IMPROVING ACCESS TO WATERSHED MANAGEMENT INFORMATION

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Watershed management research has been performed for 70-plus years to evaluate the usefulness of selected vegetation management programs intended to increase water yields and other resource benefits in the Salt and Verde River Basins of Arizona (Baker 1999; Fox et al. 2000). Studies were conducted in mixed conifer, mountain grassland, ponderosa pine, pinyon-juniper, chaparral, and riparian vegetation types. However, access to this information is largely limited to technical publications and reports, which tend to become obscure to much of the public with time, and access to actual research data is even more limited.

In 1997, personnel from the USDA Forest Service and faculty from the University of Arizona collaborated on a project to make available the research data and reports resulting from years of work on the Beaver Creek Experimental Watershed, located in north-central Arizona; the project is currently being expanded to include information and data from additional experimental sites in the Central Arizona Highlands (Young and Baker 1998). This project was sponsored by the International Arid Lands Consortium (IALC), and its objective was to deliver this information to the public via the Web (Baker et al. 2000a, 2000d; Huebner et al. 2000). The resulting Web site, "Managing Arid and Semi-Arid Watersheds" (http://ag.arizona.edu/OALS/watershed/index.html), features information and data that can be applied to other arid and semi-arid regions in the world facing similar natural resource management problems (Baker et al. 2000a, 2001). Here we present our effort to meet the original objective of making resource information and data collected on the Beaver Creek watershed accessible to land managers, researchers, educators, students, and the general public, and we show how it has been expanded to include information and data from other vegetation types and watersheds.

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LAYOUT OF THE WEB SITE

One of the challenges in developing this Web site was to provide enough detail to make it useful to professional researchers and land managers yet still general enough for educators, students, and the public. The first phase of the project included extensive collection of information to meet a variety of user needs (Young and Baker 1998). The site offers introductory topics (Figure 1) describing research watersheds, watershed management techniques, and public land management issues, and includes information on the Central Arizona Highlands (the green button links; Baker et al. 2001). Other links (blue buttons) include a section on a training course in watershed management developed for college students and a listing of Web resources for K–12 teachers and students. There is also information on selected aspects of watersheds, hypertext links to other related resources on the Web, and a search engine for the site. The Web site is being developed in a hierarchal fashion with access to the most general information from the home page and then to more specific information as one goes deeper into the site, until you can eventually obtain access to actual field data (e.g., climatic, streamflow, water quality, vegetation, and wildlife).

Detailed resource information and data collected during the Arizona Watershed Program (Fox et al. 2000) are available to meet the more advanced needs of land management professionals and researchers. Links (yellow buttons; Figure 1) to seven major vegetation types in the southwestern region of the United States allow access to more specific information, including links to an overview section with vegetation distribution maps, climate, research site descriptions, treatments and results, management implications of results, lists of plants and animals, field data, and a searchable bibliography for each vegetation type (Baker et al. 2000b). To illustrate, by clicking the ponderosa pine yellow link button and then the

