

Topic 2

Maps as Data

2.1 Visualizing Map Surfaces

For thousands of years, points, lines and polygons have been used to depict map features. With the stroke of a pen a cartographer could outline a continent, delineate a road or identify a specific building's location. With the advent of the computer, manual drafting of these data has been replaced by the cold steel of the plotter.

In digital form these spatial data have been linked to attribute tables that describe characteristics and conditions of the map features. Desktop mapping exploits this linkage to provide tremendously useful database management procedures, such as address matching, geo-query and routing. *Vector-based* data forms the foundation of these techniques and directly builds on our historical perspective of maps and map analysis.

Grid-based data, on the other hand, is a relatively new way to describe geographic space and its relationships. Weather maps, identifying temperature and barometric pressure gradients, were an early application of this new data form. In the 1950s computers began analyzing weather station data to automatically draft maps of areas of specific temperature and pressure conditions. At the heart of this procedure is a new map feature that extends traditional points, lines and polygons (discrete objects) to continuous surfaces.

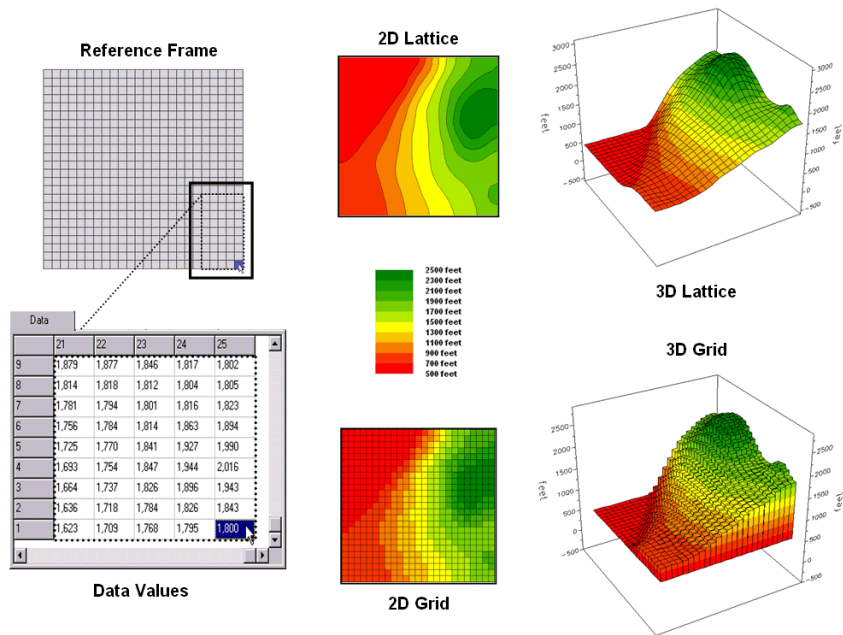


Figure 2-1. Grid-based data can be displayed in 2D/3D lattice or grid forms.

The rolling hills and valleys in our everyday world is a good example of a geographic surface. The elevation values constantly change as you move from one place to another forming a continuous spatial gradient. The left-side of figure 2-1 shows the grid data structure and a sub-set of values used to depict the terrain surface shown on the right-side.

Grid data are stored as an organized set of values in a matrix that is geo-registered over the terrain. Each grid cell identifies a specific location and contains a map value representing its average elevation. For example, the

grid cell in the lower-right corner of the map is 1800 feet above sea level. The relative heights of surrounding elevation values characterize the undulating terrain of the area.

Two basic approaches can be used to display this information—lattice and grid. The *lattice* display form uses lines to convey surface configuration. The contour lines in the 2D version identify the breakpoints for equal intervals of increasing elevation. In the 3D version the intersections of the lines are “pushed-up” to the relative height of the elevation value stored for each location. The *grid* display form uses cells to convey surface configuration. The 2D version simply fills each cell with the contour interval color, while the 3D version pushes up each cell to its relative height.

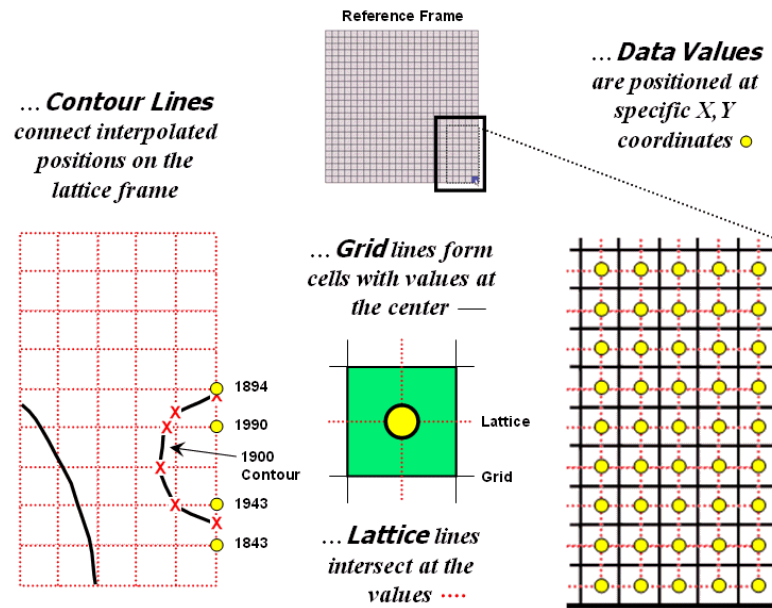


Figure 2-2. Contour lines are delineated by connecting interpolated points of constant elevation along the lattice frame.

The right-side of figure 2-2 shows a close-up of the data matrix of the project area. The elevation values are tied to specific X,Y coordinates (shown as yellow dots). Grid display techniques assume the elevation values are centered within each grid space defining the data matrix (solid black lines). A 2D grid display checks the elevation at each cell then assigns the color of the appropriate contour interval.

Lattice display techniques, on the other hand, assume the values are positioned at the intersection of the lines defining the reference frame (dotted red lines). Note that the “extent” (outside edge of the entire area) of the two reference frames is off by a half-cell. Contour lines are delineated by calculating where each line crosses the reference frame (red X’s) then these points are connected by straight lines and smoothed. In the left-inset of the figure note that the intersection for the 1900 contour line is about half-way between the 1843 and 1943 values and nearly on top of the 1894 value.

Figure 2-3 shows how 3D plots are generated. Placing the viewpoint at different look-angles and distances creates different perspectives of the reference frame. For a 3D grid display entire cells are pushed to the relative height of their map values. The grid cells retain their projected shape forming blocky extruded columns.

3D lattice display pushes up each intersection node to its relative height. In doing so the four lines connected to it are stretched proportionally. The result is a smooth wireframe that expands and contracts with the rolling hills and valleys. Generally speaking, lattice displays create more pleasing maps and knock-your-socks-off graphics when you spin and twist the plots. However, grid displays provide a more honest picture of the underlying mapped data—a chunky matrix of stored values.

