



# ArcView Spatial Analyst

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# ArcView Spatial Analyst

## An ESRI White Paper

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# ArcView Spatial Analyst

**Introduction** ArcView® GIS software lets you see, explore, and analyze spatial data on your desktop computer. Its basic mapping functionality and advanced geographic information system (GIS) capabilities allow you to create maps that show, integrate, and view your data in powerful new ways.

ArcView GIS enables you to present your work attractively. You will discover that communicating geographically is a powerful way to inform and motivate others. Working geographically enables you to understand relationships between the forces that drive your business, so you can make better decisions and get the power you need to solve problems faster.

## ArcView GIS Extensions

ArcView GIS software's extensible design makes it easy to add new capabilities when you need them. These extensions are plug-ins to ArcView GIS that you can load and unload at any time as you work. In addition to the set of extensions that come with ArcView GIS, numerous optional extensions are available.

The following table shows the numerous extensions for ArcView GIS. There are also hundreds of ESRI Business Partner extensions available and the option to create your own extensions. Note that some extensions are not available for all platforms.

Optional Extensions	Extensions Bundled with ArcView GIS
<ul style="list-style-type: none"> <li>■ ArcView Spatial Analyst</li> <li>■ ArcView 3D Analyst™</li> <li>■ ArcView Image Analysis</li> <li>■ ArcView Tracking Analyst</li> <li>■ ArcView Business Analyst</li> <li>■ ArcView Network Analyst</li> <li>■ ArcView StreetMap™</li> <li>■ ArcView StreetMap 2000</li> <li>■ ArcPress™</li> </ul>	<ul style="list-style-type: none"> <li>■ CAD Reader</li> <li>■ Database Access</li> <li>■ Dialog Designer</li> <li>■ DIGEST (ASRP/USRP)</li> <li>■ Digitizer</li> <li>■ DXF Export</li> <li>■ GeoProcessing</li> <li>■ Graticules and Measured Grids</li> <li>■ Image Readers</li> <li>■ Legend Tool</li> <li>■ MGRS Coordinate Display</li> <li>■ Military Data Reader</li> <li>■ Projection Utility</li> <li>■ Report Writer</li> <li>■ RPF Indexer</li> <li>■ S-57 Data Converter</li> <li>■ SDTS Data Import</li> <li>■ VPF Viewer</li> </ul>

## ArcView Spatial Analyst

ArcView GIS gives you tools for visualizing, analyzing, and presenting your data. The optionally available ArcView Spatial Analyst extension to ArcView GIS provides additional analytic capabilities. These new capabilities can solve problems you encounter every day, helping you make more informed decisions, saving time and money.

To tap into this level of geographic analysis technology, users previously had to purchase high-end, professional GIS software. Now, you can integrate it into the already proven capabilities of ArcView GIS. With ArcView Spatial Analyst, you can perform powerful spatial modeling and complex analysis of geographic data from your desktop all within the intuitive, easy-to-use ArcView GIS graphic user interface.

The ArcView Spatial Analyst extension allows you to create, query, map, and analyze cell-based raster data and to perform integrated vector–raster analysis. The ArcView Spatial Analyst extension for Windows also includes ModelBuilder™ technology for building and sharing spatial models.

ArcView Spatial Analyst lets users

- Create and manage automated and self-documenting spatial models using ModelBuilder.
- Convert feature themes (point, line, or polygon) to grids.
- Create raster buffers based on distance from any raster or vector feature.
- Create density maps of point features.
- Create continuous surfaces from point features.
- Create slope, aspect, hill shade, and contour from surface maps.
- Perform Boolean queries and algebraic calculations on multiple grid themes simultaneously.
- Do neighborhood and zone analysis.
- Display and reclassify grid data.
- Import data from standard formats: TIFF, JPEG, BMP, SunRaster, USGS DEM, DTM, NIMA DTED, generic ASCII, MrSID, and others.
- Access a set of even more advanced raster analysis tools through Avenue™ software requests. Avenue is ArcView GIS software's object-oriented scripting language.

