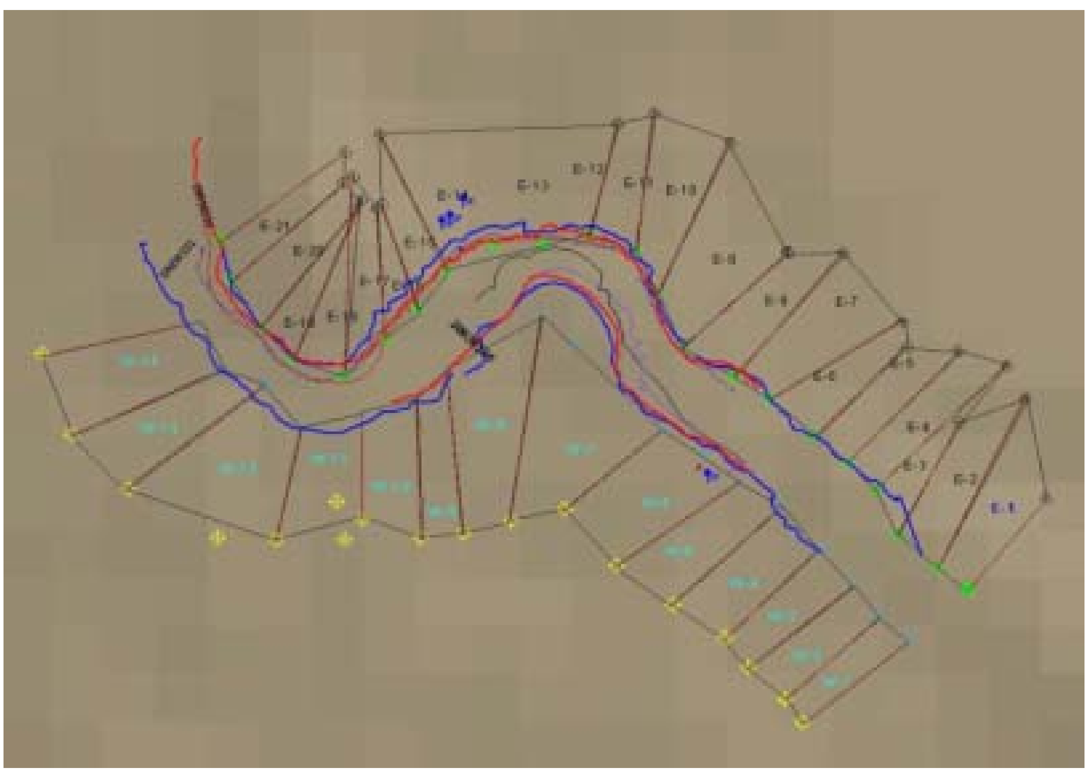


Figure 4: Study Plots and GPSed riverbanks at different times of year
as part of a ongoing seasonal Aquatic Habitat Assessment.