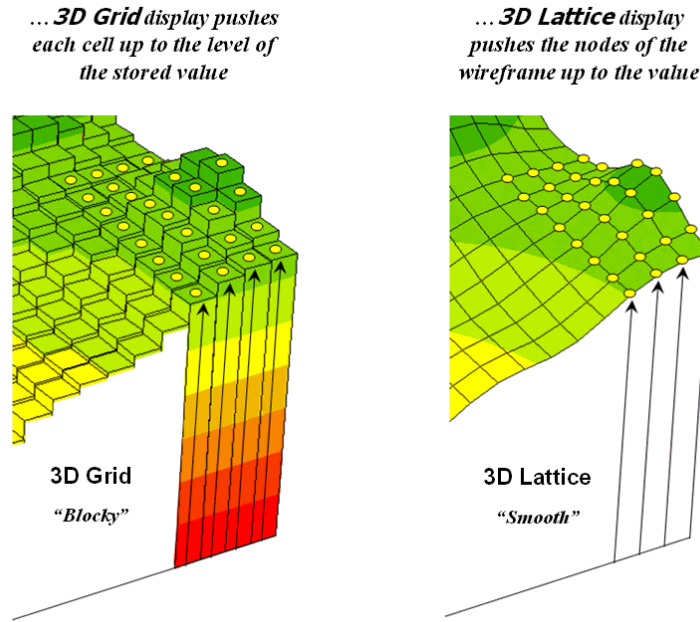


Figure 2-3. 3D display "pushes-up" the grid or lattice reference frame to the relative height of the stored map values.

2.2 Numbers First, Pictures Later

This unconventional view of maps forms the backbone for taking maps beyond mapping. Historically maps involved "precise placement of physical features for navigation." More recently, however, map analysis has become an important ingredient in how we perceive spatial relationships and form decisions.

Understanding that a digital map is first and foremost an organized set of numbers is fundamental to analyzing mapped data. But exactly what are the characteristics defining a digital map? What do the numbers mean? Are there different types of numbers? Does their organization affect what you can do with them? If you have seen one digital map have you seen them all?

In an introductory GIS course, concepts of "vector" and "raster" seem to dominate discussion of what a digital map is, and isn't. Within this context, the location of map features are translated into computer form as organized sets of X,Y coordinates (vector) or grid cells (raster). Considerable attention is given data structure considerations and their relative advantages in storage efficiency and system performance.

However this geo-centric view rarely explains the full nature of digital maps. For example consider the numbers themselves that comprise the X,Y coordinates—how does number type and size effect precision? A general feel for the precision ingrained in a "single precision floating point" representation of Latitude/Longitude in decimal degrees is*...

1.31477E+08 ft = equatorial circumference of the earth
 1.31477E+08 ft / 360 degrees = 365214 ft/degree length of one degree Longitude

Single precision number carries six decimal places, so—

365214 ft/degree * 0.000001= .365214 ft *12 = **4.38257 inch** precision

Think if “double-precision” numbers (eleven decimal places) were used for storage—you almost could distinguish a dust particle on the left from one on the right.

In analyzing mapped data, however, the characteristics of the attribute values are even more critical. While textual descriptions can be stored with map features they can only be used in geo-query. For example if you attempted to add “Longbrake Lane” to “Shortthrottle Way” all you would get is an error, as text-based descriptors preclude any of the mathematical/statistical operations.

So what are the numerical characteristics of mapped data? Figure 2-4 lists the data types by two important categories—numeric and geographic. You should have encountered the basic numeric data types in several classes since junior high school. Recall that *nominal* numbers do not imply ordering. A 3 isn’t bigger, tastier or smellier than a 1, it’s just not a 1. In the figure these data are schematically represented as scattered and independent pieces of wood.

Numeric and Geographic Data Types

...all digital maps are composed of organized sets of numbers– the data type determines what “map-ematical” processing can be done with the numbers on a map, or stack of map layers

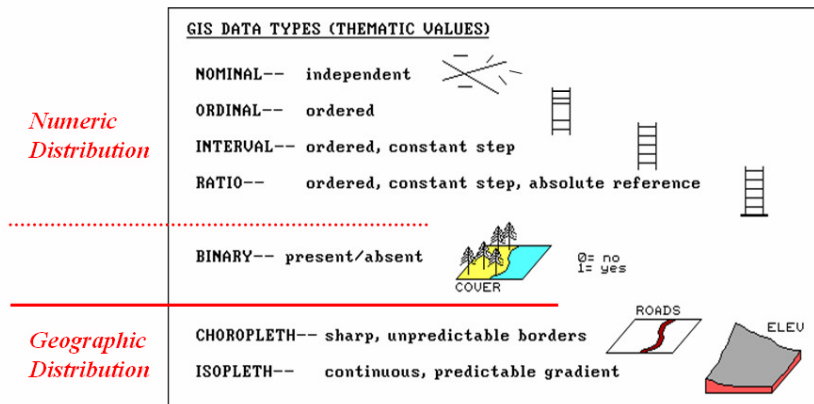


Figure 2-4. Map values are characterized from two broad perspectives—numeric and geographic—then further refined by specific data types.

Ordinal numbers, on the other hand, do imply a definite ordering and can be conceptualized as a ladder, however with varying spaces between rungs. The numbers form a progression, such as smallest to largest, but there isn’t a consistent step. For example you might rank different five different soil types by their relative crop productivity (1= worst to 5= best) but it doesn’t mean that soil type 5 is exactly five times more productive than soil type 1.

When a constant step is applied, *interval* numbers result. For example, a 60° Fahrenheit spring day is consistently/incrementally warmer than a 30°F winter day. In this case one “degree” forms a consistent reference step analogous to typical ladder with uniform spacing between rungs.

A *ratio* number introduces yet another condition—an absolute reference—that is analogous to a consistent footing or starting point for the ladder, analogous to zero degrees “Kelvin” defined as when all molecular movement ceases. A final type of numeric data is termed “*binary*.” In this instance the value range is constrained to just two states, such as forested/non-forested or suitable/not-suitable.

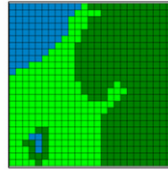
So what does all of this have to do with analyzing digital maps? The type of number dictates the variety of analytical procedures that can be applied. Nominal data, for example, do not support direct mathematical or statistical analysis. Ordinal data support only a limited set of statistical procedures, such as maximum and

minimum. Interval and ratio data, on the other hand, support a full set mathematics and statistics. Binary maps support special mathematical operators, such as .AND. and .OR.

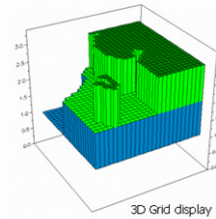
Even more interesting (this interesting, right?) are the geographic characteristics of the numbers. From this perspective there are two types of numbers. “*Choropleth*” numbers form sharp and unpredictable boundaries in space such as the values on a road or cover type map. “*Isopleth*” numbers, on the other hand, form continuous and often predictable gradients in geographic space, such as the values on an elevation or temperature surface.

Discrete versus Continuous Data

Covertypes map— values are independent and represent discrete categories (*independent numbers*); map values form sharp abrupt boundaries in geographic space (*abrupt boundaries*)



2D Grid display



3D Grid display

Discrete

Continuous

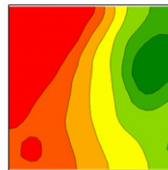
Numeric distribution
Geographic distribution

<i>independent numbers</i>	<i>range of values</i>
<i>abrupt boundaries</i>	<i>spatial gradient</i>

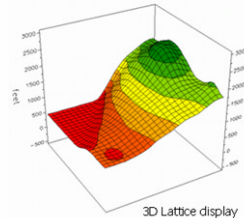
Discrete

Continuous

Elevation map— values form a continuous range with an absolute reference (*range of values*); map values form a continuous gradient in geographic space (*spatial gradient*)



2D Lattice display



3D Lattice display

Figure 2-5. Discrete and Continuous map types combine the numeric and geographic characteristics of mapped data.