## Key Features

ArcView Spatial Analyst adds an entirely new dimension to desktop mapping and GIS analysis by making sophisticated spatial analysis and visualization tools easily accessible to a large audience through ArcView GIS. ArcView Spatial Analyst enables desktop GIS users to create, query, and analyze cell-based raster maps; derive new information from existing data; query information across multiple data layers; fully integrate cell-based raster data with traditional vector data sources; and create sophisticated spatial models using ModelBuilder.

## Brings Sophisticated Raster Data Analysis to the Desktop

Cell-based raster data sets, or grids, are especially suited to representing traditional geographic phenomena that vary continuously over space, such as elevation, slope, and precipitation, and can also be used to represent less traditional types of information such as population density, consumer behavior, and other demographic characteristics. Grids are also the ideal data representation for spatial modeling and analysis of flows and trends over data represented as continuous surfaces such as hydrologic modeling or the dynamics of population change over time.

The combination of these spatial analysis and visualization tools for raster-based data with ArcView GIS software's vector-based spatial operators brings unprecedented seamless analysis, modeling, visualization, and mapping capabilities to your organization in an affordable desktop package.

ArcView Spatial Analyst provides quick access to fundamental raster data creation and modeling capabilities such as surface generation (conversion of feature themes to grid

themes from your existing data sources), surface analysis (create buffers of distance from features, determine the proximity to a feature, derive density surfaces, and perform site suitability analysis), terrain modeling (slope, aspect, hill shade, watershed delineation, visibility), and contouring.

Integrating these tools directly into ArcView GIS software's graphic user interface means that users can quickly and easily leverage these key spatial operations with just a few mouse clicks.

Additional capabilities available through the standard user interface include queries on multiple grid themes, neighborhood and zone analysis, grid classification and display, summary histograms, and more.

## Integrate Your Data

ArcView Spatial Analyst integrates your data enabling interaction between data of all types. Images, elevation models, and other raster surfaces can be combined with all of ArcView GIS software's map data, expanding the power of your data.

ArcView Spatial Analyst lets you do integrated raster–vector theme analysis such as aggregating properties of a raster data theme based on an overlaid vector data theme. For instance, regional or national maps showing the mean or the maximum precipitation for states or counties could be created by overlaying state or county boundary lines on a raster precipitation map.

ArcView Spatial Analyst can create a raster data source from any point, line, or polygon feature source (including computer-aided design [CAD] data sources supported by ArcView GIS), or import data from standard formats including TIFF, JPEG, BMP, SunRaster, USGS DEM, DTM, NIMA DTED, generic ASCII, MrSID, and others.

## Visualize Your Data

ArcView Spatial Analyst is not just high-powered analysis and modeling; it allows you to visualize your data as never before. Combined with ArcView GIS software's powerful legend editor, you can classify your data to create stunning visual displays. ArcView Spatial Analyst allows you to create a hill shade grid that provides you with a shaded surface representation of your data. If you combine this shaded surface with other data, using the innovative Brightness Theme you can create stunning realistic images across surfaces.

The distribution of information and the pattern within this information is often very important. Histograms have long been used to evaluate data and patterns, and ArcView Spatial Analyst allows you to create histograms from your grids either from selected features or from interactively defined graphic shapes.

## Analyze and Solve Your Data Problems

Ranging from simple display and query to complex topographic modeling, ArcView Spatial Analyst has the functions to analyze and solve your problems.

A key component of ArcView Spatial Analyst is the ability to perform queries across grids, allowing you to ask questions that span multiple data types and levels of information (e.g., what areas are zoned for residential development and have a high water table on a steep slope >15 percent?). This gives you the ability to leverage existing data to make more informed decisions.

Your data may frequently be available for point locations, and you may need to interpolate a continuous grid through these points. ArcView Spatial Analyst includes a

robust set of spatial interpolation functions allowing you to generate results for areas of missing data (e.g., you can use your global positioning system [GPS] points to interpolate an elevation surface).

