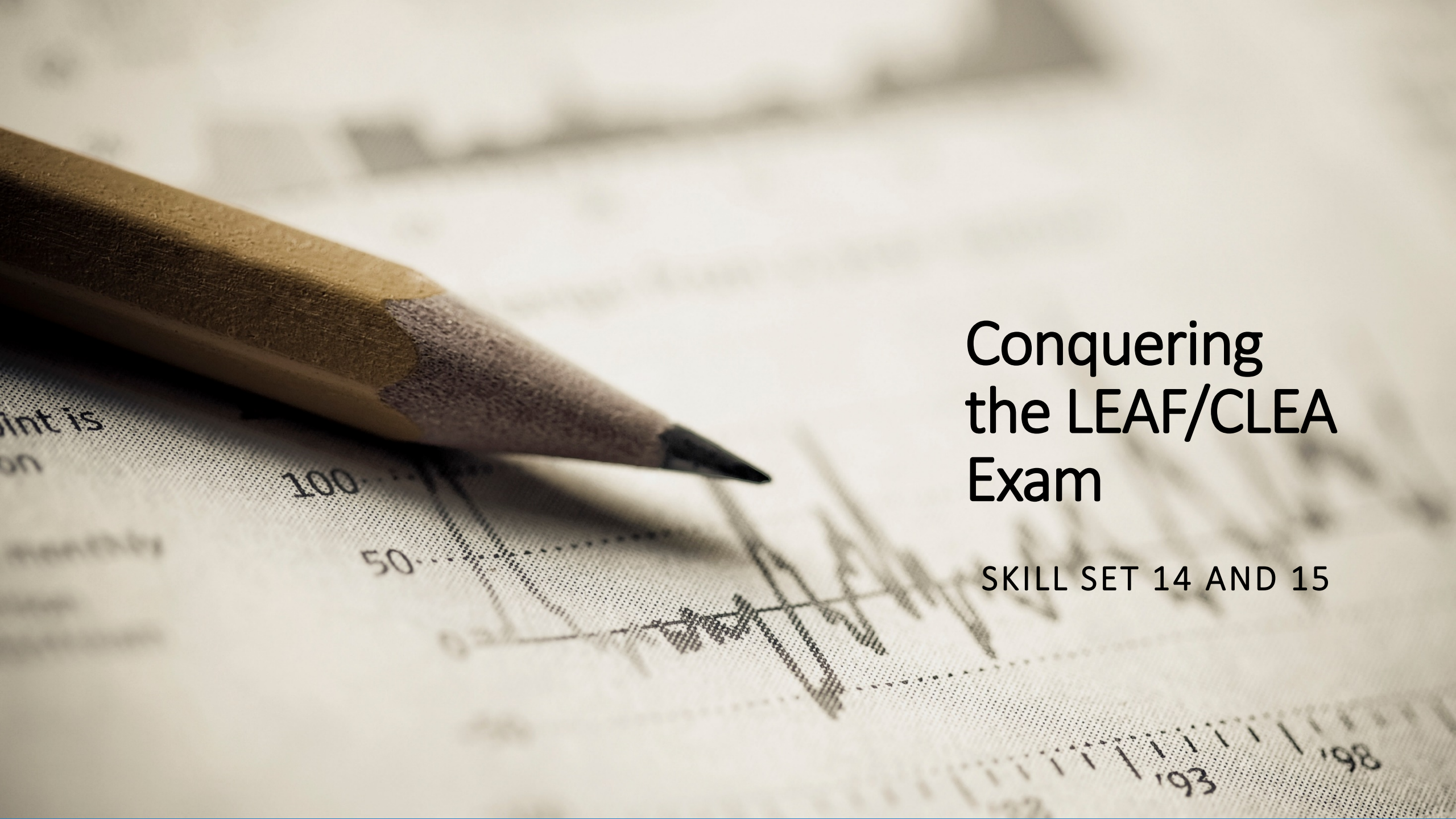

Conquering the LEAF/CLEA Exam

SKILL SET 14 AND 15

About the Instructor/Course

- Instructor – Jenny Zawitz Jennifer.Zawitz@gmail.com
- CLEA Study Guide: https://iaca.net/wp-content/uploads/2021/06/CLEA-Skill-Sets_Study-Resources-051821.pdf
- LEAF Study Guide: https://iaca.net/wp-content/uploads/2021/06/en_LEAF-Core-Competencies_Study-Resources.pdf
- Exploring Crime Analysis: Readings on Essential Skills (3rd Edition) - IACA
- Each month will cover a different section of the study guide
- Intended as a supplement NOT a substitute for the texts and the Essential Skills classes
  - This course will help you focus your studying, but the courses and text will provide the actual understanding you need to pass the tests