Figure 2-5 puts it all together. **Discrete** maps identify mapped data with independent numbers (nominal) forming sharp abrupt boundaries (choropleth), such as a covertypes map. **Continuous** maps contain a range of values (ratio) that form spatial gradients (isopleth), such as an elevation surface. This clean dichotomy is muddled by cross-over data such as speed limits (ratio) assigned to the features on a road map (choropleth).

Discrete maps are best handled in 2D form—the 3D plot in the top-right inset is ridiculous and misleading because it implies numeric/geographic relationships among the stored values. What isn’t as obvious is that a 2D form of continuous data (lower-left inset) is equally as absurd.

While a contour map might be as familiar and comfortable as a pair of old blue jeans, the generalized intervals treat the data as discrete (ordinal, choropleth). The artificially imposed sharp boundaries become the focus for visual analysis. Map-ematical analysis of the actual data, on the other hand, incorporates all of the detail contained in the numeric/geographic patterns of the numbers ...where the rubber meets the map analysis road.

2.3 Framing Maps

The last couple of columns have dealt with the numerical nature of digital maps. Two fundamental considerations remain—data normalization and exchange. **Normalization** involves standardizing a data set, usually for comparison among different types of data. In a sense, normalization techniques allow you to “compare apples and oranges” using a standard “mixed fruit scale of numbers.”

The most basic normalization procedure uses a “goal” to adjust map values. For example, a wildlife manager might set a goal of 75 animals in a 24-hour period to be used in normalizing an animal activity map (see Topic 11 on Surface Modeling). The equation, **Norm_GOAL = (mapValue / 75) * 100**, derives the percentage of the goal achieved by each location in a project area. In evaluating the equation, the computer substitutes a map value for a map location, completes the calculation, stores the result, and then repeats the process for all of the other map locations.

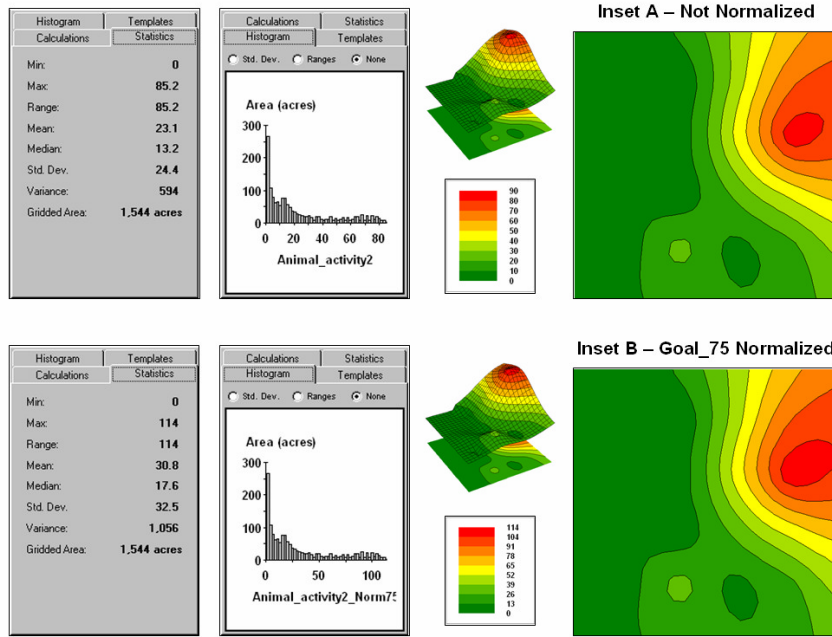


Figure 2-6. Comparison of original and goal normalized data.

Figure 2-6 shows the results of goal normalization. Note the differences in the descriptive statistics between the original (top) and normalized data (bottom)—a data range of 0.00 to 85.2 with an average of 23.1 animals for the original data versus 0.00 to 114.0 with an average of 30.8 percent for the normalized data.

However, the histogram and map patterns are identical (slight differences in the maps are an artifact of rounding for discrete display intervals). While the descriptive statistics are different, the relationships (patterns) in the normalized histogram and map are the same as the original data.

That’s an important point— both the numeric and spatial relationships in the data are preserved during normalization. In effect, normalization simply “rescales” the values like changing from one set of units to another (e.g., switching from feet to meters doesn’t change your height). The significance of the goal normalization is that the new scale allows comparison among different locations based on their individual goals— the “mixed fruit” expression of apples and oranges. Same holds for normalizing precision agriculture, environmental, business, health or any other kind of mapped data.

An alternative “0-100” normalization forces a consistent range of values by spatially evaluating the equation **Norm_0-100 = ((mapValue – min) * 100) / (max – min)**. The result is a rescaling of the data to a range of 0 to 100 while retaining the same relative numeric and spatial patterns of the original data. While goal normalization benchmarks a standard value, the 0-100 procedure rescales the original data range to a fixed, standard range.

A third normalization procedure, termed standard normal variable (SNV) rescales the data based on its central tendency by applying the equation **Norm_SNV = ((mapValue - mean) / stdev) * 100**. The result is a translation of the data to the percent variation from the average. Mapped data expressed in this form enables

you to easily identify “statistically unusual” areas— where +100% locates areas that are one standard deviation above the typical value; -100% locates areas that are one standard deviation below.

Map normalization is often a forgotten step in the rush to make a map, but is critical to a host of subsequent analyses from visual map comparison to advanced data analysis. The ability to easily export the data in a universal format is just as critical. Instead of a “do-it-all” GIS system, *data exchange* exports the mapped data in a format that is easily consumed and utilized by other software packages.

Figure 2-7 shows the process for grid-based data. Recall that a consistent analysis frame is used to organize the data into map layers. The map values at each cell location for selected layers are reformatted into a single record and stored in a standard export table that, in turn, can be imported into other data analysis software.

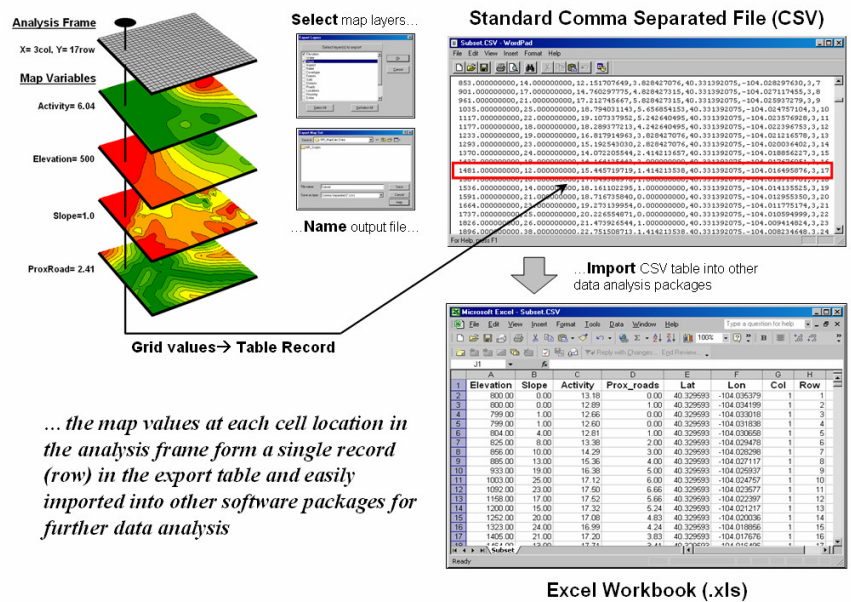


Figure 2-7. The map values at each grid location form a single record in the exported table.

