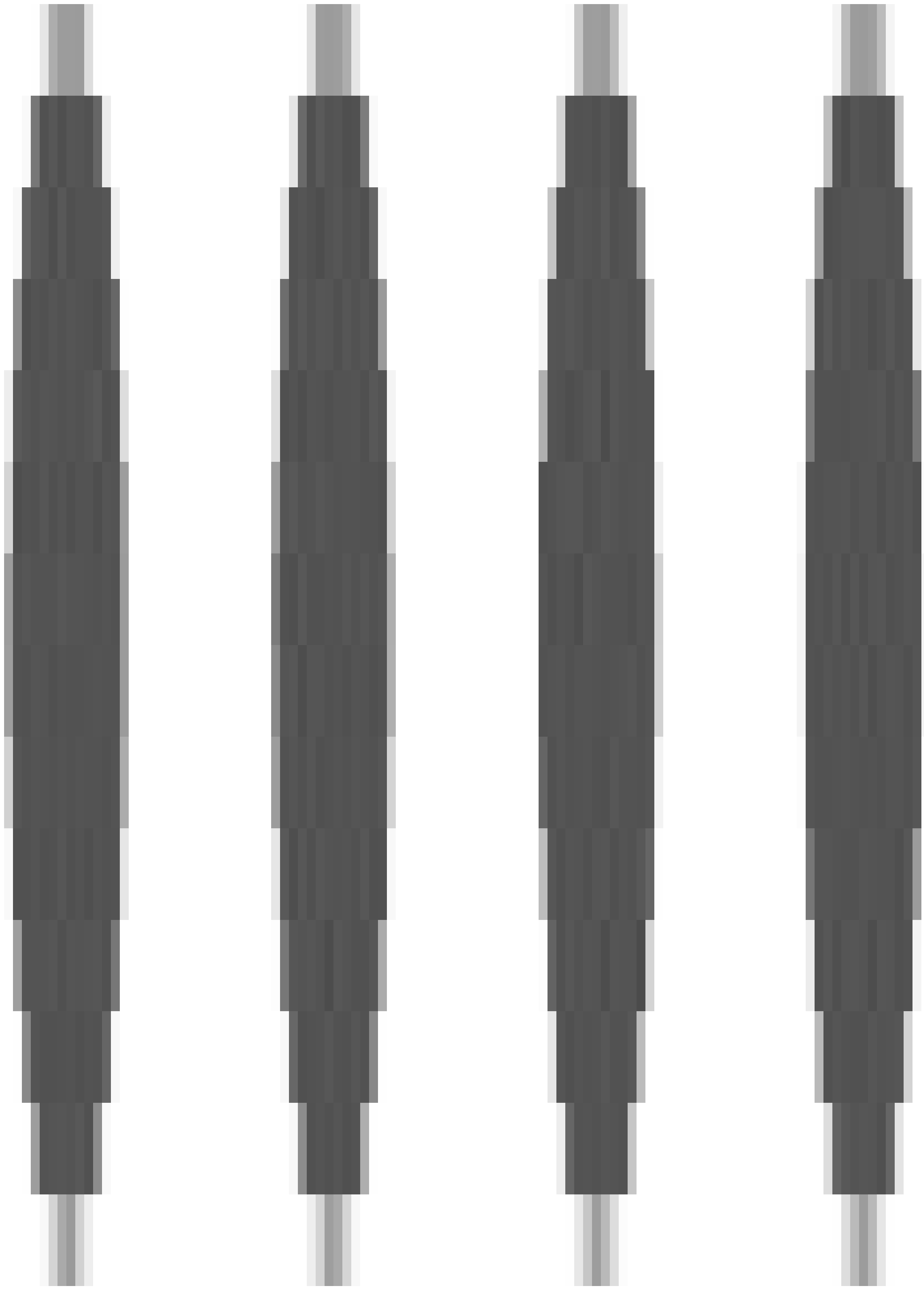

Introduction to GIS and ArcGIS

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Ch. 18: Building Geodatabases, Pt. 2

Preface

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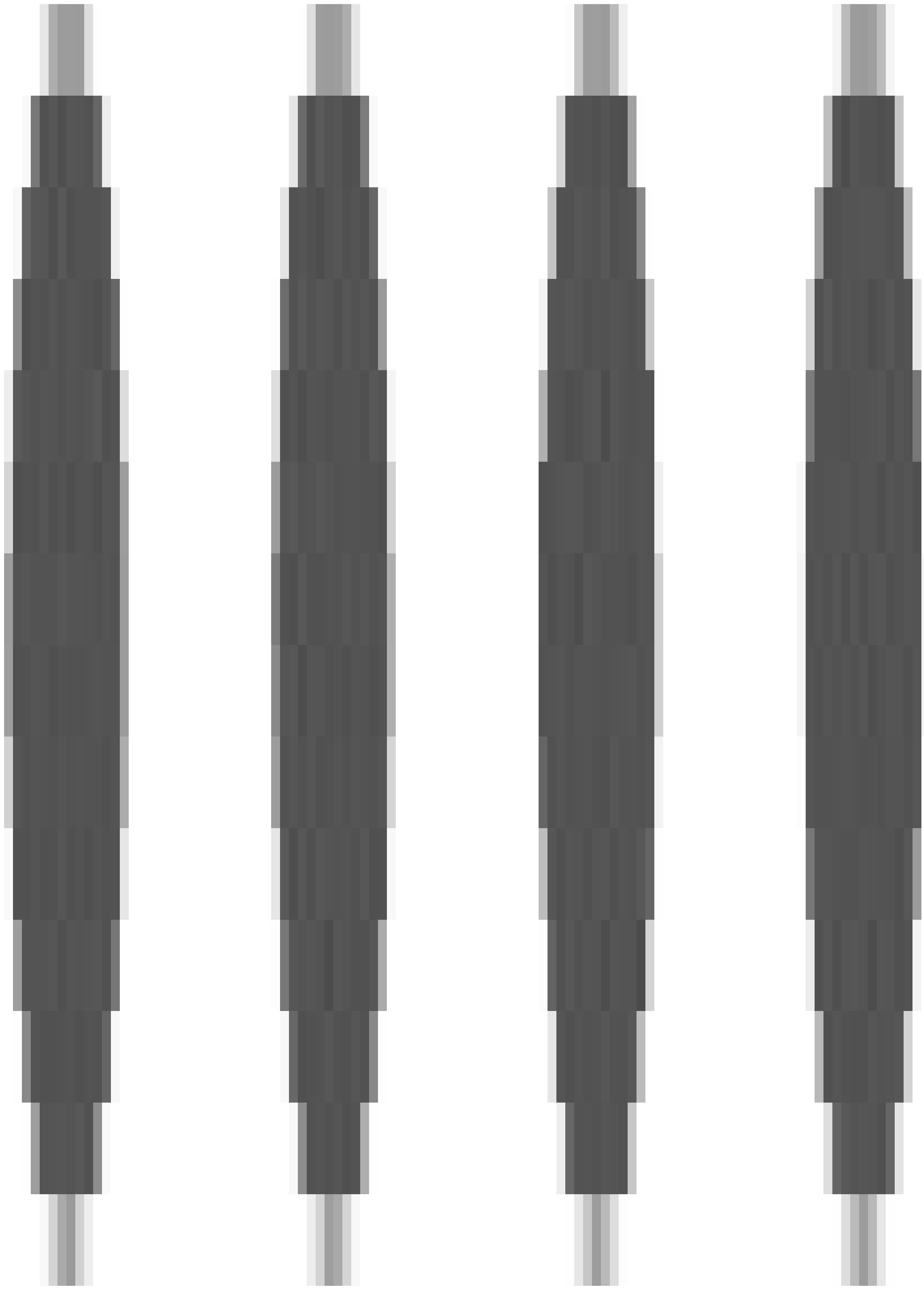
Itaught this course and wrote this summary for the students. It is an introduction to GIS and ArcGIS, with fundamental concepts, methods, and applications of GIS in spatial analysis and decision making for real world problems. Lists of instructions from the textbook were simplified into verbal commands in text form. The ArcGIS 10 application has been upgraded since, but is basically still the same. The textbook was "Getting to Know ArcGIS" by Ormsby, et al., Esri Press, 2010. (Chapter 20, Modeling, was not discussed.) I hope that you enjoy this book and find it useful.



A.S.

Ch. 1: The Geography in "Geographic Information Systems"

In the 1840's, Franklin Shaw mapped the Pacific Islands and the World while traveling, a dynamic landscape of biological and cultural effects, a harmony of people and land, patterns and themes of movement, relationship of cause and effect, an ecology.

In using Geographic Information Systems (GIS), it is important that we don't forget the "geographic" aspect of the technology. This chapter, therefore, examines the field of geography.

Geography is the depiction, description, and analysis of the spatial distribution and synergy of people, places, and things over the surface of the planet Earth. It is a natural and a social science, with application to all fields of human knowledge. It is also a syncretic science, with subdisciplines that correlate with other fields of knowledge, such as biogeography with biology, geomorphology with geology, and climatology with meteorology. Maps affect all disciplines and offer more design capabilities.

Geography is a method of understanding the World by organizing information gathered through the Scientific Method of hypothesis, observation, experimentation, and presentation. GIS is one of the discipline's tools.

But geography is also a qualitative way of seeing the World in a greater, metaphysical sense, especially since Life on Earth is being destroyed by habitat destruction, poaching, pollution, resource depletion, socioeconomic disparity, overpopulation, and hyper-militarization. We have to find solutions for these problems, i.e., the "Yes Moment."

The IKP Principle is Information, Knowledge, and Power. Your map is only as good as the latest accurate information. And that's where GIS becomes important as a tool for understanding information to facilitate decision-making.

Take, for example, the loss of orangutan habitat in Borneo due to palm oil plantations. By creating layers for factors such as habitat, farmland, forestry, and distribution of animals, planners can accommodate the species by seeing where potential farms should be located, but corrupt leaders allow foreign companies to expand palm oil plantations, really for the harvest valuable tropical hardwoods.

Another subdiscipline of geography is landscape ecology, which examines the interaction of landforms, water bodies, climate, soils, plants, animals, and people over time in a chorograph, or “snapshot” of changes. GIS and landscape ecology can be used together to create new maps.

We depict in geography with maps, such as the vector maps of the Kingdoms of Africa and cartograms of world population. We can also use satellite imagery like North America at night, aerial photographs like the Ballona Valley, and cartoons like Steinberg’s famous New Yorker cover.

We describe in geography with words, spoken and written. Great speakers such as Dr. Eugene Weber at UCLA and books like the EPA report on infill pollution inform us.

We analyze in geography with qualitative number crunching, such as a GIS map of market locations in Seattle. We also analyze qualitatively with opinion and commentary, such as in “Wild Fruits” by William David Thoreau.

Mapmaking and spatial knowledge began with the first hominoids scratching wildlife migration routes on the ground and communicating their sense of location through speech. Paleolithic cultures created more permanent records, such as in the caves of Lascaux, France, with its pictomaps showing bison runs in the area, and the Aborigines of Australia elaborate “dream maps” in caves going back over 50,000 years ago.

In the Neolithic Period, cultures had better tools to create the first real “maps.” The great hydraulic cultures of the Nile, Sumer, Indus, and China recorded history in maps and texts over five thousand years ago.

The Age of Empires saw the production of maps for warfare by powers such as the Minoans, Phoenicians, Greeks, Carthaginians, and Romans out for conquest. Their routes had to be carefully mapped out for armies and the returning slaves.

During the Dark Ages, geography was kept alive by both monks of Ireland and scholars of the Middle East until finally revving up in the Renaissance, Reformation, and Baroque Periods of European history. Americus Vespucci created a map of the world that led to his name being used for “America.”

Modern cultures have advanced geographic tools, with GIS as computerized cartography, its points, lines, and polygons attached to data that can be accessed through selection. They also “know” where they are in a coordinate system.

Geographic education is on the decline in the U.S. Schools are being torn down and teacher laid off, while in Asia the reverse is true. America does still have some top ranked programs, such as U.C., Santa Barbara, UCLA, U.C. Berkeley, and CSUN.

Geographic professions are found in teaching and also government and business. GIS is a hot skill to have in any of these fields. Half of the planners in City Hall are geographers. The Census Bureau also hires, not just every ten years. In business, GIS is used for market analysis and transportation planning. A GIS analyst can make good money in this field, while a geographic information officer (GIO) in the upper elite enjoys the unequal distribution of profits. There is a problem with bad cartographers, quick jobs, and poor design skills.

Geographic teachers make good money anyway, although it’s usually part-time and subject to budget cuts. But remember, Michael Jordan got his B.A. in geography!

Ch. 2: Cartography

To produce a successful map with GIS, first you need cartographic skills. Therefore, in this chapter, we will examine the principles and elements of cartographic design.

Cartography is the science of mapmaking, with its practices and rules, and also an art, in that one is trying to graph spatial information in a clear and pleasing format, with beauty and creativity. What's your cartographic style?

A cartographic evolution has occurred over millions of years, from hominoids scratching in the ground to Paleolithic and Neolithic cave paintings to the early maps of hydraulic civilizations to the Age of Exploration to our present day.

According to "Automation and Cartography" by Tobler, modern GIS was affected by six revolutions in technology (manual, magnetic, mechanical, optical, photochemical, and electronic), in four stages of adaptation (reluctance, replication, full implementation, and, finally, mass appeal).

Maps are a form of visual communication in which map features are like words in that they convey information to the user, or "reader," who has a spatial relationship to the mapped area, therefore the integration of spatial and non-spatial data has to reduce sensory overload by limiting the amount of information presented.

It is all a communication system of cartographer, map, themes, user speed, output, and design aesthetics, e.g., 8x11 paper is pleasing.