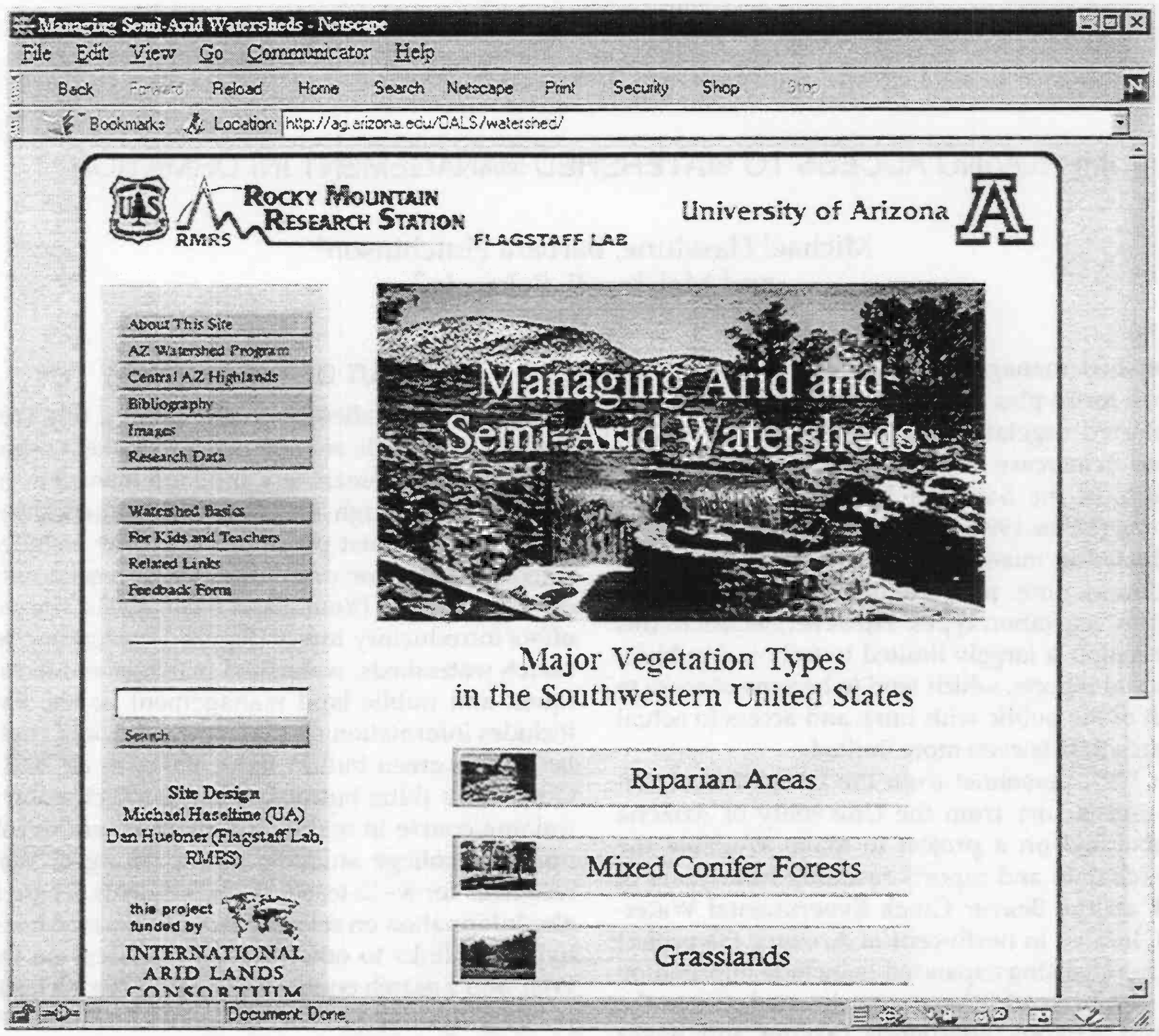

Figure 1. Home page for the Managing Arid and Semi-Arid Watersheds Web site.

Beaver Creek watershed link, a user has access to everything from a virtual tour of the watershed (275,000 acres) and watershed statistics of specific research areas, including photographs and treatment descriptions, to the successful designation of the Beaver Creek watershed as a biosphere reserve, a component of a worldwide network of biosphere reserves in UNESCO's Man and the Biosphere (MAB) Program. Detailed information on the Beaver Creek area includes treatment prescriptions and management practices used on the various experimental areas and numerous resource response data collected throughout the history of the project. Data summaries are accessible through both a text index and a clickable map to identify specific research sites. Also included is a bibliography of nearly 700 references to technical reports and bulletins, articles, theses and dissertations, books, and proceedings that relate to watershed management and the Beaver Creek watershed in particular (Baker and Ffolliott 1998; Baker et al. 2000b).

A searchable image database containing thousands of images collected during the years of research efforts in the Central Arizona Highlands is also provided (Baker et al. 2000c, 2000d). Several options are available for searching the image collections using keywords, site names, and vegetation type. Hints, examples, and drop-down lists are provided as well.

WEB SITE DEVELOPMENT

There are four distinct but interrelated objectives in development of this Web site, and information and data from the Beaver Creek Experimental Watershed is being used initially to design a template for the eventual inclusion of similar information from some 50 experimental watershed sites in other vegetation types in Arizona. The first objective was to create a relational database structure for the 20-plus years of data from Beaver Creek and a Web-based interface for easy accessibility by researchers, land managers, educators, students, and the general public. This allows the data to be used as a decision-making and teaching tool. The second objective was to create interactive Web-based maps for visually locating the experimental watersheds and their monitoring stations and for selecting and viewing the data collected at those locations. The third objective was to inventory and list information and types of data collected on other watersheds in the southwestern United States for eventual inclusion on the Web site. Related to this is the fourth objective which was to begin loading data elements from other experimental watersheds into the database for Web access.