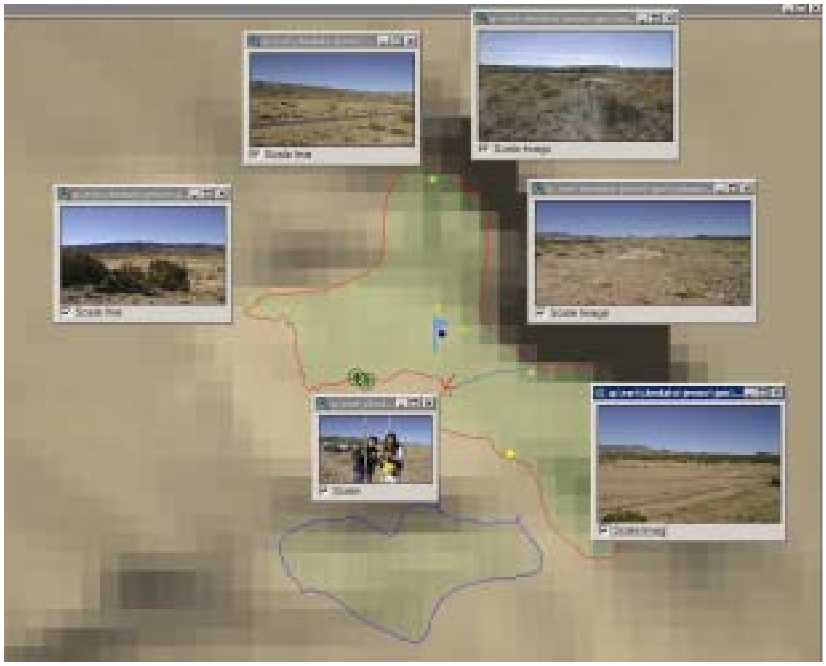


Figure 5: Photo points at potential wind energy site.

The process of converting GPS data files into visible shapefiles involves multiple, complex steps, and, for those students that undertake it, it is a powerful exercise in computer multi-tasking, involving file treatment with differential correction and appropriate coordinate system and datum export. The USGS DEMs used as the basis for GIS project development require knowledge of the UTM coordinate system. Trial, error, and ground-truthing have helped us determine that NAD 1927 is the most appropriate datum for our purposes (Fig. 6)

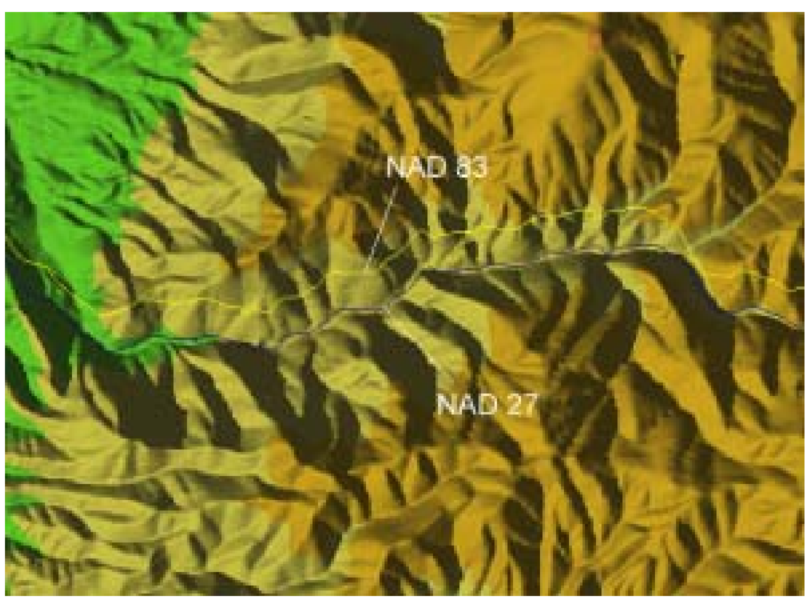
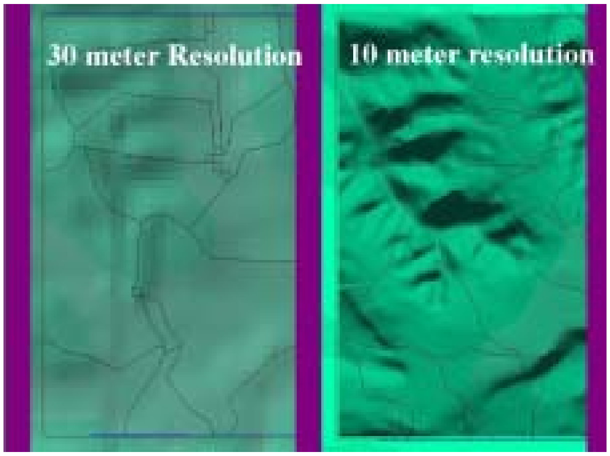
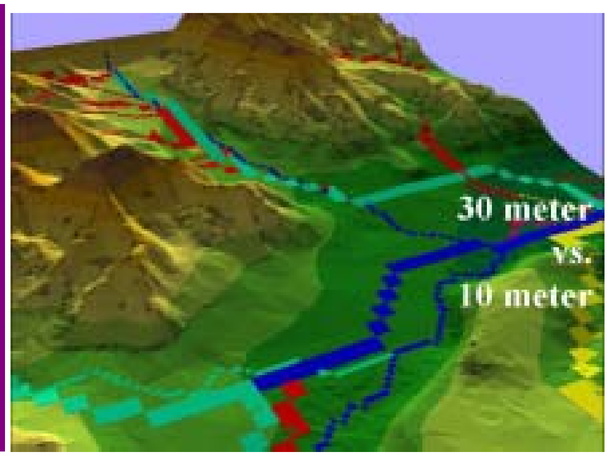


