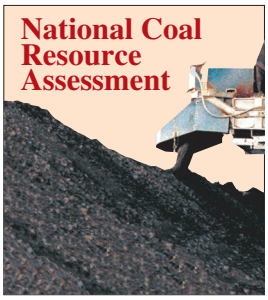
Chapter D

The Colorado Plateau Geographic Information System (GIS): An Introduction to the ArcView Project and Data Library



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By Laura R.H. Biewick[1] *and* Tracey J. Mercier[2]

Chapter D *of*
Geologic Assessment of Coal in the Colorado Plateau: Arizona, Colorado, New Mexico, and Utah
Edited by M.A. Kirschbaum, L.N.R. Roberts, *and* L.R.H. Biewick

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* This report, although in the USGS Professional Paper series, is available only on CD-ROM and is not available separately

U.S. Department of the Interior
U.S. Geological Survey

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The Colorado Plateau Geographic Information System (GIS): An Introduction to the ArcView Project and Data Library

By Laura R.H. Biewick *and* Tracey J. Mercier

Introduction

Purpose

Coal geology and resources of the Colorado Plateau in Utah, Colorado, New Mexico, and Arizona (fig. 1) were assessed as part of the U.S. Geological Survey's (USGS) National Coal Resource Assessment project. The Colorado Plateau Geographic Information System (GIS) is a digital compilation of the assessment data developed by the USGS to analyze, display, and communicate the complex geologic relationships evaluated within the Colorado Plateau region. Automation of the coal-resource-assessment process allows flexibility in scientific interpretations, provides a base line of geologic information for future coal assessments and creates a method for rapidly distributing results. This document describes the Colorado Plateau GIS, its components, and how the system developed by the USGS is used. Illustrated in figure 1 is the location of coal-bearing rocks in the Colorado Plateau and the coal assessment areas included in this GIS.

What is the Colorado Plateau Geographic Information System (GIS)?

A simplified definition of a geographic information system (GIS) is a computer system capable of storing and analyzing digital data describing places on the Earth's surface (ESRI, 1994). Many computer programs, such as spreadsheets or drafting packages, can process data describing simple geographic relationships but are not thought of as a GIS because they do not permit complex queries nor geospatial operations such as buffering, proximity analysis, or unions (geometric intersections of geographic features and their characteristics). The benefit and power of a GIS is that any attribute attached to a spatially referenced location on the Earth's surface can be evaluated and displayed in a spatial context with other similar or disparate attributes. Only the type of attributes at a location, the resolution or quality of the data, and the imagination of the digital-processing operator limits GIS.

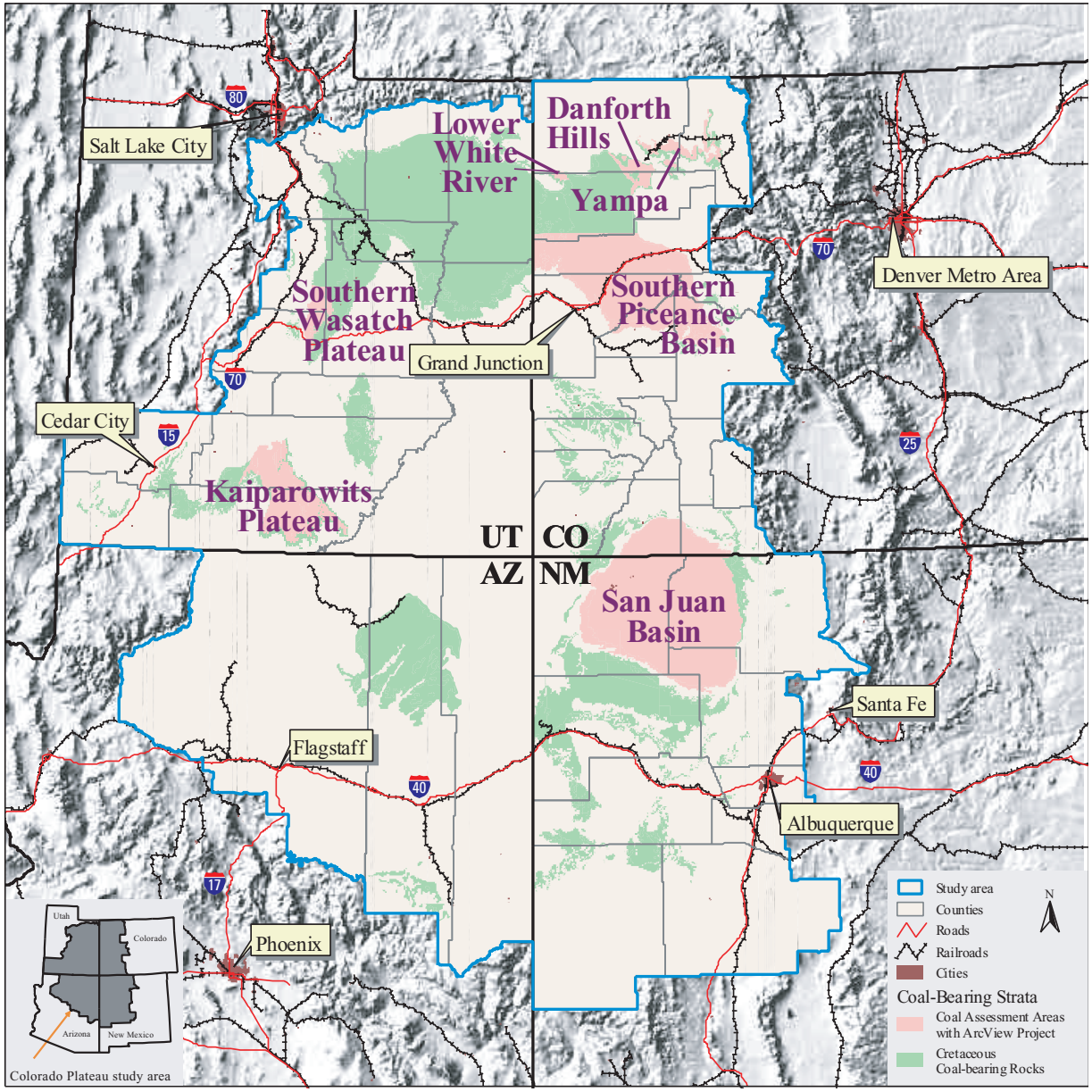


Figure 1. Map showing the Colorado Plateau assessment areas included in the ArcView project.

The Colorado Plateau GIS combines digital geologic and geographic layers of information into a reference (latitude and longitude) system permitting spatial queries, multiple visual representations, and analysis of coal resource information. Typical parameters or layers may include surface elevation, coal-bed or coal-zone elevations, overburden, coal-bed or coal-zone thicknesses, inclination of strata (dip), surface and mineral ownership, and administrative boundary information. Once the geographic and geologic data layers are georeferenced and combined (fig. 2), logical operations, spatial manipulation, and queries of the data may be performed. Typical queries relevant to the coal resource analysis may include:

1. Which major cities in the United States are within 10 mi of a coal field?
2. How much coal is within 1,000 ft of the surface in the Gunnison National Forest?
3. What is the coal energy endowment of public lands within the Danforth Hills coal field of northwest Colorado?

The information produced as a result of these queries is useful for scientific research and land-use planning by Federal and other land-management agencies, and for shaping domestic energy resource policies.

The Colorado Plateau GIS was produced by utilizing the capabilities of Environmental Systems Research Institute (ESRI, 1998) ARC/INFO and ArcView software, and Dynamic Graphics, Inc. (DGI, 1997) EarthVision software. ARC/INFO consists of a number of spatial-editing and analysis modules whose strength is in digital data manipulation. ArcView is a desktop GIS package with an easy-to-use, point-and-click graphical user interface for information analysis, display, and delivery. EarthVision is a program that provides tools for automated surface modeling, mapping, and analysis. The Colorado Plateau GIS provides coal-geology data in an ArcView project. The ArcView project is described in detail below.

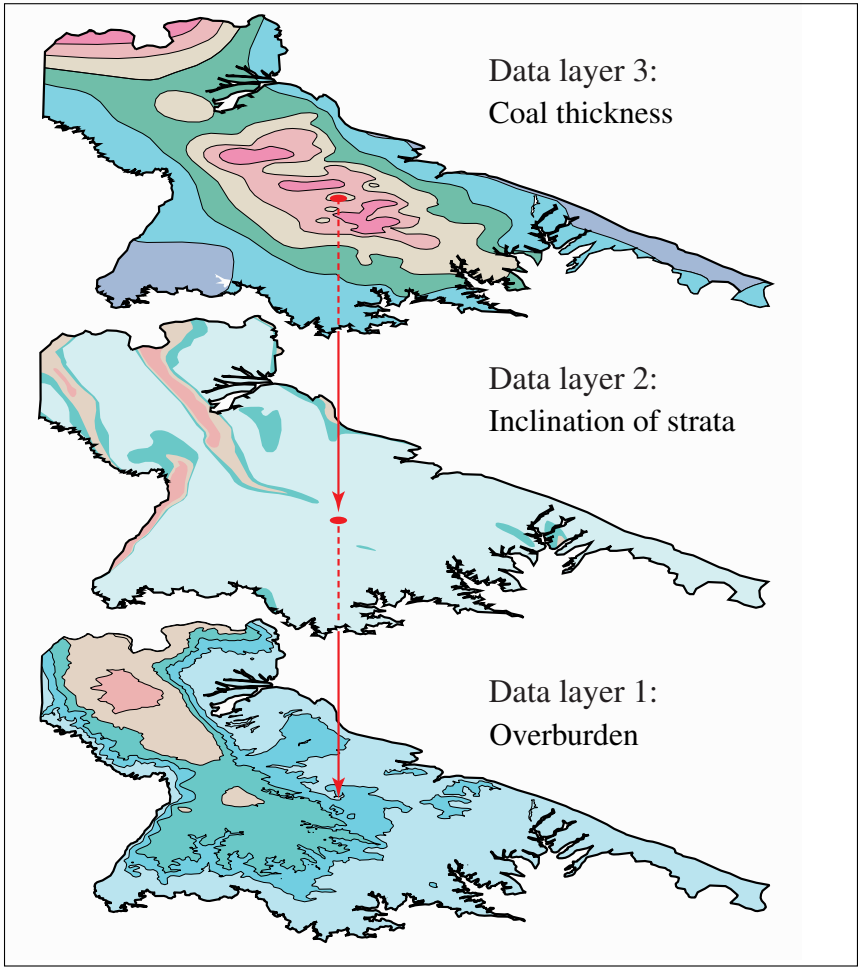


Figure 2. Diagram illustrating the concept of spatial integration of layers in GIS. Modified from Hettinger (chap. T, this CD-ROM).

How Were the Data Collected and Compiled?

Information included in this data compilation was often derived from other published reports and maps generated by numerous State and Federal agencies, including the USGS. Much of the data existed in multiple, incompatible, and hard-copy formats, sourced from various scales and covering limited extents in the study areas. Without further processing, the data was often unusable. Much work was required of project geologists to develop the surface and subsurface geologic data used in this assessment. This processing included field work and interpretations of geophysical log signatures from coal and oil-and-gas exploratory drill holes. Much work was also required to review, convert, and quality-control the input data, develop consistent themes, and generate regional and assessment-area coverages.

Two general types of information are included in this GIS and were used to generate the analytical portion of the Colorado Plateau Coal Assessment: vector data and raster data. Vector data is a coordinate-based (*x, y*) data structure commonly used to represent linear map features. The types of vector data acquired for this study include geologic and geographic data layers that define coal-bed or coal-zone outcrops, study-area boundaries, coal mine and lease boundaries, roads, cities, hydrology, counties, townships, quadrangles, geology, structural features, land management, and Federal mineral ownership (fig. 3). Occasionally, vector data were generated specifically for this study through partnerships with other State and Federal agencies, including the Bureau of Land Management (BLM) and State geological surveys. Other vector sources included downloading files from World Wide Web data sites and file transfer protocol (ftp) from Unix servers at numerous agencies. Data not yet available in digital form from external sources were derived by contracting individuals to scan and digitize existing or newly drafted maps. Vector data formats were many and varied; information was in MOSS, Microsoft Excel, ARC/INFO EXPORT, and shapefiles to name a few.

Raster is a cellular data structure composed of rows and columns. Groups of cells (pixels) represent features. Raster digital elevation model (DEM) data were acquired from the USGS National Mapping Division. Coal and overburden thickness raster files were generated in EarthVision. Raster files were processed and reformatted as needed using ARC/INFO, ArcView, and EarthVision.

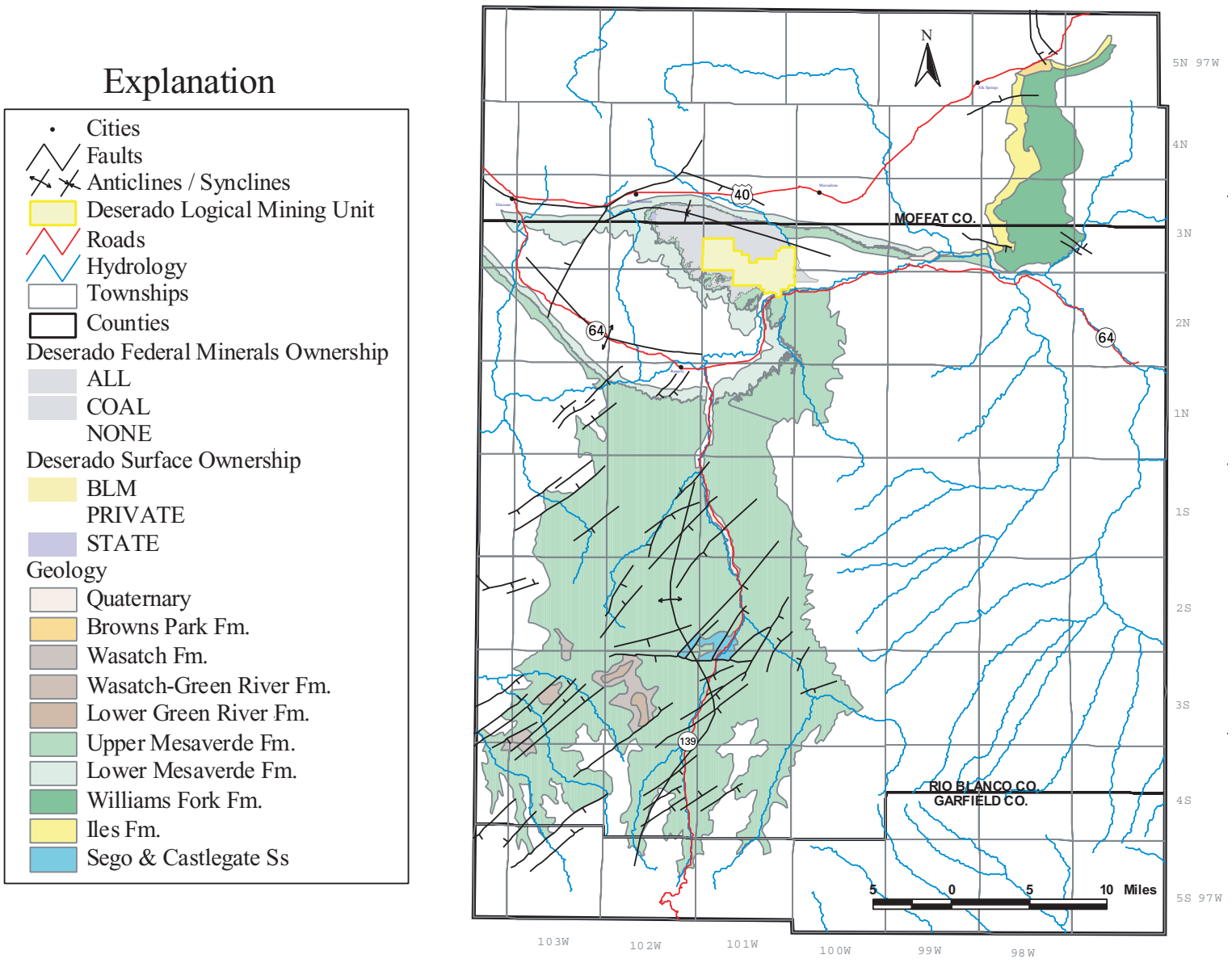


Figure 3. Example showing vector data acquired for the Lower White River assessment area, Colorado. Modified from Brownfield and others (chap. N, this CD-ROM).

The data formats included on this CD-ROM are discussed below (see Data Formats section).

To derive and develop coal resource information and statistics reported in this study, many software programs were used. Generally, the sequence used to develop coal resource summary statistics included the following:

1. Acquisition of coal stratigraphic and analytical data.
2. Entry and input of data into a database management system (DBMS).
3. Identification and correlation of coal beds and coal zones (fig. 4).
4. Surface modeling of coal beds and coal zones.
5. Conversion and transfer of vector and raster (pixel) data into a GIS.
6. Spatial integration of data layers using surface modeling and GIS processing and procedures.
7. Calculation and tabulation of coal resource tonnages by categories, including:
   a. coal thickness.
   b. overburden thickness.
   c. land management status.
   d. Federal mineral ownership.

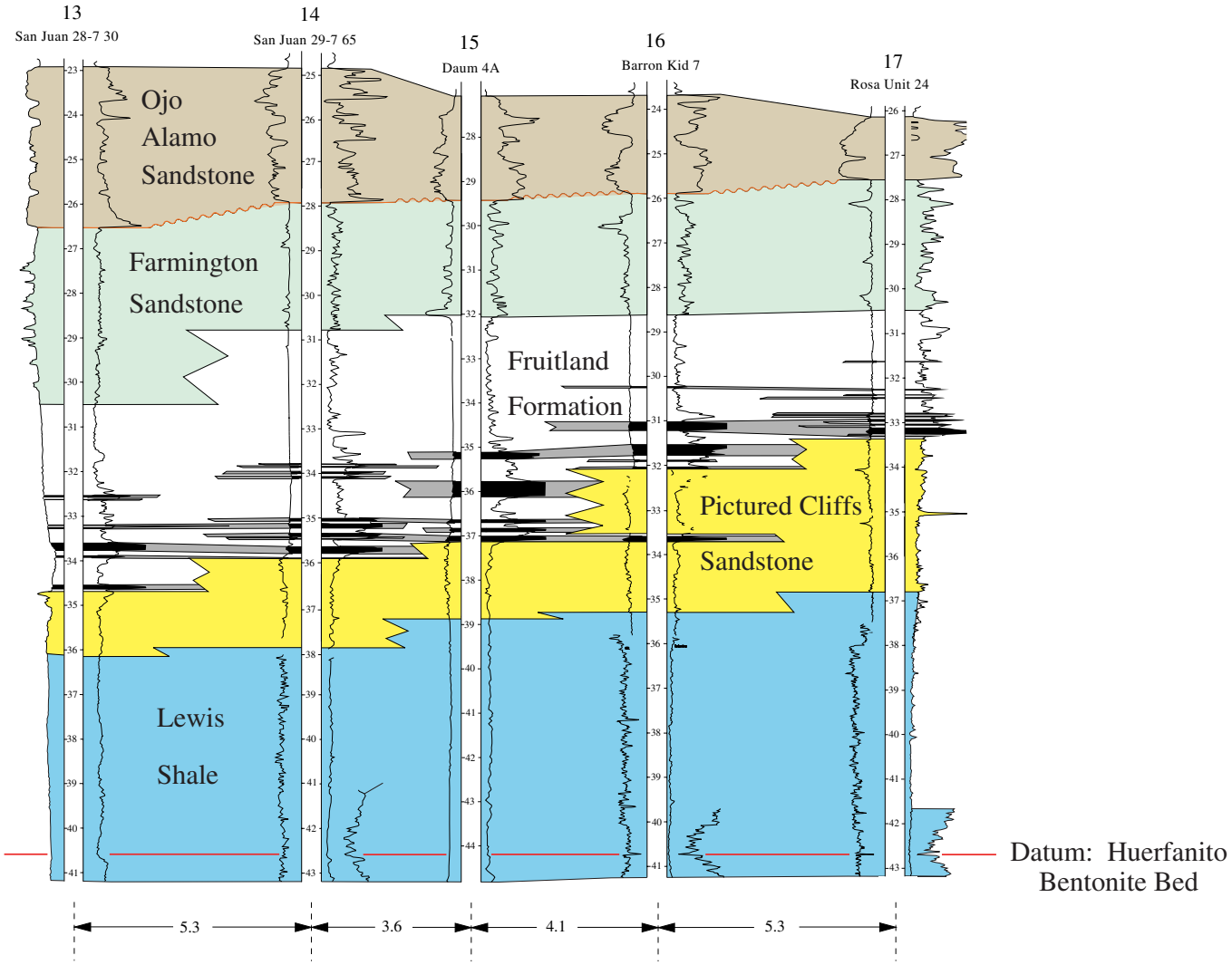


Figure 4. Example portion of a cross section showing coal (black bands) in the Fruitland Formation, San Juan Basin, New Mexico. Modified from Fassett, (chap. Q, this CD-ROM).

