CSU Geospatial Review
GEOGRAPHIC INFORMATION SCIENCE IN THE CALIFORNIA STATE UNIVERSITY SYSTEM VOLUME 6 • SPRING 2008

Figure 1: An indigenous guide at the study site in western Guyana .
Figure 2: Location map

Humboldt

"Seeing" the Forest for the Trees

Using Satellite Imagery to Study Tropical Forests in Guyana

At Humboldt State University, Rebecca Degagne and Dr. Steven Steinberg of the newly-formed Institute for Spatial Analysis (ISA) are collaborating with Dr. Terry Henkel of the Department of Biological Sciences to examine remote tropical rainforests in new ways. Their work reveals how remote sensing can be used in conjunction with traditional field sampling techniques to map the distribution of a relatively unknown but scientifically significant ectomycorrhizal canopy tree, *Dicymbe corymbosa*.

Dicymbe corymbosa forms dense, monodominant (*i.e.* mostly single-species) forests in the central Pakaraima Mountains of western Guyana. These forests have important ecological and life history traits that may help scientists better understand high species diversity in the tropics. *Dicymbe* also exhibits a symbiotic relationship with a diverse assemblage of putatively endemic ectomycorrhizal (symbiotic, root-associated) fungi — about 150 species, most of which are new to science. These fungi depend on the tree species for survival, and *Dicymbe* forests act as habitat islands for its fungal associates. Ectomycorrhizal associations such as these are rare in South America. Little is known about the regional extent of *Dicymbe corymbosa* forests; yet, this information is crucial for broader understanding of these unique habitats and requisite to inform future conservation plans.

Remote sensing can be a cost effective solution for determining land cover in regions of the world where ground-based data are difficult to obtain due to physical or socioeconomic inaccessibility. In light of this, the research team assessed the suitability of low cost, medium resolution Landsat satellite imagery for mapping the distribution of *Dicymbe corymbosa* forests in Guyana's Upper Potaro River Basin.

Data collected during Dr. Henkel's previous on-ground studies were used to drive supervised image classification of satellite images taken from August 1989 (Landsat-5 TM) and October, 1999 (Landsat-7 ETM+). In this process, ERDAS

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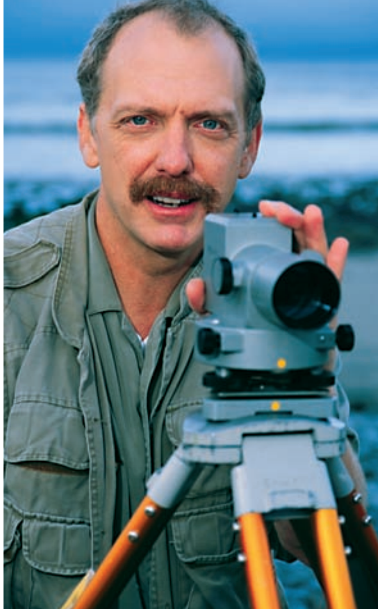
INSIDE



Director's Message
2008

Geographic Information Science: The New "Dismal Science"?

GEORG TREICHEL, a retired colleague from our Geography Department, once defined GIS to me as "documenting in exquisite detail the end of the world as we know it." While one might ascribe this to pure cynicism, there's some truth to it. Despite the rapid growth of environmental movements over the last few decades, and despite the occasional environmental success story, the pace of environmental degradation does not seem to be abating when analyzed from a global perspective. For example, the potential of biofuels replacing fossil fuels has generated excitement, yet converting extensive areas of midwestern farms to corn production has helped to expand the 'dead zone' in the Gulf of Mexico, as increased applications of fertilizers raise nitrogen and other nutrient levels in the Mississippi River. Meanwhile, farmlands expand in the Amazon to grow soybeans to compensate for the switch to corn in the midwest.

As geographic information scientists, we have the tools to see these dramatic effects. Satellite imagery is greatly expanding in availability and detail. We can compare images from year to year, from decade to decade, and we can watch as what might seem inconsequential over the short term becomes a major transformation of a landscape. I was recently reviewing SPOT imagery from the Amazon, and the expansion of rainforest clearing over the last ten years can be plainly seen. And since many GIScience professionals are also earth scientists who understand the links between rainforest ecosystems and soils, we know that this is significant not only from a biodiversity perspective, but it's also unsustainable in terms of human civilization.

