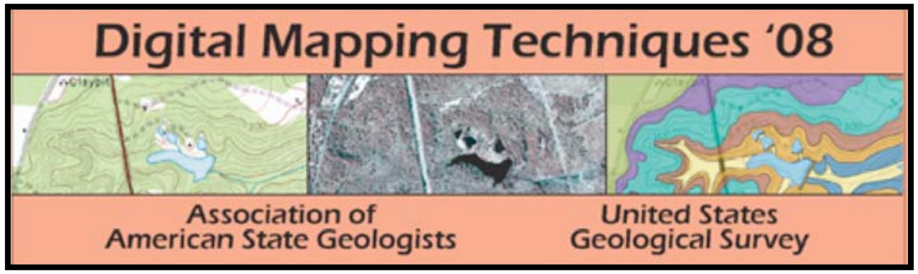

The following was presented at DMT'08
(May 18-21, 2008).

The contents are provisional and will be
superseded by a paper in the
DMT'08 Proceedings.

See also earlier Proceedings (1997-2007)
http://ngmdb.usgs.gov/info/dmt/

DIGITAL MAP PRODUCTION AND PUBLICATION AT THE GEOLOGICAL SURVEY OF ALABAMA

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ABSTRACT

Currently the Geological Survey of Alabama (GSA) is doing geologic mapping at 1:24,000 scale in conjunction with the U.S. Geological Survey's (USGS) STATEMAP program. On average, the GSA is mapping three quadrangles each field season. These maps are compiled digitally and a paper copy is completed and submitted to the USGS as a contract deliverable map. The map then goes through an internal GSA review and then is published as a Quadrangle Series Map along with a map report. The GSA has published 49 quadrangles through the STATEMAP program and, previously, in conjunction with the Tennessee Valley Association (TVA) and several other projects. The process of creating and updating digital databases for all of these quadrangles is ongoing.

Many of these maps have either been compiled in a digital format or converted into a digital format. There are two processes running concurrently: (1) the creation of new geologic maps and digital databases, and (2) the updating of previously published maps into a current digital format. Currently the GSA is releasing data in three formats. The first is a database package using ESRI-supported geodatabases. The second package is a shapefile package with most of the same available data, which can be used with most GIS software. The final package is a PDF of the map and map description. Metadata are written for all of the digital data that the GSA has created. The only portion of the publication not released within these three packages is the map report, which is available by purchase in the GSA Publications Sales office. The goal is to release the digital files of all of the STATEMAP quadrangles to the public. The release of geodatabases, shapefiles, and PDF files, via the GSA website, began in 2007.

1. Collection of Data

Current field mapping is still dominantly rooted in traditional (nondigital) data collection techniques. The geologic mappers at the GSA take a paper copy of the quadrangle into the field and collect data points using a hand-held GPS, Brunton compass, and barometric altimeter. Locations of observations are transcribed onto the map sheet (Figure 1), the observations themselves are written in a field notebook, and then the location points are commonly transcribed to a paper copy of the map. Sometimes, rather than transcribing to a paper copy, the observations are directly entered into a GIS format as points (Figures 2 & 3).

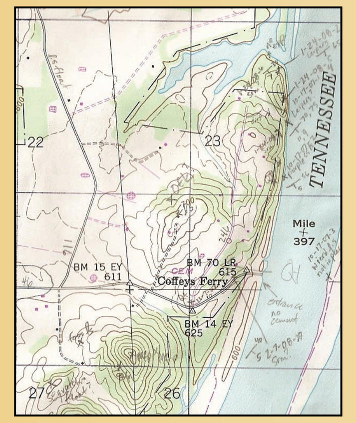

Figure 1. Field sheet with locations.

2. Compilation of Data

First, a geodatabase is created with the desired feature classes and attributes in ArcCatalog. Then, using a georeferenced USGS topographic map as a basemap, data points from field observations are entered into the database as an overall outcrop map (Figure 2). For display purposes the background colors (green and white) of the topographic tiff image are turned to null and later the base is set to a desired transparency level. Along with the outcrop points, structural points and control points are entered where observations were taken. The next step is to draw geologic contacts and structural lines. Two methods have been used. One entails drawing the lines on a clean paper topographic base. The map is then scanned on a large format scanner, georeferenced in ArcMap, and digitized from this scan. The other method is to heads-up digitize on the screen in ArcMap using the outcrop map as a guide (Figures 2 & 3). When available, water lines are downloaded from the internet and Quaternary alluvium contacts are drawn using both field observations and county soil surveys (Figure 4). Polygons of geologic units are then constructed from the lines.