The standard export file can be imported into most statistical packages, such as JMP by SAS. These modern statistical packages “aren’t your father’s” stat experience and are fully interactive with point-n-click graphical interfaces and wizards to guide appropriate analyses. The analytical tools, tables and displays provide a whole new view of traditional mapped data. While a map picture might be worth a thousand words, a few megabytes or so of digital map data is a whole revelation and foothold for site-specific decisions.

2.4 Organizing Raster Data

Map features in a vector-based mapping system identify discrete, irregular spatial objects with sharp abrupt boundaries. Other data types—raster images, pseudo grids and raster grids—treat space in entirely different manner forming a spatially continuous data structure.

For example, a *raster image* is composed of thousands of “pixels” (picture elements) that are analogous to the dots on a computer screen. In a geo-registered B&W aerial photo, the dots are assigned a grayscale color from black (no reflected light) to white (lots of reflected light). The eye interprets the patterns of gray as forming the forests, fields, buildings and roads of the actual landscape. While raster maps contain tremendous amounts of information that are easily “seen,” the data values simply reference color codes that afford some quantitative analysis but are far too limited for the full suite of map analysis operations.

Pseudo grids and raster grids are similar to raster images as they treat geographic space as a continuum. However, the organization and nature of the data are radically different.

A *pseudo grid* is formed by a series of uniform, square polygons covering an analysis area (figure 2-8). In practice, each grid element is treated as a separate polygon—it’s just that every polygon is the same shape/size and they all abut each other—with spatial and attribute tables defining the set of little polygons. For example, in the upper-right portion of the figure a set of discrete point measurements are stored as twelve individual “polygonal cells.” The interpolated surface from the point data (lower-right) is stored as 625 contiguous cells.

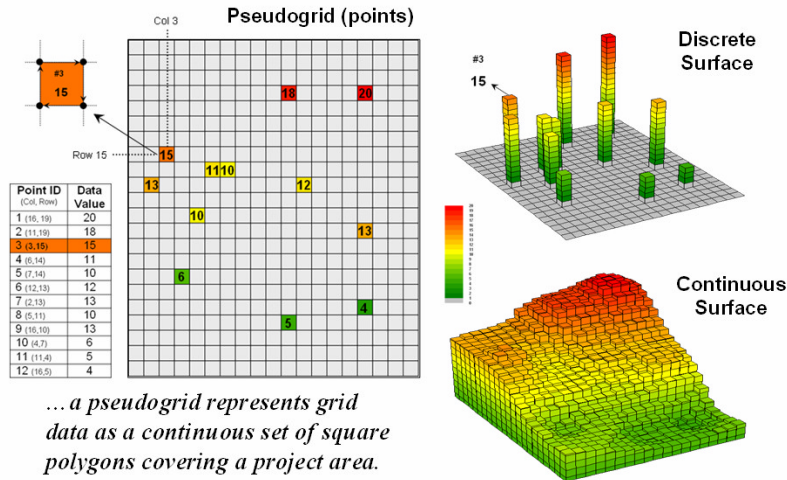


Figure 2-8. A vector-based system can store continuous geographic space as a pseudo-grid.

While pseudo grids store full numeric data in their attribute tables and are subject to the same vector analysis operations, the explicit organization of the data is both inefficient and too limited for advanced spatial analysis as each polygonal cell is treated as an independent spatial object. A *raster grid*, on the other hand, organizes the data as a listing of map values like you read a book—left to right (columns), top to bottom (rows). This implicit configuration identifies a grid cell’s location by simply referencing its position in the list of all map values.

In practice, the list of map values is read into a matrix with the appropriate number of columns and rows of an analysis frame superimposed over an area of interest. Geo-registration of the analysis frame requires an X,Y coordinate for one of the grid corners and the length of a side of a cell. To establish the geographic extent of the frame the computer simply starts at the reference location and calculates the total X, Y length by multiplying the number of columns/rows times the cell size.

Figure 2-9 shows a 100 column by 100 row analysis frame geo-registered over a subdued vector backdrop. The list of map values is read into the 100x100 matrix with their column/row positions corresponding to their geographic locations. For example, the maximum map value of 92 (customers within a quarter of a mile) is positioned at column 67, row 71 in the matrix—the 7,167th value in the list ((71 * 100) + 67 = 7167). The 3D plot of the surface shows the spatial distribution of the stored values by “pushing” up each of the 10,000 cells to its relative height.

In a grid-based dataset, the matrices containing the map values automatically align as each value list corresponds to the same analysis frame (#columns, # rows, cell size and geo-reference point).

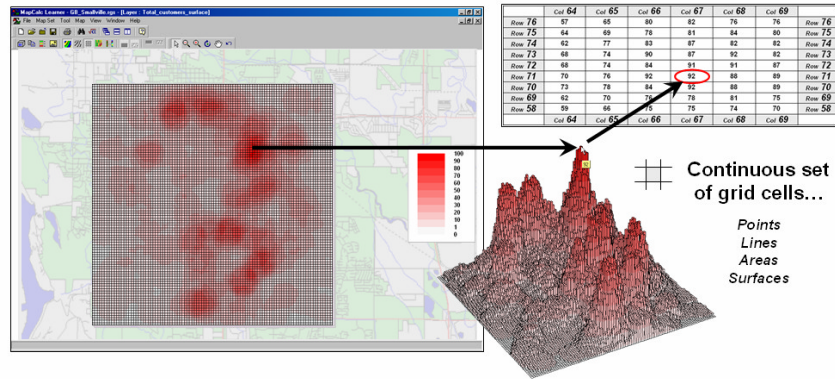


Figure 2-9. A grid-based system stores a long list of map values that are implicitly linked to an analysis frame superimposed over an area.

As depicted on the left side of figure 2-10, this organization enables the computer to identify any or all of the data for a particular location by simply accessing the values for a given column/row position (spatial coincidence used in point-by-point overlay operations). Similarly, the immediate or extended neighborhood around a point can be readily accessed by selecting the values at neighboring column/row positions (zonal groupings used in region-wide overlay operations). The relative proximity of one location to any other location is calculated by considering the respective column/row positions of two or more locations (proximal relationships used in distance and connectivity operations).

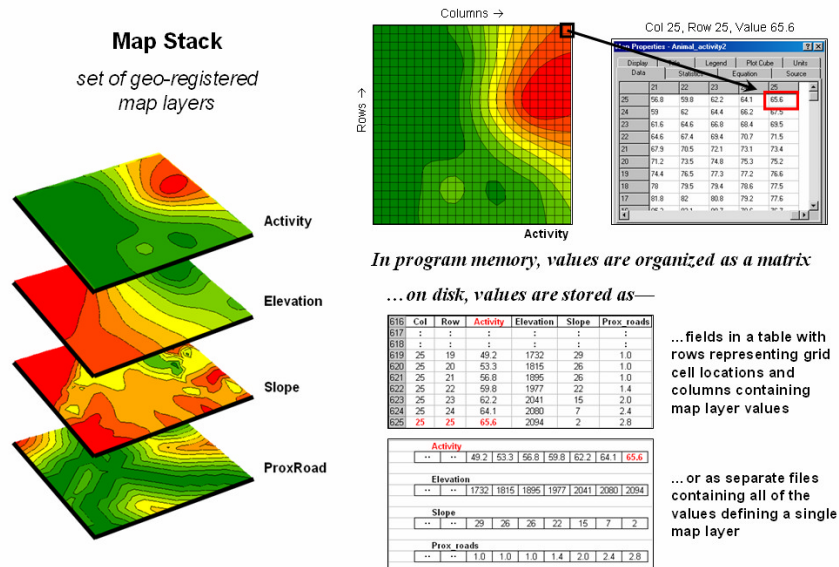


Figure 2-10. A map stack of individual grid layers can be stored as separate files or in a multi-grid table.

