Triangle Competition in Mathematical Modeling
Solutions due Sunday, November 14 at 12pm (noon) ET

Choose one of the two problems proposed below. Submit your model report (and summary) to ciocanel@math.duke.edu and ruby.kim@duke.edu (Duke teams), daftari@live.unc.edu (UNC teams), and cbutler5@ncsu.edu and ejcurcio@ncsu.edu (NCSU teams) by **Sunday, November 14 at 12pm (noon) 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 not include your team members' names**. Remember to cite your sources.

Problem 1: TriangleWell

Duke, UNC and NC State are looking to develop a new application (TriangleWell) to help students track their health habits. To minimize the number of second-party devices needed to use the app, it will take input data from various sources, including phones, smartwatches, and fitness trackers. The app will only consider step count data from devices that track this info at least every fifteen minutes. The TriangleWell developer committee would like this app to give each student insights into their sleep habits and activity levels, as well as the connections between them. Unfortunately, the developers are currently struggling with how to detect sleep when only step counts are available.

Your task is to develop a model or methodology for inferring accurate sleep patterns based on step counts. For this task, TriangleWell is giving your team a preliminary dataset sampled from 500 students through October. The vast majority of the data was collected from students who only have access to step trackers, but some students have more sophisticated devices that detect sleep. Others have manually reported their sleep times. The data has been pre-processed to be uniform across collection devices; in particular, it has been resampled to give one measurement per fifteen minutes. TriangleWell has split the data into two separate datasets based on if there are labels to indicate sleep or not:

(a) The first dataset contains 400 students with step counts every fifteen minutes.

(b) The second dataset contains 100 students with step counts and binary variables indicating if the student was asleep during each fifteen-minute interval.

Your model should be able to predict sleep in the absence of any labels. In developing your model, keep in mind that the step data and sleep labels may be inaccurate due to device noise or user error. Your team may use any mathematical techniques for your method to detect sleep, but you should explain your approach clearly and justify any decisions you make. You should validate your method for the records that include sleep information and analyze the sleep habits of all students in the provided datasets. Report on any relations you find between sleep habits and activity levels.

Write a detailed report to explain your model and findings to the TriangleWell committee. In addition to your full report, write a maximum one-page summary explaining your approach and findings addressed to your school's University President and Wellness Center.

Problem 2: Bushfire prevention

Bushfires (wildfires) are among Australia's most severe and dangerous natural phenomena, and they are only getting worse as climate change continues to warm the planet and intensify draught. In the summer of 2019-20, bushfires burned an estimated 72,000 square miles of bushland in Australia (equivalent to approximately 43% of the surface area of California). As such, the Australian government spends large amounts of money on initiatives to reduce the severity of bushfires.

There are two commonly used methods for achieving reductions in bushfire severity: hazard reduction burning (HRB) and logging. HRB is a process in which fire crews intentionally set fire to bushland in a controlled way to remove accumulated leaf litter and overgrown underbrush. In the event of a fire, such areas have much less potential to burn, resulting in less severe fires and acting as fire breaks that help mitigate spread. Logging also removes flammable material; however, unlike HRB, it removes trees rather than undergrowth. While previous evidence suggests logging reduces fire danger following the first few years, new research has shown that the young, regenerated forest experiences more severe fires [1].

The New South Wales (NSW) government is reexamining the state's bush management policy after the last few years of severe fires. They have hired your team to make recommendations about their strategy for the next ten years. To do so, your team will need to construct a model for fire spread and forest recovery. You should then use this model to determine what mix of HRB and logging is most likely to reduce bushfire severity.

Write a detailed report to explain your model and findings to the NSW fire management modeling committee. In addition to your full report, write a maximum one-page summary to the NSW Parliamentary Research Service explaining your approach and recommendations.

[1] Lauren Fuge. "Bushfire experts clash over logging impacts" *COSMOS*, 11 May 2021
https://cosmosmagazine.com/earth/climate/bushfire-experts-clash-over-logging-impacts/