Sometimes you need aggregated information across a surface. ArcView Spatial Analyst provides the ability to generate a density grid across an area where the value of each cell is the result of a units-per-specified-area calculation. This could be population density per square mile or grasshopper infestations per square kilometer. Density grids can be used as weights for modeling, such as business models or pesticide models, to best make use of your limited resources.

Once you have either opened or generated a grid you can explore the data in a more conventional manner using the contour functionality. You can generate contours by interactively picking locations on the screen or by asking ArcView Spatial Analyst to generate a set of contours at a specified interval. Contours are useful in showing topographic relief across a surface. However, sometimes you need more detailed information about a grid such as the topographic attributes.

Topographic attributes are often very important to agriculture and natural resource applications. Many natural and human processes are dependent on functions of these variables such as slope, aspect, curvature, and stream flow.

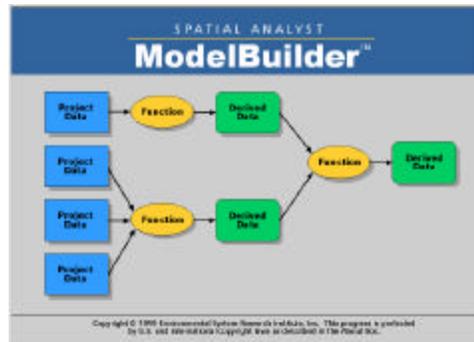
You can use both attributes and location to solve your problems with ArcView Spatial Analyst. One application of this concept is to use the distance and proximity functions to ask questions concerning how far something is and to generate allocated areas. You can also use the least-cost-path function to find the best path between two locations based on values from multiple grids.

Using ArcView Spatial Analyst you can use statistics to drive your models and generate your information. Statistics can be generated on the local level (e.g., mean rainfall at a given spot), for a given area (mean rainfall in the lodgepole forest), or on a neighborhood level (smooth anomalies by filtering the rainfall amount by replacing each value with the mean value within 5 miles of it). Additional functions are available to perform more operations on grids. These include such things as reclassification and transforming grids.

## Create Spatial Models Using ModelBuilder

ModelBuilder is a tool in ArcView Spatial Analyst that helps you build, manage, and automate spatial models for geographic areas. A model is a set of spatial processes that converts input data into an output map in ArcView GIS using a specific function such as buffer or overlay. Without ModelBuilder, the management of models and of the data supporting them can be difficult.

A sophisticated model contains a number of interrelated processes. The input data, function, and derived data together constitute a complete process. Processes are defined by the type of function they perform, that is, converting vector data to raster format, deriving slope from elevation, and so on. At any time, you may add new processes, delete existing processes, or change the relationships among processes. In addition, you may replace old data sets with newer ones, change assumptions or model parameters, and consider alternative scenarios in which input factors are prioritized differently.



A spatial model is represented as a flowchart diagram in ModelBuilder.

ModelBuilder helps you manage the complexity of a model in the following ways:

- It makes processes and the relationships among processes explicit. ModelBuilder diagrams processes and the relationships among processes in a flowchart that is dynamically updated whenever a change is made.
- It lets you set the properties of the input data, the functions, and the output data, and it records this information in the model. This makes the model output reproducible.
- It stores documentation inside the model. You can document sources of input data and assumptions you made in the model.
- It stores and manages the model files and the output data on disk.
- It lets you edit the structure of the model by adding and deleting processes or by changing the relationships among the processes.
- It lets you edit the properties of processes to experiment with alternative outcomes.

### *ModelBuilder Features*

Using ModelBuilder you can create, visualize, document, run, modify, and share models. ModelBuilder includes the following features:

- A model window where you build and save your models
- Wizards that automate the creation of new spatial processes or the editing of existing processes
- Property sheets that let you quickly modify the properties of input data, processes, or output data
- Drag-and-drop tools that let you build and connect processes manually
- Layout tools that help you arrange your model neatly
- The entire model (excluding the input data) is saved as a single XML file to enable you to easily share your model with others.