There are two fundamental approaches in storing grid-based data—individual “flat” files and “multiple-grid” tables (right side of figure 2-10). Flat files store map values as one long list, most often starting with the upper-left cell, then sequenced left to right along rows ordered from top to bottom. Multi-grid tables have a similar ordering of values but contain the data for many maps as separate field in a single table.

Generally speaking the flat file organization is best for applications that create and delete a lot of maps during processing as table maintenance can affect performance. However, a multi-grid table structure has inherent efficiencies useful in relatively non-dynamic applications. In either case, the implicit ordering of

the grid cells over continuous geographic space provides the topological structure required for advanced map analysis.

2.5 Visualizing Map Values

The digital map has revolutionized how we collect, store and perceive mapped data. Our paper map legacy has well-established cartographic standards for viewing these data. However, in many respects the display of mapped data is a very different beast.

In a GIS, map display is controlled by a set of user-defined tools—not the cartographer/publisher team that produced hardcopy maps just a couple of decades ago. The upside is a tremendous amount of flexibility in customizing map display; the downside is a tremendous amount of flexibility in customizing map display.

The display tools are both a boon and a bane as they require minimal skills to use but considerable thought and experience to use correctly. The interplay among map projection, scale, resolution, shading and symbology can dramatically change a map’s appearance and thereby the information it graphically conveys to the viewer.

While this is true for the points, lines and areas comprising traditional maps, the potential for cartographic effects are even more pronounced for contour maps of surface data. For example, consider the mapped data of animal activity levels shown in figure 2-12. The inset on the left is a histogram of the 625 grid values over the field ranging from 0.0 to 85.2 animals in a 24-hour period. The table describes the individual data ranges used to generalize the data into nine contour intervals.

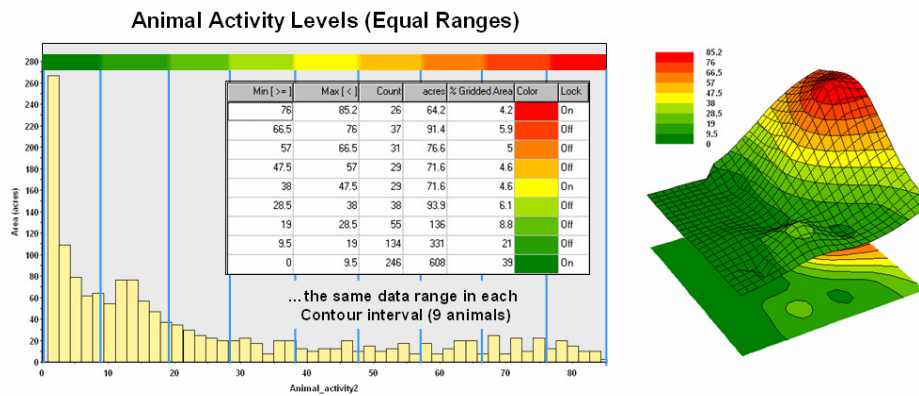


Figure 2-12. An Equal Ranges contour map of surface data.

In this case, the contour intervals were calculated by dividing the data range into nine **Equal Ranges**. The procedure involves: 1] calculating the interval step as $(max - min) / \#intervals = (85.2 - 0.0) / 9 = 9.44$ which rounds to 9.5 step, 2] assigning the first contour interval’s breakpoint as $min + step = 0.0 + 9.5 = 9.5$, 3] assigning the second contour interval’s breakpoint as $previous\ breakpoint + step = 9.5 + 9.5 = 19.0$, and 4] repeating the breakpoint calculations for the remaining contour intervals (28.5, 38.0, 47.5, 57.0, 66.5, 76.0, and 85.2 maximum).

The equally spaced vertical bars in the plot show the contour interval breakpoints superimposed on the map’s histogram. Since the data distribution is skewed toward lower values, significantly more map locations are displayed in green tones— 0 to 19 = 39 + 21 = 60% of the map area assigned to contour intervals one and two. The 2D and 3D displays on the right side of the figure show the results of “equal ranges contouring” of the mapped data.

Figure 2-13 shows the results of applying other strategies for contouring the same data. The top inset uses **Equal Count** calculations to divide the data range into intervals that represent equal amounts of the total map area. This procedure first calculates the interval step as $total\ \#cells / \#intervals = 625 / 9 = 69\ cells$

then starts at the minimum map value and assigns progressively larger map values until 69 cells have been assigned. The calculations are repeated to successively capture groups of approximately 69 cells of increasing values, generating contour intervals that capture about 11% of the data. Note that so many locations are assigned the value 0 (skewed data) that it exceeds the number allocated to the first interval. In this instance the first and second interval must be collapsed into a single interval with 22% of the data.

Notice the unequal spacing of the breakpoints (vertical bars) in the histogram plot for the equal count contours. Sometimes a contour interval only needs a small data step to capture enough cells (e.g., peaks in the histogram); whereas others require significantly larger steps (flatter portions of the histogram). The result is a more complex contour map with fairly equal amounts of colored polygons.

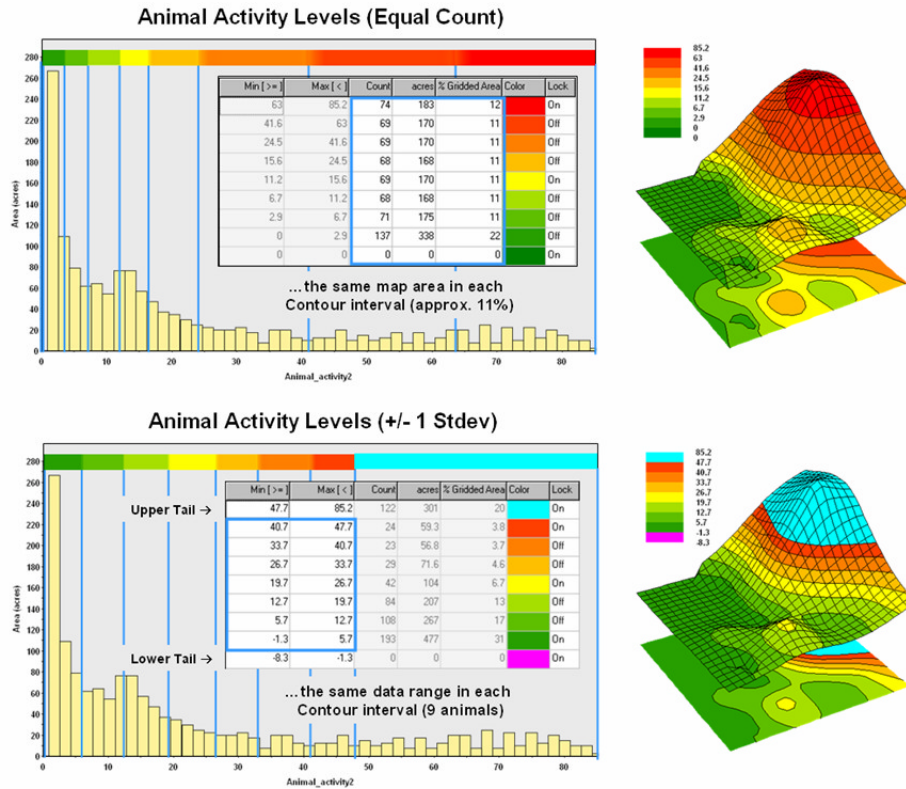


Figure 2-13. Equal Count and +/- 1 Standard Deviation contour maps.

