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New Data Sources and Derived Products for the SRER Digital Spatial Database

Abstract: The Santa Rita Experimental Range (SRER) digital database was developed to automate and preserve ecological data and increase their accessibility. The digital data holdings include a spatial database that is used to integrate ecological data in a known reference system and to support spatial analyses. Recently, the Advanced Resource Technology (ART) facility has added three new Federal geographic data products to this spatial database. U.S. Geological Survey (USGS) digital raster graphics (DRG) are scanned images of USGS topographic maps. Digital orthophoto quarter quads (DOQQ) are computer-generated images of aerial photographs that have been registered to a coordinate system and ortho-rectified. Digital elevation models (DEM) are georeferenced arrays of regularly spaced elevation values. A product description, production methodology discussion, and file format description is provided for each product. The applications of these products include reference mapping, spatial analysis, and data visualization. A sample image of each of these products is provided. These data represent an ongoing commitment to providing researchers with accurate, up-to-date, and relevant data products to support research on the SRER. Products that will be derived from these sources include slope aspect, land slope, and hillshade layers. Improved Federal geographic data products will be added to the database as they become available.

Keywords: digital databases, Federal geographic data products, SRER database

Santa Rita Experimental Range Digital Database

Ecological data have been collected at the Santa Rita Experimental Range (SRER) since its establishment in 1903, distinguishing it as the oldest continuously operating range experiment station in the world with a long-term data record that is unsurpassed in the Southwestern United States (McClaran and others 2002). The SRER digital database was developed to preserve these data and to increase their accessibility. The database includes precipitation measurements, vegetation measurements, plant synonymy tables for taxonomic groups, repeat ground photography, an annotated bibliography, and a collection of spatial data. The SRER spatial database is developed and maintained at the Advanced Resource Technology (ART) facility housed in the School of Renewable Natural Resources in the College of Agriculture and Life Sciences. The goal of the SRER spatial database project is to integrate site-based data with referenced spatial locations and to provide source and derived spatial data layers to support spatial analyses.

Existing Spatial Data

The spatial database provides information to create maps of four types: (1) human structures and boundaries, (2) topography and elevation, (3) soil and ecological sites, and (4) locations of permanent transects established in previous Forest Service studies and those still being remeasured at 3-year intervals. All currently available spatial data is downloadable in ARC/INFO export file format (*.e00) (McClaran and others 2002). The digital elevation models (DEMs) now available in the database are 30-m resolution for the four U.S. Geological Survey (USGS) 7.5-minute quadrangles covering the SRER.

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In: McClaran, Mitchel P.; Ffolliott, Peter F.; Edminster, Carleton B., tech. coords. Santa Rita Experimental Range: 100 years (1903 to 2003) of accomplishments and contributions; conference proceedings; 2003 October 30–November 1; Tucson, AZ. Proc. RMRS-P-30. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

New Spatial Data Products

Recently, three additional geographic data products for the SRER study area have become available from the Federal Government for inclusion in the SRER spatial database. Digital raster graphics (DRGs), digital orthophoto quarter quads (DOQQs), and higher resolution (10-m) DEMs will be available for the Corona de Tucson, Green Valley, Helvetia, and Sahuarita quadrangles. These products are valuable additions to the database for their potential use in research applications.

Digital Raster Graphics (DRG)

A DRG is a scanned image of a USGS topographic map, including all map collar information. Only the portion of the image inside the neatline is georeferenced to the Earth's surface. A standard palette of 13 colors, modeled after the line-drawing nature of the source map, is used for consistency among all DRGs (U.S. Department of the Interior; U.S. Geological Survey 2002b). The USGS has produced DRGs at scales from 1:20,000 to 1:125,000.

