RUTGERS
Center on Public Security

TUTORIAL FOR
CONJUNCTIVE ANALYSIS OF RISK FACTOR CONFIGURATIONS (CARFC)

by Jeremy Barnum | April 2016

Introduction

The purpose of this tutorial is to outline the steps of Conjunctive Analysis for use with Risk Terrain Modeling (RTM; www.riskterrainmodeling.com). Technically speaking, Conjunctive Analysis is a method for multivariate analysis of discrete categorical data[i]. For crime analysts or researchers who use risk terrain modeling, Conjunctive Analysis is an analytic tool that can be used to explore spatial interactions among environmental risk factors. The end product of a Conjunctive Analysis is a data matrix of behavior settings that displays every possible combination of risk factors throughout a jurisdiction and the relative frequency of crime associated with each setting. While RTM can be used to identify and validate environmental risk factors for crime, Conjunctive Analysis can be used to explore the interrelationships among those risk factors. This is referred to as a Conjunctive Analysis of Risk Factor Configurations (CARFC).

What you'll need:

- RTMDx Utility (free at www.rtmdx.com)
- ESRI ArcGIS
- SPSS or Stata

Add risk factor geotiffs (from RTMDx Utility, Pro version) to ArcMap.

Open ArcMap. Using the ArcCatalog window (Windows>Catalog), navigate to the RTMDx geotiff output folder and retrieve the geotiff for each significant risk factor from your risk terrain model.

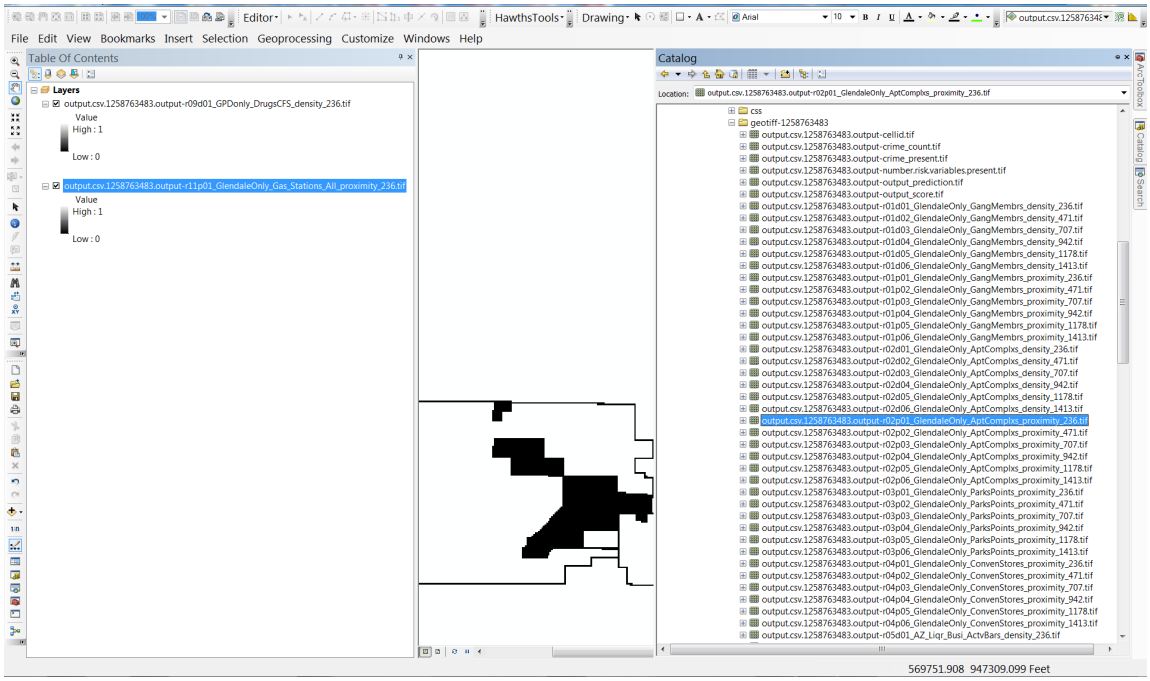
For example, the Best Model Specification table, below, identifies 9 significant risk factors, their operationalization, and spatial influence. You will need to select the corresponding geotiff for each significant risk factor (e.g., …GPDonly_DrugsCFS_density_236, …GlendaleOnly_Gas_Stations_All_proximity_236, etc.) and add it to the map.

"Best" Model Specification

The RTMDx Utility determined that the best risk terrain model was a **Negative Binomial type II** model with **9** risk factors and a **BIC** score of **3240**. The model also includes an intercept term that represents the background rate of events and an intercept term that represents overdispersion of the event counts:

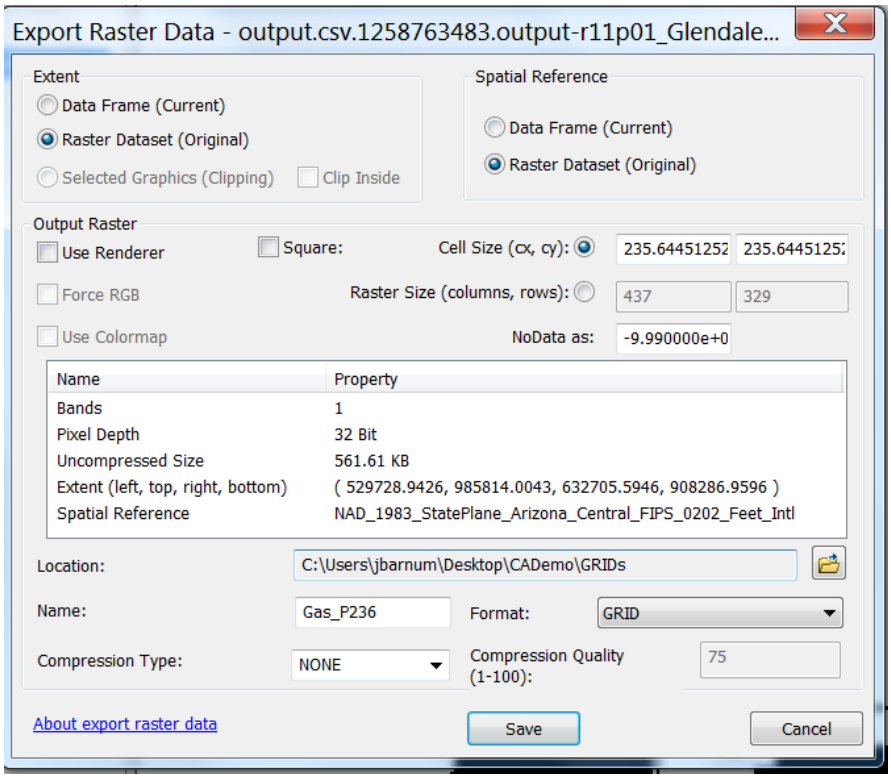
Type	Name	Operationalization	Spatial Influence	Coefficient	Relative Risk Value
Rate	GPDonly DrugsCFS	Density	236	2.3708	10.7060
Rate	GlendaleOnly Gas Stations All	Proximity	236	1.7113	5.5362
Rate	GlendaleOnly AptComplxs	Proximity	236	1.6732	5.3292
Rate	GlendaleOnly GangMembrs	Proximity	1413	1.3996	4.0536
Rate	GlendaleOnly Restaurants TakeOut	Proximity	236	1.1938	3.2996
Rate	GlendaleOnly ConvenStores	Proximity	471	1.1707	3.2242
Rate	AZ Liqr Busi ActvStores	Density	1413	1.0600	2.8864
Rate	GlendaleOnly Banks ATMs	Proximity	471	0.9764	2.6550
Rate	AZ Liqr Busi ActvBars	Proximity	471	0.9190	2.5067
Rate	Intercept	--	--	-5.6880	--
Overdispersion	Intercept	--	--	0.8938	--

You can drag and drop each geotiff from the ArcCatalog window to your Table of Contents in ArcMap (see below).



Convert each risk factor geotiff to a raster GRID.

Now each risk factor geotiff must be converted to a raster GRID. Right-click each risk factor geotiff, select "Data," and then select "Export Data." The Export Raster Data dialogue box will appear (see below).



You'll need to edit the following parameters: Location, Name, and Format. All other parameters should be left as their default option.

