

Topic 4

Mapping Visual Exposure

4.1 Identifying and Using Visual Exposure

The past several columns have discussed the concept of *effective proximity* in deriving variable width buffers and travel-time movement. The procedures relax the assumption that distance is only measured as “the shortest straight line between two points.” Real world movement is rarely straight as it responds to a complex set of absolute and relative barriers. While the concept of effective proximity makes common sense, its practical expression had to wait for GIS technology.

Similarly, the measurement of *visual connectivity* is relatively new to map analysis but has always been part of a holistic perspective of a landscape. We might not be able to manually draw visual exposure surfaces yet the idea of noting how often locations are seen from other areas is an important ingredient in realistic planning. Within a GIS, detailed maps of visual connectivity have become a reality and are nearing commonplace use.

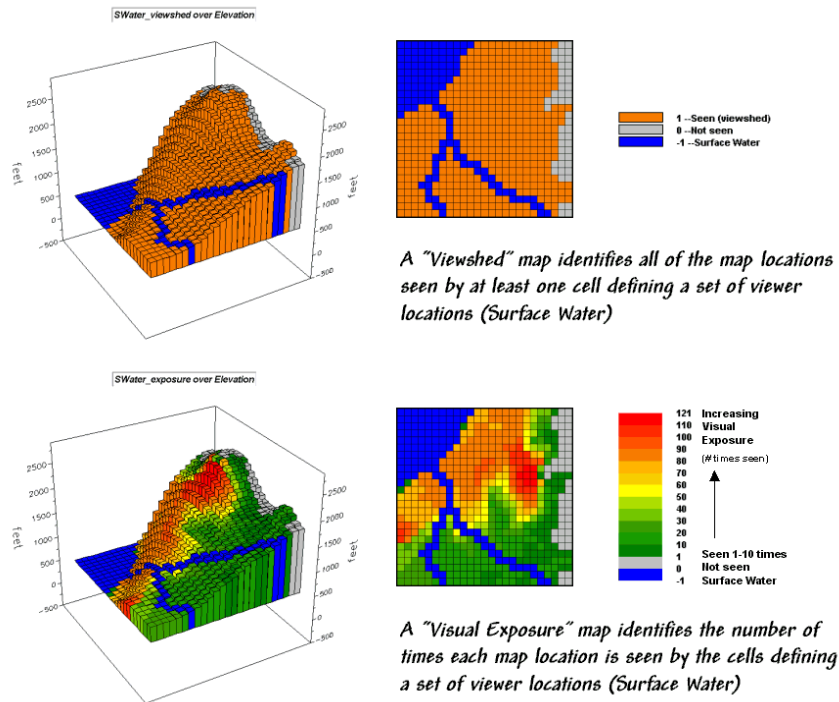


Figure 4-1. Viewshed of all surface water locations.

For example, the *viewshed* map shown in top portion of figure 4-1 identifies all the map locations that are seen (tan) by at least one cell of surface water (dark blue). The light gray locations along the right side of the map locate areas that are not visually connected to water—bum places for hikers wanting a good view of surface water while enjoying the scenery.

The bottom portion of the figure takes visual connectivity a step further by calculating the number of times each map location is seen by the “viewer” cells. In the example there are 127 water cells and one location near the top of the mountain sees 121 of them... very high *visual exposure* to water. In effect, the

exposure surface “paints” the viewshed by the relative amount of exposure—green not much and red a whole lot.

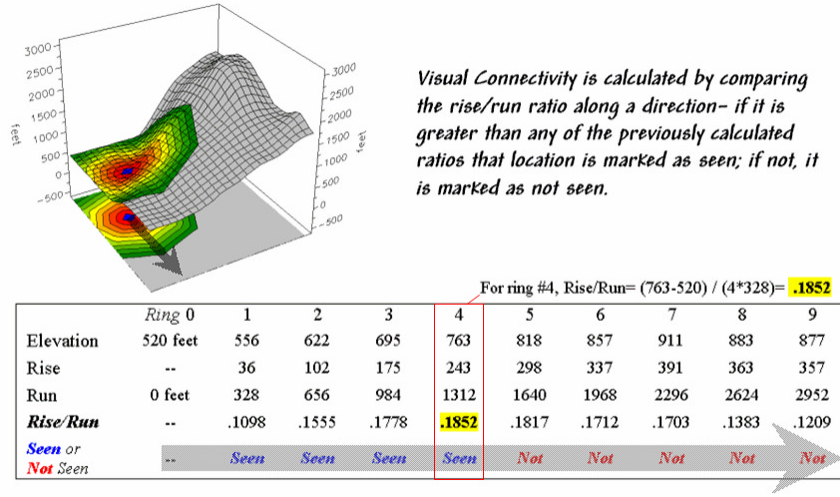


Figure 4-2. Example calculations for determining visual connectivity.

So how does the computer determine visual connectivity? The procedure actually is quite simple (for a tireless computer) and is similar to the calculation of effective proximity. A series of “distance waves” radiate out from a water cell like the ripples from a rock tossed into a pond (see figure 4-2). As the wave propagates, the distance from the viewer cell (termed the *run*) and the difference in elevation (termed the *rise*) are calculated for the cells forming the concentric ring of a wave. If the *rise/run* ratio is greater than any of the ratios for the previous rings along a line from the viewer cell, that location is marked as seen. If it is smaller, the location is marked as not seen.

In the example shown in figure 2, the rise/run ratios to the south (arrow in the figure) are successively larger for rings 1 through 4 (marked as *seen*) but not for rings 5 through 9 (marked as *not seen*). The computer does calculations for all directions from the viewer cell and marks the seen locations with a value of one. The process is repeated for all of the viewer cells defining surface water locations—127 times, once for each water cell. Locations marked with a one at least once identifies the viewshed. Visual exposure, on the other hand, simply sums the markers for the number of times each location is seen.

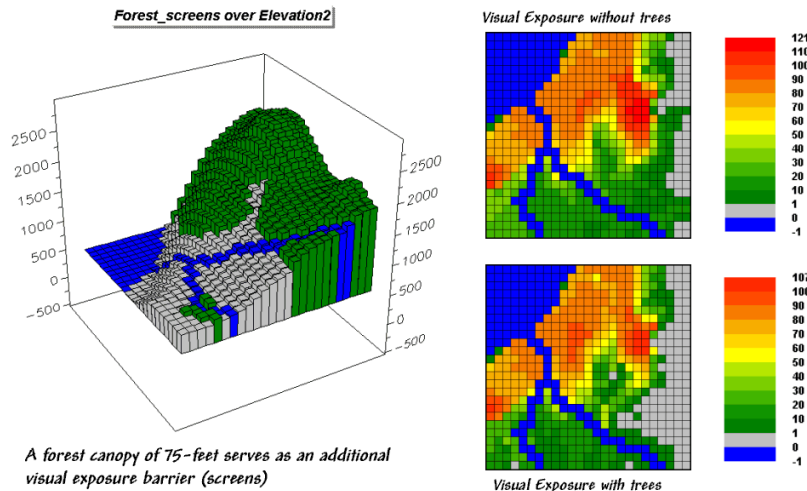


Figure 4-3. Visual screens that block line-of-sight connections can be introduced.

Now let's complicate matters a bit. Suppose there is a dense forest with 75-foot trees that grow like “chia pet” hairs out of the elevation surface. The forest canopy height is analogous to raising the elevation surface an equal amount. But unless you're a bird, your eyeball stays on the ground and the trees act like screens blocking your view.

The 3-D plot in figure 4-3 shows the effect of introducing a 75-foot forest canopy onto the elevation surface. Note the sharp walls around the water cells, particularly in the lower right corner. The view on the ground from these areas is effectively blocked. The computer “knows” this because the first ring's rise/run ratio is very large (big rise for a small run) and is nearly impossible to beat in subsequent rings.

The consequence of the forest screens is shown in the maps on the right. The top one doesn't consider trees, while the bottom one does. Note the big increase in the “not seen” area (gray) along the stream in the lower right where the trees serve as an effective visual barrier. If your motive is to hide something ugly in these areas from a hiking trail along the stream, the adjacent tree canopy is extremely important.

The ability to calculate visual connectivity has many applications. Resource managers can determine the visual impact of a proposed activity on a scenic highway. County planners can assess what is seen, and who in turn can see, a potential development. Telecommunication engineers can try different tower locations to “see” which residences and roadways are within the different service areas.

Within a GIS, users can easily simulate “what if” by changing the locations of the viewer cells and screens then comparing the visual exposure maps generated under the different scenarios—sort of like a visual impact spreadsheet. Like most things in GIS, however, “you ain't seen nothing yet”... more on visual connectivity and its uses next month.

4.2 There's More That Meets the Eye

Last month's column introduced some basic calculations and considerations in deriving visual exposure. An important notion was that “viewer” locations can be a point, group of points, lines or areas—any set of grid cells. In the example described last month, all of the stream and lake cells were evaluated to identify locations seen by at least one water cell (termed a *viewshed*) or the number of water cells seeing each map location (termed *visual exposure*).

In effect, the water features are similar to the composite eye of a fly with each grid cell serving as an individual lens. The resulting map simply reports the line-of-sight connections from each lens (grid cell) to all of the other locations in a project area.