Relational Database and Data Presentation

In fulfillment of the first objective, all currently available data files from the Beaver Creek watershed concerning the ponderosa pine and pinyon-juniper vegetation types have been imported into Microsoft Access tables, checked for anomalies, and corrected where necessary. This step was a significant part of this project due to inconsistencies in data recording over the years, the numerous number of files involved, and other factors discovered as the project progressed. The original data were in text files, with a separate file for each year, for each watershed, and for each data type. This meant that there were literally hundreds of files to be collated. To make efficient use of the database, these files needed to be combined into one table for each data type, necessitating not only the work of combining many files into one, but making sure that all files in each table were in the same format. It was during this process that anomalies were noticed and cleared up. To make the data descriptions and data format available to Web site users, these descriptions and formats were entered into their own set of tables. Refinements to the database are still being made to eliminate discrepancies and to improve usability.

There are currently seven data categories available from Beaver Creek: precipitation, air temperature and humidity, streamflow, suspended sediment, and vegetation (range and timber), along with descriptive information about each data set. Each of these categories has multiple subsets. For instance, the streamflow category contains subsets for daily, monthly, and annual water volumes and for major discharge flow rates. Remaining data categories, including solar radiation, wind, snow, water quality (precipitation and streamflow), and wildlife, will be added as financial support becomes available. We still want to develop information on how each data set was collected and summarized, to assist potential users in their understanding of the data and its quality, and to provide some examples of possible uses of each data type. Some information and data for the Whitespar experimental watersheds, in the chaparral vegetation type, are now available, and data from the Castle Creek experimental watersheds (mixed conifer vegetation type) are currently being computerized for entering into the database.

Table and Graphic Interfaces

Three interfaces have been developed for accessing these data sets—a table format, a graphic format, and a map interface. The first allows the user to select a data category, time period, watershed, and output format. The selected data can then be viewed in a table format (Figure 2) or retrieved in a structured ASCII format that can be easily imported into a spreadsheet. The second interface allows a graphical view of the data (Figure 3).

Developing the capability to graph the data was difficult because the software available within our budget required considerable manipulation to fit the needs of this project. KavaChart required considerable work to adjust it to our needs, and we expect to find or develop a better tool in the future. KavaChart does allow the user to plot data as a bar chart (Figure 3) or as a line graph and to plot two lines on a graph to compare two data sets (Figure 4). This latter capability is particularly effective for viewing results from a treated watershed with results from its control, or from results between any two watersheds (e.g., watersheds in two different vegetation types). Eventually, we hope to provide the capability of comparing two or more parameters from a given watershed (e.g., precipitation with streamflow).

Additional tools are also being developed. One is a link for a printable version of a requested data page. The display of some data sets is too wide to print properly and some information is lost. The printable version link displays the data table or graph without the left sidebar that is needed in making data selections, making it a better width for printing.

Another tool being developed is the Magic 8 Ball. It provides answers to basic questions that

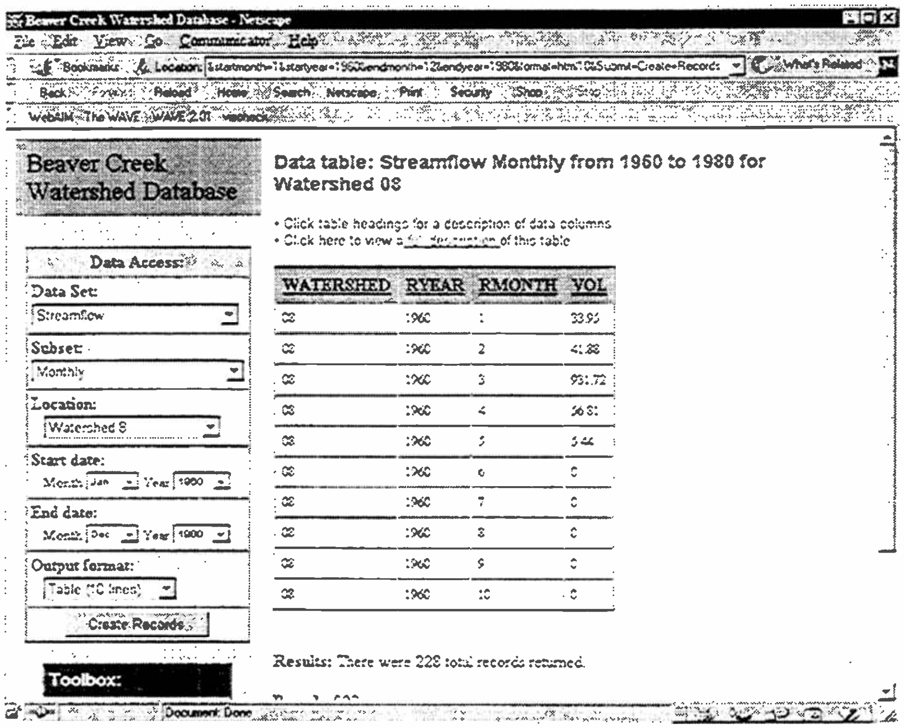

Figure 2. Table format of selected data, with data access choices on the left.