Location is where you'll save each raster GRID. Select the yellow folder icon and navigate to a desired save location. In your desired location, create a new folder (e.g., Example City Example Crime Conjunctive Analysis) to save all data for this conjunctive analysis. Within your newly created Conjunctive Analysis folder, create another new folder called GRIDs. Click once to select this folder and then select "Add" to choose this folder to save the current GRID.

Name is what you'll name each raster GRID. A good name identifies the risk factor name, operationalization, and influence. Note: raster GRID file names can only contain 13 characters. In the example above, the risk factor "proximity within 236 feet of Gas Stations" is saved as "Gas_P236."

For format, select "GRID."

Finally, click save and add your new raster GRID to the map.

Repeat each step to convert the remaining risk factor geotiffs to raster GRIDs.

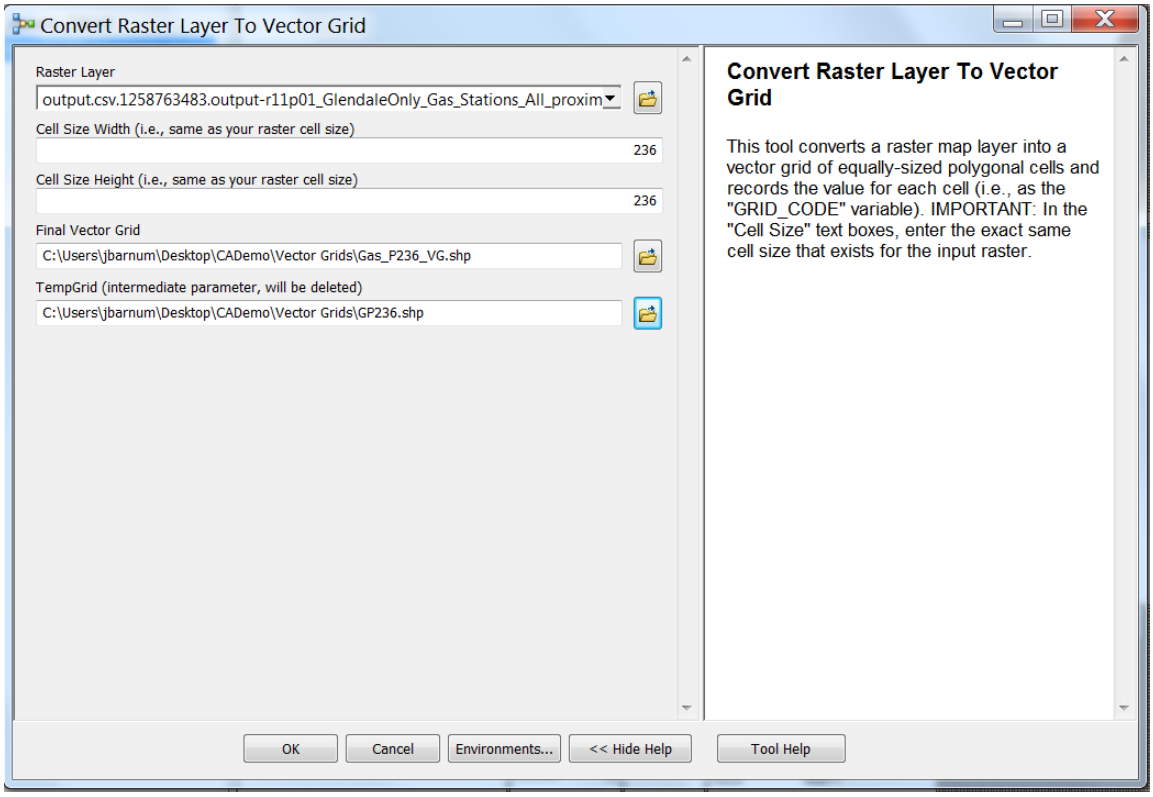
Convert each risk factor GRID to a Vector Polygon Shapefile "Grid".

Now, each risk factor raster GRID must be converted to a Grid of Vector Polygons (henceforth called a "Vector Grid").

First, download the RTM toolbox for ArcGIS here: http://www.rutgerscps.org/software.html.
Add the toolbox in your current ArcMap session by right clicking in the ArcToolbox area and selecting "Add Toolbox." Note: You may need to use the "Connect To Folder" button to connect to your downloads folder.

Open the "Convert Raster Layer to Vector Grid" tool within the Risk Terrain Tools toolbox. This tool will be used to convert each risk factor raster GRID to a Vector Grid.

You'll need to edit the following parameters: Raster Layer, Cell Size Width, Cell Size Height, Final Vector Grid, and TempGrid.



Raster Layer defines which raster GRID you will convert to a Vector Grid. Select any raster GRID (by clicking the drop-drown menu) to begin.

Cell Size Width and Cell Size Height define the size of the cells in the Vector Grid. You should indicate values (e.g., 236) that are identical to the Cell Size used in your risk terrain model. Note: you can find the cell size you used in your risk terrain model under Analysis Input Details in your RTMDx output .html report). Cell Size and Cell Height should be identical values (and the same across all risk map layers).

Final Vector Grid defines the name and save location of the Vector Grid you will create. First, select the yellow folder icon and navigate to your Conjunctive Analysis folder. Create a new folder called Vector Grids to save your current Vector Grids. Now, define the name of your current risk factor Vector Grid. Note: there are no character restrictions for Vector Grids, though Windows does not permit file and or path names to exceed 164 characters. A good name identifies the risk factor name, operationalization, and influence. This should be similar to the name you used for the raster GRID (e.g., Gas_P236_VG).

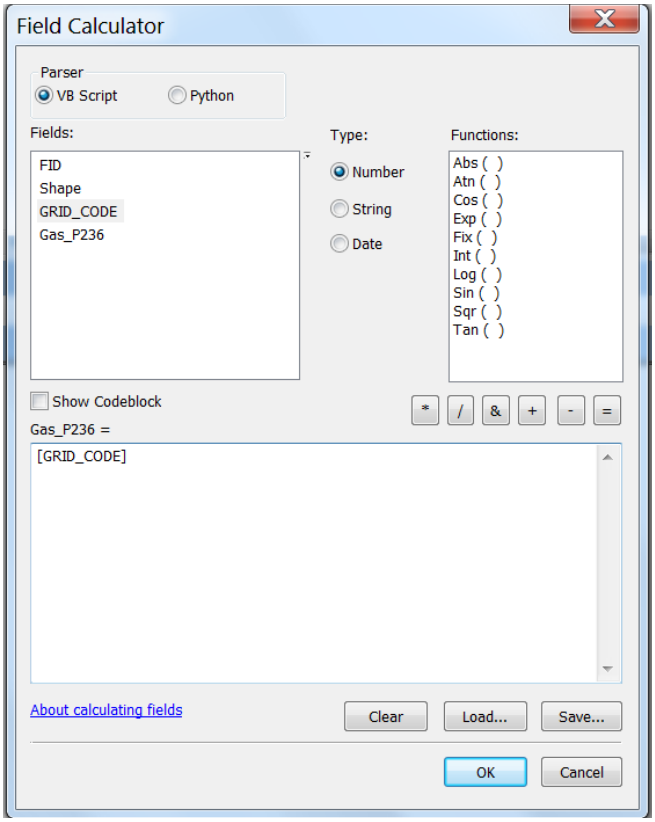
TempGrid is an intermediate parameter (required for processing). Proceed by defining a name and save location (similar to what you did for the Final Vector Grid parameter). It is good practice to direct the save location to your Vector Grid folder and use a logical name (e.g., GP236VG), but you cannot use the same name as you used for Final Vector Grid.

Click Ok. Your new risk factor Vector Grid will be added to the map.

Right-click on the new risk factor Vector Grid and open the attribute table. Delete all columns except FID, Shape, and GRID_CODE.

With the attribute table open, select the "Table Options" button and create a new column. Column type should be "Short Integer" and the column name should reflect the relevant risk factor (e.g., Gas_P236). Note: column names can only contain 10 characters.

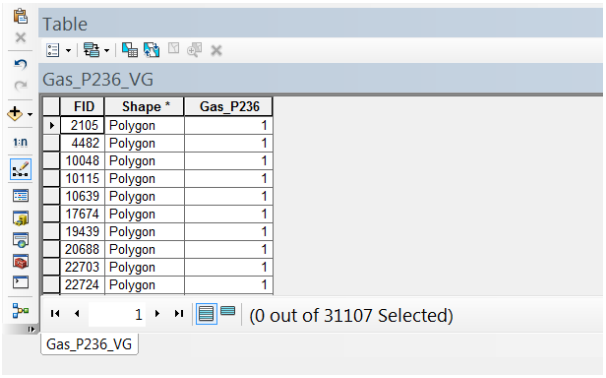
Right-click on new column heading and select "Field Calculator" (see Field Calculate dialogue box below) to calculate GRID_CODE values to the new column (disregard the warning message). Double click GRID_CODE under "Fields." Click ok.



