BIOL 3117 Take-Home Final Exam

April 10, 2018

1.0 CONCEPT

Throughout the term you have had the opportunity to learn and explore various techniques for data analysis on a variety of biological (and not so biological) data. While this approach is useful for examining different methods of analysis, it is really the continuous examination of a single data set that provides a realistic view of data analysis as an ongoing process, in which one step follows logically from another. In this exam, you will develop your own set of analyses on a new set of data, bearing in mind the experience you have gained from your work in previous labs and lectures. The objective of this exam is to provide you with a realistic simulation of the complete data analysis process, from initial exploration to presentation of final results.

2.0 TASK

You have been given a data set of physical, chemical and climate variables from 57 lakes from around Sudbury, Ontario, Canada. Also included in the data set are results from a standardized fisheries assessment survey, whereby nets were set in each lake during the summer period when lakes are thermally stratified. The location of each net was randomly selected, and number of nets set in each lake was dependent on the surface area and maximum depth of the lake. Typically, surveys lasted 3-4 days. The biological variables of interest are the average number of Northern Pike (*Esox lucius*), Smallmouth Bass (*Micropterus dolomeu*), Walleye (*Sander vitreus*), and Lake Trout (*Salvelinus namaycush*) caught per net from each survey, which represent the abundance of these species in each lake. Also included is the total number of species caught during the course of each survey. Lastly, there is the distance of each lake to the Vale smelter located in Copper Cliff, Ontario, a major historical point source of acid rain causing air pollution in the region. A complete description of the data set is contained in the metadata file accompanying this exam.

The species highlighted in this dataset share some biological characteristics, but some are different in their preferred habitats and temperatures. All of the species' preferred food items in these lakes are other fish. But, Lake Trout require deep and very cold water temperatures (<10°C) for survival and are very susceptible to acidic conditions. Walleye and Northern Pike are similar in their temperature requirements (18°C to 24°C optimum temperatures), and are somewhat tolerant to acidic conditions. Northern Pike specifically like shallow waters, whereas walleye can use shallow and deep habitats in a lake. Smallmouth Bass prefer warm water (26°C – 29°C optimum temperatures) and are the most acid tolerant of the species in this dataset. Similar to Walleye, Smallmouth Bass can use both shallow and deep habitats.

Sustaining Lake Trout populations and maintaining fish biodiversity in Southern Ontario has proven problematic over the past century. There, it has been observed that Lake Trout are very sensitive to biological, physical and chemical changes to their environment. In addition, biodiversity has declined as aquatic systems have become more influenced by human use. The Ontario Ministry of Natural Resources and Forestry (MNRF) would like to learn from these lessons and has recognized two potential issues that might affect Lake Trout populations in Northern Ontario in the next decade: climate change and the development of the Ring of Fire ferrochrome smelter. As the climate warms, it is hypothesized that cool and warm water species will make their way into more northerly lakes. In addition, as the Ring of Fire development builds up, there will be an increased human presence on northern lakes, and biodiversity may be impacted. You have been hired by the MNRF to assist in their planning process by addressing the following knowledge gaps:

1. Descriptions of the physical and chemical variables of lakes that contain Lake Trout, Walleye, Northern Pike and Smallmouth Bass are lacking, and you have been asked to provide these. Specifically, for each species you should provide a summary of the conditions in the group of lakes that it occurs in. The choice of how you describe variables is yours, but your employer will want to be assured that the choice was justified, the analysis provides a complete picture of the lakes inhabited by each species, and that the presentation of the data is clear and easy to understand.

2. The MNRF is concerned with sustaining Lake Trout populations in the face of climate change and a potentially new source of pollution from the Ring of Fire. Drawing from the data you have that are related to the smelting history of Sudbury, ON, CA, and the relatively diverse species mix of lakes in the area, specifically, they would like to know:
    a. Is there any relationship between lake trout abundance and climate? In addition, are the abundances of the other cool or warm water predatory fish species also related to climate? Subsequently, are there relationships between Lake Trout and the other predatory fish species that might be of concern to resource managers?
    b. Is there any relationship between lake trout abundance and the distance to the smelter that would help advise the placement of the smelter location in order to avoid negative impacts to lake trout populations as much as possible?

3. Lastly, the MNRF would like to identify aquatic biodiversity "hotspots", but conducting netting surveys on the ~250,000 lakes in the province would be costly and time-consuming. Is there a suite of variables that can be used to predict biodiversity? As the statistical expert, you have been asked to recommend if this is a viable alternative to netting.

3.0 DELIVERABLES

The MNRF requires these analyses to be completed by **17:00 EST, Tuesday April 17th, 2018**. Understanding that this is a rapidly approaching deadline they have elected to forego the production of a long and detailed technical report, and have instead asked you to submit an executive summary. This summary should include the following:

1. A brief summary (e.g. one page) of the methods of analysis you chose to complete your tasks, including any modifications, data handling, transformations, or changes to the data set you made. Enough information should be contained within this section to justify your choices and make it possible for someone else to repeat your analysis in the future.

2. A results section that includes the tables and/or figures related to the tasks outlined above, and text that explains your interpretation of these graphs/figures in relation to the questions at hand. Make sure the figures and tables are of publication quality.

3. A brief discussion/explanation of the descriptions of the lakes inhabited by each predator species, the threats posed to lake trout in the face of climate change and new pollution sources, and your biodiversity model.

4.0 CAUTION

You have been retained to complete this work given your experience and knowledge of statistics. The executive summary will be read by experts in fisheries biology and management. These are people with a basic knowledge of statistics, and a very solid grasp of the scientific method. It is crucially important that you provide them with enough information in your report to allow them to assess the validity of your approach to the analysis and the logic of your conclusions. They are interested in your deliverables and need to be convinced of their usefulness. MAKE SURE THAT YOUR METHODS ARE COMPLETE AND YOUR RESULTS ARE CLEARLY PRESENTED.