The final coal resource coverages contain many layers of information that have been combined into one file; accompanying attributes define the categories for which tonnage estimates are reported (table 1) in each of the assessment area chapters. A description of the coal resource calculation methodology is found in Roberts and others (chap. C, this CD-ROM) and Roberts and Biewick (1999). The coal resource data tables and summary statistics are provided for each of the assessment areas within the technical report chapters on this CD-ROM. The processing sequence, manipulation routines, and procedures are described in the metadata documentation for each of the GIS layers (see Metadata section).

Table 1. Example of an attribute table containing categories for which coal-tonnage estimates are reported.

[FS, U.S. Forest Service; fed, Federal; hypo, hypothetical; 33S2E, T. 33 S., R. 2 E.]

7.5' quadrangle	County (Utah)	Overburden (ft x 1,000)	Surface management	Coal ownership	Township and Range	Reliability	Dip (degrees)	Net-coal thickness (ft)
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	12-25	35
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	12-25	45
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	6-12	45
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	6-12	35
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	0-6	45
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	0-6	45
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	12-25	25
Posy Lake	Garfield	1-2	FS	fed	33S2E	hypo	0-6	45
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	0-6	35
Barker Reservoir	Garfield	3-6	FS	fed	33S1E	hypo	6-12	125
Posy Lake	Garfield	1-2	FS	fed	33S2E	hypo	0-6	45
Barker Reservoir	Garfield	3-6	FS	fed	33S1E	hypo	6-12	115
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	12-25	25
Posy Lake	Garfield	0-1	FS	fed	33S2E	hypo	12-25	35

The Colorado Plateau ArcView Project

General Discussion

A major component of the Colorado Plateau coal assessment GIS is the Colorado Plateau ArcView project (CP_AVP). CP_AVP provides a means of presenting the digital data provided for the geologic assessment of coal in the Colorado Plateau. CP_AVP consists of "views," each of which is composed of numerous "themes." Each theme represents a different layer of information or different feature on the Earth's surface. The themes may be interactively displayed by "toggling on or off." Figure 5 is an example of a map display of themes that include landforms, geology, faults, townships, roads, and towns in the southern Wasatch Plateau. The view includes additional themes (e.g., hydrology, counties, and mine locations) that are not shown because they have been "toggled off." The ability of the user to interact with, or reorder, the information represented by the themes in the views allows a better understanding of the spatial representation of the resource information.

With the ability to manipulate the digital data sets, for example, to edit and perform detailed queries, comes the responsibility to use the data appropriately. Descriptions of each of the GIS layers are provided in the metadata documentation (see Metadata section), and detailed descriptions of the coal geology and resources are provided in each of the technical report chapters on this CD-ROM. The technical report chapters can be accessed in a separate window while working in CP_AVP. Information on how to access the technical reports is contained in the readme file on disc 1 in this two-CD-ROM set.

The technical reports contain links in Adobe Acrobat (version 4.0 or later; Adobe Systems, Inc., 1997)—by means of bookmarks, thumbnails, or the report's table of contents—to quickly access the appropriate geologic information.

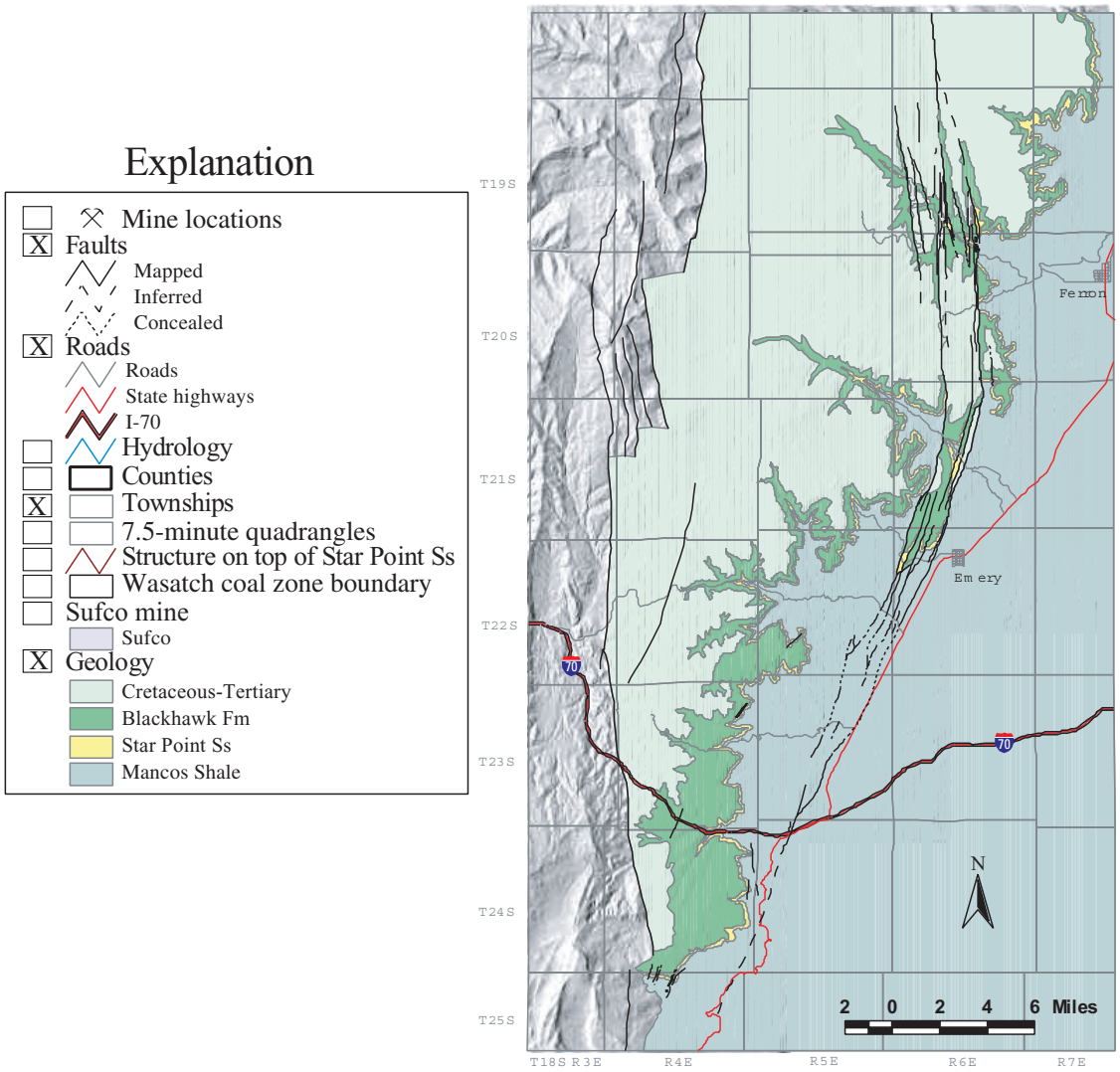


Figure 5. Example of displaying data layers (themes) in the Wasatch Plateau assessment area by "toggling" the check box on or off. Modified from Dubiel and others (chap. S, this CD-ROM).

The ArcView Project Views

CP_AVP is a compilation of views displayed at regional and site-specific scales. Regional views summarize broader aspects of the geography and coal geology of the Colorado Plateau area, whereas site-specific views show detailed coal resource assessment information within specific assessment areas of the Colorado Plateau. The views provided in this publication are listed on table 2. Also provided on table 2 are example view graphics and references to technical reports on this CD-ROM that provide detailed coal geology and resource information.

Table 2. List of ArcView views, example view graphics, and references to technical reports on this CD-ROM.

[app., Appendix number]

View List	Report References
Colorado Plateau Regional Views	
Location within the U.S.	
Assessment Areas with ArcView Project	Kirschbaum (chap. A, this CD-ROM)
Coal Fields	Kirschbaum and Biewick (chap. B, this CD-ROM)
Coal Rank	Kirschbaum and Biewick; Affolter (chaps. B and G)
Coal Geochemistry	Affolter (chap. G, this CD-ROM)
Coal-Bed Gas Plays	Kirschbaum (chap. A, this CD-ROM)
Land Management	Molnia and others (chap. E, this CD-ROM)

View List	Report References and Example View Graphic
Danforth Hills Assessment Area	Brownfield and others (chap. M, app. 2)
Geography and Geology	
A Zone Coal Maps	
B Zone Coal Maps	
C Zone Coal Maps	
D Zone Coal Maps	
E Zone Coal Maps	
F Zone Coal Maps	
G Zone Coal Maps	
Ownership	

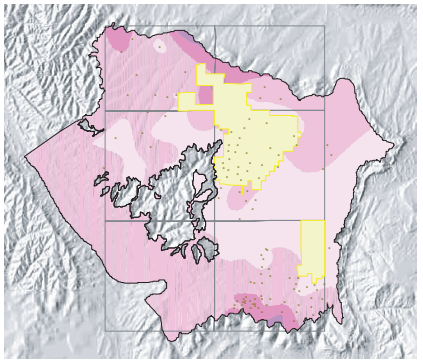
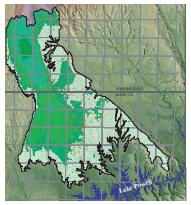
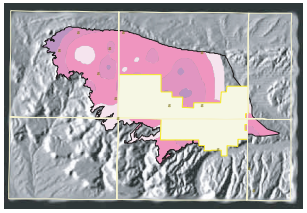


Table 2. List of ArcView views, example view graphics, and references to technical reports on this CD-ROM—*Continued*.

View List	Report References and Example View Graphic
Kaiparowits Plateau Assessment Area	Hettinger and others (chap. T, app. 6) 
Geography and Geology	
Coal Maps	
Ownership	
Summary	

View List	Report References and Example View Graphic
Lower White River Assessment Area	Brownfield and others (chap. N, app. 2) 
Geography and Geology	
Deserado Study Area -- B Zone Coal Maps	
Deserado Study Area -- D Zone Coal Maps	
Deserado Study Area Ownership	

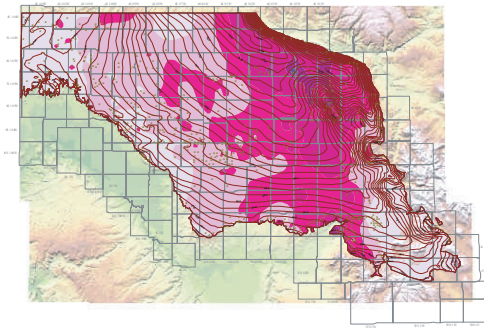
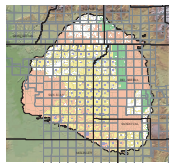
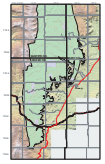
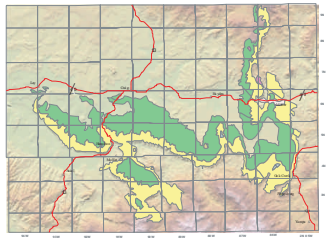
View List	Report References and Example View Graphic
S. Piceance Basin Assessment Area	Hettinger and others (chap. O, app. 6) 
Geography and Geology	
Cameo / Wheeler Coal Zone Maps	
Coal Ridge Coal Zone Maps	
Crested Butte Coal Maps	
Cameo / Fairfield Coal Group Maps	
South Canyon Coal Zone Maps	
Ownership	

Table 2. List of ArcView views, example view graphics, and references to technical reports on this CD-ROM—*Continued.*

View List	Report References and Example View Graphic
San Juan Basin Assessment Area	Fassett (chap. Q, app. 6) 
Geography and Geology	
Coal Maps	
Ownership	

View List	Report References and Example View Graphic
S. Wasatch Plateau Assessment Area	Dubiel and others (chap. S, app. 2) 
Geography and Geology	
Coal Maps	
Ownership	

View List	Report References and Example View Graphic
Yampa Assessment Area	Johnson and others (chap. P, app. 7) 
Geography and Geology	
A Zone Coal Maps	
B Zone Coal Maps	
C Zone Coal Maps	
D Zone Coal Maps	
Ownership	

Software is Provided!

Another significant development of the Colorado Plateau ArcView Project is the inclusion of the ArcView Data Publisher (AVDP), which is basically a read-only version of ArcView GIS version 3.1 software. The AVDP enables end users to access the capabilities of the ArcView project without requiring ownership of the ArcView software package. This arrangement and capability was made possible by exclusive agreements with ESRI (ESRI, 1999). AVDP allows manipulation of the ArcView project data and themes provided in this publication, but does not allow one to save or "write" modifications to the ArcView project.

Colorado Plateau ArcView Project Design

Being a custom, simplified interface, much of the standard ArcView 3.1 functionality, while included, is hidden from the user. Information is obtained primarily via pull-down menus, pop-up windows, and by pointing and clicking on views—panning and zooming is determined by the user. Any changes or additions to the project made during a session are lost upon exiting. Users having ArcView 3.1 software may use this project as well (see section entitled, Use of this Project with ArcView 3.1).

System Requirements

Although the GIS data files (see Data Formats section) can be accessed on many computer platforms (including Macintosh, Windows, and Unix), the ArcView Data Publisher software on this CD-ROM requires the Windows operating system. CP_AVP can be run on any Intel-based computer that runs Microsoft Windows NT 4.0 or higher, or Windows 95 or higher (hereafter referred to as Windows NT and Windows 95) if the system has the required minimum random access memory (RAM) and virtual memory. The list below provides the minimum and also the recommended requirements for installing and running CP_AVP.

- Computer—An industry-standard personal computer with at least a Pentium or higher Intel-based microprocessor, a hard disk, and a CD-ROM drive. Because of the size of the files, the recommended minimum CPU speed is 200 MHz. However, this ArcView project will run better on a computer with 400 MHz.
- RAM—To run CP_AVP, you will need at least 24 MB RAM (32 MB recommended). You will also need at least 17 MB virtual memory (permanent or temporary virtual memory). Memory is automatically allocated for Windows 95.
- Operating system—Windows NT 4.0 or higher, or Windows 95 or higher.
- Display or monitor—15-inch minimum display size video graphics adapter (VGA), or better, resolution monitor. Display settings are 16-bit color depth or 65,536 colors, and 1,024×768 pixels.
- Pointing device—A Microsoft mouse or compatible pointing device.
- Printer—Optional.

Getting Started

In order to use CP_AVP to analyze the Colorado Plateau coal assessment spatial data, the end user must first install the software by running "setup.exe." The setup program presents four installation options:

- Leave All Program and Data Files on the CD-ROM
  This option uses little or no disk space on the user's computer but, as a result, has the slowest performance.
- Download the Program Files Only
  This option is the default; it improves performance by installing the software, about 32 MB, to a user-specified directory, but leaves the data on the CD-ROM.
- Download All Files
  This option has the best performance but requires the user to download hundreds of megabytes of software (32 MB) and data (about 230 MB) to a hard disk.
- Download the Data Files Only
  This option improves performance by installing the data, about 230 MB, to a user-specified directory, but leaves the software on the CD-ROM. This option might be chosen by an ArcView (version 3.1 or later) user. In this case, use the ArcView project that is designed for ArcView users and resides on disc 2 (see section entitled, Use of this Project with ArcView 3.1).

Once the setup is complete, an ArcView Data Publisher 3.1 program group, accessible through the Windows Start, Programs menu, is created with two icons: one for the CP_AVP named *Colorado Plateau ArcView Project* and another named *Read Me* having information about the AVDP product.

Double-clicking the *Colorado Plateau ArcView Project* icon starts CP_AVP by loading the program, source data, and custom scripts as directed by the ArcView project file *cpca.apr*. While the project opens, the title page for the Geologic Assessment of Coal in the Colorado Plateau is temporarily displayed. Upon opening, the project displays a view showing coal-bearing strata in the Colorado Plateau study area. The assessment areas included in the ArcView project are labeled and highlighted.

The ArcView Project Help File

The CP_AVP help file provides some tailored help to get users started. Much of the information presented is discussed in more detail in the online ArcView help files that are accessible from the main menu of the ArcView project.

The assessment area views contain a variety of themes, such as landforms, water, coal-bed or coal-zone boundaries, leased areas, county boundaries, etc. Themes may be "toggled on and off" interactively by the user in order to present the data in different ways. Monochrome colors were used in color ramps, with low values represented by light colors and high values represented by dark colors.

A particular assessment area may be chosen from the opening regional view allowing the data to be viewed in greater detail and queried. There are several ways to accomplish this. The table of contents to the left of the view map display window in figure 6 shows the theme labeled 'Link to Assessment Area' in a raised box; this is the active theme. Themes are activated by a single click on the theme label. To make the theme visible, toggle the checkbox located in the table of contents at the far left edge of the theme name. With this theme active, simply click with the finger icon on one of the assessment areas. This opens the assessment area geography and geology view.

