Using GIS to Model Risk Concentration

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CoreLogic®

Conventional Definition

- "Risk concentration"
- Most commonly used to mean the risk associated with a portfolio of investments
- Portfolios are analyzed to see if there is a concentration of investments in specific sectors that would compromise the total package if that particular sector were subject to considerable loss

Spatial Definition

- Risk concentration is a measure of the aggregated value of assets at a given point in the context of the location of all assets spread over space

- A risk value score can only be calculated using GIS operations

- Once calculated, it provides an immediate visualization of risk 'hot spots' and a rank ordered table of potential high risk areas

Geographic Footprints

- All natural hazards are geographically localized
- Their damage footprint does not spread over large areas
- The largest hurricanes have an impact only along a small part of the nation's coastline and their effect diminishes quite rapidly inland
- Although an earthquake may be felt over a large area, substantial damage is usually spatially limited
- The same holds for tornados, straight line winds, and brushfire
- The most massive attack to occur on American soil (September 11, 2001) was confined to very small areas in Manhattan and Washington

Geographic Concentration

- Example = company with 1,000 assets
- Assume <u>each</u> of these 1,000 individual assets has a "very high" risk score for storm surge
- However, the amount of <u>geographic</u> <u>concentration</u> determines the <u>total</u> loss given a potential storm surge
- If all assets are concentrated within a few miles of each other, then the potential <u>total</u> loss is quite large
- Worst case scenario
- If the 1,000 assets are strung out along 1,500 miles of the Atlantic & Gulf coast, even the most severe storm will have an impact only on a limited percentage of the portfolio

Geographic Concentration
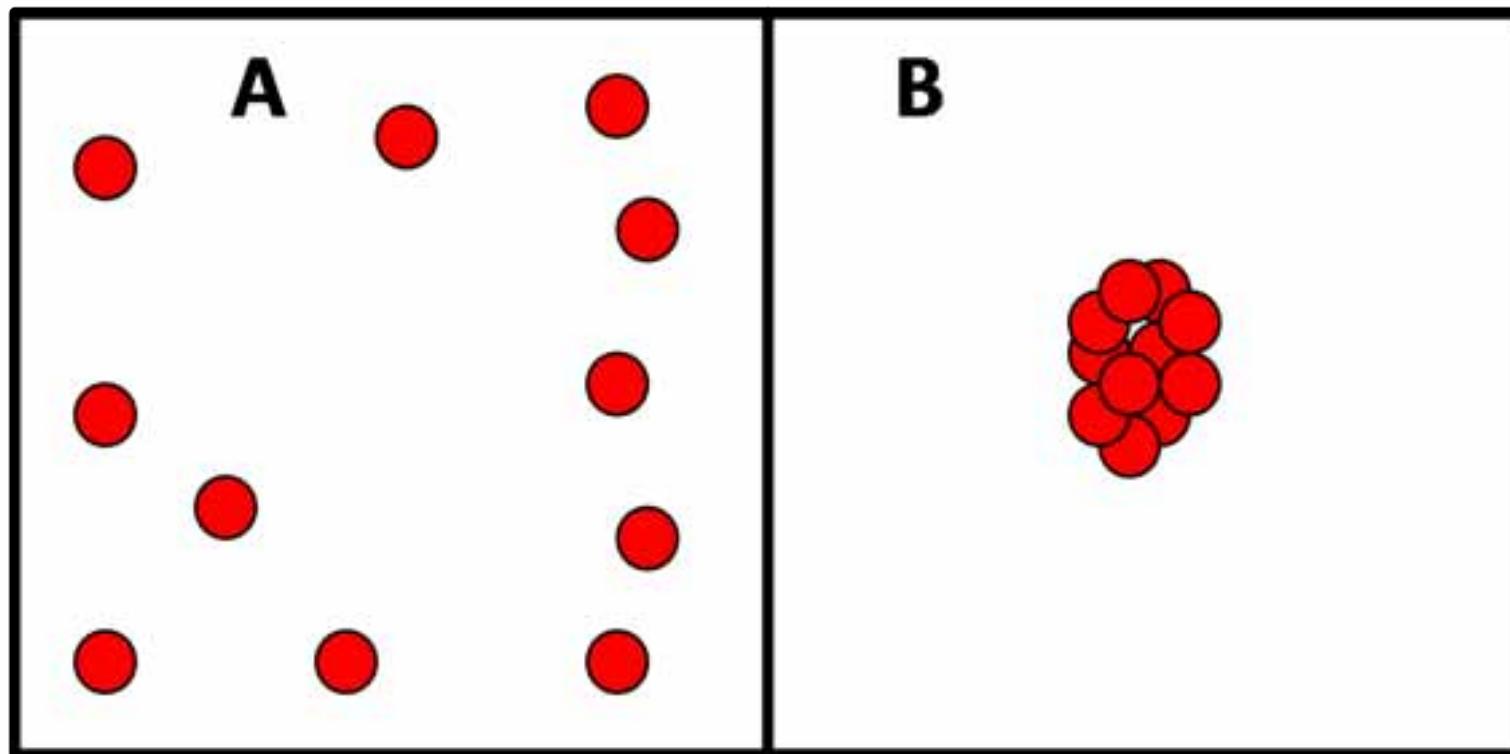
Simple Asset Summation