The bottom inset in figure 2-13 depicts yet another procedure for assigning contour breaks. This approach divides the data into groups based on the calculated mean and **Standard Deviation**. The standard deviation is added to the mean to identify the breakpoint for the upper contour interval ($contour\ nine = mean + stdev = 23.1 + 24.4 = 47.5$ to the maximum value) and subtracted to set the lower interval ($contour\ one = 23.1 - 24.4 = -1.3$ to the minimum value). Since the lower breakpoint calculated is below the actual minimum no values are assigned to the first interval.

In statistical terms the low and high contours are termed the “tails” of the distribution and locate data values that are outside the bulk of the data— identifying “unusually” lower and higher values than you normally might expect. In the 2D and 3D map displays on the right side of the figure these locations are shown as blue and violet areas.

The other five contour intervals are assigned by forming equal ranges within the lower and upper contours ($47.5 - (-1.3) = 48.8 / 7 = 6.97$ interval step) and assigned colors green through red with a yellow inflection point. The result is a map display that highlights areas of unusually low and high values and shows the bulk of the data as gradient of increasing values.

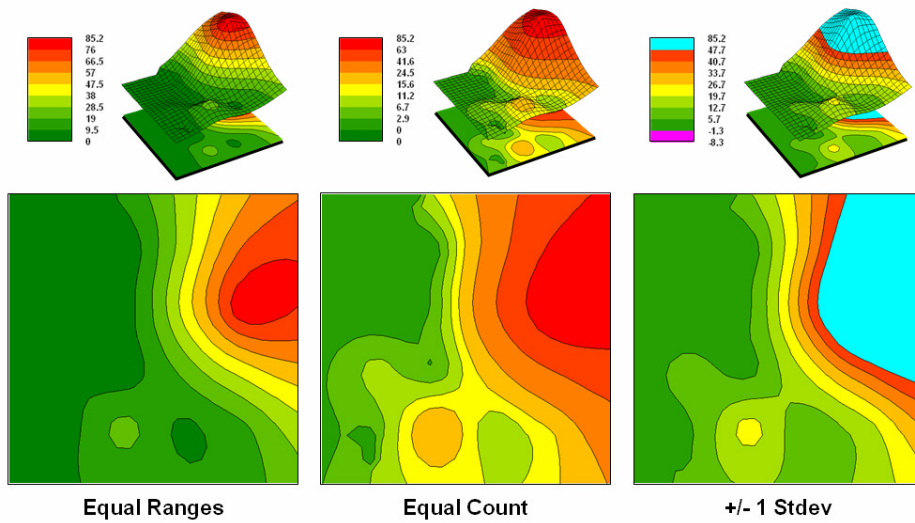


Figure 2-14. Comparison of different 2D contour displays.

The bottom line is that the same surface data generated dramatically different 2D contour maps (figure 2-14). All three displays contain nine intervals but the methods of assigning the breakpoints to the contours employ radically different approaches that generate fundamentally different maps.

So which one is right? Actually all three are right, they just reflect different perspectives of the same data distribution ...a bit of the art in the “art and science” of GIS. The translation of continuous geographic data into discrete 2D maps invariably conjures up the artful interpretation. A good rule of thumb is to be skeptical of the lines on any map that portrays continuous phenomena, such as elevation, proximity, density, exposure or activity. Visualizing and analyzing these data are usually best when the full information content of map surfaces is employed.

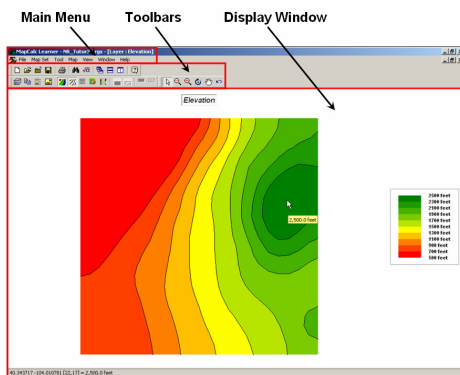
2.6 Exercises


Access *MapCalc* using the *Tutor25.rgs* by selecting **Start** → **Programs** → **MapCalc Learner** → **MapCalc Learner** → **Open existing map set** → **NR_MapCalc Data** → **Tutor25.rgs**. The following set of exercises utilizes this database.


2.6.1 Interacting with Grid Maps


The *MapCalc* user interface consists of three components—*Main Menu* with drop-down lists, *Toolbars* with direct-access buttons and *Display Window* for 2D and 3D plotting of mapped data.


In addition to these basic components special dialog boxes will pop-up depending on the operation selected. The pop-up windows are for specifying input or contain summary reports. The map displays can be easily modified and extensive tools for data summary and analysis are available. This exercise focuses on the basic display capabilities used to visualize grid-based maps.





 In the toolbar section select the *Plus+ Magnifying Glass* button, then click and drag a rectangular area on the map to enlarge the area.

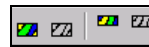
 Select the *Minus - Magnifying Glass* button, then click and slide the cursor vertically up and down to continuously enlarge and reduce the display.


 Select the *Hand* button then click and drag to move the map display in any direction.


 Select the *Rotate* button then click and drag to rotate the 3D plot in any direction.


 Select the *Reset* button to restore the default viewing specification of the map.


 Toggle on and off the *Contour Fill*, *Contour Lines* and *Grid Mesh* buttons. The grid mesh identifies the analysis frame used to store the data.

 Toggle on and off the *Floor* and *Ceiling* projections.


 Toggle on and off the *Use Cells* button to switch between lattice and grid display types. The *lattice* display type “pushes up” the intersections of the grid lines to the relative height of the elevation value stored for each location. The *grid* display type “pushes up” each grid cell centered on a data value to its relative height.

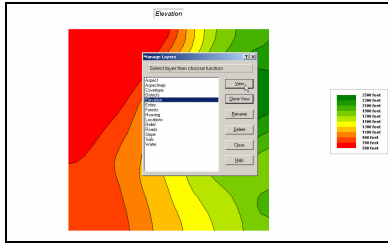
 Toggle on and off the *Data Type* button to switch between continuous and discrete data representation. This will take awhile as each elevation value is being represented as a separate symbol. *Continuous* data encompass a range of values including decimal fractions, such as elevation or soil nutrient maps. *Discrete* data contain integer values that represent distinct categories, such as land use or soil type maps.

 Toggle on and off the *3D View* button to switch between 2D and 3D display.

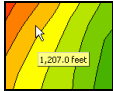
 Spend a few moments switching on and off the *3D View*, *Use Cells* and *Layer Mesh* buttons and note the changes in the map display.

2.6.2 Grid-based Thematic Mapping

 Click on the *View, rename and delete maps* button (binoculars) and note the base maps included in the *Tutor25* database. Select one of the other maps, such as slope, and press the *View* button to display it. Press *Close* to dismiss the listing. Repeat the process to re-display the **Elevation** map.



Confirm that the display is a Continuous 2D Lattice with Layer Mesh off.



As you *Mouse-Over* a map display the map value at each location is reported as the cursor moves.