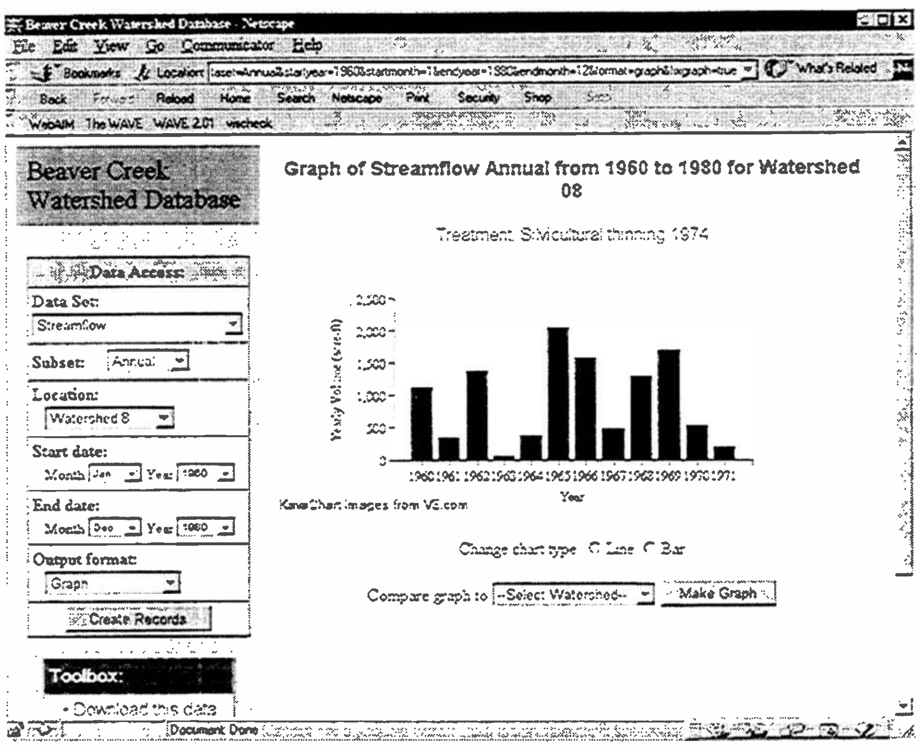

Figure 3. Example of selected data output in a graphical format.