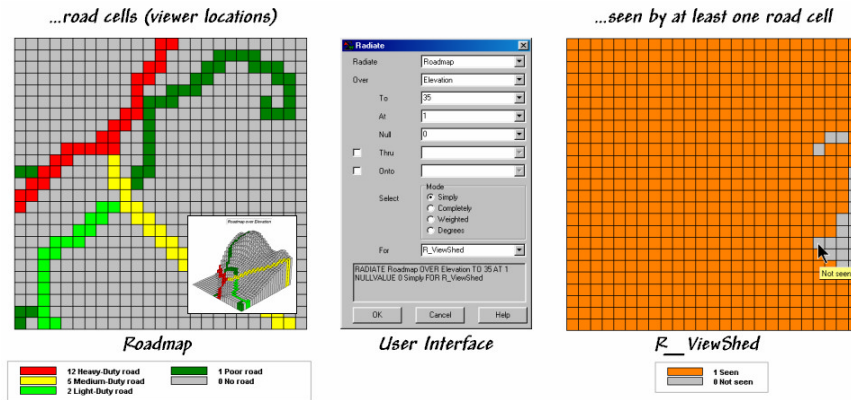


Figure 4-4. Identifying the “viewshed” of the road network.

Figure 4-4 shows a similar analysis for a road network. The cells defining the roads are shown in the map on the left with a draped display on the elevation surface as the inset. The computer “goes” to one of the

road cells, “looks” everywhere over the terrain and “marks” each map location that can be seen with a value of one. The process is repeated for all of the other road cells resulting in the map on the right—a viewshed map with seen (tan), not seen (gray).

The interface in the middle of figure 4-4 shows how a user coerces the computer to generate a viewshed map. In the example, the command *Radiate* is specified and the *Roadmap* is selected to identify the viewer cells. The *Elevation* map is selected as the terrain surface whose ridges and valleys determine visual connectivity from each lens of the elongated eyeball. The *To 35* parameter tells the computer to look upto 35 cells away in all directions—effectively everywhere on the 25x25 cell project area. The *At 1* specification indicates that the eyeball is 1-foot over the elevation surface and the *Null 0* sets zero as the background (not a viewer cell). The *Thru* and *Onto* specifications will be discussed a little later.

As the newer generations of GIS software take hold, more and more systems are replacing their command line interfaces with dialog boxes similar to the one in the example. Clicking on the *Simply* radio button instructs the computer to create a new map specified as *R_ViewShed*—the map displayed on the right in figure 4-4.

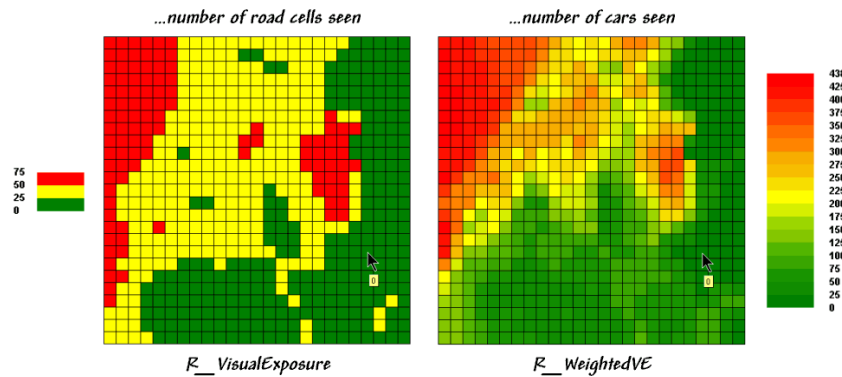


Figure 4-5. Calculating simple and weighted visual exposure.

Locations on the *R_ViewShed* map that didn’t receive any connectivity marks (value 0) are not seen from any road cell. Figure 4-5 shows results using different calculation modes and the resulting maps.

The values on the *R_VisualExposure* map were generated by clicking *Completely* to calculate the number of roads cells that “see” each location in the project area—from 0 (not seen) to 75 times seen. Generally speaking, you put ugly things where the numbers are low and pretty things where the numbers are high.

But just the sum of road cells that are visually connected doesn’t always tell the whole story. Note the values defining the different types of roads on the *Roadmap* in figure 1—1 Poor road, 2 Light-duty, 5 Medium-duty, and 12 Heavy-duty. The values were craftily assigned as “relative weights” indicating the average number of cars within a 15-minute time period. It’s common sense that a road with more cars should have more influence in determining visual exposure than one with just a few cars.

The calculation mode was switched to *Weighted* to generate the *R_WeightedVE* map displayed on the right side of figure 4-5. In this instance, the *Roadmap* values are summed for each map location instead of just counting how many road cells are visually connected. The resultant values indicate the relative visual exposure based on the traffic densities—viewer cells with a lot of cars having greater influence.

Now turn your attention to the *Thru* and *Onto* specifications in the example interface. The *Thru* hot-field allows the user to specify a map identifying the height of visual barriers within the area. In last month’s discussions it was used to place the 50-foot tree canopy for forested areas—the “chia pet” hairs on top of the elevation surface that blocks visual connections. The *Thru* map contains height values for all “screen” locations and effectively adds the blocking heights to the elevation values at each location—0 indicates no screen and 50 indicates a 50-foot visual barrier on top of the terrain.

The *Onto* hot-field is conceptually similar but has an important difference. It addresses tall objects, such as smoke-stacks or towers, that might be visible but not wide enough to block views. In this instance, the computer adds the “target” height when visual connectivity is being considered for a cell containing a structure but the added height isn’t considered for locations beyond. The effect is that the feature pops-up to see if it is seen but doesn’t hang around to block the view beyond it.

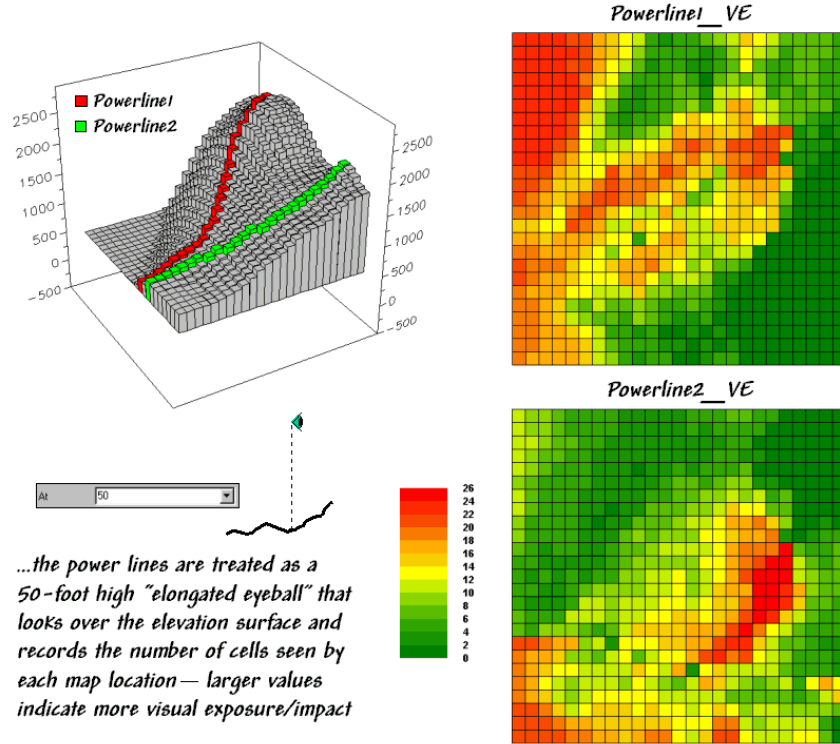


Figure 4-6. Determining the visual exposure/impact of alternative power line routes.

Figure 4-6 depicts yet another way of dealing with extended features. Assume you want to assess the difference in visual impact of two proposed power line routes shown in the 3-D inset in the figure. In this instance, *Powerline1* is first selected as the viewer map (instead of *Roadmap*) and the *At* parameter is set to 50. The command is repeated for *Powerline2*.

These entries identify the power line cells and their height above the ground. The *Powerline1_VE* map shows the number of times each map location is seen by the elongated *Powerline1* eyeball. And by “line-of-sight,” if the power line can see you, you can see the power line. The differences in the patterns between *Powerline1_Ve* and *Powerline2_VE* maps characterize the disparity in visual impact for the two routes. What if your house was in a red area on one and a green area on another? Which route would you favor? ... not in my visual backyard. Next month we’ll investigate a bit more into how models using visual exposure can be used in decision-making.

4.3 Assessing Visual Impact

Last month’s column described several considerations in deriving visual exposure maps. Approaches ranged from a simple *viewshed* (locations seen) and *visual exposure* (number of times seen) to *weighted visual exposure* (relative importance of visual connections). Extended settings discussed included *distance*, *viewer height*, *visual barrier height* and *special object height*.

Figure 4-7 rekindles the important points before tackling visual impact modeling. The maps on the left identify input information for calculating visual exposure. The *PowerLine1* map serves as an elongated

eyeball, the *TreeHeight* map identifies areas with a 75-foot forest canopy that grows like “chia pet” hairs on the *Elevation* surface.