I guess we could quit looking, and bury our heads in the sand; but like an important movie that makes you uncomfortable to watch, it's all the more important for us to keep our eyes on the planet. It's critical that as leaders in geographic information science, we continue to develop even better means for "documenting in exquisite detail" what's happening, and try to use our skills in geospatial data analysis to help make a difference.

Jerry Davis, *Director,* CSU GIS Specialty Center
San Francisco State University

Rebecca Degagne in the field next to a large *Dicymbe corymbosa* tree.

Imagine software was used to relate spectral reflectance properties measured by satellite directly to known vegetation cover, and ESRI ArcGIS software was used to create regional maps of predicted vegetation distribution. Field surveys were conducted to determine if *Dicymbe corymbosa* stands were indeed found in predicted locations. This first-hand "groundtruthing" would not have been possible without local indigenous guides, who worked closely with the field team to navigate rugged terrain, gather forest assessment data, and maintain field camps at the remote study site. The resulting in situ forest reference data revealed image classification performed well (Users' Accuracy > 80%) in distinguishing monodominant *Dicymbe corymbosa* stands from mixed-species forest.

Thematic maps developed by the research team could be vital in developing efficient sampling schemes for future ecological studies, especially as they relate to field surveys of ectomycorrhizal fungi and the wider examination of monodominant forest characteristics. Creative application of remote sensing techniques will not only add to our knowledge of *Dicymbe corymbosa*'s natural history, it could aid in conservation planning for rainforests of the Guiana Shield. Indeed, this project suggests Landsat classification may be successful at local and regional scales in identifying monodominant forests in other remote tropical regions.

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Chico

Mapping Mountain Vegetation Alliances

Efforts are currently being made to map detailed vegetation alliances covering the Cascade and Sierra Nevada foothills (60–625m elevation). In order for such a large area project to be feasible, methods for mapping vegetation rapidly and accurately must first be tested.

This pilot project represents a study for deriving vegetation maps from high-resolution digital color aerial photography, high-resolution terrain and surface models of vegetation height and rapid assessment vegetation field plot data in a geographic information system (GIS) environment. Although similar studies have been conducted in the past, none have been done in complex canyon terrain using supporting data layers to derive the attendant vegetation map.

The lower Big Chico Creek watershed, located East of Chico, CA, represents a transition zone between granitic Sierran land forms to the south and the volcanic Cascade landforms to the north. This transverse canyon encompasses over 4,507 continuous hectares of highly variable vegetation patterns covering upper Bidwell Public Park and Big Chico Creek Ecological Reserve.

Vegetation polygons were produced by interpretation of vegetation alliances from 2005 National Agriculture Imagery Program (NAIP) 1m^2 digital color air photos. Using a GIS, vegetation polygons were derived in a heads up digitizing process using a LCD touch-screen pen digitizer. The interpretation process was supplemented by using 5m radar data to produce a detailed vegetation height model and terrain surfaces for texture, as well as a interpretation key developed from field observations.

Based on previous studies and California Native Plant Society (CNPS) protocols, a Minimum Mapping Unit (MMU) of 1 hectare was used for the majority of the study area. The resulting derived polygons were attributed with both primary and secondary vegetation classes. The primary vegetation class reflects the polygon's alliance-level classification according to the *Manual of California Vegetation*. The secondary vegetation class reflects either understory vegetation or other observable associated canopy species.

A polygon was created and a primary alliance assigned if over 50% of that polygon's area was covered by that vegetation type. An alliance with two vegetation types (i.e. Live/Blue Oak) indicates that both species have equal presence within the polygon. If a subspecies was observed, but not over 50% cover it was listed in the secondary cover attribute.

To the extent possible the MMU was revised to a finer resolution (100m^2) for some habitat types such as riparian, springs, and vernal pools. This change in MMU was necessary to capture vegetation distributions in our database that fell below the MMU but were still deemed important because of their importance to the canyon's ecosystem, vulnerability to anthropogenic disturbance, or ability to act as environmental indicators.

Currently the Big Chico Creek Vegetation Map contains 872 vegetation polygons representing 23 different alliance types.