A DRG is produced by scanning a printed map at a minimum of 250 dots per inch (dpi) with a high-resolution scanner. The digital image is georeferenced to true ground coordinates and fit to the Universal Transverse Mercator (UTM) projection, which provides consistency with DOQQs and digital line graphs (DLGs). DRGs can reference either the North American Datum of 1927 (NAD 27) or the North American Datum of 1983 (NAD 83). In most cases, the DRG is referenced to the same datum as the source map; thus, a DRG produced from a paper map referenced to NAD 27 will also be referenced to NAD 27. Colors are standardized, and the image is compressed to reduce file size. The horizontal positional accuracy of a DRG is approximately equal to the accuracy of the source map. For example, a 1:24,000 DRG scanned at 250 dpi has a ground sample distance of 2.4 m (U.S. Department of the Interior; U.S. Geological Survey 2002b). The DRGs available in the SRER digital database are eight-bit palette-color images in the GeoTIFF format. Figure 1 displays a portion of a DRG zoomed to the area surrounding Huerfano Butte.

A DRG is perhaps most useful as a backdrop for other spatial data. For example, an image combining the DRG

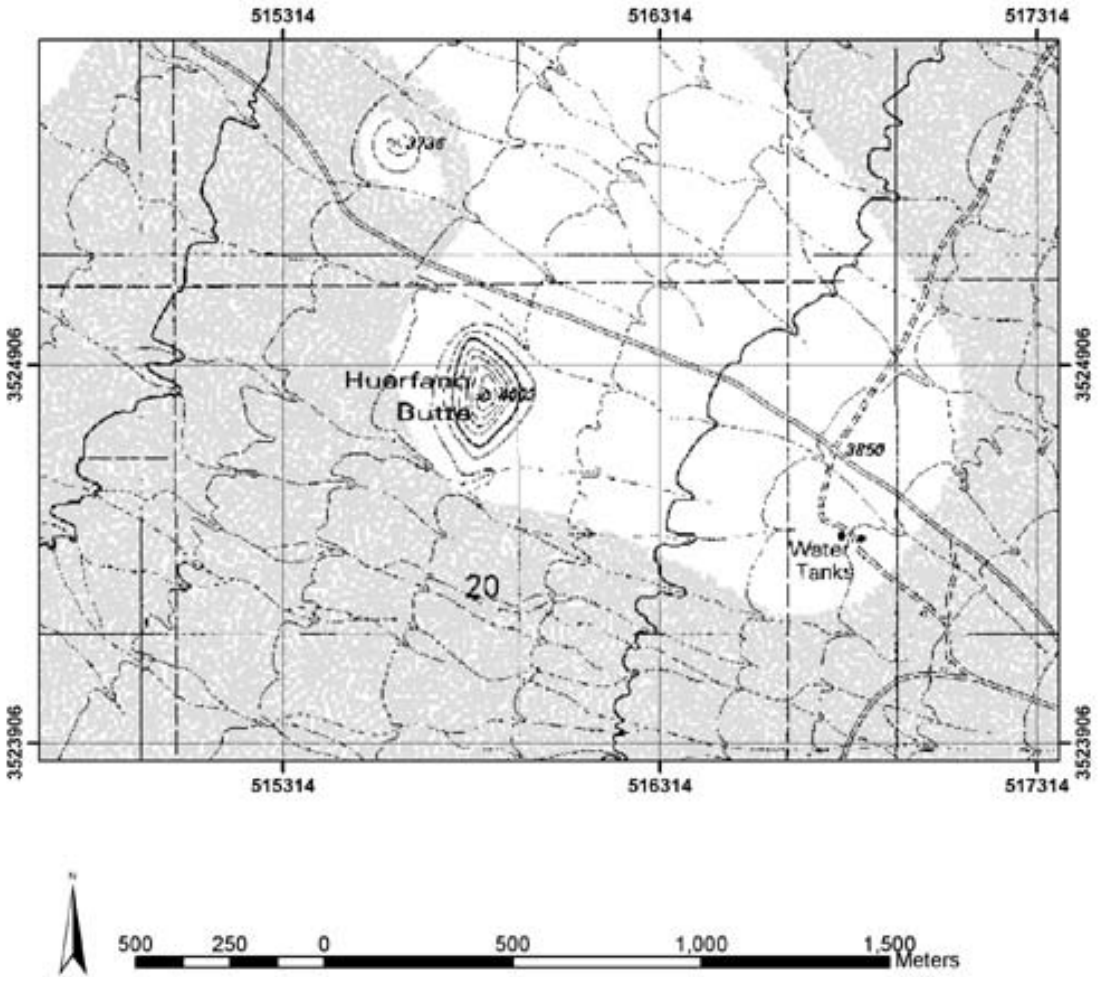

Figure 1—A portion of a USGS digital raster graphic from the Helvitia 7.5-minute quadrangle.

with DOQQs is useful for collecting and revising digital map data. A shaded relief map created by combining a DRG and a DEM provides additional details for viewing, extracting, and revising map information (U.S. Department of the Interior; U.S. Geological Survey 2002b).