GIS and Crime Mapping

SKILL SET 14

Mapping Basics

- Cartography – science of map making
- GIS – high performance computer software that allows users to process geographically related data.
- GIS stores information in virtual layers (one for each variable) that can be laid on top of each other and displayed in a multilayer map
- Geoprocessing is the ability to lay several layers of a map over top of each other to see relationships between variables
- Note: these layers can include crime, police boundaries, population density, etc.
- Maps are created using projection or a flattening of the Earth's surface (note: may cause distortion). The area involved in most crime mapping is too small to cause major issues.
- Many crime maps are geocoded by address – a process that uses the latitude and longitude of a location to position it on a map.

Types of Maps Used by Crime Analysts

- Pin Map: show a simple, single event or series and the locations of the crimes.
- Choropleth map or shaded grid map: shows the distribution of crime across a particular area.
- Hotspot map: shows hotspots located across a jurisdiction that are related to multiple criminal events or a series of connected criminal events
- Map Data: real world data are represented by four feature types in GIS
  - Point Features: discreate locations typically shown by a figure or symbol
  - Line Features: geographic feature represented by a line or set of lines (streets, railroads, bus routes)
  - Polygon Features: multisided figure represented by a closed set of lines (city boundary, census tract, police beat, neighborhood). May be very large or very small (park). AKA **vector types** in that they have finite limits, locations, beginning and end points, and do not cover the entire surface of the map.
  - Image Features: vertical photo (satellite/plane photo) that is digitized and placed within the GIS coordinates associated with it. AKA **raster images** because they are small pixels of data that cover the entire service of the map and each pixel ahs some value.

Mapping Software and Resources

- Software: MapInfo and ArcGIS are the current leaders in GIS with Arc being the most common in police departments.
  - GeoDa is a standalone spatial analysis program used as an introduction to spatial analysis
  - CrimeStat is a standalone spatial analysis program for the analysis of incident locations. Developed under research grant from NIJ. Must be used with ArcGIS or MapInfo
- Mapping Resources: places for analysts to learn about how crime mapping fits with the LE mission to prevent crime.
  - Mapping and Analysis for Public Safety (MAPS) at NIJ
  - Community Oriented Policing Services (COPS)
  - Center for Problem-Oriented Policing
  - Listservs – group email lists

Crime Mapping and Analysis Data

- Analysts may produce maps that describe a crime problem or be asked to forecast/predict when a crime will occur or demonstrate where an offender may live in relation to a series
- Extensive free resources for analysts in mapping – census data, police departments, welfare agencies.
- Be careful of the information you choose to use – garbage in, garbage out
- Consider your audience and use the scientific process of collection, collation, dissemination, and evaluation of the data
- Note that much of your data will be sample data – hard to determine what the full population of a variable is
- In formal research, need to ensure that data is properly collected following the guidelines of the scientific process – probability sample collected (difficult/impossible in crime analysis)
- Scale is also import – can overstress or undersell a problem

Contextual Data

- Contextual data contains information about people or places that is not crime related
- US Census Bureau – census taken every 10 years. Grown and expanded to include information on fisheries, manufacturing, poverty, and crime.
  - Includes information on age, race/ethnicity, gender, marital status, education, income, poverty status, employment, house value, and own/rent data
- Local Social Agencies
  - If contextual data not on Census Bureau, try local government and/or social agencies.
  - City/County planning departments can provide GIS data – can provide base maps for your GIS data
  - May also have information about liquor licenses, public assistance/housing, abandoned buildings, and graffiti clean up
  - Always ask about quality/accuracy of data to include last updated date/how often updated
  - Universities may also store data – Interuniversity Consortium for Political and Social Research