Figure 1: Measuring the canopy cover.
Figure 2: Cascade foothills.

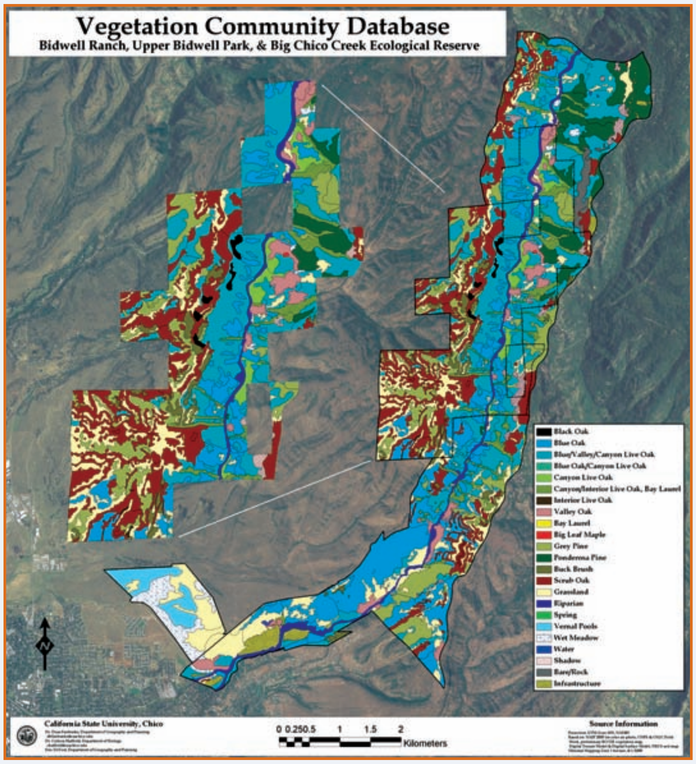

Figure 3: Big Chico Creek Vegetation Map.

A final error assessment of the map is underway to statistically prove the utility of this methodology for the larger Foothills project being implemented by California Department of Fish and Game and CNPS. It is the hopes of the project team that these derived methods will help inform the larger project.

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CalWaterMap: A GIS Tool for Small Water Agencies

Even though spatial information is readily available for the majority of California's 58 counties, many of the smaller Sacramento Valley water agencies don't have the staff, the funds, nor the expertise to take advantage of this valuable data. In 2005, CSU, Chico's Chico Geographical Information Center (GIC), received funding through the U.S. Bureau of Reclamation and the CSU's Agricultural Research Initiative to begin developing a simple and economical GIS application that would provide basic GIS assistance to these districts.

For our first task, the GIC interviewed four water agencies and compiled a needs assessment. We discovered that many of our districts have neither adequate staff time nor the budget to justify investing in GIS technology. Rather, what they preferred was a simple template with an easy-to-understand graphic interface offering a few basic GIS functions.

The GIC found a water utility design geodatabase template on ESRI's Listserv that addressed water district GIS use. We modified many of the tools and converted the application to an SDE template that could run in ArcServe on the Internet. We named the application *CalWaterMap*.

CalWaterMap is a complete water utility geodatabase with all modules intact. Modules can be turned on or off as needed. *CalWaterMap* can function as a simple tool that performs a few selected tasks or a fully functioning water district utility.

California Department of Water Resources and Butte County Association of Governments

County aerial photography (NAIP) is available from the U.S. Department of Agriculture.

Our geodatabase template runs on the ESRI platform so there are three ways to deliver the *CalWaterMap* application to the district:

- ArcExplorer for rural areas with limited dial-up Internet services and limited GIS capability
- ArcServe where the GIC would serve agency data through SDE and provide basic maintenance and help services at limited costs to the districts (DSL or satellite services required)
- ArcGIS for districts who want to begin or transition to providing their own in house GIS shop

Because *CalWaterMap* is non-proprietary, all three tiers can access the same spatial information without losing spatial integrity.

To satisfy our ARI grant, the GIC selected two water districts to test our template. We developed a simple graphic interface for tasks like editing maps, calculating area, and printing maps and graphics. With increased use, we have discovered that our two water agencies are excited at what they can now do and continue to ask for additional functionality. Starting in January of 2008, our ARI partner from the College of Agriculture will begin an assessment of the template and its use.