### *Functions in ModelBuilder*

Functions in ModelBuilder are organized by category and are accessible from a menu. The Data Conversion category includes Vector to Grid, DEM to Grid, and Point to Interpolation functions; the Terrain category includes the Slope, Aspect, Hillshade, and Contour functions; and the Overlay category includes the Arithmetic Overlay and Weighted Overlay functions. The two remaining functions are Reclassification and Buffer.

### *Customize Your Data*

ArcView Spatial Analyst also includes an extensive suite of more advanced raster analysis tools that can be accessed through Avenue. Developers are able to deliver very sophisticated spatial analysis applications based on these extended capabilities.

**Product Specifications**

ArcView Spatial Analyst is designed for power and supports a multiplatform environment for portability. You can use existing ArcView GIS features directly or import data from across the office or via the Internet (USGS DEMs, DTED, ASCII, or binary). Product specifications include the following:

- |                                      |   |
|--------------------------------------|---|
| Create Data                          | <ul style="list-style-type: none"><li>■ Interpolate a continuous surface from point measurements using kriging, inverse distance weighting, spline, or trend surface.</li><li>■ Determine the density per unit area using existing data.</li><li>■ Calculate the Euclidean distance from any feature.</li><li>■ Find the closest feature for any location.</li><li>■ Derive the least-cost path between locations using a series of grids as cost surfaces.</li></ul> |
| Spatial Modeling with ModelBuilder   | <ul style="list-style-type: none"><li>■ Design a model representing the processes of geographic analysis.</li><li>■ Organize model components and processes.</li><li>■ Communicate methodology and results.</li><li>■ Share model with others.</li><li>■ Execute model.</li><li>■ Refine model parameters and rerun model.</li></ul>  |
| Contour Data                         | <ul style="list-style-type: none"><li>■ Interactively point and click to generate contours on the fly.</li><li>■ Specify a contour interval for automatic contour generation from any grid.</li></ul>   |
| Visualize                            | <ul style="list-style-type: none"><li>■ Create shaded relief images.</li><li>■ Use histograms to explore relationships.</li><li>■ Generate profiles across your data.</li><li>■ Use brightness themes to add another dimension.</li><li>■ Classify using ArcView GIS software's standard legend interface.</li></ul>  |
| Calculate New Information            | <ul style="list-style-type: none"><li>■ Build arithmetic expressions with a grid or between grids.</li><li>■ Use multiple grids as input to complex equations.</li><li>■ Perform cross-tabulation between grids.</li></ul>  |
| Model Topographic Surface Attributes | <ul style="list-style-type: none"><li>■ Find the aspect direction for any location.</li><li>■ Calculate the surface curvature for modeling input.</li><li>■ Model the steepness of landscapes using slope.</li><li>■ Determine the visibility to or from a location.</li></ul>  |
| Answer Questions with Statistics     | <ul style="list-style-type: none"><li>■ Calculate a local statistic for each location from multiple grids.</li><li>■ Find the statistics within a zone.</li><li>■ Model an area of cells using neighborhood statistics.</li></ul>   |
| Examine Hydrology                    | <ul style="list-style-type: none"><li>■ Derive watershed boundaries.</li><li>■ Model stream flow.</li><li>■ Investigate accumulation.</li></ul>   |
| Transform Data                       | <ul style="list-style-type: none"><li>■ Merge data together into a single data set.</li><li>■ Shift grids in all directions.</li><li>■ Warp grids to fit specified dimensions.</li></ul>  |

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### Customize the Answers

- Reclassify grids into your units.
- Extract data to new files based on location or value.
- Select data for analysis.
- Identify a location.
- Set a working environment.