Right-click new column heading and select "Sort Descending" to verify the Field Calculator worked as intended (i.e., look for 1s and 0s).

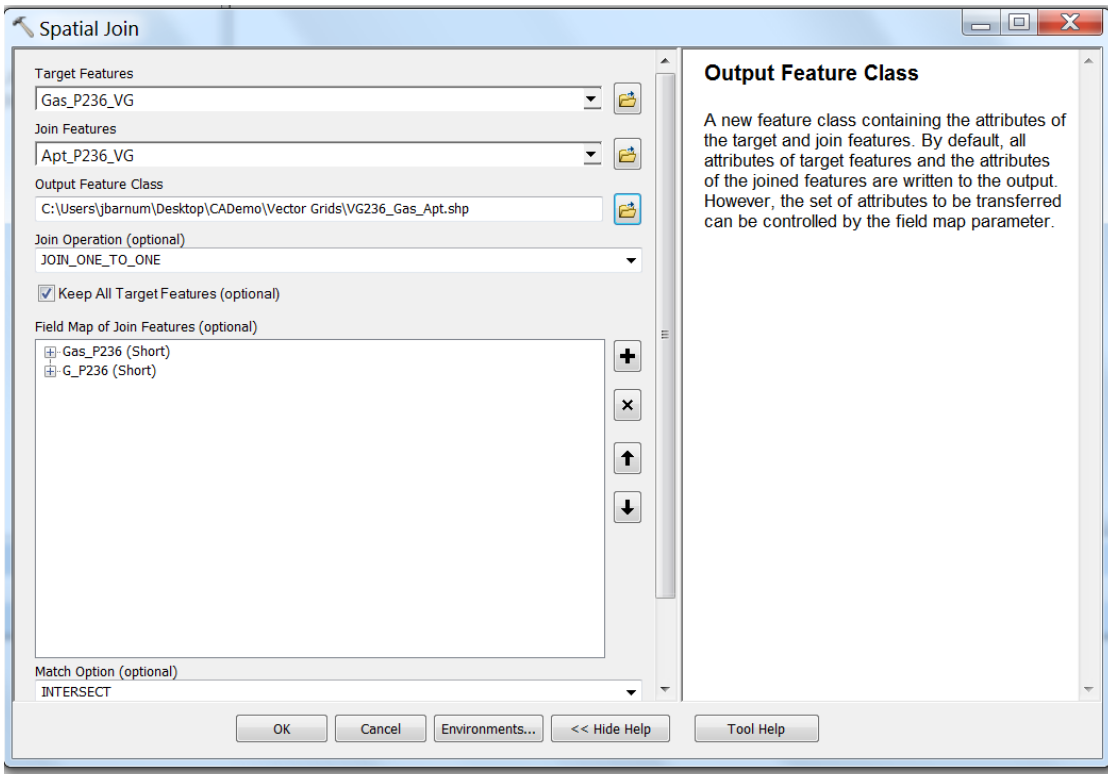
Right-click the GRID_CODE heading and select delete.

Your Vector Grid table should appear like the image below. Repeat these steps to convert remaining risk factor GRIDs to Vector Grids.



Spatially Join all Vector Grids.

Now, all risk factor Vector Grids must be spatially joined. Within ArcToolbox, navigate to "Analysis Tools," select "Overlay," and then select "Spatial Join." The Spatial Join dialogue box will appear (see below).



You'll need to edit the following parameters: Target Features, Join Features, Output Feature Class. All other parameters should be left as their default option.

Target Features refer to the risk factor Vector Grid that you intend to join *to* and Join Features refers to the risk factor Vector Grid that *is being joined*. In the image above, the Apartments Vector Grid is being joined *to* the Gas Stations Vector Grid. Note: For the first join, any two risk factor Vector Grids may be selected for the Target Features and Join Features, respectively. For subsequent joins, the most recently created Vector Grid created via the Spatial Join tool should be used as Target Features and a remaining unjoined risk factor Vector Grid should be used as Join Features. This step is repeated until all risk factor Vector Grids are joined into a single Vector Grid.

Output Feature Class defines the file name and save location. First, select the yellow folder and navigate to your Conjunctive Analysis folder. Create a new folder called Joins and save all new joins in this folder. Define a name for your current join. It is good practice to begin the name with VG (i.e., Vector Grid) and the cell size (e.g., 236). Next, include the abbreviations for the risk factor Vector Grids that have been joined, and those that are going to be joined in the current process. In the image above, Gas and Apt are the first two risk factors Vector Grids to be joined and are indicated in the name (e.g., VG236_Gas_Apt). For each subsequent join, continue to build upon the previous file name (e.g., in this example, the next join will be VG236_Gas_Apt_Gang).

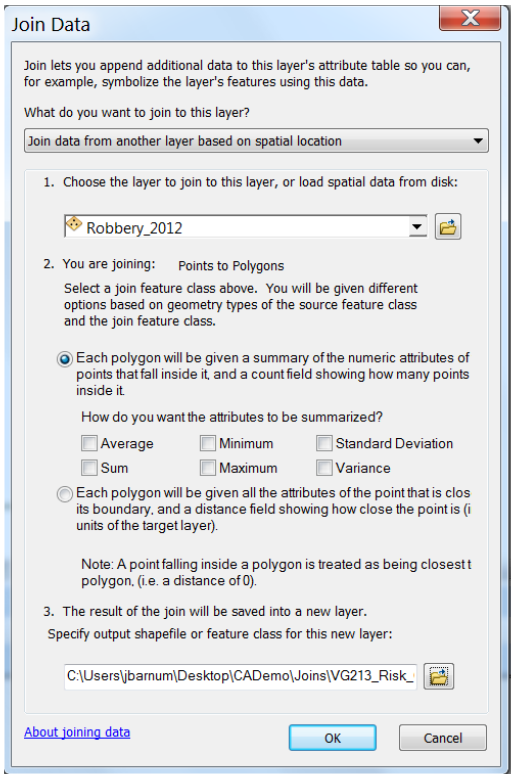
Click ok. This spatially joins the Gas Stations and Apartments Vector Grids and creates a new Vector Grid with the Gas and Apt columns in the attribute table. Recall: this Vector Grid will be used at the Target Features to join the next risk factor Vector Grid, and so on.

Repeat these steps until you have created a single Vector Grid by spatially joining together all individual risk factor Vector Grids. Once finished, open the attribute table and delete all columns except FID, Shape, and each risk factor column.

Join priority crime counts to risk factor Vector Grid.

Now, crime counts must be joined to your complete risk factor Vector Grid. First, select "Add Data." Locate the priority crime shapefile (i.e., the outcome event in your risk terrain model) and add to ArcMap.

Right-click the risk factor Vector Grid, select "Joins and Relates," and then select "Join." Be sure to "Join data from another layer based on spatial location."



You'll need to edit the 1st and 3rd parameters in the Join Data dialogue box. All other parameters should be left as their default option.

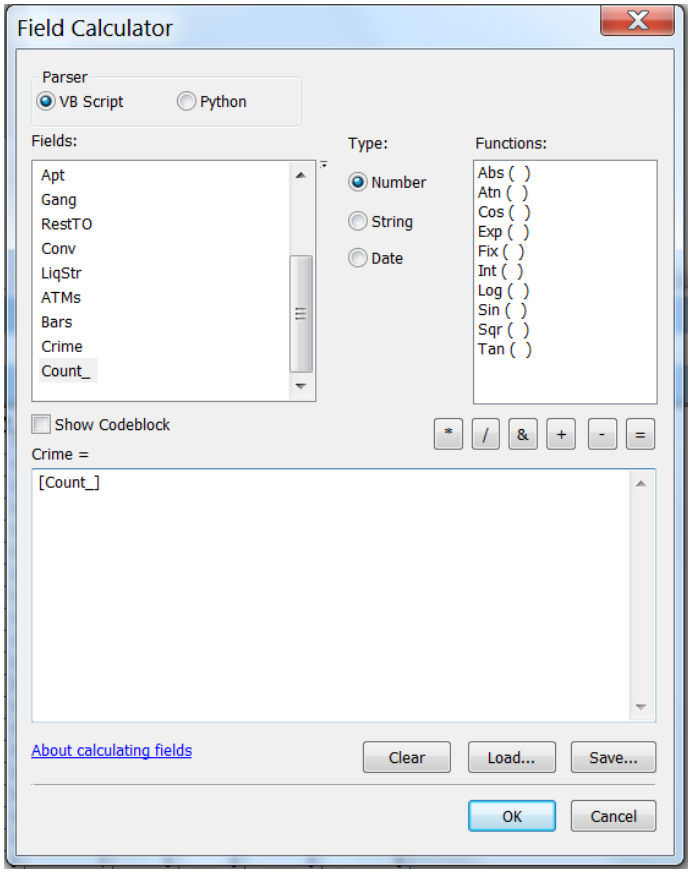
For "Choose the layer to join to this layer…" Select your priority crime.