Figure 6:GPS also allows opportunities for calibrating Datums to the UTM DEMs.
NAD 27 seems to fit better, by about 100m, than NAD 83.

Students are also able to see that the resolution of their DEMs is important in being able to visualize the landscape (Figs. 7 & 8)





Figures 7 & 8: Watershed basins and stream channels illustrate the importance of higher resolution.

Included in the opportunities for learning that flow from healthy and productive community-school relationships are wonderful links to near-peer and inter-generational interactions. Interviews with elders and interactions in an elementary or mid-school context helps the students learn that their learning is of immediate value (Figs. 9 & 10). When a young person learns from a great uncle that the birds are different from when he was the student's age, the young person has a new reason to learn. The author has on numerous occasions witnessed the attention and respect that these young people receive when they use maps they have created to teach. Powerful community members realize the great potential these young people represent to their communities, and are frank about their appreciation and encouragement.

Figure 9: Interviewing elders about their recollections of the local environment in their youth.
Figure 10: Elementary school children learn about GPS from near-peer teachers.

The positive impact on students' interest and motivation of regular guidance and participation in field activities by personnel of a community's environment department cannot be overstated. Students learn the importance of sound methodology and consistency (Fig. 11).

Figure 11: Students and Environment Department personnel sorting benthic macroinvertebrates as part of a Riparian Survey.

The Watershed Process

Using GIS to improve a young person's knowledge and understanding of their homeland is a central component of this model. When students begin the course they are asked to draw a map of their reservation. Often, their spatial knowledge of boundaries, topographical and social features is very limited. They are then shown a variety of paper maps and are introduced to ideas of representation and scale.

Using ArcView, they are then taught to identify the quads that cover the lands around their reservations and the drainages that their communities depend on. Through a sequential process they are then taught how to use Spatial Analyst to import and merge the DEMs necessary to create a master map from which they can spatially analyze any particular area of interest, or the entire map. Contours, slopes and aspect can expand the students' knowledge and lead to interesting investigations. By deriving stream channels and watershed basins, they create a powerful representation of the landscape that allows them to explore and make connections to their own experiences. Using 3D Analyst raises the visualization to an even more exciting level. This master map is used to for a variety of individually paced and independent refinements that make the map become the student's custom 'place'. (Figs. 12 – 21)

