ATTACHMENT 2:
OESAP SPATIAL ANALYSIS SOFTWARE USER'S MANUAL

OESAP Spatial Analysis Software User's Manual

1.0 Introduction

This user's manual applies to spatial analysis of OE data collected at OE sites. The software described here calculates Inter-Event, Nearest Neighbor, and Point-to-Nearest-Neighbor distances for a set of data points. The software is provided as a Microsoft Excel Add-In on the accompanying CD. An "Event" of interest could mean any OE item, only actual UXO items, or only specific types of OE items. It is suggested, but not required, that the OE analysis team include an applied statistics specialist in order to facilitate understanding of the concepts and results developed with these spatial analysis and density estimation modules. The different algorithms are described in detail below.

2.0 Installation of the Spatial Analysis Software Modules

One of the files on the CD attached to this work plan is named "Spatial Analysis Ver 1.xla". The "a" in "xla" indicates that this is an Excel "Add-In" type file. In this case it is a Visual Basic macro program including several modules. To install this Add-In you must open Excel and follow the steps listed below.

2.1 Installation Procedure

(1) Click on the **Tools** menu
(2) Select **Add-Ins**
(3) Click on **Browse**
(4) Find and select the file "**Spatial Analysis Ver 1.xla**" (wherever you saved it)
(5) Click **OK**
(6) Click **OK** again

The software is now installed. As new versions are developed you must rename or remove the old version from its directory. This is done to avoid any overlap between versions of the program. The default Add-In directory for Windows NT is "C:\WINNT\Profiles*username*\Application Data\Microsoft\AddIns". For Windows 98 the default directory is "C:\Windows\Application Data\Microsoft\AddIns".

To check whether you installed the program properly, click on Tools again. The "Spatial Analysis 1.0" option should be listed at the bottom of the Tools menu as shown in Figure ATT-2.1.

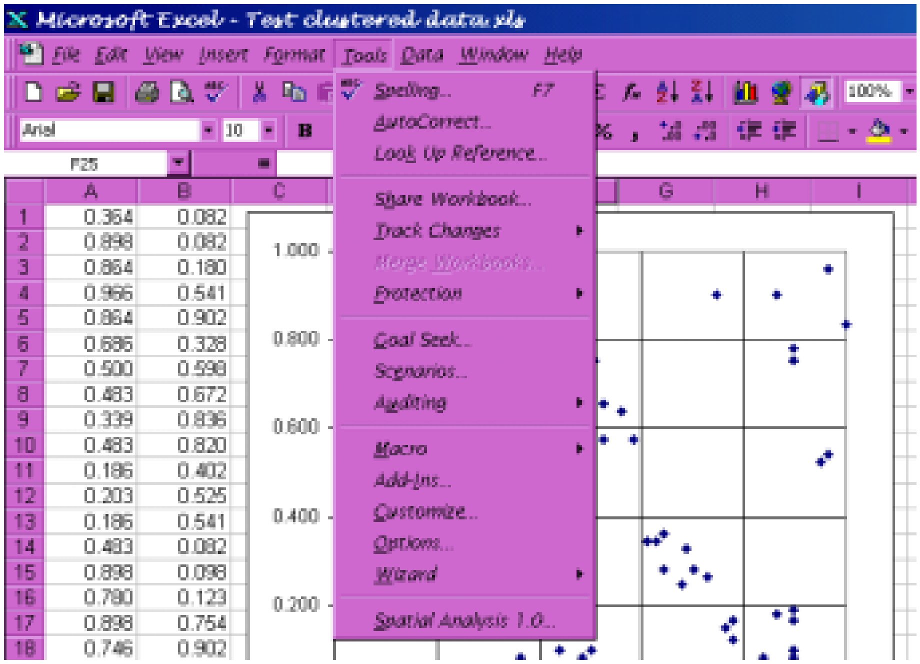


Figure ATT-2.1 Tools Menu Indicating Spatial Analysis Add-In

3.0 Operation of the Spatial Analysis Software Module

The following steps must be followed each time the spatial analysis software is used.

(1) Open Excel.

(2) Open the data file or create your own. Section 4.1 includes details about the data file format.

(3) Select the "Spatial Analysis 1.0" option under the Tools menu to start the program. The dialog box in Figure ATT-2.2 will appear. This box indicates the title of the program and that it is intended for use as part of the Fort Ord OE Sampling and Analysis Plan.

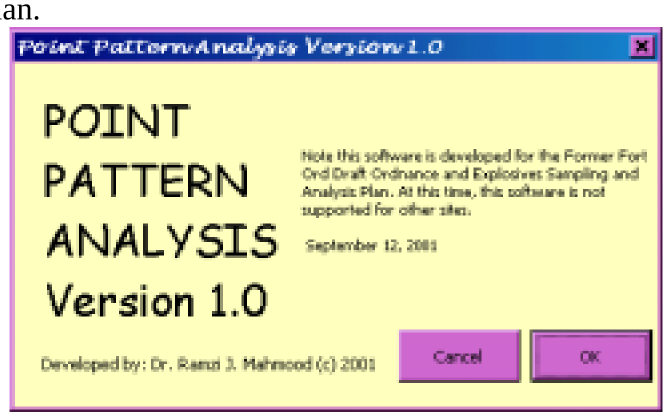


Figure ATT-2.2 Spatial Analysis Initial Dialogue Box.

(4) Click OK to continue.
(5) Select the appropriate options under the input and output tabs, as described in section 4.0.
(6) Click the Run button. The program may require several minutes to complete analysis.

4.0 Spatial Analysis Process

The overall spatial analysis process is presented in Figure ATT-2.3.

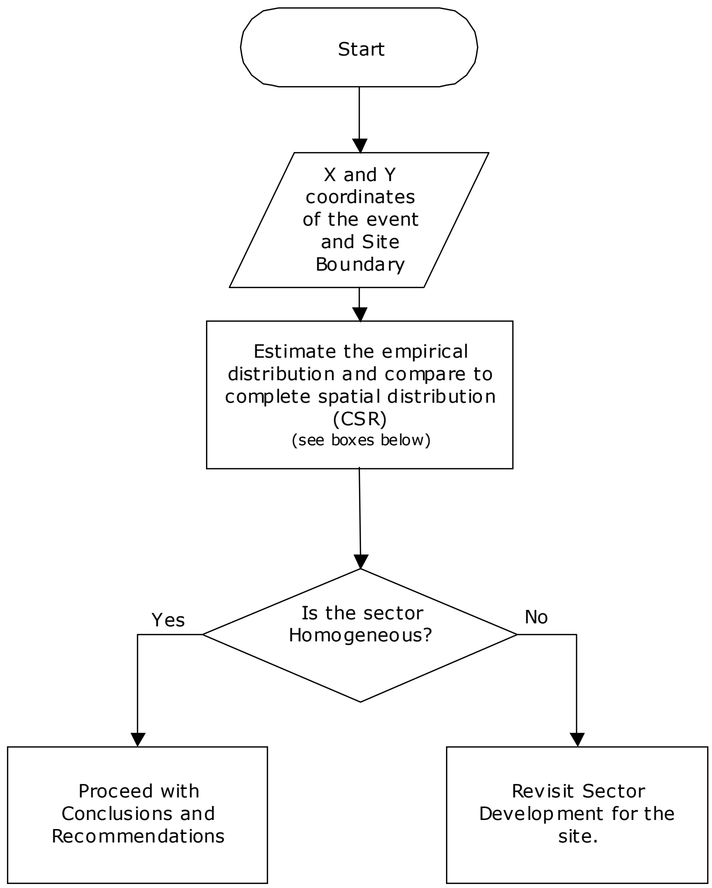


Figure ATT 2.3. Overview of Spatial Analysis Process

This figure illustrates the input of the coordinates and site boundaries followed by the actual spatial analysis. The first question to be considered is whether the data follow a completely spatially random (CSR) distribution throughout the sample area. That is, a CSR site is a homogeneous site. Site homogeneity is determined using two methods. The first method involves simulating a homogeneous site and comparing the simulation results to the actual data. The second method uses the Hopkins statistic (see Section 4.1.8 for details).

The main Spatial Analysis box (Figure ATT-2.4) has two tabs: Input and Output. The boxes and buttons under the Input tab allow choices for input data, boundary selection, and other information pertinent to performing the spatial analysis. The Output tab allows designation of the output location (worksheet or elsewhere on the current sheet). Each of the options is described in detail below.

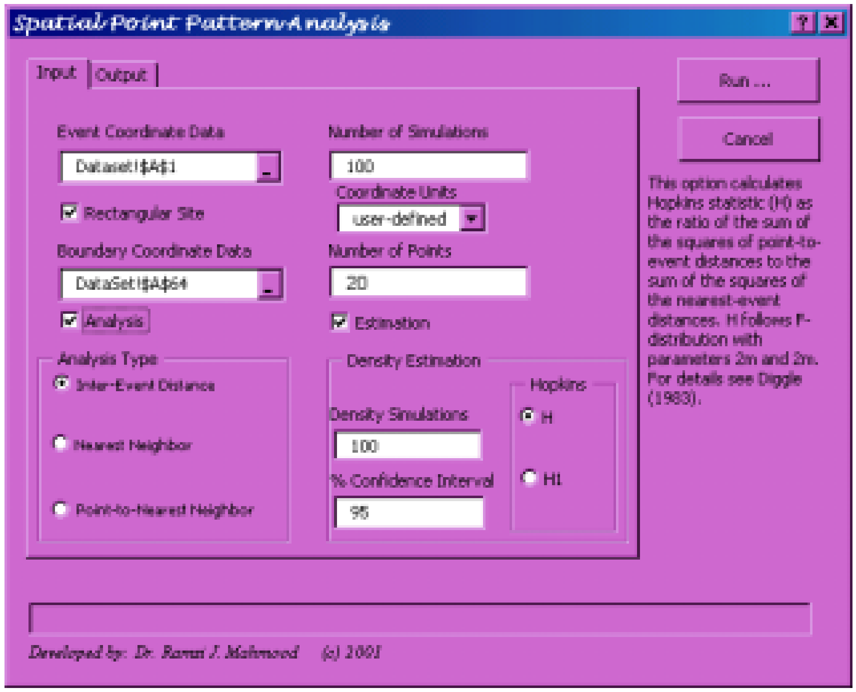


Figure ATT-2.4 Spatial Point Pattern Analysis input dialogue box.

4.1 Input

The input dialog box is shown in Figure ATT-2.4.

4.1.1 Event Coordinate Data

The Event Coordinate Data box is used to designate the location of the data to be analyzed. The data must be organized in two adjacent columns (x, y) and there must be empty lines and rows separating the coordinate data from any other filled cells. To set the event coordinate data box, click once in the box, then find your data. The data can be selected in one of two ways. The first is to just select the upper left corner cell of the data. This is shown in Figure ATT-2.4. The other way is to highlight the area by clicking and dragging the mouse pointer starting from the upper left corner through the lower right corner.

4.1.2 Rectangular Site Check Box

The Rectangular Site check box should be checked if the site is rectangular. The coordinates should be listed in counterclockwise order surrounding the site, starting with the smallest x-coordinate (Easting). Calculations for a rectangular site are much faster if this box is checked. Five points are used to describe a four-cornered box in order to “close” the description of the boundary. The last point should be the same as the first point. The data should be in two adjacent columns with at least one blank column or row between the coordinate columns and the boundary columns.

4.1.3 Boundary Coordinate Data

The coordinates of the boundary of the sample area are input here in a counterclockwise direction, starting with the smallest x-coordinate (Easting). As with the Event Coordinate Data, the upper left cell of the boundary can be selected (Figure ATT-2.4). Alternatively, all points defining the polygon boundary of the site may be selected. Either way, the coordinates should be listed in counterclockwise order. The first and last pairs of coordinates should be the same, producing a closed polygon. The data should be in two adjacent columns with at least one blank column or row between the coordinate columns and the boundary columns.

4.1.4 Number of Simulations

This parameter refers to the number of simulations executed in order to establish the average Empirical Distribution Function (EDF). Each simulation involves randomly distributing events within the site and calculating the Inter-Event, Nearest Neighbor, or Point-to-Nearest-Neighbor distances. For test data (and faster running times), this number can be as low as 30. However for an analysis of real data, this parameter should be set near 100. Note that the higher the number, the longer the execution time.

4.1.5 Number of Points

This parameter is used to designate the number of points used to calculate the EDF. The higher the number of points along this line, the smoother the resulting curve. However, there is a corresponding increase in the execution time. This parameter should not be set to less than 20.

4.1.6 Coordinate Units List

This list allows the density to be reported as items per acre, hectare, and square unit depending on the units of the input dataset coordinates.

Input	Output
Feet	items per acre
Meters	items per hectares
User Defined	items per square unit

4.1.7 Analysis and Estimation Check Boxes

The check boxes labeled "Analysis" and "Estimation" enable the spatial analysis and density estimation options. The density estimation module calculates the density and Hopkins Statistic. The spatial analyses and density estimation modules are discussed in more detail below.

4.1.8 Types of Spatial Analyses

The program tests the data for homogeneity using Inter-Event, Nearest Neighbor, or Point-to-Nearest-Neighbor distances. The simulation model generates the appropriate graph to compare the data to the maximum and minimum CSR distributions (refer to boxes at end of this manual for details). The three types of spatial analyses, Inter-Event, Nearest Neighbor, and Point-to-Nearest-Neighbor are described in the following boxes.

Inter-event Distance Simulation:

1. For n events, calculate the $\frac{n(n-1)}{2}$ pairs of inter-event distances

2. Calculate the empirical distribution function for the inter-event distances that can be determined for a given value of (t) as:

$$\hat{H}_1(t) = \frac{\#(t_{ij} \le t)}{\frac{1}{2}n(n-1)}$$

Where,
t = A given inter-event distance,
$\hat{H}_1(t)$ = Empirical distribution of an inter-event distance,
$\#(t_{ij} \le t)$ = the number of inter-event distances that are less than or equal to (t), and
n = Number of event observed within the site of interest.