For "Specify output shapefile or feature classes…" Define a name and save location. Select the yellow folder and navigate to your Joins folder. Define a name. Since this is the final join you'll make, a good name at this point is VGCellSize_Risk_Crime. Use your cell size and crime type in the name.

Click OK.

After the Risk Factor and Crime Vector Grid is added to the map, open the attribute table and create a new column. Column type should be "Long Integer" and the column name should reflect the priority crime.

Once the new column is created, right-click the heading and select "Field Calculator" to calculate "Count_" values to the newly created crime column. Double-click "Count_" under "Fields." Click OK.

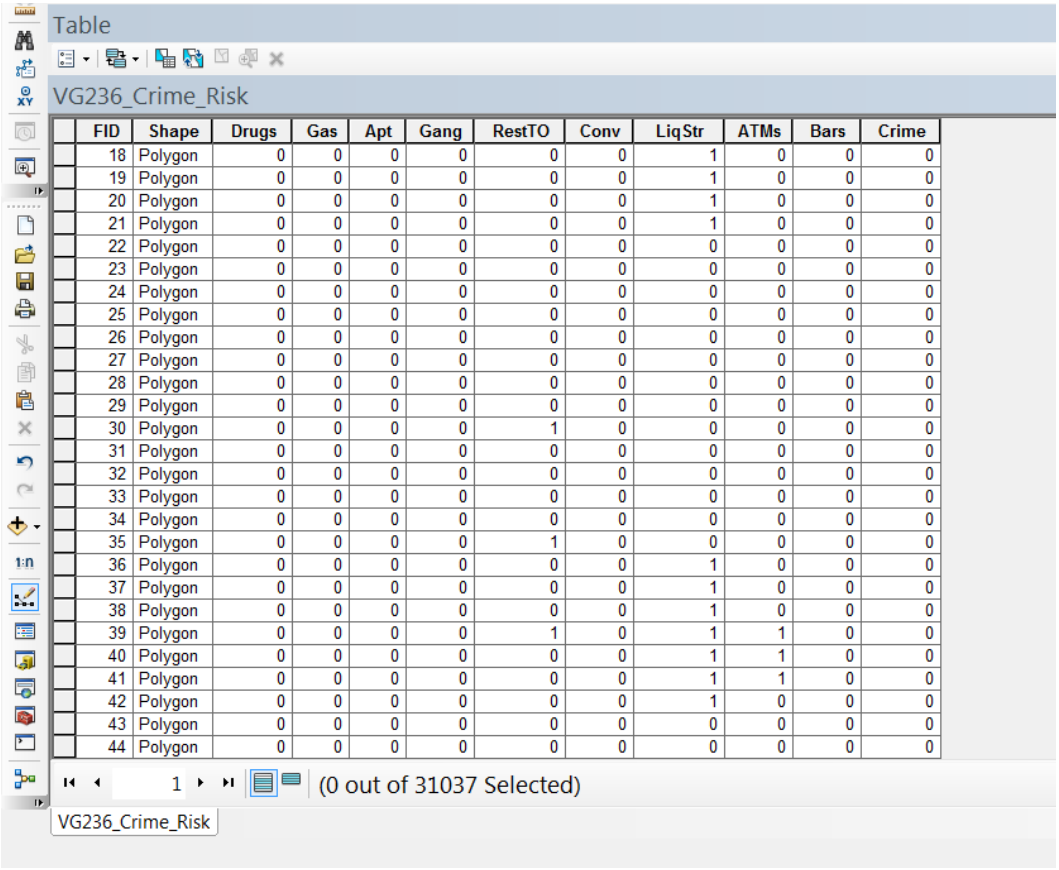


Right-click the new column and select "Sort Descending" to verify the Field Calculator worked as intended (i.e., rows should match Count_).

Delete the Count_ field.

Export final Vector Grid to .dbf.

At this point, you have created a Vector Grid with columns of 1s or 0s to indicate presence or absence of each risk factor's spatial influence at every cell throughout the study area, and a column of integer values to indicate the number of priority crimes in each cell throughout the study area (e.g., see below). This table will be exported from ArcMap to execute a Conjunctive Analysis in your statistical software (i.e., SPSS or SAS).



FID	Shape	Drugs	Gas	Apt	Gang	RestTO	Conv	LiqStr	ATMs	Bars	Crime
18	Polygon	0	0	0	0	0	0	1	0	0	0
19	Polygon	0	0	0	0	0	0	1	0	0	0
20	Polygon	0	0	0	0	0	0	1	0	0	0
21	Polygon	0	0	0	0	0	0	1	0	0	0
22	Polygon	0	0	0	0	0	0	0	0	0	0
23	Polygon	0	0	0	0	0	0	0	0	0	0
24	Polygon	0	0	0	0	0	0	0	0	0	0
25	Polygon	0	0	0	0	0	0	0	0	0	0
26	Polygon	0	0	0	0	0	0	0	0	0	0
27	Polygon	0	0	0	0	0	0	0	0	0	0
28	Polygon	0	0	0	0	0	0	0	0	0	0
29	Polygon	0	0	0	0	0	0	0	0	0	0
30	Polygon	0	0	0	0	1	0	0	0	0	0
31	Polygon	0	0	0	0	0	0	0	0	0	0
32	Polygon	0	0	0	0	0	0	0	0	0	0
33	Polygon	0	0	0	0	0	0	0	0	0	0
34	Polygon	0	0	0	0	0	0	0	0	0	0
35	Polygon	0	0	0	0	1	0	0	0	0	0
36	Polygon	0	0	0	0	0	0	1	0	0	0
37	Polygon	0	0	0	0	0	0	1	0	0	0
38	Polygon	0	0	0	0	0	0	1	0	0	0
39	Polygon	0	0	0	0	1	0	1	1	0	0
40	Polygon	0	0	0	0	0	0	1	1	0	0
41	Polygon	0	0	0	0	0	0	1	1	0	0
42	Polygon	0	0	0	0	0	0	1	0	0	0
43	Polygon	0	0	0	0	0	0	0	0	0	0
44	Polygon	0	0	0	0	0	0	0	0	0	0

First, within the attribute table, be sure all columns are deleted except, FID, Shape, Risk Factors, and Crime (see above).

Next, select "Table Options," and then select "Export."

Third, navigate to your Conjunctive Analysis folder. Define your save name as VG236_Risk_Crime (using your cell size and crime type). Then, define "Save as type" as dBASE Table. Click Save. This layer does not need to be added to the map.

Finally, save your ArcMap .mxd file within your Conjunctive Analysis folder and close ArcMap.

Execute the Conjunctive Analysis.

Now it's time to do the Conjunctive Analysis using the Risk Factor and Crime dBASE Table. First, open SPSS[ii]. Now, open your dBASE Table (File>Open). Once opened, save your dBASE Table as a .sav (SPSS) file (File>Save As). You will run the Conjunctive Analysis on the SPSS file.

Open a new Syntax (File>New>Syntax). Copy and paste the following code into the Syntax:

SORT CASES BY **var1 var2 var3...etc.** (D).

AGGREGATE /OUTFILE='/**PATH NAME GOES HERE/FILE_NAME_GOES_HERE.sav**'
/BREAK=**var1 var2 var3...etc**
/Crime_N=SUM(**Crime**)
/N_BREAK=N.