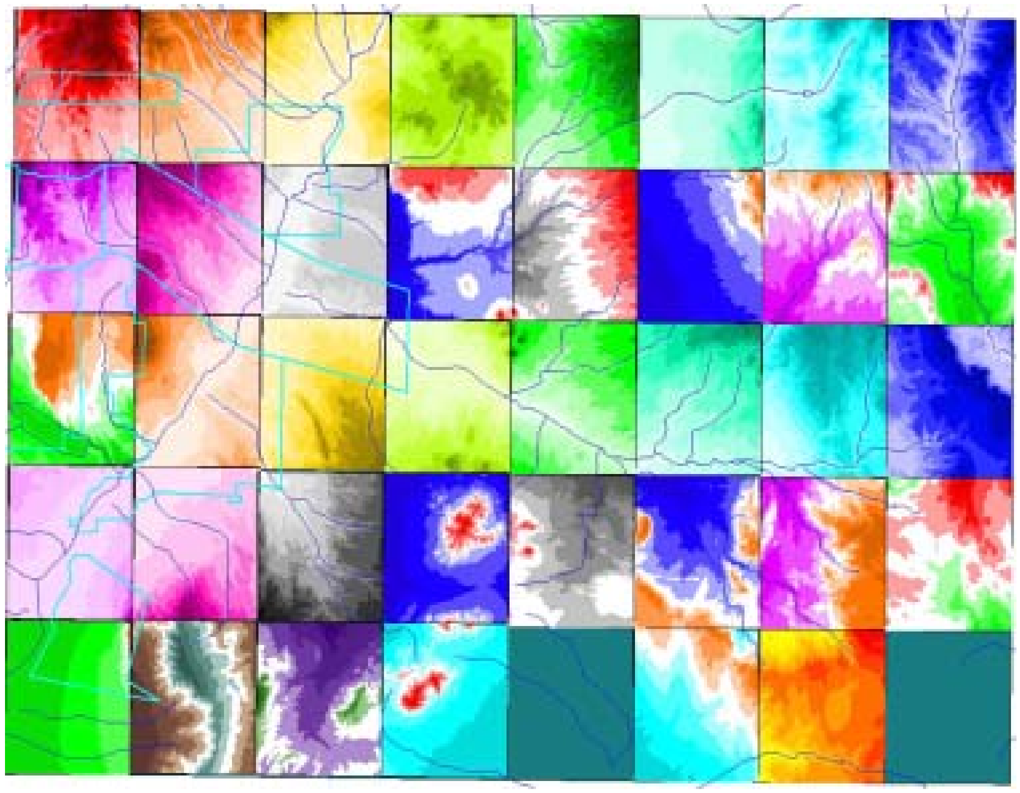


Figure 12: This map shows quads imported to include all the basins relevant to the student's reservation.