3. Compare the empirical distribution to the distribution of the inter-event distances by running Monte Carlo simulations. For each simulation, generate n events that are uniformly distributed within the area of interest, calculate the empirical distribution function (as it was done in step 1). Then calculate the average of the all the simulations as follows (as an approximation for the theoretical distribution function):

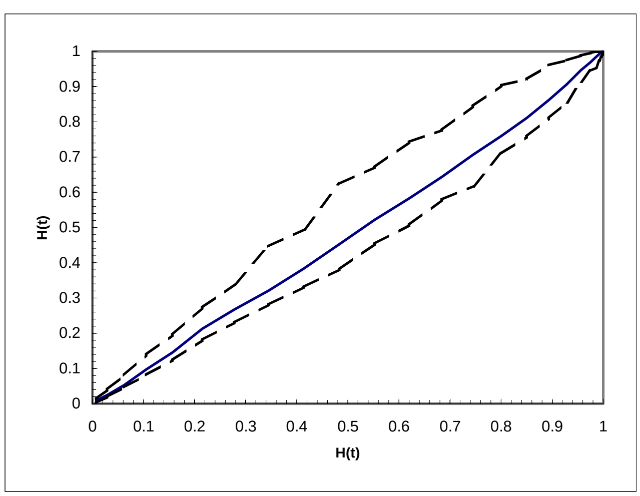
$$\overline{H}_i(t) = \frac{\sum_{i \ne j} \hat{H}(t)}{(s-1)}$$

Where,
$\overline{H}_i(t)$ = The average of Monte Carlo simulations,
s = Number of Monte Carlo simulation runs.

From the simulations, also estimate the upper U(t) and the lower L(t) bounds of the distribution function as follows:

$$U(t) = \max_{i=1,2,\cdots,s} \left\{ \hat{H}_i(t) \right\}; \qquad L(t) = \min_{i=1,2,\cdots,s} \left\{ \hat{H}_i(t) \right\}$$

3. Plot $\overline{H}_i(t)$ on the x-axis with $\hat{H}_1(t), U(t), \text{and } L(t)$ on the y-axis. If the data set is uniformly distributed (homogeneous site) the plot of $\overline{H}_i(t)$ and $\hat{H}_1(t)$ will be close to 45-degree line and within the upper and lower bounds. As shown below.



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Nearest Neighbor Distance Simulation:

1. For n events, calculate the n nearest neighbor distances
2. Calculate the empirical distribution function for the nearest neighbor distances that can be determined for a given value of (t) as:

$$\hat{G}_1(y) = \frac{\#(y_i \le y)}{n}$$

Where,

y	= A given nearest neighbor distances,
$\hat{G}_1(y)$	= Empirical distribution of an nearest neighbor distances,
$\#(y_j \le y)$	= the number of nearest neighbor distances that are less than or equal to (y), and
n	= Number of event observed within the site of interest.

2. Compare the empirical distribution to the distribution of the nearest neighbor distances by running Monte Carlo simulations. For each simulation, generate n events that are uniformly distributed within the area of interest, calculate the empirical distribution function (as it was done in step 1). Then calculate the average of the all the simulations as follows (as an approximation for the theoretical distribution function):

$$\overline{G}_1(y) = \frac{\sum_{1}^{s} \hat{G}_i(y)}{s}$$

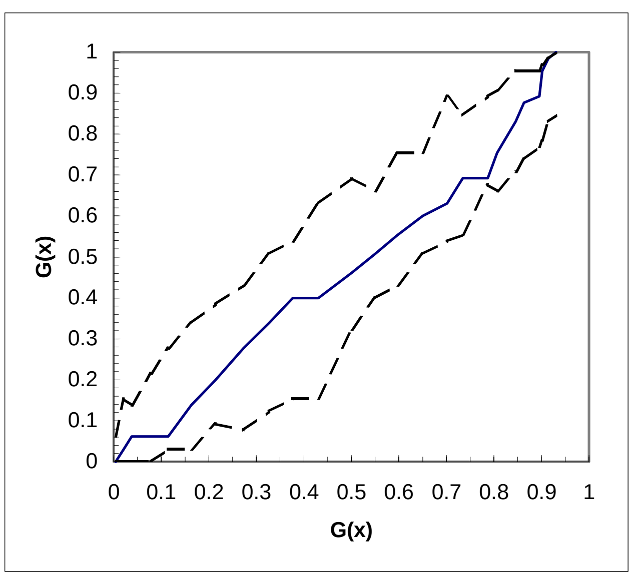
Where,

$\overline{G}_i(y)$	= The average of Monte Carlo simulations,
s	= Number of Monte Carlo simulation runs.

From the simulations, also estimate the upper U(y) and the lower L(y) bounds of the distribution function as follows:

$$U(y) = \max_{i=1,2,\cdots,s} \left\{ \hat{G}_i(y) \right\} \qquad L(y) = \min_{i=1,2,\cdots,s} \left\{ \hat{G}_i(y) \right\}$$

2. Plot $\hat{G}_1(y)$ on the x-axis with $\hat{G}_1(y), U(y), \text{and } L(y)$ on the y-axis. If the data set is uniformly distributed (homogeneous site) the plot of $\overline{G}_i(y)$ and $\hat{G}_1(y)$ will be close to 45-degree line and within the upper and lower bounds. As shown below.



Point-to-Nearest Neighbor Distance Simulation:

1. Generate m points in a regular grid KxK such that K ≈ √n.
2. For m points (generated randomly), calculate the m point-to-nearest event distances.
3. Calculate the empirical distribution function for the point-to-nearest event distances that can be determined for a given value of (t) as:

$$\hat{F}_1(x) = \frac{\#(x_i \le x)}{m}$$

Where,

x = A given inter-event distance,

$\hat{F}_1(x)$ = Empirical distribution of an point-to-nearest event distances,

$\#(x_j \le x)$ = the number of point-to-nearest event distances that are less than or equal to (x), and

m = Number of event observed within the site of interest.

3. Compare the empirical distribution to the distribution of the point-to-nearest event distances by running Monte Carlo simulations. For each simulation, generate n events that are uniformly distributed within the area of interest, calculate the empirical distribution function (as it was done in step 1). Then calculate the average of the all the simulations as follows (as an approximation for the theoretical distribution function):

$$\overline{F}_1(x) = \frac{\sum_{1}^{s} \hat{F}_i(x)}{s}$$

Where,

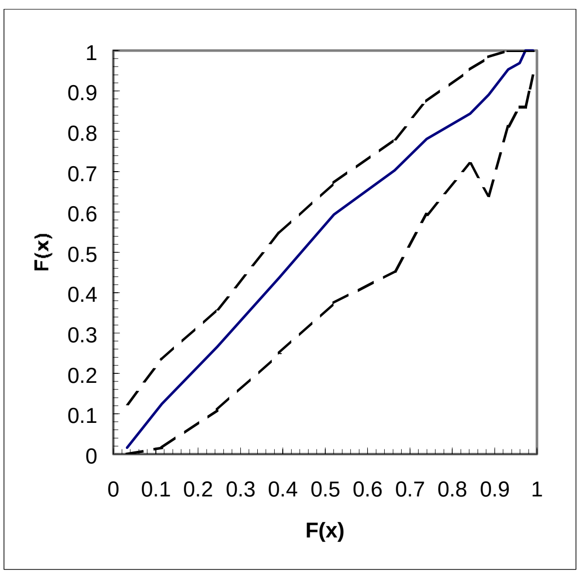
$\overline{F}_i(x)$ = The average of Monte Carlo simulations,

s = Number of Monte Carlo simulation runs.

From the simulations, also estimate the upper U(x) and the lower L(x) bounds of the distribution function as follows:

$$U(x) = \max_{i=1,2,\cdots,s} \{\hat{F}_i(x)\}; \qquad L(x) = \min_{i=1,2,\cdots,s} \{\hat{F}_i(x)\}$$

3. Plot $\overline{F}_i(x)$ on the x-axis with $\hat{F}_1(x), U(x),$ and $L(x)$ on the y-axis. If the data set is uniformly distributed (homogeneous site) the plot of $\overline{F}_i(x)$ and $\hat{F}_1(x)$ will be close to 45-degree line and within the upper and lower bounds. As shown below.



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4.1.9 Homogeneity, the Hopkins Statistic, and Density Estimation

The Hopkins statistic (Hopkins, 1954) is a method that determines if a dataset is homogeneous (completely spatially random) relative to an "event" of interest within the site. For the purposes of the Fort Ord OESAP, the events could be anomalies, OE items, just UXO items, or only specific types of OE items. The project team will determine just what will define a set of events. Two types of Hopkins statistics can be calculated, H and H_1. Both of these are based on two distances, x_i and y_i (Figure ATT 2.5). The following is a summary of the method that is used to calculate the Hopkins statistic in this OESAP.

1. Select at random (m) points ($i = 1,2,\ldots, m$) that are located in the site or area of interest. Within the software m is set equal to n (number of events of interest). However, one can estimate m in a regular (kxk) grid system as proposed by Diggle and Matérn (1981) where, $k \approx \sqrt{n}$. This latter method is not used within the software, however, there is a built-in algorithm that can incorporate this method.
2. For each point (i) measure the shortest distance (x_i) to an event (point-to nearest event).
3. For each event (i) measure the shortest distance (y_i) to another event (nearest event distance).

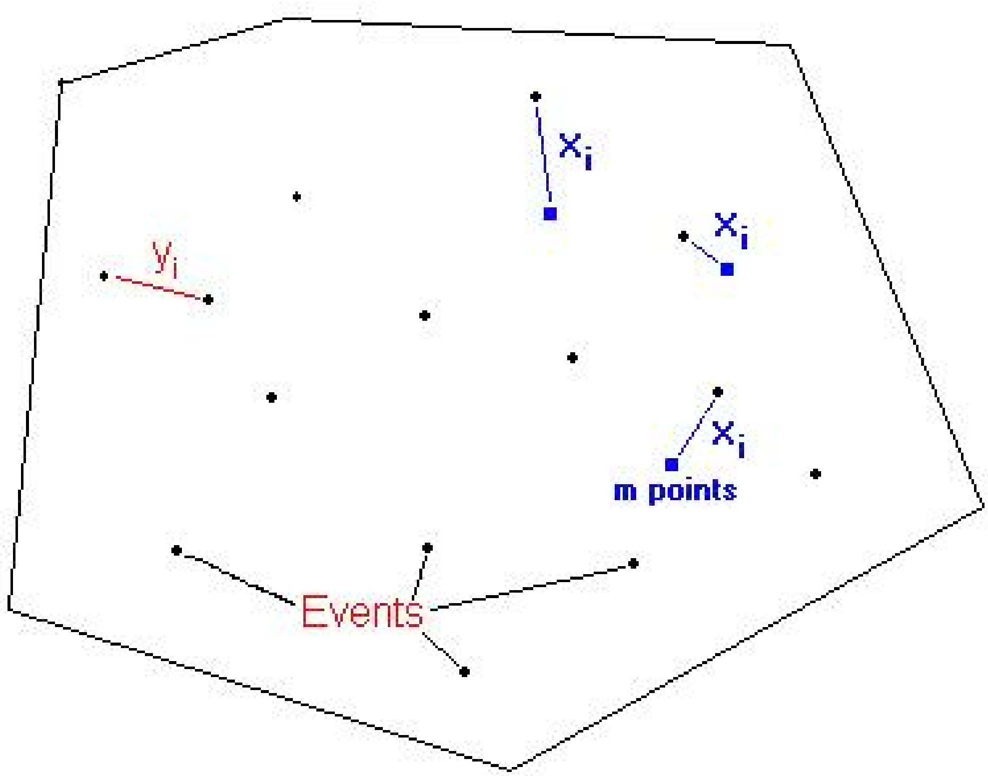

Figure ATT-2.5. Definition of Spatial Analysis Distances: y_i are the shortest distances between events (represented with black dots); x_i are the shortest distances between randomly spaced points (represented by blue squares) and neighboring events.

4. Compute one of the following statistics:

$$H = \frac{\sum_{i=1}^{m} x_i^2}{\sum_{i=1}^{m} y_i^2} \text{ , or}$$

$$\mathrm{H}_1 = \frac{\sum_{i=1}^{m} x_i^2}{\sum_{i=1}^{m} y_i^2 + \sum_{i=1}^{m} x_i^2}$$

Where,

H = Hopkins statistic
H_1 = an alternate form of Hopkins statistic
x_i = distance from a point i to the nearest event
y_i = distance from an event to the next nearest event

The algorithm calculates the Hopkins statistic based on the all events available. Distance *x* could be considered to represent a circular area that is empty (*x* is the radius of the circle). Distance *y* would then represent the radius of a circular area that has an event within it. When the Hopkins statistic is large, it indicates that the site is not homogeneous and when it is small, the area under investigation can be considered homogeneous. Note that Hopkins in his paper defined the statistic in H_1 form. Diggle (1983) used the H form of Hopkins statistic.

The distribution of events (data) in Figure ATT-2.6 illustrates a relatively homogeneous distribution. If the site has clustered data (i.e. is not homogeneous), as in Figure ATT-2.7, you would expect to see larger areas (patches) that are empty. This distribution results in large *x* values relative to the *y* distances because of event clustering and so the Hopkins statistic is large.