There are different types of maps.

A general map shows many themes together, such as a wall map of the world or a road map. It is used for planning and reference.

A specific map portrays only one or a set of features usually in large scale and fine detail for a special audience. Examples are geologic, aeronautical, nautical, planimetric, and cadastral maps.

A thematic map portrays the distribution of features or relationships, overlaid on a base map for reference.

A cartogram displays features sized according to some data set, such as a world population map by country.

A topographic map, or “topo map,” shows changes in elevation using contour lines. Closely bunched lines indicate a steep gradient.

A cognitive map portrays qualitative understanding of personal space, such as your trip from home to school, using just lines. Cognitive issues include elements, spatial representation abilities, and functions.

A choropleth map symbolizes a statistical surface on a grid, like pollution plumes, with two color ramps, two variable color progressions for two databases, and a color ramp for two hue progressions. Quantitative progression has equal color contrast steps but sharp.

In cartographic design, detail and precision are utmost. Standardization of output is critical for return business.

The first step in creating a map is map layout. Achieve map aesthetics with visual balance. Place the map center up 5% from the geometric center of the page. Orient the map to the largest polygon and then sketch it out. Features such as these are self-explanatory.

Other map layout concerns are clarity, legibility, visual contrast, clarity, legibility, balance, organization, and the use of proper colors.

The map elements are: title (location and/or theme); legend (box with symbols used for features); scale (graphic, verbal, fractional); compass rose (w/north arrow, for orientation); neatline (inner frame); border (outer frame); sources (information or base maps); projection (conic, cylindrical, azimuthal); and, a logo (for clients or marketing).

A visual hierarchy in your map emphasizes the importance of a certain feature or theme over others. This is accomplished through optical lift of the map layers, with the title as the primary layer and the base information the secondary layer. Focus perception on the figure before the ground, i.e., foreground and background. Project one and subdue the other. Create a visual centerpoint to the map’s white space, which is the whole page, vertical or horizontal orientation.

Use visual contrast in drawing lines of light and dark, thin and thick, smooth and rough texture and line weight, but be clear and legible. Value refers to the relative lightness and darkness of lines and shapes. Perception scale in Nature is light equals high, but it’s the reverse with maps.

Polygon harmony and polygon balance are achieved when polygon crosshatching is smooth, without blending classifications. Dot patterns are good for those with color blindness. To avoid noise in crosshatching, the best line texture is 45 degree diagonal. Avoid parallel line feedback vibration.

With color maps, color theory, color balance, color hue (shade or tint), and color value (relative lightness and darkness) are factors, so limit your palette. Mix strong colors with those of same value to provide intensity. Polygon colors should match legend colors.

A color ramp of values shows natural or made-up classification ranges, so it must be clear. Ramp types, with examples: single hue (white to green); bipolar hue (blue to white to red); complementary hue (blue, gray, yellow); partial hue (yellow to red); blended hue (yellow to brown); value (white to black); and, full spectrum (blue to red). Your eyes see eight to sixteen colors at one time, so apply color ramp logic in selection.

Generalization (select, classify, simplify, symbolize, induce) reduces complexity but keeps accuracy, through the use of algorithms for interpolation for vector analysis and raster analysis. Reduce map chatter and complexity.

Lastly, typographic style is important, with the theme primary, e.g., Times New Roman is popular for water. For slide legibility, use the Sixty Foot Rule: the minimum text width should be 14 inches.

Ch. 3: Introducing GIS

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Geographic Information Systems , or GIS , is a computer technology that enables the creation of maps and connecting of data to them for analysis. The maps and globes of the old science of cartography are now in a computer. A feature is each geographic object on a map or layer, while a surface is a single, continuous expanse that changes from one location to another, such as the ocean.

A traditional general map shows features with labels for identification, while a GIS layer map has different coverages portraying each attribute. Layers can be numerous, from cultural and natural sources, limited only by data collection. One goal of this course is to encourage the creation of layers of information that be used by the public.

Features are represented as points, lines, or polygons, all of which come is various sizes and shapes.

Polygons are large enough to have boundaries, such as countries and lakes.

Lines are narrow, such as roads and rivers. Lines connect and have contiguity. Annotating lines to data takes a large file.

Points are single objects, such as a tree, or you. A point can be a location or an aggregate. Location on small- scale, aggregates on large.

All of these are called vector data.

Surfaces are represented by numeric values rather than shapes, i.e., measurable values for any particular location on the Earth's surface, e.g., elevation.

These are called raster data.

Examples include elevation, temperature, and rainfall. A raster is a matrix of identically sized square cells, each of which represents a unit of surface area, such as one or ten meters, and contains a measured or estimated value for that location. Vector data can be abrupt, such as changes in vegetation, but raster surfaces can show that transition.

Features have location based on coordinate systems of latitude and longitude, with an x-axis and a y-axis, the intersection of which is the origin. Feature locations are specified by their distance from the origin. Polygons and lines can necessitate a number of coordinates, according to their shape. Township and range plane coordinates are set by sect, baseline, and prime meridian.

Scale is the relationship between the size of features on a map and the size of the corresponding location, and is expressed as a ratio. For example, 1:125,000 means the features are 125,000 times smaller than their true size. 1:1 would be an actual scale. The rule is: small areas use large scale, while large areas use small scale. Examples a world map, a midlatitude U.S. map, and a map of Los Angeles.

Zooming in on a map changes the scale but not the degree of generalization, unlike an areal photograph. Feature detail depends on scale. The coastline of California at large scale is very rugged, but at small scale is very smooth.

Information relating to a feature in a layer is stored in a table. There are an infinite number of types of data that can be stored, and another goal of this course is to create new databases.

A table is comprised of a record (row) of a feature and field (column) of type of information, or attribute. Features on a GIS map are linked to an attribute table that can be accessed for information. Each feature may have its own specific table, or be linked to a general table with others. Information can then be displayed in map form, often as a combination of map layers, e.g., gun control laws in the world and deaths by handgun maps.

A thematic map can be created using attribute tables, such as energy consumption or net migration. Color ramping rules discussed earlier must be followed here.

Attribute tables can also be queried regarding spatial relationships between features such as distance, adjacency, overlap, intersection, and containment, using their coordinates. Examples are cities near rivers, countries bordering each other, and rivers crossing borders,

New features can be created by overlapping layers, such as crop types, elevation, rainfall, and soils for a specific plant. Where the right ones overlap, you have created a new feature, with its own boundaries, and also a new layer.

Before computerization, thematic maps were made on plastic mylar sheets for overlays, to show particular relationships between factors. Ian McHarg used such overlays of soils, geology, vegetation, etc. in his landscape architecture book “Design with Nature” to encourage a natural approach in site planning. The overlays created new maps very much like GIS, but without the ability to do spatial querying.

In the 1960’s, the U.S. Census Bureau began digital mapping, creating TIGER files, a spatial dataset on socioeconomic factors. Schools like Harvard were also developing computerized mapping, like SYMAP and GRASS.

Then private companies started to offer GIS packages for business applications. Companies like Intergraph, MapInfo, and ESRI became leading vendors of software. In 1981, ESRI released Arc/Info, for use on mainframes, and then in 1992, ArcView, for desktop computers.

GIS has slowly been adopted by government, business, and academic institutions over the years and is ready for future technologies. How about a GIS “app” for cell phones, either as a stand-alone application or a certain type of information tied to a certain place, e.g, statistics about the U.S. that can be pulled up by pressing on a certain state on your cell phone screen. Does anyone have that yet?

Other current hardware issues in GIS include display, storage, capture, networking, plotting, data transfer, output, integration, and customized solutions for customers.

Ch. 4: Introducing ArcGIS 10

ArcGIS is a GIS software product line, just like many others out there. However, it is only used on PCs with Windows or mainframe computers, unless you install Windows on a Macintosh. There are apps for Macintosh, such as Cartographica. ESRI's products share a common user interface and can freely exchange maps and data.

ArcReader comes with every installation and can be downloaded for free from ESRI. It lets you view and print maps, navigate and zoom in on a map.

ArcView is the tool for making such maps. You can also query data, analyze spatial relationships, and overlay map layers to see relationships for a location.

ArcEditor has ArcView, but also more data creation and editing tools, such as versioning, allowing multiple editors of a table at one time and disconnected editing allowing data to be checked out of a database, edited in the field, and then checked back in.

ArcInfo has all of the above plus spatial analysis tools, and the ArcInfo workstation.

ArcMap has a data view for creating, symbolizing, and analyzing data. It also has a layout view for adding map elements and printing.

ArcCatalog contains the data to be used as well as other maps to be incorporated as layers.

ArcGIS Spatial Analyst is an extension that allows looking at statistical surfaces, to map and analyze measured data across a surface with raster cells. It can represent, query, and statistically summarize this data, as well as estimate values at other locations using mathematic interpolation of known sample values.

3D Analyst allows one to see spatial data in three dimensions, fly though terrain, model cities, and analyze visibility, volume, downhill path, etc.

Geostatistical Analyst is used to evaluate measured spatial data according to statistical principles, to get the value distributions of datasets compare to normal, bell-shaped distributions, and look for correlations. It is also used to make maps of predicted values.

Other programs from ESRI include Mobile GIS, Online GIS, Server GIS, fields of activity, the first especially useful in surveying and GPS work.

Ch. 5: Projections

Amap projection is a way to represent a three-dimensional surface such as a sphere on a flat, two-dimensional surface like a piece of paper. The idea is to shine a light from within the sphere onto a type of surface. However, there are imperfections in the portrayal of feature properties like area (size), shape, distance, and direction, or in some combination of the above.

A conic projection looks like an ice cream cone placed over the Earth, with the light shining out to create the outline. The Lambert Conic is good for midlatitude, regional, and topographic maps. They are equivalent, having good feature size.

A cylindrical projection looks like a cylinder wrapped around the Earth. They are good for navigation because they are conformal, with good feature shape, but distorted area. The Mercator Projection is an example, seen on the seat screen on airplanes for travel.

An azimuthal projection is made when a piece of paper is placed tangentially to one point on the Earth, usually the North or South Pole. It is good for airplane navigation, because it preserves true direction and distance from a center point to all other locations on the map.

The Sinusoidal projection has good area, not shape.

The Robinson projection is the best at preserving feature properties.

The Earth is a spheroid, like an orange. It is not perfectly round, but more oval-shaped. It bulges out at the center and flattens at the poles, due to rotation gravitational pull. It is 7,926 miles in diameter and 24,902 miles in circumference. Also like an orange, its surface is rough, with ridges and valleys. The lowest point is the Mariana Trench at 36,200 feet and the highest is Mt. Everest at 29,029 feet.

The surface of the Earth has been plotted with a geographic coordinate system that allows us to reference specific locations.

Latitudes, or parallels, run east and west, and show how far you are from the Equator, with the Equator being 0 degrees, the North Pole, 90 degrees North, and the South Pole, 90 degrees South. Latitudes are always equidistant, the same distance apart.

Longitudes, or meridians, run north and south and show how far you are from the Prime Meridian in Greenwich, England, which is at 0 degrees, 180 degrees East, and 180 degrees West. Longitudes narrow towards the poles. The mesh of intersecting parallels and meridians is called a graticule.

Latitude and longitude are measurements of angles, not distance, thus their values are expressed in degrees, minutes, and seconds. We use angles because of the convergence of longitudes towards the poles. The angle between longitudes stays the same, but the distance diminishes. If you slice the "orange" through the center, you get a great circle, shortest route between two distances. Great circles include the Equator and all longitudes.

Locations of features are referenced on the graticule of intersecting lines along a horizontal x-axis and a vertical y-axis, with the coordinates measured in distance, not angles. Thus, for example, Los Angeles is 34 degrees north latitude and 118 degrees west longitude. The x and y coordinates depend on which map projection is used, units of measure, and where the map is centered.

One problem is that there are different estimates of the Earth's size and shape, i.e., different spheroids, leading to different coordinate systems and the necessity to adapt them to one another. There are different spheroid models for the Earth, with different coordinate systems and thus locations for features. Some models have the Earth as a perfect sphere but tectonic displacements must be rectified. These include State Plane UTM, California Zones, NAD (North American Datum), and NAV (nautical).

Spatial accuracy, affected by displacement of real from mapped, creates planimetric differences, thus every spatial dataset has either a geographic coordinate system (latitude, longitude) or a projected coordinate system (x, y values). It also has other coordinate system information, such as the dimensions of the sphere or spheroid model it's based on for the first, and projection, measurement units, and geographic coordinate system for the latter. You can find this data under Description in ArcCatalog or the Properties dialog box, or Source tab in the Layer Properties dialog box in ArcMap.

When adding a layer to a data frame in ArcMap, it displays according the coordinate values of its features- geographic or projected. If you add a second layer, it may not have the same coordinate system, but with on-the-fly projection, ArcMap automatically changes the added layer's coordinates to match the first layer, thankfully.

ArcMap has hundreds of coordinate systems to use. ArcMap stores the first layer's coordinate system as a property of the data frame. When the second layer is added, the geographic coordinate system is analyzed and ArcMap changes it to match the first. And so on for additional layers.

However, you can assign any coordinate system you want to the data frame, not keeping the original one. On-the-fly works best when layers are based on the same geographic coordinate system. If they're not, you have to assist ArcMap in assuring accuracy, especially for local maps demanding great detail. For general or small-scale maps, that's not so important. You will respond to a "Geographic Coordinate Systems Warning" box if there is a problem and then may have to make a geographic coordinate systems transformation, and specify or modify the transformation.

