Walnut Gulch Experimental Watershed (WGEW) Database Support

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Abstract

The United States Department of Agriculture's (USDA) Agricultural Research Service (ARS) has developed an active and diverse rangeland research program on a number of different watersheds across the southwestern United States. One of the most significant of these, established in 1954, is the Walnut Gulch Experimental Watershed (WGEW) located near Tombstone, AZ. The Southwest Watershed Research Center (SWRC) in nearby Tucson, AZ was established in 1961 to support the research and data collection at WGEW. Since that time, SWRC scientists have been seeking new and improved methods to more efficiently and effectively utilize rangelands while improving their long-term sustainability. An initial effort required to achieve this objective involved collecting data and developing databases from the watershed that could be used to help understand problems from WGEW and related areas with little or no research data. Early efforts to collect data for database development focused on basic resources such as geology, soils, vegetation, rangeland ecological site, instrumentation, climate, precipitation, watershed boundaries, drainage, and roads. This poster is used to demonstrate how some of the data from these basic databases is currently being used to describe WGEW for education, research, technology development and transfer.

Keywords: rangeland, watershed, hydrology, database, geographic information system (GIS)

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Introduction

The need for hydrologic information has been widely recognized by scientists, legislators, and conservationists for decades. Major data collection and analysis programs have been promoted in many developed countries to facilitate this need.

This paper describes the effort to summarize this data in a spatial Geographic Information System (GIS). The ARS has been conducting research on the hydrologic responses of rangeland watersheds since the agency was established in 1953. To assist the development of a new scientific understanding of hydrologic processes, and to solve water resources problems in the United States, the Administration and Congress invested several million dollars in the expansion of the watershed experimental program. During the 1950s and 1960s some intensively instrumented watersheds were established in different physiographic regions of the United States.

The Walnut Gulch Experimental Watershed WGEW was selected as a research facility by the United States Department of Agriculture (USDA) in the mid-1950s. The Southwest Watershed Research Center (SWRC) in Tucson, Arizona was established in 1961 to administer and conduct research on the WGEW. Research objectives specifically identified for this area include soil, water, and air concerns within a semi-arid rangeland environment (Renard et al. 1993).

The WGEW encompasses approximately 150 square kilometers in southeastern Arizona. The watershed is representative of approximately 60 million hectares of brush and grass covered rangeland found throughout the semiarid southwest. It is considered a transition zone between the Chihuahuan and Sonoran Deserts. Elevations within the watershed range from 1250 m to 1585 m MSL. Livestock grazing is the primary land use with mining, some urbanization and recreation uses also occurring.

SWRC scientists use a variety of basic data collected from within the area to study the hydrology of rangeland watersheds and the effects of changing land uses and practices on the hydrologic cycle.

Methods

Data collected within and about the WGEW can be used and displayed in various ways to describe the watershed for better understanding by scientists for research problem identification and analysis, and for technology transfer of research results to land managers and other users. One way of displaying this information is through the use of GIS technology (Wagenet 1988, Whittaker 1993).

A variety of national, regional, and local data can be used to generate maps and other visual tools using GIS technology including:

- Four Corners Region
- Arizona
- San Pedro River Basin
- Walnut Gulch Experimental Watershed (boundary, contours, flumes, geology, geomorphology, rain gauges, metflux stations, soil moisture plots, streams, stream order, township and range, land ownership, stock ponds, rangeland ecological sites, roads, soils (NRCS - STATSGO, SSURGO), shop location, sub-watersheds, thiessen map, vegetation, utilities, dems, flow accumulation, flow direction, slope, streams, landcover, etc.)

Results

GIS technology is being used to model physical, structural, and functional characteristics of arid and semiarid ecosystems (Coffin and Lauenroth 1989, Burke et al. 1990, Price et al. 1992). A brief description of the results using GIS to display soils and rangeland ecological site data follows.