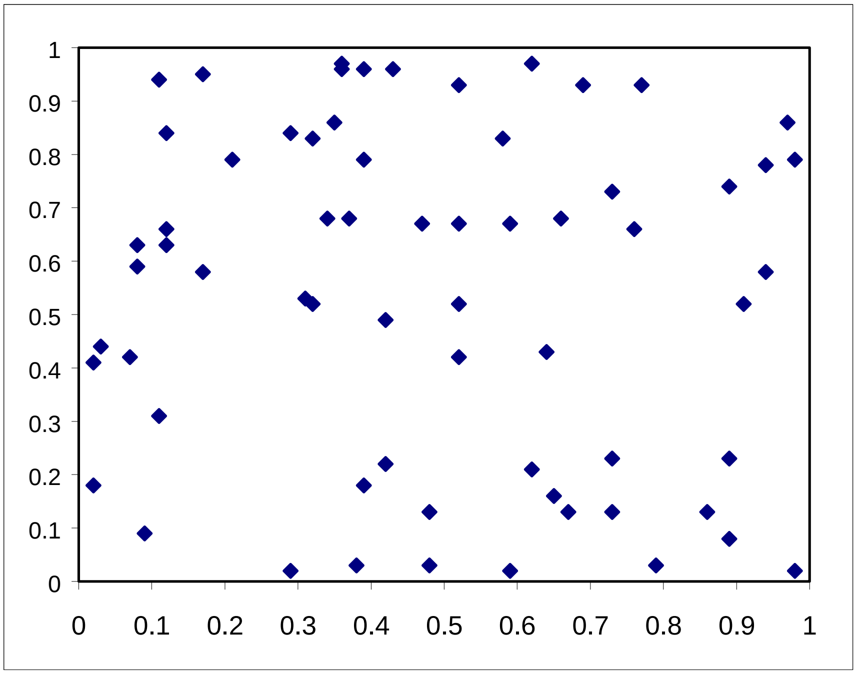

Figure ATT-2.6 – Example of events considered to be homogeneously distributed (from the sample data “homogeneous data.xls” provided with accompanying software)

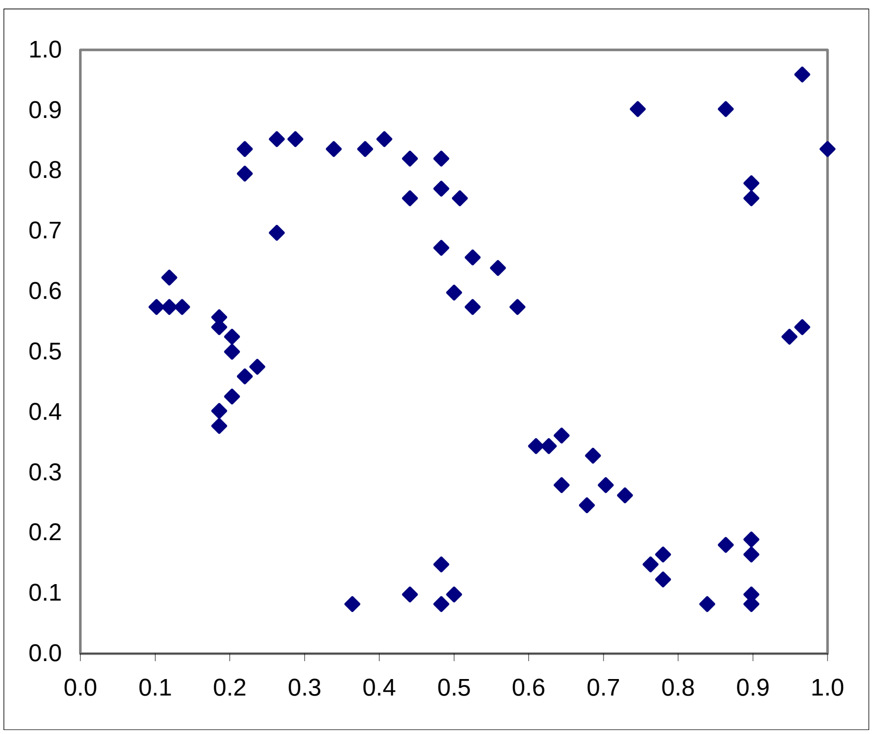

Figure ATT-2.7 – Example of an area with clustered events (from the sample data “clustered data.xls” provided with accompanying software).

Statistically, *H* follows an F-distribution. This distribution arises from a ratio between two sums of squares each of which has its own degrees of freedom (df). The degrees of freedom associated with the numerator and denominator are designated as (df1 and df2), respectively. These two parameters define a specific F-distribution (Figure ATT-2.8). H follows an F-distribution with both degrees of freedom equal to m. H_1 follows a beta distribution BETA(m,m). Note that a beta distribution is defined by two parameters. The software uses the beta distribution. However, H_1 follows a normal distribution (Figure ATT-2.9) with a mean of 0.5 and variance of $(4(2m+1))^{-1}$ when the number of events n is large (n > 50). The accompanying spatial analysis software module (Spatial Analysis Ver. 1.0) calculates the Hopkins statistic. The calculated *H* value can be compared to the computed F-distribution value to objectively determine whether it is large enough. If $H > F$, then the site is not homogeneous. Otherwise, the site is considered homogeneous. The same logic applies with the H_1 statistic compared to the appropriate value from a beta distribution.

There are several methods to estimate the density of an event. Two methods are outlined here. The first method is based on the estimate of a Poisson process and is applicable to sites that are CSR. The density λ is estimated using the following equation (from Ripley, 1981):

$$\tilde{\lambda} = \left(\frac{m}{2\sum_{i=1}^{m} x_i} \right)^2$$

This estimate can be generalized if we look for *k* nearest events from each point. In this case, x_i represents the smallest distance from point *i* that contains *k* events. That is, the density estimate can be represented by:

$$\hat{\lambda} = \frac{mk}{\pi \sum_{i=1}^{m} x_i^2}$$

The other method (Diggle, 1975 and 1977) involves two measurements: Point-to-Nearest event and event-to-nearest event (i.e. Nearest Neighbor) distances. This method is more appropriate for areas that are not CSR. The density is estimated as follows:

$$\lambda^* = \frac{m}{\pi \left(\sum_{i=1}^{m} x_i^2 \sum_{i=1}^{m} y_i^2 \right)^{\frac{1}{2}}}$$

The attached software uses Diggle's method to estimate the density.

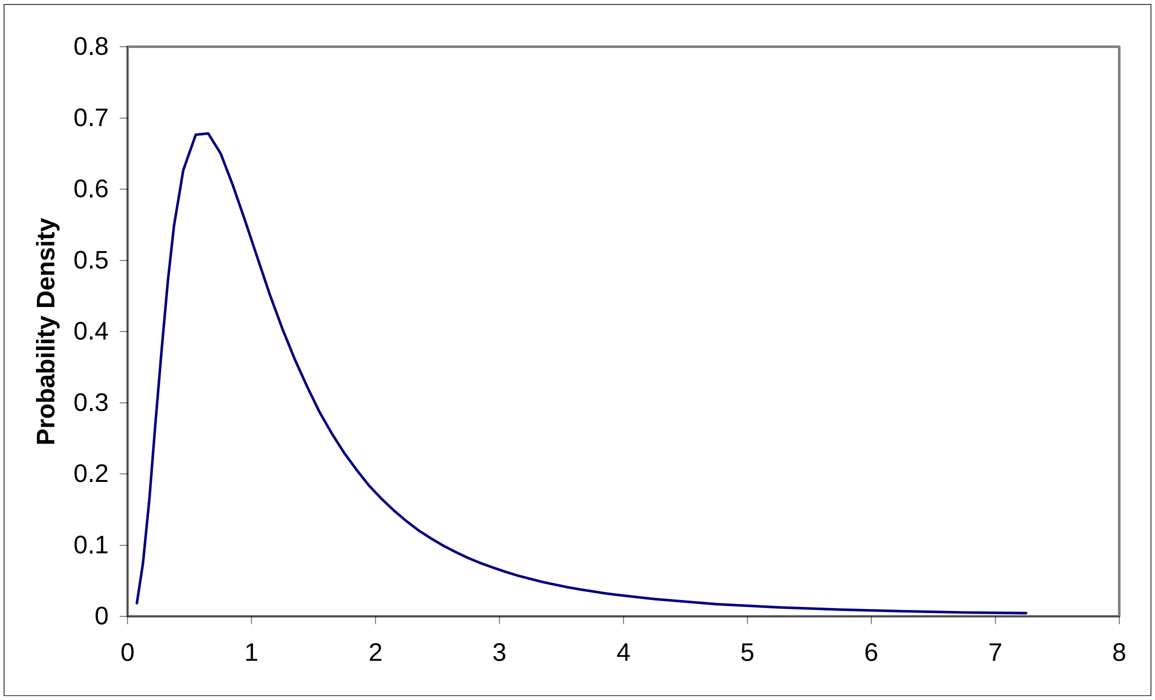

Figure ATT-2.8 – F Distribution

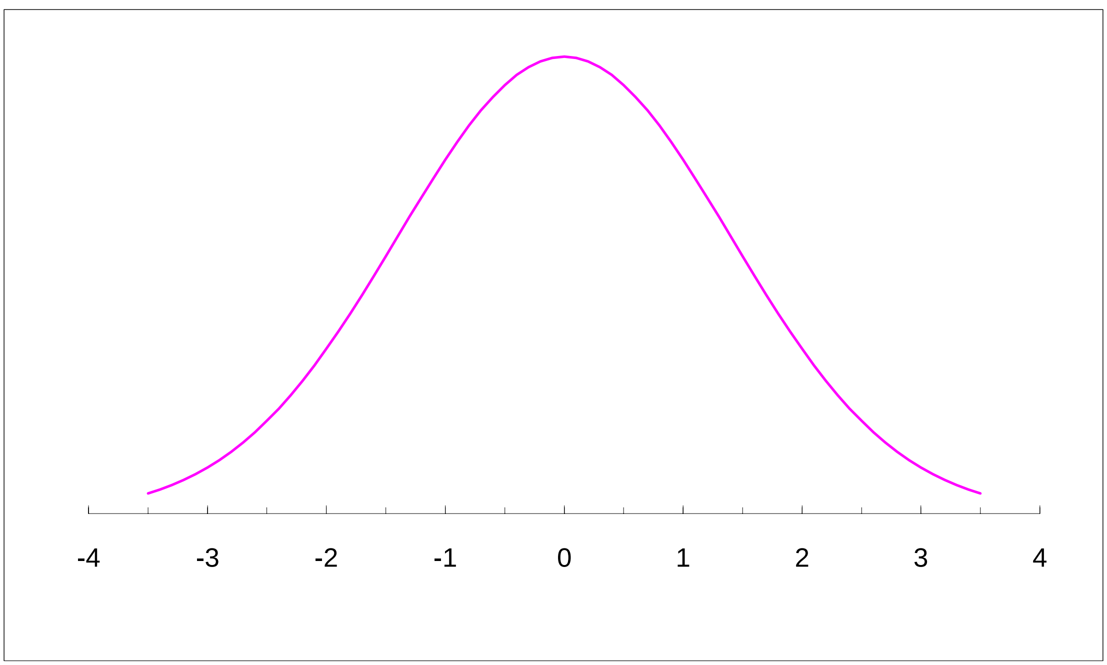

Figure ATT-2.9 – Normal Distribution

4.2 Output

The output dialog box is shown in Figure ATT-2.10.

4.2.1 Screen Update Check Box

If this box is checked the screen is updated as the simulations are completed. Updating the screen during program execution slows the process significantly.

4.2.2 Problem Title

The text entered in the Problem Title area will appear on the output above the EDF data if the analysis check box is checked.

4.2.3 Output Options

The user can select the output location in the Output Options section. If the Range radio button is selected, the output will appear in the same worksheet as the dataset, starting at the cell location specified. Alternatively the user can choose to direct the output to a new worksheet. The name of the new worksheet cannot be the same as an existing worksheet in the current workbook.

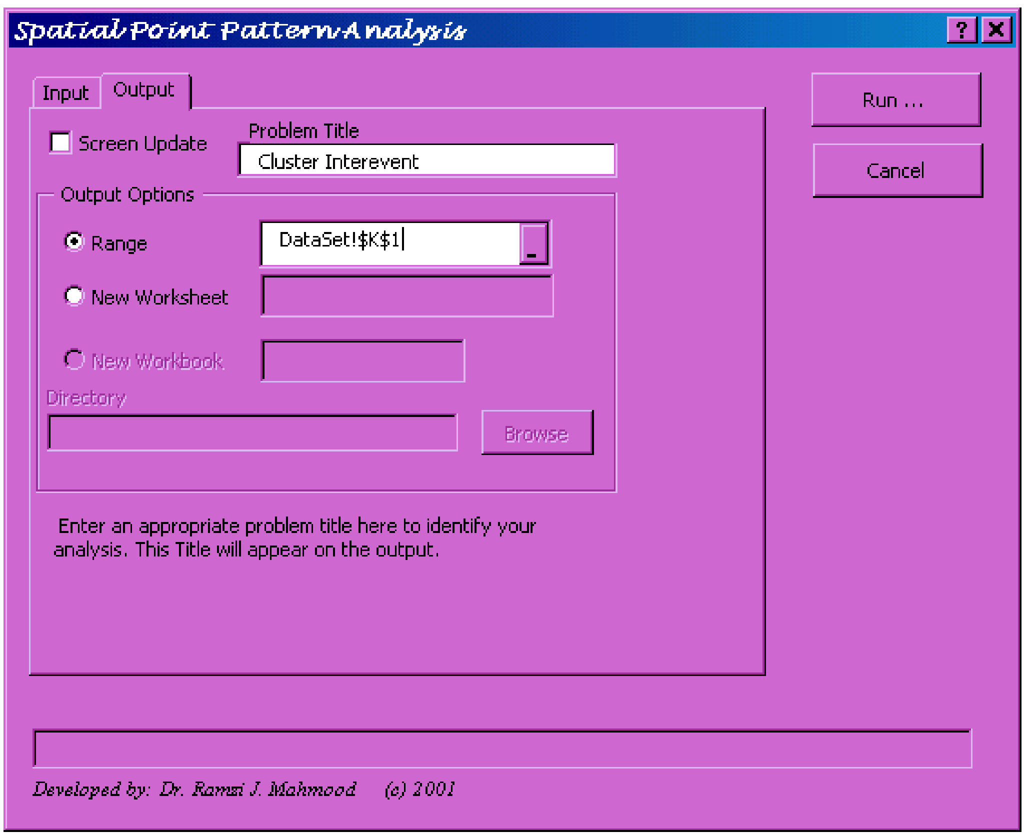

Figure ATT-2.10 Spatial Point Pattern Analysis output dialogue box.