Features in a geographic dataset always have coordinates but a particular shapefile may have become detached from its coordinate system as a separate file (.prj). In this case, ArcMap will choose the best fit to the layer. Features in a spatial dataset may have lost their projected coordinate system, in which case, ArcMap warns you that an on-the-fly transformation cannot be done. You then have to define the projection by getting information from the original source.

The exercises for this chapter utilize ArcCatalog (Catalog window, Contents, Preview, and Description, Shapefile Properties window), and ArcMap (Bookmarks menu, Data Frame Properties dialog box, Coordinate System tab and folders, Copy and Paste, Add Data, Data View, Layout View, ArcToolbox, Data Management Tools, and Define Projection).

Ch. 6: Map Presentation

Amap template can be used in ArcMap to generate a quick map, with all the map elements discussed earlier. All you do is add data and the map is ready to print. You can also add layers.

When creating an ArcMap document, the layout page, or “virtual page,” is blank and has a single data frame with a normal template. You can add data, resize it, insert data frames, add elements, and save it as a map document, or you can open a custom template with a predesigned layout.

You can also create new templates, with your own arrangement of map elements and data frames, by saving as a map document. The exercises in this function utilize ArcMap (Getting Started, Browse, Open, Layout, Pan, Zoom, Bookmarks, Data Frame Properties, Reference System Properties, Tools, Select Elements, and Grids).

Geographic information like street addresses can be turned into points on a map, if you have a table of coordinate values. You must have x- and y-coordinates in either a geographic or projected coordinate system. The exercises in this function utilize ArcMap (Layout, Standard Toolbar, Spatial Reference Properties, Browse Dataset, and Symbol Selector).

You can also draw graphics on a map with the tools on the Draw Toolbar, after you’re happy with the display scale, because graphics don’t scale proportionally when you zoom in or out. The exercises in this function utilize ArcMap (Layout, Zoom, Draw, Rectangle, Properties, Symbol, Identify, Call-out, Font Size, and Export Map).

A good map should have a good layout in design and proper use of map elements, discussed in an earlier chapter. The layout can be portrait (vertical) or landscape (landscape) and of any size. ArcMap has rulers, guides, and a grid for arranging map elements, even resizing and rotating. They have to be turned on.

Exercises in this function utilize ArcMap (Getting Started, Existing Maps, Browse, View, Layout View, Layout Zoom Whole Page, Page and Print Setup, Map Page Size, Guides, Snap to Guides, Toolbar, Scale, Overview, Pan, Select Elements, Group, Flip, Rotate, Draw, Rectangle, Fill Color, Align, Insert, Scale Bar Selector, Scale Bar Properties, Adjust, Show, Border, Background, Preview, Insert, and Neatline).

These are the concerns you will have in producing a map for your customer: purpose (need, larger perspective, user specifications, and trade-offs); cost estimates (staff, materials, cost to research, digitize, and process data); data accuracy; preliminary matching of data to need; checking composite proofs; client review for changes; production, delivery, quality assurance; and, revision and maintenance.

Ch. 7: Exploring ArcMap

ArcMap is an application that allows one to display, investigate, analyze, and produce maps.

The ArcMap window has a map display, table of contents of layers, and toolbars, all of which can be customized to your needs.

A floating toolbar can be docked by dragging it to the interface, and undocked by clicking the gray bar on the left edge and dragging it away. You can hide, show, or customize toolbars.

The catalog window and search window can also be docked and can be collapsed into a tab or shown in full.

The auto hide button allows use of the tab feature. Docking preferences are saved for future sessions, as well as window sizing. You can further customize the interface under contents, desktop help.

Open a map document in the new document dialog box to see a preview and then the actual file, which can consist of different layers of geographic information, listed in a table of contents, and may have a graticule of longitude and latitude, discussed earlier.

A layer can be turned on or off in the check box and be repositioned in the table. Right clicking the layer will give a context box. The properties box helps to define the layer with name.

With the zoom in tool turned on, the cursor becomes a magnifying glass. Zooming in changes the map scale, however, often measured as a ratio, with each unit on a map equaling so many on the Earth's surface, from large to small scale, such as 1:1, 1:250, 1:125,000, 1:280,000, and 1:1,250,000.

The select elements tool gets information by being pointed over part of a map such as map tips, a layer property, as well as label features.

The pan tool, a little hand, is used to drag around the display.

The identify tool allows one to display information about a feature.

The full extent tool shows the whole map or layer.

Some map layers such as labels can only be displayed at a smaller scale, or details at a larger scale and will be grayed out otherwise, so zoom in and pan around. Use the magnifier tool with its crosshairs over the point. Magnify and then draw a rectangle, and zoom in. A spatial bookmark can be created for such detailed views.

Use the measure tool, with chosen units in metric or U.S., then place the cursor, as a crosshairs at the begin point, click, and then draw to the end, point, click, and measure.

An attribute table stores more detailed layer information, with rows of features and columns of categories. You can access the table by right clicking a layer and choosing its attribute table. Each attribute is called a field. The intersection of a row, or record, and field is called a cell, which contains a certain attribute value.

You can adjust the display width of columns and drag, rearrange, or hide them. Records, or rows, can also be dragged or rearranged.

You can also position the attribute table alongside a map and highlight information and see it displayed. You can also switch between attribute tables at the bottom of one. Fields or records can be resorted by right clicking and choosing the style. You can also get statistical analysis by right clicking a field.

Ch. 8: Exploring ArcCatalog

ArcCatalog is an app for managing geographic data, which you can copy, move, delete, search, preview, and create.

The ArcCatalog window contains a catalog display for viewing spatial data and a catalog tree for browsing data, as well as some toolbars.

There are different types of spatial data, such as geodatabases, coverages, shapefiles, CAD files (computer-aided design), rasters, and TINs (triangulated irregular networks). Each format has its own icon in ArcCatalog. (The shapefile icon, for example, is a green rectangle, with different patterns for points, lines, and polygons).

Another type of file is a layer file, or a set of instructions for displaying spatial datasets with certain colors, symbols, line widths, etc.

ArcCatalog is one way to browse for spatial data. You can also use Internet search engines. But, ArcCatalog does have a lot of existing file sets, in folders organized by subject. You can also preview features and attributes of data before adding them to a map. You can examine and edit metadata, or “data about data,” like creation date, coordinates, spatial extent, attributes, and, standards.

In the ArcCatalog window, the catalog tree lists the data and services the application is connected to, such as local hard drives in your office or organization. You can also connect to subdirectories, network drives, databases, Internet servers, and other services.

Under customize, options, general, you can select which types of data to access. Be sure to click off the hide extensions button.

The connect to folder button on the standard toolbar allows one to set up a direct connection to a file folder, such as the local disk on your lab computer, and set up a connection with each folder by selecting it.

Each chapter folder has subfolders that can be added as well, such as geodatabases, shapefiles, and layer files. A geodatabase contains feature classes, or groups of points, lines, and polygons representing geographic data. With a file selected in the catalog tree, then use the details button on the standard toolbar to show file type. Also use the contents tab, large icons button, list button, and thumbnails button when dealing with files.

With thumbnails, for example, you can select the countries feature class in the world geodatabase, preview tab, create thumbnails button, and then click contents to see the thumbnail.

The preview tab can be used with the zoom in tool to drag an area on the map, and then click identify and then click a feature to identify it and get the identify results window, and click the full extent button to zoom to the full extent of data. Preview the attributes of a dataset by selecting a table of attributes. Others tabs are geography tab, description tab, and metadata tab.

ArcCatalog has a lot of metadata, but you can also manage and create your own. In the catalog display, click the description tab to see the thumbnail you created, then click edit to access metadata data. Metadata can be created in the description tab. In fact, due to reformatting, ArcGIS 10 is requiring all metadata to be upgraded. Check out the new categories of metadata on-line.

Click contents, world, map on the catalog tree, and then details to restore a display to its initial state.

You can search for map data on a disk or a network by name, file, type, location, creation data, or other metadata. You can use the search button to open the search window, and search results are indexed, but you have to specify a search location. Search results are listed in the catalog tree, with an index/search options box. A folder must be indexed to be searched. Search results are listed and can be hovered over for a brief description. When you find a dataset, make sure you click the data link and not the description. Click preview to view the file, such as a raster dataset of seafloor elevation. You can use the identify tool and click on locations to identify values such as elevation. In the preview tab, you can view or access a shapefile, the actual spatial data, or the layer file, i.e., the artwork created on top of it (symbology, colors, shapes, sizes that you store and don't have to recreate every time). Every layer file is associated and depends on a spatial dataset.

You can add data to ArcMap by dragging it from ArcCatalog, view it as a map display and table of contents called a data view, or as a layout view for printing. In layout view, the map layers are small rectangles called data frames on a background called the virtual page. Data frames have different sets of data usually related to a common subject, or show different views of the same data. In data view, you can see just one data frame at a time. The display window has the contents of the active data frame, boldfaced in the table of contents.

In ArcMap, open the open file browser, select a file and preview it. To add a file from ArcCatalog, drag it to the ArcMap display window and the layer file is added to the ArcMap table of contents. You can rename it by right clicking the layer and choosing properties, general, name.

In layout view, the map is seen as a rectangular, and a layout toolbar appears, docked or floating. A map document has a single data frame, occupying space on the virtual page, with other elements added to the layout like a title. Click insert and data frame to add a new one, which is then boldfaced, or active.

You can drag the frame around the virtual page and switch back to data view and add layers to the new data frame, or do it in layout view as well. Click data view in the layout window, which, along with the layout view button, can be used instead of the view button to switch between views.

If an active frame contains no layers, the display window appears empty. You can then drag a feature class form ArcCatalog to the ArcMap display window and release the mouse button, thus the feature class is added as a layer to the new data frame.

You can add more layers from ArcCatalog or from the layers data frame by copy and paste, then click layout view to see the layers in the new data frame. To change the color of the layer, click the data view button to switch to data view, then right click the polygon symbol in the table of contents to get a color palette. Then rename the data frame in the table of contents, right click new data frame and the context menu, click properties, then click the general tab, and the name box. The new name is displayed in the table of contents.

Ch. 9: Symbolizing Features & Rasters

Features are often symbolized on a map by assigning colors, markers, sizes, widths, angles, patterns, transparency, and other properties. They can look like the feature represented, like a blue lake polygon or streetlamp icon, or by line thickness of streets or widths of highways for importance. Cities are symbolized by circles, but they are not round.

Symbols can be modified into subsymbols, such as different patterns for wetland, saltpan, and ephemeral lakes.

Scale affects symbology. At a small scale, a city is a point, at large, a polygon.

You can create your own symbols and organize them by category. Added datasets have their own symbols that can be changed in the layer attribute table, then save the new layer's symbology as a layer file (.lyr), to add to a map with the features already symbolized the way you want. Raster cells are symbolized by changing their color.

A dataset has default symbols, such as points as small circles and polygons with outlines, with colors randomly chosen, but you can change the default symbology, such as polygons, points, and background color of the data frame.

A data frame may contain two or more layers, such as countries as polygons and cities as points. Right click a layer in the table of contents to open the color palette and select a new one. To change a polygon's outline width or color, click the layer in the table of contents to get the symbol selector dialog box, then choose from predefined symbols or use the options frame to pick new colors and widths for the polygon outline.

To change points, click the layer, symbol selector dialog box, predefined symbols, and change size, color, and angle. To change point labels, right click the layer name, not the symbol, and click label features.

To change the background color of the data frame, right click it, then click properties to get the data frame properties dialog box, the frame tab, and the background dropdown box to select a color.

You can also symbolize features by category attributes. A layer attribute table of information can be used to create symbols, such as different colors for each country polygon according to name, or by political system, like red for Democrat and blue for Republican states. Categorical attributes such as names or descriptions are qualitative or descriptive. They can be text or numbers that stand for descriptions.

To symbolize countries by name so each has a different color, open the map in layout view, click view, data view, and then full extent. Right click the countries layer in the countries data frame and click properties, layer properties dialog box, symbology tab, and show box, with methods for symbolizing features, such as features/single symbol option, but instead select categories, unique values option, value field drop-down list containing the fields in the attribute table used to symbolize the countries, then the color scheme from the dropdown list of patterns.

The large window in the dialog box shows features to be symbolized, all or some of them. Set the value field list to name, then click add all values to see each feature in the countries layer listed in the value column with a symbol from the color scheme assigned to it; the label column displays the feature name as it will appear in the table of contents; and, the count column shows the number of features being symbolized and the number of features that have each value, such as one for each value because each country name is unique.

Click color ramp for a list of color schemes and choose the one you want. Right click the colors, not the dropdown arrow, to see on the context menu, click graphics view to unselect it so the image of the color is replaced by its name. Click the color ramp dropdown list, scroll to pastels and select. In the symbol column, uncheck the check box next to all other values. The all other values symbol is used when you want to assign unique symbols to features and the rest be identical. So now the countries are symbolized by pastels, with the table of contents showing the name of each and its symbol. You can also change individual colors by right clicking the symbol in the table of contents and changing it. To label the countries with their names, right click the countries layer and click label features.

You can add a river map by right clicking the rivers data frame and then activate. Click the plus sign next to the data frame, full extents, then the data frame layer you want. Right click the rivers layer, then open attribute table to see information available: name, type, status, and navigability. You can symbolize by type, by double clicking the rivers layer to open layer properties, symbology tab, categories, unique values option, value field dropdown arrow, type, then add all values. The add values button lets you select particular attribute values and assign symbology to features that have them. Other features are assigned a single symbol, the one designated for other values. If the all other values check box is unchecked, these features are not displayed at all.

In the symbol column, double click line symbol, then symbol selector, find the symbol you want, select. In the symbol column of the layer properties dialog box, double click the symbol next to the certain value you want, opening the symbol selector. Then type the word river into search box and click the search button to get symbol to index, then select.