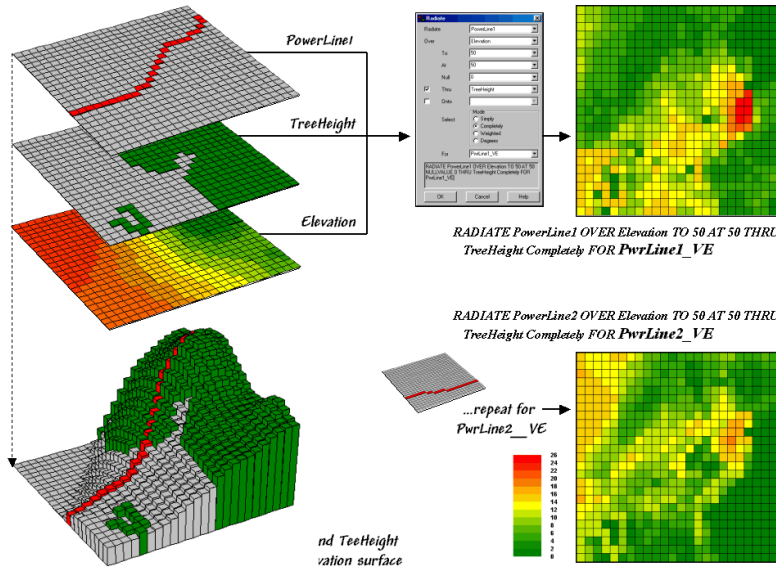
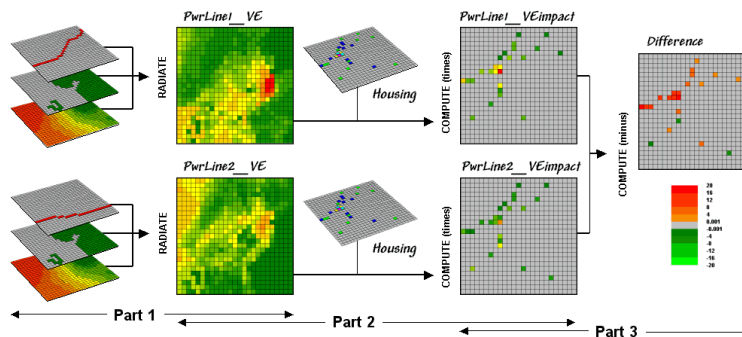


Figure 4-7. Calculating visual exposure for two proposed power lines.

The 3-D inset is a composite display of all three input maps. The user interface shown in the middle is used to specify viewer height (*At 50*) that raises the power line 50-feet above the surface. A large distance value (*To 50*) is entered to force the calculations for all locations in the study area. Finally, the visual exposure mode is indicated (*Completely*) and a name assigned to the derived map (*PwrLine1_VE*).

The top-left map shows the result with red tones indicating higher visual exposure. The lower-left map shows visual exposure for a second proposed power line that runs a bit more to the south. It was calculated by simply changing the viewer map to *PowerLine2* and the output map to *PwrLine2_VE*. Compare the patterns of visual exposure in the two resultant maps. Where do they have similar exposure levels? Where do they differ? Which one affects the local residents more?



Operation	Operation Detail	Display	Clean Up
NOTE	Part 1 – Determine the visual exposure to both power lines for all locations...	2D	<input type="checkbox"/>
RADIATE	RADIATE PowerLine1 OVER Elevation TO 50 AT 50 NULLVALUE 0 THRU TreeHeig...	2D	<input type="checkbox"/>
NOTE	Part 2 – Determine the visual impact of both powerlines for housing areas...	2D	<input type="checkbox"/>
COMPUTE	COMPUTE Housing Times PwrLine1_VE FOR PwrLine1_VEimpact	2D	<input type="checkbox"/>
COMPUTE	COMPUTE Housing Times PwrLine2_VE FOR PwrLine2_VEimpact	2D	<input type="checkbox"/>
NOTE	Part 3 – Computer the difference in visual impact.	2D	<input type="checkbox"/>
COMPUTE	COMPUTE PwrLine1_VEimpact Minus PwrLine2_VEimpact FOR Difference	2D	<input type="checkbox"/>

...the processing flow for determining the relative visual impact involves five command sentences (script)

Figure 4-8. Determining visual impact on local residents.

This final question requires a bit more processing to nail down—locating the residential areas, “masking” their visual exposure and comparing the results. Figure 4-8 outlines a simple impact model for determining the exposure difference between the two proposed routes. The visual exposure maps on the left are the same as those in figure 1 and serve as the starting point for the impact model.

The *Housing* map identifies grid cells that contain at least one house. The values in the housing cells indicate how many residences occur in each cell—1 to 5 houses in this case; a 0 value indicates that no houses are present. This map is multiplied by the visual exposure maps to calculate the visual impact for both proposed routes (*PwrLine1_VEimpact* and *PwrLine2_VEimpact*). Note that exposure for areas without a house result in zero impact—0 times any exposure level is 0. Locations with one house report the calculated exposure level—1 times any exposure level is the same exposure level. Locations with more than one house serve as a multiplier of exposure impact—2 times any exposure level is twice the impact. The final step involves comparing the two visual impact maps by simply subtracting them. The red tones on the *Difference* map identify residential locations that are impacted more by the *PowerLine1* route—the higher the value, the greater the difference in impact.

The dark red locations identify residents that are significantly more effected by route 1—expect a lot of concern about the route. On the other hand, there are only three locations that are slightly more affected by route 2 (dark green; fairly low values).

The information in the lower portion of figure 4-8 is critical in understanding GIS modeling. The conceptualization of a spatial problem, such as visual impact on residents, must be translated into a sequence of map analysis operations. In this instance, there are three parts— 1) visual exposure, 2) visual impact and 3) comparison. Each of the sentences in the script shown at the bottom of the figure is entered via a command dialog box similar to the one in figure 1. The script can be saved, edited and re-run at a later time or on another project area.

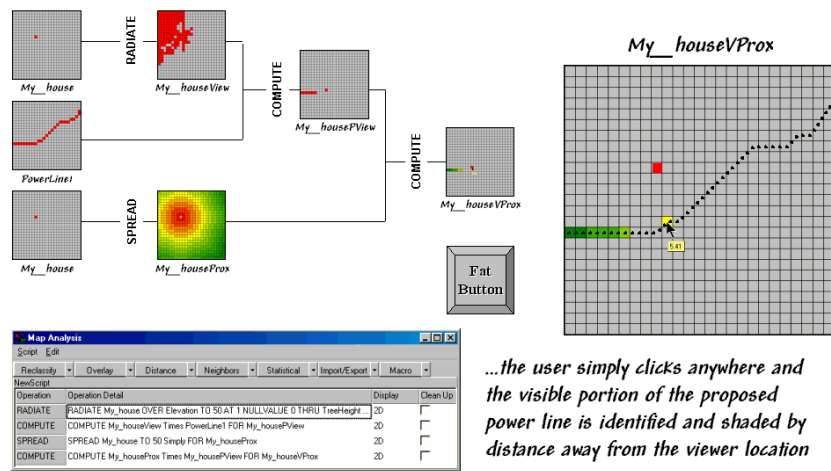


Figure 4-9. Determining visible portions of a proposed power line.

The ability to save and re-run a map analysis sequence sets the stage for the current revolution in GIS technology. Figure 4-9 shows another simple impact model that determines the visible portion of a power line route and its distance from any location.

The flowchart shows the logical structure of the analysis and the intermediate maps generated—

- Ü Calculate the viewshed from the selected point
- Ü Mask the portion of the route within the viewshed
- Ü Calculate proximity from the selected point
- Ü Mask the proximity for just the proportion of the route.
- Ü

The script identifies the four sentences that solve the spatial problem. The revolution is represented by the “Fat Button” in the figure.

Within a GIS, the *fat button* calls a command script that dutifully executes the stored commands. In this example, the user would push the fat button and the program would direct them to “click anywhere on the base map.” Once the location is set, the *My_house* map is defined and the script is run for that location. The next thing the user would see is the final map indicating the visible portion of the route and how far away it is. Click on another location and its result is displayed.

The ability to pop-up special input interfaces and launch command scripts moves the paradigm of a “GIS Toolbox” to one of “Application-specific” solutions. With the advent of COM-object modules the entire application can be moved outside of the GIS. The bottom line is to expect to see a lot of map analysis applications taking hold in places you never dreamed. Heck, they could be links within an impact statement that encourages a reader to “click anywhere on the base map” to see what you would see.

4.4 Visual Vulnerability

The previous sections introduced fundamental concepts and procedures used in visual analysis. As a quick review, recall that the algorithm uses a series of expanding rings to determine relative elevation differences from the viewer position to all other map locations. Elevation differences that are less than those in previous rings are not seen.

The top portion of figure 4-10 illustrates the procedure. The ratio of the elevation difference (*rise* indicated as striped boxes) to the distance away (*run* indicated as the dotted line) is used to determine visual connectivity. Whenever the ratio exceeds the previous ratio, the location is marked as seen (red); when it fails it is marked as not seen (grey).

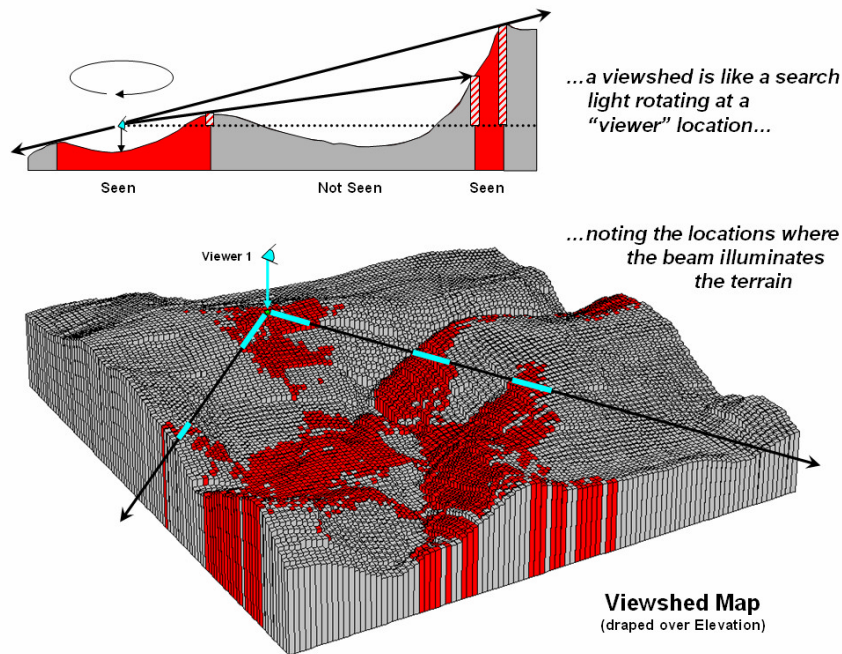


Figure 4-10. Calculating a viewshed map.