Digital Orthophoto Quarter Quads (DOQQ)

A DOQQ is a computer-generated image of an aerial photograph with the effects of camera tilt and topographic relief removed to create a uniform-scale orthophoto. It combines the image characteristics of a photograph with the geometric qualities of a map. The files include an ASCII header that contains data for identifying, displaying, and georeferencing the image. To facilitate the spatial referencing of other spatial data to the DOQQ, both North American Datum of 1927 (NAD 27) and North American Datum of 1983 (NAD 83) coordinates for the upper left pixel are contained in the header (U.S. Department of the Interior; U.S. Geological Survey 2002a). DOQQs are available as black and white, color, or color infrared images with a 1-m resolution.

A DOQQ is created by scanning an aerial photograph transparency at high resolution. The aerial photo should be a quarter-quadrangle centered image that meets the standards of the National Aerial Photography Program (NAPP). The digital image is then ortho rectified using computerized mathematics to generate an orthophoto. The orthophoto is put into the Universal Transverse Mercator (UTM) projection and referenced to NAD 83 (U.S. Department of the Interior; U.S. Geological Survey 2002a).

The source of the DOQQs included in the SRER database is aerial photography taken by NAPP in 1996. Each DOQQ is a color infrared (CIR) image with 1-m resolution in the GeoTIFF format, representing an area of 3.75 minutes longitude by 3.75 minutes latitude with a 50- to 300-m overlap between adjacent images to facilitate tonal matching and mosaicking. The CIR images were produced for areas in southern Arizona, including the SRER. Average file size of a 3.75-minute CIR DOQQ is 11 megabytes (U.S. Department of the Interior; U.S. Geological Survey 2002a). Figure 2 displays a portion of a DOQQ zoomed to the area surrounding Huerfano Butte.

Any geographic information system (GIS) that can manipulate raster images can incorporate DOQQs. A DOQQ