Next, in the symbol column of the layer properties dialog box, uncheck the check box next to all other values. The new symbology is displayed by selecting rivers by type, e.g., intermittent or perennial. Then check your progress by click layout view under the view menu.

Quantitative attributes are measurements or counts of features. An example is a country's area in square kilometers as a measurement.

A style is a collection of predefined symbols, colors, and other map elements such as labels, north arrows, scale bars, and borders, to create layer files. You can also make your own, or use ArcMap's, through search help, library, visualization, symbols. After symbolizing the layer, save it as a layer file, storing symbology information for a spatial dataset.

For example, open layout view, and then data view to see active data frame, then either drag layer form ArcCatalog or use the add data button to navigate folder connections to add a point layer such as animals.

Symbolize the layer using an attribute of various animal names, then apply the symbols for each type of animal. Double click the animals layer, layer properties dialog box, symbology tab, show box, categories, unique values option. Click add all values, then in the symbol column, click the check box next to all other values to uncheck it. In table of contents, click point symbol next to each animal, then symbol selector, scroll through the list, select. Click style references, then conservation style to get symbol, scroll down and find the appropriate one for each animal. You can change size in the options frame, and color, then save this animals layer and set of symbols as a layer file by right clicking the layer and then save as layer file. However, it will remain referenced to its parent shapefile, which must also be sent along as well if shared.

You can also symbolize rasters.

A raster is a matrix of identically sized cells, each with a quantitative value, such as elevation, rainfall or temperature, measured at the location represented by the cell. Symbolize a raster by assigning colors to cell values or ranges of cell values. Raster values lie on a continuous scale such as numbers and are symbolized by color ramps. Each raster of elevation, temperature, etc. has a different color ramp.

Hillshade is derived from the elevation raster by angle and altitude of light source.

Satellite images and aerial photographs are rasters with cell values as measurements of reflected light.

Scanned maps are rasters in which cell values are measurements made by the scanning device.

You can display raster data with ArcMap, but to work with it, you need Spatial Analyst, 3D Analyst, or Geostatistical Analyst, all extensions that come with the sample CD. You can also get raster data in many formats on the Internet or from commercial vendors.

To add elevation and hillshade raster layers, use the add data button, then create pyramids for the raster layer. A pyramid is a version for a raster dataset, varying from coarse to fine resolution, used to improve the drawing speed of raster layers as you zoom in and out, with coarse at full extension, finer as you zoom in. The resolution corresponds to amount of detail at a given scale. Pyramids are stored as a field with the extension, .rrd.

To rename to raster layer, double click the layer and get layer properties, general, layer name, and type, then drag the new hillshade layer to the topography data frame. Drag the elevation layer in, change color ramp for this layer by right clicking the layer, zoom to layer, double layer, choose layer properties, symbology, and show box for different symbology methods.

The stretched method has subtle transitions along the color ramp but no precise info about which data values are associated with which shades of color.

The classified method has less subtle transitions in color, exact value ranges corresponding to which shades.

The unique values method has a different color for every data value in the raster, as long as there are no more than 2,048 unique data values.

The discrete color method assigns a color to each unique value until reaching the maximum number of color chosen, then choose color in the color ramp dropdown list, such as the elevation #1 color ramp.

You can also make the elevation layer partially transparent so the hillshade layer shows through, by double clicking elevation layer, layer properties dialog box, display tab, transparency text box, and type in value you want. Then choose bookmarks, close-up and zoom in on the scale dependent layers display, right click elevation layer, zoom to layer, and lastly check view layout view.

Ch. 10: Classifying Features and Rasters

Feature attributes can also be quantitative, i.e., counted, measured, or estimated numbers, like population, lengths, sizes, or numeric.

To symbolize quantities, attribute values lie in relation to one another on a continuous scale, divided into groups of values or classes, to classify data by choosing number of classes and method to determine classes.

Quantitative values are on a number scale of real numbers (integers) or special numbers, like degrees, so the symbology is scaled by graduated color, graduated symbol, proportional symbol, or dot density.

Graduated color is the most common. It displays features as shades in a range of colors that changes gradually called a color ramp. For instance, with countries by population, each is a different shade of color according to population, dark to light. This is most effective on polygon layers because subtle color differences are easier to detect on large features.

Graduated symbols represent features with different marker sizes, and is used with point layers but can be applied to lines and polygons as well, with markers drawn inside the features, e.g. graduating circles.

Proportional symbols vary in size according to the value symbolized. It works best when the range of values for an attribute is not too wide.

Dot density is used for polygon layers only, with quantities shown by a random pattern of dots within the feature. The more dots, the greater the value. Dots are randomly placed and are a precise quantity of the attribute symbolized, though not to be mistaken as exact spatial location.

There are seven methods of feature classification:

Natural breaks is the default, with classes according to cluster and gaps in data.

Equal interval is a class of equal value ranges for a range of values, such as dividing 100 into four classes.

Defined interval is the same as above except the interval determines the number of classes, such 100 divided by 10, not four.

Quantile has classes with equal numbers of features, e.g. choose five classes for layer with 100 features, get class breaks so 20 features fall into each class, with value range varying from class to class.

Standard deviation shows classes according to a specified number of standard deviations from the mean value.

Geometric interval produces classes based on class intervals with geometric series or patterns with a constant coefficient multiplying each value in the series.

Manual lets you create your own class breaks.

To classify, open a map, click view, data view, right click layer, then open attribute table, right click field name and click sort, then click attribute table, then double click layer in table of contents to open the layer properties dialog box, symbology tab, show box, quantities to see options: graduated colors, graduated symbols, proportional symbols, and dot density.

The value field dropdown shows available attributes, numeric only. Click the value dropdown arrow, then value, to see classes already done. The symbology is applied to the map but number of features may vary per class, like Africa population.

Double click the countries layer to open the layer properties dialog box, symbology tab, classes dropdown arrow, number of classes, and value ranges. Adjust, click apply, move layer properties dialog box away from map display to see both, see new classification, so you can change classes, bunch them up to show focus on the highest feature class, such as population of Nigeria.

Under the symbology tab, click classify for the classification dialog box with current method, number of classes, and even statistics, i.e., a large window histogram, or frequency distribution chart, with an x-axis of values and y-axis of features, and class breaks in blue lines. Columns represent percentage of range values, with default number as 100 in columns box. Highlight default value and change so each gray column in the histogram has a different percentage of value range. The histogram shows class breaks falling in relation to data.

In natural breaks, reflect clusters in data, so Nigeria is its own class. In the classification frame, click method dropdown arrow, equal interval to adjust class breaks, so each class has same range of values and can even have classes with no values in them. All numbers can be up at one end, such as population in Nigeria as compared to rest of Africa.

In the quantile method, each class has an equal count of values. Click method dropdown arrow, new method, quantile, apply, and compare layer properties box to map display. On the map, each class has an equal number of countries.

In the symbology tab, click classify, classification dialog box, method dropdown arrow, natural breaks, classes dropdown, then make easier to read with commas, which can also be put in class labels, under symbology tab, label column heading, format labels, number format dialog box, then numeric labels: decimal points, commas, alignment, rounding off, and special notations (currency, numeric, direction percentage, custom, rate, fraction, scientific, angle). Click symbology tab, show class ranges to see every class corresponding to a feature value.

Manual classification reveals groupings in data that standard classification methods might miss, such as census tract with high income or age groups as percentage of population, so set class breaks.

Open map, view, data view, bookmarks menu, elevation area, zoom in, then in table of contents, double click elevation layer, properties dialogue box, symbology tab, classify values by change to classified, click classified in show box to see default is five classes and method as natural breaks. Click classes dropdown, number, right click color ramp, uncheck graphic view, click dropdown arrow, set color ramp, click classify, break values box, and change to class break in histogram.

Manual classification replaces values in the break values box, but you can also drag blue class break lines in the histogram to new positions, right click a class break to delete it or an empty part of histogram to insert new break. To make sure each class begins and ends with a value in the attribute table, check snap breaks to data values at the bottom of the classification dialog box. Gaps may exist between classes, but also more accurate value distribution. Click okay to update symbology tab.

To symbolize with a new color, in symbol column, double click new color symbol assigned to each class, change, then also reformat labels, get ride of decimal places in number format box, by clicking label column and click format labels, in rounding frame of number format dialog box, click number of decimal places option, type in zero.

To map density with a graduated color map, e.g., population people per square unit of area, use the population attribute and area attribute, simply divide population by area, so divide one attribute by another to find ratio between them called normalization, to calculate density, e.g., normalize population by income to get income per capita.

Right click the countries layer in table of contents, open attribute table to see attributes to be normalized. Close, double click the countries layer, layer properties dialog box, symbology, show box, quantities, graduated colors option, fields frame, click value dropdown arrow, then attribute such as population, click normalization dropdown arrow, and then kilometers so values in range column express population per square kilometer, with values rounded in labels column, the default for normalized data, then set the color ramp, close properties box. Population density may be different map from population, e.g., Rwanda vs. Nigeria.

To represent density with dot density maps, open layer properties dialog box, symbology, show box, dot density option, field selection frame, select field (population), highlight it, then right arrow so field is added to right box and dot symbol is assigned to it. Then set symbol color for dots in symbol column, right click dot symbol, get color palette, select, then in background frame, click line button, color square, color palette, no color, okay to turn off country outlines. Then in densities frame of symbology tab, highlight dot value and enter value for each dot, such as 1,00,000, then okay. But the random dot pattern isn’t the real distribution.

Click properties, symbology, dot density symbol properties, use masking check box, to select a mask area to exclude them from a lake or place them all in a buffer area.

You can use graduated and chart symbols of different sizes to represent features or information. Quantitative attributes can also be symbolized as pie charts, bar charts, or stacked bar charts for each feature in a layer.

The pie chart symbolizes percent contribution to a total, and even of various attributes, like GDP from sectors, or population groups.

The bar chart compares attributes where values do not make up a whole, like spending.

A stacked bar chart shows the cumulative effect of attributes, like all items and breakdown of types of communication devices.

Right click a layer, open the attribute table to see attributes, close, then double click layer, layer properties dialog box, symbology tab, show box, quantities, graduated symbols, value dropdown arrow, symbol column, then size-rank, so symbols appear, and you can change symbol with template button, symbol selector, symbol, change angle value, select color, okay. Now new symbols are applied to the symbology tab, then in symbol size, change size, replace numeric labels with descriptions with label column, click and then input box opens, type in new label, press enter to get next label, and rename.

Next, select the minus sign by a data frame, right click power data frame, activate, click plus sign by power data frame; right click countries layer, open attribute table, see data, close, double click countries layer, layer properties dialog, box, symbology tab, show box, charts, pie option, dialog box changes to show choices for pie, with the field selection box showing numeric attributes in the table; then in field selection box, click field, hold down control key and click the others, to select more than one field at a time, then click right arrow to add them to right box and a symbol color is assigned to each attribute from the current selected color scheme.

To change colors, in symbol column, right click symbol, then select in color palette for each symbol, click background color square to open the symbol selector, fill color square, color palette, choose, outline color square and select, then okay to get back to layer properties dialog box, at bottom of symbology tab, click size button, to see pie chart size dialog box, change default size, okay, then layer properties dialog box, apply. At the bottom of the layer properties dialog box, click properties to open the chart symbol editor, display in 3D, then under the symbology tab, click size, pie chart size dialog box, change size, okay to close the layer properties dialog box. Click view, layout view.

Ch. 11: Labeling Features

Alabel is any text that names or describes a map feature, including proper names, descriptions, or numbers. ArcMap labels specifically represent values in a layer attribute table . Other text added to a map don't have the same attributes, such as staying close to features associated with it as you zoom in or out, whereas text position relative to feature may change markedly if you zoom or pan the map.

Dynamic labeling allows you to label all features in a layer with a single click, but ArcMap chooses the label positions, which may change if other map layers are added or removed. However, dynamic labels can be converted to annotation, where each label becomes a piece of text that can be independently moved and modified, the best way to control appearance and placement.

Dynamic labels are easy to use because they behave as a group, turn on or off, change symbols, attribute values, etc. But, they may have to be converted to annotation later due to problems.

Open a map with geocoded features, zoom in with bookmarks to see detailed view. In table of contents, right click layer, label features, then go back to table of contents, double click layer, layer properties dialog box, labels tab, to get label field dropdown list to see which field in attribute table is being used for labels. Below are label symbology, fonts, and size. Click color square, color palette, select. Then go to font list, scroll, select, then size dropdown list, select, and then style button. All so new label properties are applied to map.

To add text, use the text tool on the draw toolbar, move mouse over map to get crosshair, then click where want text, type enter. To increase font size, right click the text, context menu, properties dialog box, text tab, change symbol, get symbol selector dialog box, scroll down to label style you want, click okay, okay on properties dialog box. So new properties are applied to text. To move text, move mouse pointer over text to change cursor to four-headed arrow, drag text, release it, then click anywhere else to unselect.

To put dynamic icons on the map, activate layer, then to choose another field in layer attribute to use for labeling, go to table of contents, double click layer, layer properties dialog box, labels tab, label field dropdown arrow, click select, such as name, click okay.

Setting rules for placing labels may have to be done if dynamic labels are not placed in a pleasing position. You can change positions.

Labels for points can occupy any of eight positions around the feature, above, above right, right, below right, below, below left, left, above left.

You can rank positions and prohibit certain ones, like over water. Line feature labels go above, on, or below and can follow curves. Polygon labels, however, always go to the most centered position, matching text to polygons.

Labeling priorities can also be set for each layer in a map, with one layer having priority if they overlap.

