Using Python to conduct Emerging Hot Spot Analysis on Wildlife Road Mortalities in South Texas

Thomas J. Yamashita

31 March 2019

1 Abstract

Roads can have a significant negative impact on wildlife. These effects can be reduced through the construction of mitigation structures such as exclusionary fencing and wildlife crossing structures. Gaps in the fenced area can lead to reduced effectiveness and the emergence of wildlife road mortality hot spots. In South Texas, the Texas Department of Transportation built 11.9 km of exclusionary fencing which is broken by 18 private driveways and three major road intersections to reduce ocelot vehicle mortalities. This occurred between September 2016 and May 2018. Surveys of wildlife road mortality have been conducted since August 2015 and will continue through 2023. Emerging hot spot analysis allows one to assess how hot spots have changed through time at fine spatial and temporal scales. This is typically conducted in ArcGIS, however, this tool excludes locations with no data throughout all time periods. These should be true zeros and by excluding them, it alters the way spatial neighbors are compared, potentially affecting the overall hot spot analysis. Using Python 3, I intend to develop a tool that conducts the same analysis, however, locations within the survey transect without data will be included in the analysis as a true zero. Having a Python based tool for this analysis will speed up processing time and reduce the number of steps required to complete the analysis allowing it to be used more broadly for examination of other highways and longer time periods.

2 Introduction

Roads can have wide-ranging impacts on wildlife, from increased mortality to providing havens from predators. While roads can provide some benefits to wildlife, the majority of their effects are negative with mortality caused by vehicle collisions being the major threat (3). To reduce the negative impacts of roads, mitigation structures are often built which are intended to keep wildlife off roads while maintaining habitat connectivity. This is often done through the construction of exclusionary fencing and wildlife crossing structures; fences keep wildlife from getting on to the road and funnel them towards safe crossings (1). Unfortunately, on major roads, it is not always possible to have continuous fencing along an entire stretch of road. Gaps often exist in the fence for private driveways and major intersections creating spaces where wildlife can access the roadway. These gaps reduce the effectiveness of exclusionary fencing and can create hot spots of wildlife road mortalities (2).

In Cameron County, Texas, ocelots (*Leopardus pardalis*) are critically endangered with one of the major threats being ocelot vehicle collisions (4). On State Highway 100 (SH100), a road with several known ocelot mortalities, the Texas Department of Transportation built 11.9 km of exclusionary fencing and five wildlife crossing structures to reduce ocelot mortalities while still allowing them to disperse across SH100. Construction occurred from September 2016 to May 2018. This fence is not continuous and is broken by three major intersections and 18 private driveways. At the intersections, wing walls (fencing that extends perpendicular to SH100) were constructed while at the driveways, wildlife guards were built to reduce the chance that an animal will access the road. Nevertheless, these represent gaps in the fence and therefore could become hot spots for wildlife mortality. This project is unique in that wildlife road mortality surveys have been conducted since September 2015 allowing for an examination of how spatial patterns of mortalities have changed since before construction of mitigation structures.

A useful tool for assessing changes in hot spots over time is Emerging Hot Spot Analysis in ArcGIS (5). It breaks up a spatial dataset into space-time blocks creating a three dimensional polygon dataset with spatial coordinates on the x and y axes and time on the z axis. It then conducts the Getis-Ord test for hot spots on each level of z and the Mann-Kendall time series test to see how the hot spot z scores change through time. This allows one to determine whether hot spots are emerging, shrinking, or not changing through time. While this is a potentially very useful tool for assessing how construction of mitigation structures affects wildlife road mortality, it considers any location with no values (no mortalities) in any level of time to be a NULL value (Fig. 1). Within the survey transect, this value should be a zero, not NULL, yet ArcGIS has no way to handle this type of data omission without adding dummy values into the dataset. Not including these cells could alter how the tool compares a cell to its neighbors. For example, with a neighborhood distance of three space-time blocks and the first two nearest neighbors are NULL, it compares to blocks that are five units away which alters the calculation of the hot spot z-score. With a small dataset and small gaps in the fence, this can fundamentally alter the interpretation of the results. Therefore, a tool is needed that will conduct the same analysis but will force NULL values within the survey transect to be zero instead of NULL.

3 Objective

My objective for this project is to develop a script using Python 3.7 that will conduct emerging hot spot analysis using all space-time blocks even those that have no mortalities.

4 Methods

Using data collected from wildlife road mortality surveys on mammals and herpetofauna between September 2015 and December 2018 stored in an excel file, I will develop a Python 3 script that will break an excel file into time blocks, conduct hot spot analysis on each time block, and finally, conduct the Mann-Kendall test to compare hot spot z-scores within each time block. I will use the pysal package in Python to conduct the hot spot analysis and the mkt module to conduct the Mann-Kendall test (this replicates the Mann-Kendall test in R). To visualize the results, the data will be exported to shapefile format and a map will be created in either Python or ArcGIS.

Initially, outputs from the python script will be compared to ArcGIS outputs to ensure that both tools are calculating the same values. Next, modifications will be made to correct the issue with the ArcGIS version of the tool. Initial comparisons will be made between netCDF files generated in ArcGIS to ensure comparability then they will be generated within Python using the input excel file. If all is successful, these steps will be merged into a single module that can be used for road mortality data as more data is added to the dataset.

