

# Understanding & Predicting Illegal Dumping Using Spatial Analysis

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## Introduction

Illegal dumping is a problematic anthropogenic issue that is plaguing both developed and developing countries alike. Illegally dumped items are those that have been discarded outside of one's private property and approved disposal areas. Dumping is different than littering (which is not being studied in this paper) in that it littering consists of smaller items such as cans, fast food trash, or plastic bags, while illegal dumping tends to involve larger items like furniture and electronic goods or large quantities of smaller items that individually would be considered litter.

Illegal dumping has been an ongoing issue for the residents of the City of Victorville, situated 17 miles northeast of the Cajon Pass along the Mojave River, especially in recent years due to its population boom and the rise and fall of the housing market during the great recession of 2008.

The goal of this project is to better understand illegal dumping, by mapping dump site locations, categorizing dump sites, and creating a predictive model using GIS tools that will make it easier for Victorville city administrators to assess illegal dumping risk within city limits. Empirical Bayesian Kriging (EBK), Weighted Overlay, Fuzzy Membership, Optimized Hot Spot Analysis, and Risk Analysis Overlay were all used to determine which method is most suitable for assessing dumping risk within the city limits.



Figure 1. Study area, the City of Victorville

## Data and Data Sources

The data that was used for this project came from a combination of field surveys as well as archival data from the City of Victorville, County of San Bernardino, and Southern California Edison.

Table 1. Data and data sources used in the project

Dataset	Source
Field Collection	Samuel Hiebert
Code Enforcement Reports	City of Victorville
Solid Waste and Trash Reports	City of Victorville
City of Victorville City Limits	City of Victorville
Street Lights	SCE
Centerlines	City of Victorville
Parcels	County of San Bernardino/City of Victorville

## Methodology

This project relied on several different methods in order to complete its overall predictive goals. The methods adopted include: collecting field data, reported data, and spatially referencing them to their geographic location in ArcMap.

This project used three different methods to develop a predictive model and compare them to determine which is the most suitable for future studies. The five methods that were used to describe and possibly predict illegal dumping included, Empirical Bayesian Kriging (EBK), weighted reclassify overlay, fuzzy membership, optimized hot spot analysis, and a risk overlay analysis carried out by unioning vector layers. The EBK tool used a spatial algorithm based on the illegal dump points to develop its own unsupervised prediction model. Weighted overlay and fuzzy membership models required that a multi-ring buffer tool be used to calculate the distance from populated areas, street lights, and open areas. Based on a scoring factor of how many actual illegal dump sites were found within the study area a weight and membership could be established. The optimized hot spot analysis required a fishnet grid that was compared with the collected illegal dumping sites to show the areas where dumping was most concentrated. The same fishnet grid was used in developing the risk overlay analysis, which focused on illegal dump sites in relation to 2010 Census population density data and street lighting data for the city of Victorville.

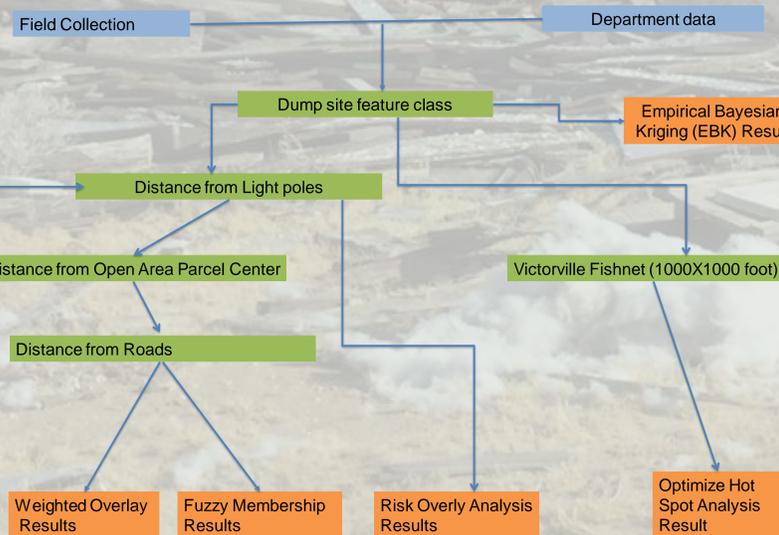


Figure 2. The model consist of data collection through field and departments and was run through several different models to help predict illegal dumping.