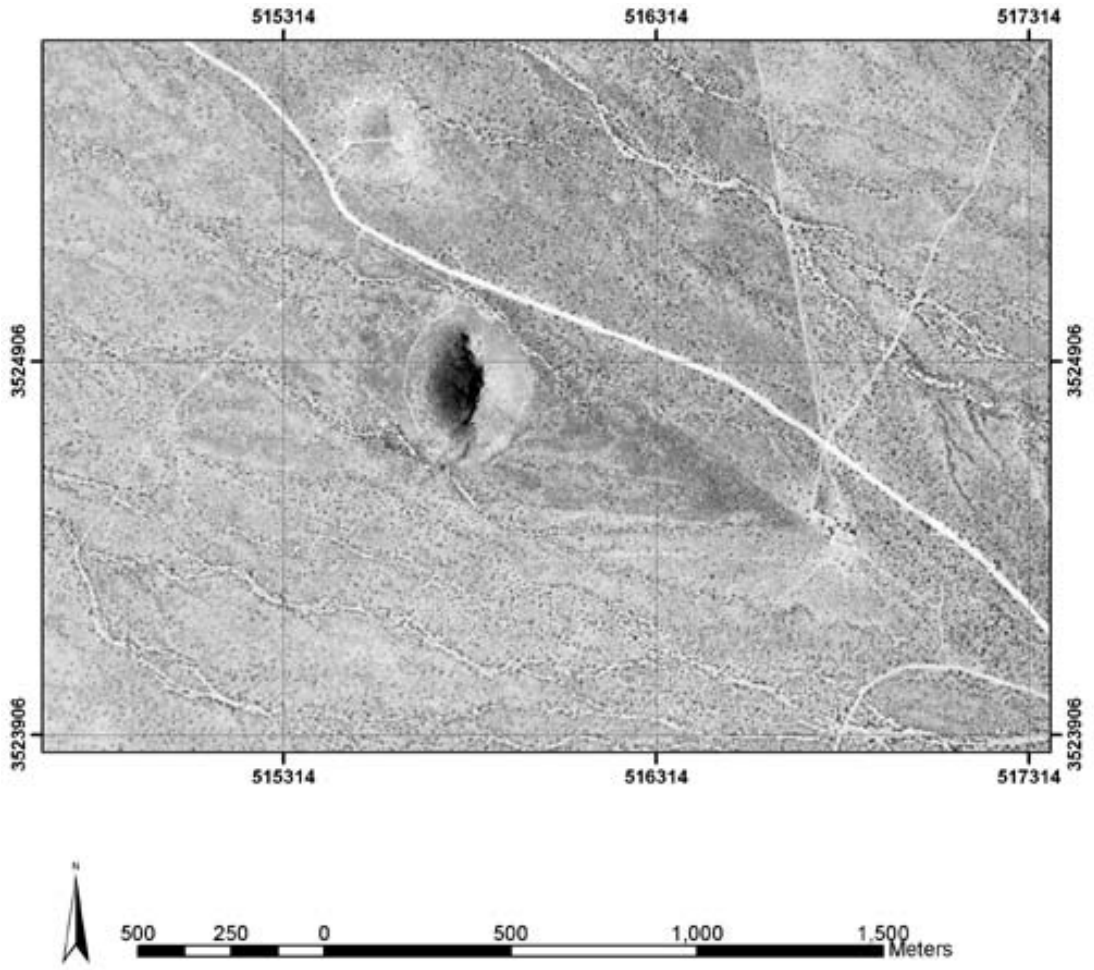

Figure 2—A portion of a digital orthophoto from the Helvetia 7.5-minute quadrangle showing Huerfano Butte.

may be used as a base layer for displaying and modifying associated spatial data, as well as evaluating data for completeness and accuracy, particularly on DLGs (U.S. Department of the Interior; U.S. Geological Survey 2002a). Color infrared (CIR) DOQQs include the near infrared band and may be processed to identify actively growing vegetation.

Digital Elevation Models (DEM)

A DEM is a georeferenced array of regularly spaced elevation values at a 30-m or 10-m resolution. The grid cells are regularly spaced along south to north profiles ordered from west to east. The USGS produces five types of DEMs ranging from 7.5-minute to 1-degree maps (U.S. Department of the Interior; U.S. Geological Survey 2002c).

A 7.5-minute DEM (corresponding to a USGS 7.5-minute topographic quadrangle map) is created by interpolation using either photogrammetric sources or vector data DLG hydrographic (stream channel) and hypsographic (elevations represented as contours) data. The DEM is horizontally referenced to the UTM projection and either the NAD 83 or NAD 27 datum and vertically referenced to the North American Vertical Datum of 1929 (NAVD 29). The horizontal accuracy of 7.5-minute DEMs derived from vector or DLG source data must have a root-mean-square error (RMSE) of one-half of a contour interval or better. For 7.5-minute DEs derived from a photogrammetric source, 90 percent have a vertical accuracy of 7-m RMSE or better, and 10 percent are in the range of 8 to 15 m. For 7.5- and 15-minute DEMs derived from vector or DLG hypsographic and hydrographic source data, an RMSE of one-half of a contour interval or better is required (U.S. Department of the Interior; U.S. Geological Survey, 2002c).

The DEMs available from the SRER digital base are 10-m resolution in the Spatial Data Transfer Standard (SDTS) format. This format allows the transfer of georeferenced spatial data with potentially no loss of information between dissimilar computer systems (U.S. Department of the Interior; U.S. Geological Survey 2000). DEM files are approximately 9.9 megabytes for the 7.5-minute coverage. Figure 3 displays a portion of a 10-m DEM with hypsographic shading zoomed to the area surrounding Huerfano Butte.

A variety of products may be derived from DEMs. Maps displaying slope percent or degrees of slope can be in spatial analyses. A map displaying aspect could be used to infer vegetation types in areas where north- and south-facing slopes are characterized by different plant species. The accuracy of a vector stream layer could be visually checked by overlaying it on a hillshade map. DEMs form the basis for many hydrologic models that are used to predict runoff and estimate erosion potential. Drainage networks can also be derived from DEMs.