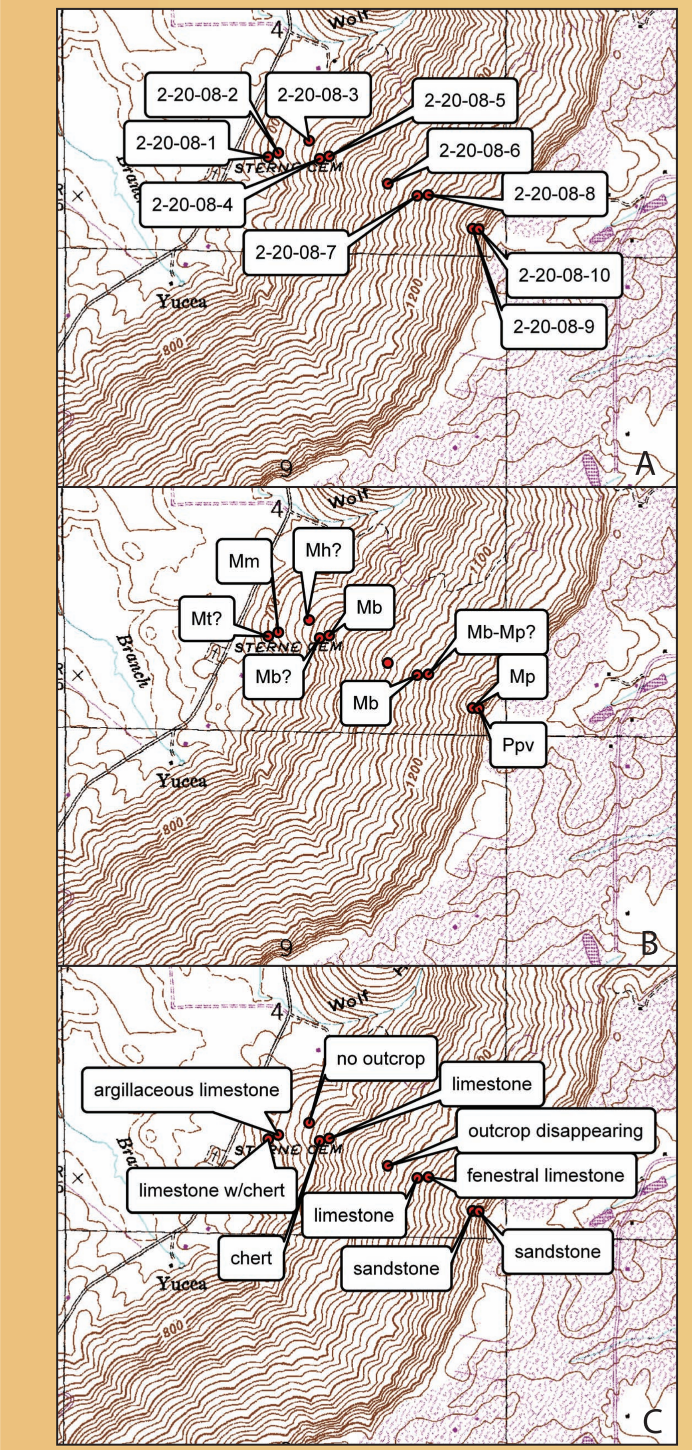

Figure 2. Three labeling schemes used to help make interpretations of geologic units and contacts. A. Observation points, date used as identifier. B. Field-interpreted geologic units. C. Lithology of rocks at each observation point.