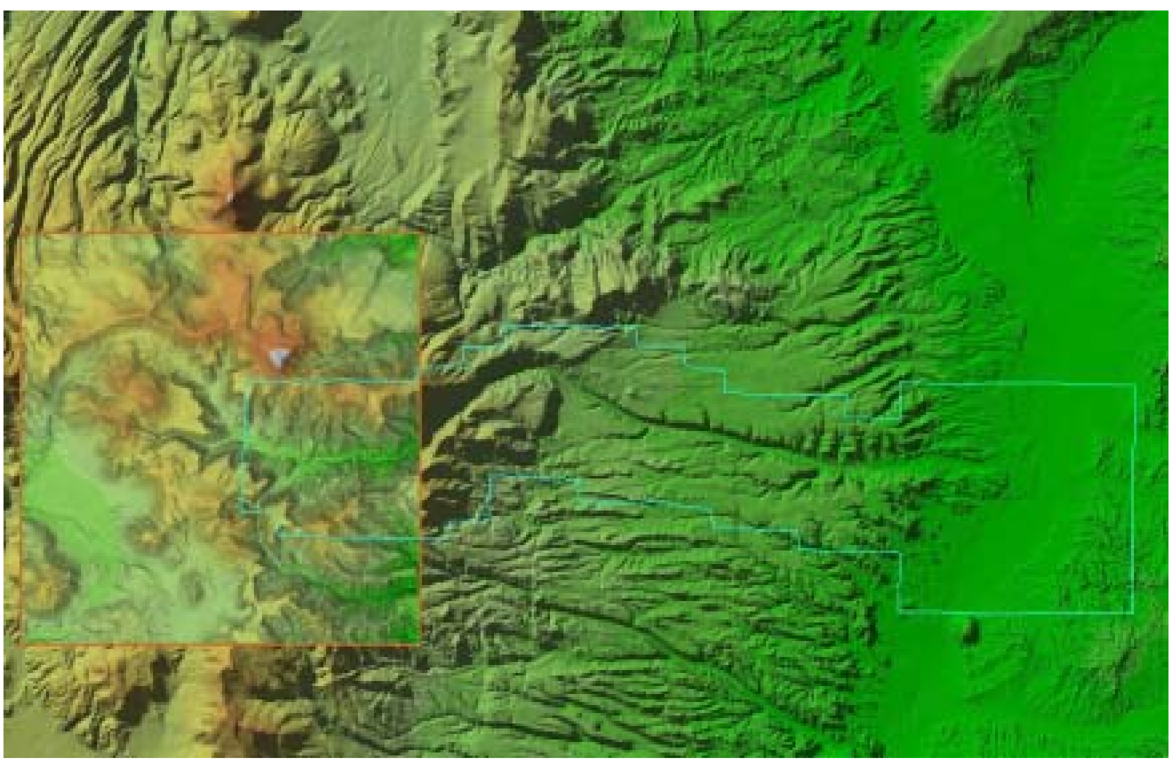


Figure 13: Map calculator is used to merge the DEMs into one seamless map, and an area of interest, in this case the headwaters of the reservation's primary watershed, can be clipped out for further analysis.

Figure 14: The clipped grid.

Figures 15 – 17: contours, slopes, and aspect

.

These maps become part of an inventory, and can be easily transferred into an image that can be shared, giving the student a powerful way to communicate geographically. Whether trying to identify areas with the highest potential for erosion following a forest fire, planning inventories of plant species, or simply learning elevations, the student now has powerful graphic tools for further study.


Figure 18: Flow accumulation shows graphically, albeit faintly, the most likely place to find water.

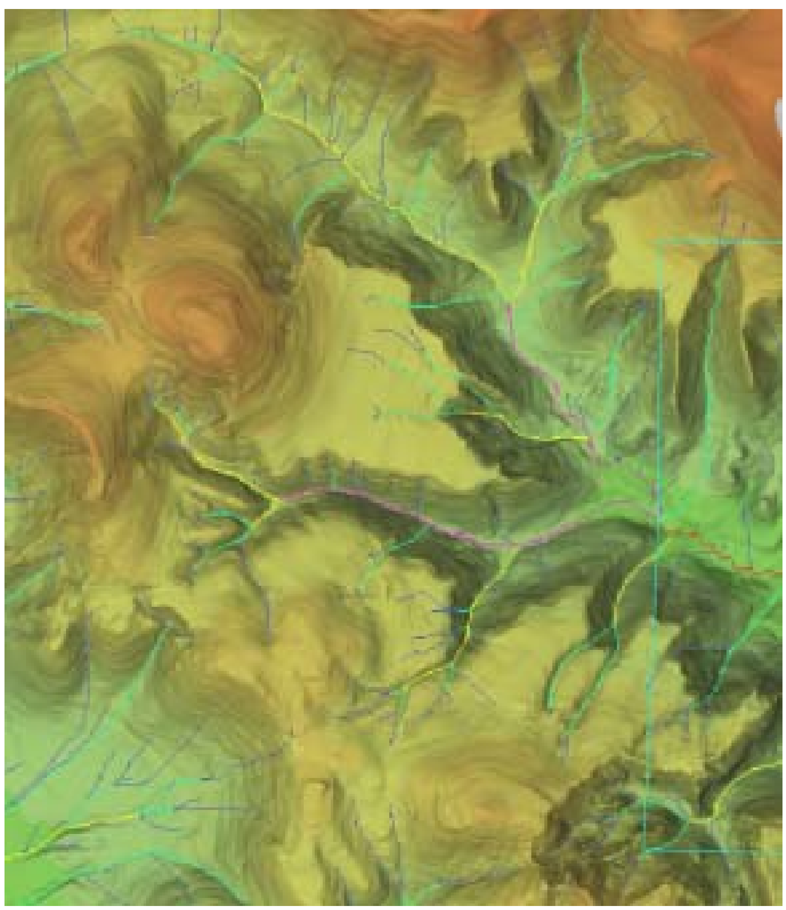


Figure 19: The Straehler method beautifully refines the stream channels.