To conceptualize the procedure, imagine a searchlight illuminating portions of a landscape. As the searchlight revolves about a viewer location the lit areas identify visually connected locations. Shadowed areas identify locations that cannot be seen from the viewer (nor can they see the viewer). The result is a **viewshed map** as shown draped over the elevation surface in figure 4-10. Additional considerations, such as tree canopy, viewer height and view angle/distance, provide a more complete rendering of visual

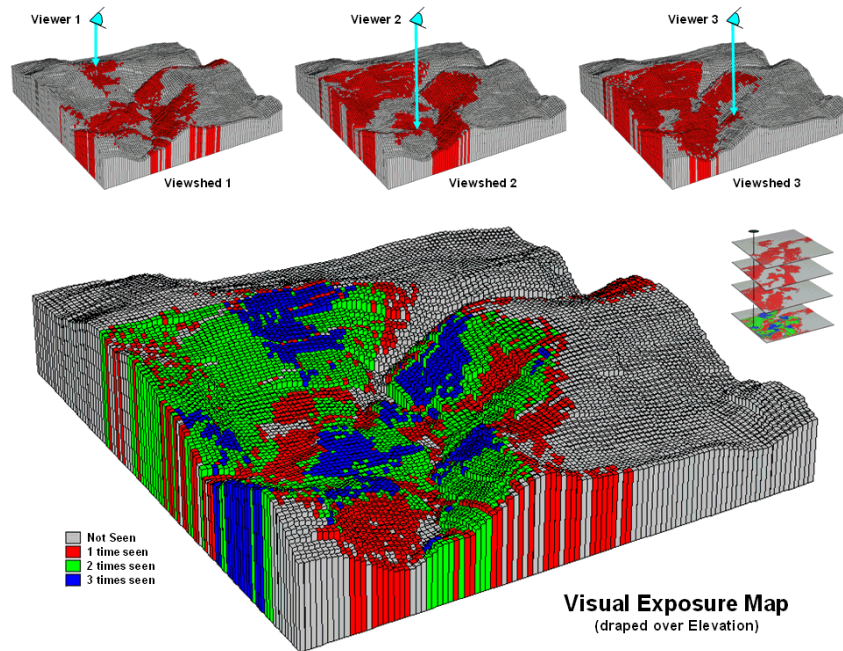


Figure 4-11. Calculating a visual exposure map.

connectivity.

The top portion of figure 4-11 shows the viewsheds from three different viewer locations. Each map identifies the locations within the project area that are visually connected to the specified viewer location. Note that there appears to be considerable overlap among the “seen” (red) areas on the three maps. Also note that most of the right side of the project area isn’t seen from any of the locations (grey).

A **visual exposure** map is generated by noting the number of times each location is seen from a set of viewer locations. In figure 4-11 this process is illustrated by adding the three viewshed maps together. The resulting visual exposure map in the bottom of the figure contains four values—0= not seen, 1= one time seen, 2= two times seen and 3= three times seen—forming a relative exposure scale.

The top portion of figure 4-12 shows the result considering the entire road network as a set of viewer locations. In addition, the different road types are weighted by the number of cars per hour. In this instance the total “number of cars” replaces the “number of times seen” for each location in the project area.

The effect is that extra importance is given to road types having more cars yielding a **weighted visual exposure map**. The relative scale extends from 0 (not seen; grey) to 1 (one car-location visually connected; dark green) through 12,614 (lots and lots of visual exposure to cars; dark red). In turn, this map was reclassified to identify areas with high visual exposure—greater than 5,500 car-locations (yellow through red)—for a map of **visual vulnerability**.

A visual vulnerability map can be useful in planning and decision-making. To a resource planner it identifies areas that certain development alternative could be a big “eyesore.” To a backcountry developer it identifies areas whose views are dominated by roads and likely a poor choice for “serenity acres.” Before visual analysis procedures were developed, visceral visions of visual connectivity were conjured-up with knitted-brows focused on topographic maps tacked to a wall. Now detailed visual vulnerability assessments are just a couple of clicks away.

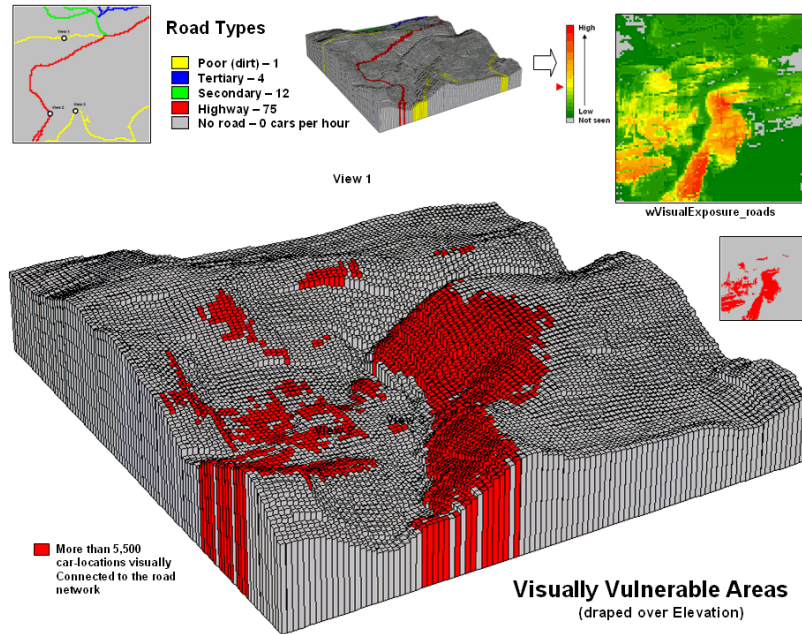


Figure 4-12. Calculating a visual vulnerability map.

4.5 Visual Aesthetics

The previous section described procedures for characterizing *visual vulnerability*. The approach identified “sensitive viewer locations” then calculated the relative visual exposure to the feature for all other locations in a project area. In a sense, a feature such as a highway is treated as an elongated eyeball similar to a fly’s compound eye composed of a series of small lenses—each grid cell being analogous to a single lens.

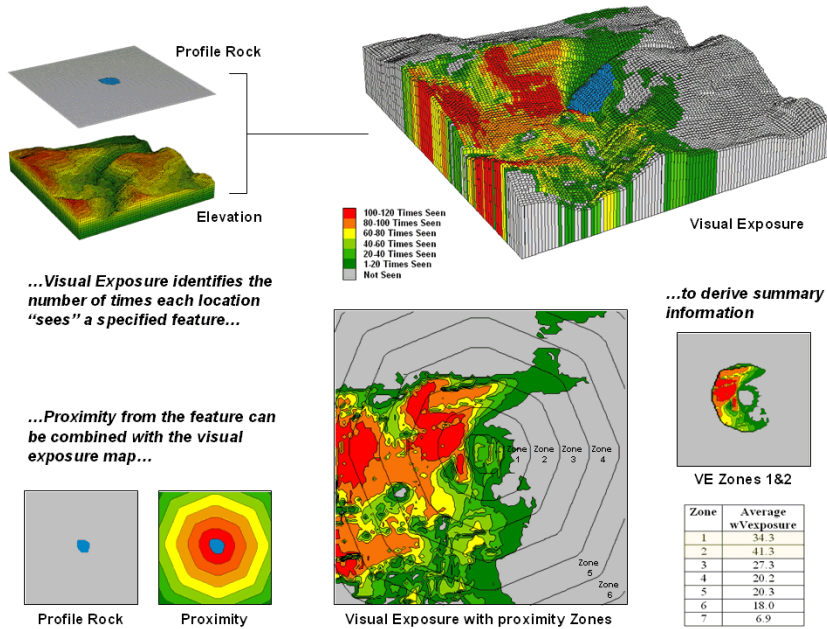


Figure 4-13. Visual connectivity to a map feature (Profile Rock) identifies the number of times each location sees the extended feature.

In figure 4-13, Profile Rock is composed of 120 grid cells positioned in the center of the project area. In determining visual exposure to Profile Rock, the computer calculates straight line connectivity from one of its cells to all other locations based on its relative position on the elevation surface. Depending on the unique configuration of the terrain some areas are marked as seen and others are not.

The process is repeated for all of the cells defining Profile Rock and a running count of the “number of times seen” is kept for each map location. The top right inset displays the resulting visual exposure from not seen (VE= 0; grey) to the entire feature being visible (VE= 120; red). As you might suspect, a large amount of the opposing hillside has a great view of Profile Rock. The southeast plateau, on the other hand, doesn’t even know it exists.

The lower portion of figure 4-13 extends on the concept of visual exposure by introducing distance. It is common sense that something near you (foreground) has more visual impact than something way off in the distance (background). A proximity map from the viewer feature is generated and distance zones can be intersected with the visual exposure map (lower-right inset in figure 4-13). The small map on the extreme right shows visual exposure for just distance Zones 1 and 2 (600m reach). The accompanying table summarizes the average visual exposure to Profile Rock within each distance zone—much higher for Zones 1 and 2 (34.3 and 41.3) than the more distant zones (27.3 or less).