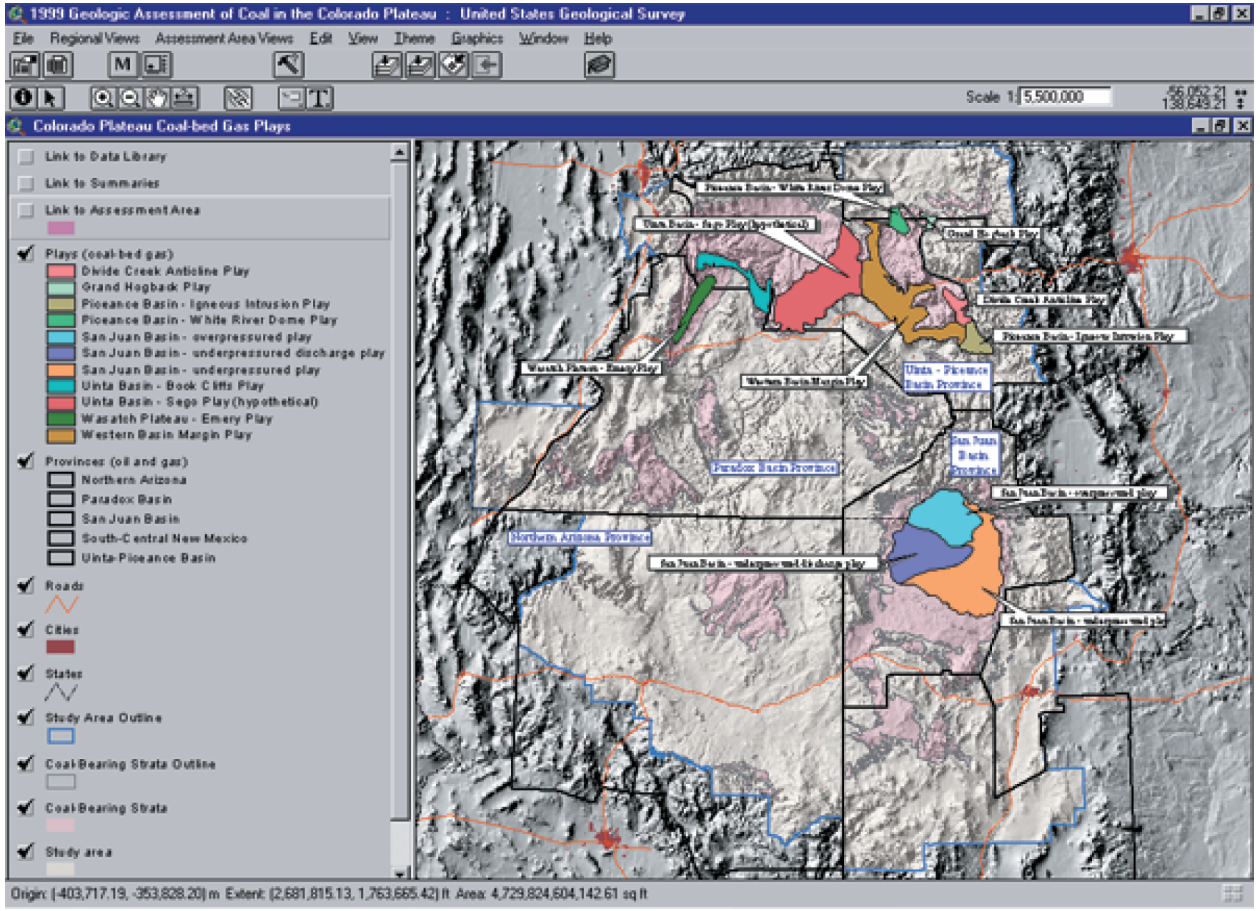


Figure 6. Example view of oil and gas provinces and plays in the Colorado Plateau, showing methods of choosing an assessment area view.

Another method of choosing an assessment area is to click on the Assessment Area Views menu in the top menu bar, which activates a pull-down list of the assessment areas. A single mouse click on one of the assessment areas activates a pop-up window containing a list of the available assessment area views. Content of the assessment area views includes (fig 7.):

- 'Assessment area' Geography and Geology: Locates the assessment area within surrounding geography. Themes include geology (surficial, structure), base maps, landforms, etc.
- 'Assessment area' Coal Maps (one or more views): Includes public drill-hole and outcrop data points, coal thickness isopach maps, overburden isopach maps, landforms, and maps showing reliability categories used in the calculation of coal resources.
- 'Assessment area' Ownership: Land and coal ownership. In the Western United States, the Federal Government owns the surface of approximately 60 percent of the area underlain by coal-bearing rocks (Biewick, 1997). Federal lands in assessment areas in the Colorado Plateau can vary from 7 percent to 99 percent, and Federal coal ownership can vary from 54 percent to 99 percent.
- 'Assessment area' Summary (optional): The Kaiparowits Plateau assessment area contains a summary view that shows where geologic conditions are more favorable for current underground mining technology, as described in Hettinger and others (chap. T, this CD-ROM).

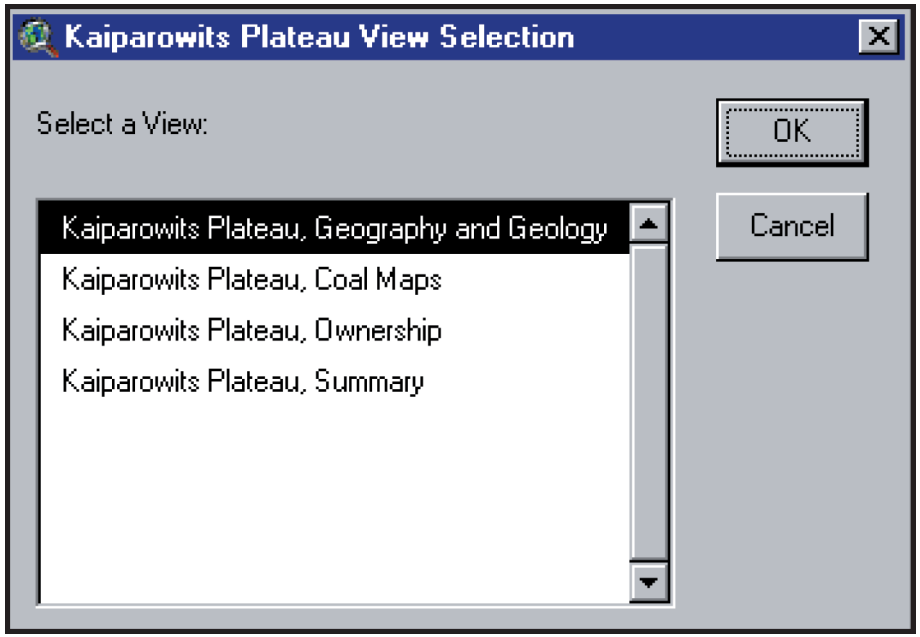


Figure 7. Example of an assessment area view selection as seen in the Colorado Plateau ArcView project.

To navigate back to the extent of the Colorado Plateau study area, click on the Regional Views menu in the top menu bar and choose one of the seven Colorado Plateau views.

While designed primarily for interactive use and viewing on a computer, a print tool is provided allowing users to create and print hard-copy maps. The print tool is described below.

Regional Views

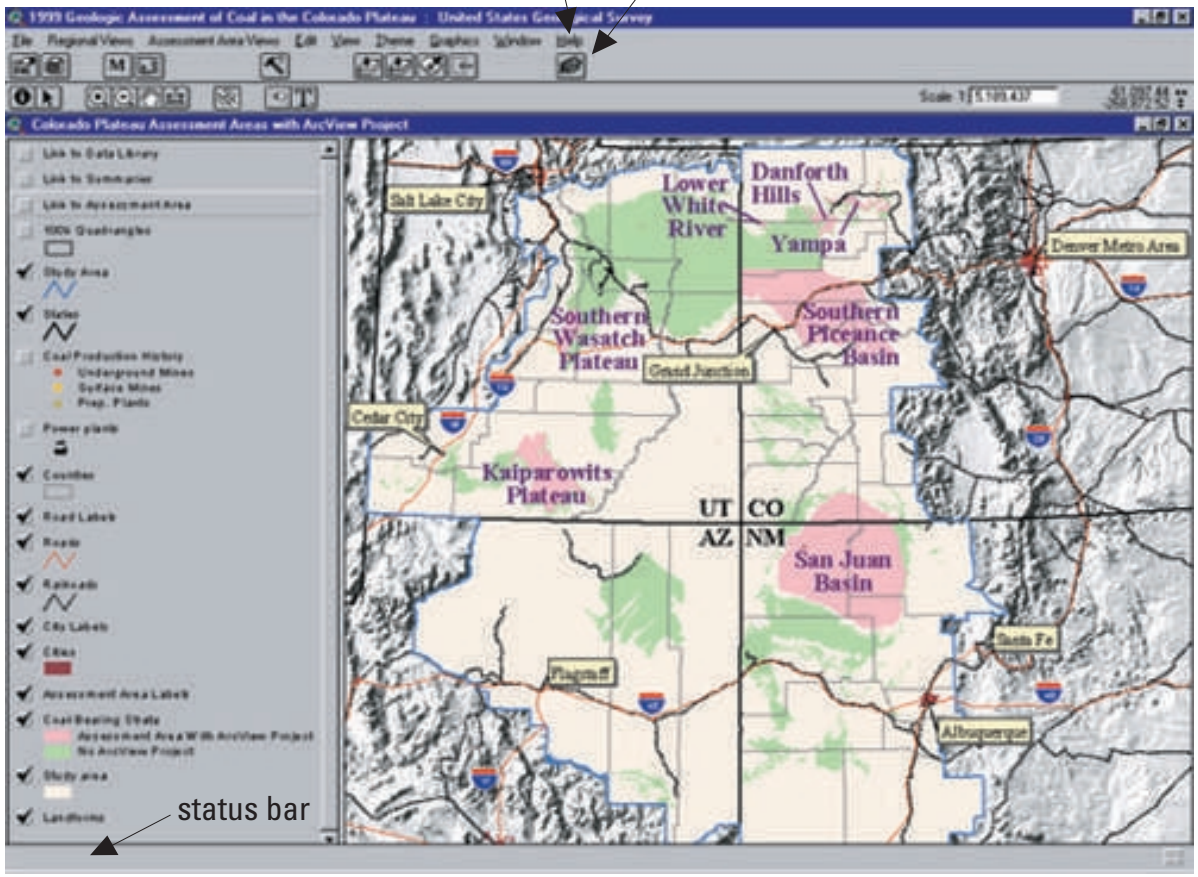
Regional views are intended to give the user information regarding the assessment areas within the Colorado Plateau study area. From each regional view, individual assessment areas may be selected to display detailed information about that particular assessment area and its coal resources.

The *Colorado Plateau Assessment Areas with ArcView Project* regional view is the first screen displayed as the user opens the Colorado Plateau ArcView project. The ArcView application has user controls located in the panels above the view display area. The view GUI consists of pull-down menus, buttons, and tools for various functions. Below the regional view window is a status bar. When the cursor is placed over a button or tool, a one-line description of the operation that the button or tool performs is displayed in the status bar. Included in the tool bar at the top of the application is a **Help File** button, which, when pressed, displays an Adobe Acrobat document containing the help file and the chapter that describes the Colorado Plateau GIS in detail. Also included in the uppermost menu bar is a **Help** pull-down menu, which accesses additional information on standard ArcView features and functionality in the online help files. The user can move, resize, minimize, or maximize any of the windows in ArcView.

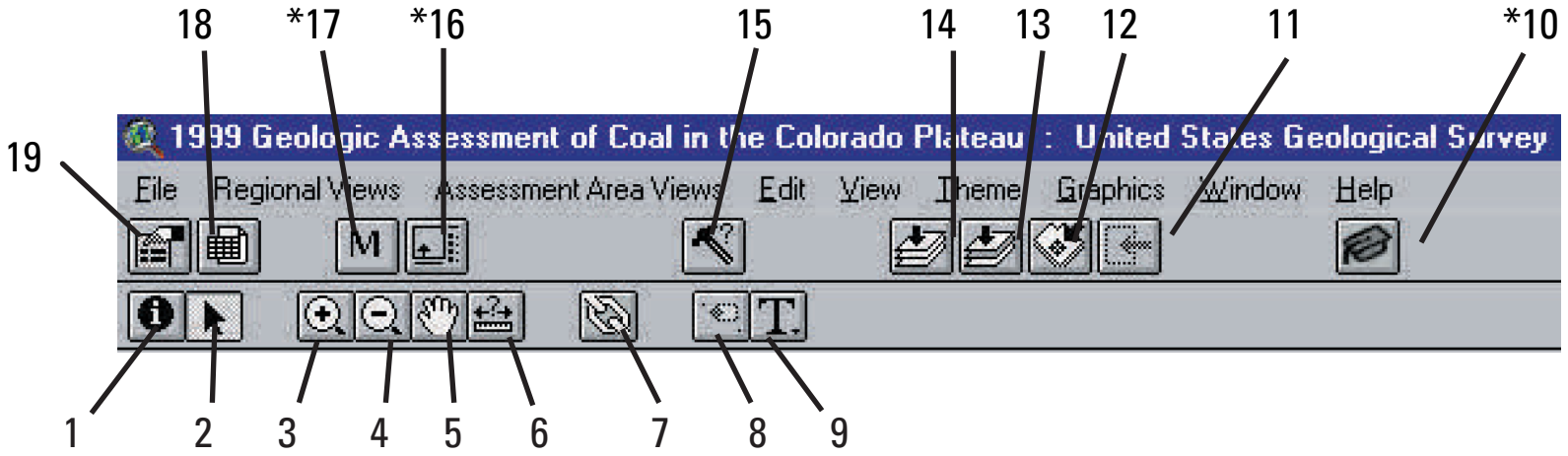
The **Regional Views** drop-down menu can be selected to access other regional views in the project. Assessment-area views (for those with an ArcView Project—highlighted) can be opened by clicking an assessment area on the regional map or from the **Assessment Area Views** menu, which brings up a dialog box with a view list.

Additional information on standard ArcView features and functionality is available from the Help pull-down menu.

The Colorado Plateau ArcView project contains a Help File button to access the customized help file and the paper that describes the Colorado Plateau GIS in detail.



Tool Bar (Views)



1. *Identify Tool*—Displays the attributes associated with a particular feature in the view Map Display. What county is this? What town is this? What coal information is available at this drill-hole location?
2. *Pointer Tool*—Selects, moves, and resizes graphics.
3. *Zoom In Tool*—Zooms in to an area at a point you select with a mouse click. One can drag a rectangle to zoom in to an area.
4. *Zoom Out Tool*—Zooms out from a point you select with a mouse click. One can drag a rectangle to include a particular area when zooming out.
5. *Pan Tool*—Drags the display in the direction you move the cursor.
6. *Measure Tool*—Measures distance.
7. *Hot Link Tool*—Follows a hot link in the active themes.
8. *Label Tool*—Labels a feature in the active theme with data from its table.
9. *Text Tool*—Creates text on the display.

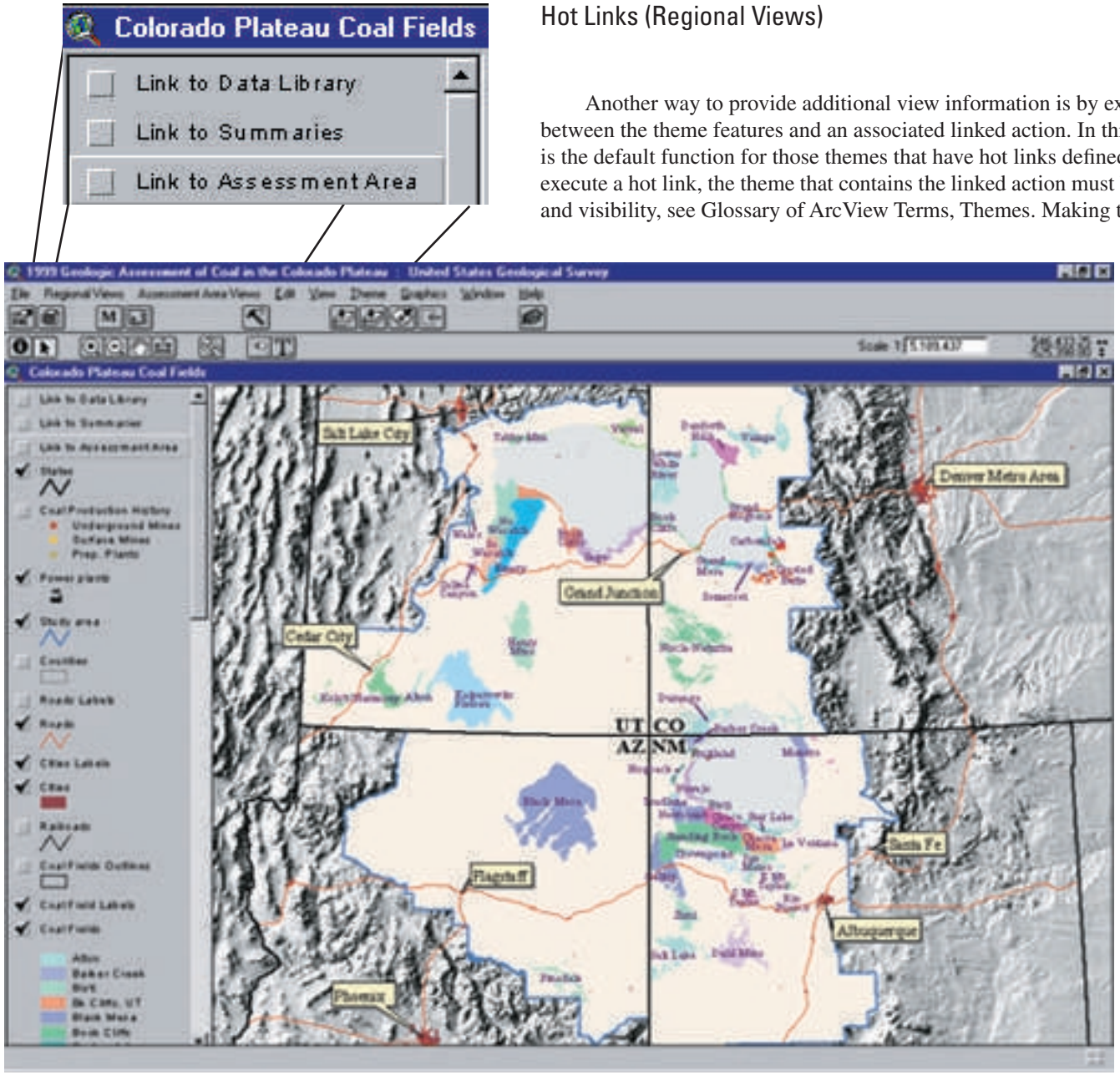
*10. *Tutorial Button*—Opens and displays the help file for the Colorado Plateau ArcView project. Additional help on standard ArcView features and functionality is available in the online help files accessed in the uppermost menu bar.

11. *Zoom to Previous Extent Button*—Goes back to the previous extent you were viewing.
12. *Zoom to Selected Button*—Zooms to the extent of the selected features.
13. *Zoom to Active Themes Button*—Zooms to the extent of active themes.
14. *Zoom to Full Extent Button*—Zooms to the extent of all themes.
15. *Query Builder Button*—Displays the Query Builder to select features with a logical expression. To obtain a list of possible choices for a specified attribute, click in the box to the left of Update Values in the Query Builder window. Now select the attribute of interest.

*16. *Make Map Button*—Creates a map layout from the active view for hard-copy printing.

*17. *Metadata Button*—Displays the metadata document (which contains the type of data found in a readme file) for the active theme.