## Timeline

Task	Proposed	Reality
Collecting field data	April 4- June 2	April 4- June 23
Gathering information from other departments	April 14- June 28	April 4- June 23
Process data and organize it in file geodatabase	April 14- June 28	April 25- June 23
Use geostatistical methods to analyze data	June 29- July 10	July 11- July 30
Create maps and graphs	July 11- July 21	July 25- July 30

## Results

The results from the EBK, weighted overlay, fuzzy membership, optimized hot spot, and risk overlay analysis models yielded various findings. None of the models clearly predicted where illegal dumping is occurring without some speculation. The risk overlay analysis generated the best predictive raster. Its results agreed with both collected data, as well as areas that are suitable for dumping. The limitations of this model include, it only uses two variables, it does not factor out areas that will never have illegal dumping such as the Southern California Logistics Airport (SCLA) and the square areas leave too much ambiguity to where illegal dumping is occurring. Optimized Hot Spot reaffirmed areas where illegal dumping is occurring based on the data collected however, does little to predict where else in the city it might be occurring. Weighted Overlay and Fuzzy Membership did not offer the continuous predictive data however, did offer areas of possible illegal dumping. EBK results had no variables which created a continuous raster based on dumping directional trends.

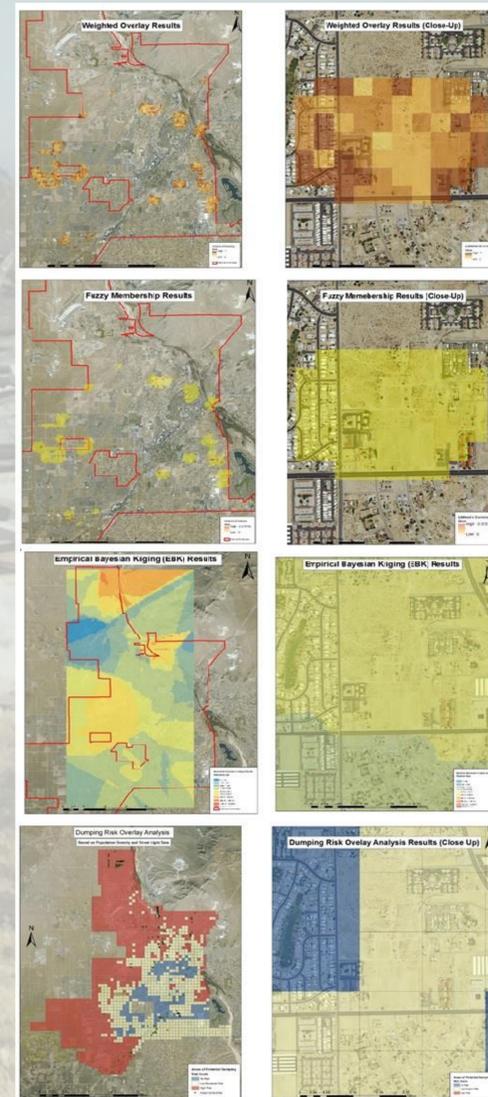


Figure 3. Results from using Weighted Overlay (top-left) Weighted Overlay close-up (top-right), Fuzzy Membership (left), Fuzzy Membership close-up (right), Empirical Bayesian Kriging (left), EBK close-up (right), Risk Overlay Analysis (left), Risk Overlay Analysis close-up (right).

## Discussion

Completing this project had significant benefits from the resulting data. I was fortunate enough to gain licensing for the use of ArcMap through both Cal State Long Beach as well as the City of Victorville to help complete this project. The validity of the results varied, as not all dump sites were located where the models indicated they would occur. The risk overlay analysis did provide proof that using variables such as distance to street lights and population density can predict where dumpsite might be. In some parts of the study areas, the model contradicted with some of the sites discovered as show in the weighted overlay results which focused on potential sites based on distance to population, street lights, and roads. Not all possible predictive factors that contributed or restricted illegal dumping were included such as fenced off property such as the area around the SCLA or homeless encampments for example. In the EBK analysis these factors could have changed the results and should be items to consider in future studies. The City of Victorville has expressed interest in this study because of this ongoing issue in the city. Knowing where illegal dumping is occurring or likely to occur, can help departments better structure their efforts and focus. The parameters in this study were just a few selected out of an array of different factors that can contribute to illegal dumping.

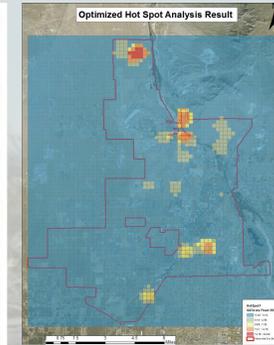


Figure 4. Results from using the optimized hot spot analysis

## Conclusion

In this exercise, the data favored the Risk Overlay Analysis method when it came to analyzing illegal dumping. The advantage to using this method was its ability to interpolate a continuous surface based on the distance to factors positively and negatively impact dumping risk. The EBK, weighted overlay, and fuzzy membership approach should not be ruled out for use in future studies though they were not particularly affect for this project.. Their parameters may need to be adjusted to better display the information and gain meaningful insight. More consistent data could have contributed to the successful run of these models offering more detail than the ones generated in this project.

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