Data Sharing Issues

- Number of entities that might request data from crime analysts and maps
- Other agencies may want data for their own analysis – may be difficult to have RMS communicate. May be designed for the agency specifically. May go through regional data-sharing systems
- Academic researchers may want data for their own research projects. Important both parties be clear about what the data will be used for and how confidentiality will be maintained. Institutional review boards should review the research proposals to identify problems.
- Citizens and community groups may request information. Many agencies have crime mapping availability for their citizens on the department website or produce periodic maps. Names and addresses of those involved in crime may be considered public information (state specific)
- Commercial use of crime maps – mortgage brokers, insurance agents, or private security could use maps in discriminatory ways

Data Classification

- Purpose is to simplify complex geographic distributions into a meaningful presentation of data to the reader.
- Organizing data into groups of clusters based on a numeric or statistical distribution
  - Two main components: number of classes into which the data is to be organized and the method by which classes are assigned
- Natural breaks: default data classification option in most GIS software packages. Good technique for determining natural groups or clusters of values in the data. Looks for breaks between groups of data values. Feature classes are where the big jumps in data occur. Limited for time-series analysis like comparing time periods from one year to another.
- Equal interval: breaks the range of data from low to high into a number of equal subgroups or classes dictated by the user. Good for data comparison between different time periods.
- Quantile: Equal number of observations or data points into each class as determined by the user. Four classes of data = 25% of the data in each. Well suited for linearly distributed data.
- Standard Deviation: should only be used when data approximates a normal distribution. Divide data into one, two, or three standard deviations after determining the mean.

Crime Map Types in Detail

- Point Symbol Mapping – each symbol or data on a map represents a discrete occurrence
  - Useful for illustrating spatial density.
  - Difficult when data distribution is so dense that the points coalesce into a mass.
  - Can use a graduated symbol map when dealing with co-located events.
  - Calculate the frequency to create a graduated symbol map
- Choropleth Maps
  - AKA area symbol maps or statistical surface maps
  - Indicates aggregation of data over an area as opposed to a point map which demonstrates discrete events.
  - Select an enumeration area or the geographic polygon that you will use to analyze and illustrate your data.
  - May need to spatially join or assign reporting district polygons to an event.

For LEAF – Things that Make Up a Map

- Note you may be given a map and asked to find problems with it on your exam.
- Check for a compass (North arrow), scale, title, labels, legend, etc.
- If you find those requirements are met, see if you find mistakes in the color or symbols
- Use IACA website to examine the maps they have posted for examples of “good maps”

Spatial Analysis and Forecasting

SKILL SET 15

Spatial Queries Basics

- Spatial query: retrieving data via a map
- GIS software includes a database management system that is typically a relational database to store attributes of spatial data.
- Can import data from other database sources or access data in other database systems via an ODBC connection
  - Find is the simplest attribute searches with the intention of locating a single record
  - Restricted query – can enable the retrieval of a subset of data by placing restrictions on attributes (can crime in a given month or a descriptive or geographic feature)
- Adjacency: topological property of having an edge or a boundary in common.
- Proximity: a buffer is a zone around a point, line, or polygon that is spatially related to the feature. Common technique in crime mapping. Creating a buffer entails determining what radius or proximity should be around a specified feature.
- Area: measure of a planar region. (comparing size or area of police beat and comparing it to others)
- Length or Distance and Connectivity: length of road segment, how does it connect to other streets.

About Spatial Analysis

- Using mapping and spaces to identify trends and patterns in crime.
- Using maps to demonstrate trends/patterns and search for information.
- Must convert data spatially – creating data within a space using geocoding.
- Need to define High Crime Areas – these areas are more commonly discussed as hot spots.
  - Definitions vary, but in this case, we are defining it as a group of similar crimes committed by one or more individuals at locations within close proximity to one another.
  - Cluster crime incidents
  - Can also include arrests, CFS, disorders, etc.
  - Commonly characterized by (1) relatively high volume of crime, (2) evidence of spatial clustering, and (3) observable pattern of time occurrence and duration
  - Hot spot areas will vary depending on the unit of analysis, scale of the map, and the amount of data mapped – no set definition of a hot spot.