5.0 Results

The program output can include three sections, the graphical results, the Hopkins statistic results, and the summary conclusion (Figure ATT 2.11). If the analysis check box was selected in the input dialog box the graphical results will be located in the upper left of the output worksheet. If the Density Estimation check box was selected the Hopkins statistic results will be located below the graphical results. The summary report box is located below the other results.

Cluttered Data Inter-Event Analysis

Inter-Event Distance Simulations

Distance	Data EDF*	CSR** EDF	CSR Min	CSR Max
0	0	0	0	0
0.053187	0.02697	0.008662	0.004231	0.013749
0.106374	0.074564	0.031787	0.021682	0.048123
0.15956	0.118985	0.069154	0.056584	0.09413
0.212747	0.152829	0.1177	0.097832	0.140137
0.265934	0.197779	0.174802	0.144368	0.225806
0.319121	0.254892	0.239937	0.182443	0.304072
0.372307	0.331042	0.307144	0.268641	0.364886
0.425494	0.432047	0.374696	0.301957	0.459016
0.478681	0.504495	0.456579	0.389212	0.548387
0.531868	0.567953	0.530873	0.462718	0.625595
0.585054	0.635114	0.595923	0.50238	0.720783
0.638241	0.69487	0.65771	0.566367	0.740878
0.691428	0.758329	0.741211	0.635114	0.838181
0.744615	0.817557	0.793321	0.69963	0.881015
0.797802	0.892121	0.849149	0.750925	0.920148
0.850988	0.936542	0.892993	0.819672	0.964569
0.904175	0.969857	0.930915	0.890005	0.966684
0.957362	0.990481	0.960999	0.925436	0.988366
1.010549	0.998942	0.978001	0.95082	0.995769

* Empirical Distribution Function
** Complete Spatial Randomness
0.486311 Mean of Inter-Event Distance
0.241512 Standrad deviation of Inter-Event Distance

Density Estimate
4.39E+01 2.5% Percentile Items/unit area
5.53E+01 Average density Items/unit area
6.89E+01 97.5% Percentile Items/unit area

Hopkins (H) Statistic
2.706 2.5% Percentile
4.24 Median
7.09 97.5% Percentile
1.424 F-Statistic

****** Summary Report ******
5.53E+01 Average Density Items/unit area
The site is not homogeneous based the Hopkins test statistic
Based on the EDF graph, the site is not homogeneous

Inter-event Distance Matrix

Events

0	0.534	0.509513
0.534	0	0.10373
0.509513	0.10373	0
0.757024	0.46401	0.375133
0.754192	0.914224	0.814632
0.698216	0.803473	0.702325
0.379812	0.775475	0.705292
0.557412	0.935778	0.857834
0.507256	0.855902	0.775766
0.078645	0.45728	0.430875
0.475	0.059	0.101139
0.424005	0.143694	0.08551
0.878046	0.697	0.599964
0.354249	0.274401	0.197363
0.359388	0.389343	0.302344
0.539356	0.583123	0.48278
0.767628	1.014002	0.919278
0.7712	0.913226	0.81267
0.687255	0.776971	0.675435
0.403565	0.775766	0.701838
0.549626	0.92136	0.84277

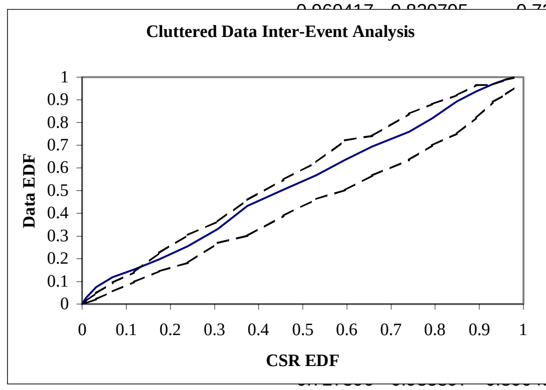

Figure ATT 2.11. Example output from both graphical and Hopkins statistic analysis.

5.1 Graphical Results

The simulation model generates the appropriate graph (Inter-Event, Nearest-Neighbor, or Point-to-Nearest Neighbor) that compares the dataset to a completely spatially random (CSR) distribution. The x axis of this graph is the CSR average empirical distribution function (EDF) from the simulations. The maximum and minimum EDFs are plotted as dashed black lines against the average EDF. The Inter-Event, Nearest-Neighbor, or Point-to Nearest-Neighbor distances are represented by a blue line on the same graph. If that blue line falls within the simulated envelop (dashed black lines), the dataset is uniformly distributed (homogeneous). If the dataset line crosses above the maximum EDF line or below the minimum EDF line the dataset is not uniformly distributed.

5.2 Hopkins Statistic Results

In addition to the graphical results, the Hopkins statistic results can also be reported. The Hopkins statistic is included in the output along with the designated percentiles. The F or beta statistic is reported for comparison. If the Hopkins statistic is smaller than the F or beta statistic the dataset is homogeneous. Otherwise the dataset is not homogeneous.

The Hopkins statistic results also include the density estimate, as calculated using Diggle's method described in section 4.1.9. If both the graphical and Hopkins statistic methods are selected the software displays a mean and standard deviation that can be used to select the distance between transects or buffer zone distance for future sampling plan designs.

5.3 Summary Report

The summary report box concisely outlines the result of the analyses. If the results of the two methods (graphical and statistical) are inconsistent, inspect the data visually. Also, run all simulations (inter-event, nearest neighbor, and point-to-nearest event) and make sure the graphical results are consistent. If the results are not consistent, increase the number of simulations to increase the confidence in the statistics generated.

If the analysis results indicate that the dataset is not homogeneous the sectors must be refined. The OE Site Boundary Determination and Sector Development SOP should be followed to divide the site into homogeneous areas. After resectorization, check all new sectors for homogeneity prior to additional analysis.

6.0 References

Diggle, P. J. 1975. Robust Density Estimation Using Distance Methods. Biometrika. 62(1):39-48.

Diggle, P. J. 1977. A Note on Robust Density Estimation for Spatial Point Pattern. Biometrika. 64(1):91-95.

Diggle, P. and Matern, B. 1981. On Sampling Designs for the Estimation of Point-Event Nearest Neighbor Distributions. Scand. J. Statist. 7:80-84.

Hopkins, B. 1954. A New Method for Determining the Type of Distribution of Plant Individuals. Annals of Botany. 18 (70) 213:227.

Ripley, B. 1981. Spatial Statistics. Wiley Interscience. New York, NY.

7.0 Program Listing

```
Public distance(1 To 1000, 1 To 1000), Point(1 To 200, 1 To 2)
Public PEdistance(1 To 1000, 1 To 1000), PEDistanceRange As Range, iPlist(1 To 1000)
Public XE As Range, BRange As Range, NBPoints As Integer
Public BB As Range, Y(1 To 50), D(1 To 50)
Public add1, iList(1 To 1000), distf(1 To 1000)
Public n As Integer, Pline(1 To 100)
Public onsite As Boolean
Public Bline(1 To 1000, 1 To 4), Oldsheet
Public DistanceRange As Range, YO As Range
Public Xcoor(1 To 1000), Ycoor(1 To 1000), ResultsSheet
Public xminb, xmaxb, yminb, ymaxb, starttime
Public OldName, EDfData(1 To 1000), AnalysisTitle$, outputAddress, EDfDatax(1 To 1000)
Public ybar(1 To 1000) As Single, EDFMin(1 To 1000) As Single, EDFMax(1 To 1000) As Single
Public Ndistances, Nsimulations, m As Integer
Public EXCoor(1 To 1000), EYCoor(1 To 1000), Standard_Deviation, Distance_Mean
Public DataWorkbook As Workbook, IsItCSR As Boolean, steep As Boolean
Public NewWorkbook, NBreakPoints As Integer, BoderPoints As Integer



Sub RunPPA()
   SpatialPoint.LabelProgress.Width = 0
   Load Logo
   Logo.Show
End Sub

Sub InitialSetup()

   With SpatialPoint
      .OK.Enabled = False
      .Cancel.Enabled = False
      .LabelHelpInput.BackColor = &HFF&
      .LabelHelpInput.Caption = _
         "In order to stop the program press Ctrl-Break and then push End"
   End With

   starttime = Timer

   Set Oldsheet = ActiveSheet
   OldName = Oldsheet.Name
   Set DataWorkbook = ActiveWorkbook
   DataBookName = DataWorkbook.Name

   '
   '  This part determines where to show the output
   '

   If SpatialPoint.BtnOutputRange.Value Then
      outputAddress = Range(SpatialPoint.RefOutputRange.Value).Address
      Cn = Range(outputAddress).Column
      Rn = Range(outputAddress).Row
      Range(outputAddress & ":" & Range(outputAddress).Offset(65535 - Rn, _
         256 - Cn).Address).Cells.Clear
      Set ResultsSheet = ActiveSheet
      NewWorkbook = ActiveWorkbook.Name
   End If

   '
   '  This part determines if the sheet name entered exits
   '


   If SpatialPoint.BtnNewWorksheet.Value Then
      newname = SpatialPoint.TbxNewWorksheet.Value
```

```
    NewSheet = True
    Do While NewSheet

        For Each Item In ActiveWorkbook.Sheets
            If Item.Name = newname Then
                MsgBox "The Sheet name " & newname & " you entered already exit!"
                newname = InputBox("Enter a new name")
        Else
            NewSheet = False
        End If
        Next Item
    Loop
    Set ResultsSheet = Sheets.Add
    ResultsSheet.Name = newname
    NewWorkbook = ActiveWorkbook.Name
    outputAddress = Range("A1").Address
End If

'
'   This part handles adding a new workbook for the output
'

If SpatialPoint.BtnNewWorkbook.Value Then

    outputfile = SpatialPoint.tbxFileLocation.Value & SpatialPoint.TbxNewWorkbook.Value

    Workbooks.Add
    ActiveWorkbook.SaveAs FileName:=outputfile & ".xls", FileFormat:=xlNormal, _
        Password:="", WriteResPassword:="", ReadOnlyRecommended:=False _
        , CreateBackup:=False
    Set ResultsSheet = ActiveSheet
    outputAddress = "A1"
    NewWorkbook = SpatialPoint.TbxNewWorkbook.Value & ".xls"

End If

Windows(NewWorkbook).Activate
Oldsheet.Activate
Set XE = Range(SpatialPoint.EventCoordinates.Value).CurrentRegion
n = XE.Rows.Count


For i = 1 To n
    EXCoor(i) = XE.Cells(i, 1).Value
    EYCoor(i) = XE.Cells(i, 2).Value
Next i

Set BRange = Range(SpatialPoint.BoundaryLine.Value).CurrentRegion
NBPoints = BRange.Rows.Count

xminb = Application.WorksheetFunction.Min(BRange.Columns(1).Value)
xmaxb = Application.WorksheetFunction.Max(BRange.Columns(1).Value)
yminb = Application.WorksheetFunction.Min(BRange.Columns(2).Value)
ymaxb = Application.WorksheetFunction.Max(BRange.Columns(2).Value)

'
'   This part determines if the site is rectagular. Calculations are less
'   involved when the site is rectangualr.
'

If Not SpatialPoint.Rectangle Then
    add1 = BRange.Cells(1, 1).Address
    add2 = Range(add1).Offset(NBPoints - 1, 3).Address
    Set BRange = Range(add1, add2)

    For i = 1 To NBPoints
        Bline(i, 1) = BRange.Cells(i, 1).Value
```

```
        Bline(i, 2) = BRange.Cells(i, 2).Value
        Bline(i, 3) = Sqr(Bline(i, 1) ^ 2 + Bline(i, 2) ^ 2)
        If Bline(i, 2) = 0 Then
          Bline(i, 4) = Atn(1) * 2        ' pi/2
        Else
          Bline(i, 4) = Atn(Bline(i, 1) / Bline(i, 2))
        End If
      Next i
      BRange.Value = Bline

      Call PrepareBoundary
    End If

    'XE.Activate


    If SpatialPoint.chkanalysis Then


      If SpatialPoint.InterEvent Then

        AnalysisTitle = "Inter-Event Distance "
        Call TitleSetup(outputAddress)
        Call IE_Main
        Call EDFPlot
        Call CheckPlot

      ElseIf SpatialPoint.NearestNeighbor Then

        NNB = 1
        AnalysisTitle = "Nearest Neighbor Distance "
        Call TitleSetup(outputAddress)
        Call NN_Main
        Call EDFPlot
        Call CheckPlot

      ElseIf SpatialPoint.PointNearestEvent Then

        PNE = 1
        AnalysisTitle = "Point-to-Nearest Event Distance "
        Call TitleSetup(outputAddress)
        Call PNE_Main
        Call EDFPlot
        Call CheckPlot

      End If

    '
    '  Delete the temporary sheet without alerting the user
    '  for deleting the sheet.
    '
      Application.DisplayAlerts = False
      Sheets("Temp1").Delete
      Application.DisplayAlerts = True

    End If

    If SpatialPoint.btnDensity Then
      'If NNB = 0 Then
      '   Call InterEventDistance
      '   Set DistanceRange = Oldsheet.Range("I1" & ":" & Range("I1").Offset(n - 1, _
      '       n - 1).Address)
      '   DistanceRange.Value = distance

      '   Call nearest
      'End If
```