### Using ArcView Spatial Analyst

ArcView Spatial Analyst supports a diverse range of applications. ArcView Spatial Analyst enabled Jenkins Consulting, Greyback Mountain State Park officials, and the University of Redlands with the Salton Sea project to make better and more informed decisions through geographic spatial analysis.

### Jenkins Consulting

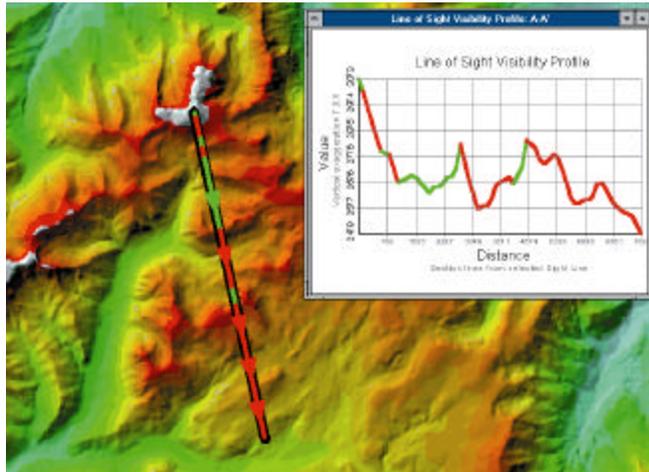
George Jenkins is an agricultural consultant, advising farmers how to get the most crop out of their soil. Jenkins just received the results from the lab on the soil samples he took at the Smith farm. He pulls out paper and plots the source points of this data. He writes the data next to these points. Around and between them, he'll draw lines to show the varying concentrations of soil nutrients in Smith's fields. It will take hours to plot the concentration of even one of the soil nutrients he tested for. It will take days to plot them all, map out exactly where to spread each nutrient, and show just how much to buy, and determining total cost will take even longer.

With ArcView Spatial Analyst, Jenkins could do the same job faster and more accurately. He would simply enter the tabular data he received from his chemist into his desktop PC and let ArcView Spatial Analyst do all this work in a matter of seconds. ArcView Spatial Analyst not only works fast, but also produces more readable maps and clearer reports. Smith will soon hold a map that clearly illustrates a thoroughly detailed report. In the diagram below, Jenkins has shown, in tabular form, the varying concentrations of four important soil nutrients and properties: P, K, NO<sub>3</sub>, and pH level. The extrapolated contour lines show what levels of these nutrients need to be applied in various areas of the field.



### Greyback Mountain State Park

State officials have determined that Greyback Mountain State Park needs to build a new visitor center. Since most visitors come to this park to climb the peak and enjoy the view, park planners need to answer the question, "Can I see the new visitor center from the peak?" They can answer this question without leaving their offices. They use ArcView Spatial Analyst to show a terrain relief map. Hill shading and colored elevation make the lay of the land immediately recognizable. ArcView Spatial Analyst software's visibility function shows the land visible from the peak. ArcView GIS presents the results in integrated planimetric and profile views. This analysis shows the areas not visible from the peak.