Until now, small water districts have been left out of the GIS equation. We feel that applications like *CalWaterMap* will change this. While initially the GIC will be concentrating our efforts on simple functions like queries, reports, map edits, and the ability to print simple land use, soil and ditch maps, these are major steps for many agencies where maps are still drawn by hand or not at all.

The GIC has had inquiries from eight additional northern California water agencies interested in using the *CalWaterMap* application.

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2008 COMING EVENTS

June 23 & 24, 2008
University Consortium for GIS (UCGIS)
Summer Assembly, Minneapolis, MN,http://www.ucgis.org/

August 4-8, 2008
Twenty-eighth annual ESRI International User Conference
San Diego Convention Center, San Diego, California
http://www.esri.com/events/uc/

August 12 – 15, 2008
Society for Conservation GIS (SCGIS) Annual Conference
Asilomar Conference Grounds, Monterey, California
http://www.scgis.org/
The SCGIS conference is the week after the ESRI User Conference.

March 22-27, 2009
AAG Annual Meeting, Las Vegas, Nevada
http://www.aag.org/

GIS users will gather August 4-8 in San Diego, CA to connect, learn, and share at the 2008 ESRI UC.

What is Geographic Information Science (GISci)?

GEOGRAPHIC INFORMATION SCIENCE is the synthesis of spatial theory, methods and technologies used to study and map geographic relationships, distributions, networks, temporal change and other spatially aware information in order to better understand and manage limited earth resources. It includes:

GEOGRAPHIC INFORMATION SYSTEMS (GIS)
Comprehensive databases tied to location, with an integrated set of tools for querying, analyzing, and displaying information. Important classes of GIS tools include those that support: (1) logical map overlay, (2) proximity analysis and spatial buffering; (3) network analysis (e.g. of roads or streams); (4) geocoding and address matching; and (5) three-dimensional surface modeling.

REMOTE SENSING
Analysis of the earth's surface and interpretation of its features using imagery collected from air or space platforms. Image processing methods use visible and invisible (e.g. ultraviolet and infrared) parts of the electromagnetic spectrum as well as active radiation (RADAR and LIDAR) to interpret land cover patterns of vegetation, soil, land use, and environmental systems, including up-to-the-minute changes in these systems.

CARTOGRAPHY
The art and science of making maps. Cartographical theories and methods focus on information content, symbolization and design to appropriately communicate the results of studies.

GLOBAL POSITIONING SYSTEMS (GPS)
Provides a means for determining earth location and navigation, using a constellation of satellites and the technology for interpreting their signals. Field data collection for GIS and remote sensing projects is increasingly dependent on GPS.

WHILE HAVING ITS ROOTS in geography, many disciplines have contributed to the development and use of Geographic Information Science. In the CSU System, anthropologists, biologists, business marketers, computer scientists, economists, engineers, environmental scientists, foresters, geologists, historians, journalists, landscape architects, natural resource planners, oceanographers, political scientists, sociologists, urban planners, and wildlife scientists also use these technologies in their classes and for their research.

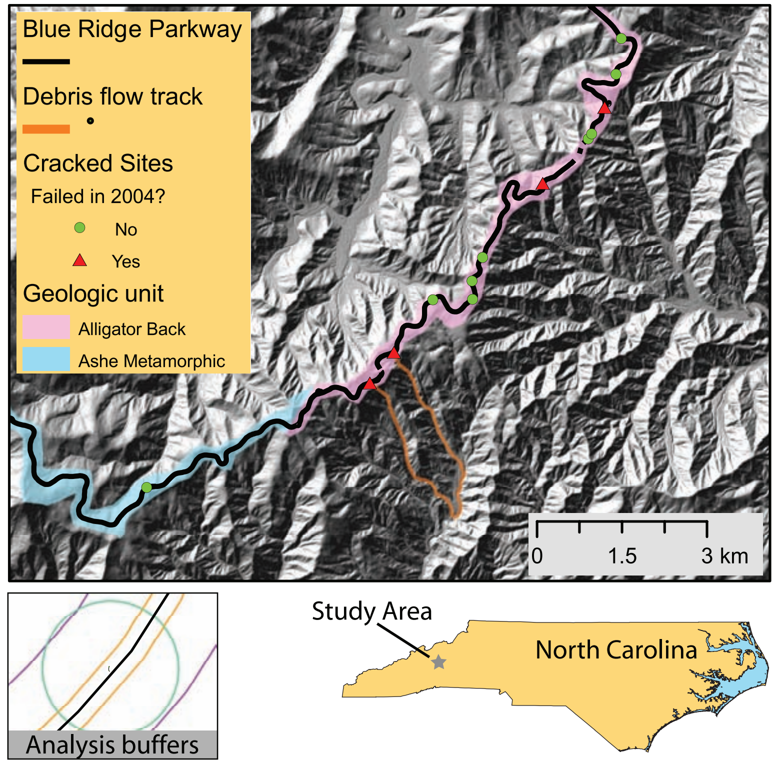
The *CSU Geospatial Review* is on the **Web at www.calstate.edu/gis**