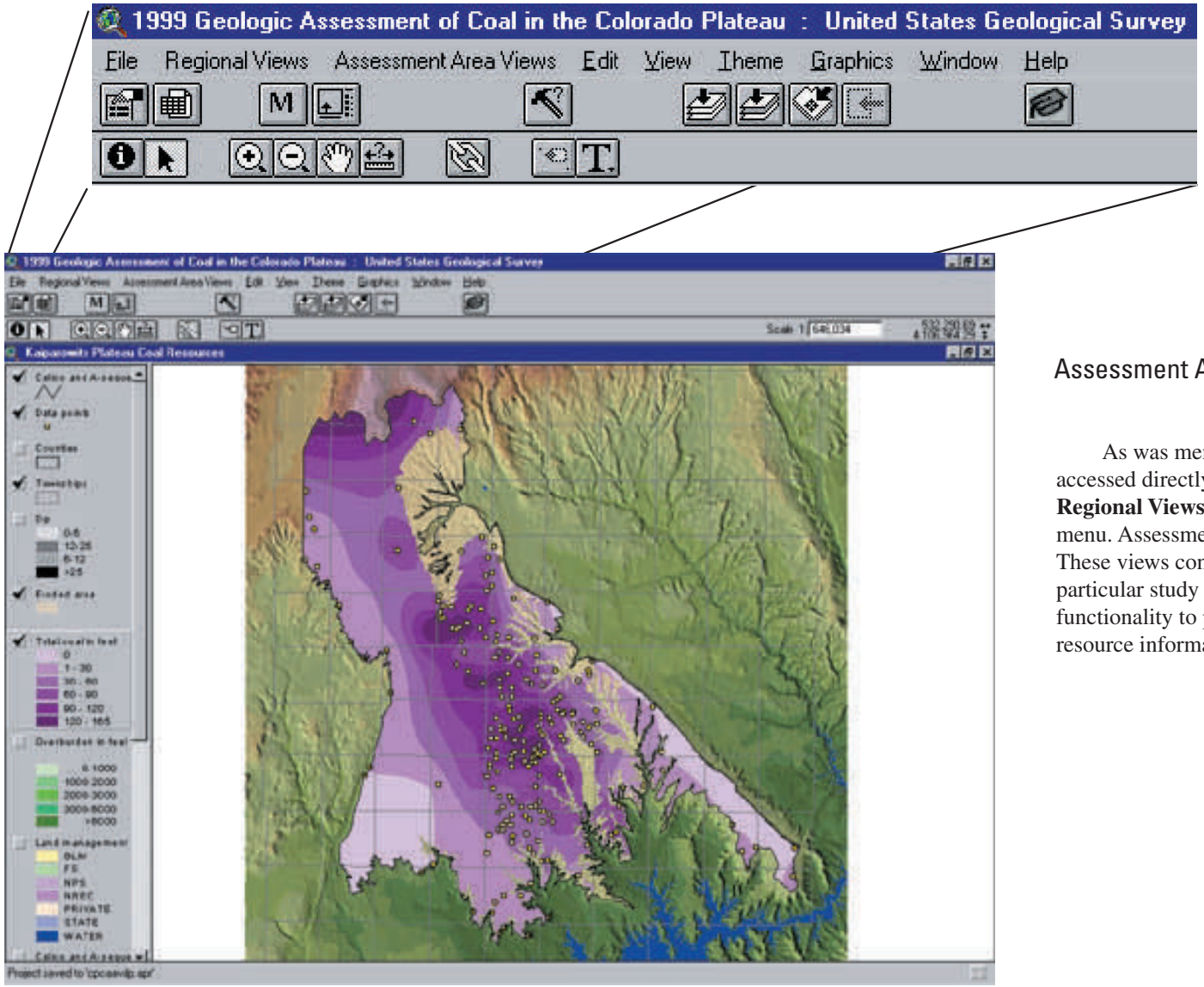
18. *Theme Table Button*—Opens the tables of the active themes.
19. *Theme Properties Button*—Displays the dialogue box to view and (or) edit properties of the active theme.



Hot Links (Regional Views)

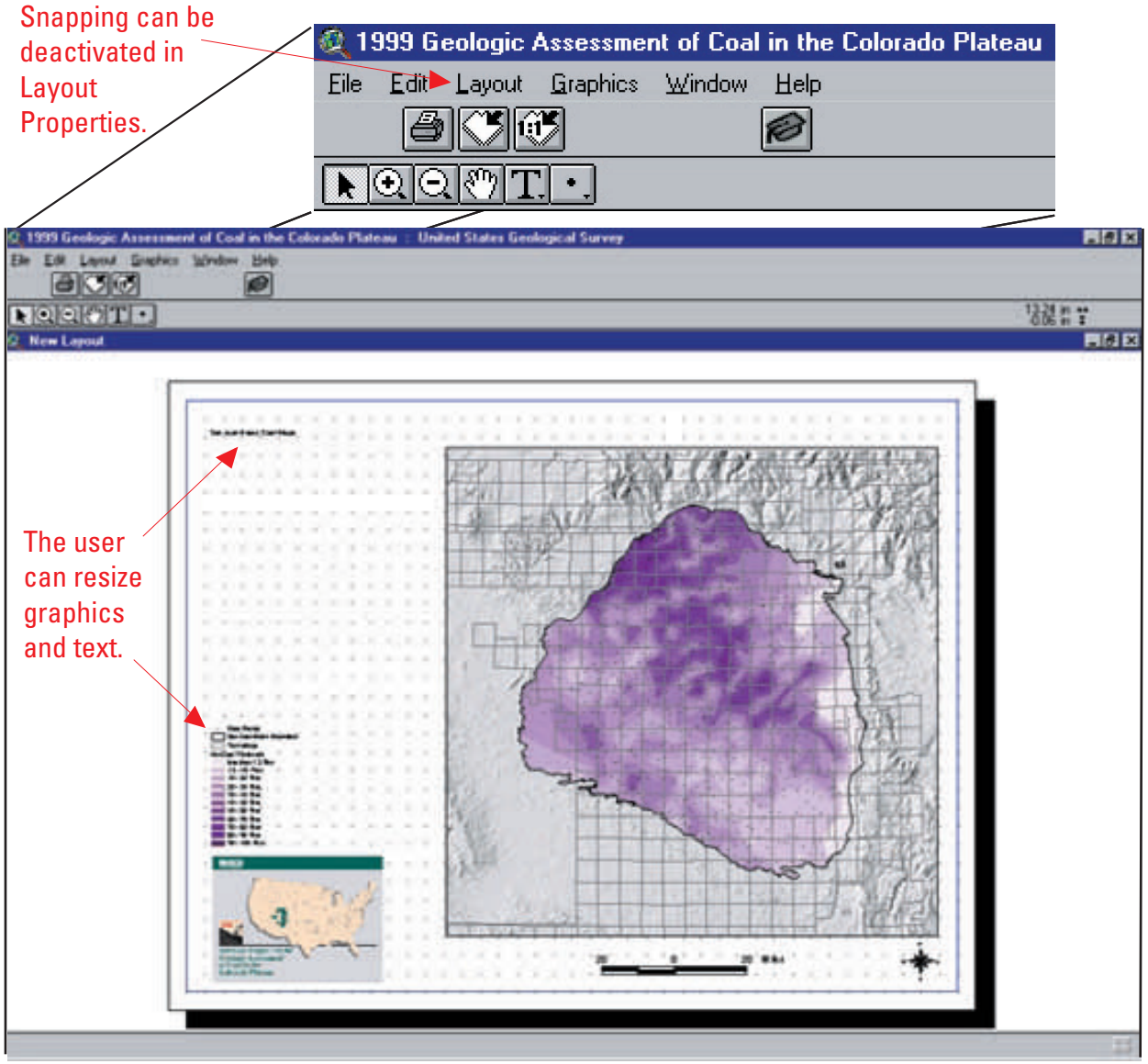
Another way to provide additional view information is by executing "Hot Links" that have been defined between the theme features and an associated linked action. In this project, the Hot Link tool is the default function for those themes that have hot links defined (the theme names begin with "Link to"). To execute a hot link, the theme that contains the linked action must be activated (for information on theme activation and visibility, see Glossary of ArcView Terms, Themes. Making the theme visible will show which features in the Map Display are associated with the hot link). Then click with the finger icon on the feature of interest in the view Map Display. If a hot link is associated with the feature, it will execute at that time. The Hot Link tool icon appears dimmed if a hot link has not been defined for the active theme. In the standard ArcView program this tool appears as a lightning bolt and so the ArcView online help menu files describe this tool as such.

The Hot Links that have been defined for various themes in this project perform a linked action, such as displaying a text file, opening another ArcView project view, or linking to an external application via an Avenue script. Hot links have been defined in each Colorado Plateau regional view to link to detailed location views of each of the assessment areas in the ArcView project. Other information that has been hot-linked includes coal-field summaries and data-library flow charts that open and display in a separate window via Acrobat Reader (Adobe Systems, Inc. 1997). The Acrobat window can remain open and can be reduced and (or) repositioned to facilitate referencing associated information while working in ArcView.



Assessment Area Views

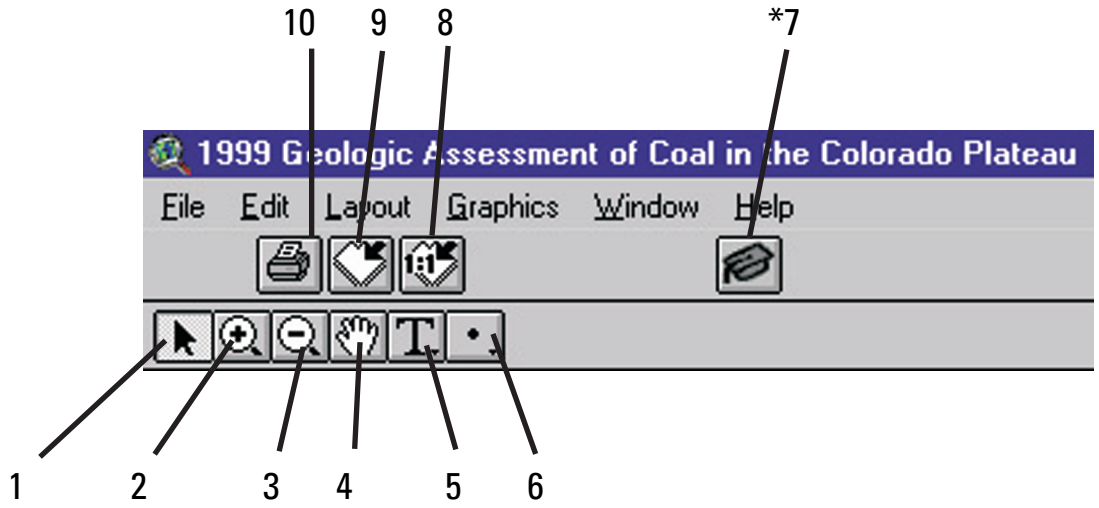
As was mentioned previously, each view can be accessed directly from any other view by using either the **Regional Views** menu or the **Assessment Area Views** menu. Assessment area views contain a variety of themes. These views contain the detailed themes that apply to that particular study area. Assessment area views provide the functionality to perform detailed queries and display coal-resource information.



Hard-Copy Prints

A Layout is an assembly of components that can appear on a hard-copy map. This ArcView project contains a make map button in the view tool bar that creates a layout and adds a title, scale bar, legend, north arrow, and USGS logo to any view. Clicking on the Make Map button (see button 16 in the description of the Views Tool Bar) activates a pop-up window that allows the user to choose between three output page sizes: 8.5x11, 12.75x16.5, and 17x22, and then name the new layout. On the layout page, the user can add and resize graphics and text as desired. Once the layout is complete, it can be sent to a printer or plotter.

Tool Bar (Layouts)



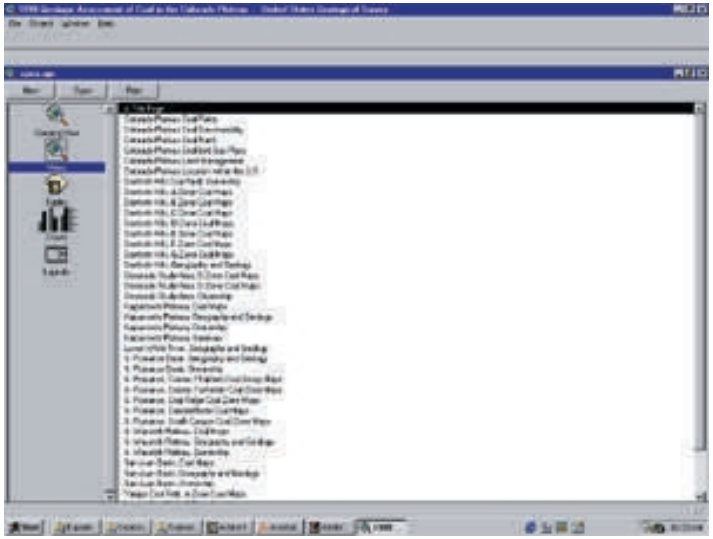
* Designates customized buttons

1. *Pointer Tool*—Selects frames or graphics on the layout by pointing or dragging.
2. *Zoom In Tool*—Zooms in to an area at a point you select with a mouse click. One can drag a rectangle to zoom in to an area.
3. *Zoom Out Tool*—Zooms out from a point you select with a mouse click. One can drag a rectangle to include a particular area when zooming out.
4. *Pan Tool*—Drags the display in the direction you move the cursor.
5. *Text Tool*—Creates text on the display.
6. *Draw Tool*—Creates points, lines, rectangles, circles, or polygons on the display.

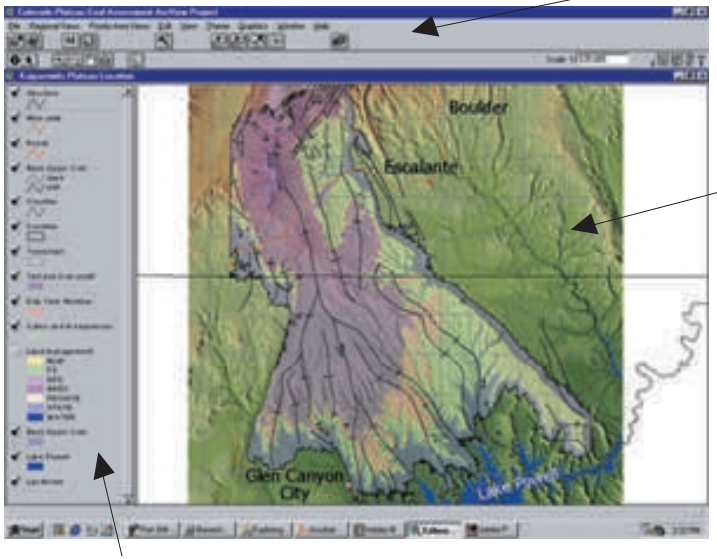
*7. *Tutorial Button*—Opens and displays the help file for the Colorado Plateau ArcView project. Additional help on standard ArcView features and functionality is available in the online help files accessed in the uppermost menu bar.

8. *Zoom to Actual Size Button*—Zooms to display the actual size of the layout (1:1).
9. *Zoom to Page Button*—Zooms to the page.
10. *Print Button*—Prints the current layout.

Project Window



View Window



Glossary of ArcView Terms

The ArcView Project Window provides the user access to all the components contained in the project file. Each document type that can be accessed by the user is listed in this window. This window is accessible by selecting “1 cpca.apr” from the **Window** pull-down menu.

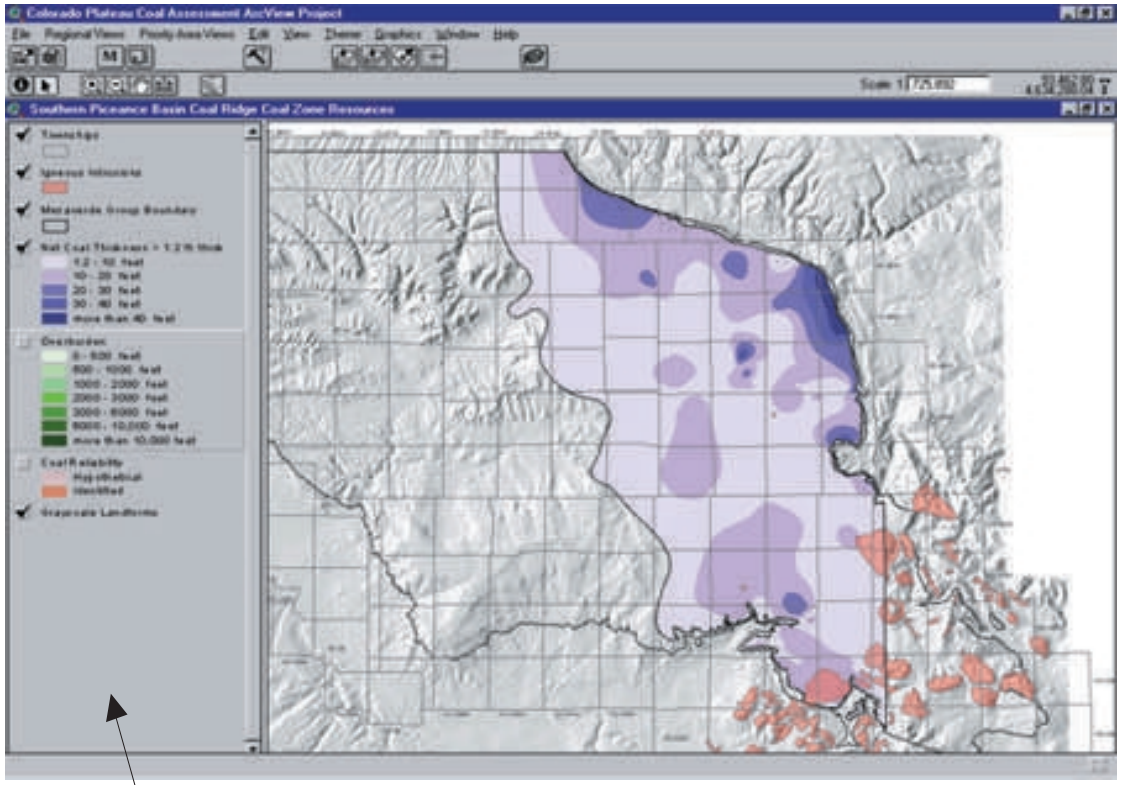
The View Window consists of thematic information such as rivers, roads or assessed coal zones. The View Window is made up of 3 parts:

1. Table of Contents (TOC)
2. Map Display
3. View Graphical User Interface (GUI)

The TOC lists the geologic and geographic themes in the view, the associated legends and symbology, and allows the user to interactively select, reorder, and display themes in the Map Display. The Map Display contains the graphics. The menus, buttons, and tools shown in the View Window header make up the GUI that is used to perform operations on views and themes.

