The Location Profiler Model

In its simplest definition, the *Location Profiler* is a modeling tool that computes and averages the distance to a series of points from anywhere within a map area. The algorithm generates a grid, where at each cell, a value is calculated that represents the average distance to all point locations surrounding that cell and lying within a defined search radius. As the term implies, the user is creating a geographic profile of an area that measures proximity to a series of sites using spatial relationships (spacing, distribution, density). By identifying those locations on the map that are the shortest average distance to all or some of the sites, the grid file can be used to represent geographic centre(s) of activity. The points may represent sites as varied as crime occurrences — what is the possible centre of activity from which a criminal is operating; or customer locations — what is the best possible location for a delivery hub given the current distribution of customers. The model can be further refined to take into account weighting factors that specify the relative influence of each site compared with those surrounding it.

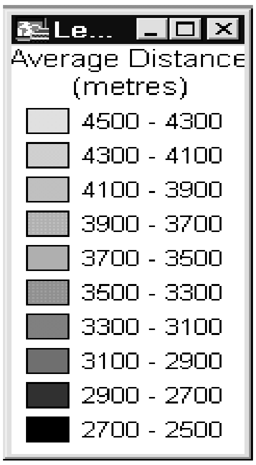
Three settings are critical in making the *Location Profiler* a truly effective modeling tool:

1. the number of points to which the distance is computed from each grid node,
2. the relative influence or weighting of each point in the averaging calculation, and
3. the distance decay function of the weighting factor.

Setting the Number of Points

As described above, the *Location Profiler* algorithm measures, at each cell of the grid, the distance to every point lying within the search area and calculates the average value. However, the pattern of geographic centres generated by the process will vary depending upon the number of points used for each grid cell calculation. The number of points is determined by a combination of:

1. defining a search area around each grid cell to select points, and
2. defining the minimum and maximum number of points to be used for each calculation.



The Figures 4.4. and 4.5 show the result of varying the number of points used by the *Location Profiler* for each grid cell calculation. By default, the algorithm sets the search radius and the maximum number of data points to include **100 percent** of the points in the table. Using the default settings will thereby create a grid that defines the most central region of the point location data base.