San Francisco

"Forecasting" road failure in mountainous topography

Road-fill failures initiated during heavy rainfall are a common problem for transportation networks in mountainous terrain. These failures can result in millions of dollars in property damage, are costly to repair, and result in protracted road closures disrupting normal travel for months. Fill failures can also result in debris-flow, allowing sediment deposition in watersheds that can perturb the natural environment to the extent that some habitats are not recoverable. Normally, these types of failures are repaired and mitigated once the failure has already occurred, and little attention is given to predicting future events.

However, recent progress in topographic analysis and the implementation of new GIS-based technology facilitated the development of a method to "forecast" road-fill failures. Topographic attributes are readily extracted in a GIS and are also an excellent proxy for slope stability. Slope angle is arguably the most fundamental and readily quantifiable of these topographic attributes. Data from a GPS delineated road polyline, a ~6m resolution LiDAR-derived digital elevation model (DEM), VisiData™ and field reconnaissance were used to develop a new approach to road-fill stability analysis along the scenic Blue Ridge Parkway, North Carolina.



Map showing portion of study area on Blue Ridge Parkway, North Carolina. GIS analysis buffers: Purple - 30m road; orange - 6m remove road; light blue - 30m cracked/failed site; black - road polyline; green point - cracked/failed GPS site

The road polyline was georeferenced in the field using VisiData, a GIS-based technology. Essentially, VisiData provides the user with a software interface for analyzing archived records of pavement conditions including 160° forward-view digital video, mosaic photographs of the pavement surface, and a spectral analysis of pavement conditions. All data are collected by three technicians operating a vehicle outfitted with various cameras, sensors and GPS. VisiData was developed for the Federal Highway Administration for their road monitoring and maintenance program. The software and data were not initially intended for use in slope stability analysis, but have proved quite useful in this endeavor.

Field observations support the assumption that Arc-Form Pavement Cracks (AFPC) are a positive indicator of slope instability. Thus 30m buffers around GPS locations of AFPCs were used to extract the slope attributes with immediate proximity to the unstable fill-slope. A 30m buffer was similarly calculated along the "entire" roadway and slope attributes were extracted. A 6m buffer was applied to the road polyline to extract a slope distribution that represented the "flat" slopes associated with the paved surface.

These 3 slope distributions were imported into a data analysis program, where flat slopes were subtracted from the AFPC distribution and the entire distribution, respectively. Student's t-test show that the means of the AFPC and entire slope distributions had a difference of ~10°, and that the mean slope of 30m buffered locations of previous fill failures fall toward the lower end of the range. This result was not expected, as slope angle is the dominant driving force in slope failure and the higher values of mean slope were expected to be associated with failure sites.

A working hypothesis for this unexpected result is that the upslope contributing areas of the failed basins are significantly greater than that of unfailed sites. This suggests that flow accumulation is a second-order variable controlling slope stability.

A physically-based shallow landslide model, SHALSTAB (for ArcView 3.x), verified the results of this topographic and slope stability analysis. This model uses topographic attributes and soil properties to calculate an index of landslide susceptibility based on basic slope-stability and steady-state flow equations. The model results complemented the results of the mean-slope distribution method, and demonstrated that the method can be used as a reliable tool for forecasting road-fill failure. With continued refinement and field verification in other study regions, these relatively simple GIS methods could prove to be a cost- and time-efficient tool for analyzing stability of road-fills in mountainous topography.