The ability to establish weighted visual exposure for features is critical in deriving an *aesthetic map*. In this application various features are scaled in terms of their relative beauty— 0 to 10 for increasing pretty places and 0 to -10 for increasing ugly places. For example, Profile Rock represents a most strikingly beautiful natural scene and therefore is assigned a “10.” However, Eyesore Mine wash is one of the ugliest places to behold so it is assigned a “-9.” In calculating weighted visual exposure, the aesthetic value at a viewer location is added to each location within its viewshed. The result is high positive values for locations that are connected to a lot of very pretty places; high negative values for connections to a lot very ugly places; zero, or neutral, if not connected to any pretty or ugly places or they cancel out.

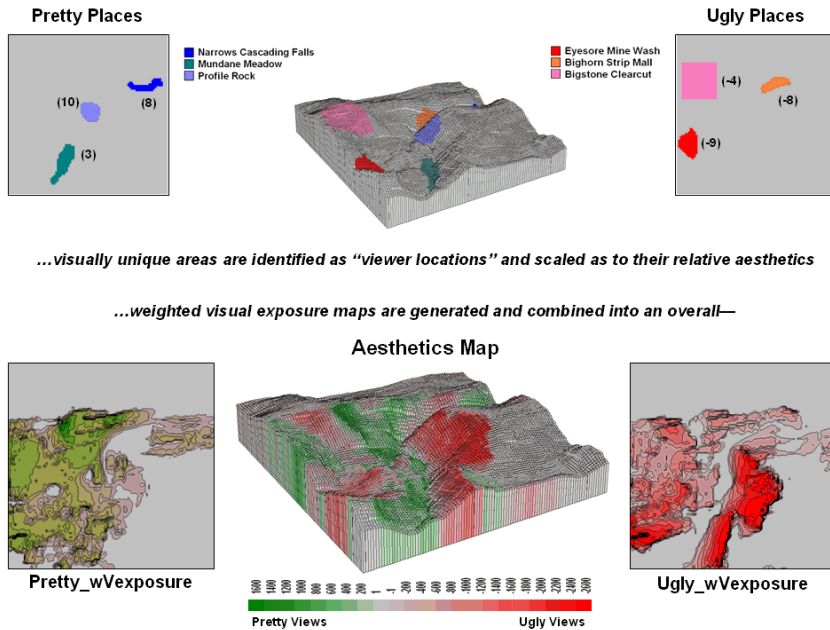


Figure 4-14. An aesthetic map determines the relative attractiveness of views from a location by considering the weighted visual exposure to pretty and ugly places.

The top portion of figure 4-14 shows the aesthetics ratings for several “pretty and ugly” features in the area as 2D plots then as draped on the terrain surface. The 2D plots in the bottom portion of the figure identify the total weighted visual exposure for connections from each map location to pretty and ugly places.

The overall aesthetic map in the center is analogous to calculating net profit—revenue (think Pretty) minus expenses (think Ugly). It reports the net aesthetics of any location in the project area by simply adding the *Pretty_wExposure* and *Ugly_wExposure* maps. Areas with negative values (reds) have more ugly things within their view than pretty ones and are likely poor places for a scenic trail. Positive locations (greens), on the other hand, are locations where most folks would prefer to hike.

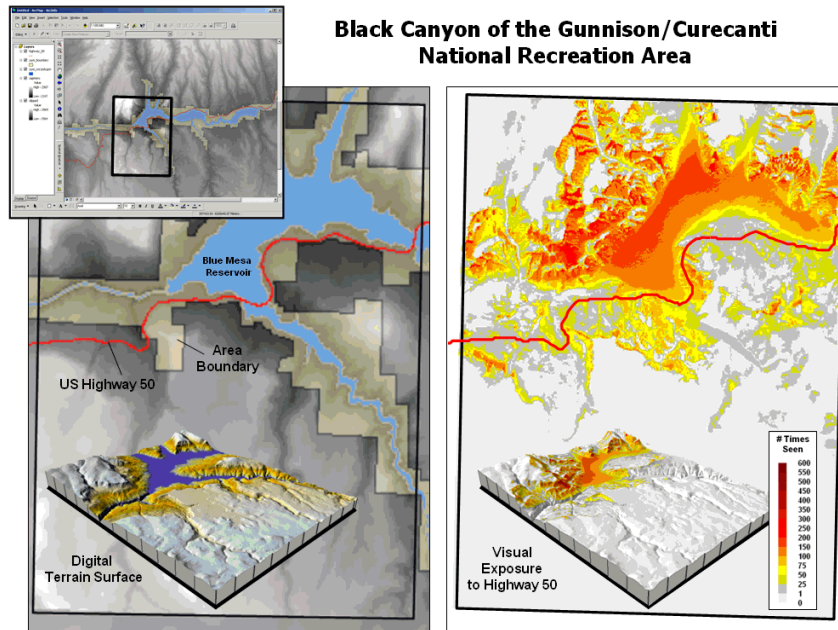


Figure 4-15. Weighted visual exposure map for an ongoing visual assessment in a national recreation area.

Real-world applications of visual assessment are taking hold. For example, a senior honors thesis project is underway at the University of Denver by a student intern with the National Park Service (see author’s note). The project will develop visual vulnerability maps from the reservoir in the center of the park and a major highway running through the park (right side of the figure 3). In addition, aesthetic maps will be generated based on visual exposure to pretty and ugly places in the park.

It seems to be a win-win situation with the student getting practical GIS experience (not to mention a lot of awesome hiking for field verification) and NPS will get cutting-edge procedures and maps they need for effective resource planning. My guess is that there is a university near you that is looking for “a few good clients” to take GIS education beyond the classroom—give them a call.

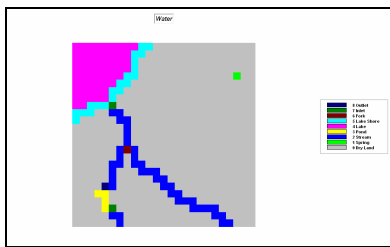
4.5 Exercises

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.

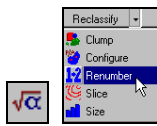
4.5.1 Calculating Viewsheds



Use the *View* button (binocular icon) to select and display the **Water** map.



Note that there are eight different types of water depending on its flow.



Press the *Map Analysis* button and choose **Reclassify** → **Renumber** to access the dialog box for reclassifying map values. Complete the input specifications as shown below to derive a binary map of *Flowing Water*

Renumber: Water
 New Value: 1
 Old Value: 1
 Old Upper Value: 8



Select the **Water** map from the drop-down list, then specify **1** as the *NewValue*, **1** as the *OldValue* and **8** as the *OldUpperValue*. Press the **Add** button to submit the reassignment phrase.

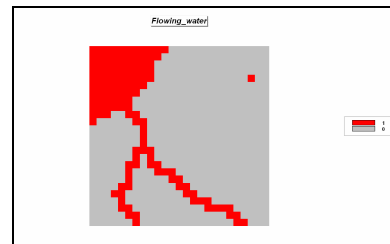
Renumber dialog box showing the command: **RENUMBER Water ASSIGNING 1 TO 1 THRU 8 FOR Flowing_water**

Specify **Flowing_water** as the new map name and press **OK** to create a binary map where 1= any water type and 0 = not water. The command that is generated is—

```
RENUMBER Water
ASSIGNING 1 TO 1 THRU 8
FOR Flowing_water
```



Press the *Use Cells* button to set the display type to *Grid*.

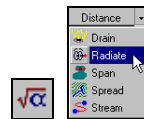
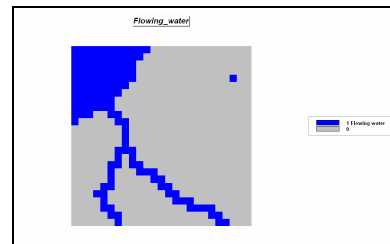


Shading Manager (Flowing_water)

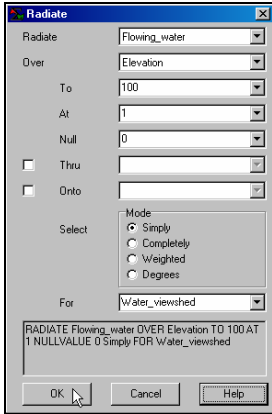
Category	Count	Area	% Grid/Total Area	Color
1 Flowing water	126	396	9.7	Blue
0	497	1,227	90.3	Grey



Press the *Shading Manager* button then enter “**Flowing water**” as the category description. Double-click on the red *Color* and choose **blue** from the color pallet. Click **OK** to submit the display changes.



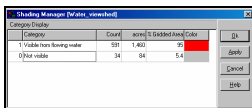
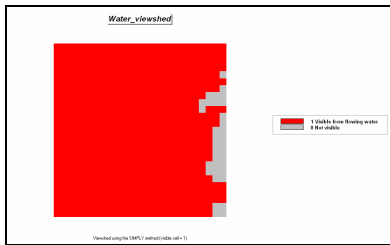
Press the *Map Analysis* button and choose **Distance** → **Radiate** to access the dialog box for visual analysis. Complete the input specifications as shown below to derive a binary map of *Water_viewshed*.



RADIATE Flowing_water OVER Elevation TO 100 AT 1 NULLVALUE 0 Simply FOR Water_viewshed

Press the **Help** button to get a description of the *Radiate* command's function and input fields. Specify...