Column Name	Value	Units
Latitude	40.346843	
Longitude	-104.018395	
Elevation	1,436.0	feet
Water	0.0 - Dry Land	
Slope	43.0	Percent
Aspect	8.0 - NW	
Relief	5.0 - 1300-1...	
Covertyp	3.0 - Forest	
Forests	3.0 - Good	
Soils	2.0 - Lowland	
Districts	2.0 - District 2	
Roads	0.0 - No Road	
Locations	0.0	
Housing	0.0 - No Hous...	
Entire	1.0 - All cells	
Aspectmap	8.0	

Double-click anywhere in a map display to pop-up the *Data Inspection* tool that reports the values for all map layers at the current cursor position (drill-down). Close the pop-up table by clicking on the “X” in the upper-right corner.

40.347045 -104.019300 [15,20] = 1,436.0 feet

Also, note that as you mouse-over the position and value of the displayed map is shown in the lower-left corner of the display window.



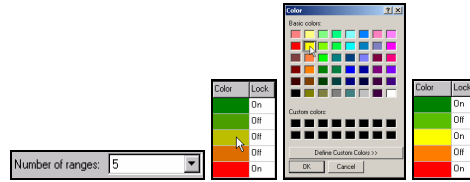
Click on the *Shading Manager* button (or right-click on the display and select *Shading Manager*) to pop-up the map legend editing window.

Min	Max	Count	acres	% Gridded Area	Color	Lock
2300	2500	38	93.851	6.08	Green	On
2100	2300	30	74.053	4.9	Light Green	Off
1900	2100	46	113.698	7.36	Yellow-Green	Off
1700	1900	72	177.823	11.53	Yellow	Off
1500	1700	59	145.716	9.44	Orange	Off
1300	1500	56	138.307	8.96	Red-Orange	On
1100	1300	51	125.958	8.16	Red	Off
900	1100	53	130.688	8.49	Dark Red	Off
700	900	93	229.218	14.73	Dark Red	Off
500	700	128	316.13	20.49	Dark Red	Off

Note that there are 10 contour intervals from 500 to 2500 feet and that each interval step is 200 feet. Also note that the 500 to 700 interval covers most of the project area (128 cells for 316 acres or 20%). The interval is assigned a dark red color.



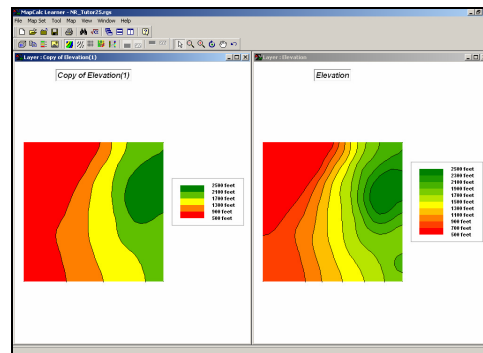
Click on the *Binocular* button and select the **Elevation** map from the listing of map layers and press the *Clone View* button.



Change the *Number of Ranges* from 10 to **5** and note the change in the listing of the contour intervals. Change the *Color Ramp* so the yellow inflection is at the 3rd interval by 1) clicking **Off** the **Lock** by 4th interval, 2) clicking **On** the color block at the 3rd interval, 3) selecting **Yellow** from the color pallet and pressing **OK**. Press **OK** in the shading manager window to finalize the map display.



Click on the *Tile Vertically* button to display all of the open map displays. Minimize the *Total_customer* map so the two displays of the yield data are side-by-side. Note the differences between the two maps—spatial patterns appear to have changed somewhat yet the data is the identical.



Five Intervals

Ten Intervals



Click the *View* (binocular) button and select the **Elevation** map from the listing of map layers and press the *Clone View* button to create another copy of the same data.




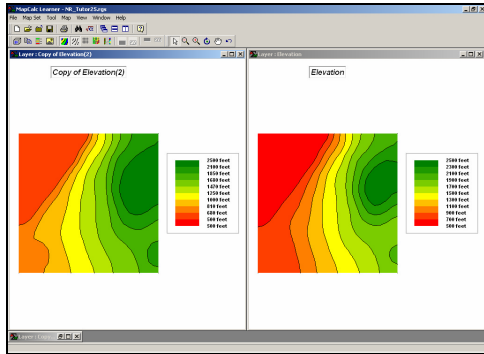
Equal Count

Access the *Shading Manager* and change the *Calculation Mode* from Equal Ranges to **Equal Count**. Note the changes in the contour intervals. In this instance the contour intervals are defined by equal percentages of the map area

(approximately 155 acres each) with the min/max range for each interval varying widely.

Because there is more than 155 acres of the value 500 feet it forms two interval ranges.

 Place the *Equal Ranges* and *Equal Count* displays side-by-side—note the differences in the map appearance, yet the data are the identical.




Min	Max	Count	acres	% Gridded Area	Color	Lock
2100	2500	69	147.944	10.89	Gr	On
1900	2100	59	140.716	9.44	Gr	On
1600	1900	64	158.065	10.24	Gr	On
1470	1600	62	155.995	10.08	Gr	On
1200	1470	61	154.056	9.76	Gr	On
1000	1200	62	153.125	9.92	Gr	On
800	1000	62	153.125	9.92	Gr	On
600	800	62	155.995	10.08	Gr	On
500	600	123	303.761	19.68	Gr	On
500	500	0	0.0	0.0	Gr	On


Equal Count


Min	Max	Count	acres	% Gridded Area	Color	Lock
2300	2500	36	93.891	6.69	Gr	On
2100	2300	30	74.092	4.93	Gr	On
1900	2100	46	117.609	7.36	Gr	On
1700	1900	72	177.823	11.52	Gr	On
1500	1700	59	145.716	9.44	Gr	On
1300	1500	56	138.307	8.89	Gr	On
1100	1300	51	125.958	8.14	Gr	On
900	1100	53	130.898	8.49	Gr	On
700	900	52	127.219	14.72	Gr	On
500	700	128	316.13	20.69	Gr	On

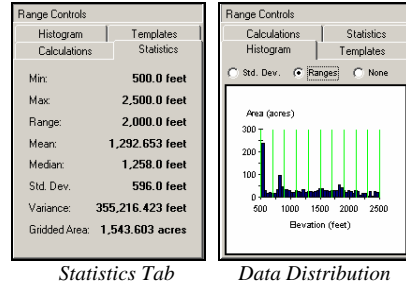
Equal Ranges



 Maximize the *Equal Count* map by clicking on the *Maximize* button (box shape) in the upper-right corner of the display window. Note that each map display is contained in its own window and standard Microsoft Windows procedures are used.

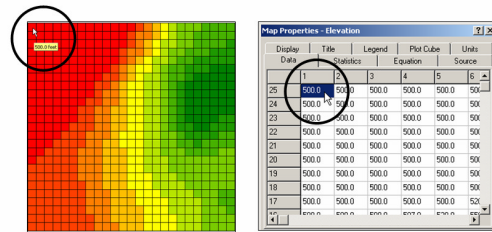
2.6.3 Map Summary Statistics and Charts

 Click on the *Binocular* button and select the **Elevation** map to restore the original display of the elevation data.

 Click on the *Shading Manager* button then the *Statistics* tab for a summary of the map data comprising the yield map. Click on the *Histogram* tab and select the **Ranges** option for a plot of the data distribution indicating the contour interval breaks. Click **OK** to dismiss the shading manager.