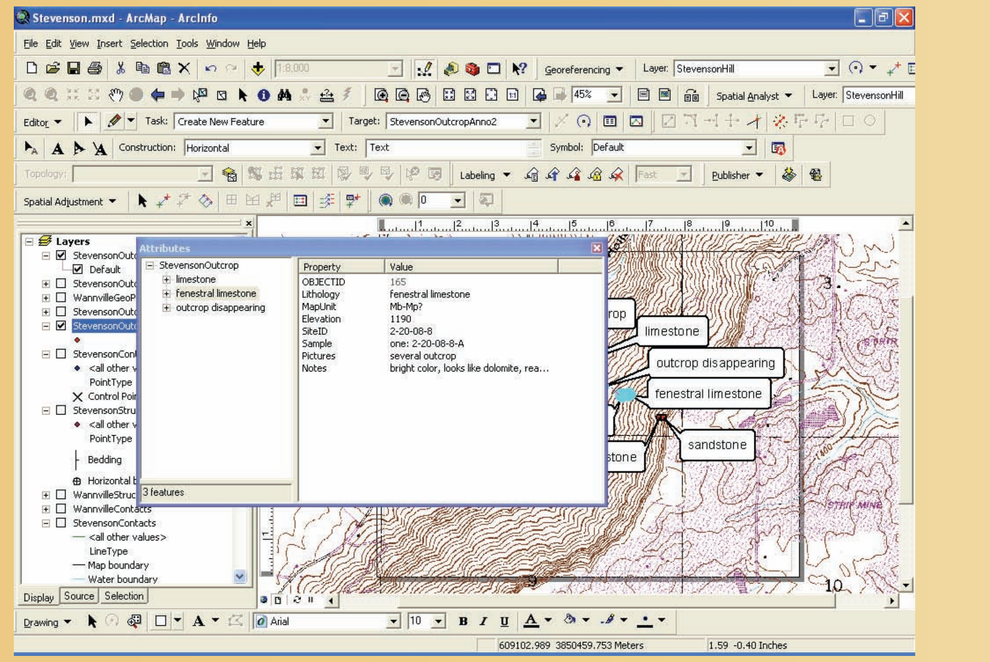

Figure 3. Attributes entered from field observations. At each location the lithology, probable geologic unit, altitude (from altimeter), sample ID, samples and/or pictures taken, and notes associated with that location are recorded.

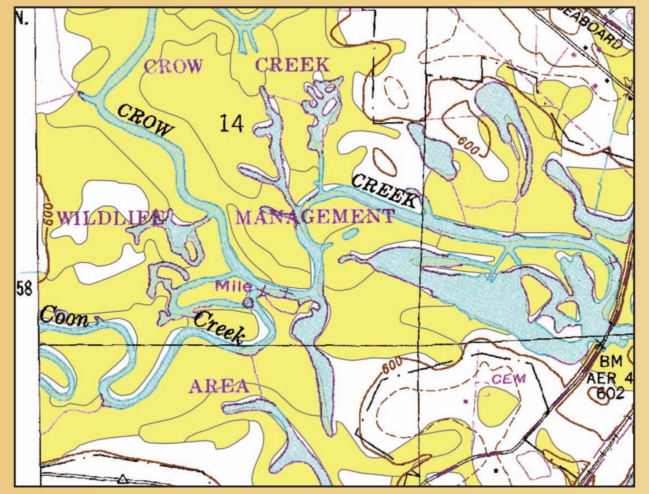

Figure 4. Soil data from county surveys. Alluvial soils are used to constrain location of Quaternary deposits.

3. Construction of Map and Database

Once the field observations and interpretations are entered, the database is populated with the desired data (Table 1 and Figures 5-8). After the population of all features is complete, feature-linked annotation is constructed in ArcMap for necessary layers. Commonly, these include the dip numbers for the structural points, map units for the geologic polygons, and names for specified lines such as names on faults and structural cross section lines. The feature-linked annotation allows for easy movement of the annotation to desired positions on the map. Additionally, when changes are made to attributes, the feature-linked annotation is automatically updated, reducing the chance for label errors on the map.

Construction of the cross section is still done by an entirely nondigital process. Unfortunately, only 30-meter DEMs are available in the current mapping area and provide too coarse a surface profile for some available cross section building programs. The desired line is drawn on the map and the elevations are gleaned from the topographic base and transferred to a piece of graph paper to get the surface profile. The cross section is then drawn using structural observations and known thicknesses or approximate thicknesses of units. After the cross section is completed by hand, it is scanned and drawn in Adobe Illustrator and then added to the layout.