Glossary of ArcView Terms—*Continued*

Themes



View Window TOC

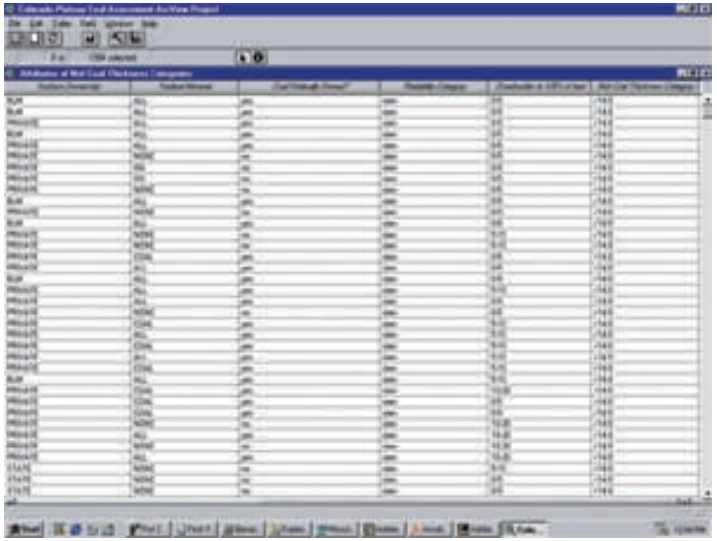
An ArcView theme is a spatial representation of a single data source and is derived from feature data such as shapefiles and ARC/INFO coverages, or image data, such as TIFF files. The theme and associated legend and symbology are listed in the Table of Contents (gray) portion of the View Window. Themes must be activated in order to perform operations and utilize many of the view menus, tools, and buttons. Themes can be made "active" by clicking on the desired theme in the View Window Table of Contents. The active theme name and its associated legend become a raised box within the Table of Contents. To make the theme visible or not visible in the Map Display, simply toggle the checkbox located at the far left edge of the theme.

There are several methods for end users to find out more about the data sources and location of the files displayed on the View Window. Each method requires the appropriate theme to be activated.

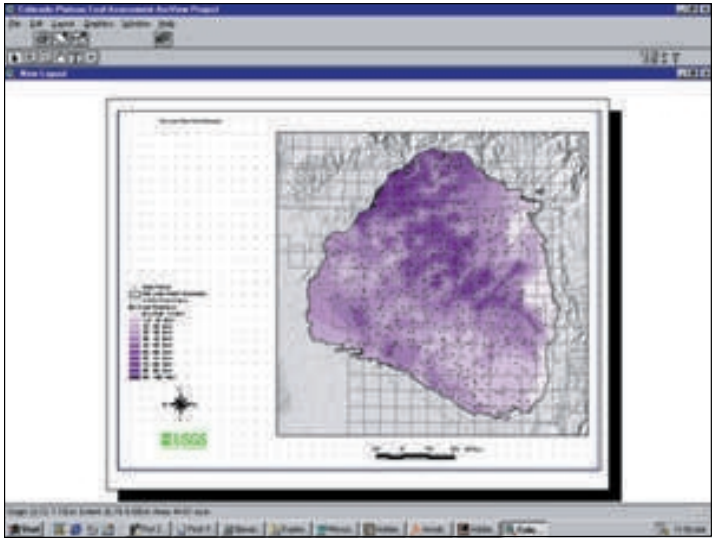
1. Select "Properties" from the **Theme** pull-down menu. Highlight the "Definition" tool to list the source data path.

2. Select the **M** button on the tool bar to access and display the metadata (or readme file) documentation for the particular theme or source data file. Source file names exist in the metadata document title and are followed by a brief description of the file in parentheses. Other_Citation_Details, approximately lines 11 to 13, describes the path to the data by providing the region or assessment area scale folder where the source data file resides.

Table Window



Layout Window



Glossary of ArcView Terms—*Continued*

ArcView permits analysis of tabular data. Tabular data often contain attribute information about a particular location or feature in its associated theme. Tabular data with no spatial component can also be opened in ArcView. Multiple tables can be joined or temporarily related for data retrieval, query, analysis and map display. Theme attribute tables for "active" themes can be displayed by selecting the "Open Theme Table" button or "Table" from the **Theme** pull-down menu. To return to the view, close the Table Window by selecting "File" on the Table menu and clicking on "Close"; or click on the "X" in the upper right corner of the Table Window.

A layout is a digital representation of a "map" generated in ArcView. The map page is designed for users to place view content and standard graphics (titles, scale bar, legend, north arrow, text) in desirable locations for printing a hard-copy map. This ArcView project (*cpca.apr*) contains a customized map-making button to simplify map layout creation (see button 16 in the description of the Views Tool Bar).

Use of this Project with ArcView 3.1

The ArcView project can be opened by anyone having ArcView 3.1 for Windows. ArcView 3.1 users can open CP_AVP (the AVDP version), but they will have to add controls back into the project that are disabled in the AVDP program (writing out data, saving the project, etc.) To eliminate these extra steps, two versions of the ArcView project file, *cpca.apr*, have been included on this CD-ROM publication, one for the AVDP (resides on disc 1) and one for the ArcView user (resides on disc 2). ArcView 3.1 users can open the file *cpca.apr* on disc 2 (the data disc). The data disc also contains the entire data library (see Data Library section below) and the StratiFact database files (see Kirschbaum, chap. A, this CD-ROM).

Unix users with ArcView 3.1 can open the ArcView project (*cpca.apr*), but, because of the inherent differences of the Windows and Unix operating systems, there may be functionality issues with portions of the project that execute separate Windows programs (i.e., links to PDF files via Acrobat Reader; Adobe Systems, Inc. 1997). Because there is no ability in ArcView 3.1 to save projects in Macintosh-compatible format (ArcView 2.1), we are unable to provide a Macintosh version of the ArcView project. However, users with ArcView 2.1 for the Macintosh can access the shapefiles and (or) coverages and TIFF image files (see discussion on Data Formats below) included in this publication to create their own custom ArcView projects.

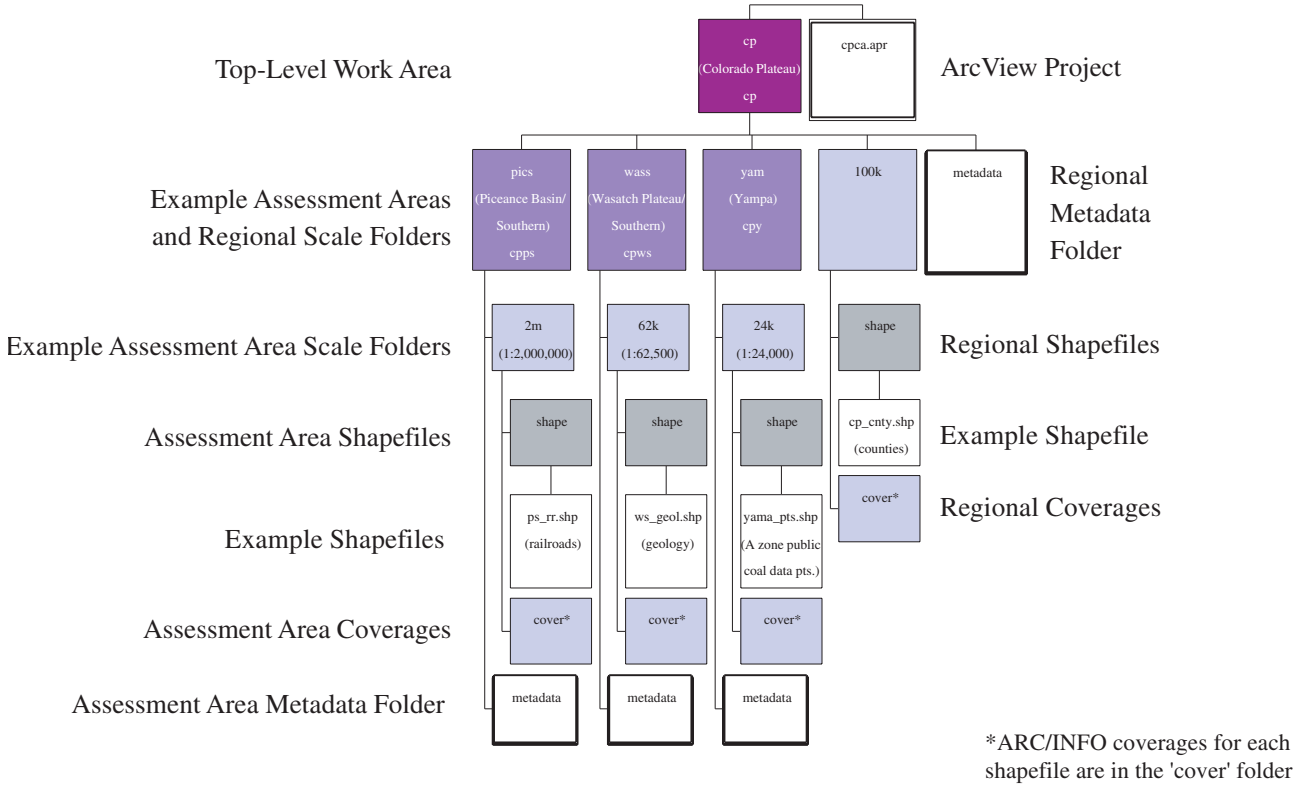


Figure 8. The Colorado Plateau GIS data-library structure.

The ArcView project, *cpca.apr*, has been designed to access data files from the adjacent *cp* folder. The directory structure is the key or pathway for ArcView. To locate and display themes, the ArcView project stores the source data paths. As long as the ArcView project is stored adjacent to the directory (*cp*), within which all the data files are stored, the ArcView project will open successfully (fig. 8). Moving the ArcView project relative to the data will require editing to adjust paths stored within the project file or development of system-specific environment variables for ArcView in the system properties.

Data Library

How to Find Files

The data files contained in the Colorado Plateau Coal Assessment GIS database are stored in a structured data library on CD-ROM disc 2. As shown in figure 8, the data library is organized into a hierarchical structure with the top-level directory designated as *cp* for the Colorado Plateau. Regional files covering the entire Colorado Plateau are stored in subfolders directly below *cp*. The *cp* folder is also subdivided into work areas that define the assessment areas for which ArcView project views were created. Subfolders beneath the assessment-area folders contain data specific to those areas. Scale folders define capture resolution of data. Beneath each scale folder, the data are grouped in subfolders by data format (shapefiles, coverages, etc.). The metadata folder contains documentation files for each data layer in that particular work area.

Data Formats

The vector data provided on this CD-ROM are in three formats:

1. ArcView shapefiles (.shp)
2. ARC/INFO coverages
3. ARC/INFO EXPORT files (.e00)

Shapefiles are digital representations of a theme or map. Shapefiles are the native, **non-proprietary** data format developed from ArcView desktop GIS. They consist of three to five files that have standard three-character suffixes (.shp, .dbf, .shx, .sbn, and .sbx).

Coverages also are digital representations of a theme or map. Coverages are a **proprietary** data format native to ARC/INFO professional GIS software. Coverages store feature parameters and attribute parameters in separate tables within a workspace.

The terms, shapefile and coverage, are often used interchangeably in this publication because they contain the same data and file names, but exist in different file formats (figs. 8–16). These files store map features and associated feature-attribute tables as a unit of one or more layers. Both shapefiles and coverages can be interactively added to views as feature data sources (themes) within the ArcView Project.

EXPORT files are a common interchange format developed by ESRI and are produced by exporting the associated Arc feature tables and Info attribute tables of a coverage.

The raster data has been converted to TIFF image files. CP_AVP accesses feature-based vector shapefiles and TIFF image files.

Data Structure

Figure 9 is a detailed representation of the Colorado Plateau data library showing the structure of the Colorado Plateau regional files with the assessment area subdirectories along the left side of the flow chart. Data-library flow charts provide a user's guide to the location and naming conventions of the feature- and image-data sources contained in the data library and the ArcView project; they also provide a brief description of each data set. The data library structure for each assessment area is shown in figures 10, 11, 12, 13, 14, 15, and 16. These data-library charts are linked for reference from each of the Colorado Plateau regional views within the ArcView project (activate 'Link to Data Library' theme in the view Table of Contents).

Within the work area subfolders are important individual components for spatial analysis and the ArcView project. Work areas provide an umbrella to store data in numerous formats. Scale and resolution of the data are important factors in arranging the hierarchy of a data repository. Multiple-scale data sources are necessary to adequately display national, regional, and site-specific products. The scale at which data were captured is important in analysis and interpretation; it gives an immediate identifier to the level of detail and alerts users to the appropriate maximum scale for relevant data use. It also provides a more useful means of storage than including the resolution of the data in the file name. To do the latter may pose a problem because the file names can become very long, making it difficult to adhere to the 8.3 file-naming convention (ISO 9660) required by some software programs. When known, shapefiles and coverages are grouped by scale. This publication provides spatial data sets in shapefiles (in the 'shape' folder), ARC/INFO workspaces (the 'cover' folder) and ARC/INFO EXPORT files (the 'e00' folder). ARC/INFO workspaces store both coverages (spatial locations) and associated attributes (INFO tables).

Migration through this hierarchical structure may at times seem cumbersome; however, this type of data grouping facilitates storage of information sourced from various scales and covering various extents in the study area. An alphabetical listing of all regional files can be found under one folder: the metadata subfolder of *cp*. Likewise, alphabetical listings of all files contained within an assessment area are found in the metadata subfolder directly below that assessment-area folder. The metadata documents contain the same or very similar file names as the data they describe, but with the '.met' extension (see Metadata section below). Some metadata documents apply to more than one closely related data file (see Metadata section). Within each metadata document (on lines 11 to 13), the region or assessment-area scale folder is listed in Other_Citation_Details. This is the folder where the source file(s) reside(s).

By providing the data in several formats, the GIS data library can be accessed directly from the CD-ROM (disc 2) with software packages that read shapefiles, ARC/INFO coverages, ARC/INFO EXPORT files, etc. To accommodate users who choose to improve AVDP performance by downloading the data and the program files to their hard drive, the *cp* folder and the AVDP project (*cpca.apr*) have been copied to the *data* folder on disc 1 where only the files used by CP_AVP (about 200 MB) reside (coverages and EXPORT files have been deleted). The data are provided in geographic decimal degrees. Views, rather than the actual data, are projected to a preferred regional or local projection. Other components stored below work-area folders include images, metadata documents, text files, and flow charts.

To help increase efficiency and avoid typing long path names on Unix systems, shortcuts have been developed that expedite moving through the directory structure within ARC/INFO and at Unix system level (Biewick and others, 1997). The use of these shortcuts and the ARC/INFO startup file are discussed below in the section on ARC/INFO and Unix Platform Considerations.

The file names are significant, descriptive, and designed to be intuitive. They give basic thematic information. The naming conventions used for the geologic assessment of coal in the Colorado Plateau are shown in table 3. Detailed documentation is included in the formal metadata for each shapefile and coverage.

Table 3. GIS file-naming conventions used.

[Coverages and shapefiles common to many study areas have an up-to-three-letter area-defining prefix, e.g.: kai_dip.shp (dip in the Kaiparowits Plateau). Coverages and shapefiles unique to a study area do not necessarily have the area-defining prefix, e.g.: csb_bnd.shp (Calico Sequence Boundary). Text between the prefix and the suffix is theme descriptive. File names can be no longer than 8 characters in order to adhere to the 8.3 file-naming conventions (ISO 9660)]

DATASET NAME PREFIX	(prefix description)
cp	Colorado Plateau
csb	Calico sequence boundary
dan	Danforth Hills
des	Deserado
kai	Kaiparowits Plateau
kjh	Cret. John Henry Fm.
lwr	Lower White River
pic	Piceance Basin
ps	Piceance Basin/Southern
sjb	San Juan Basin
ws	Wasatch Plateau/Southern
yam	Yampa

THEME DESCRIPTIVE TEXT (tdt)	(tdt description) i.e., assessment zone
a	A zone
b	B zone
bh	Huerfanito bentonite
bkd	base Cret. Dakota Fm.
bkw	Base Cret. Wahweap Fm.
c	C zone
cb	Crested Butte
cr	Coal Ridge
cw	Cameo/Wheeler
d	D zone
e	E zone
f	F zone
g	G zone
kdt	Cret. Drip Tank Member
mv	Mesaverde
sc	South Canyon
1	<1 ft thk
12	1-2.3 ft thk or 1-2.4 ft thk
14	>14 ft thk
20	>20 ft thk
23	2.3-3.5 ft thk or 2.5-3.4 ft thk
24	24K
37	3.5-7 ft thk or 3.5-7.4 ft thk
42	14.1-20 ft thk
74	7-14 ft thk or 7.5-14 ft thk
100	100K
nt	no coal thickness values
t	total coal

DATASET NAME SUFFIX	(suffix description)
adit	mine adits
bnd	boundary
cbi	coal-bearing interval
cf	coal fields
chm	geochemistry
city	cities
cline	anticlines and/or synclines
cnty	counties
dip	dip
dl	data library
fin	final unioned coverage
flt	faults
geol	geology
glf	landforms (grayscale)
hyd	rivers/hydrology
intr	intrusions
l	line shapefile
leas	leases
lf	landforms (color)
lmu	logical mining unit
lown	land ownership
mn, min or mine	mines
mph	mine production history
own	ownership (land and mineral)
play	oil and gas plays
pp	power plants
prov	oil and gas provinces
pts	data pts
qd	quadrangles
rd	roads
rr	railroads
st	State boundaries
stdy	study area
strc	structure
sum	summary map
th or thk	coal thickness (for isopach lines)
tr	townships
wtr	water bodies

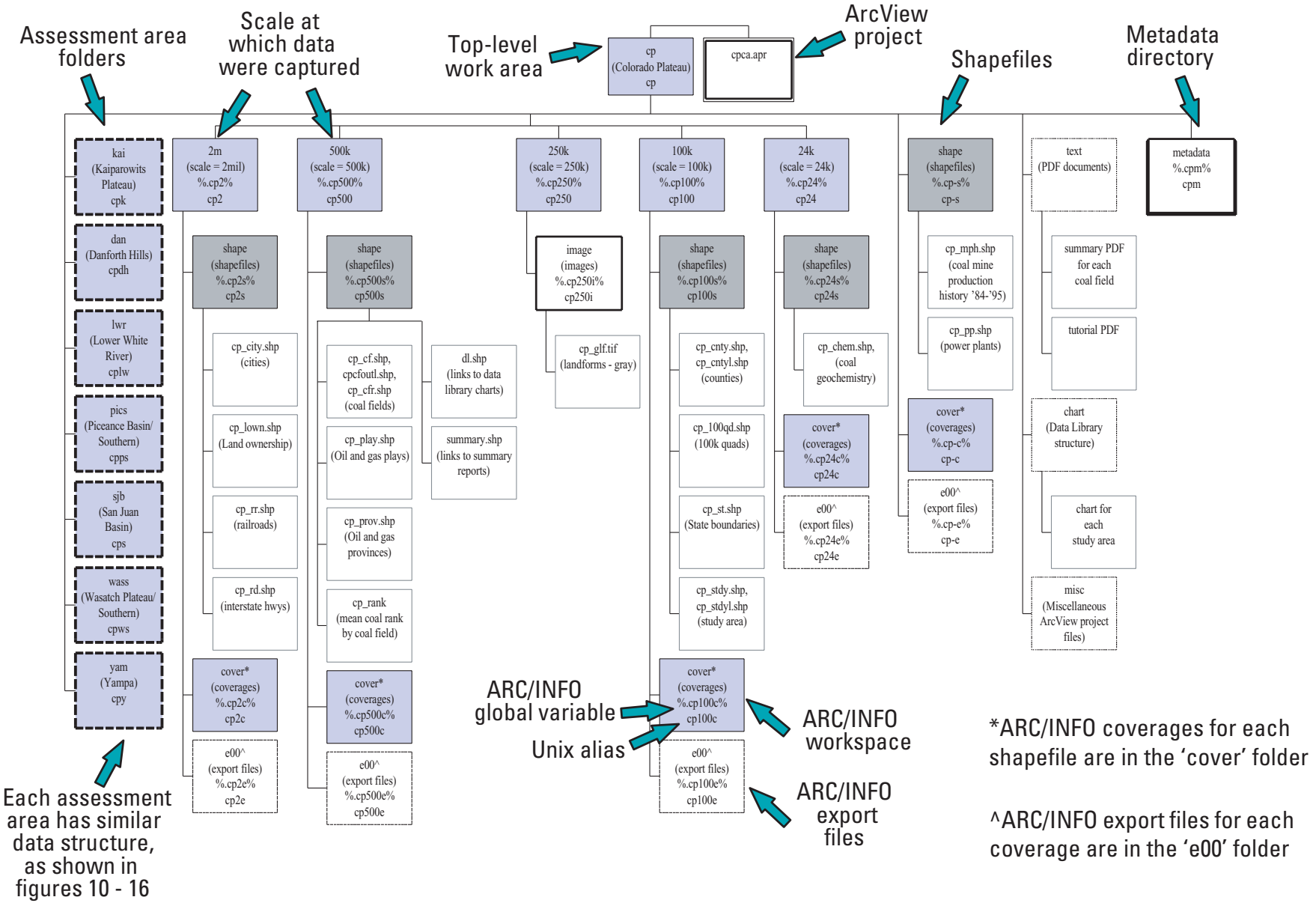


Figure 9. Data library—Colorado Plateau regional files.