Identifying High Crime Areas

- High Crime Area maps are useful when they answer analytical questions based on crime theory and subsequently guide appropriate police action.
- Note again the complications of repeat addresses in maps. In this case, a graduated symbols are important to demonstrate the significance of crime at repeat addresses.
- Larger dots can obscure smaller dots and therefore should be restricted to large-scale maps.
- Can also deal with repeat addresses by setting a threshold for (minimum number of crimes) before a point is displayed. Be careful when determining that threshold in that it can influence the identification of a high crime area (show a problem as less of a problem than it is)
- Hot streets are more challenging using GIS. Can plot crime incident locations and match them to street layouts. Can also join the points file to the street segments file of the map. Need to review the results carefully.

Analytical Methods with Crime Maps: Manual Analysis and Choropleth Map Analysis

- Manual Analysis: AKA "eyeball analysis" – visually scan distribution in search of points that are clustered together.
  - Commonly used, but not as accurate. Hard to identify location, relative scale, size, and shape of hot spots when crime data is shown as points.
  - Fuzzy mode analysis: choose an appropriate search radius around a point and then total the number of points within that radius. Aggregating these points shows points that are very close or overlapping each other. Very useful for comparing hot spots. (ex: shows events in bar and in a block radius)
- Choropleth Map Analysis: AKA Graduated Color Map, Area Symbol Maps, or Statistical Surface Maps.
  - Map divided into polygons based on administrative or political boundaries (neighborhood/police beats)
  - Data values are calculated for each polygon based on classification schemes. Display variable in ordinal fashion – lowest to highest crime. Classification scheme will impact the outcome of the maps.
  - Must be cognizant that not all areas are the same sizes and you can't compare areas of unequal size.
  - Can compensate by using normalizing variables (neighborhood size) before assigning value to a polygon
  - Hot areas can be depicted by using bounded areas like polygons, but note they are artificial boundaries
    - Not useful for showing crime patterns that cross boundaries.

Analytical Methods with Crime Maps: SD Analysis and Grid Cell Mapping Analysis

- Standard Deviation Analysis: determine mean center of the crime series and drawing rectangles or ellipses around the center based on standard deviations from the mean. (((O)))
  - Limitation to depicting hot spot analysis is that they are rarely depicted accurately with bounded polygons (like choropleth maps)
  - Useful for evaluating hot spots over time. Show events within the standard deviations before and after a police action in the same area.
- Grid Cell Mapping Analysis: density analysis and compensates for choropleth/SD limitations
  - Uses surface estimation techniques – must first calibrate cell size and search radius parameters so that the results are meaningful and useful. Then a mathematical function visits the center of each cell and within a pre-determined search radius.
  - Simple Density Analysis – when mathematical function is applied to each cell, the number of incidents within a given radius are added together and then divided by the area of the radius = value assigned to cell. Cell represents the number of incidents near that cell divided by the incidents around the cell.
  - Kernel Density Interpolation/Smoothing Technique – a bell-shaped function or kernel is applied over every cell, i.e. the greater weight is given to incidents closer to the center of the radius.
  - Dual kernel density – produces a risk value associated with crime density and allows for comparative density analysis. Compare two different crime types or crimes at two different time periods.

Analytical Methods with Crime Maps: Grid Cell Mapping Analysis (cont)

- Density analysis does not depict physical boundaries so it produces a more realistic image of the shape of the hot spot distribution.
- Advantage over point map because overlapping points or stacked points are added together and represented with a single color
- For density maps, you must determine a threshold for what defines a hot spot. Also, changes to the search radius or grid cell size can yield different maps. Smaller search radii will yield greater local variations. Must also consider the study size of the area which can impact the appearance of the computed density surface.
- Analysts must use their judgment to determine where boundaries should lie by examining the data on the map for hot spots.
- Of note, density maps need to be calibrated manually because they do not consider natural or manmade variables that may affect density (doesn't conform to water, a freeway, etc.). You can mitigate this by incorporating raster making in GIS – build a mask around areas that are not appropriate for inclusion in density analysis (lake) to give a more realistic view of the density of crime.
- Be sure to include a legend with colors and labels for low/high density for your audience.