A soil survey was conducted on the WGEW in 1965-1966 and updated in 1993-1994 by the Soil Conservation Service (SCS), with soil names and descriptions being approved in 1967. The survey was conducted through a request made by the Hereford and Whitewater Draw Soil Conservation District for the Agricultural Research Service. During this survey, soil boundaries were outlined on a map and associated with a specific mapping symbol (USDA SCS 1993). The fundamental unit of the soil survey is the soil series, the basic soil taxonomic unit from which the rangeland ecological site is built. The rangeland ecological site represents a combination of different soil series with similar characteristics. The soil series that comprise a rangeland ecological site are often associated by location, texture, etc. and other soil properties.

The U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) has established the National Soil Information System (NASIS) that includes three geographic databases representing different intensities of mapping (Soil Survey Staff-NRCS 1997). The State Geographic database (STATSGO) has been developed at a scale of 1:250,000 and archived in one by two degree topographic quadrangle units (Figure 1). Soil Survey Geographic (SSURGO) maps are made at scales ranging from 1:12,000 to 1:63,360 and digitized so that they duplicate the original county soil survey maps (Figure 2). These data are archived in 7.5-minute USGS topographic quadrangle units and are patched together to create county versions of SSURGO.

The National Soil Geographic (NATSGO) database is the most general geographic database. It contains digital data developed nation-wide on a scale of 1:7,500,000. The database consists of spatial data, such as the digital MLRA map and attribute data, including data on map unit components and composition that are derived from the STATSGO file.

GIS data layers were created for each of the soil survey mapping symbols (Figure 3) and used to generate a watershed map that displays the soil boundaries within the WGEW.

A rangeland ecological site survey was conducted by the SCS in 1965-1966 in conjunction with the soil survey. Soil mapping units, vegetation, and site attributes were used to determine boundaries of the sites (USDA SCS 1997). The rangeland ecological site is the basic unit of a hierarchical natural resource classification system. A rangeland ecological site is a distinctive kind of land that differs from others in its ability to produce a characteristic natural plant community. Rangeland ecological sites are taxonomic units, not mapping units. However, when a rangeland ecological site occurs over a relatively large area, the site can be designated as a mapping unit, even on relatively small-scale imagery.

Figure 1. STATSGO provides minimum definition of soils within WGEW due to large scale.

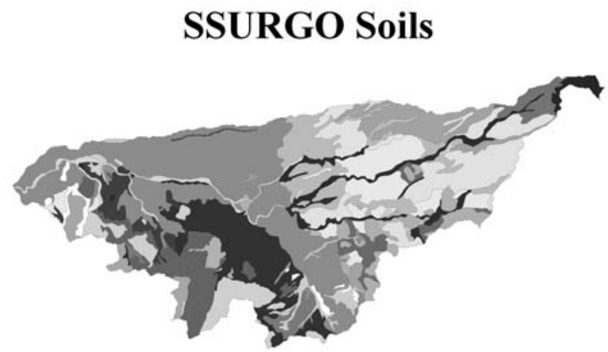

Figure 2. SSURGO is widely used due to detail shown within watersheds.