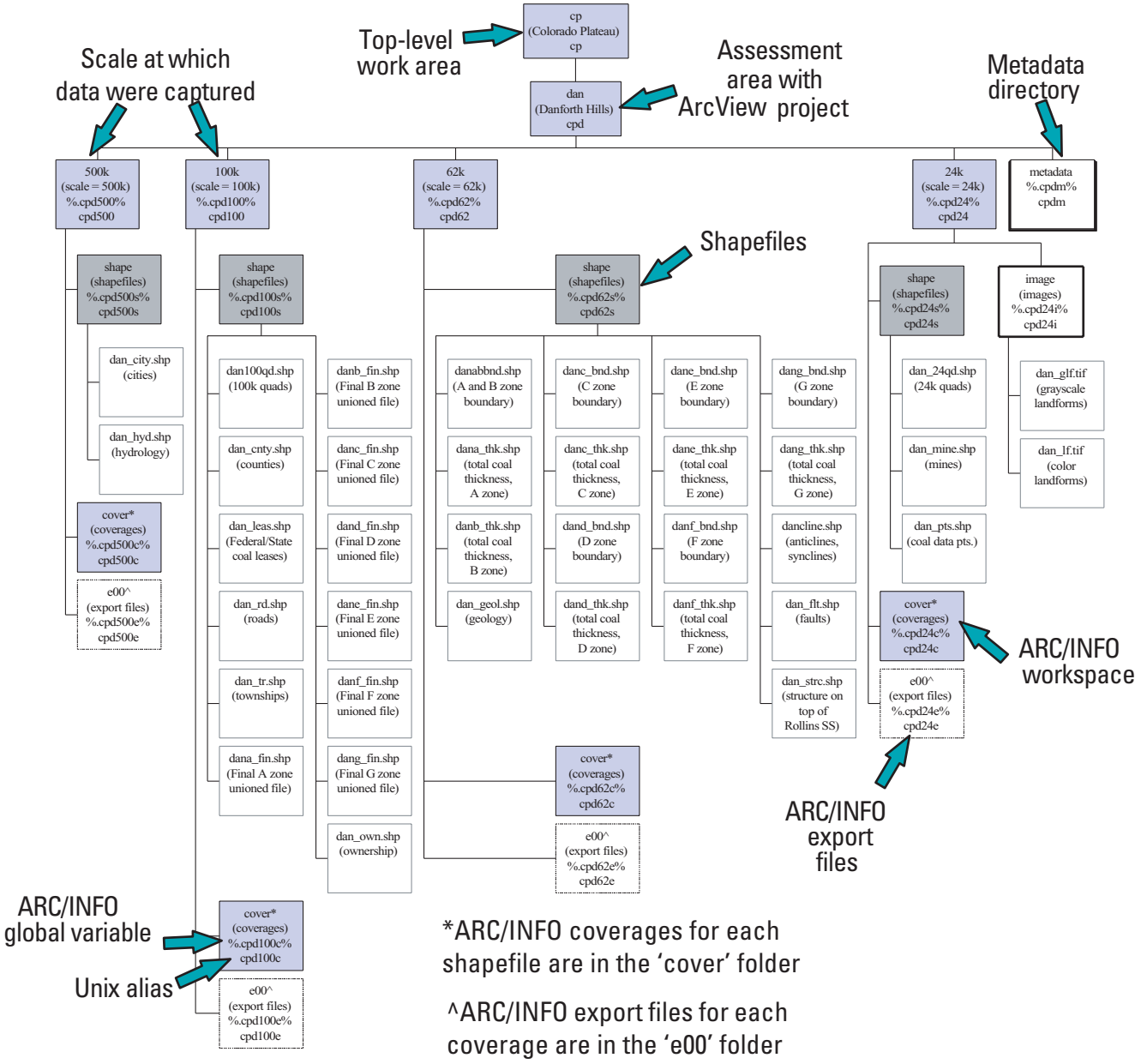


Figure 10. Data library—Danforth Hills assessment area.

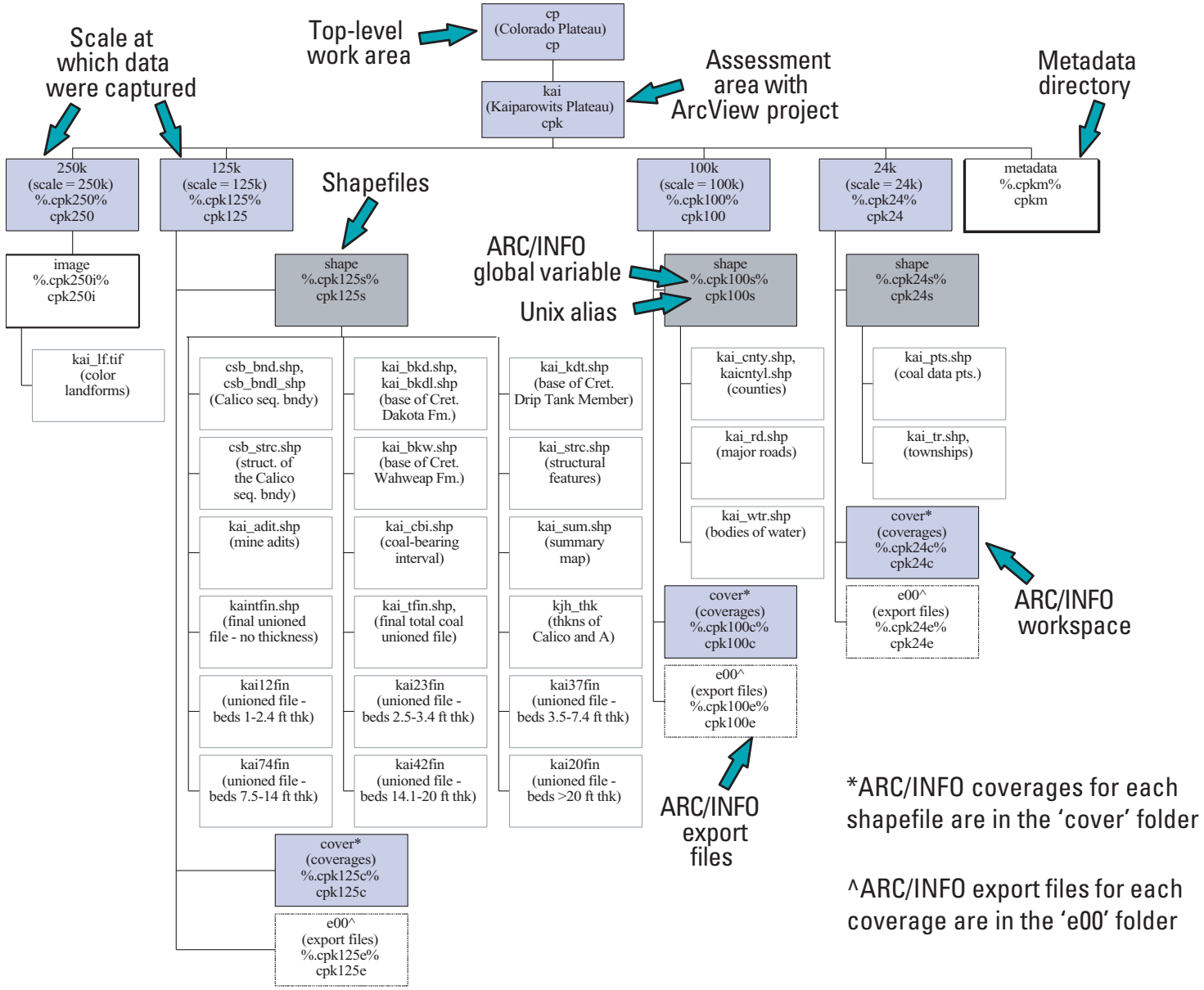


Figure 11. Data library—Kaiparowits Plateau assessment area.

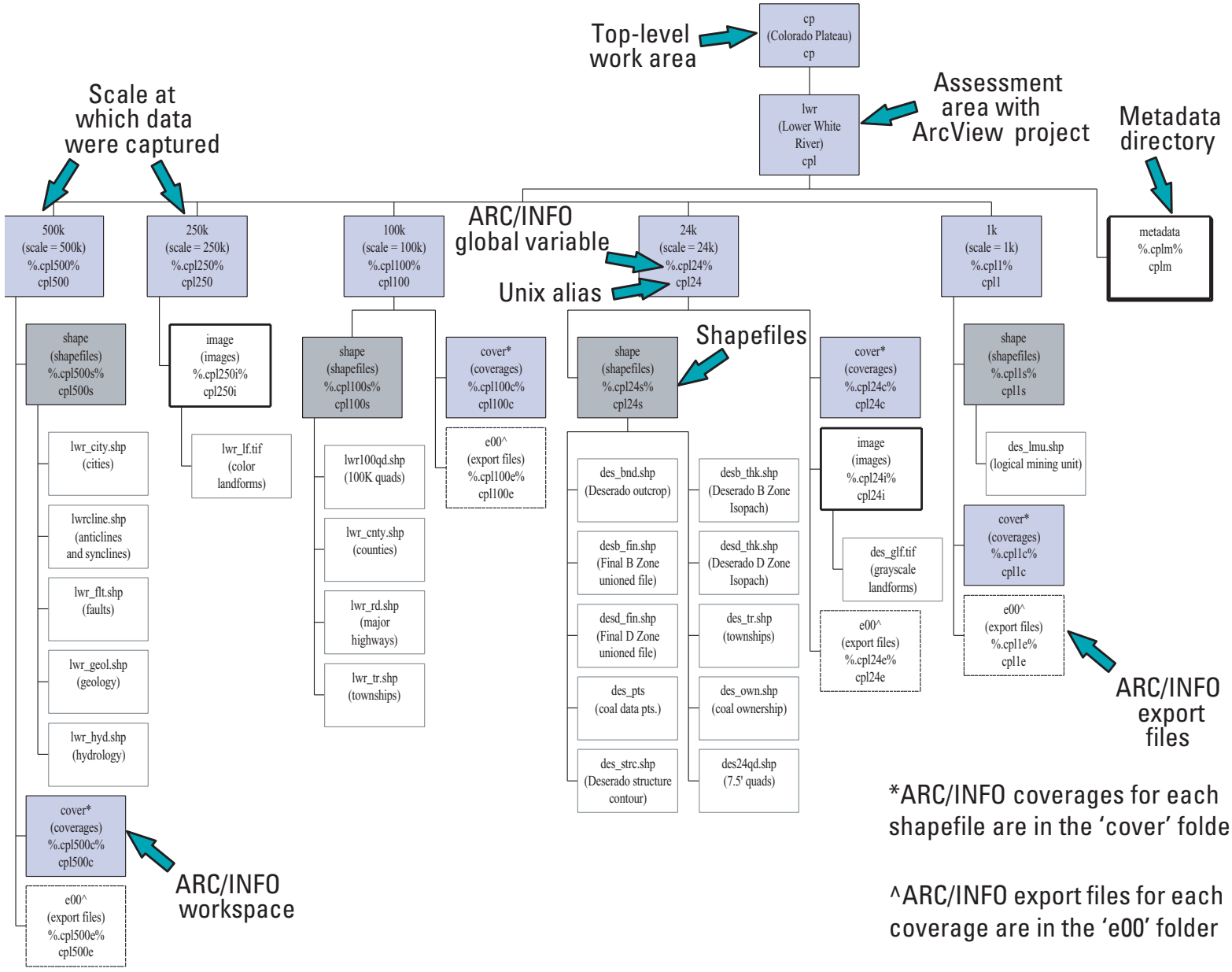


Figure 12. Data library—Lower White River assessment area.

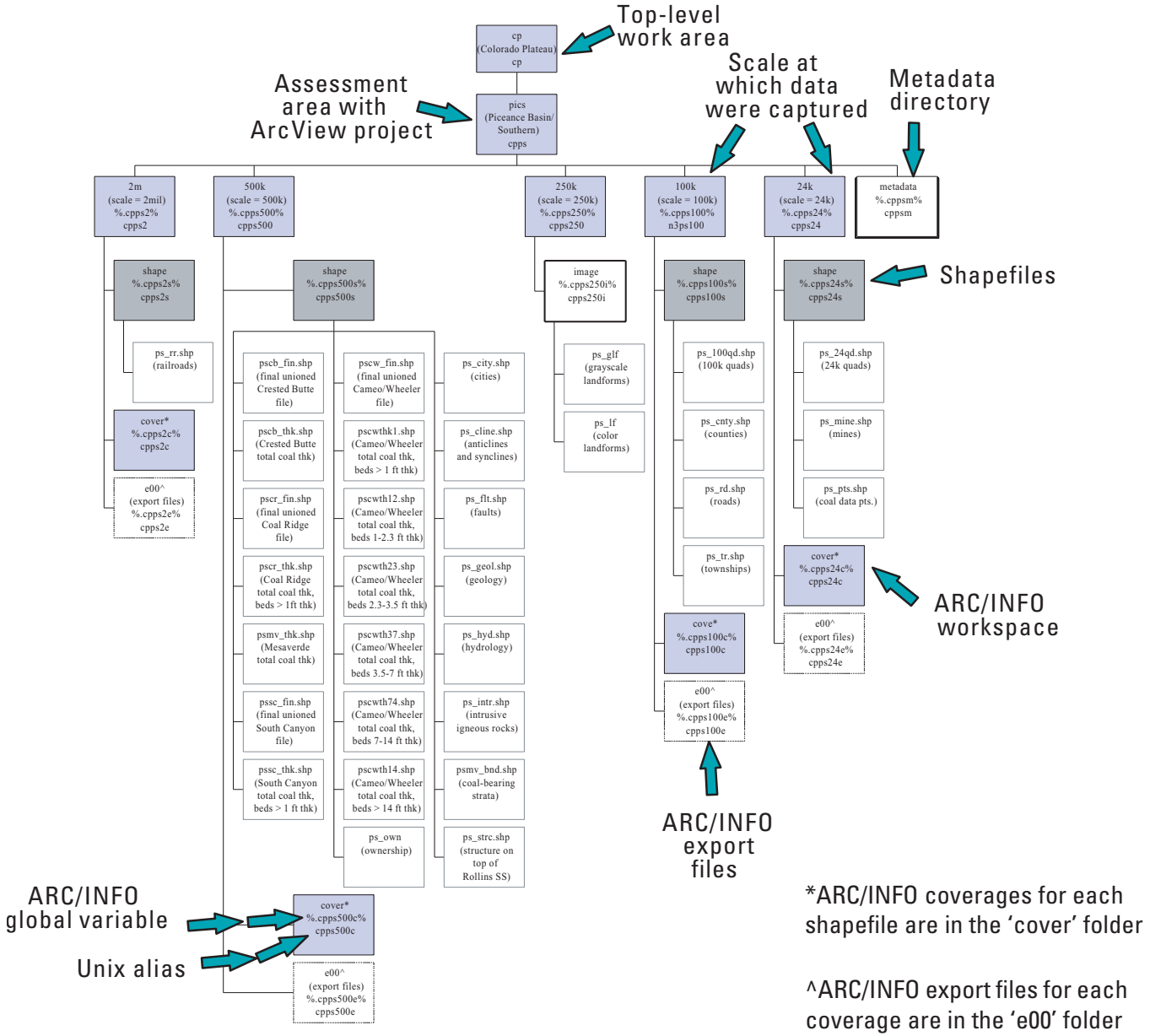


Figure 13. Data library—Southern Piceance Basin assessment area.

