EEB498 – Research Proposal - 2017

Gregory Huang

Host-parasite spatio-temporal relationships in the Greater Toronto Area

Introduction

Urbanization of landscapes can influence species diversity and interactions by altering the environment (Keesing, 2006). In general, urbanization of an area will lead to homogenization of the landscape, which will subsequently lead to less species diversity (Olden, 2004). The decrease in diversity can contribute to a population's increased vulnerability to disease spread, particularly in terms of host-parasite relationships (Poisot, 2017). The Greater Toronto Area (GTA) has high levels of both spatial and temporal variability in urbanization, which makes the GTA a good candidate area for this research project, as it focuses on the investigation of the dynamics between urbanization and host-parasite interactions (Watts, 2015).

Since this research project is a continuation from Dr. Alexander Watts' thesis (Watts, 2015), I will be using the same Toronto Wildlife Centre (TWC) database Watts (2015) used. The TWC is an organization that rescues stray and injured animals across the GTA, and documents any parasites that are found in these rescued animals. The location and time of where each of the individuals was rescued, e.g. an intersection in the city, is also recorded. The data set includes more than 10,000 of these entries, spanning six years from 2007 to 2012. In addition to the raw data, Watts (2015) also used gridding metrics to parse the GTA into 1 km by 1 km grids, and assigned each grid a yearly urbanization index, which is a metric that is used to measure the degree of urbanization a landscape is experiencing. This project will be adopting the same gridding system.

Processes of Interest

There are multiple “processes” brought about by urbanization that need to be investigated first, before identifying and analyzing the specific consequences of urbanization on host-parasite species interactions. In general, there are two main processes that the project will focus on: biological and environmental. An example of a biological process is the shift in host dispersal ranges. Changes in habitat such as paving new streets, building new bridges, and general construction can cause native hosts to gain or lose access to certain areas in the region, resulting in the modification of dispersal ranges compared to pre-urbanization ranges (Sutherland, 2000). Furthermore, alterations in host species dispersal can also lead to shifts in encounter and contact rates for both host-to-host and host-to-parasite relationships, which both contribute to parasite transmission (Sutherland, 2000). An example of an environmental process is the decrease in percentage and overall lowering of the quality of host habitats (Melles, 2003). Higher human population densities as an outcome of urbanization is a surrogate for the decline of quality habitats, and put more stress on specialist hosts compared to generalist hosts (Keesing, 2006). As generalists have higher tolerances of habitat changes, urbanization of an environment can lead to homogeneity of the species in the region (Olden, 2004). A combination of these processes leads to the hypothesis that as a landscape becomes increasingly urban, more hosts in the region will become generalist species, and as a result, show an uptick of generalist host-parasite interactions.

What this project is interested in is investigating specifically the GTA's spatial and temporal responses to urbanization, i.e. the dynamics of host-parasite patterns that are observed over the years, and whether the hypothesis applies to the TWC data set or not. To do that, each of the 1km by 1km grids will be checked for yearly changes in urbanization indexes, and the TWC animal data will be overlaid to check the host-parasite activities in each grid. What happens to the host-parasite relationships when an area rapidly develops into an urban zone in a year? Conversely, what happens if the change occurs gradually? What happens if an urbanized area returns to a rural state? These are the kind of questions that will be asked when analyzing the grids.

Procedures and Goals

Before I start the actual analysis of the TWC data, there are a few parameters that needs to be clarified. The most important parameter is the urbanization index mentioned in Watts (2015). Multiple factors, such as deforestation and human population density, combine to yield this index. Deciding which factors to contribute more to this index will be the first issue that needs to be tackled. After specific parameters are set, a preliminary "heatmap" for each year will be done on ArcGIS for quality checking. A heatmap essentially finds spatial clusters of the same host-parasite interactions taken from the raw TWC data, without the usage of the grid. This can help identify dominant interactions before grid-specific host-parasite interactions are run to confirm that the results make sense.

Once preliminary work is complete, I will begin the actual in-depth analysis of how host-parasite interactions vary in space (spatially) and time (temporally) in the GTA.

The primary methods of analysis are through bipartite graphs and beta-diversity tests in R Studio. A bipartite graph generated in this study will be temporally regulated and will specifically look at the volume of interactions between the hosts and parasites present in a specific time frame. The two disjoint sets involved in the bipartite will be hosts and parasites respectively. Fig. 1 in the appendix is an example of a bipartite graph generated from the 2007 data. The green bar indicates the hosts, and the purple bar indicates the parasites. The areas linking the two sets indicate the volume of interactions. Beta-diversity analysis is done for checks in species diversity after an environment changes status in the urbanization index, to validate our hypothesis (Ostfeld, 2005 and Poisot, 2017). I will also be using ArcGIS for visual data presentation and analysis. Then, after these plots and calculations are done, I will identify the patterns, and check if these patterns occurred due to changes in the degrees of urbanization. If there are statistically significant interactions between the patterns and urbanization, the results will be crucial for providing more information for important epidemiological and ecological issues, such as betterment of managing potential zoonotic disease spread in densely populated cities and strategies for mitigating biodiversity dilution brought about by urbanization (Ostfeld, 2005).

References

Keesing, F., Holt, RD., Ostfeld, RS. (2006) Effects of species diversity on disease risk. Ecology Letters 9(4): 485-98

Melles, S., S. Glenn, and K. Martin. 2003. Urban bird diversity and landscape complexity: Species–environment associations along a multiscale habitat gradient. Conservation Ecology 7(1): 5. [online] URL: http://www.consecol.org/vol7/iss1/art5/

Olden, JD., Leroy Poff, N., Douglas, MR., Douglas, ME., Fausch, KD. (2004). Ecological and evolutionary consequences of biotic homogenization. Trends in Ecology and Evolution 19(1): 18-24

Ostfeld, RS., Glass, G., and Keesing, F. (2005). Spatial epidemiology: an emerging (or re-emerging) discipline. Trends in Ecology and Evolution 20(6): 328-36

Poisot, T., Gueveneux-Julien, C., Fortin, MJ., Gravel, D., Legendre, P. (2017) Hosts, parasites and their interactions respond to different climatic variables. Global Ecology and Biogeography. 26: 942-951

Sutherland, G. D., A. S. Harestad, K. Price, and K. P. Lertzman. 2000. Scaling of natal dispersal distances in terrestrial birds and mammals. Conservation Ecology 4(1): 16. [online] URL: http://www.consecol.org/vol4/iss1/art16/

Watts, AG. (2015) Effects of Landscape Spatial Heterogeneity on Host-Parasite Ecology (Ph.D. Thesis)

Appendix

Fig 1. Example bipartite graph for 2007 TWC data.