LAYERS	FEATURES	DATA
Points	***Structural Points***	Point types, strike and dip values
	Control Points	Locations where contacts between two units are identified
Lines	***Contacts***	Geologic contacts, faults, and water boundaries
	Structural Lines	Anticlines and synclines
	Cross Section	Cross sections
Polygons	***Geology Polygons***[1]	Geologic units Map unit abbreviations Age
Annotation	***Contacts*** ***Structural Lines***	Names of features with proper names (most commonly, faults and structural lines)
	Structural Points	Dip values on structural points
	Geology Polygons	Map unit abbreviations

[1] Unit descriptions are found in the metadata.

Table 1: Features, layers, and data currently used in Geological Survey of Alabama maps.

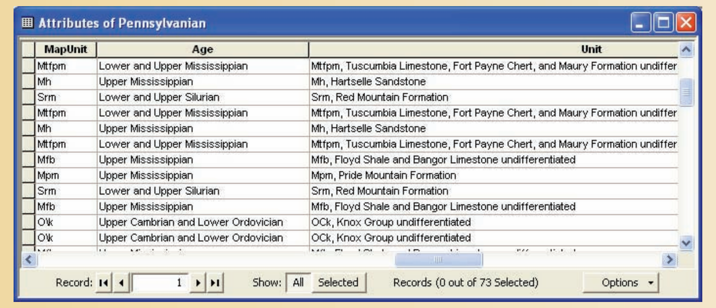

Figure 5. Attribute table for geologic units. Attributes include map unit abbreviation, unit name, and age.

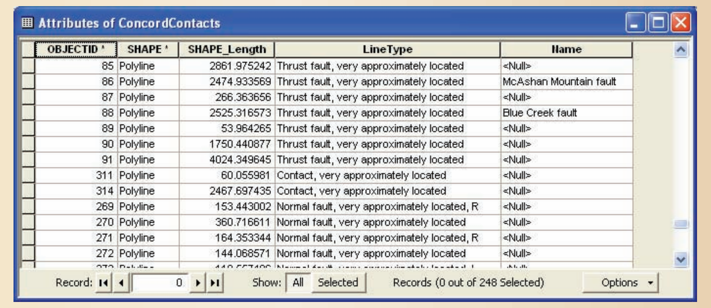

Figure 6. Attribute table for geologic contacts. Attributes include type of contact or fault, and name of feature, if any.

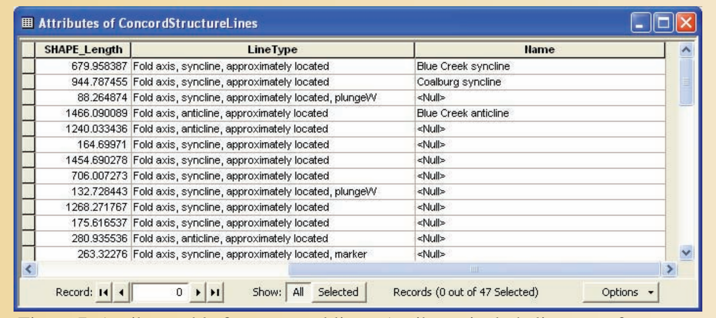

Figure 7. Attribute table for structural lines. Attributes include linetype of structural line and name of feature, if any.

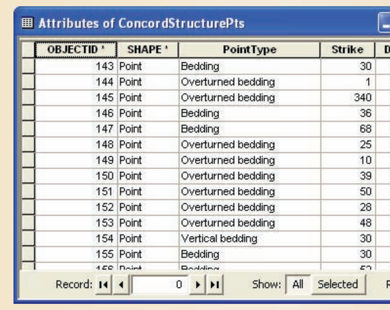

Figure 8. Attribute table for structural points. Attributes include structural point type, strike (using 0-360 azimuth), and dip.

Metadata

Metadata are written within ArcCatalog for each feature class and then exported in text (.txt) format. The information that is the same in each feature class (citation, distribution, etc.) is done only once in ArcCatalog and then is copied and pasted into each feature class's metadata in Notepad. Metadata for each feature class is completed in Notepad and then imported back into ArcCatalog. Also, a complete set of metadata is compiled in Notepad and then imported at the Geodatabase and Feature Dataset levels.

Overall, the objective to put most, if not all, of the data in the database is ongoing. The most important data remaining in the metadata are the geologic unit descriptions (Figure 9). Preferably, this data would be in the GeologyPolygons feature class/shapefile, but a suitable presentation for this is unknown. There is no word wrap feature in the attribute table, and users would have to scroll through a single line to read the description.