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```
        Call DensityEstimate

    End If

    SpatialPoint.LabelProgressTitle.Caption = "Total time was " & _
        Format((Timer - starttime) / 60, "0.0") & " minutes"

    With SpatialPoint
        .Cancel.Caption = "Close"
        .Cancel.Enabled = True
    End With


End Sub

Function MinifLoca(List) As Integer
'   This function finds the minimum element such that
'   it subject to a condition
'


xmin = Application.WorksheetFunction.Min(List)
'MinifLoca = Application.WorksheetFunction.Match(xmin, List, 0)

End Function

Sub InterEventDistance()
    '
    '   In this procedure the distances between events
    '   XE is the event coordinates
    '   n is the number of events

    '   Generate the upper triangle

    '
    '   Set XE = Range(SpatialPoint.EventCoordinates.Value)
    '   This line was deleted to accomodate the simulation
    '
    'n = XE.Rows.Count
    For i = 1 To n
        distance(i, i) = 0
    Next i
    sumied = 0
    For i = 1 To n
        For j = i + 1 To n
            delx = XE.Cells(i, 1) - XE.Cells(j, 1)
            dely = XE.Cells(i, 2) - XE.Cells(j, 2)
            distance(i, j) = Sqr(delx * delx + dely * dely)
            sumied = sumied + distance(i, j)
            distance(j, i) = distance(i, j)
        Next j
    Next i


End Sub
Sub nearest()
    '
    '   This procedure calculates the iList vector that list the
    '   nearest neighbor to event 1 through n.
    '   The nearest distance can be accessed by Distance(i, iList(i))
    '   Note: iList is a row vector as far VB is concerned. So it needs
    '   to be transposed if it is printed to a column within the spreadsheet.
    '
    Dim theRange As Range, xx As Range
    '
    '   Set XE = Range(SpatialPoint.EventCoordinates.Value)
    '   See intereventdistance module for justification
```

```
    '
    'n = XE.Rows.Count
    For i = 1 To n
        If i = 1 Then    ' Need to exclude the zeros along the diagonal
            Set xx = Range(DistanceRange.Cells(1, 2).Address & _
                 ":" & DistanceRange.Cells(1, n).Address)
            'xmin = Application.WorksheetFunction.Min(xx)
        ElseIf i = n Then
            Set xx = Range(DistanceRange.Cells(n, 1).Address & _
                ":" & DistanceRange.Cells(n, n - 1).Address)
            'xmin = Application.WorksheetFunction.Min(xx)
        Else
            x1 = DistanceRange.Cells(i, 1).Address & _
                ":" & DistanceRange.Cells(i, i - 1).Address
            X2 = DistanceRange.Cells(i, i + 1).Address & _
                ":" & DistanceRange.Cells(i, n).Address
            Set xx = Union(Range(x1), Range(X2))
        End If
        xmin = Application.WorksheetFunction.Min(xx)
        Set theRange = DistanceRange.Rows(i)
        iList(i) = Application.WorksheetFunction.Match(xmin, _
            theRange, 0)
    Next i

End Sub
Sub EmpiricaDistFunction(distf, Nsize, Y, EDFy)
    '
    '  In this procedure, the empirical distribution function is calculated
    '  Distf is the list of distances of interest (e.g., nearest neighbor)
    '  EDFy is the array that contains the values of CDF the correspond to
    '  the distance y
    '  Nsize is the size of EDF
    '
    EDFy = Application.WorksheetFunction.CountIf(distf _
            , ">=" & Y) / Nsize

End Sub
Sub IE_Main()

    Call InterEventDistance                 ' Generate the interEvent distances
    Windows(NewWorkbook).Activate
    LeftCorner = Range(outputAddress).Offset(3, 8).Address
    RightCorner = Range(LeftCorner).Offset(n - 1, n - 1).Address
    Set DistanceRange = ResultsSheet.Range(LeftCorner & ":" & RightCorner)
    DistanceRange.Value = distance

    Nsimulations = CInt(SpatialPoint.NumberSimulations.Value)
    Ndistances = CInt(SpatialPoint.NumberDistances.Value)

    ymax = Application.WorksheetFunction.Max(DistanceRange)
    For i = 1 To n
        If i = 1 Then    ' Need to exclude the zeros along the diagonal
            Set xx = Range(DistanceRange.Cells(1, 2).Address & _
                 ":" & DistanceRange.Cells(1, n).Address)
        ElseIf i = n Then
            Set xx = Range(DistanceRange.Cells(n, 1).Address & _
                ":" & DistanceRange.Cells(n, n - 1).Address)
        Else
            x1 = DistanceRange.Cells(i, 1).Address & _
                ":" & DistanceRange.Cells(i, i - 1).Address
            X2 = DistanceRange.Cells(i, i + 1).Address & _
                ":" & DistanceRange.Cells(i, n).Address
            Set xx = Union(Range(x1), Range(X2))
        End If
        If i = 1 Then
            ymin = Application.WorksheetFunction.Min(xx)
        Else
```

```
            ymin1 = Application.WorksheetFunction.Min(xx)
            If ymin1 < ymin Then
                ymin = ymin1
            End If
        End If
    Next i
    yrange = ymax - ymin
    For K = 1 To Ndistances
        Y(K) = ymin + (K - 1) * yrange / Ndistances
        EDfDatax(K) = (Application.WorksheetFunction.CountIf(DistanceRange, "<=" & Y(K)) _
            - n) / 2 / (n * (n - 1) / 2)
    Next K

    dataAddress = Range(outputAddress).Offset(3, 0).Address
    Set YO = ResultsSheet.Range(dataAddress & ":" & _
        Range(dataAddress).Offset(Ndistances - 1, 0).Address)
    YO.Value = Application.WorksheetFunction.Transpose(Y)
    Set Yhato = ResultsSheet.Range(Range(dataAddress).Offset(0, 1).Address & ":" & _
        Range(dataAddress).Offset(Ndistances - 1, 1).Address)
    Yhato.Value = Application.WorksheetFunction.Transpose(EDfDatax)

    Nied = (n ^ 2 - n) / 2              ' Number of Inter-event distances
    sumied = 0
    sumiedsq = 0
    For i = 1 To n
        For j = i + 1 To n
            sumied = sumied + distance(i, j)
            sumiedsq = sumiedsq + distance(i, j) ^ 2
        Next j
    Next i
    Distance_Mean = sumied / Nied
    Standard_Deviation = Sqr((Nied * sumiedsq - sumied ^ 2) / (Nied * (Nied - 1)))


    Call MonteCarloIE

End Sub

Sub NN_Main()

    '
    '   Need to calculate the actual distribution based on the event
    '   Reported
    '

    'Oldsheet.Activate

    Call InterEventDistance

    Windows(NewWorkbook).Activate

    ResultsSheet.Activate

    LeftCorner = Range(outputAddress).Offset(3, 8).Address
    RightCorner = Range(LeftCorner).Offset(n - 1, n - 1).Address
    Set DistanceRange = Range(LeftCorner & ":" & RightCorner)
    DistanceRange.Value = distance



    Call nearest
    '
    '   Need to calculate the expected distribution from a homogeneous
    '   distribution.
    '   These simulations are repeated Nsimulations times
    '   Also, the envelope of the maximum and minimum values from the
    '   simulations is estimated for comparison purposes.
```

```
    Nsimulations = CInt(SpatialPoint.NumberSimulations.Value)
    Ndistances = CInt(SpatialPoint.NumberDistances.Value)
    '
    '   Generate distance overwhich the CDF is estimated
    '
    For i = 1 To n
       distf(i) = distance(i, iList(i))
    Next i
    Distance_Mean = Application.WorksheetFunction.Average(distf)
    Standard_Deviation = Application.WorksheetFunction.StDev(distf)

    '
    '   Yrange allows to guess the distances overwhich we can estimate
    '   the empirical distribution function
    '   This should be revisited for a more robust mehtod
    '
    ymax = Application.WorksheetFunction.Max(distf)
    ymin = Application.WorksheetFunction.Min(distf)
    yrange = ymax - ymin

    FirstCell = ResultsSheet.Range(outputAddress).Offset(3, 6).Address
    LastCell = ResultsSheet.Range(FirstCell).Offset(n - 1, 0).Address
    Set EDFO = ResultsSheet.Range(FirstCell & ":" & LastCell)
    EDFO.Value = Application.WorksheetFunction.Transpose(distf)
    '
    '   Calculate the distance overwhich the empirical distribution
    '   is calculated y(k). Also, calculate the empirical distridution
    '   for the data EDFData(k).
    '
    For K = 1 To Ndistances
       Y(K) = ymin + (K - 1) * yrange / Ndistances
       EDfDatax(K) = Application.WorksheetFunction.CountIf(EDFO, "<=" _
          & Y(K)) / n
    Next K  ' Should check the statement above countif syntax and the
          '   name of the array dist

    dataAddress = ResultsSheet.Range(outputAddress).Offset(3, 0).Address

    Set YO = ResultsSheet.Range(dataAddress & ":" & _
       Range(dataAddress).Offset(Ndistances - 1, 0).Address)
    YO.Value = Application.WorksheetFunction.Transpose(Y)

    FirstCell = ResultsSheet.Range(dataAddress).Offset(0, 1).Address
    LastCell = ResultsSheet.Range(FirstCell).Offset(Ndistances - 1, 0).Address

    Set Yhato = ResultsSheet.Range(FirstCell & ":" & LastCell)

    Yhato.Value = Application.WorksheetFunction.Transpose(EDfDatax)

    '
    '   This part runs the simulations for Nsimulations times for each
    '   of the distances (Ndistances)
    '
    '
    '   The TempSheet inserts a sheet to use for the simulation
    '   The sheet is named "Temp1"
    '   Later I need to add a module to make sure this is a unique
    '   name. At this stage this is not important.
    '

    Application.ScreenUpdating = SpatialPoint.ChkScreenupdate

    Call MonteCarloNB


End Sub
```

```
Sub PNE_Main()

    '
    '  Need to calculate the actual distribution based on the event
    '  Reported
    '  For this simulation, we need to divide the site into grids
    '  Number of grids obtained by grid = Int(N), where N is the
    '  number of points
    '  The center of each grid will be considered the initial point
    '  to estimate the empirical distribution.
    '  Then by simulation we can generate the actual distribution and envelope
    '  of the distribution
    '


    'Oldsheet.Activate

    Nsimulations = SpatialPoint.NumberSimulations.Value
    Ndistances = SpatialPoint.NumberDistances.Value

'    grid = Int(Sqr(n))
'    m = grid ^ 2
'
'      Generate the x and y coordinates for the points located in the middle of each grid
'
'    For i = 1 To grid
'        For j = 1 To grid
'            K = grid * (i - 1) + j
'            Point(K, 1) = xminb + (j - 0.5) * (xmaxb - xminb) / grid
'            Point(K, 2) = yminb + (i - 0.5) * (ymaxb - yminb) / grid
'        Next j
'    Next i

    m = n
    Call RandomPoints(m)

    For i = 1 To m
        Point(i, 1) = Xcoor(i)
        Point(i, 2) = Ycoor(i)
    Next i

    '
    '  Calculate the distances from the points to nearest event
    '

    Call PointEventDistance

    Windows(NewWorkbook).Activate

    PEDLeftCorner = ResultsSheet.Range(outputAddress).Offset(6 + n, 8).Address
    PEDRightCorner = ResultsSheet.Range(PEDLeftCorner).Offset(n - 1, m - 1).Address
    Set PEDistanceRange = ResultsSheet.Range(PEDLeftCorner & ":" & PEDRightCorner)

    PEDistanceRange.Value = PEdistance


    '
    '  Generate the nearest event to each of the points
    '

    For i = 1 To m
        xmin = Application.WorksheetFunction.Min(PEDistanceRange.Columns(i))
        Set theRange = PEDistanceRange.Columns(i)
        iPlist(i) = Application.WorksheetFunction.Match(xmin, _
            theRange, 0)
        distf(i) = PEdistance(iPlist(i), i)
```

```
    Next i
    Standard_Deviation = Application.WorksheetFunction.StDev(distf)
    Distance_Mean = Application.WorksheetFunction.Average(distf)
    FirstCell = Range(outputAddress).Offset(3, 6).Address
    LastCell = Range(FirstCell).Offset(m - 1, 0).Address
    Set EDFO = Range(FirstCell & ":" & LastCell)
    EDFO.Value = Application.WorksheetFunction.Transpose(distf)

    DMin = Application.WorksheetFunction.Min(distf)
    DMax = Application.WorksheetFunction.Max(distf)
    DRange = DMax - DMin

    For K = 1 To Ndistances
       D(K) = DMin + (K - 1) * DRange / Ndistances
       EDfDatax(K) = Application.WorksheetFunction.CountIf(EDFO, "<=" & D(K)) / m
    Next K


    dataAddress = Range(outputAddress).Offset(3, 0).Address
    Set YO = ResultsSheet.Range(dataAddress & ":" & _
       Range(dataAddress).Offset(Ndistances - 1, 0).Address)
    YO.Value = Application.WorksheetFunction.Transpose(D)
    Set Yhato = ResultsSheet.Range(Range(dataAddress).Offset(0, 1).Address & ":" & _
       Range(dataAddress).Offset(Ndistances - 1, 1).Address)


    Yhato.Value = Application.WorksheetFunction.Transpose(EDfDatax)

    '
    '  This part runs the simulations for Nsimulations times for each
    '  of the distances (Ndistances)
    '
    '
    '  The TempSheet inserts a sheet to use for the simulation
    '  The sheet is named "Temp1"
    '  Later I need to add a module to make sure this is a unique
    '  name. At this stage this is not important.
    '


    Call MonteCarloPNE


End Sub


Sub PointEventDistance()
    '  In this procedure the distances between events
    '  XE is the event coordinates
    '  n is the number of events