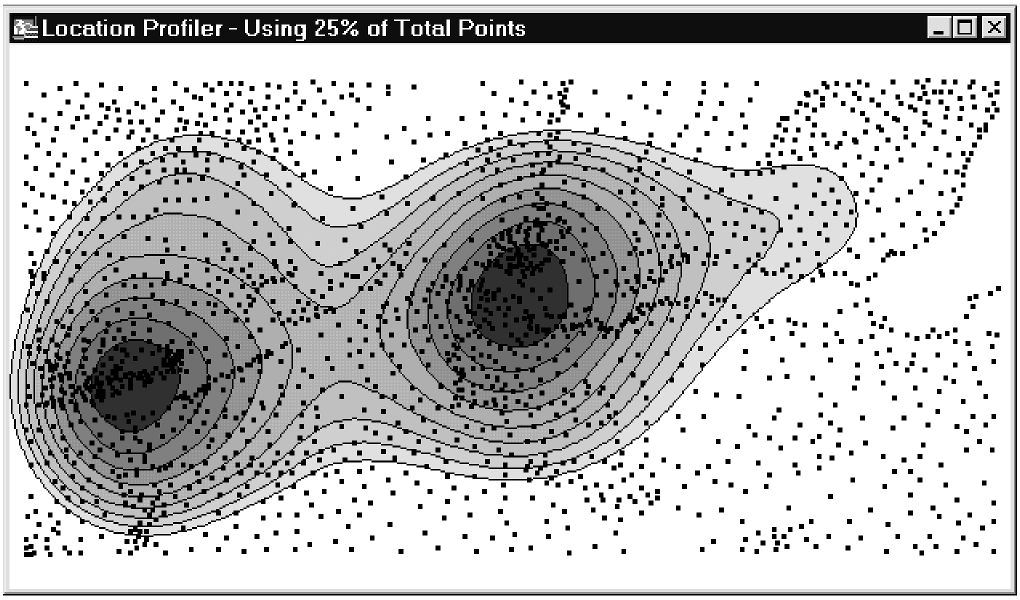
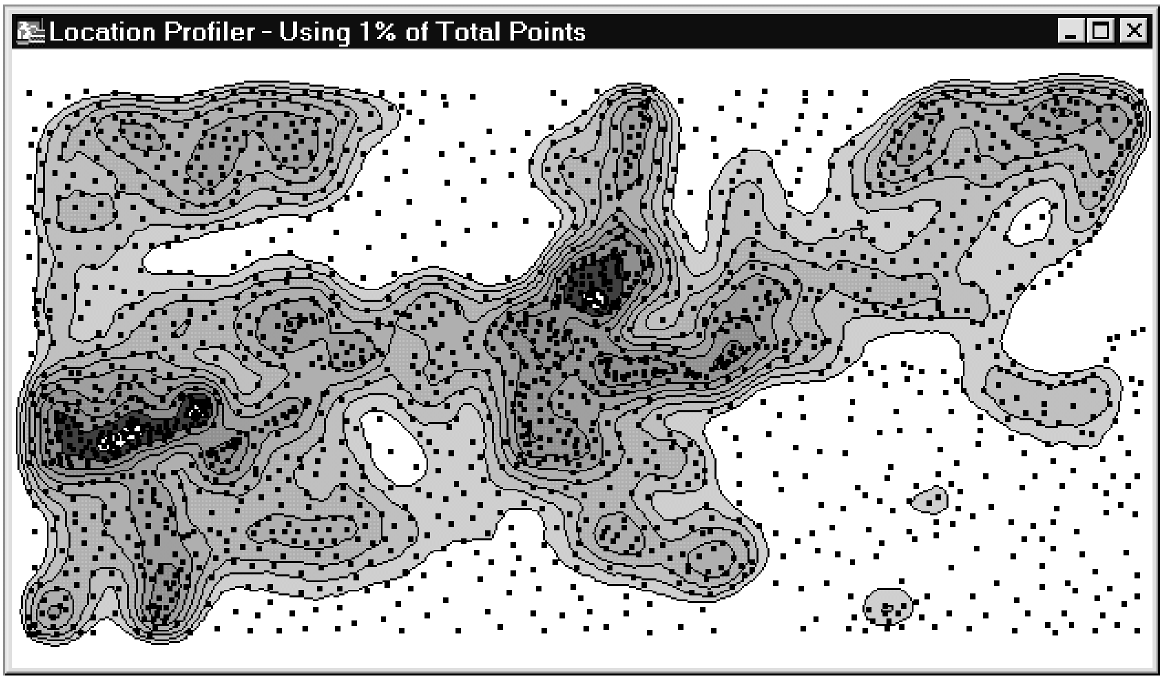
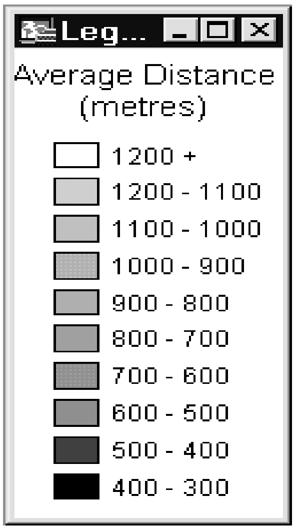


Figure 4.4. This illustration shows the geographic profile of a table of point locations (represented by black dots) calculated using 25 percent of the total number of points. Sites lying within the more central contour regions are closer to the surrounding points than sites lying within the outermost regions.





Reducing the number of points involved in each grid cell calculation, by decreasing both the search radius and the maximum number of data points, tends to create a more complex profile that highlights local zones of greater point density within the overall distribution of points. This may be useful if, for example, the user wants to highlight local areas of greater site density across a geographic area.

Figure 4.5. This illustration shows the geographic profile of the same table of locations calculated using only one percent of the total points. Note the tendency to highlight local concentrations of points giving an effective visual representation of variations in point density across the map area.

In addition to defining a search area that controls the number of sites used in the distance averaging calculation, an exclusion radius can also be defined. The exclusion radius is used to create a circular area immediately surrounding each grid cell within which site locations are excluded from the calculation. For example, in trying to calculate a potential centre of criminal activity, in certain cases reasoning may suggest that criminals will not operate within a set distance from their home base. Therefore, at any grid cell (representing a potential home base), sites that lie within this minimum distance should not be included in the distance averaging calculation.

Using Point Weighting

The *Location Profiler* allows the use of weighting values attached to points. If all data points are considered to be of equal importance, then their weighting values would all be equal (typically 1). If some data points are considered to be more important, or perhaps more reliable, correspondingly higher values may be attributed to them. In real terms, the weighting factor may represent a relative confidence value assigned to each point if, for example, each site represented a human observation. The factor may also be a measure of frequency if, for example, each site represented a freight company's customer and showed the number of deliveries per month. In each case, the distance calculation is treated as a multiple of the weighting factor. For example, if the weight represented frequency of deliveries, then each distance calculation would be handled as a multiple measurement based upon the frequency value.