The bolded text within each command line needs to be edited to reflect your data.

var 1, var2, var3… should be changed to the column names used in your dBASE Table. Use only a space between each variable name and do not include the crime column in this command line. The list of variables can be copied and pasted to follow the "/Break=" command, but do not include "(D)" at the end. For example,

SORT CASES BY Gas_P236 Apt_P236 Bus_D472 (D).
…
/BREAK= Gas_P236 Apt_P236 Bus_D472

PATH NAME… should reflect the file path that leads to the folder where you prefer your conjunctive analysis data matrix to be saved. For example,

/OUTFILE='/Users/jbarnum/Desktop/ConjunctiveAnalysis

FILE NAME… defines the conjunctive analysis matrix that you will create. For example,

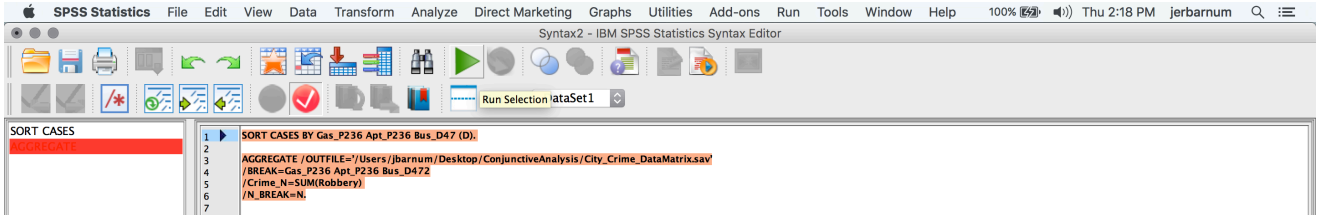
/OUTFILE='/Users/jbarnum/Desktop/ConjunctiveAnalysis/City_Crime_DataMatrix.sav'

Crime… should reflect your priority crime (i.e., from your risk terrain model). Be sure it is defined in the exact same way that you defined your priority crime column. For example,

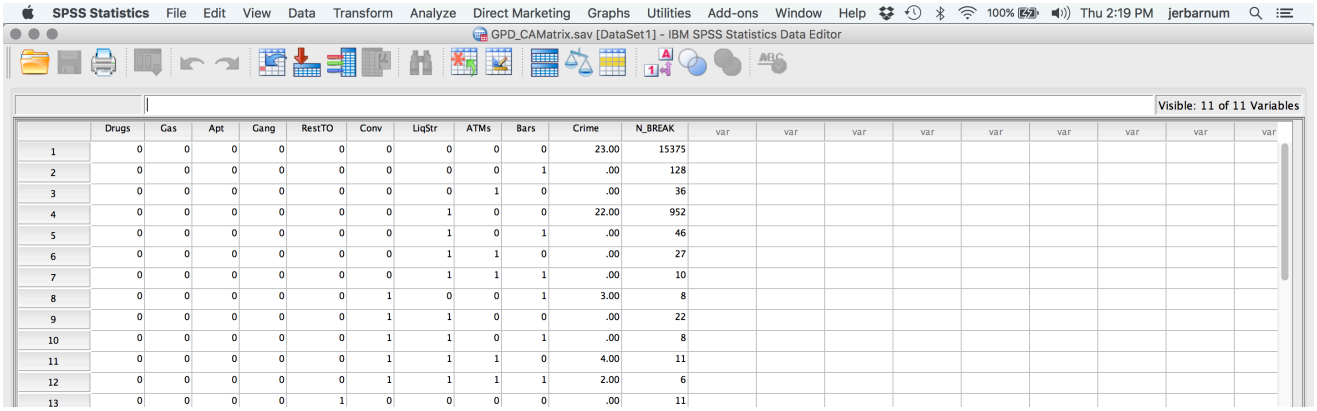
/Crime_N=SUM(Crime)

Before proceeding, check for errors/typos.

Now, highlight the syntax and click run by clicking the green arrow (see below). Note: this process creates a new SPSS file (separate from the currently open data file) – the Conjunctive Analysis Data Matrix. If the process fails to complete, check the Output file for any errors. If errors exist, double-check your Syntax for errors and then re-run.



You can find the newly created Conjunctive Analysis Data Matrix in the folder, and with the file name, that you've indicated in the syntax via Path Name and File Name. Now, open your Conjunctive Analysis Data Matrix in SPSS. Again, if your file doesn't exist, your syntax may contain errors. Check your Output file for errors and then check your Syntax.



	Drugs	Gas	Apt	Gang	RestTO	Conv	LiqStr	ATMs	Bars	Crime	N_BREAK
1	0	0	0	0	0	0	0	0	0	23.00	15375
2	0	0	0	0	0	0	0	0	1	.00	128
3	0	0	0	0	0	0	0	1	0	.00	36
4	0	0	0	0	0	0	1	0	0	22.00	952
5	0	0	0	0	0	0	1	0	1	.00	46
6	0	0	0	0	0	0	1	1	0	.00	27
7	0	0	0	0	0	0	1	1	1	.00	10
8	0	0	0	0	0	1	0	0	1	3.00	8
9	0	0	0	0	0	1	1	0	0	.00	22
10	0	0	0	0	0	1	1	0	1	.00	8
11	0	0	0	0	0	1	1	1	0	4.00	11
12	0	0	0	0	0	1	1	1	1	2.00	6
13	0	0	0	0	1	0	0	0	0	.00	11

Save your Conjunctive Analysis Data Matrix as an .xls file (File>Save As). Because they are different file extensions, you can use the same name as the SPSS file (e.g., City_Crime_DataMatrix).

Finally, be sure to save your Syntax and Output files in your Conjunctive Analysis folder.

Prepare the Conjunctive Analysis output for reporting.

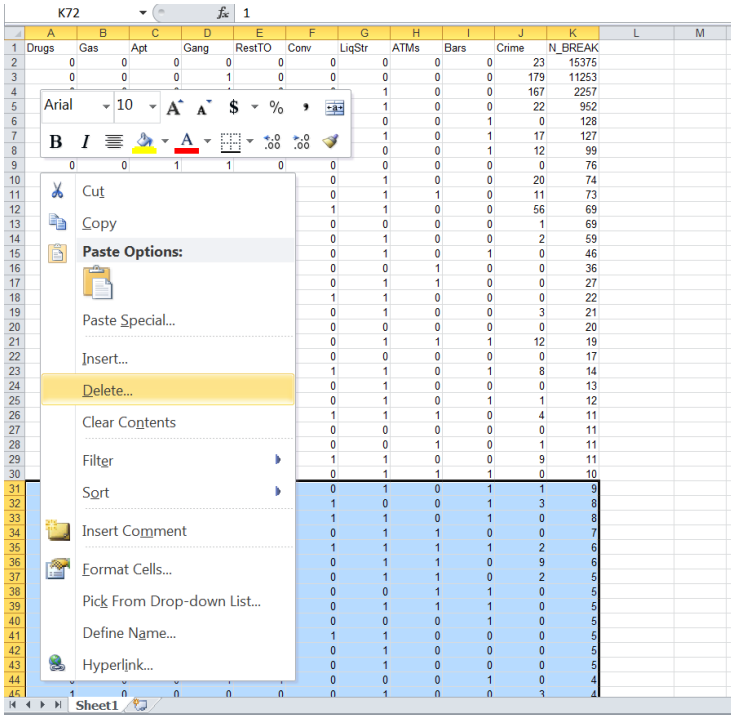
As previously described, the conjunctive analysis produces a data matrix displaying every combination of risk factors throughout the study area. The number of possible combinations is determined by the number of risk factors and categories within them (here, the number of categories is two: 1 indicates presence of risk factor's spatial influence and 0 indicates absence of influence). For example, 9 risk factors have the *potential* to create 512 combinations (e.g., 2^9=512). Each combination can be considered a "behavior setting." The conjunctive analysis will also identify the number of times each particular behavior setting appears in the study setting (n_break) and the number of crimes each behavior setting is responsible for.

The data matrix of behavior settings can be quite large, thus it is important to prepare the information produced by the conjunctive analysis so that it can be meaningfully reported. This can be done using Microsoft Excel. Typically, you'll want to focus on *dominant* behavior settings and the most criminogenic behavior settings.

First, open your conjunctive analysis data matrix .xls file in Microsoft Excel. Before proceeding, verify that the number of rows does not exceed the number of possible behavior settings. If the number of rows exceeds the number of possible behavior settings, verify that you've opened the correct file (i.e., the data matrix you created and NOT the .sav file you used to create the data matrix).