    '  Generate the upper triangle

    Dim i As Integer, j As Integer
    Dim delx As Single, dely As Single
    Dim X As Single
    '
    '  Set XE = Range(SpatialPoint.EventCoordinates.Value)
    '  This line was deleted to accomodate the simulation
    '
    For i = 1 To n
       For j = 1 To m

          delx = XE.Cells(i, 1) - Point(j, 1)
          dely = XE.Cells(i, 2) - Point(j, 2)
          PEdistance(i, j) = Sqr(delx * delx + dely * dely)
```

```
        Next j
    Next i

End Sub
Sub PointNearest()
    '
    '  This procedure calculates the iList vector that list the
    '  nearest neighbor to event 1 through n.
    '  The nearest distance can be accessed by Distance(i, iList(i))
    '  Note: iList is a row vector as far VB is concerned. So it needs
    '  to be transposed if it is printed to a column within the spreadsheet.
    '
    '

    '  Set XE = Range(SpatialPoint.EventCoordinates.Value)
    '  See intereventdistance module for justification
    '
    For i = 1 To m
        xmin = Application.WorksheetFunction.Min(DistanceRange.Columns(i))
        Set theRange = DistanceRange.Columns(i)
        iPlist(i) = Application.WorksheetFunction.Match(xmin, _
            theRange, 0)
    Next i

End Sub
Sub RandomPoints(NPoints)
    '
    '  Need to generate random points that fall within the boundary
    '  of the site
    '  BLine is the site border line that closes and should go
    '  counterclock wise.
    '  YmaxB, YminB, XmaxB, and XminB are the limits of a box that contains
    '  the site boundary
    '
    'Dim Xcoor(1 To 1000), Ycoor(1 To 1000)
    'Dim Bline(1 To 100, 1 To 4), Pline(1 To 50) As Integer
    For i = 1 To NPoints

        K = 1
        Do While K = 1

            Xcoor(i) = xminb + (xmaxb - xminb) * Rnd(Timer)
            Ycoor(i) = yminb + (ymaxb - yminb) * Rnd(Timer)
            '
            '  Check these points if they are within the site
            '
            If SpatialPoint.Rectangle Then
                Exit Do
            Else
                Call boundary(Xcoor(i), Ycoor(i))
                If onsite Then
                    Exit Do
                End If
            End If
        Loop
    Next i



End Sub
Sub PrepareBoundary()
    '
    '  This procedure is designed to trace the boundary line and count
    '  number of inflection points to make it easier to identify whether
    '  a point that is generated at random is located wihin the site bounday
    '
    '  PLINE() is an array that contains these inflection points
    '  For example,
```

```
    '  PLINE(1) is the first inflection point where x starts decreasing
    '  Also, there is alway an even number of inflection points since
    '  the site boundary closes itself.
    '
    '  BLine(NBPoints,4) is an array that contain the coordinates of the
    '  boundary, r2, and theta. The latter two are measured
    '  from the origin to the point.
    '
    '  NBPoints is the number of boundary points.
    '
    K = 1
    i = 2
    Do While i <= NBPoints - 1
        If Bline(i, 4) > Bline(i - 1, 4) Then
            Pline(K) = i - 1
            K = K + 1
            Even = 1
            Do While Even = 1 And i <= NBPoints - 1
                If Bline(i, 4) < Bline(i - 1, 4) Then
                    Pline(K) = i - 1
                    K = K + 1
                    Even = 0
                End If
                i = i + 1
            Loop
        End If
        i = i + 1
    Loop
    Pline(K) = NBPoints
    NBreakPoints = K
End Sub
Sub boundary(x0, y0)
    '
    '  This routine is designed to develop boundary segments that defines
    '  the limits of a site. A linear interpolation will be used in between
    '  the points. This routine will allow us to determine if a point is
    '  within the limits of a given site.
    '
    '  This is important when we simulate a site with randomly generated
    '  points to make sure that the point is within the site of interest.
    '
    '  The boundary should be setup with a starting point and closes the
    '  boundary with the starting point going counter clockwise.
    '
    Dim r(1 To 1000)
    r0 = Sqr(x0 ^ 2 + y0 ^ 2)
    If x0 = 0 Then
        s0 = 2 * Atn(1)          '  pi/2
    Else
        s0 = Atn(y0 / x0)
    End If
    smax = Application.WorksheetFunction.Max(BRange.Columns(4))
    smin = Application.WorksheetFunction.Min(BRange.Columns(4))
    If s0 > smax Or s0 < smin Then
        onsite = False
    Else
        's = Bline(1, 4)
        BorderPoints = 1
        For i = 1 To NBreakPoints
            If i = 1 Then
                irow1 = 1
                irow2 = Pline(1)
            Else
                irow1 = Pline(i - 1)
                irow2 = Pline(i)
            End If
            addr1 = BRange.Cells(irow1, 4).Address
```

```
        addr2 = BRange.Cells(irow2, 4).Address

        RangeMax = Application.WorksheetFunction.Max(Oldsheet.Range(addr1 & ":" & addr2))
        RangeMin = Application.WorksheetFunction.Min(Oldsheet.Range(addr1 & ":" & addr2))
        If s0 < RangeMax And s0 > RangeMin Then

            If i / 2 - Int(i / 2) <> 0 Then
                L = Application.WorksheetFunction.Match(s0, Oldsheet.Range(addr1 & _
                    ":" & addr2), -1)
            Else
                L = Application.WorksheetFunction.Match(s0, Oldsheet.Range(addr1 & _
                    ":" & addr2), 1)
            End If
            If i = 1 Then
                Shift = 0
            Else
                Shift = Pline(i - 1) - 1
            End If
            x1 = BRange.Cells(Shift + L, 1).Value
            X2 = BRange.Cells(Shift + L + 1, 1).Value
            y1 = BRange.Cells(Shift + L, 2).Value
            y2 = BRange.Cells(Shift + L + 1, 2).Value
            Dx = X2 - x1
            Dy = y2 - y1
            If Dx <> 0 Then
                term1 = -Dy / Dx * x1 + y1
                term2 = 1 - Dy / Dx * x0 / y0
                YY = term1 / term2
                xx = x0 / y0 * YY
            Else
                YY = y0 / x0 * x1
                xx = x1
            End If
            r(BorderPoints) = Sqr(xx ^ 2 + YY ^ 2)
            BorderPoints = BorderPoints + 1
            'Range("H4").Offset(i - 1, 0).Value = x
            'Range("H4").Offset(i - 1, 1).Value = y
            'Range("H4").Offset(i - 1, 2).Value = r2(i)
        End If
    Next i
    If BorderPoints - 1 = 2 Then
        If r0 < r(1) Or r0 > r(BorderPoints - 1) Then
            onsite = False
        Else
            onsite = True
        End If

    ElseIf BorderPoints - 1 > 2 Then

        For i = 1 To BorderPoints - 1 Step 2
            rmin = Application.WorksheetFunction.Min(r(i), r(i + 1))
            rmax = Application.WorksheetFunction.Max(r(i), r(i + 1))
            If r0 >= rmin And r0 <= rmax Then
                onsite = True
            End If
        Next i

        For i = 2 To BorderPoints - 1 Step 2
            rmin = Application.WorksheetFunction.Min(r(i), r(i + 1))
            rmax = Application.WorksheetFunction.Max(r(i), r(i + 1))
            If r0 >= rmin And r0 <= rmax Then
                onsite = False
            End If
        Next i

    End If
```

```
    End If

End Sub
Sub MonteCarloNB()
    '  MonteCarloNB(Ndistances, Nsimulations, n, Bline, Pline, ResultsSheet, y)
    Dim i As Integer, j As Integer, K As Integer, L As Integer

    Set tempsheet = Sheets.Add
    tempsheet.Name = "Temp1"
    Total = Ndistances * Nsimulations

    Application.ScreenUpdating = SpatialPoint.ChkScreenupdate

    For K = 1 To Ndistances

        If K > 1 Then
            runTime = Timer - T0
            TimeRemaining = runTime / (K - 1) * (Ndistances - K + 1)
            If TimeRemaining > 60 Then
                Title1 = Format(TimeRemaining / 60, " 0.0") & "  minutes"
            Else
                Title1 = Format(TimeRemaining, " 0") & " seconds"
            End If
            SpatialPoint.LabelProgressTitle.Caption = _
                " Estimated time remaining (Nearest Neighbor Analysis) " & Title1
        Else
            T0 = Timer
        End If
        For L = 1 To Nsimulations
        '
        '  First generate random coordinates that are within the site.
        '  This simulates a unifrom randomly distributed events within
        '  the site. This will be compared to the distribution of the
        '  data (EDFData).
        '

            Call RandomPoints(n)


            tempsheet.Range("A1").Select
            Set XE = tempsheet.Range("A1", Range("A1").Offset(n - 1, _
                    1).Address)
            XE.Columns(1).Value = _
                Application.WorksheetFunction.Transpose(Xcoor)
            XE.Columns(2).Value = _
                Application.WorksheetFunction.Transpose(Ycoor)

            Call InterEventDistance

            Set DistanceRange = tempsheet.Range("I1" & ":" _
                & Range("I1").Offset(n - 1, n - 1).Address)
            DistanceRange.Value = distance

            Call nearest

            For i = 1 To n
                distf(i) = DistanceRange.Cells(i, iList(i)).Value
            Next i

            Set EDFO = tempsheet.Range("g1" & ":" & Range("g1").Offset(n - _
                    1, 0).Address)
            EDFO.Value = Application.WorksheetFunction.Transpose(distf)
            '
            '  Calculate the distance overwhich the empirical distribution
            '  is calculated y(k). Also, calculate the empirical distridution
            '  for the data EDFData(k).
            '
```

```
            EDfData(L) = Application.WorksheetFunction.CountIf(EDFO, "<=" _
                & Y(K)) / n

            Call UpdateProgress(((K - 1) * Nsimulations + L) / Total)
        Next L
        ybar(K) = Application.WorksheetFunction.Average(EDfData)
        EDFMin(K) = Application.WorksheetFunction.Min(EDfData)
        EDFMax(K) = Application.WorksheetFunction.Max(EDfData)
    Next K
    SpatialPoint.LabelProgressTitle.Caption = "Simulation is complete ... Plotting"

    ResultsSheet.Activate
    FirstCell = ResultsSheet.Range(outputAddress).Offset(3, 2).Address
    LastCell = ResultsSheet.Range(FirstCell).Offset(Ndistances - 1, 2).Address

    Set YO = Range(FirstCell & ":" & LastCell)

    'Set YO = ResultsSheet.Range("c1" & ":" & Range("c1").Offset(Ndistances _
        - 1, 2).Address)
    YO.Columns(1).Value = Application.WorksheetFunction.Transpose(ybar)
    YO.Columns(2).Value = Application.WorksheetFunction.Transpose(EDFMin)
    YO.Columns(3).Value = Application.WorksheetFunction.Transpose(EDFMax)

    Application.ScreenUpdating = True

End Sub

Sub MonteCarloIE()

    Dim i As Integer, j As Integer, K As Integer, L As Integer

    'Windows(NewWorkbook).Activate
    'Set BRange = Sheets(Oldsheet).Range(SpatialPoint.BoundaryLine.Value)
    'xminb = Application.WorksheetFunction.Min(BRange.Columns(1).Value)
    'xmaxb = Application.WorksheetFunction.Max(BRange.Columns(1).Value)
    'yminb = Application.WorksheetFunction.Min(BRange.Columns(2).Value)
    'ymaxb = Application.WorksheetFunction.Max(BRange.Columns(2).Value)

    Windows(NewWorkbook).Activate
    Set tempsheet = Sheets.Add
    tempsheet.Name = "Temp1"
    Total = Ndistances * Nsimulations
    Application.ScreenUpdating = SpatialPoint.ChkScreenupdate

    For K = 1 To Ndistances
        If K > 1 Then
            runTime = Timer - T0
            TimeRemaining = runTime / (K - 1) * (Ndistances - K + 1)
            If TimeRemaining > 60 Then
                Title1 = Format(TimeRemaining / 60, " 0.0") & "  minutes"
            Else
                Title1 = Format(TimeRemaining, " 0") & " seconds"
            End If
            SpatialPoint.LabelProgressTitle.Caption = _
                "Estimated time remaining " & _
                "(Inter-Event Analysis) " & Title1
        Else
            T0 = Timer
        End If

        For L = 1 To Nsimulations
        '
        '  First generate random coordinates that are within the site.
        '  This simulates a unifrom randomly distributed events within
        '  the site. This will be compared to the distribution of the
        '  data (EDFData).
```

```
    '

      Call RandomPoints(n)


      tempsheet.Range("A1").Select
      Set XE = tempsheet.Range("A1", Range("A1").Offset(n - 1, _
          1).Address)
      XE.Columns(1).Value = _
        Application.WorksheetFunction.Transpose(Xcoor)
      XE.Columns(2).Value = _
        Application.WorksheetFunction.Transpose(Ycoor)

      Call InterEventDistance
      Set DistanceRange = tempsheet.Range("I1" & ":" _
        & Range("I1").Offset(n - 1, n - 1).Address)
      DistanceRange.Value = distance

      EDfData(L) = (Application.WorksheetFunction.CountIf(DistanceRange, "<=" _
            & Y(K)) - n) / 2 / (n * (n - 1) / 2)
      Call UpdateProgress(((K - 1) * Nsimulations + L) / Total)

    Next L
    ybar(K) = Application.WorksheetFunction.Average(EDfData)
    EDFMin(K) = Application.WorksheetFunction.Min(EDfData)
    EDFMax(K) = Application.WorksheetFunction.Max(EDfData)
  Next K
  SpatialPoint.LabelProgressTitle.Caption = "Analysis is complete ... Plotting the data"