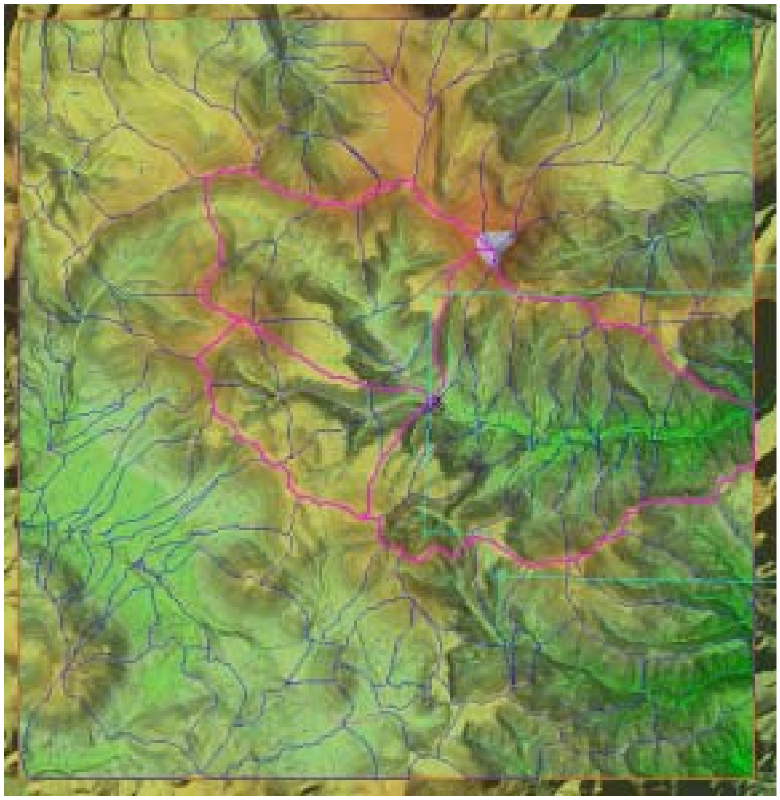


Figure 20: Basins give final definition to the community's water sources.

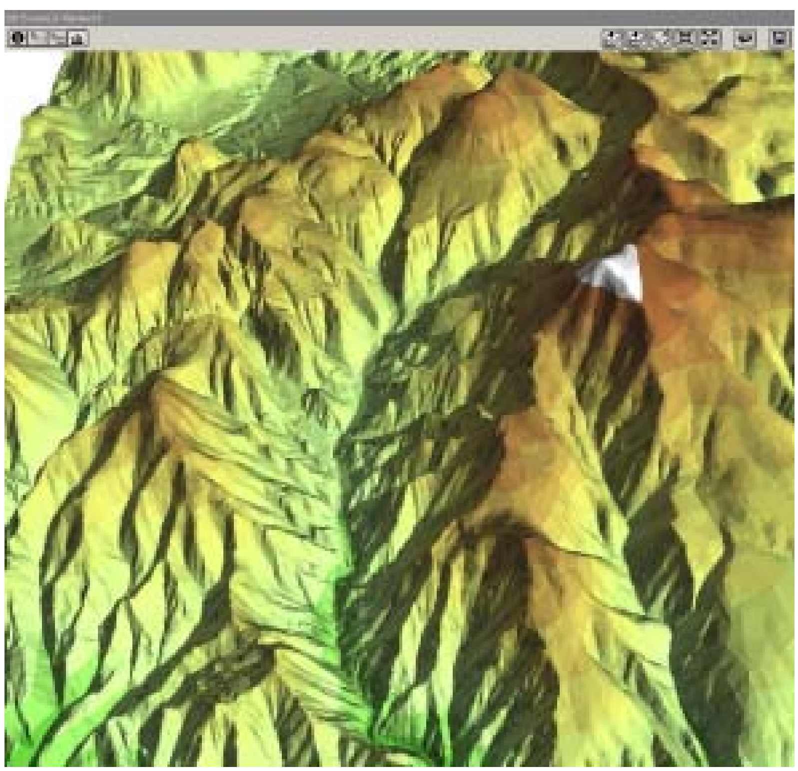


Figure 21: 3-D Analyst puts an even more powerful tool in the hands of the students.

The watershed is an over-arching curricular context that unifies the diverse foci of common partner interest. The physical, chemical and biological processes that are accessible intellectually when considering where your water comes from, or why your forest is able to provide wood and habitat for the game you hunt, are inexhaustible by sheer time-constrained investigation. Using ArcView to model watershed basins, and their associated contributing drainages, is a powerful means for connecting seemingly unrelated phenomena.