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GIS Career Awareness Learning Modules for High Schools

High School GIS education is usually constrained by expensive GIS software and limited computer equipment in schools. A series of web-based GIS career awareness learning modules are developed to provide free GIS education tools for high school teachers and students (http://geoinfo.sdsu.edu/hightech/GISCareerLearningModules_top.htm). Through the four GIS learning modules, high school students can learn basic concepts of geographic information system technologies and understand the importance of geospatial applications. The on-line "GIS Career Awareness Learning Modules" can be incorporated into existing high school classes to provide students with an informative, stimulating, hands-on experience. The modules are designed as the following:

- Learning Module 1: *The Digital Globe* (using Google Earth software to illustrate the geographic concepts of latitude/longitude coordinate systems, decimal degrees, map layers, address matching, etc.).
- Learning Module 2: *GIS Applications in Various Fields* (Using ArcIMS and Google Maps from many different types of GIS: political campaign, crime mapping, environmental monitoring, disaster management, etc.) to demonstrate the importance of GIS.
- Learning Module 3: *The Cutting Edge and Future of GIS* (mobile GIS, GPS, and web-based collaborative Google map mash-up forum) to illustrate the future GIS technology and the potential impacts for our society.
- Learning Module 4: Writing an Essay of GIS career awareness (600 words by combining the short answers from modules 1,2, and 3).

High school students can finish the four learning modules within four days and receive a certificate from the NSF-ATE program indicating the completion of the GIS CAREER awareness learning modules. The website also combines several educational tools, including Web Mapping Services (ArcIMS), GIS videos (YouTube), and GIS learning exercises. By utilizing free online video services, high school teachers can demonstrate the applications of GIS in actions in various ways. Teachers can download GIS learning module instructions from the website in PDF or Word document format in order to use them directly or to customize the contents for their own courses.

The development and the implementation of the web-based GIS awareness modules are a collaborative effort between San Diego State University and San Diego Mesa College. The project is funded by a National Science Foundation (NSF) Advanced Technological Program (ATE) for the purpose of promoting geospatial career awareness among students and teachers in community colleges and high schools.

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High school students and teachers can download these GIS career awareness learning modules (in PDF or MS Word) or watch on-line videos to learn about GIS concepts and applications

Fresno

Interactive Campus Directory at CSU, Fresno

Getting around a university campus like California State University, Fresno is not easy. For someone new to the campus it is even more difficult to find a particular office or classroom. The Interdisciplinary Spatial Information Systems (ISIS) Center at California State University, Fresno has developed a spatially-enabled, interactive, web-based campus directory using ESRI ArcIMS (http://cmap.csufresno.edu/website/campus/).

The development of this web application was inspired by the large number of students who knocked at our door at the beginning of every semester to look for a classroom in the building. After a quick prototype test using ArcIMS, it was clear that this web application would be useful for anyone who would like to locate a building on the campus, to find a department office or a room in a building, to search a facility by its name, or to locate a service on the campus. Some just simply want to look around the campus in this virtual world.

The implementation of the design started with data identification and collection. The base data sets are; building footprints, streets, parking lots, and room floor plans for each building. Other data sets that make the application valuable are locations of the campus information centers, emergency phones, disabled parking, parking permit dispensers, wireless hotspots, and smoking areas. All the data were available in AutoCAD format from campus plant operations. A six-inch pixel resolution aerial image was used as a backdrop layer.

The AutoCAD to ArcGIS geodatabase conversion was straightforward in ArcGIS 9.x. Transformation and registration of the data from AutoCAD space to real world coordinates was implemented by creating link files between known locations in the aerial image and features such as corners of buildings. The campus information in Excel spreadsheet format was converted to a MS Access database.

To take cartographical advantage of ArcMap, the map the display is generated from, the ArcMap service in ArcIMS was used. Substantial interface customization has been done to make the application user friendly and compatible with all operating systems and browsers.

The campus community has been a great source of feedback as they all want to make sure they are included and are quick to point out needed corrections. We have had a lot of good suggestions we are assessing for future improvements.

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