Focus on "Dominant" Behavior Settings

Dominant behavior settings appear in the study setting at 10 times or more (i.e., have a n_break value of 10 or higher). To remove non-dominant behavior settings, sort the n_break column descending (i.e., largest to smallest). Select all rows with a value of 9 or less, right-click, and select delete.



Focus on "Criminogenic" Behavior Settings

"Criminogenic" behavior settings can be defined in a number of ways. One way is by the raw total number of crimes that occur in behavior settings. The "Crime" column that was created in the conjunctive analysis denotes this.

The percentage of crime behavior settings contained is another way to gauge how criminogenic they are. To calculate this, create a new column with the name "Percent Crime." In the first row under Percent Crime, use an Excel formula to divide the number of crimes in that behavior setting by the number of overall crimes, and then multiply that value by 100.

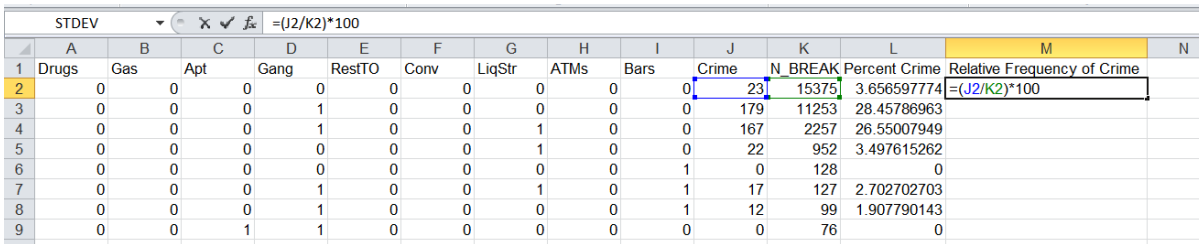
In the example below, "J2" identifies the number of crimes in the behavior setting and "629" is the number of overall crimes in the study setting during the study period (the latter should be the same number of events tested in your risk terrain model; see your RTMDx Output). Apply this formula to the remaining rows (you can do this by positioning your mouse over the lower right-hand corner of the cell until a "plus" appears, then double-clicking).

STDEV =(J2/629)*100

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Drugs	Gas	Apt	Gang	RestTO	Conv	LiqStr	ATMs	Bars	Crime	N_BREAK	Percent Crime		
2	0	0	0	0	0	0	0	0	0	23	15375	=(J2/629)*100		
3	0	0	0	1	0	0	0	0	0	179	11253			
4	0	0	0	1	0	0	1	0	0	167	2257			
5	0	0	0	0	0	0	1	0	0	22	952			
6	0	0	0	0	0	0	0	0	1	0	128			
7	0	0	0	1	0	0	1	0	1	17	127			
8	0	0	0	1	0	0	0	0	1	12	99			
9	0	0	1	1	0	0	0	0	0	0	76			

Crime and Percent Crime do not account for the total area each behavior setting represents in the study setting. For example, some behavior settings have a higher n_break value, which indicates a larger area (and necessarily, more crimes). A **rate** can be calculated – referred to here as the Relative Frequency of Crime – to control for this issue.

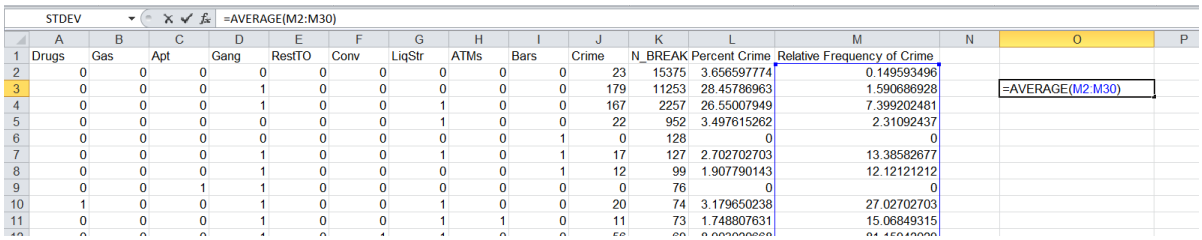
Create a new column with the name "Relative Frequency of Crime" (RFC) to calculate the number of crimes as a function of the number of times a behavior setting appears. In the example below, "J2" identifies the number of crimes in the behavior setting and "K2" identifies the number of times that behavior setting appears in the study setting. Apply this formula to the remaining rows. Sort the RFC column descending to identify the most criminogenic behavior settings.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Drugs	Gas	Apt	Gang	RestTO	Conv	LiqStr	ATMs	Bars	Crime	N_BREAK	Percent Crime	Relative Frequency of Crime	
2	0	0	0	0	0	0	0	0	0	23	15375	3.656597774	=(J2/K2)*100	
3	0	0	0	1	0	0	0	0	0	179	11253	28.45786963		
4	0	0	0	1	0	0	1	0	0	167	2257	26.55007949		
5	0	0	0	0	0	0	1	0	0	22	952	3.497615262		
6	0	0	0	0	0	0	0	0	1	0	128	0		
7	0	0	0	1	0	0	1	0	1	17	127	2.702702703		
8	0	0	0	1	0	0	0	0	1	12	99	1.907790143		
9	0	0	1	1	0	0	0	0	0	0	76	0		

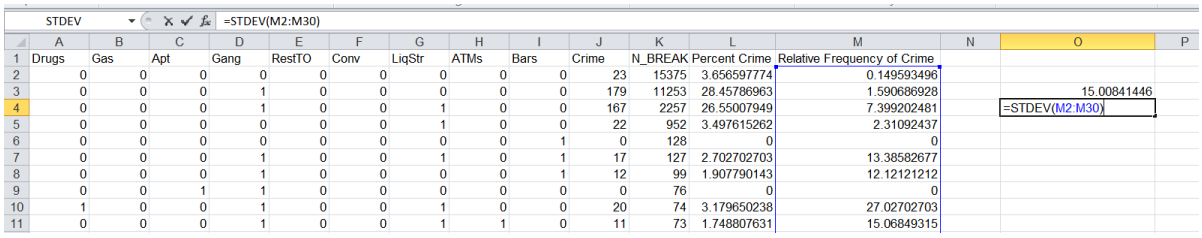
At this point, the conjunctive analysis data matrix contains all dominant behavior settings. Because this number may still be quite large, it may be necessary to further reduce the number of behavior settings to allow for better prioritization of risky places. This can be done by eliminating behavior settings that do not meet a certain threshold based on the RFC. For example, you may calculate the mean RFC, and eliminate behavior settings that have a RFC below the mean[iii]. More stringently, you may choose to eliminate behavior settings below one standard deviation above the mean RFC, or below two standard deviations above the mean RFC. Note: The number of behavior settings to display, and the thresholds used to make those determinations, are inherently subjective and will vary depending on the particular characteristics of the problem and jurisdiction.

Calculate the mean RFC



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Drugs	Gas	Apt	Gang	RestTO	Conv	LiqStr	ATMs	Bars	Crime	N_BREAK	Percent Crime	Relative Frequency of Crime			
2	0	0	0	0	0	0	0	0	0	23	15375	3.656597774	0.149593496			
3	0	0	0	1	0	0	0	0	0	179	11253	28.45786963	1.590686928		=AVERAGE(M2:M30)	
4	0	0	0	1	0	0	1	0	0	167	2257	26.55007949	7.399202481			
5	0	0	0	0	0	0	1	0	0	22	952	3.497615262	2.31092437			
6	0	0	0	0	0	0	0	0	1	0	128	0	0			
7	0	0	0	1	0	0	1	0	1	17	127	2.702702703	13.38582677			
8	0	0	0	1	0	0	0	0	1	12	99	1.907790143	12.12121212			
9	0	0	1	1	0	0	0	0	0	0	76	0	0			
10	1	0	0	1	0	0	1	0	0	20	74	3.179650238	27.02702703			
11	0	0	0	1	0	0	1	1	0	11	73	1.748807631	15.06849315			