Using Distance Decay Functions

A distance decay function can be applied to all points in the location table assuming a weighting factor has also been assigned. Distance decay can be used in the *Location Profiler* model if it is assumed that data points which are close to the grid point are more relevant than those lying farther from the grid point. In other words, the user must decide if it is reasonable to expect that, as the distance to the data points approaches the outer edge of the search radius, the contribution of these values approaches 0. A decay value of 1 is suggested for data points close to the grid node, and it falls to 0 for data points closer to the edge of the search radius. A distribution of this type typically has an inflection point somewhere along its length. An inflection point is the point along the distribution where the slope either stops increasing in value or stops decreasing in value. For typical distance decay curves shown in Figure 4.6, the slope is 0 where X = 0 and gradually decreases, becoming more negative, until the inflection point is reached, at which point the slope stops becoming more negative, and gradually increases, returns to 0 again as X approaches 1.

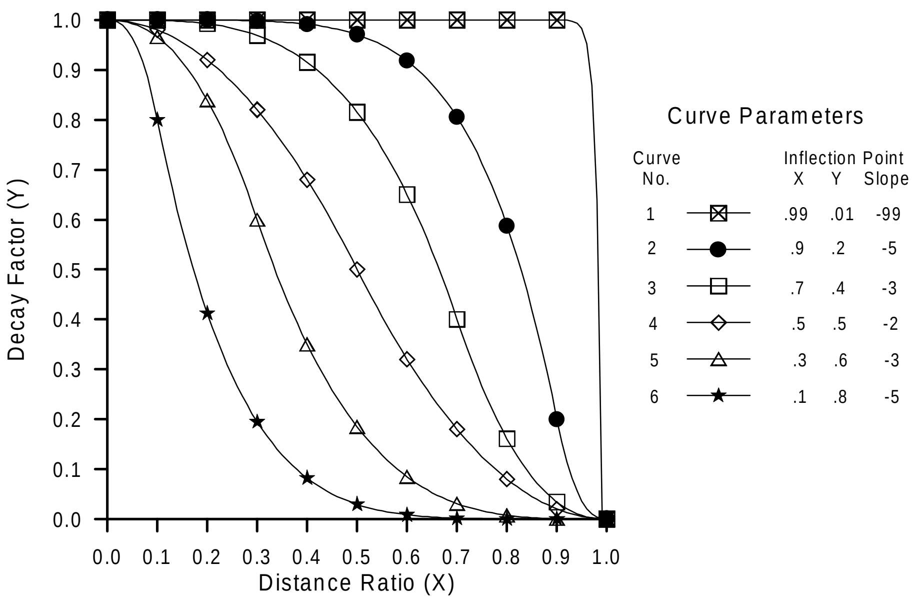


Figure 4.6. Shown here are six search radius distance decay curves supported *by Vertical Mapper's Location Profiler*. Values along the X-axis represent a ratio obtained by dividing the distance between the grid point and data point by the search radius. It is suggested that **Curve 3** represents the most typical search radius decay function that could be applied to the widest variety of modeling parameters.

A similar decay function can be applied to the exclusion zone of the grid cell but using a curve with positive slope. In this case, the slope is 0 where X = 0 and gradually increases, becoming more positive, until the inflection point is reached and then gradually decreases and returns to 0 as X approaches 1.