5 Broader Impacts

Successful development of this tool will increase the accuracy of the emerging hot spot analysis by effectively accounting for locations within survey transects as zeros. Additionally, this can be quickly applied to other highways being studied in this project to compare highways through time quickly and efficiently. Within ArcGIS, using model builder, conducting this analysis requires four steps which have to run independently one after the other, so developing an all-inclusive python script will allow all steps to be conducted quickly and accurately, potentially significantly reducing the amount of effort required for some statistical analyses.

Generally, this analysis is useful because it allows for a fine-scale examination of how mortality patterns have changed through time, enabling one to examine the causes of those changes. The analysis can identify seasonal and linear shifts in mortalities so one can better determine how effective a mitigation project is using this method over simple hot spot analysis or time series analysis alone.

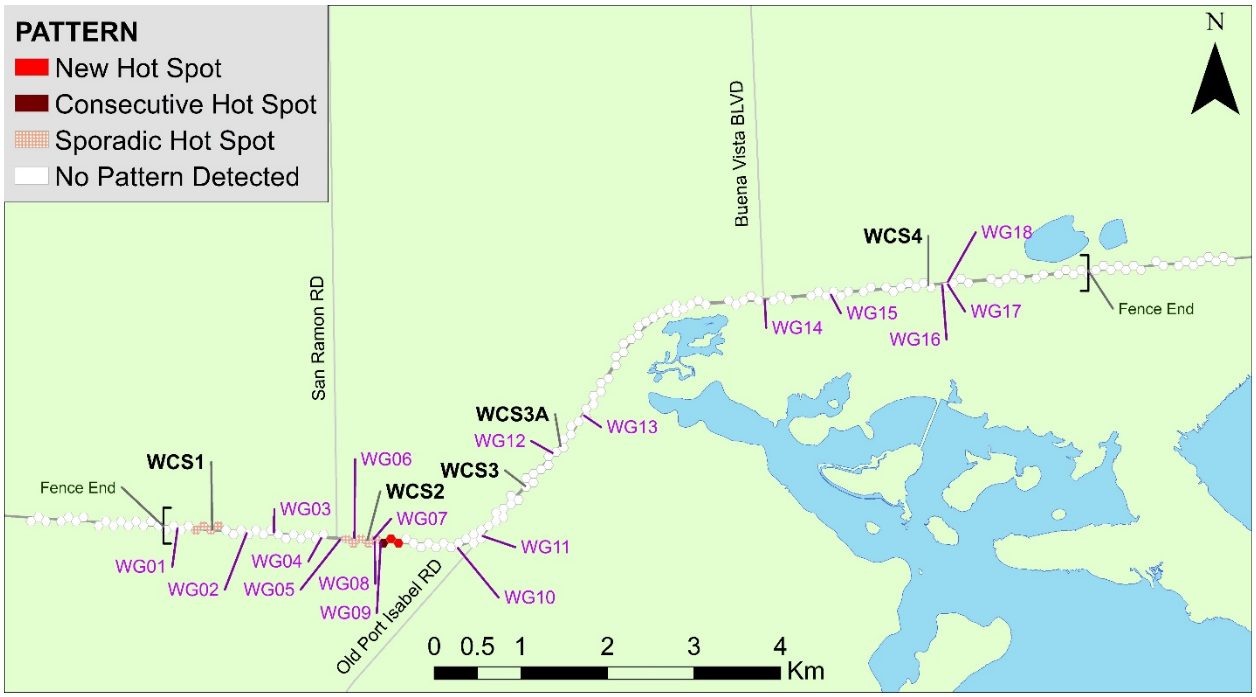

Figure 1: ArcGIS output of Emerging Hot Spot Analysis showing NULL space-time blocks where a zero should be

6 Bibliography

References

[1] Clevenger, A., Chruszcz, B., and Gunson, K. Highway mitigation fencing reduces wildlife-vehicle collisions. *Wildlife Society Bulletin 29*, 2 (2001), 646–653.

[2] Cserkész, T., Ottlecz, B., Cserkész-Nagy, , and Farkas, J. Interchange as the main factor determining wildlife–vehicle collision hotspots on the fenced highways: spatial analysis and applications. *European Journal of Wildlife Research 59*, 4 (2013), 587–597.

[3] Forman, Richard, T. T., Sperling, D., Bissonette, J. A., Clevenger, A. P., Cutshall, C. D., Dale, V. H., Fahrig, L., France, R., Goldman, C. R., Heanue, K., Jones, J. A., Swanson, F. J., Turrentine, T., and Winter, T. C. *Road Ecology: science and solutions*. Island Press, Washington D.C., 2003.

[4] Haines, A. M., Tewes, M. E., and Laack, L. L. Survival and sources of mortality in ocelots. *The Journal of Wildlife Management 69*, 1 (2005), 255–263.

[5] Harris, N. L., Goldman, E., Gabris, C., Nordling, J., Minnemeyer, S., Ansari, S., Lippmann, M., Bennett, L., Raad, M., Hansen, M., and Potapov, P. Using spatial statistics to identify emerging hot spots of forest loss. *Environmental Research Letters 12*, 2 (2017), 024012.

7 Timeline

- Week 1 (4/1-4/5) – This is proposal defense week
  - Examine ArcGIS scripts, codes, and output netCDF files for conducting the analysis
- Week 2 (4/8-4/12)
  - Write some code that theoretically replicates the analysis
  - Compare to the ArcGIS outputs
- Week 3 (4/15-4/19)
  - Convert excel file to netCDF with correct space-time blocks
- Week 4 (4/22-4/26)
  - Combine everything into a single script
- Week 5 (4/29-5/3) – Due week
  - Write paper and make presentation