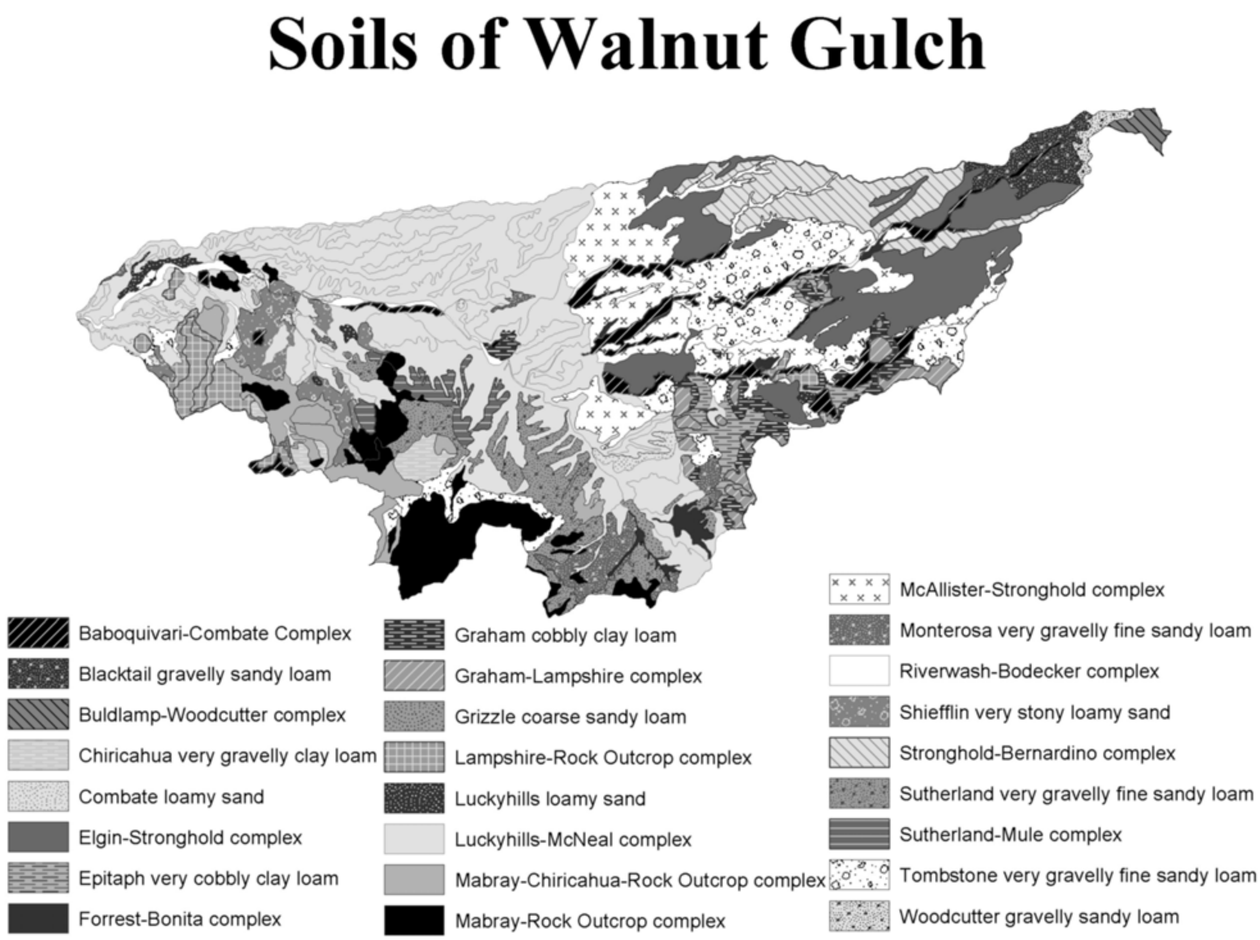

Figure 3. WGEW with soil mapping unit boundaries delineated.

A land classification system developed by USDA and described in Agricultural Handbook No. 296 (USDA, 1981) divides the United States into several hierarchical categories based on natural resource characteristics and land uses. Land resource categories, as described in this handbook, used at national levels are Land Resource Units (LRU), Major Land Resource Areas (MLRA), and Land Resource Regions (LRR). The information provided in this handbook affords resource managers a basis for making decision about national and regional agricultural concerns, identifies needs for research and resource inventories, provides a broad base for extrapolating the results of research within national boundaries, and serves as a framework for organizing and operating resource conservation programs.

GIS data layers were created for each of the rangeland ecological sites (Figure 4) and used to generate a watershed map displaying the site boundaries within the WGEW.

As an illustration, characteristics of MLRA 41 (Southeastern Arizona Basin and Range), which covers parts of Arizona and New Mexico, are given in the following example: each LRR is comprised of a number of MLRAs, which in turn are comprised of a number of LRUs, which are made up of multiple rangeland ecological sites. The following example shows one of the three Resource Units within LRR d, MLRA 41, and several rangeland ecological sites within the Resource Unit as used in Arizona.