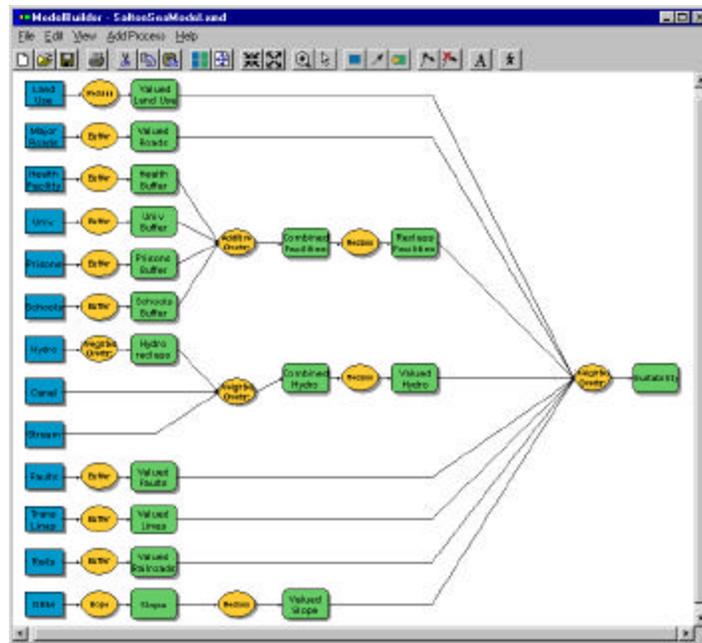


### The Salton Sea Project

The Salton Sea, California's largest inland water body, was accidentally created in December 1904 when a levee broke along the Colorado River. Because other California wetlands are being destroyed, the man-made Salton Sea has become important as a wildlife refuge for fish and birds. The Salton Sea is dying. Originally a freshwater lake, it is now approximately 25 percent more saline than the Pacific Ocean, and the salinity continues to rise.

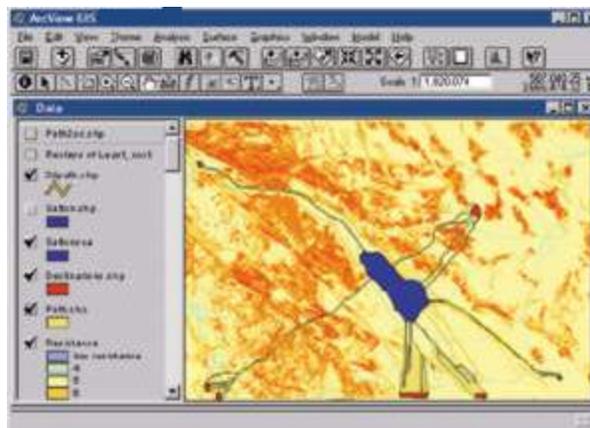
The Bureau of Reclamation commissioned the Center for Environmental Management, University of Redlands, Redlands, California, to see if GIS technology could be used to help save the Salton Sea. The university used the ModelBuilder functionality included in ArcView Spatial Analyst 2 to explore one proposal to pump saline water from the Salton Sea into nearby dry lakebeds. They wanted to show how GIS technology could be used to find the least expensive path for building pipelines. Using ModelBuilder, they created their model and ran it to generate a map showing the most suitable areas to construct a pipeline.

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*Salton Sea Model Created Using ModelBuilder in ArcView Spatial Analyst*

The university team designed the pipeline suitability model in four days. It would have taken them weeks to build a model this large without ModelBuilder. The team could come up with ideas to improve the model and test them immediately. They could increase the importance of avoiding streams or decrease the importance of being near transmission lines and then rerun the model to get new results, all in only a few minutes. ModelBuilder allowed them to spend more time thinking and less time adjusting the model.



*The Map Showing Proposed Pipeline Paths in ArcView GIS*

The University of Redlands and the Bureau of Reclamation compared the least-cost paths created using GIS tools with those created by hand by engineers working with paper maps. Most of the paths in the two models matched, but a few of the paths differed. The engineers working with paper maps decided that in some areas it would be less expensive

to tunnel through steep slopes rather than go around them. The university team could add this constraint into the GIS model and run it again without redoing all their work.

## System Requirements

ArcView Spatial Analyst 2 requires ArcView GIS 3.2 and is supported on the following Microsoft Windows operating systems:

- Windows 95/98
- Windows NT
- Windows 2000

ArcView Spatial Analyst 1.x requires ArcView GIS 3.x and is supported on the following UNIX platforms:

- Digital UNIX (version 4.0 or higher)
- Hewlett-Packard 700 and 800 series (HP-UX version 10.20 or higher)
- IBM RS/6000 (AIX version 4.1.4.0 or higher)
- SGI (IRIX version 6.2 or higher)
- Sun (Solaris 2.5 or higher)

## Conclusion

ArcView Spatial Analyst is fully integrated with the ArcView GIS environment, and therefore, is very easy to use. Display and query of data is simple and commonly used functions have been included in the ArcView Spatial Analyst graphical interface. Selecting reclassifications, symbol sets, color palettes, and so forth, is intuitive, especially for those already familiar with the ArcView GIS legend editor. ArcView Spatial Analyst displays an annotated legend with every view. Composite displays of two grids are easily accomplished.