  YOAddress = Range(outputAddress).Offset(3, 2).Address
  Set YO = ResultsSheet.Range(YOAddress & ":" & _
    Range(YOAddress).Offset(Ndistances - 1, 2).Address)

  'Set YO = ResultsSheet.Range("c1" & ":" & Range("c1").Offset(Ndistances _
    - 1, 2).Address)
  YO.Columns(1).Value = Application.WorksheetFunction.Transpose(ybar)
  YO.Columns(2).Value = Application.WorksheetFunction.Transpose(EDFMin)
  YO.Columns(3).Value = Application.WorksheetFunction.Transpose(EDFMax)

  Application.ScreenUpdating = True

End Sub


Sub MonteCarloPNE()

  Dim i As Integer, j As Integer, K As Integer, L As Integer

  Set tempsheet = Sheets.Add
  tempsheet.Name = "Temp1"

  Application.ScreenUpdating = SpatialPoint.ChkScreenupdate
  Total = Ndistances * Nsimulations
  For K = 1 To Ndistances
    If K > 1 Then
      runTime = Timer - T0
      TimeRemaining = runTime / (K - 1) * (Ndistances - K + 1)
      If TimeRemaining > 60 Then
        Title1 = Format(TimeRemaining / 60, " 0.0") & "  minutes"
      Else
        Title1 = Format(TimeRemaining, " 0") & " seconds"
      End If
      SpatialPoint.LabelProgressTitle.Caption = _
        " Estimated time remaining (Point-to-Nearest Neighbor Analysis) " & Title1
    Else
      T0 = Timer
    End If
```

```
        For L = 1 To Nsimulations
        '
        '  First generate random coordinates that are within the site.
        '  This simulates a unifrom randomly distributed events within
        '  the site. This will be compared to the distribution of the
        '  data (EDFData).
        '

            Call RandomPoints(m)

            tempsheet.Range("A1").Select

            Set XE = Oldsheet.Range("A1", Range("A1").Offset(n - 1, _
                    1).Address)
            For i = 1 To m
                Point(i, 1) = Xcoor(i)
                Point(i, 2) = Ycoor(i)
            Next i


            Call PointEventDistance

            Set DistanceRange = tempsheet.Range("I1" & ":" _
                & Range("I1").Offset(n - 1, m - 1).Address)
            DistanceRange.Value = PEdistance

            For i = 1 To m
                xmin = Application.WorksheetFunction.Min(DistanceRange.Columns(i))
                Set theRange = DistanceRange.Columns(i)
                iLoc = Application.WorksheetFunction.Match(xmin, _
                    theRange, 0)
                distf(i) = PEdistance(iLoc, i)
            Next i

            Set EDFO = tempsheet.Range("g1" & ":" & Range("g1").Offset(m - _
                    1, 0).Address)

            EDFO.Value = Application.WorksheetFunction.Transpose(distf)
            EDfData(L) = Application.WorksheetFunction.CountIf(EDFO, "<=" & D(K)) / m
            Call UpdateProgress(((K - 1) * Nsimulations + L) / Total)
        Next L

        ybar(K) = Application.WorksheetFunction.Average(EDfData)
        EDFMin(K) = Application.WorksheetFunction.Min(EDfData)
        EDFMax(K) = Application.WorksheetFunction.Max(EDfData)
    Next K
    SpatialPoint.LabelProgressTitle.Caption = "Simulation is complete ... Plotting"

    Windows(NewWorkbook).Activate
    YOAddress = ResultsSheet.Range(outputAddress).Offset(3, 2).Address
    Set YO = ResultsSheet.Range(YOAddress & ":" & _
        Range(YOAddress).Offset(Ndistances - 1, 2).Address)

    YO.Columns(1).Value = Application.WorksheetFunction.Transpose(ybar)
    YO.Columns(2).Value = Application.WorksheetFunction.Transpose(EDFMin)
    YO.Columns(3).Value = Application.WorksheetFunction.Transpose(EDFMax)

    Application.ScreenUpdating = True

End Sub
Sub EDFPlot()
    '
    '  This routine is designed to plot the empirically derived
    '  distribution function for a homogeneously distributed objects
    '
    Dim xx As Range, y1 As Range, y2 As Range, y3 As Range
```

```
GName = ResultsSheet.Name
Worksheets(OldName).Activate
ResultsSheet.Activate

dataAddress = Range(outputAddress).Offset(3, 0).Address
Set datatoplot = Range(dataAddress & ":" & Range(dataAddress).Offset(Ndistances - 1, _
   4).Address)

Range(dataAddress).Activate
Set xx = datatoplot.Columns(3)
Set y1 = datatoplot.Columns(2)
Set y2 = datatoplot.Columns(4)
Set y3 = datatoplot.Columns(5)

Charts.Add
ActiveChart.Location where:=xlLocationAsObject, Name:=GName
ActiveChart.ChartType = xlXYScatterLinesNoMarkers
ActiveChart.SeriesCollection(1).XValues = xx
ActiveChart.SeriesCollection(1).Values = y1
ActiveChart.SeriesCollection.NewSeries
ActiveChart.SeriesCollection(2).XValues = xx
ActiveChart.SeriesCollection(2).Values = y2
ActiveChart.SeriesCollection.NewSeries
ActiveChart.SeriesCollection(3).XValues = xx
ActiveChart.SeriesCollection(3).Values = y3

With ActiveChart
   .PlotArea.Height = 300
   .PlotArea.Width = 300
End With

ActiveChart.PlotArea.Select
With Selection.Border
   .ColorIndex = 16
   .Weight = xlThin
   .LineStyle = xlContinuous
End With

Selection.Interior.ColorIndex = xlNone
With ActiveChart
   .HasTitle = True
   .ChartTitle.Characters.Text = SpatialPoint.TbxProblemTitle.Value
   .Axes(xlCategory, xlPrimary).HasTitle = True
   .Axes(xlCategory, xlPrimary).AxisTitle.Characters.Text = "CSR EDF "
   .Axes(xlValue, xlPrimary).HasTitle = True
   .Axes(xlValue, xlPrimary).AxisTitle.Characters.Text = "Data EDF "
End With
ActiveChart.Legend.Select
Selection.Delete
ActiveChart.Axes(xlCategory).Select
With ActiveChart.Axes(xlCategory)
   .MinimumScale = 0
   .MaximumScale = 1
   .MinorUnit = 0.05
   .MajorUnit = 0.1
   .Crosses = xlAutomatic
   .ReversePlotOrder = False
   .ScaleType = xlLinear
   .DisplayUnit = xlNone
   .HasMajorGridlines = False
   .HasMinorGridlines = False
End With
ActiveChart.Axes(xlValue).Select
With ActiveChart.Axes(xlValue)
   .MinimumScale = 0
   .MaximumScale = 1
```

```
        .MinorUnit = 0.05
        .MajorUnit = 0.1
        .Crosses = xlAutomatic
        .ReversePlotOrder = False
        .ScaleType = xlLinear
        .DisplayUnit = xlNone
        .HasMajorGridlines = False
        .HasMinorGridlines = False
    End With
    ActiveChart.SeriesCollection(3).Select
    With Selection.Border
        .ColorIndex = 1
        .Weight = xlThin
        .LineStyle = xlDash
    End With
    With Selection
        .MarkerBackgroundColorIndex = xlNone
        .MarkerForegroundColorIndex = xlNone
        .MarkerStyle = xlNone
        .Smooth = False
        .MarkerSize = 3
        .Shadow = False
    End With
    ActiveChart.SeriesCollection(2).Select
    With Selection.Border
        .ColorIndex = 1
        .Weight = xlThin
        .LineStyle = xlDash
    End With

    'ActiveChart.PlotArea.Select
    'w = ActiveChart.PlotArea.Width
    'h = ActiveChart.PlotArea.Height
    'factor = w / h
    'ActiveSheet.Shapes("Chart 1").ScaleHeight factor, msoFalse, msoScaleFromTopLeft

End Sub
Sub UpdateProgress(Pct)
    With SpatialPoint
        .FrameProgress.Caption = Format(Pct, "0%")
        .LabelProgress.Width = Pct * (.FrameProgress.Width - 10)
        .Repaint
    End With
End Sub
Sub GetDefaults()
    '   Reads default settings from registery
    Dim ctl As Control
    Dim CtrlType As String

    For Each ctl In SpatialPoint.Controls
        CtrlType = TypeName(ctl)
        If CtrlType = "TextBox" Or _
           CtrlType = "ComboBox" Or _
           CtrlType = "OptionButton" Or _
           CtrlType = "CheckBox" Or _
           CtrlType = "SpinButton" Or _
           CtrlType = "RefEdit" Then
           ctl.Value = GetSetting _
            (APPNAME, "Defaults", ctl.Name, ctl.Value)
        End If
    Next ctl

End Sub
Sub SaveDefaults()
    '   Writes default settings from registery
    Dim ctl As Control
    Dim CtrlType As String
```

```
    For Each ctl In SpatialPoint.Controls
        CtrlType = TypeName(ctl)
        If CtrlType = "TextBox" Or _
           CtrlType = "ComboBox" Or _
           CtrlType = "OptionButton" Or _
           CtrlType = "CheckBox" Or _
           CtrlType = "SpinButton" Or _
           CtrlType = "RefEdit" Then
           SaveSetting APPNAME, "Defaults", ctl.Name, ctl.Value
        End If
    Next ctl

End Sub

Sub DensityEstimate()
    '
    '   This module is designed to estimate density of event based on Diggle (1975 and 1977)
    '   The estimate is based on Hopkins sampling approach
    '
    '
    '   Calculate the sum of squares of the nearest neighbor distances
    '
    Dim Hopkins(1 To 2000), EventDensity(1 To 2000)
    Dim theRange As Range
    Windows(NewWorkbook).Activate
    Set XE = Range(SpatialPoint.EventCoordinates.Value)
    'Range("G1" & ":" & Range("G1").Offset(65535, 249).Address).Cells.Clear

    'grid = Int(Sqr(n))
    'm = grid ^ 2
    '
    '   Generate the x and y coordinates for the points located in the middle of each grid
    '
    'For i = 1 To grid
    '    For j = 1 To grid
    '        K = grid * (i - 1) + j
    '        Point(K, 1) = xminb + (j - 0.5) * (xmaxb - xminb) / grid
    '        Point(K, 2) = yminb + (i - 0.5) * (ymaxb - yminb) / grid
    '    Next j
    'Next i

    Windows(NewWorkbook).Activate
    ResultsSheet.Activate
    LeftCorner = Range(outputAddress).Offset(3, 8).Address
    LRightCorner = Range(LeftCorner).Offset(n - 1, n - 1).Address

    Set DistanceRange = ResultsSheet.Range(LeftCorner & ":" & LRightCorner)

    Call InterEventDistance
    DistanceRange.Value = distance

    Call nearest

    P = 0.5 * (100 - CSng(SpatialPoint.TbxConfidence.Value))
    m = n
    AreaFactor = 1
    Select Case SpatialPoint.CmbxUnits.Value
        Case "feet"
            AreaFactor = 43560
            AreaLabel = " Items/acre"
        Case "meters"
            AreaFactor = 10000
            AreaLabel = " Items/hectare"
        Case "user-defined"
            AreaFactor = 1
            AreaLabel = " Items/unit area"
```

```
    End Select
    '
    '   Decide which Hopkins statistic to use H or H1
    '

    If SpatialPoint.ObtnH.Value Then
        HopkinsTitle$ = " Hopkins (H) Statistic"
        TestStatistic$ = " F-Statistic"
        StatValue = Application.WorksheetFunction.FInv(P / 100, 2 * m, 2 * m)
    Else
        HopkinsTitle$ = " Hopkins (H1) Statistic"
        TestStatistic$ = " Beta distribution"
        StatValue = Application.WorksheetFunction.BetaInv(1 - P / 100, m, m, 0, 1)
    End If


    'Call SiteArea(area)

    'acres = area / 43560

    DensityoutAddress = ResultsSheet.Range(outputAddress).Offset(Ndistances + 7).Address


    NdensitySimulations = CInt(SpatialPoint.tbxDensitySimulations.Value)

    LeftCorner = Range(outputAddress).Offset(3, 8).Address
    PEDAddressLeft = Range(LeftCorner).Offset(n + 3, 0).Address
    PEDAddressRight = Range(PEDAddressLeft).Offset(n - 1, m - 1).Address
    Set PEDistanceRange = ResultsSheet.Range(PEDAddressLeft & ":" & PEDAddressRight)
'    Range(PEDAddressLeft).Offset(-2, 0).Value = "Point-to-Nearest Event Distance Matrix"
'    Range(PEDAddressLeft).Offset(-1, 0).Value = "Points"

    If NdensitySimulations = 1 Then

        Call RandomPoints(m)

        For i = 1 To m
            Point(i, 1) = Xcoor(i)
            Point(i, 2) = Ycoor(i)
        Next i
        '
        '   Calculate the distances from the points to nearest event
        '
        Call PointEventDistance

        PEDistanceRange.Value = PEdistance
        '
        '   Generate the nearest event to each of the points
        '
        sumxsq = 0
        sumysq = 0
        For i = 1 To m
            xmin = Application.WorksheetFunction.Min(PEDistanceRange.Columns(i))
            Set theRange = PEDistanceRange.Columns(i)
            iPlist(i) = Application.WorksheetFunction.Match(xmin, _
                theRange, 0)
        Next i
        For i = 1 To m
            sumxsq = sumxsq + PEdistance(iPlist(i), i) ^ 2
            sumx = sumx + PEdistance(iPlist(i), i)
            sumysq = sumysq + distance(iPlist(i), iList(iPlist(i))) ^ 2
        Next i
        Pi = 4 * Atn(1)

        If SpatialPoint.ObtnH.Value Then
            Hopkins(1) = sumxsq / sumysq
        Else
```