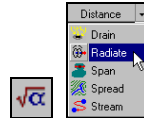
- Flowing_water** as the *viewersMap*
- Elevation** as the *surfaceMap*
- 100** as the # of grid spaces away
- 1** as the *viewer_heightValue*
- Simply** as the calculation *mode*
- Water_viewshed** as the *newMap*



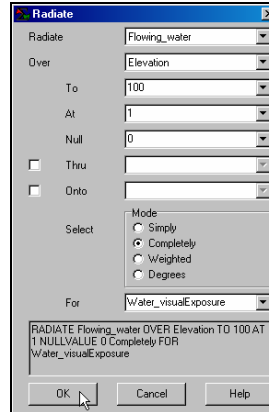
Double-click on the map legend to pop-up the *Shading Manager* dialog box. Enter a description for the map *Categories* 1 and 0. Note that approximately 95% of the project area is visually connected to flowing water and that the few “not visible” areas are concentrated along the eastern edge.

On your own, follow a similar visual analysis procedure to generate a *viewshed* map (**Roads_viewshed**) of any road location (based on the **Roads_type** map). What percent of the project area is visually connected to roads?

4.5.2 Calculating Visual Exposure

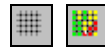


Press the *Map Analysis* button and choose **Distance** → **Radiate** to access the dialog box for visual analysis. Complete the input specifications as shown below to derive a visual exposure map showing “how many” water grid cells are visually connected to every location within in the project area.

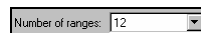
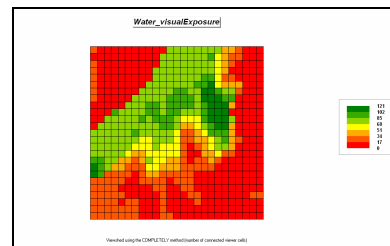


RADIATE Flowing_water OVER Elevation TO 100 AT 1 NULLVALUE 0 Completely FOR Water_visualExposure

Selecting the “*Completely*” calculation mode identifies the number of connected viewer cells. Larger values indicate higher visual exposure to water—locations that “see” a lot of water (and by direct line-of-sight, are seen a lot from water locations).



Press the *Layer Mesh* button to superimpose the analysis grid. Press the *Use Cells* button to set the display type to *Grid*.

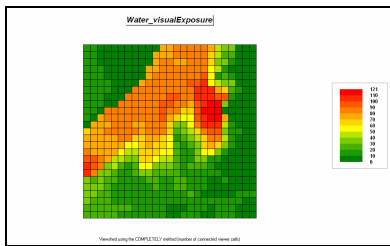
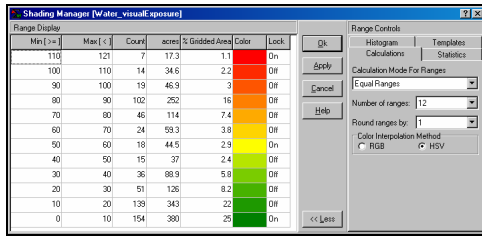


Double-click on the legend to pop-up the *Shading Manager*. Change the *Number of ranges* to **12**. Note that the data intervals are expressed as increasing steps of 10 additional viewer cells (water locations).

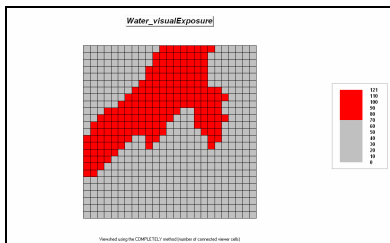
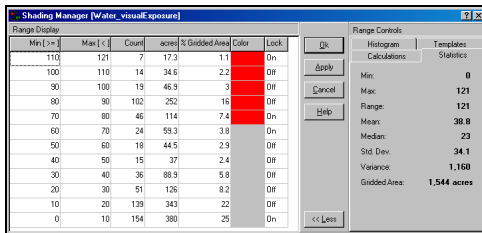
Under the *Lock* column, click **Off** the automatically assigned *yellow* inflection point

for the range 30 to 40. Click the *Color* block for range for 50 to 60 and select **yellow** from the pallet to reset the color inflection point on the color ramp. Switch the colors for the min and maximum ranges by clicking on the respective color blocks and choose **green** for the lowest range and **red** for the highest range.

Press **OK** to generate the new display.



Use the *Shading Manager* to create a display that isolates the areas of very high visual exposure (70 or more water locations visible) as red with a background of grey—set **grey** as the *Color* from 0-10 through the 60-70 intervals and **Lock** on **red** for the 70-80 and 110-121 ranges.

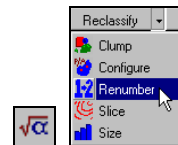
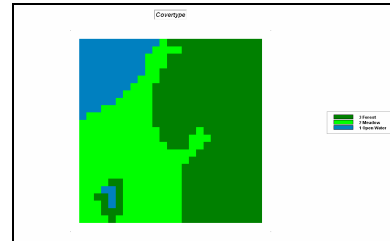


On your own, follow a similar visual analysis procedure to generate a *visual exposure* map (**Roads_visualExposure**) of any road location (based on the **Roads_type** map). What is the

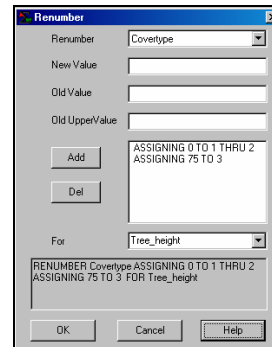
highest visual exposure to roads in the project area?

4.5.3 Accounting for Screens

Use the *View* button (binocular icon) to select and display the **Covertypes** map.



Use the *Map Analysis* button and choose **Reclassify** → **Renumber** to access its dialog box and complete as shown.

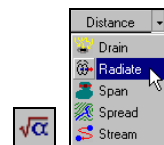


RENUMBER Covertypes
ASSIGNING 0 TO 1 THRU 2 ASSIGNING 75 TO 3 FOR Tree_height

Hint: Do not forget to press the *Add* button to enter each *Renumber* phrase...

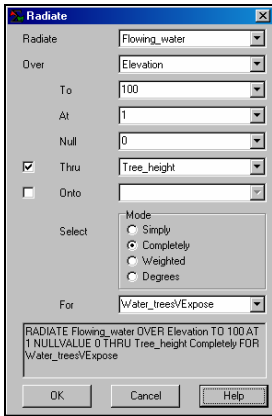
ASSIGNING 0 TO 1 THRU 2 (*Water & Meadow*)
ASSIGNING 75 TO 3 (*Forest*)

...to indicate the height of the vegetation canopy (same units as the Elevation map). This assigns 0 feet for *water* and *meadow* locations and 75 feet for *forested* ones.



Press the *Map Analysis* button and choose **Distance** → **Radiate** to access the dialog box for visual analysis. Complete the

input specifications as shown below to derive a visual exposure map accounting for the height of the tree canopy.



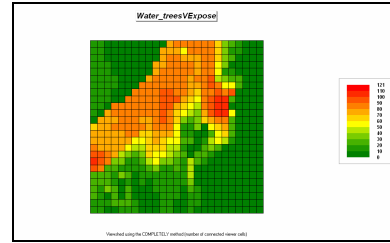
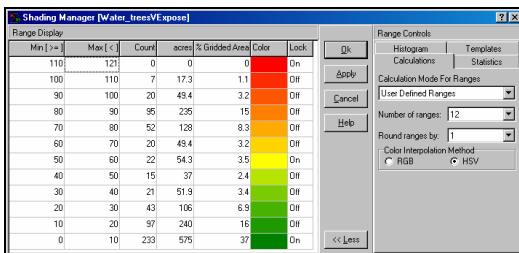
RADIATE Flowing_water OVER Elevation TO 100 AT 1 NULLVALUE 0 THRU Tree_height Completely FOR Water_treesVExposure

Number of ranges: 12 Double-click on the legend to pop-up the *Shading Manager*. Change the *Number of ranges* to 12.

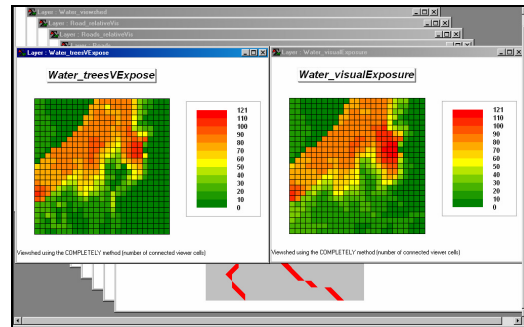
Calculation Mode For Ranges: User Defined Ranges Change the *Calculation Mode* to *User Defined Ranges*.

Min [>=]	Max [<]
110	121
100	110
90	100
80	90
70	80
60	70
50	60
40	50
30	40
20	30
10	20
0	10

Starting at the bottom of the *Min [>=]* column enter values increasing by 10 as shown, then ending with 121 at the top of the *Max [<]* column. Set the Color settings the same as before— **green** for the lowest range, **red** for the highest range and **yellow** for the 50 to 60 range. Press **OK** to display the map using the custom legend that is the same as used for displaying the *Water_visualExposure* map generated in the previous section.



Click on the *Restore Down* button in the upper-right corner of the display. Use standard Windows “click-and-drag/size” techniques to position the *Water_visualExposure* and *Water_treesVExposure* side by side as shown below.



Note the visual differences between the two maps—visual exposure with and without accounting for the height of the tree canopy. The area of high visual exposure (red tones) that accounts for the tree canopy barriers has a similar shape but is smaller than the corresponding area without trees.