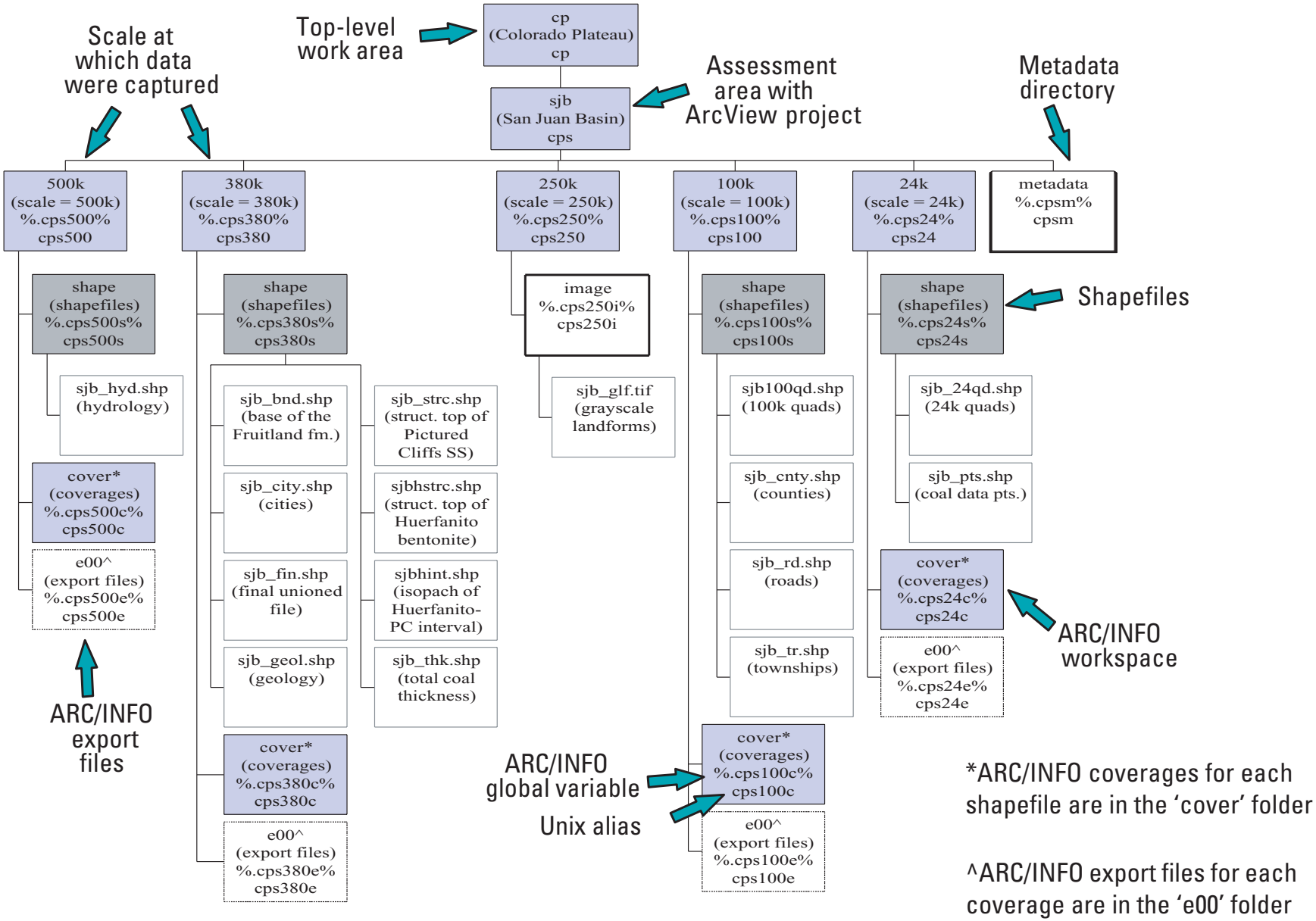


Figure 14. Data library—San Juan Basin assessment area.

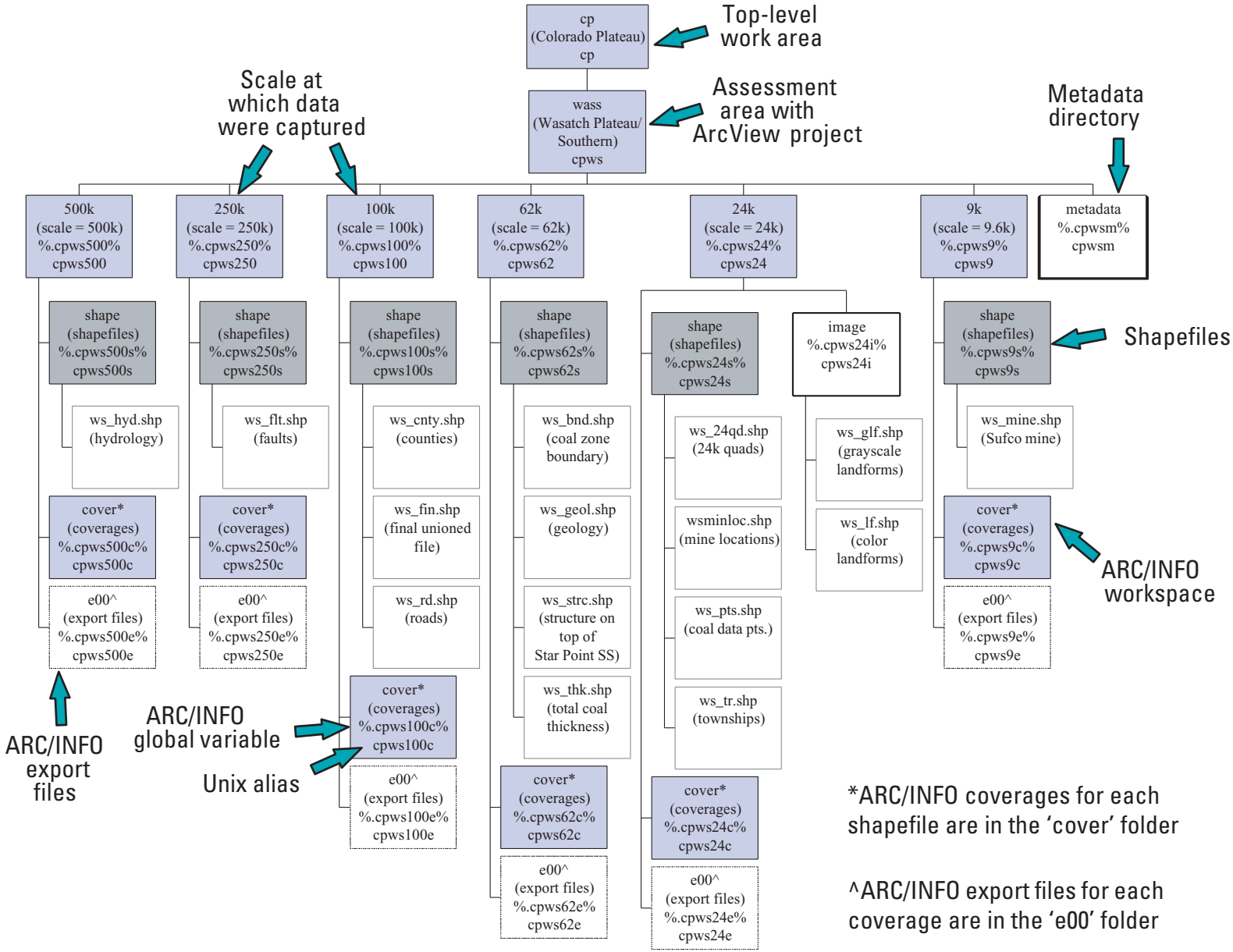


Figure 15. Data library—Southern Wasatch Plateau assessment area.

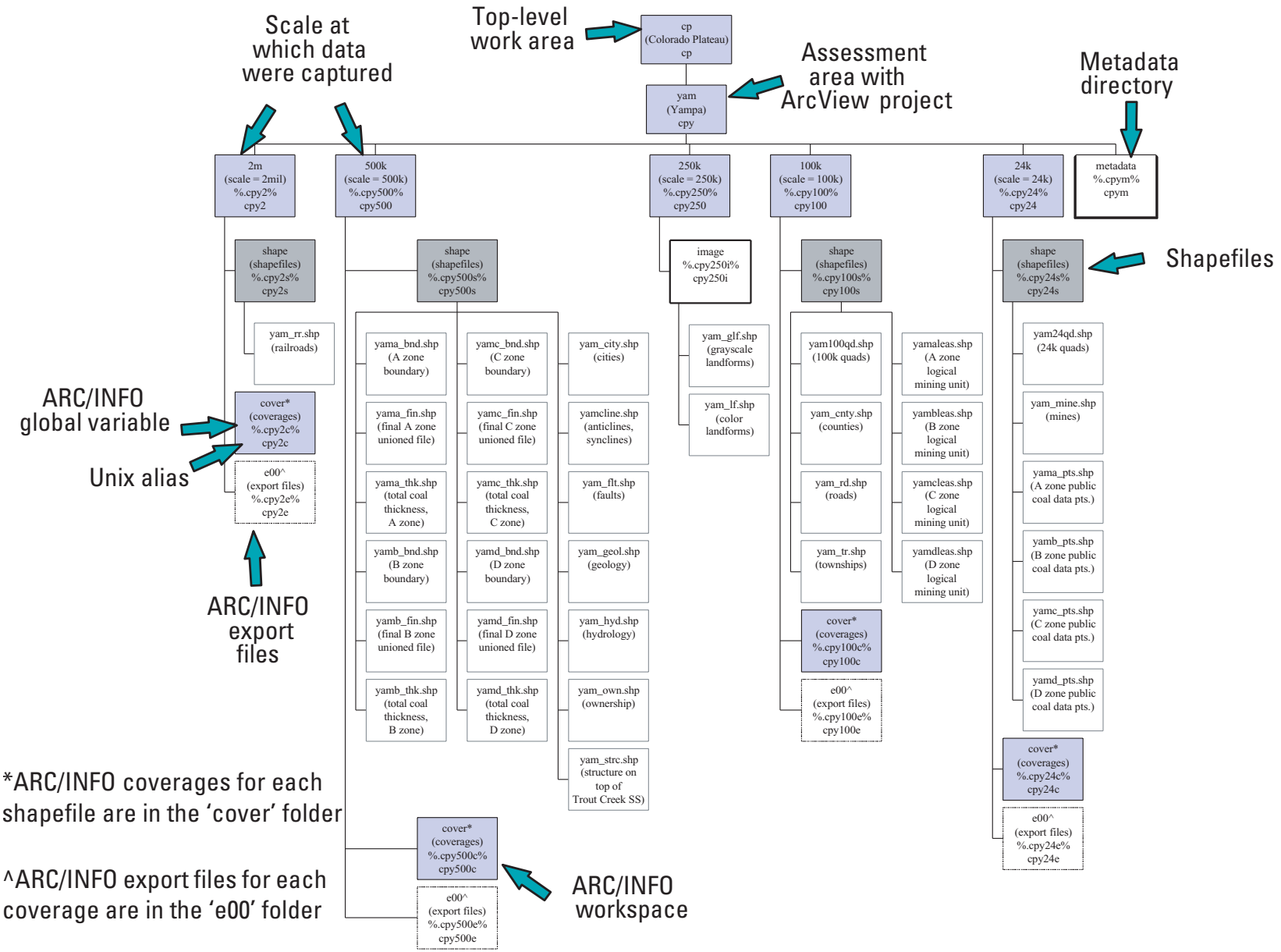


Figure 16. Data library—Yampa assessment area.

Metadata

A critical aspect of providing data files is the documentation of those digital layers or themes in readme-type files. The documentation files provided in this publication are called metadata (information about data). At the most fundamental level, metadata are intended to answer some general data questions:

- What does the data set describe?
- Who produced the data set?
- Why was the data set created?
- When was the data set created?
- How was the data set created?
- How reliable are the data; what problems remain in the data set?
- How can someone get a copy of the data set?
  (Modified from Schweitzer, P.N., 1998, Putting Metadata in Plain Language: U.S. Geological Survey [accessed 3/5/99 on the World Wide Web at URL <http://www.geoplace.com/gw/1998/0998/998abc.asp>].)

Metadata are formatted using a standard that has been developed so that data can be found on the World Wide Web. "One of the main benefits of creating consistent metadata is that they can be made available through the National Geospatial Data Clearinghouse (NGDC). The clearinghouse is a distributed array of metadata sources, each retaining local control of its operations, but responding to user queries from a few World Wide Web gateways. The chief advantage for users is that they don't have to learn a hundred different search interfaces created separately by a hundred different Federal and State agencies and private-sector organizations. Instead, a search request can be directed to several different data providers at once." (Schweitzer, P.N., 1998, Putting Metadata in Plain Language: U.S. Geological Survey [accessed 3/5/99 on the World Wide Web at URL <http://www.geoplace.com/gw/1998/0998/998abc.asp>])

As a result of the 1994 Executive Order 12906 (see Appendix), metadata documentation is required for all post-1994 digital spatial information generated by U.S. Government agencies. Documentation augments utility, educates people about the data, assists them in determining its usefulness, and helps track content and data quality. Metadata is being organized by the Federal Geographic Data Committee (FGDC) into a national clearinghouse of digital information, the National Spatial Data Infrastructure (NSDI). NSDI serves as a metadata repository, provides pointers to accessible digital information, reduces digital compilation effort within the Federal Government and public sector, and provides a forum for exchange of data and ideas.

For each of the GIS layers (shapefiles, coverages, images) included in the Colorado Plateau data library, FGDC-compliant metadata have been compiled using several tools including: (1) tools developed by the USGS (xtme, cns, mp, and document.aml); (2) ArcView 3.0 Metadata Collector Extension; (4) corpsmet95; and (5) the Unix text editor. The metadata are stored in an ASCII text file. Each metadata document contains the same name as the shapefile (or coverage) with the .met extension added. Some metadata documents apply to more than one file. For example, in several of the assessment areas where more than one coal zone was assessed, the same procedures where used to create each of the total-coal thickness files (*_thk*), the coal-zone boundary files (*_bnd*), and the final unioned coverages (*_fin*). Therefore, only one metadata document is needed to describe *dana_fin, danb_fin, danc_fin,* etc., and that metadata file name is *dan_fin.met*. Another example of one metadata document describing more than one file is *ps_thk.met*; it describes the processes used to create the total-coal thickness files for several net-coal thickness categories in several coal zones. The metadata for each shapefile is stored in the 'metadata' folder that resides one level below the region or assessment-area directory. For example, each shapefile in the Kaiparowits Plateau has a metadata document stored in *cp/kai/metadata* (fig. 11); likewise, each shapefile in the southern Wasatch Plateau has a metadata document stored in *cp/wass/metadata* (fig. 15). The metadata folder lists all the files contained within a work area. For more information on metadata visit http://geology.usgs.gov/tools/metadata/. Information on Executive Order 12906 and the metadata tools that were used for the geologic assessment of coal in the Colorado Plateau are provided in the Appendix.

ARC/INFO and Unix Platform Considerations

As stated earlier, the Colorado Plateau GIS data library can be accessed directly from the CD-ROM with software packages that read shapefiles, ARC/INFO coverages and (or) ARC/INFO EXPORT files. To help increase efficiency and avoid typing long path names on Unix and Windows NT systems, shortcuts have been developed that expedite moving through the hierarchy of the data library structure within ARC/INFO and at Unix system level (Biewick and others, 1997).

ARC/INFO: Global Variables

In ARC/INFO, shortcuts are in the form of global variables. The global variables eliminate a lot of typing, and allow a user to process coverages in workspaces other than the current workspace. The global variables are listed on the data library flow charts (figs. 9–16) and are used in ARC/INFO as follows: rather than type the entire directory path, use the global variable to move to the desired workspace. For example, to move to the workspace cp/lwr/100k/cover/, at the Arc prompt, type: w %.cpl100c%

Global variables in ARC/INFO must start with a period, such as .cpl100c. The reference to the variable is accomplished by enclosing in percent (%) signs. To describe the coverage cp_cf (Colorado Plateau coal fields) from a workspace other than the one in which it resides, at the Arc prompt, type: describe %.cp500c%cp_cf

An Arcedit example is as follows: displaying the Colorado Plateau coal fields with the State and county lines in red can be accomplished by typing:

```
ec %.cp500c%cp_cf
bc %.cp100c%cp_cnty 2
```

The global variables are activated on a Unix machine by first performing a global edit on the paths in the file *stat_cp*, which is provided in the *cp* folder on disc 2. In that file, one can append to the */cp* path the drive letter of the user's CD-ROM drive (i.e., replace */cp* with *e:/cp*). If the data (*cp*) are downloaded to a server, add the entire path, including the name of the disk, to where the data library was copied. For instance, if the data (*cp*) are housed on a disk named *coal2* on a SUN server, change */cp/* to */coal2/cp/*. Next, copy *stat_cp* from the *cp* folder to *$ARCHOME/stations/stat_cp*, and put the *.arc* file (a startup file also included in the *cp* folder on disc 2) in your home directory. The *.arc* file contains a single command (*&station cp*) that activates the stations file (*stat_cp*) each time the ARC/INFO program is initialized.

Unix System Level: Aliases

Aliases are Unix-platform codes used to define long commands. The aliases work the same as the global variables except at the Unix-system level, rather than within ARC/INFO; they also expedite utilization of the directory structure. In order for the aliases to work, the user must edit the paths in the file *alias.txt*, which is also found in the *cp* folder on disc 2. The procedure is the same as that described for *stat_cp* (append to */cp/* the drive letter of the CD-ROM drive, or the name of the disk, to where the data library was copied). The following statement must be added to the *.cshrc* file in your home directory:

```
source alias.txt
```

In this case, the *alias.txt* file would also reside in your home directory; if not, include the path to *alias.txt* in the command, i.e., *source /coal2/alias.txt*. The aliases are activated each time you log onto the Unix system or by typing from your home directory: *source .cshrc*

Examples for using Unix-system aliases are as follows:

To use an alias to move to the directory that contains the metadata for all of the coverages within the Danforth Hills assessment area (*cp/dan* directory), at the system prompt type: cpdm, which stands for *cp/dan/metadata*.

To list the files in cp/dan/100k/shape/, type: cpd100s to move to that directory, and then type: *ls –al*

Acknowledgments

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Schweitzer, P.N., 1998, Putting Metadata in Plain Language, GIS World [accessed 3/5/99 on the World Wide Web at URL http://www.geoplace.com/gw/1998/0998/998abc.asp].

URL's:

http://andes.esri.com/arcscripts/scripts.cfm

http://badger.state.wi.us/agencies/wlib/sco/metatool/cns.htm

http://badger.state.wi.us/agencies/wlib/sco/metatool/cormet95.htm

http://badger.state.wi.us/agencies/wlib/sco/metatool/document.htm

http://badger.state.wi.us/agencies/wlib/sco/metatool/mp.htm

http://badger.state.wi.us/agencies/wlib/sco/metatool/mtools.htm

http://badger.state.wi.us/agencies/wlib/sco/metatool/xtme.htm

http://corpsgeo1.usace.army.mil/

http://edcwww.cr.usgs.gov/webglis

http://geology.usgs.gov/tools/metadata/

http://www.geoplace.com/gw/1998/0998/998abc.asp

http://www.csc.noaa.gov/metadata/text/download.html

Glossary

attribute 1. A characteristic of a geographic feature described by numbers or characters, typically stored in tabular format, and linked to the feature by a user-assigned identifier (that is, the attributes of a well, represented by a point, might include depth, location, and gallons-per-minute).
2. A numeric, text, or image data field in a relational database table that describes a spatial feature such as a point, line, node, area, or cell (ESRI, 1994).

coverage A digital version of a map forming the basic unit of vector data storage in ARC/INFO. A coverage stores map features as primary features (such as arcs, nodes, polygons, and label points) and secondary features (such as tics, map extent, links, and annotation). Associated feature-attribute tables describe and store attributes of the map features (ESRI, 1994).

overburden The amount of rock that overlies a specified coal bed.

pixel A contraction of the words *picture element*. The smallest unit of information in an image or raster map. Referred to as a cell in an image or grid (ESRI, 1994).

project In ArcView, a file that uses five types of documents to organize information: views, tables, charts, layouts, and scripts.

raster A cellular data structure composed of rows and columns. Groups of cells represent features. The value of each cell represents the value of the feature. Image data is stored using this structure (ESRI, 1994).

shapefile ArcView's format for storing the location, shape, and attribute information of geographic features.

theme A set of related geographic features, such as streets, cities, or townships, and the attributes (characteristics) of those features.

vector A coordinate-based data structure commonly used to represent point, linear, and polygon map features. Each linear feature is represented as a list of ordered *x, y* coordinates. Attributes are associated with the feature (as opposed to a raster data structure, which associates attributes with a grid cell). (ESRI, 1994).

view A component of an ArcView project used for displaying, querying, and analyzing geographic themes (ESRI, 1996).

