Triangle Competition in Mathematical Modeling Solutions due Sunday, November 12 at 5pm ET

Choose <u>one</u> of the two problems proposed below. Submit your model report (and summary) to hannah.scanlon@duke.edu by **Sunday, November 12 at 5pm ET**. Reports received after this time will not be considered.

Your report should start with a cover sheet that includes the following information: names of your team members, title of your report, and which problem you chose to solve. The rest of the pages in your report **should <u>not</u> include your team members' names**. Remember to cite your sources.

Problem 1: Human Impact on Baltic Seabird Populations[1]

Humans are present in almost all ecosystems, but with the restrictions due to COVID-19, conservationists have used this unique opportunity to better quantify the role of humans in ecosystems. Cara Giaimo from *The New York Times* reported results from a study which found that the abrupt absence of tourists in Stora Karlsö, a nature reserve off the coast of Sweden and key breeding site for seabirds, has negatively impacted the island's colony of common murres [2]. On the island of Stora Karlsö, tourist traffic was canceled for the whole 2020 season (typical tourist season is from early May until the end of August), resulting in a decline of human presence on island by 92% when compared to the visitor numbers from the previous three years [3].

In the study, researchers investigated how the absence of tourists affected the behaviors of sea eagles, and consequently, how the changes in the behaviors of the sea eagles affected the population of the common murres [3]. Common murres on Stora Karlsö have been under protection since 1880, allowing the population to recover from centuries of hunting and egg collection [3]. During the 30-year period from 1975 to 2005, the common murres population growth was found to be steady, but slow, with an annual growth rate of 1.3% [4]. From 2005 to 2015, the average annual growth rate was estimated to be 5.1% [4]. Common murres nest on crowded sea cliffs, making their eggs, if unattended, an easy target for predation from herring gulls and hooded crows [3].

Without the tourists to deter the white-tailed eagles from the island, there was a sevenfold increase of white-tailed eagle observations on the island. Before the lockdown, between 2010 and 2019, the maximum monthly number of eagles reported to an open national database varied between 0 and 7. During lockdown in 2020, the maximum number of eagles reported varied between 11 and 33 [3]. The white-tailed eagles rarely prey on common murres, but in 2020, for the first time, the researchers observed the eagles attacking murres around the breeding cliffs and on water [3].

The increased presence of the eagles resulted in a sevenfold increase in occasions where the common murres leave locations of breeding synchronously for a significant period of time [3]. The increased frequency of such occasions was found to delay egg laying and to create more opportunities for egg predation. More specifically, the breeding period begins in mid-April with a single egg laid 15 days after mating [1]. The egg incubates for 28-35 days [1]. After hatching, both parents help with the daily feeds [1]. The flightless chick leaves the colony, called fledging, with the male parent when it is 15 to 30 days old. The male parent stays with the chick as it continues to depend on the parent for over a month [1,4]. Hentati-Sundberg et al. hinted at the long-term impact of these changes stating in [3], "As the eagle disturbance affected different sub-colonies differentially, we cannot provide a colony-wide productivity figure for 2020, but our judgement is that the murre productivity observed in 2020 is too low to be long-term sustainable for this population."

Suppose you have been hired by the Baltic Seabird Project to help determine the long-term sustainability of the common murres population on the island. You have been charged with analyzing the impact of the absence of tourists in 2020 (note that travel restrictions to Sweden ended on April 1, 2022) on the population of the common murres on the island of Stora Karlsö.

Create a mathematical model to predict changes in trends in the common murres population resulting from the COVID-19 restrictions.

Write a detailed technical report to explain your model to the Baltic Seabird Project. Make sure to highlight how your model accounts for what is known about the murres' population and behaviors as well as the effects of the COVID-19 restrictions. In addition to this report, write a one page letter summarizing your findings for the Baltic Seabird Project, sharing your confidence in your results and recommending a course of action to best protect the common murres population.

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[1]Shared by Dr. Kara Maki (RIT).

Problem 2: Prescription refusals[2]

Pharmacy prescription refusals are a pressing social justice issue that affects people with identities that are already marginalized. In many states, it is either explicitly legal or not explicitly illegal for a pharmacist to refuse to fill a customer's prescription if the pharmacist has a moral or religious objection. Anecdotal press reports suggest that commonly refused drugs include hormones for transgender individuals, contraceptives for people who can become pregnant, drugs for terminating a pregnancy, and HIV prophylaxis drugs primarily for men who have sex with men. Unfortunately, it is difficult to understand how widespread the issue is or what impact it has on marginalized populations because pharmacies do not keep track of refusals.

You work for an advocacy group that is concerned about the potential impact of pharmacy refusals throughout the state of North Carolina. **Your task is to develop a model for measuring the potential impact on people in marginalized groups when NC pharmacies make refusals.**

You may use the census data[3] provided for the state of North Carolina to make rough estimates of the demographics in various parts of the state. The provided data tables include demographic information and latitude and longitude for the residents of NC (see the provided Table Index for additional information). You also have access to pharmacy names and locations throughout the state[4]. Ultimately, you would like to use these datasets and your model to predict the number of individuals potentially impacted by refusal of different drugs by pharmacies in different locations in NC. Note that you do not need to use all data provided for your predictions.

Write a detailed technical report to explain your model and findings to the analytics team of your advocacy group. In addition, write a one-page letter to the governor of NC explaining the main results of the report and pointing to areas of the state where more detailed, on-the-ground work could help researchers and activists understand the scope of refusals and mitigate the impact on marginalized individuals.

The data set can be found at the following link: `https://drive.google.com/drive/folders/1qjYNPRNgOWJA5fc_mLZgMH_ONw8GTQAi?usp=sharing`

References

[1] Common murre. `https://nhpbs.org/wild/commonmurre.asp`.

[2] Cara Giaimo. Covid-19 kept tourists away. why did these seabirds miss them? `https://www.nytimes.com/2021/01/22/science/seabirds-covid-tourism.html`, 2021.

[3] Jonas Hentati-Sundberg, Per-Arvid Berglund, Aron Hejdström, and Olof Olsson. Covid-19 lockdown reveals tourists as seabird guardians. `https://doi.org/10.1016/j.biocon.2021.108950`, 2021.

[4] Olof Olsson, Jonas Hentati-Sundberg, and Jonas Hentati Sundberg. Population trends and status of four seabird species (uria aalge, alca torda, larus fuscus, larus argentatus) at stora karlsö in the baltic sea. `https://doi.org/10.34080/os.v27.19558`, 2017.

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[2]Shared by Dr. Chad Topaz at Williams College and the QSIDE Institute `https://qsideinstitute.org/`. Any follow-up work on this project must be done in collaboration with QSIDE.

[3]Taken from the American Community Survey (ACS) 2021. See `https://www.census.gov/programs-surveys/acs` for more information.

[4]Curated from `https://linc.osbm.nc.gov/explore/dataset/pharmacies-in-north-carolina/table/`