Calculate the standard deviation of the RFC



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Drugs	Gas	Apt	Gang	RestTO	Conv	LiqStr	ATMs	Bars	Crime	N_BREAK	Percent Crime	Relative Frequency of Crime			
2	0	0	0	0	0	0	0	0	0	23	15375	3.656597774	0.149593496			
3	0	0	0	1	0	0	0	0	0	179	11253	28.45786963	1.590686928		15.00841446	
4	0	0	0	1	0	0	1	0	0	167	2257	26.55007949	7.399202481		=STDEV(M2:M30)	
5	0	0	0	0	0	0	1	0	0	22	952	3.497615262	2.31092437			
6	0	0	0	0	0	0	0	0	1	0	128	0	0			
7	0	0	0	1	0	0	1	0	1	17	127	2.702702703	13.38582677			
8	0	0	0	1	0	0	0	0	1	12	99	1.907790143	12.12121212			
9	0	0	1	1	0	0	0	0	0	0	76	0	0			
10	1	0	0	1	0	0	1	0	0	20	74	3.179650238	27.02702703			
11	0	0	0	1	0	0	1	1	0	11	73	1.748807631	15.06849315			

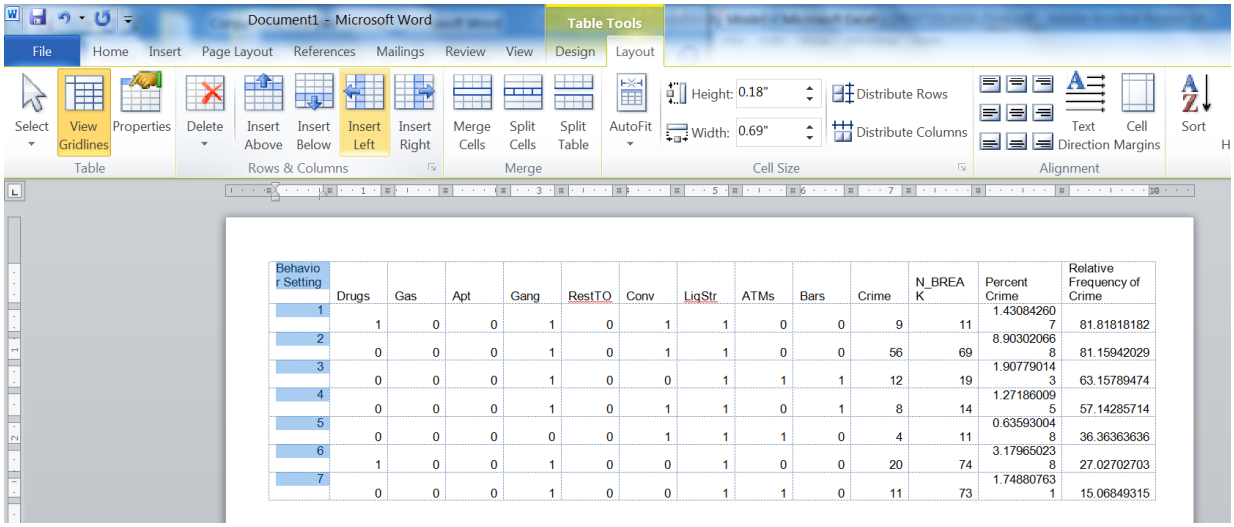
To calculate one standard deviation above the mean, simply add the standard deviation value to the mean. To calculate two deviations above the mean, simply add the standard deviation value to the value calculated by adding the mean and one standard deviation value. In other words, add the standard deviation value to the mean twice. Eliminate rows below desired threshold.

At this point, you can select all remaining rows and columns in your data matrix and copy and paste into Microsoft Word to prepare for reporting.

Communicate meaningful information.

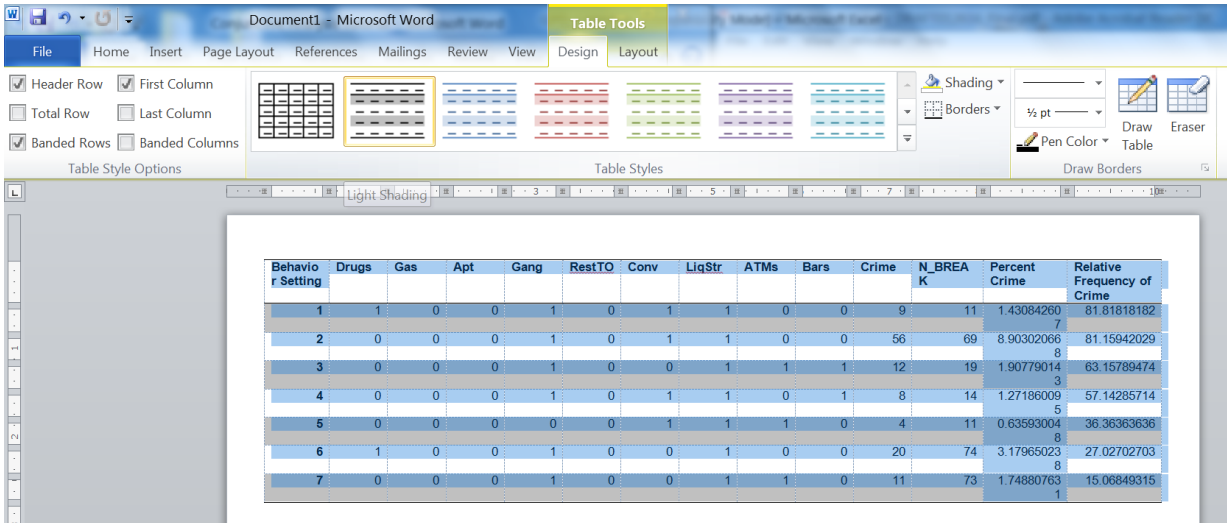
It is easiest to prepare your data matrix in a blank Microsoft Word document using narrow margins and a landscape orientation. Once that table is finished, it should fit within a standard 8.5x11 layout with 1-inch margins.

First, insert a new column to the very left side of the data matrix. Name this column "Behavior Setting" and then number the rows consecutively.



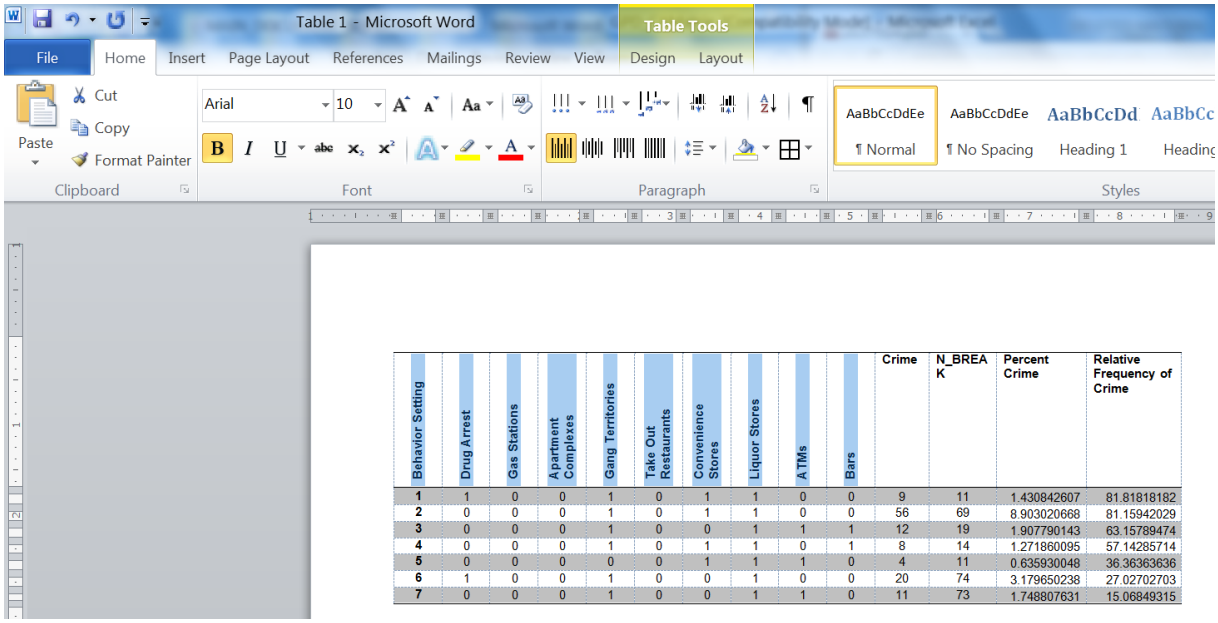
Behavior Setting	Drugs	Gas	Apt	Gang	RestTO	Conv	LiqStr	ATMs	Bars	Crime	N_BREAK	Percent Crime	Relative Frequency of Crime
1	1	0	0	1	0	1	1	0	0	9	11	1.430842607	81.81818182
2	0	0	0	1	0	1	1	0	0	56	69	8.903020668	81.15942029
3	0	0	0	1	0	0	1	1	1	12	19	1.907790143	63.15789474
4	0	0	0	1	0	1	1	0	1	8	14	1.271860095	57.14285714
5	0	0	0	0	0	1	1	1	0	4	11	0.635930048	36.36363636
6	1	0	0	1	0	0	1	0	0	20	74	3.179650238	27.02702703
7	0	0	0	1	0	0	1	1	0	11	73	1.748807631	15.06849315

Next, select the "Design" tab and choose a theme.