```
      Hopkins(1) = sumxsq / (sumxsq + sumysq)
   End If

   EventDensity(1) = m / (Pi * Sqr(sumxsq * sumysq)) * AreaFactor
   EventDensity(2) = 1 / (2 * sumx / m) ^ 2 * AreaFactor


   Range(DensityoutAddress).Offset(1, 1).Value = AreaLabel & " (Density Estimate, Diggle 1977)"
   Range(DensityoutAddress).Offset(2, 1).Value = AreaLabel & " (Density Estimate (Poisson Process))"
   Range(DensityoutAddress).Offset(3, 1).Value = HopkinsTitle$
   Range(DensityoutAddress).Offset(4, 1).Value = TestStatistic$
   Range(DensityoutAddress).Offset(1, 0).Value = Format(EventDensity(1), " Scientific")
   Range(DensityoutAddress).Offset(2, 0).Value = Format(EventDensity(2), " Scientific")
   Range(DensityoutAddress).Offset(3, 0).Value = Format(Hopkins(1), "0.000")
   Range(DensityoutAddress).Offset(4, 0).Value = Format(StatValue, "0.000")

Else

   For K = 1 To NdensitySimulations
      If K > 1 Then
         runTime = Timer - T2
         TimeRemaining = runTime / (K - 1) * (NdensitySimulations - K + 1)
         If TimeRemaining > 60 Then
            Title1 = Format(TimeRemaining / 60, " 0.0") & "  minutes"
         Else
            Title1 = Format(TimeRemaining, " 0") & " seconds"
         End If
         SpatialPoint.LabelProgressTitle.Caption = _
            "Estimated time remaining (Density Calculation) " & Title1
      Else
         T2 = Timer
      End If

      Call RandomPoints(m)

      For i = 1 To m
         Point(i, 1) = Xcoor(i)
         Point(i, 2) = Ycoor(i)
      Next i

      '
      '  Calculate the distances from the points to nearest event
      '
      Call PointEventDistance

      PEDistanceRange.Value = PEdistance


      '
      '  Generate the nearest event to each of the points
      '


      sumxsq = 0
      sumysq = 0
      For i = 1 To m
         xmin = Application.WorksheetFunction.Min(PEDistanceRange.Columns(i))
         Set theRange = PEDistanceRange.Columns(i)
         iPlist(i) = Application.WorksheetFunction.Match(xmin, _
            theRange, 0)
      Next i
      For i = 1 To m
         sumxsq = sumxsq + PEdistance(iPlist(i), i) ^ 2
         sumysq = sumysq + distance(iPlist(i), iList(iPlist(i))) ^ 2
      Next i
      Pi = 4 * Atn(1)
```

```
        If SpatialPoint.ObtnH.Value Then
            Hopkins(K) = sumxsq / sumysq
        Else
            Hopkins(K) = sumxsq / (sumxsq + sumysq)
        End If

        EventDensity(K) = m / (Pi * Sqr(sumxsq * sumysq)) * AreaFactor
        Call UpdateProgress(K / NdensitySimulations)
    Next K


    With Range(DensityoutAddress)
        .Value = " Density Estimate"
        .Font.Bold = True
        .Font.Size = 12
    End With


    With Range(DensityoutAddress).Offset(4, 0)
        .Value = HopkinsTitle$
        .Font.Bold = True
        .Font.Size = 12
    End With

    With Range(DensityoutAddress)
        .Offset(-1, 0).Value = Standard_Deviation
        .Offset(-2, 0).Value = Distance_Mean
        .Offset(1, 1).Value = Format(P, "0.0") & "% Percentile " & AreaLabel
        .Offset(2, 1).Value = "Average density " & AreaLabel
        .Offset(3, 1).Value = Format(100 - P, "0.0") & "% Percentile " & AreaLabel
        .Offset(5, 1).Value = Format(P, "0.0") & "% Percentile"
        .Offset(6, 1).Value = "Median "
        .Offset(7, 1).Value = Format(100 - P, "0.0") & "% Percentile"
        .Offset(8, 1).Value = TestStatistic$
        .Offset(10, 0).Value = "**** Summary Report ****"
        .Offset(10, 0).Font.Size = 12
        .Offset(10, 0).Font.Bold = True
        .Offset(11, 1).Value = "Average Density " & AreaLabel
    End With

    leftCell = Range(DensityoutAddress).Offset(10, 0).Address
    RightCell = Range(DensityoutAddress).Offset(13, 5).Address
    Set ReportBox = Range(leftCell & ":" & RightCell)
    ReportBox.BorderAround , xlThick, xlColorIndexAutomatic

    With Range(leftCell & ":" & Range(leftCell).Offset(0, 5).Address)
        .MergeCells = True
        .HorizontalAlignment = xlCenter
    End With


    'Fval = Application.WorksheetFunction.FInv(p / 100, 2 * m, 2 * m)
    AvgDensity = Application.WorksheetFunction.Average(EventDensity)
    LLDensity = Application.WorksheetFunction.Percentile(EventDensity, P / 100)
    ULDensity = Application.WorksheetFunction.Percentile(EventDensity, 1 - P / 100)
    MedHopkins = Application.WorksheetFunction.Median(Hopkins)
    LLHopkins = Application.WorksheetFunction.Percentile(Hopkins, P / 100)
    ULHopkins = Application.WorksheetFunction.Percentile(Hopkins, 1 - P / 100)
    Range(DensityoutAddress).Offset(1, 0).Value = Format(LLDensity, "Scientific")
    Range(DensityoutAddress).Offset(2, 0).Value = Format(AvgDensity, "Scientific")
    Range(DensityoutAddress).Offset(3, 0).Value = Format(ULDensity, "Scientific")
    Range(DensityoutAddress).Offset(5, 0).Value = Format(LLHopkins, "0.000")
    Range(DensityoutAddress).Offset(6, 0).Value = Format(MedHopkins, "0.000")
    Range(DensityoutAddress).Offset(7, 0).Value = Format(ULHopkins, "0.000")
    Range(DensityoutAddress).Offset(8, 0).Value = Format(StatValue, "0.000")
    Range(DensityoutAddress).Offset(11, 0).Value = Format(AvgDensity, "Scientific")
```

```
        If ULHopkins < StatValue Then
            Range(DensityoutAddress).Offset(12, 0).Value = _
                "The site is homogeneous based on the Hopkins test statistic"
            If IsItCSR Then
                If Not steep Then
                    Range(DensityoutAddress).Offset(13, 0).Value = _
                    "Based on the EDF graph the site is homogeneous"
                Else
                    Range(DensityoutAddress).Offset(13, 0).Value = _
                    "Based on the EDF graph the site is not homogeneous (slope exceeds 1)"
                End If
            Else
                Range(DensityoutAddress).Offset(13, 0).Value = _
                "WARNING ... based on the graph site is not homogeneous"
            End If
        Else
            Range(DensityoutAddress).Offset(12, 0).Value = _
                "The site is not homogeneous based the Hopkins test statistic"
            If IsItCSR Then
                If Not steep Then
                    Range(DensityoutAddress).Offset(13, 0).Value = _
                    "Warning ... based on the EDF, graph the site is homogeneous"
                Else
                    Range(DensityoutAddress).Offset(13, 0).Value = _
                    "Based on the EDF graph, the site is not homogeneous"
                End If
            Else
                Range(DensityoutAddress).Offset(13, 0).Value = _
                "Based on the EDF graph, the site is not homogeneous"
            End If

        End If

    End If
    If Not SpatialPoint.chkanalysis Then

        With Range(outputAddress)
            .Offset(1, 8).Value = "Inter-event Distance Matrix"
            .Offset(2, 8).Value = "Events"
        End With
        FirstCell = Range(outputAddress).Offset(4 + n, 8).Address
        Range(FirstCell).Value = "Point-to-Nearest Event Distance Matrix"
        Range(FirstCell).Offset(1, 0).Value = "Points"

    End If
End Sub
Sub TitleSetup(outputAddress)

    If SpatialPoint.NearestNeighbor Then
        kk = 6
        NNLabel$ = "NN Distances"
    Else
        kk = 4
        NNLabel$ = ""
    End If

    With ResultsSheet.Range(outputAddress)
        .Value = SpatialPoint.TbxProblemTitle.Value
        .Offset(1, 0).Value = AnalysisTitle & "Simulations"
        .Offset(2, 0).Value = "Distance"
        .Offset(2, 1).Value = "Data EDF*"
        .Offset(2, 2).Value = "CSR** EDF"
        .Offset(2, 3).Value = "CSR Min"
        .Offset(2, 4).Value = "CSR Max"
        .Offset(2, 6).Value = NNLabel$
        .Offset(1, 8).Value = "Inter-event Distance Matrix"
        .Offset(SpatialPoint.NumberDistances.Value + 3, 0).Value = _
```

```
        "* Empirical Distribution Function "
      .Offset(SpatialPoint.NumberDistances.Value + 4, 0).Value = _
        "** Complete Spatial Randomness "
      .Offset(SpatialPoint.NumberDistances.Value + 5, 1).Value = _
        "Mean of " & AnalysisTitle
      .Offset(SpatialPoint.NumberDistances.Value + 6, 1).Value = _
        "Standrad deviation of " & AnalysisTitle
      .Offset(2, 8).Value = "Events"
    End With

    FirstCell = ResultsSheet.Range(outputAddress).Offset(4 + n, 8).Address
    ResultsSheet.Range(FirstCell).Value = "Point-to-Nearest Event Distance Matrix"
    ResultsSheet.Range(FirstCell).Offset(1, 0).Value = "Points"

    Windows(NewWorkbook).Activate

    If kk = 6 Then
      ResultsSheet.Range(outputAddress).Offset(2, 6).ColumnWidth = 10
    End If

    With ResultsSheet.Range(Range(outputAddress).Offset(2, 0).Address _
      & ":" & Range(outputAddress).Offset(2, kk).Address)
      .Font.Bold = True
      .WrapText = True
      .HorizontalAlignment = xlCenter
    End With
    With ResultsSheet.Range(outputAddress & ":" & Range(outputAddress).Offset(0, 4).Address)
      .MergeCells = False
      .HorizontalAlignment = xlLeft
      .Font.FontStyle = "Bold"
      .Font.Size = 16
    End With
    With ResultsSheet.Range(outputAddress).Offset(0, 8).Font
      .FontStyle = "Bold"
      .Size = 16
    End With


End Sub
Sub SiteArea(area)

    '
    '   This subroutine is designed to calcuate the area of site, given
    '   the boundary coordinates. It assumes that the boundary closes
    '   on itself. That is, the first and last points are the same.
    '

    NBPoints = BRange.Rows.Count
    area = 0
    For i = 1 To NBPoints - 1
      area = area + BRange.Cells(i, 1).Value * BRange.Cells(i + 1, 2) - _
        BRange.Cells(i, 2).Value * BRange.Cells(i + 1, 1)
    Next i

    area = Abs(area) / 2

End Sub
Sub testhw()
With ActiveChart.ChartArea
    .Height = 400
    .Width = 400
End With
End Sub
Sub CheckPlot()
    IsItCSR = True
    steep = False
    For i = 2 To Ndistances - 1
```

```
        If EDfDatax(i) < EDFMin(i) Or EDfDatax(i) > EDFMax(i) Then
            IsItCSR = False
        End If
    Next i
    '
    '   Check the slope of the line and compare to 1.
    '   This check is done only when the line is within the
    '   envelope.
    '
    If IsItCSR Then
        LineSlope = Application.WorksheetFunction.Slope(EDfDatax, ybar)
        LineIntercept = Application.WorksheetFunction.Intercept(EDfDatax, ybar)
        Ybarmean = Application.WorksheetFunction.Average(ybar)
        sumx1 = 0
        sume1 = 0
        For i = 1 To Ndistances
            sumx1 = sumx1 + (ybar(i) - Ybarmean) ^ 2
            sume1 = sume1 + (EDfDatax(i) - LineSlope * ybar(i) - LineIntercept) ^ 2
        Next i
        SlopeSD = Sqr(sume1 / (Ndistances - 2) / sumx1)
        Tval = Application.WorksheetFunction.TInv(0.05, Ndistances - 2)
        ULSlope = LineSlope + Tval * SlopeSD
        LLSlope = LineSlope - Tval * SlopeSD
        If ULSlope < 1 Or LLSlope > 1 Then
            IsItCSR = False
            steep = True
        End If
    End If
End Sub
Sub TestPlot()
    Dim MyBlock As Range
    CSR = True
    Set MyBlock = Range("A4:E23")
    NN = MyBlock.Rows.Count
    For i = 1 To NN
        If MyBlock.Cells(i, 2).Value < MyBlock.Cells(i, 4) Or MyBlock.Cells(i, 2).Value > MyBlock.Cells(i, 5).Value Then
            CSR = False
        End If
    Next i
    If CSR Then
        LineSlope = Application.WorksheetFunction.Slope(MyBlock.Columns(2), MyBlock.Columns(3))
        LineIntercept = Application.WorksheetFunction.Intercept(MyBlock.Columns(2), MyBlock.Columns(3))
        Ybarmean = Application.WorksheetFunction.Average(MyBlock.Columns(3))
        sumx1 = 0
        sume1 = 0
        For i = 1 To NN
            sumx1 = sumx1 + (MyBlock.Cells(i, 3) - Ybarmean) ^ 2
            sume1 = sume1 + (MyBlock.Cells(i, 2) - LineSlope * MyBlock.Cells(i, 3) - LineIntercept) ^ 2
        Next i
        SlopeSD = Sqr(sume1 / (NN - 2) / sumx1)
        Tval = Application.WorksheetFunction.TInv(0.05, NN - 2)
        ULSlope = LineSlope + Tval * SlopeSD
        LLSlope = LineSlope - Tval * SlopeSD
        If ULSlope < 1 Or LLSlope > 1 Then
            IsItCSR = False
            steep = True
        End If
    End If

End Sub
```