To position a label, go to table of contents, double click the layer, layer properties dialog box, labels tab, placement properties dialog box, placement tab. You can then rank each possible position in the dialog box graphic so rank each by number, with 1 as most desirable and so on, or put an 0 to signify that position can't be used.

To change location, click change location, get initial point placement dialog box, click setting for where you want it, click okay, okay placement properties dialog box, close layer properties dialog box. Next, in table of contents, turn on the layer, right click it, label features to label more features, such as a river, so use labeling toolbar, click customize menu, toolbars, labeling, then label priority ranking button, get label priority ranking dialog box, to see map layers listed by labeling priority, then simply move layer to top, then in label priority list, click default, click top arrow to move layer to top, click okay, so an certain layer like rivers will get more rivers labeled.

To change the appearance of labels, in table contents, double click layer, layer priorities dialog box, label tab, symbol, symbol selector, scroll down to label style, select style, click okay, click apply on layer properties dialog box. Move layer properties box away to see new properties applied to labels.

The label display depends on the subtle interrelationship of features, other labels, and the display scale, so even a small change in symbology can make labels appear or disappear.

To make labels follow the curve of lines, click labels tab, placement properties, placement tab, orientation frame, curved, click okay, then close the layer properties dialog box.

You can also make labels scale-dependent so they don't clutter the map as you zoom in. Do this by opening the layer, labels tab, scale range, scale range dialog box, don't show labels when zoomed option, out beyond text box, select number. When focus is off the out beyond text box, it turns into a ratio, okay in layer properties dialog box to close it. So, the label is only visible at scales larger than the selected scale. Check them by zooming in on a bookmark, then click layer.

By default, ArcMap doesn't put labels on top of one another, so depending on scale or zoom, some features may not be labeled, but you can overlap them. See contents tab under desktop help, using interactive labels and creating annotation

The label tool on the draw toolbar allows you to label features one at a time by clicking them. These interactive labels, like annotation, can be put anywhere and changed to your desire. You can specify exact positions or individual symbolization, unlike dynamic labels. To do Tahiti, for example, you must convert labels to annotation, usually at the end to make final adjustments.

Annotation is saved with the map document and can also be saved to a geodatabase, if that's what you're working with. So then you can copy, edit, and add new map documents.

To label a few features in a layer, use the label tool on the draw toolbar, to click a particular feature and have full control over placement and appearance.

Open table of contents, turn on layer, then on draw toolbar, click dropdown arrow by new text tool, tool palette, label tool, label tool options dialog box, choose placement option (you or ArcMap, i.e. automatic best placement), and adjust position later. Then close label tool options, click point to label, to move label, go to tools toolbar, click select elements tool, move mouse pointer over label, to change to four head arrow, drag label to place, right click to open context menu, nudge, or use arrow keys to nudge labels.

To convert to annotation, go to table of contents, right click the layer, convert labels to annotation dialog box, store to geodatabase or in map document. Click option to store in map, click convert. Label position changes slightly and affects the display of other labels, so go to tools toolbar, select elements tool, click on a label and drag it.

Remember to use the refresh view button now and then as you work on anything.

You can add or subtract layers or activate them for users, such as tourism and natural and cultural sites, etc.

Ch. 12: Querying Data

The main strength of GIS, apart from being a glorified computerized cartography, is its ability to store and retrieve information linked to features in an attribute table, though not always symbolized and labeled on the map, but still useful. There are different methods for retrieving information.

Interactive feature selection allows you to retrieve information about a feature by clicking on and highlighting it to display its identity or records in the layer attribute table. The fastest way to get information about a feature is to identify it.

Attribute feature selection allows you to retrieve information by writing a query to select features meeting specific criteria. This is the best way to compare information about several features, selecting the features on the map and then looking at their records in the layer attribute table.

Finding features allows you to retrieve information by inputting a piece and seeing which feature it belongs to. When you have a piece of info but don't know which feature it belongs to, use it to search the map for the feature.

Lastly, hyperlinking allows you to link and access other information beside attributes related to a feature, such as pictures, text documents, or web pages associated through hyperlinks by clicking a hyperlinked feature to open a file on disk, pointing your web browser to a URL, or running a macro, or series of commands. Hyperlinks associate features with things that can't be stored as attribute values, such as web pages.

To study these methods, open a map with layers such as streets and parcels classified as for sale or not. Zoom in, use identify tool to learn more about parcels. Right click neighborhood parcels, on context menu, click zoom to layer, then tool toolbar, identify tool, then click a parcel for identify window with feature attribute values, showing layer name, value and top attribute set as primary display field, such as owner. Identify from dropdown list to pick layer which features you are identifying. By default it is the topmost layer, i.e., the first in the table of contents that contains a feature at the location you click.

Then check a few more parcels and see the info in the identify window changes.

Identify features is the fastest way to access information, but it is not convenient for comparing attributes of several features, so do select features on map, then look at records in layer attribute table.

In the table of contents, click list by selection button. By default all layers are selectable, but you want to select only features from the parcel layer, so click toggle selectable button to move other layers to not selectable category, then click selection menu, selection option. In the selection option dialog box, selection tolerance is set to five pixels, but if working with small features with many others adjacent, reduce tolerance, to ensure when clicking a location, you won't select more than one feature at a time. In the selection tolerance box, replace value of five with zero, click okay, click selection menu, interactive selection methods, add to current selection, on tools toolbar, click select features tool, on map, click each parcel you want to compare, such as for sale, so each parcel is added to the selection set.

If you select a parcel by mistake, click selection menu, interactive selection method, remove from current selection, then click selected parcel to unselect it. In table of contents choose how many parcels are selected and names of parcel owners. Selected parcels are outlined in color and in the attribute table for the layer; records are also highlighted. Right click parcels, click open attribute table, to see highlighted parcels, but if not, click show selected records button. Scroll through the table to the right to see its attributes, compare values for each feature, right click a field name, then on the context menu, click sort descending, then click gray tab to the left of the first record so it is highlighted in yellow as the corresponding map feature. Then close the attribute table. The yellow highlight on the feature disappears, then click selection menu and clear selected features.

Remember, changing the selection color for features and records default selection colors can be done and also be set independently for each layer. See under the contents tab in help and navigate to library, management, data types tables, display, field properties, understanding.

To select features by attribute, interactive selection works when you can see what you're looking for, but to select features according to criteria that you can't see on the map, write a query.

A query selects features that meet specified conditions. A simple query consists of an attribute, a value, and a relationship between them such as greater than or equal to. A complex query connects simple queries with terms like "and" and "or." Relationship terms and connecting terms are called operators. Queries are written in Structured Query Language (SQL).

To build a query, open a dialog box, click an attribute, an operator, and a value. Also, a query wizard lets you write queries by choosing from dropdown lists.

To demonstrate the query method, open a map layer, click selection menu, select by attributes dialog box, layer dropdown arrow, click select field from the layer attribute table appear in fields list near top of dialog box. When field is highlighted, you can display its attribute values in the unique values list on the right, while buttons on left are used to choose operators.

So, the first condition you want to test is the yes value. In field box, scroll to a field, double click it, click equals sign button, click get unique values, box, double click "y" for yes. The query is displayed in the expression box at the bottom of dialog box.

When applying a query, ArcMap searches attribute table for records with same yes value in status field, so corresponding features are selected on map. Click apply, and see on map features with same value.

To write a complex query, in select by attributes dialog box, click the "and" button, then in fields box, double click another value, click equals button, click get unique values, double click a number in the unique values box, so records will be selected on if they have the yes in status and your number in the other field. Click apply, to see fewer features due to added condition.

Then add another condition to query. In select by attributes dialog box, click the and button, in fields box, double click another condition, and use, for instance, the less than button, so in attribute table, only records with yes status, number field and the new conditions are selected. Click apply to see even fewer features selected. To remove a query click clear in the select by attributes dialog box.

To use the find tool to locate an object or feature on map and display attributes, on the tools toolbar, click find tool, find dialog box, features tab, specify layer and field to search in, click in dropdown arrow, layer, search options, infield option, dropdown arrow, select, click find, then ArcMap searches table and displays matching record. Now, locate it on map and get attributes by click a feature in the bottom of search window, features flash in briefly, then on tools toolbar, click identify button, then feature, in identify window, scroll down to find information.

Attribute information is useful but you may also want to use pictures, documents, web pages, and macros hyper linked to features. The attribute table of the layer has a field called IMAGE that contains paths to photos of, for instance, houses for sale, you will hyperlink the features to the photos.

In table of contents, double click layer, layer properties dialog box, display tab, tech support hyperlinks using field, click dropdown arrows, click image, below dropdown list make sure document option is selected, click okay. On tools toolbar, click hyperlink tool, on map hyperlinked features are outlined in blue, click any such feature to display photo of property, which open in the computer’s default image software.

Remember, in creating hyperlinks, there are two ways to go: one is to add document paths or URL addresses to a field in layer attribute table, which is efficient if you are hyperlinking many features. The other is to click a feature and specify the document path or URL, if using just a few hyperlinks, or if it is the only way to hyperlink a feature to more than one object. For more info, click contents in help, library, maps, layers, interacting, then hyperlinks.

To create reports that organize, format, print the information contained in an attribute table, use report generator, which can also add simple reports to the map layout. For more detailed reports, the optional install, Business Objects Crystal Reports (BOCR).

Open map, map layer, click view, point to reports, click create report, report wizard dialog box opens, layer table dropdown list specifying the layer or table you want to work with. Available fields scrolling box lets you choose attributes to include in the report.

You may want some information and not others, so make sure layer table dropdown list shows the feature list, then in available fields box, click a field, click add fields in middle of dialog box, so the field moves from available fields box to the report fields box, in the report viewer contents field dropdown list, so it will be displayed when you preview the report.

To ensure the report contains only data for selected features, click dataset options button, selected set option, okay, next in the report wizards dialog box, next, in fields column. Choose a field from dropdown list and in the sort column, choose ascending from dropdown list. The size of dialog box may be different, but you probably can't see the whole report. The dropdown list at top of dialog box lets you change preview scale. Click next, set orientation to landscape, click next, then select style, have lock is default style, click next, replace text in title box with your title, make sure preview report option is chosen, click finish.

You can preview the report, then print by to send to printer.

To edit a report, click edit button in top left corner of report viewer window, to get report design window, with top right box of report components to customize, then below are element properties associated with highlighted component and other fields. When report component is highlighted, the element is selected in the report template view in the middle, so the template area represents how your report pages will look.

To fit each attribute info on one line, widen the report address column, by clicking the field to highlight it, then in element properties scroll down to layout category and expand size property, in width property, double click current value and replace with new number, enter, click run report button to preview changes.

You can also align headings, click edit button to return the design mode, in template area, click field header component, in element properties under appearance category, change alignment property to right and repeat for other field header components, then click run report, then print if satisfied.

Remember, adding reports to layouts, within a map document, you can add a report to a layout by click add button in report viewer dialog box and load it from the report properties dialog. More info can be found under contents, help, library, mapping, reports, export, loading.

Ch. 13: Joining and Relating Tables

Layer attribute tables contain descriptions of features like names, prices, lengths, etc., as well as spatial information which enables ArcMap to draw a point, line, or polygon in the right place on a map. This spatial information stored in the shape field specifies the type of feature in a layer and defines its location.

However, a layer attribute table information may not have what you want to show, so you may need other attribute tables of information, though they may not have a shape field, just the info. Such a table may be from a database, or what you create yourself, but it can't be used to create a map because it has no feature type or location. This non-spatial attribute table can be connected to a layer attribute table using a table join or a table relate.

A table join appends the attributes of a non-spatial table to the layer attribute table, making one big table.

A table relate keeps the two tables separate but linked, so record selections in one cause corresponding selections in the other.

Both processes depend on making record matches between the two tables. So, the tables need a common attribute, i.e., a field of shared values such as the country field name, since both have it. Thus the record "Mexico" in the non-spatial table can be matched to "Mexico" in the layer attribute table.

Cardinality, i.e., the relationship between tables, determines whether to join or relate tables.

Join tables when each record in the layer attribute table has no more than one matching record in the non-spatial table. Each record in the layer attribute table has just one match in the non-spatial table, e.g., each country has just one capital. But, the reverse is also true, each capital belongs to just one country, so this relationship shows that the table has one-to-one cardinality.

You relate tables when each record in the layer attribute table may have more than one match in the non-spatial table, such as when you select a feature in the layer attribute table, all the matching records in the non-spatial table are also selected. This table one-to-many cardinality shows each record in the layer attribute table having many matches in the non-spatial table, such as cities in a country. By joining such tables, you would lose information, i.e., only one of the matching records for a feature in the non-spatial table could be appended to the layer attribute table.

In joining tables you can use the appended attributes to symbolize, label, query, and analyze the features in a layer.

A non-spatial table of statistics is joined to a layer attribute table of features that can then be symbolized by various attributes.

A table join is preserved only within a map document; the tables remain separate on disk, and can be undone at any time, or you can permanently append attributes by exports a joined layer as a new dataset, discussed in chapter 11.

In our example, open a map layer, click bookmarks, large scale view, zoom in, right click a layer, open attribute table, click show all records button, see attributes already there, then close the attribute table, next on standard toolbar, click add data button, then in add data dialog box, navigate to the data you want, click add, and data table is added to the table of contents. When a table is added to a map, the button at the top of the table of contents switches from list by drawing order to list by source, so paths to disk are shown for all data in the map.

Then, in the table of contents right click the added data table, click open, find the attribute that is the common attribute to be used to join the tables, then in added attribute table, right click common field heading, context menu, click freeze/unfreeze column, scroll to check, see the added data is the last field in the table. The tables should have common attributes, however, if not, a null attribute will be appended to them, with cardinality if just one to one match.