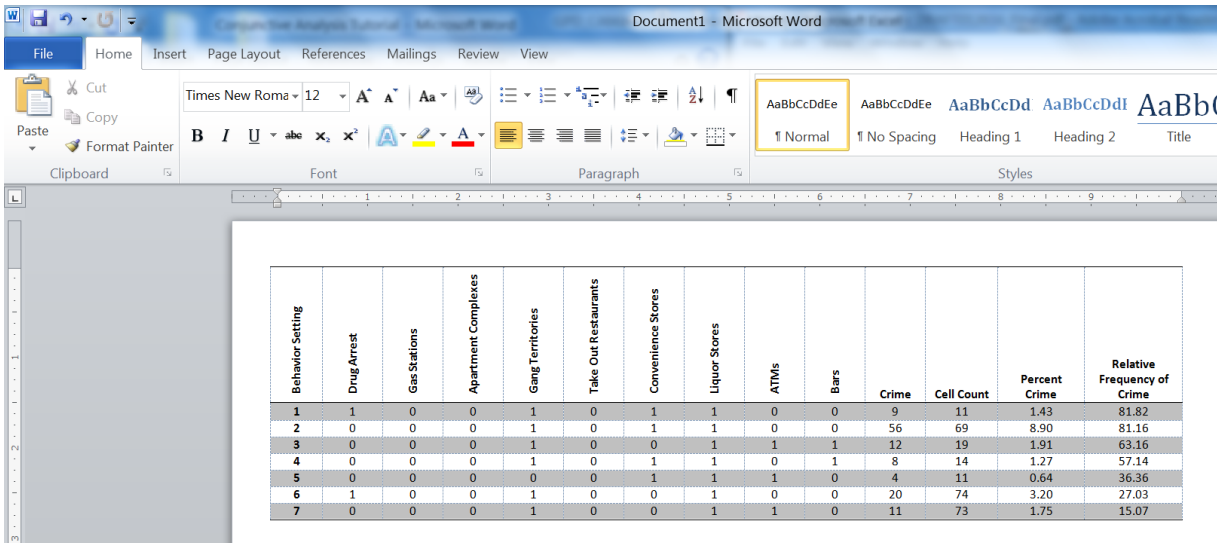
Behavior Setting	Drugs	Gas	Apt	Gang	RestTO	Conv	LiqStr	ATMs	Bars	Crime	N_BREAK	Percent Crime	Relative Frequency of Crime
1	1	0	0	1	0	1	1	0	0	9	11	1.430842607	81.81818182
2	0	0	0	1	0	1	1	0	0	56	69	8.903020668	81.15942029
3	0	0	0	1	0	0	1	1	1	12	19	1.907790143	63.15789474
4	0	0	0	1	0	1	1	0	1	8	14	1.271860095	57.14285714
5	0	0	0	0	0	1	1	1	0	4	11	0.635930048	36.36363636
6	1	0	0	1	0	0	1	0	0	20	74	3.179650238	27.02702703
7	0	0	0	1	0	0	1	1	0	11	73	1.748807631	15.06849315

Now, select the “Behavior Setting” and risk factor column headings. Under the “Layout” tab, re-orient the text direction (see below).



Behavior Setting	Drug Arrest	Gas Stations	Apartment Complexes	Gang Territories	Take Out Restaurants	Convenience Stores	Liquor Stores	ATMs	Bars	Crime	N_BREAK	Percent Crime	Relative Frequency of Crime
1	1	0	0	1	0	1	1	0	0	9	11	1.430842607	81.81818182
2	0	0	0	1	0	1	1	0	0	56	69	8.903020668	81.15942029
3	0	0	0	1	0	0	1	1	1	12	19	1.907790143	63.15789474
4	0	0	0	1	0	1	1	0	1	8	14	1.271860095	57.14285714
5	0	0	0	0	0	1	1	1	0	4	11	0.635930048	36.36363636
6	1	0	0	1	0	0	1	0	0	20	74	3.179650238	27.02702703
7	0	0	0	1	0	0	1	1	0	11	73	1.748807631	15.06849315

Rename the column headings. It is also a good idea to appropriately align the columns. Column headings should be bottom centered, and row information should be center centered. Finally, remove all but two decimal places for values under Percent Crime and RFC.



Behavior Setting	Drug Arrest	Gas Stations	Apartment Complexes	Gang Territories	Take Out Restaurants	Convenience Stores	Liquor Stores	ATMs	Bars	Crime	Cell Count	Percent Crime	Relative Frequency of Crime
1	1	0	0	1	0	1	1	0	0	9	11	1.43	81.82
2	0	0	0	1	0	1	1	0	0	56	69	8.90	81.16
3	0	0	0	1	0	0	1	1	1	12	19	1.91	63.16
4	0	0	0	1	0	1	1	0	1	8	14	1.27	57.14
5	0	0	0	0	0	1	1	1	0	4	11	0.64	36.36
6	1	0	0	1	0	0	1	0	0	20	74	3.20	27.03
7	0	0	0	1	0	0	1	1	0	11	73	1.75	15.07

As a final step, adjust the column sizes. Attempt to make the table small enough for a standard 8.5x11 inch sheet of paper with 1-inch margins.

Interpret the Conjunctive Analysis Data Matrix.

The final data matrix below displays 7 dominant behavior settings with a RFC greater than the mean for calendar year 2012 crime incidents in a major city in the United States. Together, these behavior settings constitute less than 1% of the study area, but are responsible for 19% of the crimes.

Table 1: Conjunctive Analysis Data Matrix of Behavior Settings for Calendar Year 2012 Incidents of Crime in City, STATE

Behavior Setting	Drug Arrest	Gas Stations	Apartment Complexes	Gang Territories	Take Out Restaurants	Convenience Stores	Liquor Stores	ATMs	Bars	Crime	Cell Count	Percent Crime	Relative Frequency of Crime
1	1	0	0	1	0	1	1	0	0	9	11	1.43	81.82
2	0	0	0	1	0	1	1	0	0	56	69	8.90	81.16
3	0	0	0	1	0	0	1	1	1	12	19	1.91	63.16
4	0	0	0	1	0	1	1	0	1	8	14	1.27	57.14
5	0	0	0	0	0	1	1	1	0	4	11	0.64	36.36
6	1	0	0	1	0	0	1	0	0	20	74	3.20	27.03
7	0	0	0	1	0	0	1	1	0	11	73	1.75	15.07

The risk terrain model suggests that that confluence of weighted risk factors at particular locations creates high risk for crime. The conjunctive analysis suggests that the *spatial interaction* of risk factors creates risky locations for crime.

The most problematic behavior setting is characterized by the *spatial interaction* of drug markets, gang territories, convenience stores, and liquor stores. This behavior setting has the highest RFC of 81.82 and appears 11 times in the study settings. It contains 9 crimes, or 1.43% of all crimes in the study setting during the study period.

The data matrix also shows that gang territories and liquor stores appear frequently in the most problematic behavior settings, suggesting that these factors *consistently aggravate* the risk posed by other factors in the risk terrain model.

Endnotes

[i] Miethe, Hart, and Regoeczci (2008) The Conjunctive Analysis of Case Configurations: An Exploratory Method for Discrete Multivariate Analyses of Crime Data, *Journal of Quantitative Criminology, 24*, 227-241.

[ii] Conjunctive Analysis can also be completed in STATA and SAS. The syntax code for these programs is provided by Miethe, Hart, and Regoeczci (2008).

[iii] A method used in one jurisdiction was to calculate the mean RFC of behavior settings that include 10 or more cells (i.e., dominant behavior settings), but then select any behavior setting from the entire matrix that has a RFC greater than the mean, even if the N is less than 10 cells.

For examples of CARFC applied to real-world research and practice, see
http://www.rutgerscps.org/publications.html > scroll down to Conjunctive Analysis