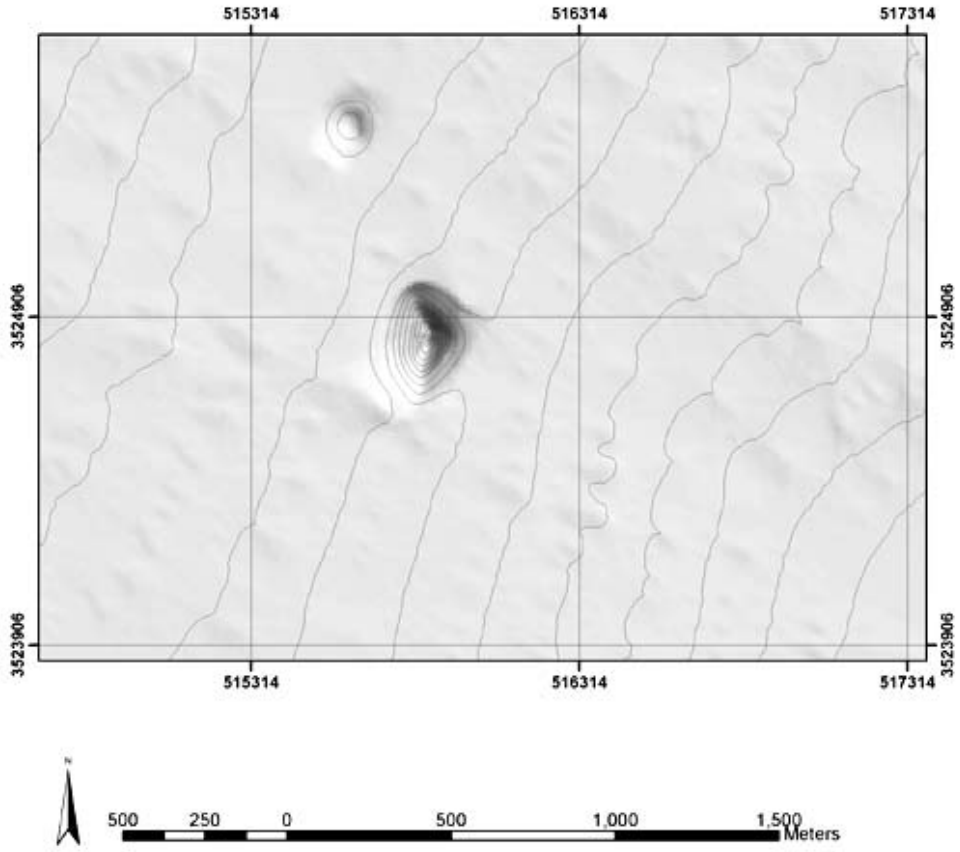

Figure 3—A portion of a 10-m digital elevation model of the area surrounding Huerfano Butte displayed as a hillshade with 10-m contour lines.

Future Plans

The addition of these new Federal geographic data products represents a commitment toward the project goal of providing spatial data for reference and spatial analyses. The current project plans for the spatial database include the update of Federal geographic data products and development of standard products derived from the DEMs and DOQQs. As funding permits, standard product development from the DEMs will include land slope data, slope aspect data, and hillshade images. The land slope and slope aspect data will add to the utility of the spatial database, as these themes are commonly used in spatial analyses. The CIR DOQQs will be processed into false color images using green color to show actively growing vegetation. These images may be used as reference themes in cartographic products, or as a product for input into further image processing applications.

The National Elevation Dataset (NED) is a new raster product produced by the USGS to provide seamless DEM data for entire country (U.S. Department of the Interior; U.S. Geological Survey 2002d). The NED represents an effort by the USGS to respond to the need for seamless topographic data that has been processed to remove slivers, artifacts, and other abnormalities. Although originally developed at a resolution of 1 arc-second (about 30 m), the USGS is in the process of completing the incorporation of the 10-m DEMs into NED for southern Arizona. As the 10-m data for the SRER quadrangles becomes available, it will be added to the spatial database. The 10-m NED will provide for improved surface modeling for hydrological applications.

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