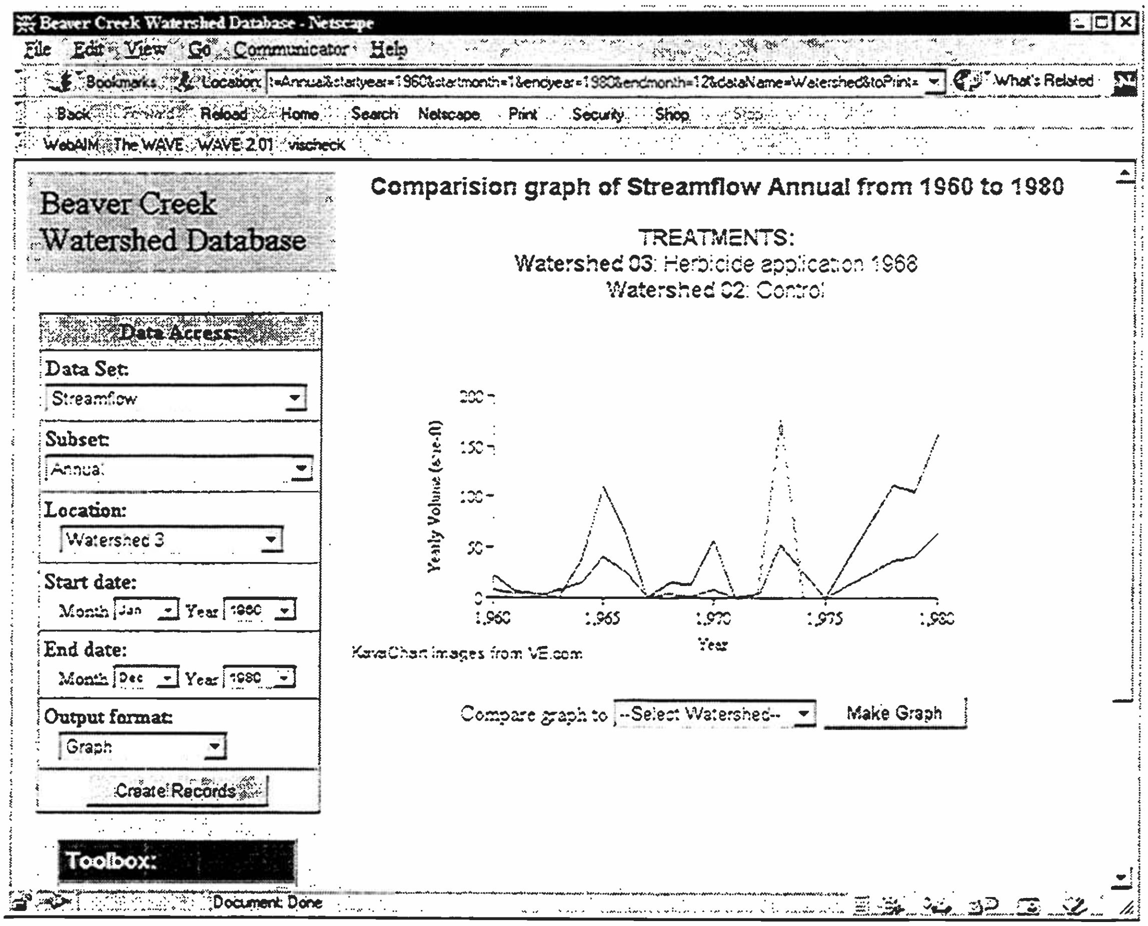

Figure 4. Example of comparisons of streamflow on two watersheds.

users might have while visiting the Web site. Five types of frequently asked questions (FAQ) are currently set up to be addressed: basic information questions, questions concerning use of the data provided, questions addressing the effects various treatments can have on a watershed, questions about conclusions that may be drawn from the watershed research performed, and questions about the treatments used in the study (Figure 5). This tool is in a preliminary stage of development, and needs substantial work. However, it promises to be a simple mechanism for answering questions that users may have and for learning how to be inquisitive and to formulate questions about our environment.

Map-Based Interface

The third interface is map based, allowing users to choose the watershed or stream gage of interest and to view their associated data (Figure 6). This Web-based GIS interface has been implemented using ESRI's ArcIMS Internet Map Server. Map layers for a variety of land features help users locate themselves and provide visual reference to such things as watershed treatments and gage locations. The layers currently provided include towns, stream gages, streams, highways and roads, watershed treatments and boundaries, the Beaver Creek Experimental Watershed boundary, a 1993 Landsat satellite image, elevation, and shaded relief. In this way, users who do not know the names of the watersheds or other attributes of the area that are used in the textural interface, but are familiar with the area geographically, can make more informed decisions in selecting data of interest. The map-based interface is linked to the same database as the textural interface and can provide results in the same way the textural interface does.

By choosing from the various tools provided, the user can zoom in on a particular area for more detail (Figure 7), choose different layers to show or