Statistical Tests for Hot Spots

- Can also use spatial statistics in addition to crime maps to objectively determine hot spots
- Help determine if clustering is occurring and, if so, is it due to random chance.
- Point Pattern Analysis – use a point map to determine if patterns of points are clustered, uniform, or randomly distributed. In this, analysts develop a graduated point map and confirming clusters with spatial correlation statistics. This will identify if clusters of crime are random or not.
- Tests for clustering include
  - Nearest Neighbor Index
  - Spatial Autocorrelation
    - Moran's 1
    - Geary's C

Statistical Tests for Clustering - NNI

- The Nearest Neighbor Index (NNI): test that compares the actual distribution of crime data against a randomly distributed data set of the same sample size
- Distances are calculated between a point and its nearest neighbor, repeated for all points.
- The average distance is calculated for both the actual and randomly distributed sets. The NNI is the ratio between the average distance of the actual and the random data sets.
- if the points are closer in the actual data set than the random one, this may indicate a relationship not based on random chance.
- Note test only points out if clusters exist, not where they are
- CrimeStat III is a computer program that can do this for you.

Statistical Tests for Clustering Spatial Autocorrelation

- AKA spatial dependency – assumes criminal events that occur in different locations yet in close proximity are related.
- Positive spatial autocorrelation indicates that areas with high crime rates are clustered together, and areas with low crime rates are clustered together.
- Moran's I: Global statistic that shows whether the pattern is clustered, dispersed, or random. Can be positive or negative. Moran's I closer to +1 indicates clustering while closer to -1 indicates dispersion. Can compare to the normal distribution to get significance.
- Geary's C: used for analyzing small neighborhoods and describing dispersion of hot spots. Similar to non-spatial statistics in that you are measuring deviations in intensity values of each point to each other.
- Local Indicators of Spatial Association (LISA) statistics: Gi and Gi* statistics which perform computations a grid cell output (density map) to determine if there is an association between data by comparing local averages to global averages

Temporal and Geographic Considerations

- High crime areas can be acute or chronic
- Want to describe hot spots not only spatially but also temporally
- Time range selected by analyst will impact the presence and size of the hot spot.
- Consider time of day and day of week, as well as holidays, seasonal changes, and weekends
- Help determine if there has just been displacement or actual reduction of crime.
- Must look into geographic features that impact crime as well
- May find similarities in locations (bus stops, malls, etc.)
- May also be notable because of non-crime data – may demonstrate clustering of a problem neighborhood even if traditional crime is not seen (graffiti, noise complaints, arrests, DV, etc.)
- Should consider non-spatial factors like commercial robberies targeting a specific product (cigarettes). Can include MO commonalities, exceptional volume of crime, and spatial analysis.

Risk Terrain Modeling (RTM)

- Leverages data from various sources with geography as the common denominator and use readily accessible methods that other people could easily replicate.
- Identifies risks that come from features of a landscape and model how they co-locate to create a unique behavior setting to crime.
  - Ex: “dark alleyway” – alleyway feature and poor lighting feature. Can compute the interaction effect to determine the probability of criminal behavior occurring
- To start RTM, select and weigh the factors that are geographically related to crime. Final model is produced to create a picture of places where criminal behavior is statistically more likely to occur. Useful for urban planning, public health, traffic safety, etc.
- Hot spots tell where clustering is occurring but not necessarily why. RTM helps this.
- Put RTM map and spatial data map side by side to see if there is any overlap. RTMDx Utility is software that can help with this, automating most steps of RTM

Journey to Crime

- Analytical method which estimates the likely home base of perpetrators, usually one committing multiple related offenses. Based on location theory of crime
- Journey to crime states that people commit crimes as part of their daily routine. Crime locations will be relatively close to where the offender works, sleeps, and engages in recreational activity, including paths between (like Routine Activity Theory).
- Awareness spaces are key – places the offender spends a lot of time and therefore are most familiar.
- Crime is committed in places familiar to the offender but not places they will be recognized.
- Type of crime and difficulty involved will influence how close the crime is to the offender's "home base". The farther they are from home, the fewer crimes will be committed (distance decay).
- Factors that will influence how far the offender might travel to commit a crime include crime type, method of operation, time of day, day of week, and property value being targeted.
- May also want to examine the victim's travel patterns
- Geographic profiling falls into this category.

Conclusions

- Read the books and take the classes to strengthen understanding.
- Try to apply the things learned to your every day work to “make them stick”.
- Use the study guides.
  - https://iaca.net/about-clea/ (links for program outline and study guides here)
  - https://iaca.net/about-leaf/ (links for program outline and study guides here)
- Next month: Effective Analytical Writing (Skill Set 16) and Analytical Products (Skill Set 17). Note: this session is a week earlier than normal – 11/3.

Any questions?