Close added data table, in table of contents, right click original table, on context menu, point to joins and relates, click join, in dropdown list at top of join data dialog box, click join attributes from a table selected, in dropdown list, click down arrow. Click common field attribute; in dropdown list #2, choose added data table; in dropdown list #3, specific common attribute field as common attribute in the added data table, then in join options section, keep all records, then get message if want to build an index for the common attribute field in the added data table, click yes. Thus, ArcMap joins attributes in the added data table to the original table, matching the records by their common attribute.

In the table of contents, right click original data layer, click open attribute table, to see joined table has attributes from both tables, scroll to right to check, then added data will be the right of the common attribute column; to the right of the common field column are the field from the added data table, shown using field aliases, a more user friendly description of the field content, to turn off aliases, click the table options menu, click show field aliases on context menu, resize fields to see entire name, scroll to right to see field you wanted, values are null if there are not matching records.

Close table, in table of contents, double click original data layer to open layer properties dialog box, symbology tab, show box, categories, value field dropdown arrows, scroll to bottom, click data field you want, click add all values button; in value column, see description of field values, which may cut off, so place mouse pointed over value to see whole line. Count column show number of features corresponding to each type of value.

Click symbol column heading, properties for all symbols, get symbol selector dialog box, select style in scrolling box, highlight the default and type in size, color, angles, then in symbology table, uncheck the all other values check box, click color ramp drop down arrow and click basic random scheme, first one in list, and see symbology applied to map. In table of contents, place mouse pointed over labels to see full descriptions.

To relate tables, they should be associated by a relate instead a join when a record in the layer attribute table may have many matches in the non-spatial table. When tables are related, you can highlight records in either table to see matching records in the other.

A non-spatial table is related to a layer attribute table, you can select a feature on the map to see data in the table or select a record in the non-spatial table to highlight a feature on the map.

Click bookmarks menu, zoom in view to see a buffer layer now visible; click windows menu, overview to show the area you’re zoomed to; close overview window, click bookmarks menu, click the point you want; at this scale, the point is labeled with a name; on tools toolbar, click identify tool, click on a point to identify it, and see attributes but perhaps not the data you want which is on a separate table to add to the map document.

Close identify window, on standard toolbar, click add data button, get add data dialog box, navigate to data, click on it, click add, the table to is added to table of contents and list by source tab is selected.

In table of contents, right click the added table, click open, the table has various data field columns, but the common attribute is still the point of feature name; the two tables have a one to many relationship to each, i.e., the added table may have more than one records pertaining the original table features, so you must relate the tables to each other to see all the records.

Close added table, in the table of contents, right click original table layer, joins and relates, relate, dropdown #1 of relate dialog box, click common field name, dropdown #2, choose added table, dropdown #3, choose common field name, as common attribute in the added data table, dropdown #4, highlight default name, type in new one. A relate is established between the two tables.

In table of contents, click list by selection button, under selectable, click toggle for a certain attribute as selectable, others as non selectable; on tools toolbar, click select features tool, on map, click a feature or point to select it, in table of contents right click the original layer, click open attribute table, label options menu, context menu, related tables, click added table, so that attribute table opens in a new tab, to see four or so records match the records for that certain feature selected; so next, close attribute tables, click bookmarks, choose another feature or point, make sure select features tool is still selected on tools toolbar, click the new feature; then, in table of contents, right click original layer, click open attribute table, table options menu, related tables, click added table, so its attribute table opens in a new tab, to see the new feature may have a different number of matching records.

You can use a relate in the other direction also by making a selection on the added table and then seeing which features match it on the original layer are selected.

To do this, at bottom of added table, click show all records button, click the table options menu, context menu, select by attributes, methods set to create new selection, fields scrolling box, double click attribute to start expression, click equals button, click unique values, double click attribute wanted, click apply, see in added attribute table, click show selected records button to show only selected records, to see original layer features with that attribute, in new data table, click table options menu, point to related table, click original layer to see selected attributes of the original table as updates, click title bar to bring forward, close attribute tables, in table of contents right click original layer, point to selection, click zoom to selected features to show them. Then you can make a new layer from the selected features, as discussed in chapter 11 in Ormsby, making a selection layer map.

When you save a map document, joins and relates are saved and restored when you open it. To remove a join, right click the layer with joined attributes, joins and relates, remove joins, name of join, to remove, relate, point to remove relates, click name of relate.

Ch. 14: Selecting Features by Location

To find a feature location by its spatial relationship to another feature or whether it's in the same or a different map layer, there are four types of spatial relationships :

Distance: points are chosen if they are a certain distance from a main point.

Containment: points are contained within a selected polygon.

Intersection: lines intersect a chosen line.

Adjacency: polygons adjacent to a chosen polygon.

There are variations on these main types, totaling thirteen spatial relationships in all, such as containment or complete internal containment of an area within a polygon.

To use a location query is the first step.

To select features by location, choose two layers and specify a spatial relationship. Features in the first layer are then spatially compared to features in the second layer and selected if they satisfy the requirements. If the spatial relationship is distance, choose distance value and measurement units to apply, such as all cities within one mile of rivers. Select in the location dialog box I want to select features form, from the dropdown menu of selection method, then specify layers to search, then the operator of that are within from the spatial relationship dropdown menu, then the operator features in this layer, such as rivers. You also have to apply a search distance. The program calculates all cities that satisfy the relationship.

For more help, click contents, help, library, mapping, layers, interacting, select by location.

The general process is to have a map with layers open, click selection menu, select by location, get selection method, the default which is select features from, in layers box, check layer you want, in list of source layers, click dropdown arrow, select, in spatial selection methods, dropdown arrow, click target layers features within a distance, for example of source layer feature, the check box to apply a search distance to features is checked, and search distance defines distance within which features will be selected, replace distance value with your own, click distance units dropdown arrow, choose units, so now you have specified all features with a certain distance and measurement units so features will be selected if within this distance, then click apply to see features selected on map.

Next, refine the search by choose features from the selected set that meet another criteria. In the select by location dialog box, click selection method dropdown, select form currently selected features, in layers box, leave current layer checked, go to dropdown list of layers, new layers, in list of spatial selection methods, click dropdown, target layers features containing the source layers feature, but leave apply check box for search distance unchecked, so program will examine the selected layer to see which ones also contain second criteria. Those that do will remain selected, those that don't will be unselected, then click apply, close.

To combine an attribute query and a location query is the next method.

Location and attribute queries can be used together to solve a problem, such as finding cities with certain population (attribute query) within a certain distance of a fault line (location query).

In table of contents, turn on a layer with information such as census tracts with income, etc., however, census tracts may overlap your previous layer features. Right click census tract layer, open its attribute table, select column of attributes to use as criteria for location, at top of table, click table options menu, select by attributes, to get method dropdown list set to create a new selection, in fields box, double click the attribute, click greater than sign button, press space bar, type in number, click and button, in field box, double click another attribute, click greater than button, type in another number to get expression of for example census tracts with certain number of households and average yearly income over certain amount, click apply close attribute table, the select by attributes dialog box closes also.

In the display, see census tracts selected by criteria, then turn off previous layer to see just census tracts, then turn previous layer back on and use selected census tracts to selected features they overlap, by click selection menu, select by location, selection method dropdown, select from the currently selected features in, in target layer box, click previous layer check box, in list of source layers, click dropdown arrow, click census tracts, in list of spatial selection methods, click dropdown arrows, click target layers features have their centered in the source layer feature. So, original features with centers in one of the selected census tracts will be selected. Thus, you've found any features that substantially overlap the selected census tracts and thus share their attributes you want.

Then, underneath source layer dropdown list, check box to use selected features is checked, meaning only the features with census tracts layer will be used in the spatial selection, then click apply, close, then in table of contents, turn off census tracts layer, to see original feature with only one feature sleeted according to all four attributes selected.

Then, in table of contents, right click features layer, point to selection, click zoom to selected features, to zoom to that feature, then you can add new layers to show even more attributes such as zoning and buildings, etc.

On standard toolbar, click add data button, add data dialog box, open data such as zoning overlays, and building sites, so two new layers are added to map, then, in table of contents, turn off buildings layer, double click zoning layer to open its layer properties, definition query tab.

Remember a definition query resembles an attribute query in that you write an expression to find features with particular attributes, but the difference is that features satisfying an attribute query are selected, while features satisfying a definition query are displayed and the rest are hidden, so you want only a certain features within a zoning overlay such as commercial.

In definition query tab, click query builder, in field box, double click DESC to add it to expression box, this attribute contain zoning code descriptions, click equals button, click get unique values, double click commercial, click okay, so query is displayed in definition query box, click okay on layer properties dialog box, so now the only features displayed in the layer are those with your commercial zoning request, but then add another criteria such as has shopping center.

On tools toolbar, click zoom in tool, drag zoom rectangle around commercial area containing shopping center, in table of contents, turn off building layer, so now you need to specify buildings to identify them with a certain square footage from the shape area field in the layer attribute table.

Remember, in joining attributes by location, select features in one layer according to spatial relationship to features in other layers. You can use the same kinds of spatial relationships such as containment, distance, and intersection to join the attributes of features on one layer to features in another. This operation, called a spatial join, may also create new attributes such as a count of features in one layer that are contained by features in another layer or distance measurements between features in two layers.

An example is a layer of earthquake points spatially joined to a layer of counties, giving output of county totals for various earthquake attributes. This spatial join is based on containment, creating an output table with attributes of counties layer plus three new ones, with the counties symbolized by number of quakes.

Thus, the same layer of earthquake points is spatially joined to a layer of cities to find the distance from each city to the earthquake nearest it. This spatial join is based on distance, to make output table with attributes of both cities and quakes layers. The location attribute shows the nearest earthquake to each city. The new distance attribute shows how far away the earthquake was.

You do a spatial join in the same way as a table join. In table of contents, right click target layer, the one you are joining attributes to, point to joins and relates, click join, get join data dialog box, choose join data from another layer based on spatial location, then select the join layer, the output layer attributes vary according to the spatial relationship between the target and join layers and the options you choose in the dialog box.

For more help, click contents table, help, library, data management, geographic data types, tables, joining by spatial query, about jointing attributes of features by location.

Ch. 15: Preparing Data for Analysis

Geoprocessing makes new datasets from old ones, using the toolboxes one adds to ArcMap or ArcCatalog. This is usually done after an analysis project that uses several datasets and the plans to process them for a result.

Datasets may have to be massaged because they are either too detailed, too generalized for your map scale, don't have all the attributes you need, or too much data is cluttering the map.

Toolboxes are used to streamline datasets. The first way is by dissolving a group of features with a common attribute into one. Or, secondly, you can trim a dataset to your area of interest using features in one layer to clip features in another. Lastly, there's the old process of simply making a selection on a layer and creating a new layer from it.

A dissolve creates a new layer in which all features in an input layer with the same value for a specified attribute become a single feature, e.g., all states dissolved by sales region.

A new layer's attribute table has a standard geometry called shape, feature identifiers attributes (FIDs), and attributes used in the dissolve regions. Other attributes included are in the input table as an attribute, now summed up in the output table.

The dissolve process begins with go to table of contents, right click layer, open attribute table, see attribute you want to work with, which may've been previously constructed with an operator, x by y, then close table.

Click geoprocessing menu, click search for tools, go to dissolve tool in data management tools toolbox (you can also find a tool in the ArcToolbox window button), in the search window click on data management tools, generalization, dissolve tool, dissolve dialog box, see input features, output feature class, dissolve fields, (each tool has a similar dialog box, but its own functionality and settings and has a show help button; tools with many settings have scroll bar on the right, or you can resize the dialog box, an operation applied to the next tool opened), in dissolve, in input features dropdown list, select a layer, a default path and file names appear for the output data and list of attributes to be dissolved in dissolve fields box.

Output data is saved as a shapefile or geodatabase feature class. Check your sources, click browse next to output feature class box, navigate to source data, double click, type in name in name box, save output feature class info as updated, in dissolve field box, click attribute check box, so each set of polygons will be dissolved into a single feature.

You can also summarize the attribute values of dissolved features by a variety of statistics, such as summarize one attribute by the sum statistic type to total the values of that layer. You can also get the mean, range, and standard deviation, i.e., numeric attributes.

In dissolve dialog box, scroll to statistics field, click dropdown, layer to add to list, so layer name display in the field column, then specify type of statistic in statistic type column, click dropdown, click e.g., SUM.

Tools execute in the background while you continue working. A progress bar at the bottom of the tool window shows percentage of completion and then a notification on the system progress.

A new layer is added to the map. Open the layer, or click add data, go to geodatabase and add layer, then click geoprocessing menu, geoprocessing options dialog box, add results of operations to display box, okay, to add new geoprocessing layers to map. The new geoprocessing layer will have a random color.

In table of contents, right click layer, zoom to layer, right click layer, open attribute table, resize table to show fields, such as attributes, statistical fields. Measurement attributes are automatically maintained for geodatabase feature classes, i.e., shape-length and shape-area.

Use graph wizard to create graphs such as column graph, pie area graph, and scatter graph. Set properties for elements like titles, axes, graph markers, and bars in a bar graph. Save graphs with map document or as file with .grf extension that be added to any map document.

On an existing map, click views menu, graphs, create, value field dropdown, choose type such as SUM-standvalue, also set graph type, vertical is default, default layer, attributes to graph, label the x-axis. Graph changes with updates, in x label field dropdown list, choose, uncheck add to legend, click next, in second panel change default graph title, footer, remove axis titles.

In title box under general graph properties, replace graphs with others, in footer box, type in type, so left axis values display on graph but title does not, make same change to bottom axis, so graphs displays in window floating on application, if resizing graph window, values along left axis change.