Students are also encouraged to begin to answer questions about who their neighboring landowners are. Whether they are private lands, State lands, BLM, National Forest, or a neighboring reservation, this important knowledge will help them in the future if they are ever in a position of responsibility in their community. Through their fieldwork with community members, they are already becoming aware that water quality and quantity, air quality, biodiversity and development issues are important and relevant topics of interest and action.

There is no limit to the ways that on-the-ground GPS information can be mapped and related spatially. When students wade through a stream trying to get a clear signal to map study area boundaries, or simply stand stationary to get a point, the learning experience is substantial. When the data is then realized in a multi-dimensional mapping database the learning is exponential. When the students realize that hey are adding to a living repository of baseline information their learning has the reality of being consequential.

GIS is a wonderful vehicle for understanding community and making learning relevant. It offers the spatial connection that young people need, and it is accessible through their preferred medium – fast computers and capable software. If a young person chooses to apply for a summer employment position because he held a data logger and made a map, then the community of which he/she is a member has gained immeasurably.

GIS also happens to be the hook that keeps outsiders interested. We are not sure that a specific reason has ever been articulated, but we are sure that a certain reverence is afforded the young person who can relate a community issue geographically.

Each one of our young participants comes from a culture and community that predates the modern maps. The boundaries are conditional legal barriers and only exist in the abstract, while air, water and biota flow across these boundaries driven by forces that are not containable. In this context the tribal, legal, and state boundaries are learned, and geographical change is understood as alive, not fixed, as in a static textbook representation.

To the extent that a spatial orientation can be used to stimulate learning, the learning of GIS and GPS technology are powerful means. When a student has the sense that what he or she is learning is connected to the survival of his or her way of life there is an added incentive to pay attention.

Of approximately 200 students who have participated in the Community Based Education Model, more than 50% have been involved, or are involved, in further education and community work related to issues studied during their participation in the program, practicing skills that were first learned as high school sophomores, juniors and seniors. Summer internship programs have been consistently employing 10 or more students each year, since 1998.

Conducting this type of work is costly and it seems that integrating GIS into school curricula widely is problematic. There seem to be a number of reasons for this. Teachers are overwhelmed and underpaid. Teachers are under constraints to fulfill established curriculum goals, and though many might want to include a unit or two on GIS, in some way relevant to the student's experience, they do not know enough about it to feel confident doing so. Regular community fieldwork requires a school schedule that will accommodate significant blocks of time. Transportation is key. Without available vehicles and a budget that can support it, our work would not be possible.

The activities and insights described herein have evolved since 1996 and could only be possible with the consent and support of the participating communities and the school's leadership. Funding stipulations and logistical constraints are limiting factors in a curriculum with limitless potential. Leadership that recognizes the enormous contributions that their youth can make through geographical awareness can help provide for the delivery of such a learning model.

Acknowledgements:
Our program, and this work, would not have been possible without the generous funding and technical support of Intel and the United States Department of Energy, or the essential participation of the Governors and many other members of our partner communities. Many thanks to Peter Broffman and Jim Reed of Intel, and Brandt Petrasek of DOE for all your wonderful inspiration and support. The Santa Fe Indian School leadership has been an enthusiastic supporter of this experimental approach and has guided its evolution from the very beginning. Special thanks go to Superintendent Joseph Abeyta, Glenda Moffitt, Hal Schultz and Felisa Gulibert for their guidance and support. The many young people who have participated in the program over the years deserve all the credit. Theresa Chavez, Matthew Pecos, Smokey Trujillo, Luke Reed, Arthur Eberiel, Paul Bunker, Lars Rahm, Tiffany Lee, Bittah Becker and Kimimila Locke deserve special acknowledgement as the developers and sustainers of this important work.

Mark Ericson
Community Based Education Model
Santa Fe Indian School
1501 Cerrillos Road
Santa Fe, New Mexico 87505
Telephone: 505-989-6325
Fax: 505-989-6317
e-mail: mericson@sfis.k12.nm.us and podin8r@earthlink.net