ArcView Spatial Analyst raster–vector integration is the most advanced technology available. Wherever possible and sensible, ArcView Spatial Analyst will take vector data as input to raster modeling functions. No longer do you need to convert your vector data to raster in order to use them in a raster function. ArcView GIS software's selected set applies to ArcView Spatial Analyst functions that take vector data as input. For example, ArcView Spatial Analyst has interactive data exploration tools to display and query cells and their attributes in a table or draw histograms of data distribution within selected features or interactively defined shapes. (ArcView Spatial Analyst allows you to select a vector polygon and draw a histogram of the distribution of cell values within the polygon.)

ArcView Spatial Analyst includes easy-to-use tools for building and executing various types of spatial models. ArcView Spatial Analyst users can use ModelBuilder's process wizards and diagramming tools to interactively construct flow diagrams that visually represent processes of geographic analysis. Models can be created, saved, and rerun using different input data and function parameters enabling users to readily explore alternative scenarios. ModelBuilder provides not only the framework necessary to construct, execute, and modify spatial models but also an excellent means to document and present models to others.

ARC GRID™ software is a complete raster modeling and analysis extension package to ESRI's ArcInfo™ enterprise GIS software. ArcView Spatial Analyst is a subset of the ARC GRID software package, integrated with ArcView GIS and packaged with an easy-to-use graphic user interface.





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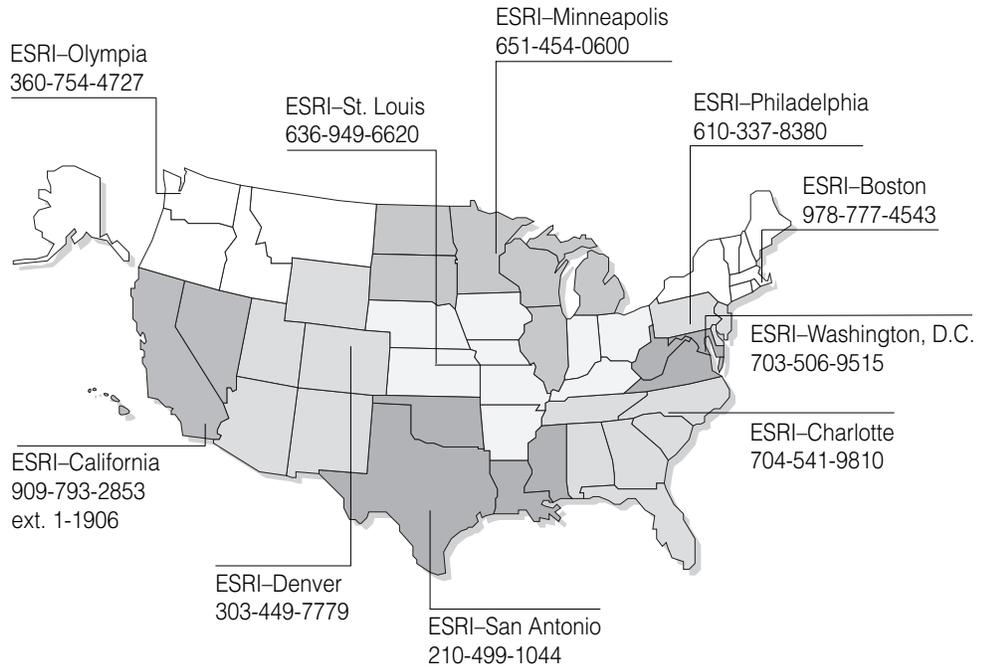
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