Now add graph to map layout by right clicking graph title bar, context menu, add to layout, close graph window, so graph displays in middle of layout page, with blue selection handles, and automatic layout elements such as title and labels. Next, on tools toolbar, select elements tool, drop graph to where you want it, click outside layout page to unselect graph.

To clip layers, i.e., trim features in one layer using boundaries of polygon features from another layer, e.g., you have a shapefile of streets, but just want those within one zip code in the county, use polygon feature of that zip code to clip out just streets you need. Clipping makes smaller datasets to deal with and analyze such as total length of roadways in that one zip code.

First, select layer you want to create new layer with, click list by selection, toggle to which attribute to make not selectable, on tools toolbar, click select features tool, on map click feature to select it, now outlined in cyan, in table of contents, right click layer, create layer from selected features so now new layer added to top of table of contents, referencing same geodatabase feature class. The new selection layer doesn’t create new dataset, but you can, though, export a selection layer or set of selected features as a new dataset.

Click white area of map to deselect feature, click list by drawing order button in table of contents, turn off layer, drag selection layer to bottom of table of contents, go to geoprocessing menu or search for tool in ArcToolbox, search or catalog windows, use clip tool to clip lines in a certain polygon, go to geoprocessing menu, click clip, select layer with input features to be clipped, the layer to clip with, and output feature class, like with dissolve, output of clip can be either shapefile or geodatabase feature class.

In input features dropdown list, choose line, line clip features dropdown, layer selection, browse button next to output feature class dropdown, go to database , in name box, type lines layer, make sure output feature class info is update in clip dialog box, click okay.

After the clip tool finishes processing, get notification, then click clip link to view results window, with summary of input and output layers, parameters, operation, and elapsed time.

After operation, close results window, in table of contents, turn off layer, and look at selected layer with lines clipped to its boundary, added to map this layer is, then in table of contents, right click selected feature layer, open attribute table, to see number of lines reduced from original layer, table has attributes to determine area around lines.

To export data, a dissolve or clip creates new datasets or you can make a new dataset by making a selection on a layer and exporting the selected features.

The process starts with select by location within polygons on original layer, selection menu, select by location, in dropdown box, in box of layers to select from, check the layer, in source layer list, choose, in spatial selection methods, click target features completely within source layer feature, apply.

Then close select by location box, go to table of contents, right click point layer, point to data, export data so export list is set to selected features, or you can use same coordinate system as layer’s source data, click browse button next to output shapefile or feature class box, in saving data dialog box, go to save as type list to set file and personal geodatabase feature classes, go and choose, in name box, choose or write, click okay export data dialog box so export selected points to new feature class, and prompts you too add data to map, click yes.

In table of contents, turn off points layer, so new layer only has points in selected feature, default symbol not informative enough, so in table of contents, double click selected feature layer, in layer properties dialog box, symbol tab, import, okay to import symbology like text, click okay close layer properties dialog box.

Ch. 16: Analyzing Spatial Data

Often it is necessary to solve problems by comparing spatial relationships among features in one or more different layers. This spatial analysis includes distances, systems analysis, etc. The geoprocessing tools in ArcToolbox help to prepare data and analyze it spatially.

A buffer is an area drawn at a uniform distance around a feature, representing a critical zone, like environmental resources or city services. Features in the buffer have a different status from those outside of it.

An overlay shows overlaps between features in two different layers, thus creating a dataset with new features defined by lines of overlap.

In a union overlay, nonoverlapping areas are in the output dataset, which has three types of features: those only in the first layer, those only in second layer, and those created by areas of overlap between the two.

In an intersect overlay, only the overlapping geometry is preserved, and features have attributes from both input layers.

The process can be summed up as: "before overlay," with two layers overlapping; "after union," with a new layer with three features; and, "after intersect," with a new layer with one feature.

Overlay analysis creates new features where input layers overlap.

To buffer features, a buffer is a polygon created in a new layer, which is drawn at a constant distance, like around a point in a layer, or at a distance varying according to attribute values. A buffer can be a concentric ring in multiple distances or intervals. If features are close, tight, the buffers overlay, to keep them as such or join as multiple rings.

The process begins with open ArcToolbox on menu, analysis tools, proximity, double click buffer, name box fill in, output feature info update, buffer distance select, type of unit select, dissolve type select. If buffer polygons overlap, boundaries can be dissolved to make one single feature, okay, buffer tool processes, get pop up notification, click buffer link to view report, results window.

You can change buffer color if needed, by go to table of contents, right click new buffer layer, attribute table, see single record in buffers dissolved into multipart polygon, i.e., a polygon with discontinuous boundaries.

Standard attributes for polygon features are class-object, shape, shape length, and shape area.

To create size buffer dependent on size, go to table of contents, right click layer, attribute table, ArcToolbox, double click buffer, input features dropdown, select, browse button in output feature class box, navigate to layer you want, double click, name box, type in, save, buffer distance, field option dropdown, deselect distance, but don't dissolve buffers as before, click okay, buffer link notification, results report.

So now you have added another new layer to the map. To see at closer scale, close ArcToolbox, click bookmarks, close up, table of contents, right click layer, attribute table, to see attributes also from input table because you didn't dissolve, close attribute table, turn off layer, in table of contents, turn on or off layers as needed in these operations. You can also zoom to layer when one is selected and see buffers.

Overlaying data is done two ways.

A union overlay combines features in two input layers to create a new dataset. You have two polygons, overlapping, to get two new features, total overlap, or areas in either feature that don't overlap.

Union layer attributes include all the attributes of both input layers, however, not every record has a value for each attribute, due to overlaps or exclusions, thus the output table has attributes of both input layers and output features get the attributes values of input features with which they are spatially coincident.

The identifier attribute is called a FID or OID, which are in conflict due to original input attribute of object fields with unique ID number for each features, so you don't want a table with three object i.d. fields, so resolve conflict by renaming input layer fields in union layer, with prefix of FID-, followed by input layer name.

In an intersect overlay, only area of overlap is preserved.

To create a single new feature, intersect layer output table has standard attributes plus those of both input layers, but each attribute is populated in every record.

A union overlay requires both input layers to be polygon layers, but an intersect has input layers can either be polygons layers, or one polygon and one line layer, to crate output of a line layer.

The process begins, go to standard toolbar, click ArcToolbox, analysis tools, overlay, double click union tool, to specify layers to overlay and designate an output feature class, click input features dropdown, select, layer to add to list of layers to be processed in union, click input features dropdown, select another layer, click browse if necessary next to output feature class box, in output feature class dialog box, navigate to layer, in name box, type in new name, save.

By default, the output layer attribute table has the standard attributes plus both input layers attributes, or you can omit input layer identifier attributes, or you can omit all input attributes except the identifier to creates smaller output table convenient to work with and you can later do a join or relate back to the input layer from the common identifier attribute.

To get the original input layer identifier attributes, click join attributes dropdown, click select, okay, so portion completed you now have new layer to map consisting of all buffered areas form the two input layers, defining a new zone. Next, in table of contents, right click one layer, open attribute table, to see that it has standard polygon feature class attributes (object id, shape, shape length, shape area), and also renamed identifier attributes from input layers, FID layer one, FID layer two.

Attributes are not populated for every record in a union attribute table, but identifier attributes are completely populated, every record has the new layer id value and also the original layers values id's, regardless of which input feature is spatially coincident with the output feature.

Thus, the origin layer's object id value has the feature's new identifier and the new layer's FID value coincides spatially with the feature with the same number in the new layer, i.e., the new layer attribute table has a value in it related to the original layers.

You can use this info of which is in and which is out. Click new layer, go to ArcToolbox window, double click union tool, input features dropdown, selection new original layer to the list of input layers, go to browse, output feature class dialog box, navigate and select, in name box, type title, leave join attributes dropdown list set to all, so this time you will include all input attributes in the union layer, okay, so final layer has been added to map.

Then, zoom in to see results of spatial analysis, after looking at attribute table, go to table of contents, right click layer, open attribute table to see original layer input layer attribute renames the object id. If a record has a value other than in this field, it means the output feature coincides spatially with a bigger feature.

Close ArcToolbox, go table of contents, turn off all layers except new one, click bookmarks menu, close up, turn on labels, double click new layer, layer properties dialog box, labels tab, specify method, click label field dropdown, select, okay, so now new polygon is on map. Now, change colors with symbology tools.

To calculate attribute values, you can write an expression to calculate attribute values for all records in a table or just for selected ones. For numeric attributes, the expression can include constants, functions, or values from other fields in the table. For text attributes, the expression can include character strings that you type or text values form other fields.

You now want to adjust value further in new layer, so create a definition query to display new polygons from doing, then recalculate stand values to get new number.

Go to table of contents, double click new layer properties dialog box, click definition query tab, query builder dialog box, fields box, select layer to add it to the expression box, click equals button, click get unique values, select, okay, query displays in the definition query box, okay in layer properties dialog box, on map, only features satisfying query are displayed. The layer attribute table will show only the records corresponding to these features.

Next to update attribute values for those features, go table of contents, right click new layer, open attribute table, to see new records rather than all original ones, values in original layer need to be updated, some of original polygons were preserved intact in new layer but some polygons were overlapped by a buffer, split in the last overlay, resulting smaller polygons have correct area values due to program automatic update shape area attribute, but other values were simply copied over form original table are wrong, to correct values you must multiply the area of each feature by its value per meter.

To do this, right click field name, field calculator, dialog box, double click shape area to add to expression box, click multiplication button, go to fields box again, double click value per meter, so this expression gives you the updated values, but you may have to change values expressed, so click at beginning of expression and type opening parenthesis followed by a space, click at end of expression, type a space by follow by a closed parenthesis, then click division button, type a space, type in number, okay, right click layer field name, click statistics, close window.

In building a spatial model, the last two chapters discussed spatial analysis operations like dissolve, clip, buffer, union with ArcToolbox, steps in a larger analytical process.

Draw a flowchart or diagram and identify goals and analytical steps to it, what data needed, what geoprocessing required, outputs and inputs to new operations.

Modelbuilder can help in this, with design window for spatial analysis operations defined, sequentially connected, carried out, drag drop icons, a workflow diagram tool, processing environment, keep track of operations that you run, results, interdependencies, a way to build a larger project from component parts and run processes. Models can change to incorporate new data, conditions assumptions. Ch. 20 in Ormsby has exercises in Modelbuilder.

Ch. 17: Building Geodatabases

Spatial data organized into features classes in different formats can be managed in ArcCatalog and added as layers to ArcMap, such as shapefiles, coverages, CAD fields, and geodatabases.

A feature class is a group of points, lines, or polygons representing geographic objects of the same kind, such as countries or rivers.

A shapefile is a single feature class, such as a point feature class of cities. A geodatabase, on the other hand, contains sets of feature classes. A world polygon feature class of countries contains a polyline feature class of rivers, cities, and other features.

Coverages and CAD files are sets of feature classes also, but different. A coverage has polygon feature classes representing polygons while an arc feature class represents the same countries as lines.

Thus, a geodatabase has a dataset with different feature classes, a shapefile is an individual feature class, a coverage has an arc, label, polygon, and tci representing the feature class, and a CAD file has point, polygon, polyline, and annotation.

Shapefiles and coverages are products of GIS, but geographers have been using coverages for decades. ESRI did not invent them.

These various spatial data formats are compatible and interconvertible, with spatial data added to a map in a layer, regardless of the source file.

A geodatabase is the most sophisticated spatial data format, though with certain disadvantages. You can store multiple feature classes, annotation labels, and create attribute domains, i.e., valid values or ranges of values for an attribute field to minimize data entry mistakes by prohibiting invalid values, such as open or closed for a water valve status field. Other geodatabase benefits require ArcEditor or ArcInfo.

A field geodatabase stores datasets in a folder of files, up to one terabyte, accessed from a computer, but only edited by one user at a time.

A personal geodatabase uses a Microsoft Access data field, .mdb. Limited to 2 GB, the effective database size is smaller, half a gigabyte, before database performance slows down.

A multiuser geodatabase allows large workgroups or enterprises, with no size limit in file, to do multiple editing, and work with a relational database management system such as Oracle Microsoft SQL Server, etc.

For help, go to contents, help, professional library, data management, geodatabases, overview, types. In ArcCatalog, you can create geodatabases, shapefiles, or coverages, but you need ArcEditor or ArcInfo to also import export data between formats.

The process to make a personal geodatabase and import coverage and shapefile data, begins with go to Arccatalog, catalog tree, double click layer, right click mydata, new, field geodatabase, so now a new personal geodatabase is created in my data folder, name it as you wish, enter, has .gdb file extension. If you can't see the field extension, go to customize, options, general, uncheck field extensions, okay, to import polygon feature class from coverage to your new geodatabase.

In the ArcCatalog display widow, right click .mdb field, import, feature class, to open feature class tool, go catalog tree, double click data folder, select, click polygon feature class, drag it to input features box in dialog box. Drag the polygon icon from the coverage, not the arc, label, or tic files.

So now the path to feature class displays in input features box, in output location box. ArcCatalog assumes that you want to import data to a new geodatabase or you can change output location in output feature class, type name, okay, when operation done, get pop-up notification. Now, coverage polygons are converted to a feature class in your new geodatabase.

Go to catalog tree, expand new geodatabase folder, double click new .gdb layer to see new feature class. If you don't, click view menu, refresh, now preview data, go catalog tree, click feature class, in display window click preview tab.

Now you can also import shapefiles. Go to catalog tree, right click .gdb file, import, feature class, to open feature class to geodatabase tool, in catalog tree, go to folder, find .shp file, drag it to input features box of dialog box, so now its path displays beneath input features box in the first row of a list holding multiple feature classes, now go to another .shp file, drag it to input features box, see its path added to list, output geodatabase box already correctly set to geodatabase, okay, pop-up notification appears, in catalog tree, expand mydata folder, double click .gdb file to see new feature classes, click feature class to preview, click to preview another also, in display window click contents tab.