- Start with summation of assets within polygons (BG, ZIP, grid, hexagons)
- Sum assets for each cell and then return a map/table of cells with the associated total asset value
- <u>Not</u> an acceptable solution because:
  - It ignores the role of distance to other cells containing assets
  - It does not produce a robust and understandable <u>metric</u> of risk concentration

Have To Consider Distance

$$M = \sum_{n}^{i=1} A(\$)\Big/ D_{ij} \; for \; D < X$$

Where:

M = the metric,

A($) = the total asset value in a cell,

Dij = distance from cell i to each cell j

X = a distance limit (say, 5 miles)

Note: the distance value for Cell i = 1

ArcGIS Hot Spot Analysis

- Hot spot analysis solves part of the problem
- Returns Getis-Ord Gi* statistic
- Not an easily understood statistic
- Hard to compare different risk hot spots
- Does not incorporate hazard data

Spatial Risk Concentration Index - SRCI

- Requires a consistent metric
- Requires a constant metric
- Requires a comparable metric
- Geoconcentration metric = G

Simple Geoconcentration Index

- Simple G metric is insufficient
- Two cells could have identical G values, but vary widely in the total amount of insured assets in question
- Alternative metric

$$SRCI = (1 + G) * \sum Cell\ Assets$$

Where
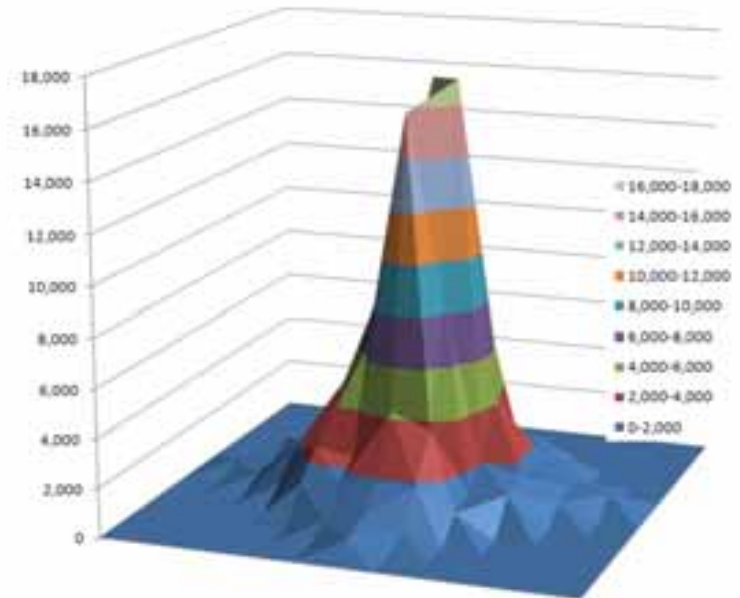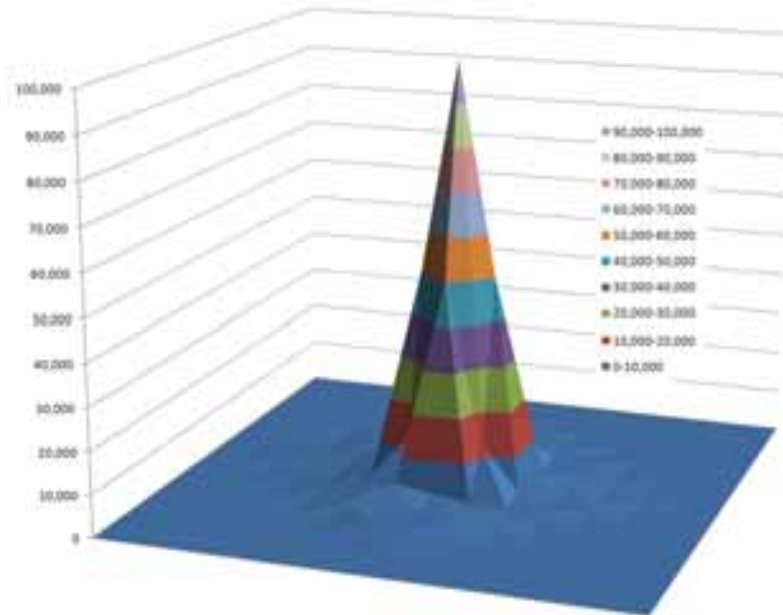SRCI = Spatial Risk Concentration Index
G = Geoconcentration Coefficient
Cell Assets = the value of all assets in the cells used to compute G.

Multiplier

- The multiplier (1+G) varies between 1 and 2 (0 ≥ G ≤ 1)
- Complete concentration doubles the value of the multiplier
- The application of the multiplier to the total value of cell assets provides an instant comparison and ranking metric
- Example:
  - Two cells with multiplier of 1.5
  - Cell 1 = centered in cells containing total assets of $100,000,000
  - Cell 2 = centered in cells with total assets of only $10,000,000

EXAMPLE	G	TOTAL ASSETS	MULTIPLIER	SRCI
1	0.5	$100,000,000	1.5	150,000,000
2	0.5	$10,000	1.5	15,000

- 25x25 grid of test cells.
- Cell values = total asset values (homes, businesses, *etc.*) in millions of dollars