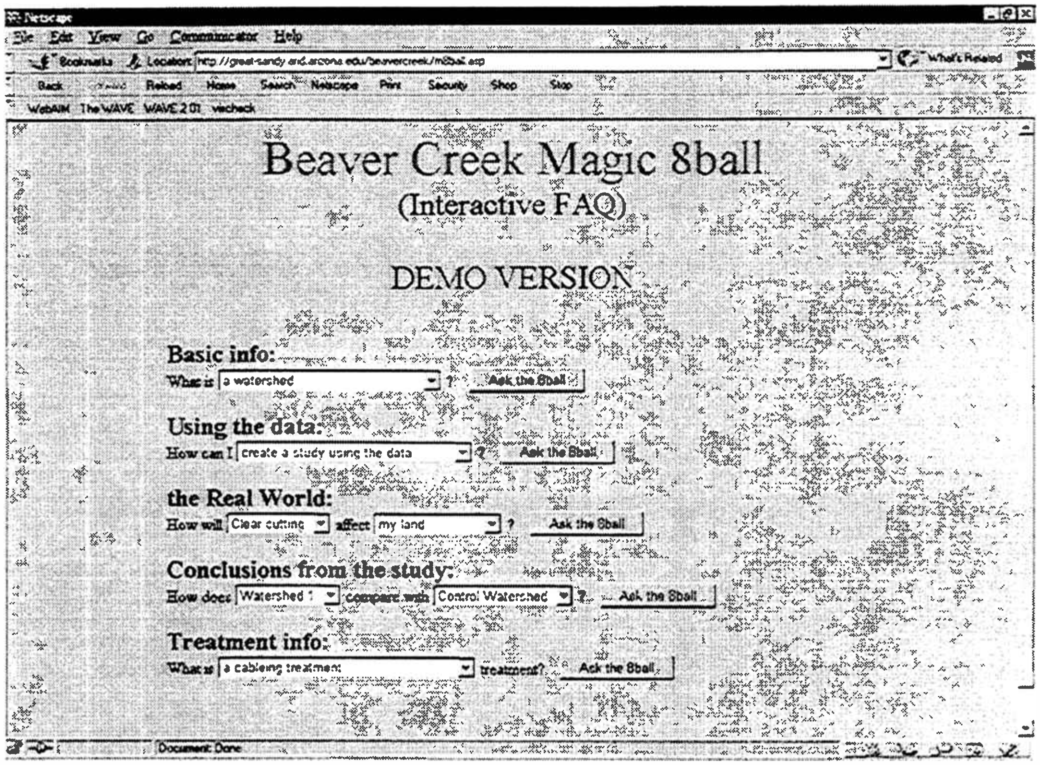

Figure 5. Illustration of the use of a tool to answer frequently asked questions.

hide, emphasize features, and display data for watersheds or gaging stations. This map interface is currently in a preliminary state and is undergoing further development and expansion.

Future Development

The previous discussion of the development of our Web site makes it clear that some of our sections are rough or in mere outline form. Our philosophy is that it is better to show the user the intent of what we want to accomplish than to wait for a finished product. In the spirit of good stewardship, we are attempting to provide easy access to research information that has been collected with public funds and that is often tucked away in technical publications that become even more obscure and hard to find with time. This does not even address the fact that extensive, long-term data sets are seldom easily available to the public or even other professionals. We think that we have made a good start, but we've only scratched the surface of possibilities and our aspirations are to continue to improve upon our site as we receive user comments and we continue to be exposed to new and improved Web technology. Our imaginations and future funding appear to be the major limitations to what we can do with this vast collection of natural resource information. Some examples already in mind include the following:

- Improved graphing capability.
- Field maps of various sampling and collection sites.
- Access to collection of repeat photography, both aerial and on the ground.
- Use of animation to illustrate various processes working on our southwestern watersheds and as a visual learning tool.
- Online access to publications and reports, particularly those that are less accessible.

PROJECT EVALUATION

An advisory group has been created to provide evaluation of the development of the Web site. This group consists of watershed faculty and students, USDA Forest Service personnel, and community members; they will be asked to fill out evaluation questionnaires and to meet with project staff to discuss their observations about the Web site's organization and content. Individual programs, such as the training course in watershed