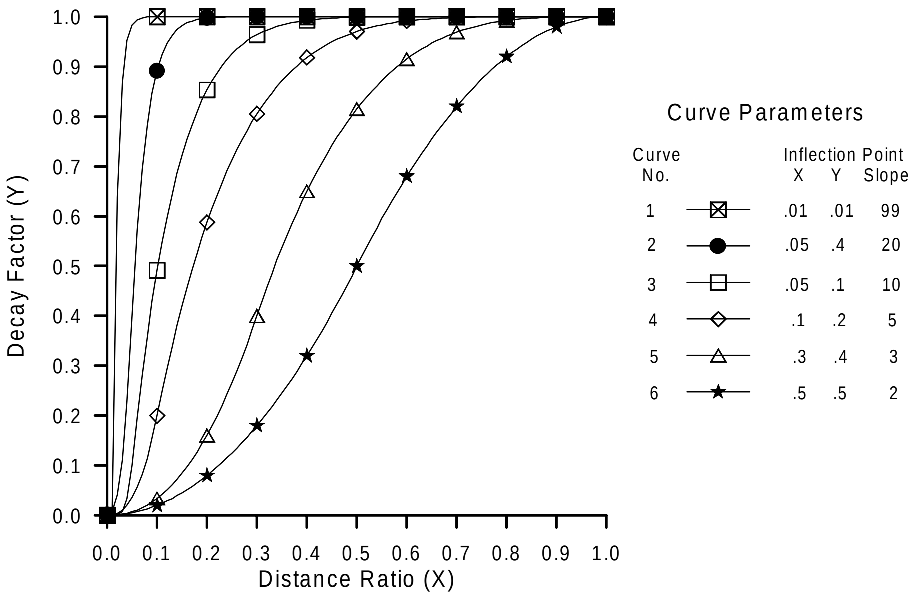


Figure 4.7. Shown here are six exclusion radius distance decay curves supported *by Vertical Mapper's Location Profiler* . Values along the X axis represent a ratio obtained by dividing the distance between the grid point and data point by the exclusion radius. It is suggested that **Curve 3** represents the most typical exclusion radius decay function that could be applied to the widest variety of modeling parameters.

There are various methods that can be used to obtain the distributions shown in Figures 4.6 and 4.7. Most techniques require the user to specify the location (X,Y coordinates) of the inflection point, and the slope at this inflection point. Given an appropriate distance decay curve, a decay factor can therefore be determined for any distance value measured between the grid cell and a weighted point location. When X = 0 (at the grid cell assuming no exclusion radius setting), Y equals 1 (no distance decay factor), and the slope is 0. When X = 1 (at the outer edge of the search radius), Y = 0 (100 percent decay), and again the slope = 0.

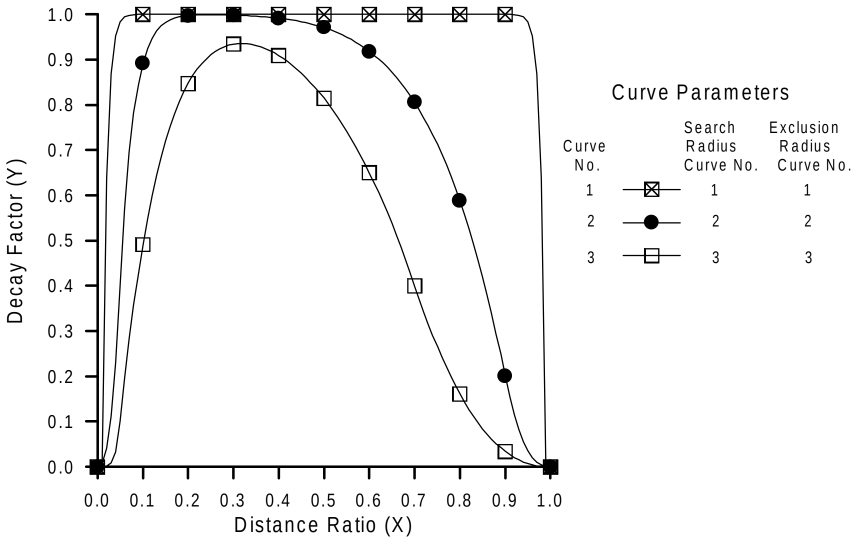


Figure 4.8 This figure shows the blending relationship between distance decay functions relating to the exclusion zone and the search zone. A continuous function can be created by choosing complementary curves that will distance weight all point locations lying between the grid node and the search radius.

The Y-axis indicates the decay factor associated with the data point. This decay factor, which is always between 0 and 1, is then multiplied by the weighting factor associated with the data point to obtain the weighted value. This weighted value is then multiplied by the measured distance between the grid point and data point, to get a weighted distance. The weighted average distance for the grid point is obtained by summing all the weighted distances for each data point, and dividing by the sum of all the weighted values of the data points.

Creating Buffers

One of the more powerful applications of the *Location Profiler* tool is in the creation of buffer grids that measure continuous distance from individual points (store locations) or lines (road networks). The procedure is implemented by forcing the algorithm to measure the distance to only **ONE** point at every grid node. By setting both the maximum and the minimum number of points used for each grid cell calculation to 1, the new grid represents a continuous surface of distance from a single point where distance values increase as they move away from the point. Therefore it is possible to generate a continuous buffered surface from a single point or a series of points representing store locations. Similarly, a buffer grid can be generated from road line work by first converting the road to a series of closely spaced points using the *Poly2Point* utility in *Vertical Mapper*. This process is fully described in Lesson 5 the of the *Installation and Tutorials* manual. As shown below, the resulting grid is an effective and very accurate representation of a buffer that measures the distance to the nearest road point from every location in the map area. This relationship is used in many advanced spatial modeling problems dealing with issues ranging from commercial site selection to environmental impact assessment.