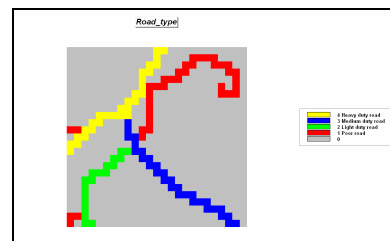


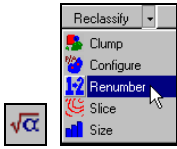
Aside: Each map display is contained in a separate window. Standard Windows techniques such as cascading, horizontal and vertical “tiling” is available.

4.5.4 Calculating Weighted Visual Exposure

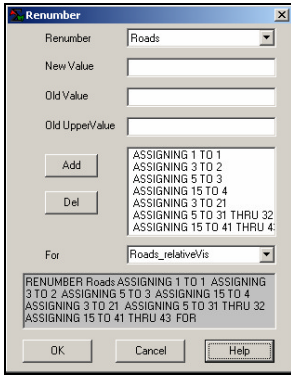


Use the *View* button (binocular icon) to display the *Roads_type* map.





Press the *Map Analysis* button and choose **Reclassify** → **Renumber** to access its dialog box and complete as shown.

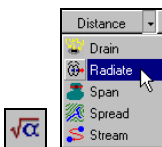
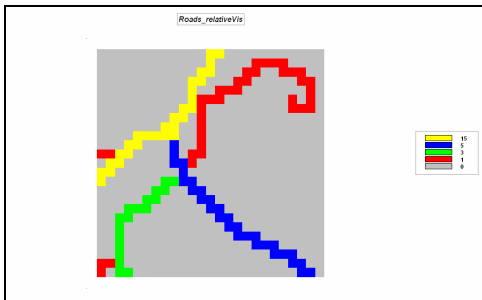


RENUMBER Roads
 ASSIGNING 1 TO 1 ASSIGNING 3 TO 2 ASSIGNING 5 TO 3
 ASSIGNING 15 TO 4 ASSIGNING 3 TO 21
 ASSIGNING 5 TO 31 THRU 32 ASSIGNING 15 TO 41
 THRU 43 FOR Roads_relativeVis

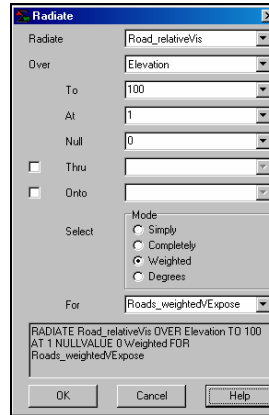
Hint: Do not forget to press the *Add* button to enter each *Renumber* phrase...

- ASSIGNING 1 TO 1 (one car)
- ASSIGNING 3 TO 2 (three cars)
- ASSIGNING 5 TO 3 (five cars)
- ASSIGNING 15 TO 4 (fifteen cars)

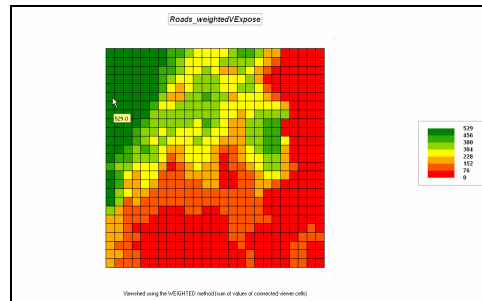
...to indicate the relative number of cars in a given period of time.



Press the *Map Analysis* button and choose **Distance** → **Radiate** to access the dialog box for visual analysis. Complete the input specifications as shown below to derive a weighted visual exposure map showing the relative visual exposure to roads for every location within in the project area.

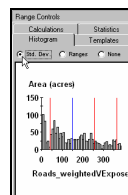


RADIATE
 Road_relativeVis OVER Elevation TO 100 AT 1
 NULLVALUE 0 Weighted FOR Roads_weightedVExpose



40.347022 -104.035075 [1,20] = 529.0 Note that the weighted visual exposure ranges from 0 to 529.0. The most visually exposed location is in the west border at column 1, row 20 as reported in the lower-left corner of the display window as the mouse is positioned over the location on the map.

4.5.5 Modeling Visual Exposure Impacts

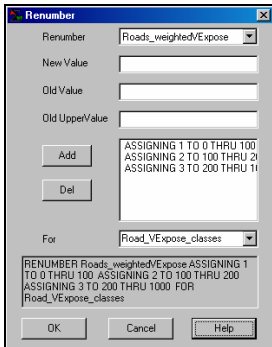


Double-click on the *Roads_weightedVExpose* map's legend to pop-up the *Shading Manager*. Select the *Histogram* tab and click *Std. Dev.* button to get a plot of the data distribution. Note that the average is about 150.

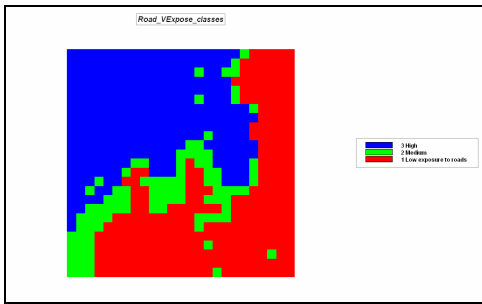
Based on the *Roads_weightedVExpose* data distribution, create a map that identifies areas of...

- Low= 1 (0-100 seen)
- Medium= 2 (100-200 seen)

High= 3 (>200 seen)
 ...visual exposure by choosing **Reclassify** à **Renumber** and completing the dialog box as shown below.



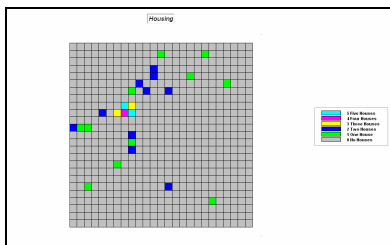
RENUMBER
 Roads_weightedVExpose ASSIGNING 1 TO 0 THRU 100
 ASSIGNING 2 TO 100 THRU 200 ASSIGNING 3 TO 200
 THRU 1000 FOR Road_VExpose_classes



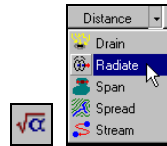
Note that the area of High visual exposure to roads is concentrated in the northwestern portion of the project area while the Low areas are generally in the southeast.



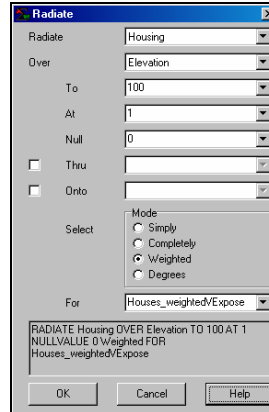
Use the *View* button (binocular icon) to select and display the **Housing** map.



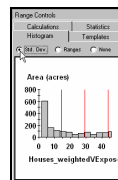
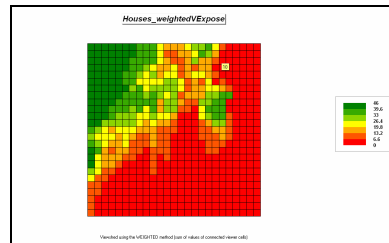
The values stored for grid cell indicates how many houses occur at that location.



Press the *Map Analysis* button and choose **Distance** à **Radiate** to access the dialog box for visual analysis. Complete the input specifications as shown below to derive a weighted visual exposure map showing the relative visual exposure to houses for every location within in the project area.



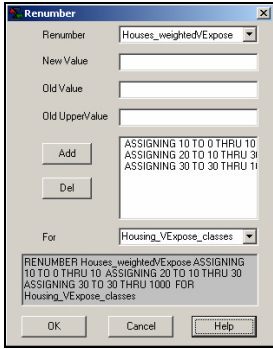
RADIATE Housing OVER
 Elevation TO 100 AT 1 NULLVALUE 0 Weighted FOR
 Houses_weightedVExpose



Use the *Shading Manager* *Histogram* tab to get an idea of the data distribution for the *Housing_weightedVExpose* surface.

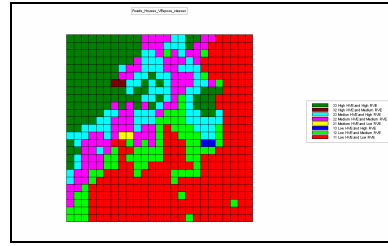
Create a map that identifies areas of Low, Medium and High visual exposure by 1) pressing the *Map Analysis* button 2) choosing **Reclassify** à **Renumber** and 3) completing the dialog box as shown below so...

- Low= 1 (0-10 houses seen)
- Medium= 2 (10-30 houses seen)
- High= 3 (>30 houses seen)



RENUMBER

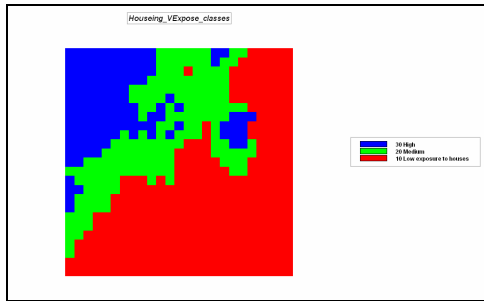
Houses_weightedVExpose ASSIGNING 10 TO 0 THRU 10
 ASSIGNING 20 TO 10 THRU 30 ASSIGNING 30 TO 30
 THRU 1000 FOR Housing_VExpose_classes



Category	Count	acres	% Gridded Area	Color
33.0 High HVE and High RVE	122	301.311	19.52	Green
32.0 High HVE and Medium RVE	2	4.94	0.32	Blue
23.0 Medium HVE and High RVE	80	197.581	12.8	Yellow
22.0 Medium HVE and Medium RVE	81	200.051	12.96	Cyan
21.0 Medium HVE and Low RVE	2	4.94	0.32	Magenta
13.0 Low HVE and High RVE	2	4.94	0.32	Red
12.0 Low HVE and Medium RVE	75	185.232	12.0	Orange
11.0 Low HVE and Low RVE	261	644.609	41.76	Red

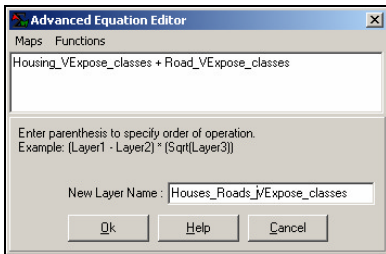


Use the *Shading Manager* to label each of visual exposure combinations. For example, the 11 value is interpreted as condition class “one-one” (Low, Low) derived by adding a 10= Low *Housing_VExpose_class* plus 1= Low *Roads_VExpose_class*.