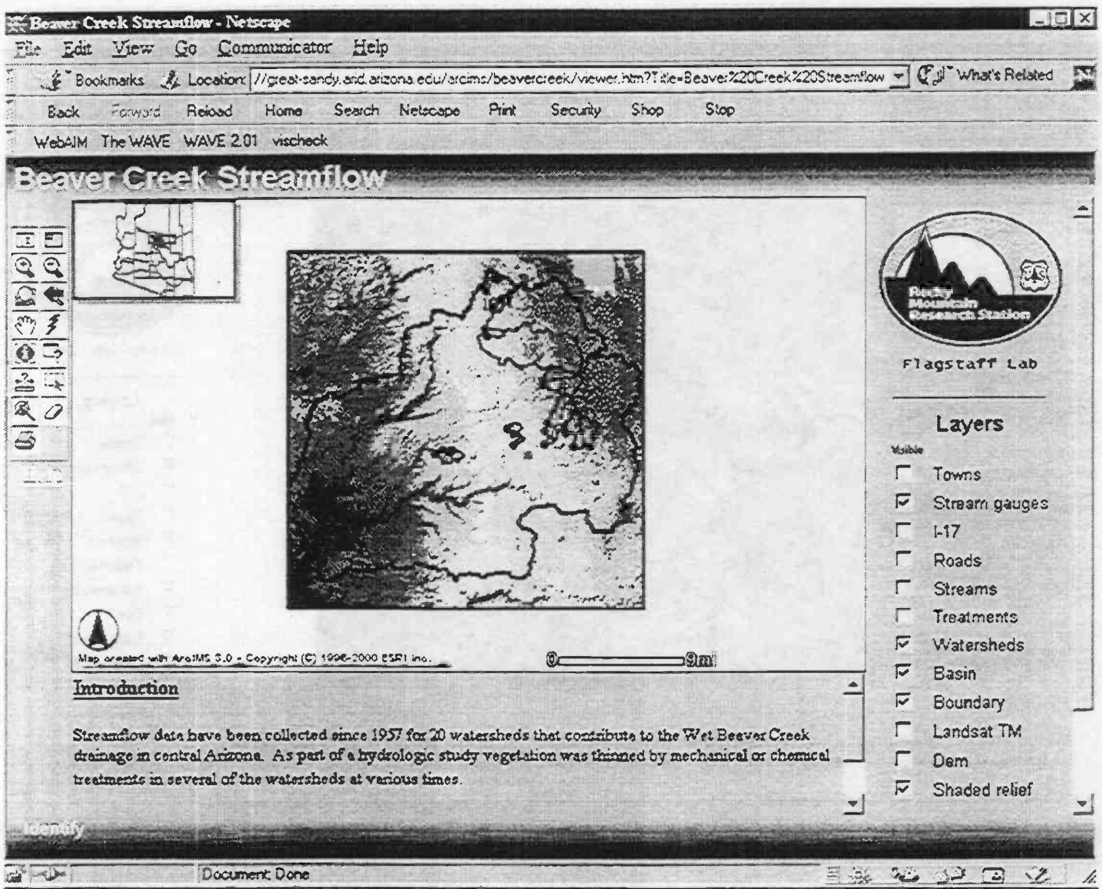

Figure 6. Map of the Beaver Creek Experimental Watershed.

management developed for college students and listings of Web resources for K–12 teachers and students, will also utilize written evaluation instruments to assess the value and impact of these components.

This work is a product of the University of Arizona's Arid Land Information Center's 30 year effort to find a cost-effective method for bringing important information on the world's arid lands to the broadest audience possible. As noted above, some areas of this Web site are still under development and there are many data sets that have yet to be converted into a machine-readable format. Project staff is committed to continuing in this effort as long as resources are available. Following completion of the project, the Arid Land Information Center will continue to offer periodic support as part of its ongoing extension-related activities and in fulfillment of the University of Arizona's and the College of Agriculture's Land Grant commitment to electronic dissemination of information.

CONCLUSIONS

Through the use of this Web site, we are attempting to bring together at one source thousands of images (Baker et al. 2000c), annotated bibliography of references to technical reports and bulletins, articles, theses and dissertations, and proceedings (Baker and Ffolliott 1998), maps, descriptive information, and 20-plus years of climatic, streamflow, suspended sediment, vegetation, and wildlife data from over 50 research sites in the arid and semi-arid southwestern United States. By bringing this practical and field-tested data on watershed management to the World Wide Web, this project provides a value-added service to researchers, practitioners, and educators throughout the world. In addition, this project seeks to make science more useful, helping the general public make better and more informed decisions concerning the use of their own natural resources. In summary, this delivery method facilitates better access to information and technology, which can ultimately contribute to the increased sustainability of arid and semi-arid watersheds.