- LRR D-Western Range and Irrigated Region
  - MLRA 41 Southeastern Arizona Basin and Range
    - Land Resource Unit 41-3 Southeastern Arizona Semi-Desert Grassland
      - Ecological (Rangeland) Sites
        - Loamy Upland 30-40 cm annual precipitation

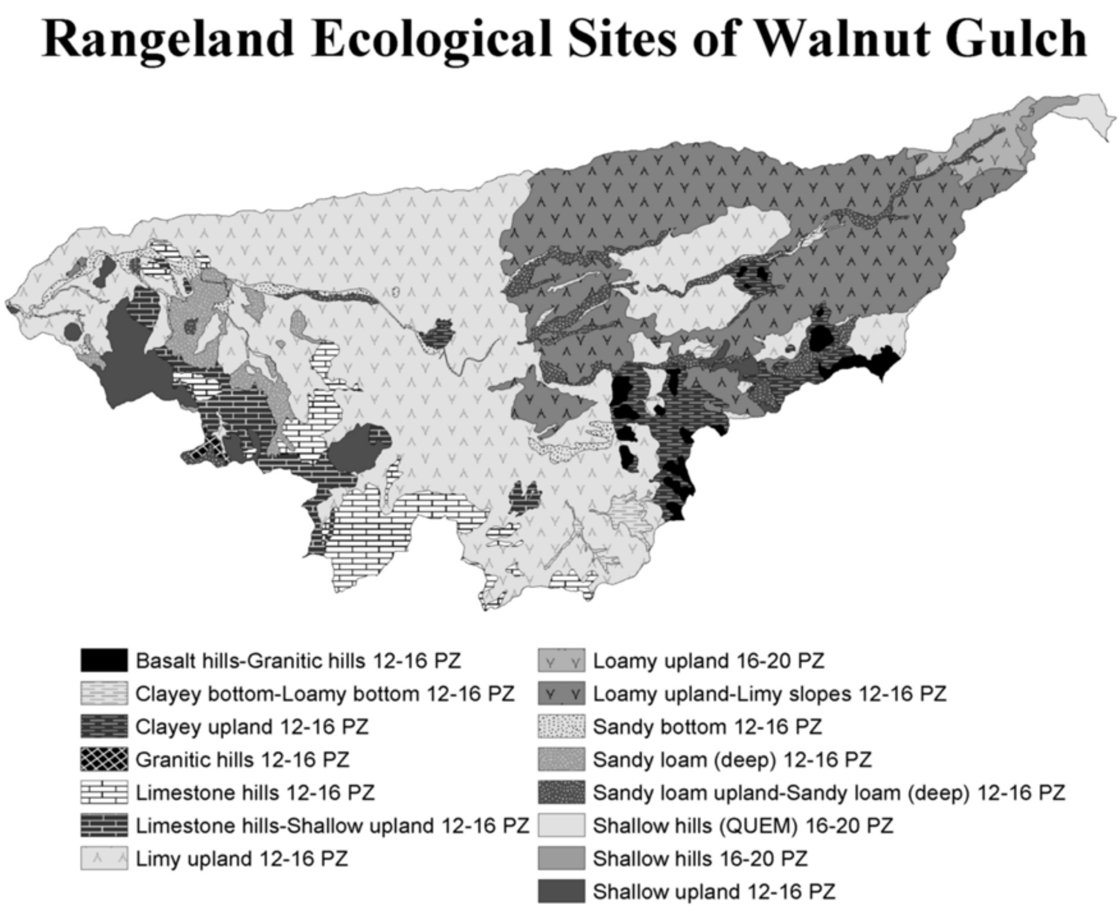

Figure 4. WGEW with rangeland ecological site boundaries delineated.

Computer and information management technologies have the potential to link together the incremental improvements from a large number of new technologies and knowledge (Holt and Rawlins 1990). Due to the volume and variety of pertinent data, efficiency of information systems is a major factor determining success in planning and implementation of an agency's management strategies (Loh and Power 1993). The data required in all natural resource management fields is naturally voluminous and heterogeneous. Creation of regional and national databases is imperative for model development, testing, and application. For example GIS can be particularly valuable in assessing temporal and spatial responses to management.

Conclusions

Due to the data requirements needed to advance system understanding, and the expense of data collection activities, more development and use of computer technology must be used. GIS can be a substantial help in bridging this gap between the data collection effort and the users of this data for technology development and transfer.

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