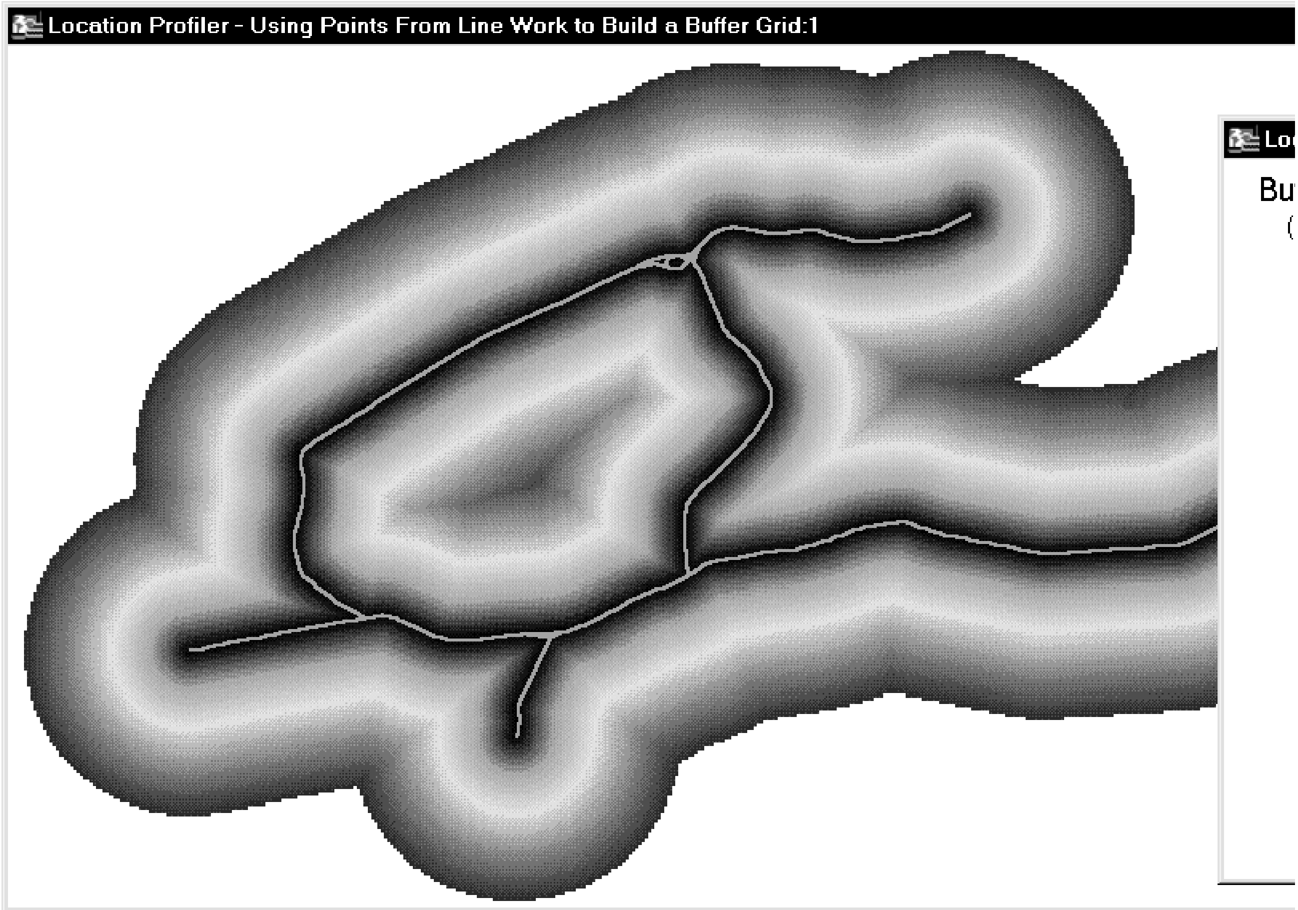


Figure 4.9. Using the *Location Profiler* to build a grid of continuous distance values from individual points making up a road network. In this case, both the minimum and the maximum number of points used to calculate each grid cell value is set to 1.