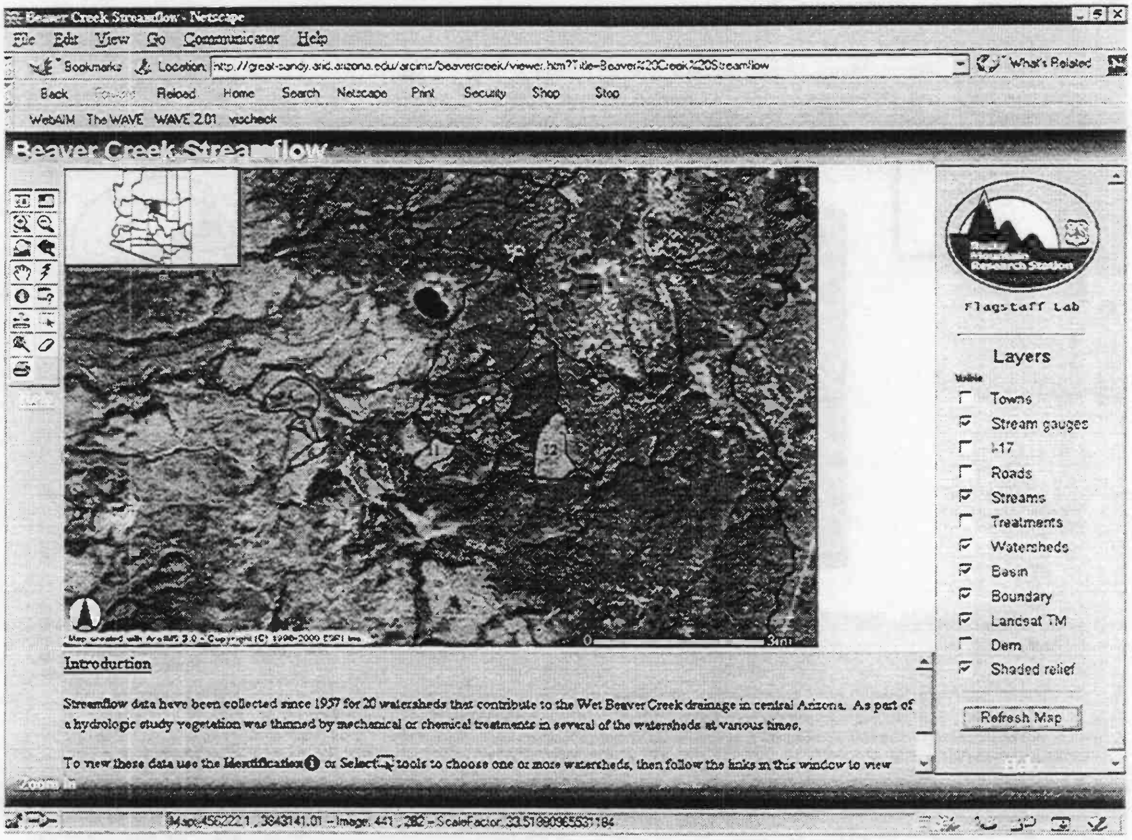

Figure 7. Illustration of the use of the zoom feature to acquire more watershed detail.

LITERATURE CITED

Baker, M. B., Jr. compiler. 1999. History of watershed research in the Central Arizona Highlands. USDA Forest Service, General Technical Report RMRS-29.

Baker, M. B., and P. F. Ffolliott. 1998. Multiple resource evaluations on the Beaver Creek watershed: An annotated bibliography (1956–1996). USDA Forest Service, General Technical Report, RMRS-GTR-13.

Baker, M. B., Jr., D. P. Huebner, and P. F. Ffolliott. 2000a. Documenting historical data and accessing it on the World Wide Web. USDA Forest Service Proceedings RMRS-P-13.

Baker, M. B., Jr., D. P. Huebner, and P. F. Ffolliott. 2000b. Accessing a personalized bibliography with a searchable system on the World Wide Web. USDA Forest Service Proceedings RMRS-P-13.

Baker, M. B., Jr., D. P. Huebner, and P. F. Ffolliott. 2000c. An on-line image data base system: Managing image collections. USDA Forest Service Proceedings RMRS-P-13.

Baker, M. B., Jr., D. P. Huebner, and P. F. Ffolliott. 2000d. Sharing watershed information though the World Wide Web. In Watershed Management and Operations Management 2000, Proceedings of the Conference, American Society of Civil Engineers, June 20–24, Fort Collins, Colorado.

Baker, M. B., Jr., B. Hutchinson, E. Pfirman, M. Haseltine, and J. Schalau. 2001. Management of arid and semi-arid watersheds: Decision-making tools and technology transfer. Hydrology and Water Resources in Arizona and the Southwest 31:8–12.

Fox, K. M., P. F. Ffolliott, M. B. Baker, Jr., and L. F. DeBano. 2000. More Water for Arizona: A History of the Arizona Watershed Program and the Arizona Water Resources Committee. Primer, Phoenix, Arizona.

Huebner, D. P., M. B. Baker, Jr., and P. F. Ffolliott. 2000. Increasing efficiency of information dissemination and collection through the World Wide Web. USDA Forest Service Proceedings RMRS-P-13.

Young, D. J., and M. B. Baker, Jr. 1998. Management of semi-arid watersheds: Technology transfer. Hydrology and Water Resources in Arizona and the Southwest 28:81–83.