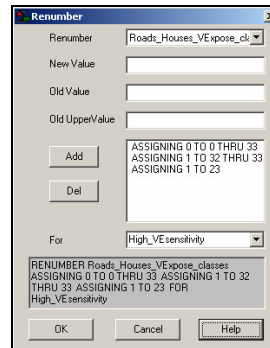
Combine the two maps indicating the classes of visual exposure to roads and houses by **Map Analysis** → **Overlay** → **Calculate** and completing the following dialog box as shown.

Isolate the visually sensitive areas by selecting **Map Analysis** → **Reclassify** → **Renumber** and completing the dialog box as shown.



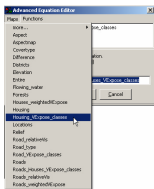
CALCULATE

Housing_VExpose_classes + Road_VExpose_classes FOR
 Houses_Roads_VExpose_classes

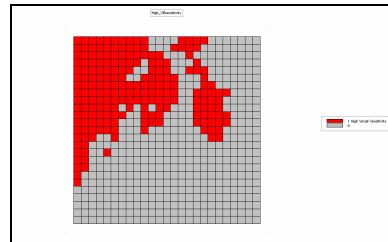


RENUMBER

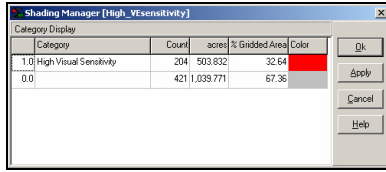
Roads_Houses_VExpose_classes ASSIGNING 0 TO 0
 THRU 33 ASSIGNING 1 TO 32 THRU 33 ASSIGNING 1
 TO 23 FOR High_VEsensitivity



Note: to select a map click on the **Maps** button and select the map from the drop-down list. You can select the math operation from the **Functions** list or simply enter the “+” symbol to indicate addition.




Press the **Use Cells** button to switch the default display to discrete data type.




Note that about a third of the project area is visually vulnerable and is concentrated in the northwestern portion of the area. “Ugly” development or activities ought to avoid these areas.

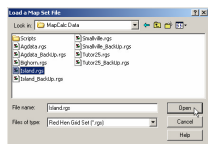
On your own, follow a similar visual analysis procedure to generate a map that identifies visual exposure classes to water (**Water** map) and forest cover (**Coverttype** map). What percent of the project area has high visual exposure to water and forest combined? “Pretty” areas like these might be potential areas for hiking trails or that new cabin you have wanted to build.

4.5.6 Extending Visual Analysis to Other Areas

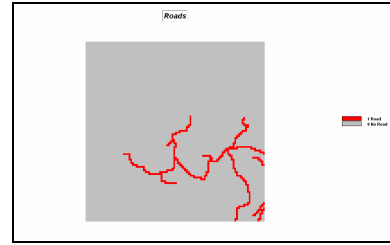
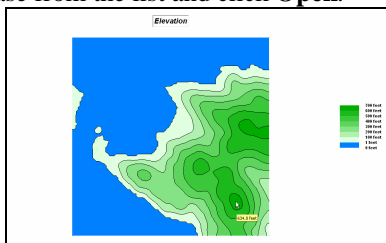
 Click on the *Map Analysis* button and select *Script* → *Save As...* and specify a file name for the command script such as **NR_Topic4.scr**. This will save all of your work so you can re-access the command file at a later date by selecting *Map Analysis* → *Script* → *Open*.

To save the database, from the main menu select **File** → **Save As...** and save the file under a different name than the basic *Tutor25.rgs* name, such as **Tutor25_Topic4.rgs**.

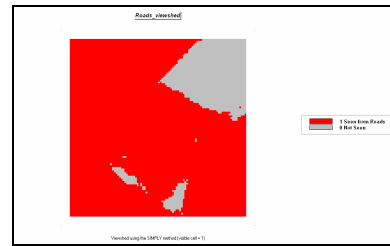
 Click on the *Open existing file* button and respond **No** to whether you want to save changes to the existing database.



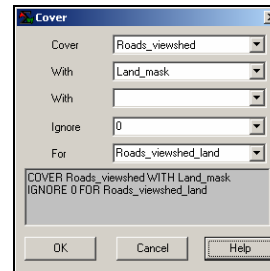
Select the **Island.rgs** database from the list and click **Open**.



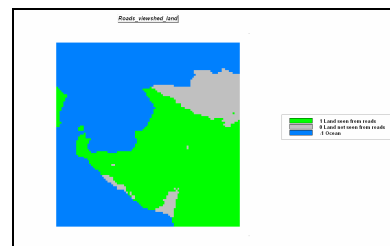
Using the **Elevation** surface and **Roads** map create a viewshed map identifying all location see from the road network.



Use the **Land_mask** map and the **Map Analysis** → **Reclassify** → **Cover** operation to enter the command...



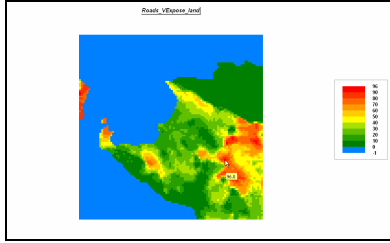
COVER Roads_viewshed WITH Land_mask IGNORE 0 FOR Roads_viewshed_land



What percent of the project area is classified as “land seen from roads.”

Repeat the procedure calculating a visual exposure map from roads. Display the map using User Defined calculation mode for ranges from **-1 to 0**, **0 to 10**, **10 to 20**, ..., **90 to 96**.

Assign **blue** to -1 to 0, **green** to 0 to 10, **yellow** to 40 to 50 and **red** to 90 to 96.



Range Display	Min	Max	Count	Area	Grid Cell Area	Color	Lock
50	98	100	1	1.400	0.09	Sn	On
80	90	100	16,074	1.09	0.09	Or	On
70	80	232	32,247	2.22	0.09	Yl	On
60	70	211	32,962	2.11	0.09	Yl	On
50	60	235	36,716	2.35	0.09	Yl	On
40	50	379	59,214	3.79	0.09	Yl	On
30	40	536	83,742	5.36	0.09	Yl	On
20	30	753	117,647	7.53	0.09	Yl	On
10	20	767	119,034	7.67	0.09	Yl	On
0	10	1543	241,074	15.43	0.09	Yl	On
0	0	9227	916,092	92.27	0.09	Yl	On

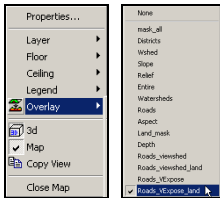
Create a more interesting display by draping the visual exposure map over a 3-dimension plot of the terrain by—



Use the *View* button (binocular icon) to display the **Elevation** map.



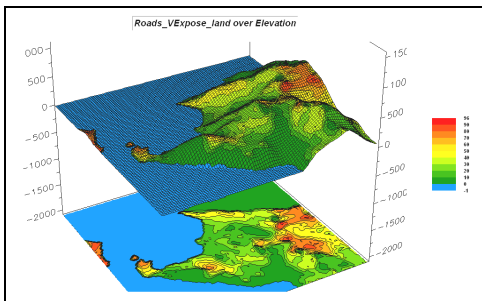
Use the *Toggle 3D view* button to switch the display to a 3-dimensional plot.



From the main menu select **Map** → **Overlay** → **Roads_VExpose_land** to superimpose the visual exposure map on the Elevation surface.

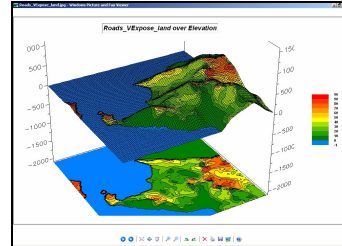


Select the *Zoom Out* tool (magnifying glass with minus sign), click/drag up/down anywhere on the display to size the plot. Use the *Move* tool (hand) and click/drag to center the plot.

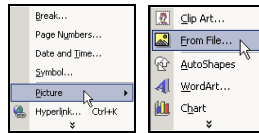


Use the *Save picture of map* button to capture a “screen grab” of the display as a file named **FancyMap_graphic.jpg**.

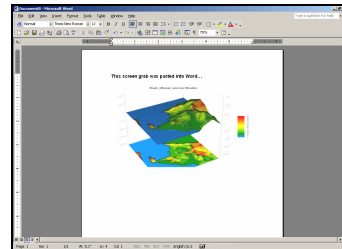
Use *Windows Explorer* to browse to the saved file and double click on it to display in your default viewer.



Open a blank *Word* document and insert the saved file into it by—



From the main Word menu select **Insert** → **Picture** → **From File...** and browsing to the saved file.



Note: The inexpensive yet versatile SnagIt program was used to capture and insert all of the graphics used in this book. To order, see... www.techsmith.com/