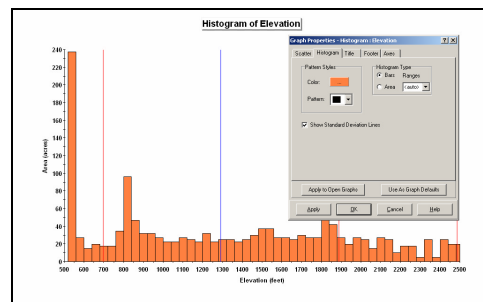


  Click on the *Layer Mesh* and the *Use Cells* buttons to generate a 2D grid display of the data. Mouse-over the upper-left grid cell in field and note the map value stored at this location (500 feet elevation).



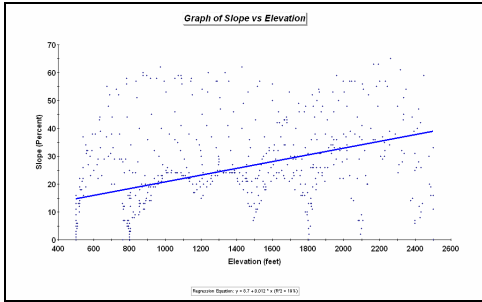
From the Main Menu, select **Map à Properties** then click on the *Data* tab to view the data table. Note that the top-right entry in the table (column= 1, row= 25, value= 500) corresponds to the upper-left cell in the map display.

From the Main menu, select **Map Set à New Graph à Histogram à Elevation** to generate a histogram plot of the data.



Right-click on the plot, then select *Properties* and set the color to *orange* and the pattern to *solid*.

From the Main menu, select **Map Set à New Graph à Scatterplot** à specifying **Elevation** as the X-axis and **Slope** as the Y-axis to generate a scatter plot of the *Elevation* versus *Slope* maps.



Note that a linear regression line is fitted to the data to help visualize the overall numerical relationship between the two map variables (see Topic 12 for more information).

2.6.4 Map Normalization

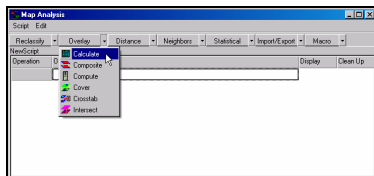
Generate a statistical summary report of the **Elevation** map by right-clicking on the map display and selecting **Shading Manager** > **Statistics** tab.

Range Controls	
Histogram	Templates
Calculations	Statistics
Min:	500.0 feet
Max:	2,500.0 feet
Range:	2,000.0 feet
Mean:	1,292.653 feet
Median:	1,258.0 feet
Std. Dev.:	596.0 feet
Variance:	355,216.423 feet
Gridded Area:	1,543.603 acres

Note the *Min* (500), *Max* (2500), *Mean* (1293) and *Std. Dev.* (596) values for the elevation data.

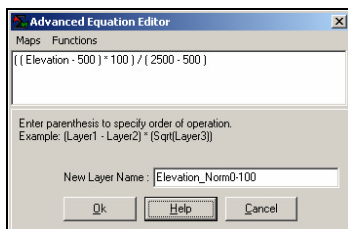


Access the analytical side of MapCalc by clicking on the *Map Analysis* button.



Select the

Overlay group of operators and choose the **Calculate** operation.



Enter the 0

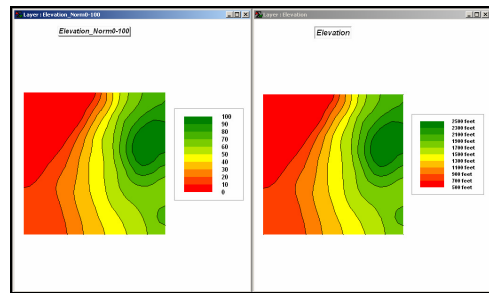
to100 Normalization equation—

$$\text{Norm}_{0-100} = ((\text{mapValue} - \text{min}) * 100) / (\text{max} - \text{min})$$

- 1) selecting **Maps** > then choosing **Elevation**,
- 2) entering the remainder of the equation, and
- 3) specifying **Elevation_Norm0-100** as the *New Layer Name*.

Press the **OK** button to submit the command and create a new map layer. Minimize the *Map Analysis* window to view the full map. Using the **Shading manager**, change the Number of Intervals to 10 and set the 40-50 interval to yellow.

Create side-by-side displays of the normalized and original elevation maps.



Note that the elevation surface has been normalized to the range 0 through 100 but retains an identical geographic pattern (spatial distribution) as the original data.

Min	Max	Count	acres	% Gridded Area	Color	Lock
95	100	38	93.951	6.09	Green	On
85	90	30	74.953	4.8	Dark Green	On
70	80	46	113.609	7.36	Light Green	On
60	70	72	177.823	11.52	Yellow-Green	On
50	60	59	145.716	9.44	Yellow	On
40	50	56	138.307	8.96	Light Yellow	On
30	40	91	226.958	14.72	Orange	On
20	30	52	128.998	8.48	Red-Orange	On
10	20	92	227.218	14.72	Red	On
0	10	128	316.13	20.48	Dark Red	On

Elevation_Norm0-100

Min	Max	Count	acres	% Gridded Area	Color	Lock
2300	2500	38	93.951	6.09	Green	On
2100	2300	30	74.953	4.8	Dark Green	On
1900	2100	46	113.609	7.36	Light Green	On
1700	1900	72	177.823	11.52	Yellow-Green	On
1500	1700	59	145.716	9.44	Yellow	On
1300	1500	56	138.307	8.96	Light Yellow	On
1100	1300	91	226.958	14.72	Orange	On
900	1100	52	128.998	8.48	Red-Orange	On
700	900	92	227.218	14.72	Red	On
500	700	128	316.13	20.48	Dark Red	On

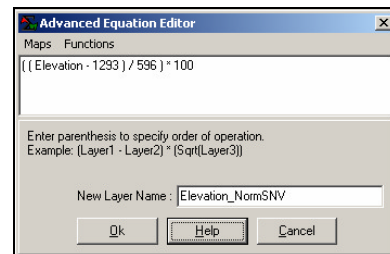
Elevation

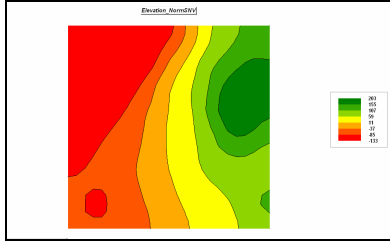
Note that the interval ranges contain the same count/acres (numeric distribution).



Repeat the map analysis process to generate a *Standard Normal Variable (SNV)* normalized map.

$$\text{Norm}_{SNV} = ((\text{mapValue} - \text{mean}) / \text{stdev}) * 100$$

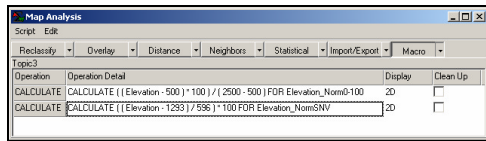




Note that the elevation data has been normalized as percent deviation from the average elevation value. Locations with SNV values less than -100 (red) indicate unusually low elevations; more than +100 (green) unusually high.



Re-access the *Map Analysis* window and note the session log contains the two commands you entered. Double-click on any of the commands causes it to be recalled so you can edit it.



Additional editing capabilities include Copy, Paste, Delete, Reordering, Notes and Pauses to extend the session log into a full featured *Macro Builder* for creating your own processing sequences or spatial models that can be stored and reused in either batch or interactive modes by others.

You can exit the program by selecting **File** à **Exit** or by clicking on the “X” in the upper-right corner of the MapCalc program window. If you want to save your work, specify a new file name, such as *Topic2_exercises.rgs*.