Attribute:
Attribute_Label: **UNIT**
Attribute_Definition: **Stratigraphic Unit Description**
Attribute_Definition_Source: Author
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: **Qal, Alluvium**
Enumerated_Domain_Value_Definition: Unconsolidated sand, silt, clay, and angular to rounded chert gravel.
Enumerated_Domain:
Enumerated_Domain_Value: **Ppv, Pottsville Formation**
Enumerated_Domain_Value_Definition: Light-gray, medium- to coarse-grained, quartzose sandstone locally containing scattered to abundant well-rounded quartz pebbles; quartz pebbles and/or claystone conglomerate locally present. Interbeds and intervals of dark-gray shale and mudstone and wavy- to lenticular-bedded sandstone and shale locally present.
Enumerated_Domain:
Enumerated_Domain_Value: **Mp, Pennington Formation**
Enumerated_Domain_Value_Definition: Lower part dominated by light-greenish-gray to light-bluish-gray, conchoidally fractured dolomicrite containing nodules and stringers of dark-gray chert and thin interbeds of dark-gray and greenish-gray shale and mudstone. Middle part includes variably gray, bioclastic limestone; cherty, argillaceous limestone; limey dolomite; and dolomite containing intervals of maroon and olive-green mudstone. In the southern part of the quadrangle, the uppermost part consists of interbedded maroon and olive-green shale and mudstone. On Keel Mountain, the uppermost part is dark-gray shale, wavy- to lenticular-bedded sandstone and mudstone, ripple-laminated sandstone, and shaly coal.
Enumerated_Domain:
Enumerated_Domain_Value: **Mb, Bangor Limestone**
Enumerated_Domain_Value_Definition: Predominantly light- to locally dark-gray, bioclastic and oolitic limestone. Medium- to dark-gray shale containing thin to discontinuous interbeds of medium-dark-gray, fossiliferous limestone common at base. Lower part includes medium-gray peloidal and fenestral limestone, light-gray dolomicrite, and thin interbeds of light-olive-green shale. Uppermost part includes interbeds of cherty limestone, olive-green and maroon mudstone, and grayish-yellow dolomicrite.

Figure 9. Example of geologic unit descriptions within the metadata.

Layout

Due to visual preferences, the map is exported out of ArcMap as an .ai file and the layout is constructed in Adobe Illustrator (see map layout on right side of poster). Since a paper map is required for both the STATEMAP contract and for GSA publication, an expanded graphics end is desired and the layout capabilities of Illustrator, presently, outweigh those of the ArcMap layout end. This, however, is a necessary step only because of the desire for a paper product.

For the digital layout in ArcMap as both .mxd and PMF files the feature classes are added with annotation feature classes placed in a layer and the geologic units in another layer. All layers are symbolized using a customized style that is released with the database. The geologic units (GeologyPolygons) layer is separated by geologic age where each geologic age is added (same feature class added multiple times only for symbolization purposes) and symbolized separately (Figure 10A). Also, the cross section is provided as a hyperlink (as a PDF) in the .mxd and PMF files in the database package (Figure 10B).