Case 2

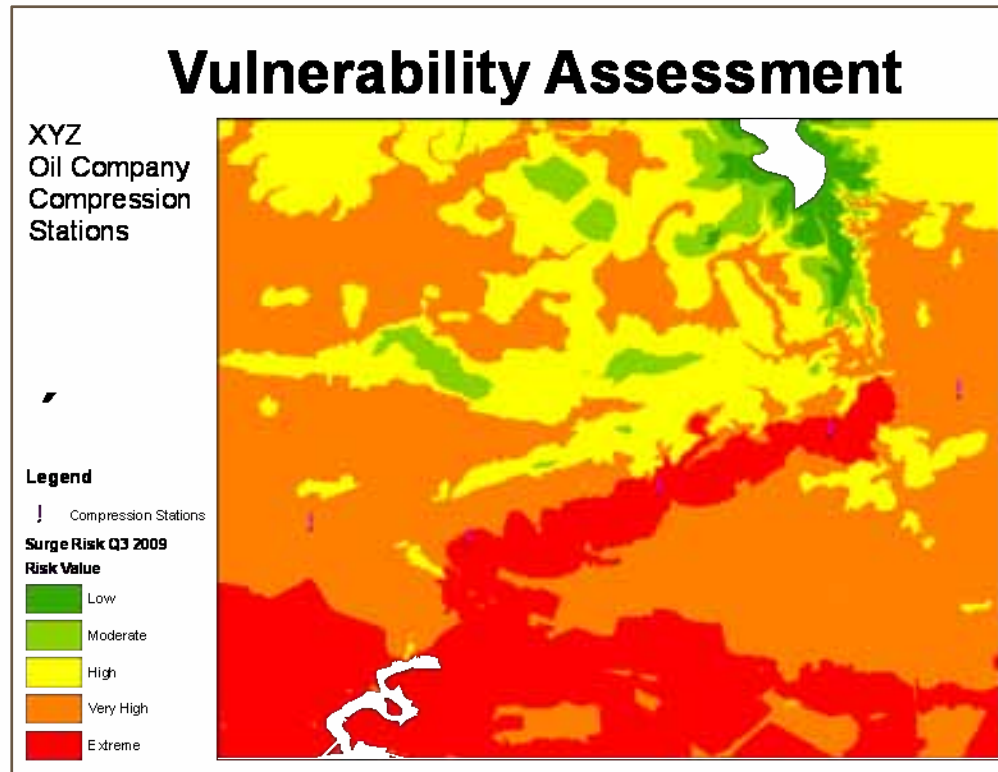| CASE	G	TOTAL ASSETS	MULTIPLIER	SRCI
1	0.76453	$1,099,188	1.76453	1,939,555
2	0.54687	$850,675	1.54687	1,315,884

Insurance Industry Needs

- Score individual asset
- Score entire book of business

Individual Asset

- Start with "dashboard"
- ESRI RAS is a good example
- Enter an address
- Return a comprehensive "picture" of risk concentration for address
- Risk Score
- Associated Hazard Scores
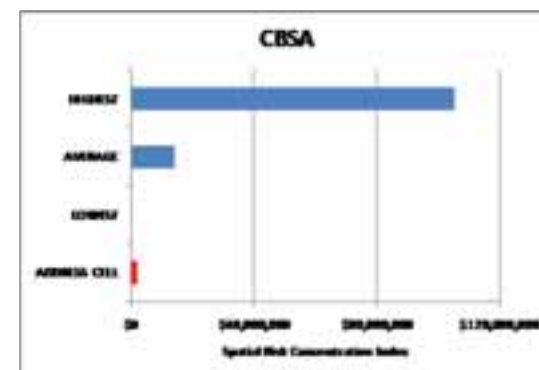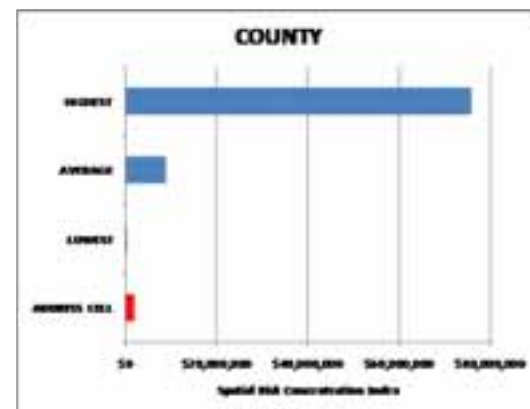
Some Assets Never Concentrated

Vulnerability Assessment

XYZ
Oil Company
Compression
Stations

Legend

! Compression Stations

Surge Risk Q3 2009
Risk Value

- Low
- Moderate
- High
- Very High
- Extreme

ASSET	TOTAL #	PERCENT AT RISK			
		FLOOD	SURGE*	WILDFIRE**	EARTHQUAKE
Wells	345	14%	19%	31%	0%
Pipeline Segments	98,516	35%	42%	42%	0%
Compression Stations	358	41%	22%	71%	0%
Storage/Staging	14	10%	50%	25%	0%

*Extreme **Texas only

Conclusions

- Some measure of risk concentration is needed
- Must be tied to hazard potential
  - Natural
  - Human (terrorism)
- Distance must be incorporated
- Geoprocessing <u>essential</u> for calculations