Appendix

Executive Order 12906

Executive Order 12906, "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure," was signed on April 11, 1994, by President William Clinton. Section 3, Development of a National Geospatial Data Clearinghouse, paragraph (b) states: "Standardized Documentation of Data. Beginning 9 months from the date of this order, each agency shall document all new geospatial data it collects or produces, either directly or indirectly, using the standard under development by the FGDC, and make that standardized documentation electronically accessible to the Clearinghouse network. Within 1 year of the date of this order, agencies shall adopt a schedule, developed in consultation with the FGDC, for documenting, to the extent practicable, geospatial data previously collected or produced, either directly or indirectly, and making that data documentation electronically accessible to the Clearinghouse network." This standard is the data documentation standard referenced in the Executive Order (Federal Geographic Data Committee, 1994).

Metadata Tools

Following is a brief description of the metadata tools that were used in this study. For more information on metadata tools visit http://badger.state.wi.us/agencies/wlib/sco/metatool/mtools.htm. This web page leads to summaries of most of the known metadata tools used for documenting geospatial data. It includes tools for entering and editing metadata and utilities for preprocessing, postprocessing, and validating metadata. Some ESRI metadata tools were accessible February 22, 1999, from http://andes.esri.com/arcscripts/scripts.cfm by searching for the keyword 'metadata.'

xtme, cns (Chew and Spit), and mp

[available February 22, 1999, on the World Wide Web at URL http://geology.usgs.gov/tools/metadata/]

xtme is a metadata entry tool that operates in the X-Windows environment. The user interface consists of a three-paned window (fig. 17). The upper window shows the hierarchically arranged metadata element tree of the current metadata file and has a pull-down menu bar for file, editing, and help operations. The middle window is used for entry and editing of metadata text, which may follow the currently selected (in the upper window) metadata element. The bottom one-line window is used to display the precedence (mandatory, optional, repeatable, etc.) of elements available on the Add menu and a short description of the function of the picks available on other menus. (Principal contact is Peter N. Schweitzer, U.S. Geological Survey, accessed February 22, 1999 on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/xtme.htm.)

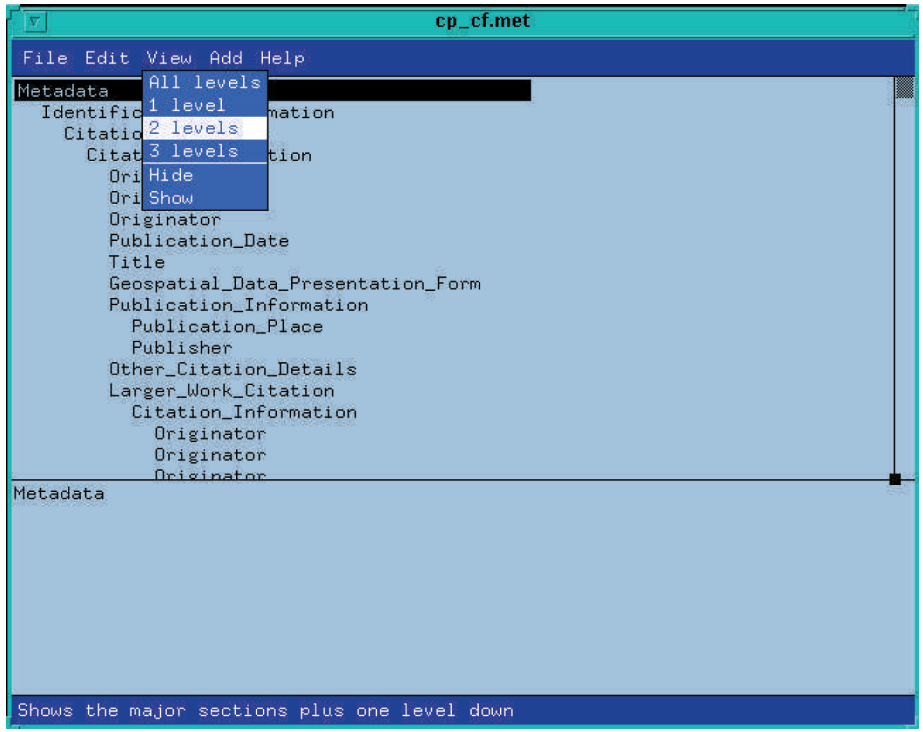


Figure 17. An example of the xtme graphical user interface (GUI).

The `depth' of the tree view can be selected. Entire sections of the metadata tree can be cut and pasted within xtme and brought in from other `X' windows, including another xtme session. Xtme is smart enough to only allow a tree to be pasted in where it is allowed. It is possible to blank all the text entered into a selected part of the metadata tree without losing the element tree itself. A 'prune' function, which removes empty elements (empty data entry elements or compound elements with empty children) below the currently selected element (in the editor), has recently been added. This may be unleashed at the highest (Metadata) element to clean up a document produced by other metadata tools that pass empty elements on through to the output report. (Principal contact is Peter N. Schweitzer, U.S. Geological Survey, accessed February 22, 1999 on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/xtme.htm.)

cns is a metadata preprocessor that processes metadata with varying degrees of conformance to the 1998 Content Standards for Digital Geospatial Metadata (CSDGM) into an output that is more compatible with mp. This is especially useful for Clearinghouses that may collect metadata from source agencies producing metadata differing in format because of the metadata tool or template employed at each agency, or because the agency metadata profile differs from the CSDGM. Cns gets confused by lines in text elements that begin with a string that is the same as an element name. Because it is designed to recognize such strings amid noise, it naturally jumps on them when they are found easily. This is a well documented 'feature,' and the author of the tool is looking for a good way to turn it off. (Principal contact is Peter N. Schweitzer, U.S. Geological Survey, accessed February 22, 1999 on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/cns.htm.) Cns provides syntax to store any text elements that the program extracts as noise into the 'leftovers' file (fig. 18).

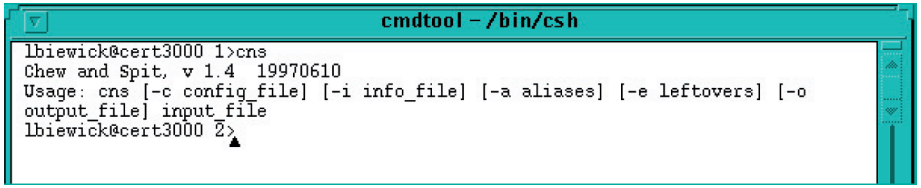


Figure 18. Metadata preprocessor—cns (Chew and Spit) syntax.

mp is a utility that checks hierarchically indented text metadata (or SGML metadata, if it is 'perfect') against the CSDGM. The error report flags deviations from the production rules for the CSDGM and element values not allowed in the domain of each element. In addition to producing a hierarchically indented (2-space indent) text output, it also produces an HTML output with a `table of contents,' an SGML output, and a DIF (Directory Interchange Format) output (fig. 19). If the metadata does satisfy the CSDGM, but does not use hierarchical indentation to indicate parent/child relationships in the metadata (e.g., numbers are used instead), mp will choke on it. However, that same metadata may be effectively preprocessed with cns, after which it may pass mp successfully. (Principal contact is Peter N. Schweitzer, U.S. Geological Survey, accessed February 22, 1999 on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/mp.htm.)

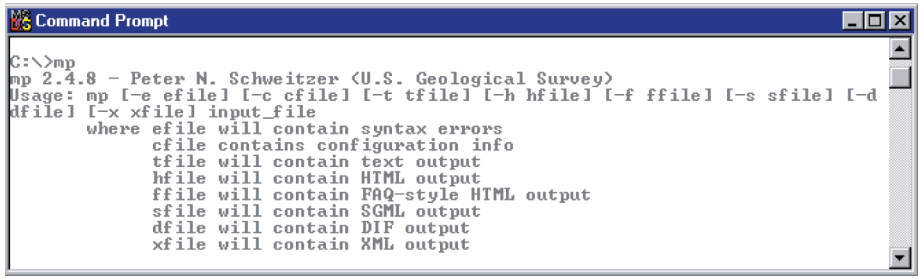


Figure 19. A compiler for formal metadata—mp syntax.

The operational characteristics (input/output) of mp are controlled through a configuration file. How to customize the configuration file is described in the tool's metadata and also (in somewhat more detail) through a web page devoted to the configuration file. Some notable items that can be controlled through the configuration file include: updating a metadata file produced under the June 8, 1994, CSDGM to the newer (1998) version of the CSDGM and production of Dublin Core elements in META tags in the HEAD of output HTML documents. A new option (-fixdoc) beginning with version 2.2.6 is specifically designed to ease conversion of metadata created with document.aml into a form suitable for further editing with tools such as xtme. (Principal contact is Peter N. Schweitzer, U.S. Geological Survey, accessed February 22, 1999 on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/mp.htm.)

Document.aml 7.0.4 Beta

The Document.aml (Arc Macro Language) tool is a metadata documentation utility to be used with Unix versions of ARC/INFO. It was originally developed by the USGS and the U.S. Environmental Protection Agency and was adopted by ESRI for incorporation into ARC/INFO version 7 (fig. 20). When Document is applied to an ARC/INFO coverage, it extracts some of the metadata information (e.g., Point and Vector Object Information, attributes) automatically, which cuts down the time and effort required to carry out the documentation. It has an online help feature. It was developed prior to the 1994 version of the Content Standards and reßected its heritage with input and output elements that do not correspond to the June 8, 1994, CSDGM. Additionally, the output reports produced by Document had irregular formatting, and a considerable amount of work still remained to bring it to a form that would pass Peter Schweitzer's metadata compiler (mp). This led to development of tools like Data Dictionary and BLMDOC.AML. A recent announcement from USGS explains improvements over these earlier versions of DOCUMENT.AML, which include a FILE option output that is close to 100 percent compliant to the CSDGM, modiÞcations to ensure that no metadata are lost in the HTML option output, and several other AML coding enhancements. An administrative feature of this tool allows contact and distribution information to be entered that will then be available to be attached to the metadata for any speciÞc data set (Principal contact is M. Negri, U.S. Geological Survey, accessed February 22, 1999 on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/document.htm.)

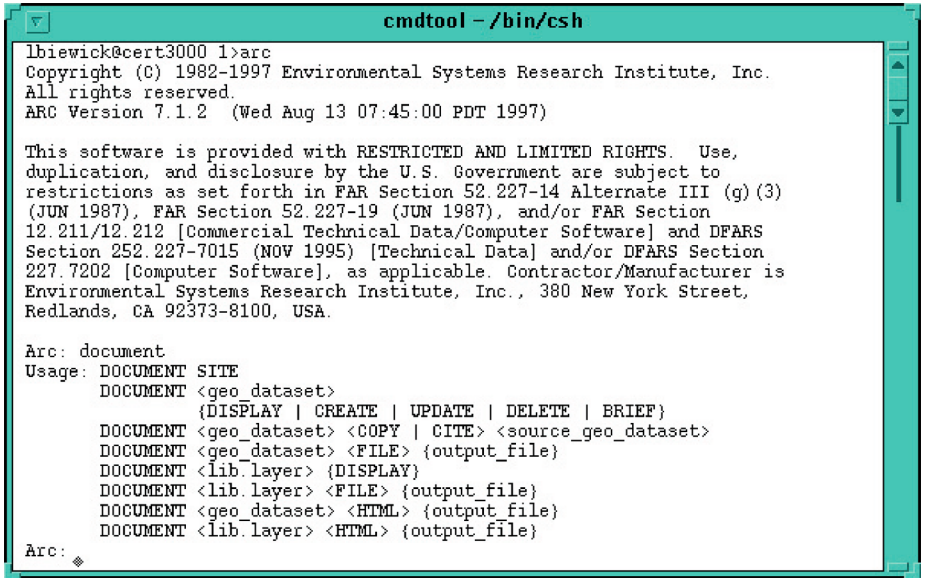


Figure 20. Metadata documentation utility—document.aml (Arc Macro Language) syntax.

ArcView 3.0 Metadata Collector Extension

[available February 22, 1999 on the World Wide Web at URL http://www.csc.noaa.gov/metadata/text/download.html]

The ArcView Metadata Collector was developed by contractors at the National Oceanic and Atmospheric Administration (NOAA), Coastal Services Center (CSC).

This is an easy-to-use software application that can be utilized by any ArcView user without having to fully understand the Federal Geographic Data Committee's (FGDC) "Content Standards for Digital Geospatial Metadata." The tool provides a dialog for creating FGDC-compliant metadata for any data type supported by ArcView including ARC/INFO coverages, ArcView shapefiles, as well as any supported image formats (fig. 21). The tool automatically extracts information (metadata), such as bounding coordinates, map projections, and attribute information. In addition, the tool stores information into .dbf files that can be edited, if needed, and reused for subsequent metadata records. The application generates output in both text and HTML formats. If you are creating metadata for an ARC/INFO coverage, you also have the option of generating an INFO file that will become part of that coverage. (accessed February 22, 1999 on the World Wide Web at URL http://www.csc.noaa.gov/metadata/text/download.html).

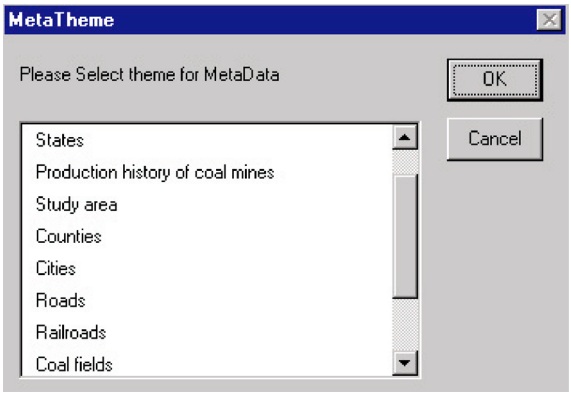


Figure 21. ArcView 3.0 metadata collector extension dialog.

Corpsmet95

[available February 22, 1999, on the World Wide Web at URL http://corpsgeo1.usace.army.mil]

Corpsmet95 is a CSDGM metadata creation tool developed under contract for the U.S. Army Corps of Engineers.

Like xtme, the interface to this tool provides multiple panes for the user. The left-hand pane displays a tree view of the metadata elements, and the right-hand pane is used for metadata entry (fig. 22). [available February 22, 1999, on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/cormet95.htm]

The depth of the metadata element tree displayed in the left-hand pane can be increased by mouse-clicking an element, similar to opening successively deeper folders in File Manager or Windows Explorer. A very nice feature of the tree view is the use of icons to indicate which elements are mandatory (a key), mandatory if applicable (a key with a superimposed question mark), optional (a question mark), one of a choice (radio buttons on the branch), and modifiers to these elements to indicate sections that are partially complete (an orange blob with exclamation point), or complete (a check mark). The degree-of-completion modifiers propagate correctly up the tree, so partially complete child elements are reflected as a partially complete parent as well. These modifiers only become visible when a subsection has been modified from its original blank state. Elements that can be repeated are sometimes indicated with a page symbol and a number following the element name; however, such elements are not indicated consistently. To add additional instances of these elements that may repeat, right-mouse-button-click on the element above the element indicated with a page symbol (e.g. Distribution_Information above Distribution_Information_1). This will cause a small pop-up menu with an 'Add' option to surface and that, on selection, would add something like Distribution_Information_2 to the metadata element tree. Right-mouse-button-clicking on repeatable elements of instance number 2 or higher will allow them to be removed. A triple dot modifier to the base symbols is used to indicate that the particular element can display deeper elements in the metadata tree (i.e., it is a compound element). When the lowest element in a branch of the tree does not have the triple dot modifier, it can be double-clicked to open that element in the right-hand window for metadata entry. [available February 22, 1999, on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/cormet95.htm]

The right-hand pane provides the means to enter metadata information by typing it into text boxes (or pasting in from other Windows applications), or by selecting from pick lists. This pane may be for the entry of a single element, or for several elements in which case the pane is 'tabbed' for each element. Additional 'tabs' may be added into the right-hand pane depending on the selection for a 'choice' element. Selecting the 'Apply' button in the right-hand pane saves changes to the section currently being edited. Selecting the 'OK' button saves the section and closes the metadata entry pane for the current element. [available February 22, 1999, on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/cormet95.htm]

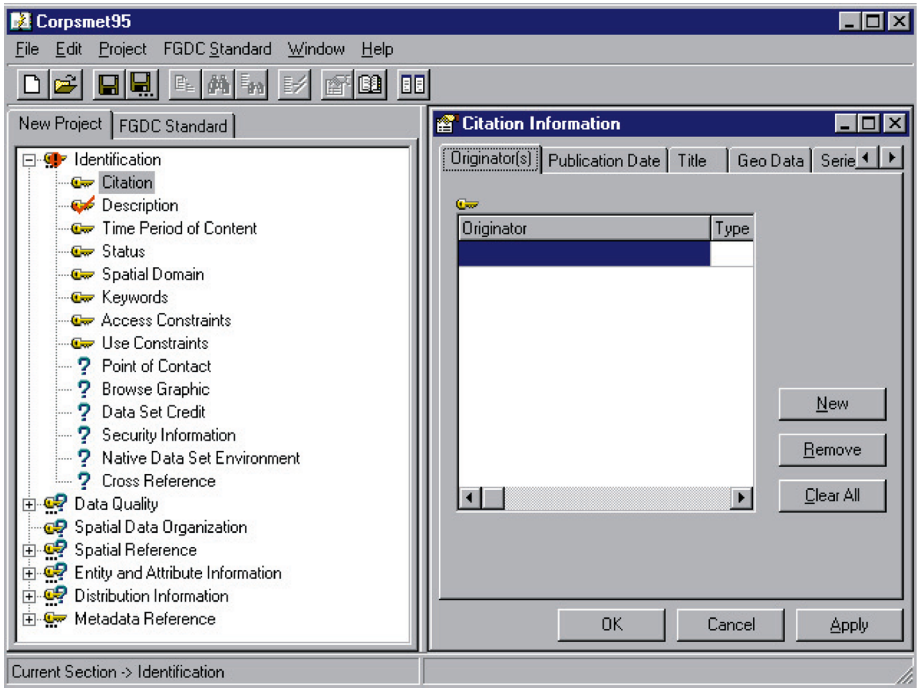
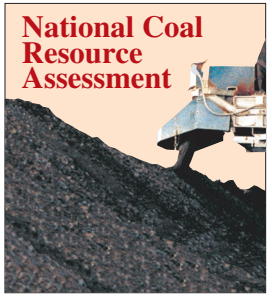


Figure 22. Corpsmet metadata creation tool.

When sections 1 and 7 (Identification Information and Metadata Reference Information) are complete (checked in the tree view), the user can 'Build a Metadata File,' that is, create an output file in ASCII form. This output metadata file breezes right through mp. Any sections that are only partially complete (according to the CSDGM production rules) are not transmitted to the output file. That last characteristic is good if you just want to output the squeaky clean parts of your metadata, but it is frustrating if you knowingly want to bend the rules a little. [available February 22, 1999, on the World Wide Web at URL http://badger.state.wi.us/agencies/wlib/sco/metatool/cormet95.htm]



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