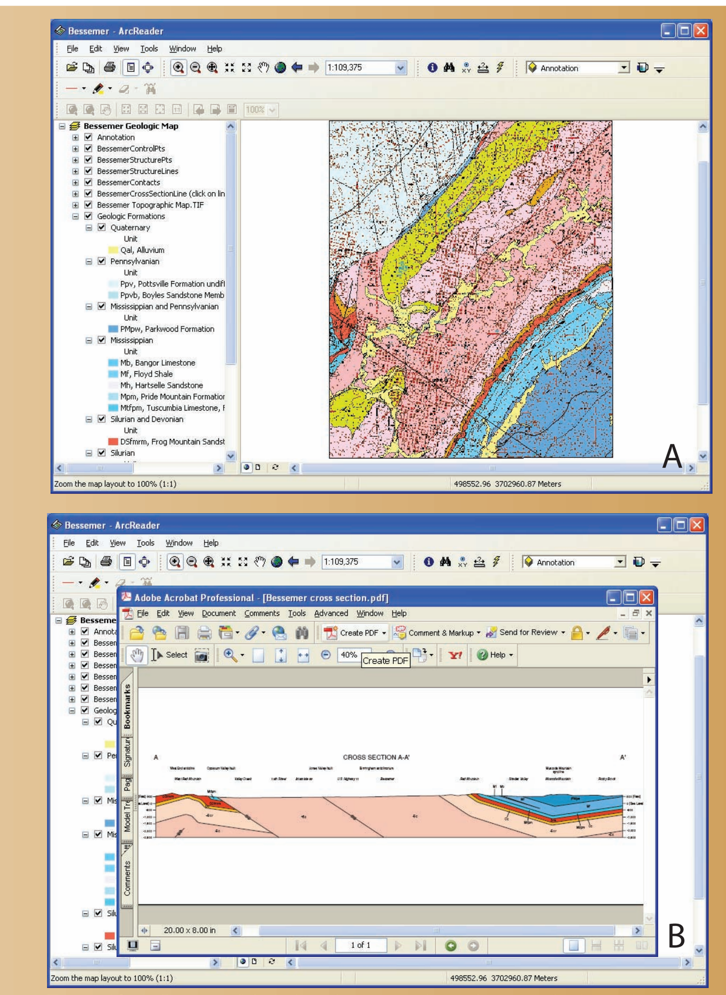

Figure 10. A. Layout of digital geologic map (same layout in both .mxd and PMF). B. View of cross section as it appears from hyperlink.

4. Publication of Map and Database

Once the database and layout are completed, a formal review process begins. The database goes through a review which includes examination of the database, metadata, and associated files. The map layout goes through an editorial review and any changes that may affect the database are addressed. Once the review process is complete, final preparations of the publication package are undertaken. Metatdata is imported back into the geodatabase and respective feature classes. A published map file package (PMF) is created, final PDFs of the layout are generated, and feature classes are exported to shapefiles for the shapefile package. The data is then posted to the Geological Survey of Alabama's website (Figure 11).

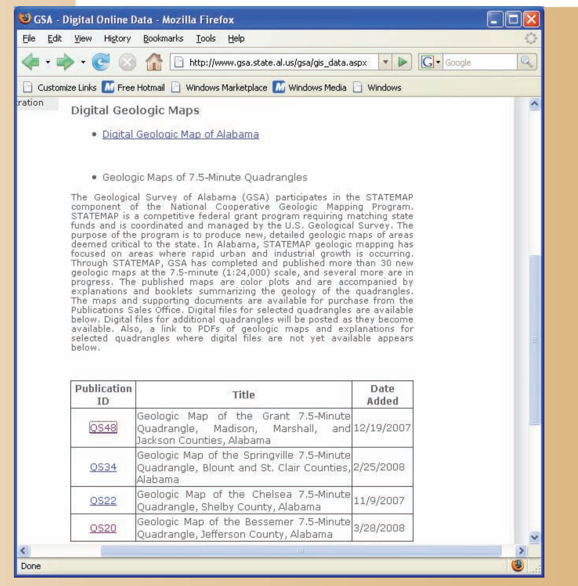

Figure 11. Geological Survey of Alabama webpage and location for downloading digital files.

The digital data for quadrangle series maps consist of:

1) A **Geodatabase** package that contains geologic vector and table data stored as data objects within an ESRI personal geodatabase format, raster data stored as ESRI format DRG-TIFF, an ESRI map document for use with ArcGIS 9.2, which allows full control of editing and rendering of the data sources, and an ESRI published map document for use with Arc Reader which allows viewing and querying of the source data along with metadata and an ArcGIS style for symbolizing the map.

2) A **Shapefile** package that contains shapefiles exported from the personal geodatabase and the same ESRI DRG-TIFF as in the Geodatabase package along with supporting files. This package does not contain annotation layers included in the Geodatabase package due to software limitations.

3) An html file with **metadata** for the entire database. (Metadata are also included within the GIS files.)

4) **PDF** file of the map sheet and a PDF file of the cross section and map explanation.

5) Readme file explaining data, reconstruction of map as it appears, and location and placement of accessory files.

5. Future

Plans for the future include moving towards digital data collection techniques by acquiring hand-held devices for mapping. The GSA is looking into purchasing, pending funding, hand-held devices to be used in conjunction with ESRI's ArcPad software. This will eliminate a transcription step and hopefully allow for an expansion of database capabilities. Also, more immediate updates include the expansion of available hyperlinks, mostly in the form of field photographs.