To create new feature classes you have to define spatial properties, feature classes geometry, such as point, line or polygon and spatial references made up of a coordinate system, a spatial domain, and a precise coordinate system, i.e., a framework for locating features on the earth's surface with latitude/longitude, or xy values.

A spatial domain defines the bounding coordinates for a feature class beyond which those features cannot be entered, so precision defines the smallest measurement made in the coordinate system, e.g., if a coordinate system is feet, a precise of 23 allows measures as small as an inch. Takes of define a spatial reference is simplified by selecting from a list of coordinate systems like statistical sources a TIN surface data model. ArcCatalog will set default domain and precise values for you, you can also import spatial reference from another dataset and modify it.

The process begins with go to ArcCatalog, catalog tree, open source, right click .gdb file, right click database, click paste, then back in ArcCatalog, catalog tree, double click folder, double click geodatabase, right click file geodatabase, point to new, click feature class, open new feature class wizard, in name box, type text, default type is polygon features, or change to line features, then click type dropdown, line features, next, since no coordinate system selected, name is unknown and name box is empty, click import, go browse for coordinate system dialog box, navigate to geodatabase, click a layer, add.

So now the coordinate system imported appears in name box, next, xy tolerance defines minimum distance between two coordinates before considered equal, accept default values, click next, so now database storage configuration enables to fine tune data stored in file geodatabase, accept default option, click next, fifth panel has field names, data types, field properties belongs to new feature class, object and shape require fields, automatically added by software, object field stores unique id number for every feature in the class, shape field stores each feature's shape and location, shapelength field created for line feature classes.

Shapelength fields and shapearea fields are made for polygon feature classes, with shape length attributes for polygons storing perimeter lengths. Measurement fields appear after creating a feature class.

In field name, column, click shape, field properties for shape field displayed, geometry type set to lien by default, click finish, in catalog tree, click plus sign next to geodatabase see a layer added to list of feature classes.

To add fields and domains, create feature class, add field to it to store attribute information, a field is defined by name, data type, like text or integer, properties varying according to data type and spatial data format, such as a domain.

A domain is a list or a range of valid values for an attribute, text, or number, defining values in domain to prevent other values mistakenly added to table, or restrict values for a numeric attribute to a particular range. Unlike other field properties, applying just to the field are define, a domain can apply to more than one field in a feature class and to more than one feature class within a geodatabase processed fields to feature class. After add fields, create domain and apply to the field, domain will ensure no values other than valid ones entered in the attribute table.

The process begins with ArcCatalog, catalog tree, double click folder, right click database, click copy, right click data, paste, in ArcCatalog, catalog tree, double click folder, double click data, double click another .gdb file, so in catalog tree, right click new layer, properties, feature class properties dialog box, fields tab, in field name column type name, install-date in first empty row, (spaces are not allowed in field names), in data type column, click empty cell next to install-date, in dropdown list, click date, in field name column, type line-type in next empty row, in data type column, click empty cell next to line type, dropdown list, click text, okay, now have two attribute fields added, now create domain and apply it, so in catalog tree, right click .gdb field, properties, database properties dialog box, domains tab, domain name column, type name, click first cell in description column, type in text, in domain properties list, default field type value is long integer and domain type is range, field type must match data type of feature class being applied to, since you made a text field, do same here, click long integer value, dropdown list, click text, domain type changes from range to coded values. A coded values domain is used when attribute values you want to enforce are best defined as a list values may be numeric because number are commonly as code in descriptions. A range domain is used when values you want to enforce are quantities with upper and lower limits.

In coded values list, click first empty cell in code column, type letter, click first cell in description column, type text, in next empty cell in code column, type text name as its description, then type another code in net empty code column cell, type text name as its description, okay.

After coded value domain has been applied to feature class, pick from dropdown list of descriptions when you enter attribute values, coded values are stored in the geodatabase, but you only see descriptions in the attribute table, now you have domain, so apply it to field of feature class. In catalog tree, right click feature class, properties, feature class properties dialog box, fields tab, field name column, line type, properties display, field properties list, click empty cell next to domain, dropdown list, click feature name such as line type.

Thus you have a domain and applied it to a feature. Finally, assign the field a default value, so choose default or type in one. Whenever a feature is added to feature class, it will automatically get this value in the field. In field properties frame, click empty cell next to default value, type in code, okay.

You can also set a default value for a field without creating a domain, but if domain is applied, a default value must be a valid domain value.

Ch. 18: Building Geodatabases, Pt. 2

Often spatial data used in a GIS has been digitized from paper maps or aerial and satellite photographs, which involves placing a map or photo on a digitizing tablet, a drawing table connected to a computer, tracing features with a puck, a device like a mouse.

In heads-up digitizing, features are drawn with a mouse directly on the computer screen by tracing an aerial photo, scanned map, or other spatial data. Like drawing a circle around a lake on a satellite image.

Features can also be digitized without tracing, using tools in ArcGIS for creating circles, rectangles, curves, and other shapes of exact dimensions. Points are the simplest features to digitize, with a single click, while lines are complicated because they have a star, end point and may change direction. Polygons are just lines that connect in the end.

Lines begin and end at endpoints; places where a line change direction or are intersected by another line are vertices. The segments between vertices are edges. You only see these when creating or deciding to edit features, looking at its edit sketch. A new feature exists only as an edit sketch until it is saved.

All digitizing to create new features or modify exiting ones are done in the course of an edit session, which begins when you click the start editing menu command on the editor toolbar and ends when you click stop editing command.

After starting an edit session, create features by using features templates, which define all the information required to create a feature, i.e., the layer where a feature will be stored, the attributes a feature is created with, and the default tool used to create that feature, so you are using the editor menu, and create feature icons on it.

A window called create features is the central place to create and manage feature templates. It has three main components, toolbar to manage templates and properties, list of templates used to create new features, and a set of tools used to define the feature's shape, i.e., the window has template options, feature templates, and construction tools.

When digitizing features, you can undo mistakes with the undo button on standard toolbar.

Drawing features is exemplified in the book by the process to create lines for a feature class like water lines. New features are often connected to existing features like boundaries of land parcel adjacent to boundaries already digitized, or new streets intersecting or extending to existing ones, or power lines to and from poles. You can auto automatically connect or snap features placed within a certain distance of each other.

Rules specifying which features, and which features parts, snap to others make up the snapping environment. Distance at which snapping occurs is the mapping tolerance process.

Try to use point data of water values and hydrants determined by GPS to digitize new water lines. Between them, see layer of land parcels, other layers of points, and lines, and parcels in are in table of contents.

Start edit session, by zoom to area to digitize lines, by click bookmarks menu, click layer. Display zooms to area to see points you are connecting. To digitize lines, add editor toolbar and star edit session. On standard toolbar, click editor toolbar, so editor toolbar opens, though tools are disabled; move editor toolbar away from map display; on editor toolbar, click editor menu, start editing, tools now enabled, create features window appears, by default no feature template selected so change target to lines layer; in create features window, click liners template, because lines must snap or connect to each other and other features like the points; set snapping environment before you start digitizing; on editor toolbar, click editor menu, snapping, snapping toolbar, open; remember, the snapping toolbar contains buttons of the main snap types, but additional are available on the snapping menu; as digitize new feature, cursor snaps to existing features according to which boxes are enabled; enabling either the vertex snapping or edge snapping for a point layer makes the cursor snap to point features; the cursor snaps when it comes within a specified distance of a features; to set snapping tolerance, click snapping menu in snapping toolbar, then option; the snap to sketch option in the snapping menu sets snapping rules that an edit sketch uses on itself. It is useful when creating a feature that intersects or connects to itself, such as a boundary line that forms a closed loop.

For more help, go to contents, help, library, data management, editing data, using snapping.

Click end, vertex, and edge snapping buttons to disable them; only point snapping button is left enabled to digitize the line, in create features window, in construction tools panel, click line, move mouse pointer over map display, changes to crosshair, move over a point, when come within snapping tolerance of valve, a circle appears and a name point identifies it; now to digitize line form one point to another, draw a line feature by click once to begin line, again at each vertex, and double click to finish line; when cursor snapped to point, click to start line, move cursor then to second point, edit sketch of line moves with the mouse, an effect known as rubberbanding; feature construction toolbar appears near the cursor, leave set to straight segment; then move cursor over second point, when cursor snaps to lit, double click to end the line; if make mistake, click undo button on standard toolbar; thus, line is created. To add more lines, when cursor still snap to second point, click to begin a new line, move cursor over to third point, when cursor snaps to it, double click to end line so now first line changes color to cyan, then default color of edit sketches to cerulean blue, the color symbolizing your line. Now create third and final line from third point to last point; by move cursor over third point so cursor snaps to it, click to start line, move cursor over to last point, when cursor snaps to it, double click to end line; now view attributes for line just created by with line selected; on editor toolbar, click attributes button, attributes window opens, showing one or more features at a time; use edit tool on editor toolbar to select features to see their attributes, or open attribute table of new line layer in table of contents to view all records; length of each line in feet calculated in shapelength field; length and area attributes mains edit by software accurately measure features in the geodatabase, though not have legal authority; o.s. official utility database would include an as-built length attribute continuing results of edit surveys.

Install date field is null because no attribute values have been entered; line type attributes values have been set to main for all three lines, in accordance with default value for lines specified earlier; default value is not right for the last line digitized, which connect last two points, so in line field, click point, dropdown list, point, now finished digitizing.

Click attribute table, editor toolbar, editor menu, stop editing, yes to save edits; close snapping toolbar and editor toolbar, undock it first if necessary. Edits saved to features class in geodatabase, so any map document containing layer will include new features.

Using feature construction tools, digitize features of polygons like parcels, process the same. Start edit session, set snapping environment, but with different tools; can set lengths and angles of edit sketch edges to precise specifications; also tools to automatic complete operations like finish a square. The process begins with want to draw polygons on satellite photo; use preliminary field measurements to digitize new parcels; can use an exiting map showing parcels displayed against background photo so see what already built and vacant lots; zoom in to your digitized parcel polygon by click bookmarks menu, first parcel site, then standard toolbar, editor toolbar, editor menu, start editing; first need to set snapping setting so boundary lines snap to vertices of existing parcels; so in create features window, parcel feature emp. chosen; editor toolbar, editor menu, snapping, snapping toolbar, vertex button, close snapping toolbar; new parcel share two sides with exiting parcels; so use task called auto complete polygon to digitize features that share boundaries with exiting features, digitize two new sides and ArcMap then finishes polygon; in create features window, click parcels, auto compete polygon in construction tools panel, in table of contents turn of other layer to see parcels more clearly; move cursor over a corner of polygon, so it snaps to its vertex and parcel vertex appears, click to begin polygon; feature construction toolbar appears nearby two boundaries must be aligned with boundaries of existing polygons; so right click on point bounding other polygon to open context menu, parallel, use escape key to close context menu or cancel effect of a menu command; move cursor over map display, without clicking, new line is constrained to parallel to line segment must clicked; with cursor anywhere in display, right click, on context menu, click length, length box, delete existing value type in new number, enter so first side of polygon down, specific length and runs parallel to boundary of adjacent polygon; so now first side of polygon complete pop-up box, type in new value, enter; cursor moves to anticipate next line segment, so move cursor over another point corner of polygon so cursor snaps to its vertex, double click to end line segment, if move cursor away from vertex, right click anywhere, finish sketch in context menu so now all sides of polygon complete automatically using existing parcel boundaries; now add second polygon, table contents, turn on another layer, click bookmarks, zoom, to digitize new polygon parcel but this polygons has no adjacent sides; so change task to polygon in the construction tools panel; use distance coordinates to set, so use distance-distance tool, on sketch tool dropdown palette to choose point of beginning for new polygon; create features window, parcels, polygon in construction tools panel, sketch tool dropdown arrow, distance tool, in table of contents, run off photo layer, move cursor over corner of polygon, click when snaps to vertex, press D key on keyboard, distance pop-up box, type in distance, enter; neo now circle appears on map, center is the vertex you click, with a radius you types in; move cursor over another corner point, click when it snaps to vertex, press D key, distance popup box, new distance, enter, so now second circle is drawn, with radius specified, the circles intersect at two points; in area of intersection, move cursor left and right without clicking; now highlighted dot ids constrained to move from one point of intersection to the other, either could be correct point of beginning, but choose the point you want according to specified need; move cursor to point of origin of polygon, click, now circles disappear, move cursor away slightly, red square make the spot, feature construction toolbar appears, now ready to digitize the parcel, suing field notes detailing lengths and angel of parcel sides; on feature construction toolbar, click straight segment tool, right click on map display, on context menu, click direction, popup box, replace value with new number, enter so now line is constrained to angular direction you set; direction command uses east as zero degrees and measure positive angles counterclockwise.

Note: if direction box incorrect, change setting, on editor toolbar, click editor menu, options, units, direction type to polar; right click anywhere above starting point, on context menu, click length, pop-up box, type in new value, enter, now first side of polygon is complete, starting point changes to a green square and current vertex a red square; now set a direction and length of to create second line segment; right click anywhere to right of red vertex, on context menu, click direction, right click anywhere to right of red vertex, context menu, click length, popup box, type in new value, enter so now second side of polygon is done, to complete last two sides, use square and finish command which completes a polygon b drawing a right angle; right click anywhere below red vertex, on context menu, click square and finish; so now polygon is down.

On editor toolbar, click editor menu, stop editing editing, yes, save edits; in table of contents, turn on subdivisions photo layer, now see have added two polygons to layer, edits saved to feature class in geodatabase updated; close editor toolbar.